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Front cover shows first board to be described — the processor/memory — in John Adam's series on the SC84 micro.

NEXT MONTH

Computer cassette recorder
A. J. Ewins describes the control electronics for a solenoid-operated cassette deck, which can therefore be used in an automatic SAVE and LOAD mode, commanded from the 8-bit parallel port of a microcomputer.

Modem
Richard Lambley details the design of the WW multi-standard modem, for which printed boards will be made available.

Cellular radio
A report on the current situation in this up-and-coming field of communications

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Plus ça change

Once in a while, the appearance of Wireless World changes a little as fashions in typography and layout evolve. In recent times, the changes have been somewhat tentative — a bold-face heading here, a rule here and a bit of unjustified typesetting (meaning ragged, not unnecessary) somewhere else. It is even possible that they have been so slight that not many readers have noticed, and also possible that uncoordinated, small changes here and there led to a style which did not hold together as well as it might have.

With that in mind, our designers and editorial people decided that the moment was right for a full-blooded effort, starting from scratch, to make the journal more attractive to the eye, since recent printing and production charges have made possible the introduction of colour and rather better paper. The new layout of pages is a great deal more in line with the best of current practice than was the earlier style and is, we think, fresher and visually more appealing.

Content is unchanged, except insofar as it is continually changing as the subject moves forward: computing, for example, occupies much more space than it did even two years ago. But the well-established features remain, and will do so long as readers want them.

One result of adopting the new style is that the familiar 'perfect-bound' method of making the issue has gone, and is replaced by 'narrow-stitching', which also means that advertisements tend to appear in unfamiliar places in the page make-up — part of the price one has to pay for the use of colour in editorial pages.

We hope you like the new appearance, which is celebrated by the first part of a description of John Adams’ new computer. His first design, the Scientific Computer, was extremely successful and this new development is similarly advanced, being disc-based and running a good deal of CP/M software. The new WW multi-standard modem also starts this month — the second design by Richard Lambley to emerge from our laboratory.

Pirate chips

Encouraged by the successful tests of Plymouth Poly’s ingenious satellite tv system, research teams in Wireless World’s laboratory block are pressing ahead with their own plans for broadcasting in the 1990s. One promising idea now under development may help do away with the ubiquitous radio pirates of which the IBA complains.

Our researchers note that the three or four pop pirates audible most evenings hereabouts are virtually indistinguishable in style and content: a needless duplication which is wasteful both of human effort and spectrum space.

To replace it, they propose a new national pop radio channel, possibly, for economies of scale, even a pan-European one. This could be distributed by satellite or perhaps as a subscriber on an existing network.

At the listener’s end would be an intelligent receiver, designs for which are already at an advanced stage. Fitted inside each one would be a speech synthesiser chip which, on receipt of encoded cues from the network, would fill gaps here and there in the spoken announcements with brief contributions of its own.

Equipped with a suitably programmed eprom, the device would draw upon a large repertoire of local place-names which it could slot into record requests and motoring flashes. With a few station ident jingles, and the addition of heavy audio compression over all, the illusion of a real local radio station would be complete.

The idea seems to have something in it for everyone. In those underprivileged regions which don’t at present have their own ds, listeners would (for the price of an eprom) be able to feel the sense of local identity now enjoyed by the more fortunate. And the former pirates themselves would be spared the hazards of possible prosecution — slight though these appear to be. Any takers?

Long queue for the QL

Once again, Sinclair Research has failed to deliver a product when promised. At a champagne breakfast launch, at which the QL computer was extensively demonstrated, Sir Clive assured us that this time there would be no delays and that the computer would be available to mail-order purchasers ‘towards the end of February’. Unfortunately the production of the QL hit a few snags. ‘Bugs’ have to be eliminated and this has led to the usual delays which could add four or five months to the promised date for delivery.

By launching a product when it is nearly ready, a manufacturer hopes to steal a march on competitors who may also be ready to launch new products. Such ‘jumping the gun’ is not new in the computer industry. It has been known for main-frame manufacturers to launch an empty box with an impressive specification and then spend the next few months attempting to meet that specification, if sufficient interest is shown by potential customers. But in the case of a personal computer like the QL, we would have thought it important to have the product ready before launch. No doubt, when it does come, the computer will be as impressive as it seemed to be, but the delays lead to a large number of disappointed customers and leaves an impression that we have all been taken in by the undoubted charisma of Sir Clive, and that gives the champagne a nasty taste. Incidentally, has anyone seen a Sinclair miniature, flat-screen tv recently?
World Telecommunications day

Telecommunications: Expanding Horizons is the theme chosen by the International Telecommunications Union for the 16th World Telecommunications Day to be held on 17th May. The day marks the foundation of the ITU which is now 119 years old. In his annual message, Richard E. Butler, Secretary-General of the ITU, praised the success of World Communications Year (1983) which combined many of the abilities of operators, manufacturers and users of telecom systems and pointed out that many nations were retaining their national committees set up for WCY so that the work may be continued.

The improvement of communications in under-developed countries has been a particular concern for the Union as it is believed that telecommunications can play a key role in development. Mr. Butler points out that 15% of all services are confined to about 15% of the world's nations.

Studies carried out by the ITU and the OECD have shown that rural communities, which had been steadily dwindling, could remain viable if they had the means of communication. This does not only apply to the 'Third World'; poorer parts of the United States became more prosperous when telephone services were installed under the Rural Electrification Administration, instituted nearly 40 years ago.

Telecommunications can contribute to the amelioration of rural conditions by improving the social environment. Such improvements come not only from improved living conditions but also from reducing the feeling of isolation felt by many rural inhabitants. Communications channels also work the other way and can inform urban dwellers of the conditions in the country and perhaps give them the will to improve them. Other spin-offs include improvements in conservation and better use of energy, in reduced transportation costs through the provision of telecommunications, for example.

WIRELESS WORLD MAY 1984

Optical-fibre cables and satellite links will further improve rural communications. On the subject of the use of satellites, Mr. Butler maintains that at present they are chiefly used for high capacity trunk circuits which could probably be better served by ground-based links and relays, especially high-capacity digital fibre-optic trunk lines including trans-oceanic links. Over the long term, he says, there are only three major areas that will always be better served by satellite communications than by any other means: aircraft, ships and rural areas.

Satellite communications are by their very nature distributed. It is much more economical to install an earth station in a rural community than to lay down a cable and one or a few channels in each village is much better than large numbers of facilities in fewer locations. The advantages of such satellite communications will become more pronounced as appropriate satellites and earth stations become available.

In brief

Ambit International, component suppliers to industry and especially to the home construction hobbyist, have moved to Park Lane, Broxbourne, Herts, though it will be retaining a sales counter at its former Brentwood home.

Laser etching — a path to bigger ICs

A new process, using a laser instead of the conventional photo resist, has been developed for the production of VLSI circuits by Toshiba in Japan. Scientists at the R & D centre, who were working on the use of lasers as a means of reducing radiation damage caused by the etching radiation, discovered that an etching phenomenon occurred when u.v. light was radiated onto a silicon wafer in chlorine gas. Based on this discovery, they subsequently demonstrated that an excimer (excited dimer) laser beam directed at a silicon wafer could etch the surface accurately without the usual photo-resist mask. The laser used is a chlorine xenon gas tube with a wavelength of 308nm. The phenomenon is believed to occur when chlorine molecules are decomposed into chlorine atoms by the action of the short wave laser beam. The chlorine atoms attach themselves to electrons freed from the silicon surface by the laser radiation. The silicon reacts to these chlorine ions to produce a silicon-chlorine gas thus etching away at the surface.

This process will enable Toshiba to reduce the number of pattern forming steps from seven to one and ensure that damage caused by the etching and pattern forming process itself is eliminated.

Part of a gallium arsenide microcircuit for microwave applications, showing integrated inductors with bridge connections. Because of the particular suitability of GaAs ICs for microwave circuits including satellite communications, Plessey, who supplied the picture, are to mass-produce such circuits. Up to now they have only been made in small batches.

Toshiba expects that when the process becomes operational "within a few years", it will make possible a major advance in precision processing of wafers and will have a great influence on the production of extremely large scale integration; a 16M bit memory has been mentioned. Fine-line engraving of 0.5 microns or below would become possible without the inherent danger of damage to the circuits caused by reactive ion etching. The expensive production equipment needed for resist coating, developing and resist removal in clean room conditions would all be eliminated.
Software course for teachers

The second pack in the Open University's Micros in Schools project is a training program for teachers which discusses software design and helps them to select the best programs from those available commercially. The course is intended for those teachers who have not explored enough on this topic and are likely to give a computer and run a fairly complex program. The first OU pack on educational computers, Awareness, would bring a user up to this level. The course requires some 40 to 50 hours' study and is suitable for both primary and secondary school teaching.

The pack starts by showing how a small Logo program is constructed and how the user can modify its operation and make short procedure calls. Educational programs are discussed, including simulations, models and information retrieval programs; drill and practice; adaptive programs and intelligent systems.

This leads to a critical analysis of three commercially published computer-assisted learning packages so that the teacher can understand the qualities that make good software good. Educational Software includes a study book, activities book and course reader, programs on disc and three commercial packages. There is also an audio cassette.

Version of the course are available for Apple II, which includes an offer for a generous discount on Apple Logo; and for the RML 380Z which includes its own RML Logo. versions for the RML 480Z, the ZX Spectrum and the BBC model B computers are being prepared. details from Micros in Schools Project, Open University, Milton Keynes.

Interactive video discs for union education

It can't be very often that a trades union gets a pat on the back from a Conservative minister. Such however is the case when the Electrician's Trades Union installed an interactive video disc player in their Union Training College at Cudham. The system is to be used to train union members in microelectronic technology and the system is to be developed jointly by the union and Epic Industrial Communications with the Department of Industry providing two-thirds of the £150 000 costs. The union and Epic will provide the balance and will market the system to industry and training institutions, next year.

At the announcement of the project, Kenneth Baker, Minister for Information Technology, said, "I am very pleased to see this project launched. A trade union, an enterprising British firm and an exciting new technology are working together in a way that should be a pattern for all".

The system will combine laser video discs with one or more microcomputers to produce a package of information graphics. According to the Managing Director of Epic, Eric Parsloe, "The system will provide a low-cost solution to a major industrial training and productivity problem and should certainly give the UK a lead in Europe".

Frank Chapple, General Secretary of the Electrical, Electronic, Telecommunications and Plumbing Union, commented; "The EEPTU is the only union to have its own training facility for running courses in new technology. Through this development the union has been able to offer a first class service that ensures that members are able to keep pace with developments in industrial technology and provide industry with the appropriate skills needed to install, commission and maintain modern plant and machinery. The joint development of the interactive videodisc learning system combines a training program on microelectronic technology with the very latest in teaching techniques and adds to the uniqueness of the union's programmes supplemented with computer-generated text and achievement".

The videodisc learning system will be able to illustrate difficult electronics concepts and will show industrial applications of installation, maintenance and repair. The disc will contain a mixture of still frames, sequences of operation with a voice commentary and live action sequences. The computer graphics will include circuit diagrams for fault diagnosis. The union will use the system to supplement their tutors and for self-paced student learning.

The hardware to be used has not yet been selected. One option is to combine a Philips Professional Laservision player with a BBC model B micro, using the Microtext language but other approaches are also being considered.

Epic have produced other interactive video systems including a project for an electronic manual for Rolls Royce and a diagnostic disc on gastroenterology for a drugs company.

Walter Tusting Cocking

It is with much regret that Wireless World announces the death at the age of 77 of Walter Tusting Cocking, C. Eng., MIEE.

Walter Cocking was first associated with the journal in the early '30s when, as a young experimenter, he developed a number of wireless circuits. He first worked as a freelance experimenter and writer and later he was invited to use the Wireless World laboratory facilities. Shortly afterwards, he became a full-time member of staff. In the days before the second world war, he established his reputation as a first-class engineer with an eye for detail and an ability to convey his developments in a concise and easy-to-understand manner.

Before the existence of an electronics industry and supporting component manufacturers, it was his contention that we should publish nothing unless the constructor could make all the special parts himself. Thus, when he developed and published the first constructional articles for television, he gave precise instructions how to wind the scan coils, first having made the flared winding mandrel out of blocks of wood. Such was the quality of his engineering.

At the outbreak of war, he had already published a number of books, including his definitive work on television, Television Receiving Equipment. Not surprisingly, he was 'co-opted' into the army, where he was involved in secret work on military projects throughout hostilities. He never discussed this work, even years later. He liked to tell the story of coming back to Dorset House, the home of Wireless World, years later, to be greeted by the newspaper seller at the door with 'Evening Standard as usual sir?'. The equally undramatic Cocking simply said 'thank you'.

In the post-war era, with the editor (H. S. Pocock and later F. L. Devereux) Walter Cocking made an enormous contribution to Wireless World, helping to maintain and improve the engineering standards and integrity of the journal. Pursuing his goal of excellence in engineering, he developed an audio amplifier using triode valves in push-pull (PX4s) that preceded the famous Williamson amplifier.

Whilst continuing to provide constructional articles and other more theoretical material, he edited the famous Wireless Engineer. Under his editorship, this achieved such a reputation for quality and integrity that a number of overseas universities accepted publication of a paper or thesis in it as being of appropriate standard to award the author a degree.

Later in his career, Cocking became editor-in-chief of Wireless World and of the successor to Wireless Engineer. He retired in 1972 but maintained constant contact through letters to the editor. A truly great technical journalist, Walter Cocking was a tremendous influence on all who worked with him and will be sadly missed. 

TJB

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<tr>
<th>62 x 34mm</th>
<th>30.35VA</th>
<th>0.35Kg</th>
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<td>20.50</td>
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### 50 VA

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<th>80 x 35mm</th>
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<td>3.00</td>
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### 120 VA

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<th>100 x 40mm</th>
<th>50.15VA</th>
<th>1.2Kg</th>
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<td>2.00</td>
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### 225 VA

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<th>140 x 45mm</th>
<th>75.35VA</th>
<th>2.2Kg</th>
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<td>3.00</td>
<td>1.00</td>
<td>0.15</td>
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WIRELESS WORLD MAY 1984

CIRCLE 026 FOR FURTHER DETAILS.
Pausaid

This low-cost speech training aid won second prize in Wireless World’s recent design competition. It offers help to a large number of people with moderate speech impairments.

There are a number of speech disorders which cause patients to lose control of their rhythm of speech or to run words together. One relatively common example is dysarthria, which results from damage to the central or peripheral nervous system. This may lead to slurring, lack of co-ordination or altered muscle tone, which reduce the intelligibility of the speaker’s words. The effects can range from a slight difficulty in pronouncing certain syllables to complete loss of the power of speech.

Dysarthria can be a sign of such diseases as Parkinsonism, multiple sclerosis and Huntington’s chorea, or it may be the result of some incident such as a stroke or head injury.

The main aim of speech therapy with dysarthritic patients is to improve the clarity of speech and to minimise the abnormal characteristics. Patients are encouraged to reduce the speed of their speech and to enunciate each syllable separately, so that they can articulate with greater precision.

Unfortunately, most find it hard to monitor their own speaking rate: they do not know when they are speaking too fast or that they are eliding words and syllables.

Some patients in these groups have spoken rapidly for most of their lives, and to change such a deeply ingrained pattern of behaviour may take a sustained effort. Many improve their speech dramatically during therapy sessions, only to slip back to their old ways when they return home. But with help of a simple training aid, these people might be able to continue their practice at home, freeing the speech therapist to deal with more sufferers.

The aid described in this article was developed in cooperation with Dr Pam Enderby, chief speech therapist of the Frenchay Hospital in Bristol. A survey carried out by Dr Enderby’s department indicates that there are some 400 000 people in the United Kingdom with moderate speech disorders; and she believes that such an aid may be able to help at least 250 000 of them.

Circuit design

The function of the aid is to monitor the wearer’s speech, analyse it for pauses and to sound a warning if the pauses are absent or spaced too widely.

To avoid false triggering by extraneous noises a throat microphone is used. The type chosen is already widely found in speech therapy departments; it is very light and comfortable to wear. The microphone plugs into a small plastics box containing the electronics, which may be supported by a carrying pouch hung around the neck. Since the aid is intended for remedial exercises

by

P.J. Pickersgill
B.Sc. and
N.J. Stewart
B.Sc.

Fig. 1. How Pausaid works: C1 charges when the user speaks and discharges during moments of silence. If he fails to pause now and then, the buzzer sounds.
and not for everyday communication, there is no need to conceal it.

Operation of the aid is centred on a capacitor which charges up as the patient speaks and discharges during pauses. If the charge exceeds a preset threshold a buzzer is triggered.

The design is based upon an LM324 quad op-amp. One section, IC19, forms a microphone amplifier with a gain of about 50. Its input is clamped by D6 and D7 to prevent damage should the battery charger be plugged into the wrong socket. IC19 is arranged as a variable gain amplifier with a maximum gain of 100 controlled by the preset resistor R6, R7, R8 and C19. IC9, is used as a comparator, its reference voltage supplied by R16 and R17.

The talk without pause time limit is fixed by D10, R12, R16 and C19, pauses necessary to prevent triggering of the buzzer are determined by D10, R16, R19, and C19. R21 sets the hysteresis for the Schmitt trigger IC19, which drives the control input of the buzzer directly. D12 resets the circuit and prevents unwanted feedback.

Using Pausaid

The unit is powered by a PP3 battery, from which it draws about 10mA during normal use. A rechargeable battery can be fitted if required: there is a charger socket on the front panel. The preset control are accessible with the help of a trimmer tool, but the patient need be concerned only with the on-off switch and the 'signal received' light.

Prototypes have been in use at the Frenchay Hospital for several months with good results. Dr Enderby reports significant improvements in the intelligibility of patients using the aid and she describes her initial tests as 'extremely encouraging'. One development she has suggested is the possibility of replacing the buzzer with a body-worn vibrator. This would help patients with hearing problems and might enable the aid to be used by others in everyday conversation without the embarrassment a buzzer causes.

Phil Pickersgill is a design engineer with Racal’s mobile communications company in Reading. He studied electrical and electronic engineering at Bristol University, graduating in 1982. Since then he has worked on the design of a variety of high frequency mobile radios.

Nic Stewart is an assistant consultant with General Technology Systems, a small independent consultancy based in Brentford, Middlesex. He studied at Bristol University, graduating with a degree in geography in 1981.
ZX81 INTERFACE

ZX81 generation and measurement interface

Addition of a few i.c.s to the ZX81 allows one to measure and generate signals with remarkable ease and accuracy. This simple circuit provides a signal generator, a d.v.m., a frequency counter/timer and a spring-board for those new to microprocessor interfacing.

Apart from its applications in games and bank-balance analysis, the home computer can prove a useful tool for measurement and control. This simple interface provides a signal generator, d.v.m. and frequency counter/timer and although it has limitations in relation to professional instruments, its performance is more than adequate for many applications. Basic program examples shown are tried and tested but you will no doubt find ways of improving them. Higher operating speeds can of course be obtained using machine code. Although both hardware and software were designed for the ZX81, modification to suit other microcomputers should be easy.

Digital voltmeter

Conversion of analogue levels to digital form may be carried out using a digital-to-analogue converter (d-to-a) and comparator circuit. The program is designed so that the computer sends out digital information to form an analogue ramp at the converter output, Fig. 1. The comparator compares the signal to be measured and the ramp voltage; when the two are equal, the comparator output connected to the computer input changes state. On detecting this change of state the computer halts ramp generation and so holds the digital equivalent of the unknown analogue signal. Program flow for analogue-to-digital conversion program is also shown in Fig. 1. This cycle may be repeated continuously, as it does in the digital voltmeter program List 1.

Using a technique known as successive approximation would be faster but I haven't tried it yet. In this method, the computer sends a digital value of half the maximum to the converter. If the comparator output is unchanged, the value is increased by 50% until it does. Similarly, if half the maximum value is too high and changes the comparator output state, the value is reduced by 50% until the comparator output changes back. The ramp approach may then be used as before or the 'too-much, too-little' approach continued until the final value is reached.

Signal generation

Signal generators such as the 8038 i.c. produce a range of waveforms with variable amplitude and frequency. They depend on an RC network for timing, which is good enough for general audio work, but where stability and repeatability are important a crystal frequency reference is desirable. Phase-locked circuits are an answer, but they become complicated when wide variations in frequency, amplitude and wave shape are required while retaining repeatability and stability. This design provides accurate programmable square and pulse signals and — with some limitations — synthesized waveforms. Synthesized waveforms were designed for the ZX81, modification to suit other microcomputers should be easy.

Fig. 1. For analogue-to-digital conversion, used to measure voltages, the computer feeds a digital-to-analogue converter with digital values starting at zero and incrementing to form a voltage ramp at the converter output. Unknown input voltage is compared with the steadily rising ramp and when the two are the same, the comparator output changes state. Sensing this change, the computer stops incrementing the digital value and thus holds a value representing the unknown input voltage.
forms are constructed from a number of discrete segments. A drawback of this method is the time taken to build the shape, i.e. if 128 steps are used, a clock running at 128 times the resulting waveform frequency is required. The more steps, the better the waveform, but for most applications 128 steps suffice. Digital values representing segments of the waveform are supplied to the d-to-a converter by the computer in the appropriate sequence. These values may be calculated by the computer and stored ready for transfer. List 2, used to generate sinewaves, is easily modified to produce more segments or other waveforms.

Squarewaves can be generated in many ways, the simplest being to use a continuously looping program which sends one and zero logic levels alternately to the output, Fig. 2. Using Basic and ZX81 fast mode, the highest frequency obtained is 190Hz, or 12kHz using machine code; lower frequencies are obtained by introducing a delay into the program. Different delays between the two logic levels will produce pulses but more interestingly, the delay may be varied each time round the loop to produce swept frequency or frequency-modulated signals.

Drawbacks to this approach are that matching the delay to the frequency required is done by trial and error and the upper frequency is rather limited. A more elegant way of controlling the generation process is to use a dedicated circuit such as the 8253 which has three separate and independently programmable 16-bit counters. The device operates by dividing a clock signal by a certain programmed value, and functions up to 2MHz. Each counter may be used in one of five modes, including ones for pulse and squarewave generation. Unfortunately, when the divisor is small, gaps between each programmable frequency are large, i.e. 1/2, 1/3, 1/4, etc, but with a high clock frequency this is not so important.

List 3 is a program for squarewave generation and simply requires a control word and two data bytes for each counter section. Division factors may be varied, and simply by changing these measurements the computer may be used to calculate the result as 16-bit hexadecimal.

Fig. 2. Pulse generation by software is simply a matter of writing a program which loops round, switching a digital output line on and off on each cycle. Mark/space ratio of the output signal is determined by proportions of delays x and z. Varying these delays for each loop can produce frequency and/or pulse-width modulation.

Fig. 3. Timer/counter connections. For frequency measurement, input pulses are counted during a period of known length and conversely for period/interval measurement, pulses of known frequency are counted during a period determined by the input signal. Frequency generation is simply a matter of sending a division ratio and control word to the 8253 timer/counter i.e.

Frequency/period measurement

Frequency is measured by simply counting the number of input pulses during a known gate period. Conversely, a period is measured using the period as a gate and counting the number of pulses of a known frequency that occur during the event. Both of these measurements may be made using the 8253 by connecting it according to Fig. 3. Counters zero and one are set as squarewave generators in mode two and the third counter is set to mode zero for pulse counting. In mode zero the counter is preset to a known value, usually FFFF16. When a positive edge is received, the counter is decremented by the clock until the gate returns to zero. The computer can then read the remaining value, subtract it from FFFF16 and display the final result.

In the case of frequency measurement, counter zero is set to produce a clock and counter one to divide this down to 0.5Hz. Counter three is then gated by the resulting 1s positive section of this signal so that frequency may be read directly in hertz.

The gating period for period and interval measurement will depend on the range required. For intervals of, say, 1s, clock pulses of 1kHz would resolve 1ms but for

integer (\(f_0\))

Least-significant byte = \(f_0 = \text{integer (}f_0\)) \times 256

Where n is low, the resulting frequency's precise value can be calculated by dividing the clock frequency by the integer of n. How to use the 8253 timer is outlined separately.

WIRELESS WORLD MAY 1984

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intervals of several minutes, a 1s clock is more appropriate. Setting the desired clock rate for best resolution is relatively simple. List 4 is a program for these measurements.

**Hardware**

Some input/output hardware is required for sending data to the d-to-a converter and for reading inputs from the comparator and timer circuits. It is also useful to have spare lines for other purposes. A popular and easy-to-use device for this purpose is the 8255. It provides two eight-bit and two four-bit ports, all individually programmable. Figure 4 shows the complete interface circuit.

Decoded address lines select the 8253 and 8255 devices; memory locations C000 to FFFF are free in the ZX81. When the circuit is active, ZX81 ram needs to be disabled so the RAMCS signal is taken low. Address lines A0 to 14 are decoded by gates, output of which enables the 74LS138 data-selector circuit. This in turn selects the 8255 for A2 and the 8253 for A1. Lines A13 are inter-

**List 1. Voltage measurement using the ZX81**

1. POKE 49155,137 Initialize 8255
2. FOR D=0 TO 255
3. POKE 49152.D
4. LET A = PEEK 49154
5. IF A = 2*INT(A/2) THEN GOTO 70
6. NEXT D
7. PRINT D; "V"
8. GOTO 20

**List 2. Sinewave generation program**

Store sine values x, x increments

1. REM xxxxxxxxxx
2. INPUT X
3. FOR N=1 TO X
4. LET P = 16513 + N
5. LET S = INT((128 * (1 + COS(2 * PI * N / 360))) * N * 360/X))
6. POKE P,S
7. NEXT N
8. GOTO 20

Run this then delete lines 40 to 70

9. LET Q = PEEK P
10. POKE 49152,Q
11. NEXT N
12. GOTO 20

Note Frequency may be reduced by inserting

55 PAUSE x

where x is the pause value.

**Fig. 4. Measurement and signal-generation interface for the ZX81**

-provides voltage, period/interval and frequency measurement, accurate and programmable pulse/squarewave signals and low-frequency synthesized waveforms through software. Spare digital i/o lines are available on the 8255 i.c.
nally decoded by both devices. Input/output port A of the 8255 supplies data to the d-to-a converter and the converter output is connected to D0 of port C. Counter one output of the 8253 is connected to D1 of port C. A 5V supply is available from the computer, but using this can lead to problems. It is better to use the 9V unregulated supply and a separate 5V regulator with a small heat sink. The ZX81 transformer should cope with this provided that no other external loads are applied. Each program shown will operate on its own using the standard 1K-byte memory; if further memory is available all of the functions could be incorporated in one large program and selected at will.

The 8253 needs an accurate clock signal best derived using a crystal. Readily available but running at 6.5MHz, the ZX81's own clock is not convenient for this purpose so I added a 1MHz crystal oscillator. The LM311 comparator is readily available and operates from a single supply rail but any similar i.c. may be used. Improved resolution at higher frequencies could be obtained by using a 2MHz crystal.

**Using the 8253 counter/timer i.c.**

Each of the 8253 timers is set up independently by sending a control word to the device. The control word selects the operating mode and has to be followed immediately by associated data. In mode zero, the data presets the count to be decremented while in mode three the data sets the division ratio. Control word format is according to Table 1. Bits four and five select the form in which the data is loaded, which can be least-significant byte only, most-significant byte only or least-significant byte followed immediately by the most-significant byte. A further option is to read and latch the counter. The double-byte load option is used here. Binary count is selected by a zero at bit zero.

Yet another facility is provided for reading the count after decrementing. Sending control word 80, reads the count and transfers it to a separate register. The register is then simply read using two 'peek' operations. Addresses for the counters are

- 49156 for counter zero
- 49157 for counter one
- 49158 for counter two
- 49159 for control

### Table 1. Control-word format for the 8253 counter/timer

<table>
<thead>
<tr>
<th>Bit Function</th>
<th>Data</th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Counter No</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Read/Load</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Mode No</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Bin./Dec.</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Data word in decimal: 54, 118, 176

### Table 2. Control-word format for the 8255

<table>
<thead>
<tr>
<th>Bit Function</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Set flag</td>
</tr>
<tr>
<td>6</td>
<td>Sel. mode zero</td>
</tr>
<tr>
<td>5</td>
<td>Port A</td>
</tr>
<tr>
<td>4</td>
<td>Port C, upper</td>
</tr>
<tr>
<td>3</td>
<td>Sel. mode zero</td>
</tr>
<tr>
<td>2</td>
<td>Port B</td>
</tr>
<tr>
<td>1</td>
<td>Port C, lower</td>
</tr>
</tbody>
</table>

Decimal data: 137

### List 3. Squarewave generation

1. POKE 49155,137 Initialize 8255
2. INPUT F F is desired frequency
3. CLS
4. LET N = 1,000,000/F
5. LET M = INT (N/256) L.s.b.
6. LET L = INT ((N/256) * 256) m.s.b.
7. POKE 49159,54 8253 Control
8. POKE 49156,L I.s.b.
9. POKE 49156,M m.s.b.
10. PRINT 1,000,000/INT N; "HERTZ" Print actual frequency
11. GOTO 20 Next frequency

### List 4. Frequency counter/timer program

1. POKE 49155,137 Initialize 8255
2. POKE 49159,54
3. POKE 49156,232
4. POKE 49156,3
5. POKE 49159,118
6. POKE 49157,208
7. POKE 49157,7
8. POKE 49159,176
9. POKE 49158,225
10. POKE 49158,255
11. LET A = (PEEK 49154)/2 read port C, d,
12. IF A = 2 * INT (A/2) THEN GOTO 110 wait for D0 = 0
13. IF NOT (A - 2 * INT (A/2)) THEN GOTO 125 wait for D0 = 1
14. POKE 49159,128
15. LET X = PEEK 49158
16. LET Y = PEEK 49158
17. CLS
18. PRINT 65536 - ((Y * 256) + X); "HERTZ"
19. GOTO 80

### Programming the 8255

The function of each port is set up by sending a control word to address 49155. Port A is set as an output and port C as input. Remaining ports may be set and used as required. Control-word format is according to Table 2. The program to initialize the circuit is POKE 49155, 137 (send control word) POKE 49125, DATA (send data to d-to-a converter) POKE 49153 (read lower port C data) Addresses for 8255 control are

- 49152 for port A
- 49153 for port B
- 49154 for port C
- 49155 for control

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TELEVISION

Improving colour television decoding-5

In obtaining improved horizontal resolution consideration must be given to the loss of luminance that occurs at the i.c. stage at this stage of signal processing the luminance is clamped, blanked and matrixed with the colour difference signals to produce the red, green and blue signals for outputs at low impedance. The TDA3561A one-chip decoder response has a 3dB peak-to-peak output at 5MHz but further h.f. losses occur in the following circuitry which provides the red, green and blue colour tube drives, typically 100V pk-pk, to the tube cathodes.

RGB tube drive stage

Many home receivers, of three or more years old will have single transistor class A video output amplifiers. These work well on negative-going edges but the load capacitance (c.r.t.+tube base and stray=12pF) can discharge through the transistor. On positive edges, the rise-time is determined by the load resistor, a.c. feedback cannot help. To obtain a reasonable performance, low-valued resistors have to be used, resulting in high dissipation (10-20 watts).

A better solution is to use some form of push-pull circuit with complementary transistors or active pull-up by means of an emitter follower.

Advantages of newer types of output stage, are better symmetrical bandwidth, lower dissipation, similar rise/fall times, and larger output amplitude. A complementary circuit is shown in Fig. 40, taken from a note issued by the Mullard Applications Laboratory, Mitcham. In this circuit, both the upper (BF423) and the lower (BF422) transistors are biased to conduct sufficiently to maintain correct d.c. conditions (at picture back level) and the capacitor 4.7nF and 2.2µF enable the transistors to provide peak currents (no voltage transients) of several times the means. This will give rise/fall times of 100ns, with a full amplitude response flat to 4MHz falling to 3dB down at about 5.6MHz and providing up to 40V pk-pk output to 9MHz. It will also handle the tube cathode input impedance of around to 9kΩ without introducing non-linearity. The colour tube current can peak to 7.5mA on peak white and at black level the input impedance reaches maximum capacitance. Dissipation in this type of output stage, in typically 1W per channel. The lower-dissipation circuit can be readily mounted on the tube base thus reducing the load capacity to 8pF and improving performance further.

It is better to use the voltages on the A2 second grids of the c.r.t. to balance the cut-off voltages of the three RGB electron guns. The guns then operate with similar resolution (defocusing at high beam currents), video drive, black to white grey-scale tracking and input cathode loading.

For the regular TX10 receiver, Fig. 39, lower trace was obtained by applying the line sweep to pin 10 (the luminance input) of the decoder chip (TDA3561A) and using a low capacitance (2.2pF) X 100 test probe at the output of the video drive amplifier which feeds the cathode of the gun (see Fig. 37). Figure 39, 1st line, shows that the colour subcarrier frequency if 6dB down. In fact the situation is somewhat worse than this because, in addition there is the effect of a subcarrier notch, a 6MHz sound notch and a (far from perfect) luminance delay line before the decoder chip. As it is not intended to use these three components in the modified receiver (although details of them will be given later), it is only necessary to consider from pin 10 (luminance input) of the i.c. (TDA3561A) onwards.

The output drive stages to the c.r.t. cathodes plus equalisation circuits for TDA3561A remain to be considered for improvement. The TX10 receiver video output circuit provides both active pull-up and active pull-down and the line sweep shows that a video excursion of 100V pk-pk can be achieved nearly up to the edge of the band.

Such an output stage is shown in the circuit diagram of the decoder chip TDA3561A, Fig. 40. Some compensation for the 3dB response drop across the decoder chip, and for the loss that occurs in the three transistor output stages may be achieved by adding capacitance across the feedback resistors carrying the RGB decoder outputs. In the circuit of Fig. 40 capacitances of 27-33pF connected across the 2.7Ω resistors from pins 12, 14 and 16 (R, G and B outputs, respectively) will give a suitable lift.

The type of output stage used in the Ferguson TX10 receiver, Fig. 41, is a class A stage in which the lowest transistors 653, 652 and 651 form the amplifying stages for each of the R, G and B feeds and 659, 658, 657 emitter followers provide active pull-up; note that resistors 665, 664 and 663 must be low-capacitance components. Some crossover distortion occurs as the emitter followers begin to conduct on pull up. This effect can be seen on a line-sweep oscilloscope trace of the output waveform but it is difficult to discern on inspection of the displayed picture. Again, the feedforward resistors on the output pins 12, 14 and 16 are shunted with a series LCR combination of 33µH, 151µF and a 1kΩ resistor (for the TX10) to give a flatter rise.

Fig. 39. Top trace is the luminance sweep 0.5 to 8.5MHz applied to pin 10 of the TDA3561A decoder chip. Lower trace is the signal at the tube cathode (pin 2) showing loss in response at high frequencies in the decoder chip and the video output drive circuit.

Fig. 42. Typical frequency response of TDA3561A colour demodulator chip through to the RGB output stage. This was the green drive to the c.r.t. cathode.

Fig. 43. Video sweep showing output of modifier comb board with the subcarrier notch retained by the f.e.t. gate connected to ±12V rail; modifier turned off.

by D. C. A. Read B.Sc. (Eng), M.I.E.E.
response. The capacitor and the inductor resonate so that the lift does not continue beyond subcarrier frequency. Figure 42 shows the typical overall frequency response of the TDA3561A colour demodulator chip through the RGB output stages; in practice, Fig. 42 was the output response of the green drive to the tube cathode.

From a comparison of Fig. 39 with Fig. 42 it is apparent that there is some ringing at the beginning and end of each line. On investigation, it was found that the leads carrying RGB signals between the decoder chip and the tube base board (which contains the RGB output video drives transistors) must be carefully positioned. In the circuit condition shown in Fig. 39, the rings were at a high amplitude because these leads were passing near the switched mode power supply. Since the power supply chopping rate is line-locked (operating at 15.625kHz), magnetic field 'rings' from the transformer can readily be picked up by the wires. Figure 42 shows that, with careful positioning, 'rings' at the end of the active line are greatly reduced and can be made virtually invisible on the final display picture.

The response trace shown in Fig. 43 was taken with the notch...
removed.

Alternative circuits between the i.f. and decoder

The added circuit board shown last month may not be appropriate if the tuner i.f. uses a surface acoustic wave filter with the colour subcarrier frequency 4-6dB down, or if the tube cannot display video signals in the region 3.5 to 5.5MHz, or if the received signal is poor.

To investigate these difficulties reception tests were carried out on a South of England transmitter with the results shown in Figs 44 to 51. The test equipment was first placed 'back-to-back' to determine response flatness and the effect of channel filters. Insertion gain and group delay responses are shown in Fig. 44 and 45. The extra marker indicates fnc, the left end of the trace is zero in terms of the baseband frequency (0-5.5MHz video). Figs 46 and 47 are the gain and group delay responses with the transmitter included in the chain. Amplitude errors are within ±1dB over the range 0-5.5MHz, but the phase errors increase greatly above fnc. Subtracting the test equipment errors (back-to-back test, Fig. 45) from the Fig. 47 full-line trace gives the broken-line response curve which indicates approximately the resulting group delay and shows that at 5MHz the error is 100ns or nearly half the period of fnc. With such an error it is difficult to obtain zero 7.8kHz twitter at the chroma transitions (chroma input

Fig. 44. Figure shows amplitude response of the test modulator and demodulator connected back-to-back (1dB/cm).

Fig. 45. Trace shows the group delay response of the modulator and demodulator (50ns/cm).

Fig. 41. Part of the TX10 receiver showing components associated with the decoder chip.
Fig. 46. A BBC 1 transmitter in the south of England. Figures show the amplitude response (right), group delay characteristic (Fig. 47, middle) and i.t.s. test signal performance (Fig. 51, below).

Fig. 47. Insertion loss 4.65dB, Reverse voltage loss 10.51dB, Forward voltage loss 22.33dB, Power loss 7.14dB, Voltage loss 14.01dB, Insertion loss 5.68dB.

Calculated values:

Band-pass filter, R, = 510Ω

Impedance of post modifier/modulator filter, R, = 75Ω.

Filter or delay line

R, = 510Ω, the characteristic impedance of gaussian band-pass filter used for chroma filtering, Fig. 34 March, R, = 75Ω.

Calculated values:

To reduce the need for low impedance drive stages and to avoid awkward inductor or capacitor values it is often advantageous to scale the network impedance. To use standard 75Ω test equipment these networks are suggested.

R, = 471.01Ω
R, = 81.2Ω
Power loss 14.01dB
Forward voltage loss 22.33dB
Reverse voltage loss 5.68dB
Insertion loss 10.51dB

Filter or delay line

R, = 106.07Ω
Power loss 7.66dB
Forward voltage loss 10.67dB
Reverse voltage loss 4.65dB
Insertion loss 7.14dB

This circuit avoids the high losses of matching pads. 81Ω resistor may be removed to reduce insertion loss. With the above circuit placed close to the generator the output waveform was unaffected — but check with oscilloscope.

820 to 1.8kΩ to suit delay line. For 150Ω filter, make left two resistors 106Ω, 150Ω on right. For 510Ω filter make left 471Ω, right 510Ω.

Fig. 48. Television screen photograph showing similar effects of residual 7.8kHz at colour transitions caused by lack of amplitude and/or phase symmetry in chroma path. Such symmetry should be maintained because the V-spectrum shifts on alternate lines, see Fig. 4 Dec 1983 issue; also Fig. 72.

Fig. 49. With an input of 100% colour bars, photograph shows screen with a minimum of cross-luminance at colour transitions. Colour bar generator was fed directly to the comb filter (Fig. 34 circuit).

Fig. 50. Conditions as for Fig. 49 but with inclusion of the transmitter and receiver tuner plus i.f. section in the signal path. Results are still better than a luminance notch decoder only, but the possible improvement compared with Fig. 49 conditions is about half.

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In the inductor details for the Fig. 34 circuit L, should read 10μH not 5. Inductors 13 & 14, not included on that list, are 22μH Panion or Sigma chokes. Also in that diagram, please ignore the 60ms delay figure at DL2 and disregard the last five words in note 3 (which refer to the phase equalizer C9, L9, C10, and L10). Capacitors 20 and 25 should be polystyrene types.

Apologies for the slip in the caption on page 32, where T9 should have read T9, T10.

* A circuit board layout that will be available for the decoder design has a dual in-line arrangement for the 796 i.c. (Motorola's MC1496 or 1596 suffix G or L is available from Ambit.)
SC84 Microcomputer

Designed for engineers and enthusiasts, the SC84 microcomputer uses a 6MHz Z80 processor and has 64K-bytes of ram — but its main feature is that it can be used with a disc operating system and much readily available applications software.

I designed my first computer, the Scientific Computer published by Wireless World in 1979, to gain experience with microprocessors. This small system had novel features for its time including a hardware number cruncher and up to 5K-byte of ram! Looking back, the Scientific Computer appears embarrassingly primitive but, judging from correspondence, it served its purpose of giving readers the best possible introduction to microprocessors — hands-on experience.

This new design has a similar objective but it also permits the use of much readily-available software including word processors, language interpreters and compilers. Retained features are the Z80 microprocessor, the resident machine-code operating system extended to provide extra commands, and general accessibility needed for engineering applications. New features are the 64K-byte of user memory, a high-resolution c.r.t. controller and a flexible i/o section including interfacing for 3.5, 5.25 or 8in single or double-sided, single or double-density disc drives. Up to 32 lines of 96 characters or 192 by 192 picture elements may be displayed and graphics and characters may be mixed.

My disc operating system, SciDOS (see note at end of article), is compatible with most software written for the standard 8-bit operating system CP/M. I have also designed software to make use of special features of the computer, in particular the v.d.u. These programs include utilities such as a disc directory and an extended Basic interpreter. Much of this software was developed in conjunction with the Scientific Computer whose disc interface came later, so users of the original computer will find that their software runs on the SC84 with little or no modification.

SC84 reflects the shift towards microcomputers with most of their programming on disc rather than in read-only memory. The only rom in this design is an 8K-byteeprom which on switch-on or reset copies the resident operating system into random-access memory (ram) and is then switched out, leaving the system entirely dependent on ram. There are two advantages in this approach. Firstly, having everything in ram means that every aspect of the computer is open to experimentation. Secondly, while a system with, say, Basic in ram will be ready to program in Basic as soon as it is switched on, that rom is an encumbrance when you want to use anything else but Basic. The classic argument against disc-based systems is that a ram-based system is ready for use as soon as you switch it on, whereas initiating a disc-based system can take as much as 45 seconds. SC84 initiates in just under one second and leaves virtually all of the system ram available for whatever you want — Basic, Pascal, machine-code assembly, word-processing etc. A major feature of SC84 is that a disc operating system, SciDOS, has been written especially for it. As well as implementing those commands and functions necessary for CP/M compatibility, this software provides some extra commands and functions which make the system of use to those who see a computer as more than a black box. SciDOS has been kept small by efficient programmin;

by J. H. Adams

SC84

Processor

4/6MHz Z80 processor. Maximum 64K-byte ram. 58K-byte ram available using SciDOS.

Display

Up to 32 lines of 96 characters fully programmable. Scrolling window determined by software. Graphics mode 0 gives 192 by 96 pixels, mode 1 gives 192 by 192 resolution. Characters and graphics may be displayed simultaneously.

Input/output

Up to four single or double-sided 8, 5.25, 3.5 or 3m disc drives may be used, either single or double density. RS232 serial i/o data rates range from 1 to 38400baud with separate transmit/receive clocks. Synchronous serial i/o format is 5 to 8-bit auto-search and sync. or asynchronous 5 to 8-bit with 1, 1.5 or 2 stop bits. RTS and CTR signals control serial data flow. Eight-bit parallel data input is buffered by schmitt i.cs. Eight-bit parallel output drives five t.t.l. loads. Three mos i/o lines operate event counters, pulse timers and 280 interrupts. Four mos timer lines are available for timing and sound generation.

John Adams is currently working on a high-resolution colour graphics processor using the 7220, and an eprom programmer interfacing to SC84 but with its own processor.
Timing for Z80 memory read and write cycles. 'Early write' cycles are common in larger systems but are not found in most eight-bit processors.

The Z80 dynamic RAM, bus and write and the clock timing cycles are common for dynamic RAM, I/O, control (far right). On resetting, part of the ROM content is loaded into high RAM and the ROM is then switched out, leaving up to 64K-bytes for user programs.

First of SC84's three main sections — the processor — with 64K-byte RAM, operating system, ROM and logic for dynamic RAM, bus driver and reset control (far right). On resetting, part of the ROM content is loaded into high RAM and the ROM is then switched out, leaving up to 64K-bytes for user programs.

Timing for an op-code fetch. The Z80 microprocessor has a special register for use with dynamic RAMs which provides a refresh address coinciding with a refresh control signal.

The dynamic memory control is quite novel. For this reason, and for the bad publicity that dynamic memory sometimes gets, it is worth detailing a few interrupt-service routines. Each device capable of interrupting is supplied with one or a range of such 'interrupt vectors' during the computer's initialization so that an interrupt occurs the Z80 is able to pick out and make a call to specific routines for each interrupting vector. The strength of the system should be that by changing an interrupt vector or a particular entry in the table of addresses, different service routines can be provided for the same interrupt line. This is particularly important, for example, with the disc controller used which uses one interrupt line to signal both a request for data from the system during disc writing and the offer of a data byte during disc reading. This 'interrupt acknowledge' sequence is condition seven in Table 2.

Z80 clock

Z80 address lines

Program counter on Ap-Ap

Refresh address on Ap-Ap

MREQ

RAS

RFSH

Address-multiplexer control

Ram address lines

A7-A7 A0-A15 A0-A8 (refresh)

CAS

Data output Data valid

W (during read cycle) Data goes inactive well before CAS occurs

W (during write cycle) Data goes low well before CAS to ensure an 'early write'
This has been a description of a memory read cycle. A write cycle is similar in that the RAS signal connects cells to buses and releases sense amplifiers and then the CAS signal operates the latching multiplexer and activates the write strobe. The difference is that the signal on the data-input pin is routed through the multiplexer to the cell. During a normal write cycle the data output pin will follow the output of the cell while CAS is active. This might seem to preclude the use of dynamic memory in circuits usually associated with static memory, where the same line is used for data input and output, but it is possible to prevent the output of a dynamic memory from coming on when CAS goes active by arranging for the write signal to go active before CAS does. These 'early-write' cycles are common in large systems but are not found in microprocessors such as the Z80 where the WR signal goes active well into the memory cycle and is too late to be of use. One answer is to use an eight-bus buffer between the RAMs and the data bus, but my solution is to use the inverse of RD as a write strobe. Whenever RD goes high, i.e. at the end of reading memory or i/o, the write strobe goes low and so the dynamic memory is primed for a write cycle. If the write strobe is removed from the memory by RD going active low at the beginning of the cycle, well before CAS is applied, the contents of the memory will be preserved and so the bus will not be broken, but if it is not possible to cut off the write strobe during the write cycle, the effect is unnoticeable.

The sequence of pulses for the dynamic memory is generated by a series of Schmitt buffers (IC's of 741). RAS is generated by the leading edge of memory-request signal MREQ, which triggers monostable (IC's of 555). A potentiometer sets the RAS pulse length. For the devices specified in the diagram MREQ should last for at least 200ns and have a fall-off period of 120ns. In practice this adjustment is not too critical with a system running at 4MHz as a complete RAS cycle lasts at least two clock cycles which corresponds to 500ns. Set the potentiometer to give the off-period required for the memory devices used. If it is not possible, to its mid-position for a 4MHz microprocessor or at least its minimum for a 6MHz version.

---

As for the features of its operation before the full address is in. The bus line is, naturally, physically much wider than the individual cell which has now been connected to it. In the scheme of the row-address strobe (RAS) and the potential stored in the column driven but lost on the bus. At one point on the bus is a sense amplifier assembled on the bus, each bus line being addressed at a time. The address is latched into the memory, the highest bit is stored and the other seven are decoded to decide which of the 128 cells in each of the rows should be connected to the bus line for that row.
Fibre optic communications

First of a three-part series reviews the fundamentals of fibre optic transmission and outlines the main advantages and limitations in using optical fibres as a communications medium.

Part 1 — Optical fibres and waveguide transmission

An optical fibre is a dielectric waveguide made from glass (or occasionally of a transparent polymer) and essentially consists of two regions, a core region and a cladding region, Fig. 1. Protection and a degree of mechanical strength is provided by the outer jacket. The fibre is characterized by a refractive index profile as a function of radial distance from the fibre axis, as illustrated in Fig. 2. Silica is used for the majority of fibres with either germanium or boron doping to achieve the desired refractive indices. Inexpensive fibres can be made from perspex polymer but they exhibit very high losses of around 500-1000 dB/km.

The most convenient type of fibre to describe is the multimode step-index fibre of Fig. 2(a), where the core region has a constant refractive index, n, that is larger than the constant refractive index of the cladding region. This fractional refractive index step difference $\Delta$ is only small, usually around 1%, but is sufficient to produce light guidance by total internal reflection under certain conditions. In a multimode fibre the core diameter is large compared to the wavelength of light, hence propagation in the fibre can be modelled adequately by using geometrical optics. For a typical multimode step-index fibre we might have $n = 1.5$, $\Delta = 0.099$ with $\Delta = 0.01$, core diameter of 50μm and a cladding diameter of 100μm.

Lengths of optical fibre can be joined together with very low losses (0.1 to 0.3dB) by fusing their ends together whilst clamped in a special alignment jig. Demountable connectors require a high degree of mechanical precision for best results, with losses of around 1dB per connector pair being typical. In Figure 3 a point source is shown entering the light rays over a wide range of angles. Ray 1 enters parallel to the fibre axis and simply propagates straight along the axis. Ray 2 strikes the fibre at an angle relative to the axis. Because the air outside the fibre has an index of refraction of 1.0 whilst the fibre core has a refractive index of about 1.5, the ray is bent toward the fibre axis according to Snell's law of refraction. After travelling a short distance along the fibre ray 2 strikes the core-cladding boundary and is refracted again. If the angle of incidence at the core-cladding interface is sufficiently small, the ray will totally internally reflect and continue to propagate along the fibre following a zig-zag path. However, if the angle of incidence is too large, ray 3 for example, the ray will enter the cladding region and ultimately be absorbed by the higher losses in the cladding and jacket. Note that the light will still be correctly guided even when the fibre is subject to bending or twisting. Obviously under these conditions the zig-zag light paths will be somewhat modified.

The maximum internal angle $\theta_{\text{int max}}$ a ray may have relative to the fibre axis and still be guided is given by Snell's law:

$$\sin \theta_{\text{int max}} = n_0^{-1} \sqrt{2\Delta}$$

$$\sin \theta_{\text{ext max}} = \sqrt{2\Delta}$$

where $n_0$ is core refractive index, n the cladding refractive index, and $\Delta$ the fractional index step ($n_i - n_e/n_o$). For $n = 1.5$ and $\Delta = 0.01$ then $\theta_{\text{int max}} = 5.5^\circ$, corresponding to $\theta_{\text{ext max}} = 8.1^\circ$. An equivalent way of describing a fibre is by way of its numerical aperture (NA), defined as $\sin \theta_{\text{int max}}$ in this example NA = 0.1.

It is a feature of optical fibres that they require a light source with a narrow emitting angle to efficiently couple power into the fibre. Two requirements conflict when deciding on a suitable value of $\Delta$ and hence NA for a fibre. A large step index makes it easier to couple power into the fibre but the increased total internal reflection angle allows a greater number of zig-zag paths per unit length. The increased length for some rays tend to smear out fast data pulses and reduces the potential bandwidth available. On the other hand a low value of $\Delta$ produces a higher bandwidth fibre but makes it more difficult to couple energy into the fibre.

The two major fibre characteristics of interest from a communications point of view are (Fig. 2)

1. The numerical aperture (NA)
2. The mode distribution (MD)

These two properties determine the propagation characteristics of a fibre pair being bent or twisted.

For a typical step index multimode fibre

$$n = 1.5$$

$$\Delta = 0.099n$$

$$\theta_{\text{int max}} = 5.5^\circ$$

$$\sin \theta_{\text{int max}} = 0.1$$

and $\theta_{\text{ext max}} = 8.1^\circ$
Fig. 4. Light loss in a multimode fibre approaches the theoretical minimum except at the wavelengths associated with water impurities.

Fig. 5. If the bandwidth of the fibre is insufficient then adjacent data pulses can be spread out to the extent of becoming indistinguishable.

Fig. 6. Pulse spreading is much less noticeable with graded index fibres than with step index multimode fibres.

Typical attenuations for different technologies to illustrate the potential advantages of optical fibres for communication. A twisted pair of 0.65mm wires has a typical attenuation of 15 to 20dB/km at 1MHz increasing as f², but cross-talk problems restrict their use at higher frequencies. Coaxial cables require optimization for best attenuation figures, with a value of around 75dB/km being common at 100MHz. Optical fibres are clearly superior in terms of attenuation and in addition exhibit far higher bandwidths.

The maximum usable bandwidth or bit rate for a communication link occurs when two adjacent, but separate, input pulses emerge from the far end of the link smeared out in time to an extent that they are indistinguishable (assuming that the receiver has a sufficiently high bandwidth). Thus the two input pulses in Fig. 5(a) will still be detectable separately if they emerge as in (b), but not if they overlap to the extent of (c).

In a multimode fibre the bandwidth is primarily determined by two mechanisms: modal delay spread and material dispersion coupled to the source spectral bandwidth. As the amount of pulse-spreading depends on the length of the fibre it is most useful to quote the performance of a fibre as the product of its bandwidth and length. For any given fibre and source, bandwidth can be traded off against length (however the maximum length may be restricted by the allowable system attenuation, see part 3).

Modal delay spread

The first of these bandwidth-limiting factors, modal delay spread, refers to the differences in the group delays of different waveguide modes. In terms of ray optics, this is equivalent to saying that the rays which are totally internally reflected at the higher angles of incidence on the core-cladding boundary take a longer zig-zag path before emerging at the far end of the fibre. Referring back to Fig. 3 shows that a ray travelling at an angle θ relative to the fibre axis takes 1/cos θ or longer to travel an axial distance along the fibre than does a ray travelling straight along the axis. The maximum time delay difference would be

\[ \delta t_{\text{max}} = \Delta \frac{n}{c} \text{(ns/km)} \]

where c is the speed of light in vacuo. For a typical fibre with an index step \( \Delta = 0.01 \) and a core refractive index \( n_2 = 1.5 \), then \( \delta t_{\text{max}} = 2\Delta n_2 \text{ns/km} \). The pulse-smearing caused by this delay spread is equivalent to a modulation bandwidth-length product of around 5 to 10MHz/km. In other words, the pulse is spread out in time at the receiver.

Communications point of view are signal attenuation and bandwidth. Absorption of light by conversion into heat and scattering principally determine the attenuation of an optical fibre. Recently-developed laboratory fibres have attenuation figures approaching the limits set by Rayleigh scattering due to the intrinsic molecular inhomogeneities of glass. At the popular wavelength of 0.85µm (low-cost high-lifetime aluminium-gallium arsenide i.e.d.s) the Rayleigh scattering limit is about 2dB/km; at a wavelength of 1.3µm the limit is around 0.3dB/km; whilst at 1.55µm the limit is as low as 0.15dB/km, Fig. 4. Presently available commercial 'premium' fibres exhibit losses of around 2.5 to 3dB/km at 0.85µm and 0.7 to 1.5dB/km at a wavelength of 1.3µm [1].

Apart from the Rayleigh scattering limit the main loss mechanism in optical is that due to OH ‘water’ molecular excitation, as illustrated in Fig. 4. Fortunately, advanced processing and drying techniques have brought these loss regions down to manageable proportions within the last five years or so, although it is obviously wise to avoid the 1.4µm wavelength of OH excitation. Optical sources such as i.e.d.s and injection laser diodes i.l.d.s covering these near infra-red wavelengths will be described in the second part of the series.

It is instructive to compare...
words, due to modal delay spreading a 1km fibre of this type would exhibit a usable modulation bandwidth of 5 to 10MHz.

One method of reducing the modal delay spread in a multimode fibre is to make the refractive index difference of the core graded rather than stepped (refer back to Fig. 2(b)). Rays propagating in such a graded-index fibre have nearly equal delays as the higher mode zig-zag rays now take a helical path, keeping to the outer regions of the core where the refractive index is lower and hence the speed of propagation faster. By choosing a suitable index profile (usually parabolic) the modal delay-spreading can be reduced by two orders of magnitude or more relative to multimode step-index fibres.

Figure 6 shows how the modal delay spreading varies with refractive index difference Δ for both step index and graded-index multimode fibres at a wavelength of 0.85µm. To achieve the best compromise between bandwidth and source coupling efficiency it is usual for most multimode fibres to have a Δ value of around 0.01, producing typical modal delays of 50ns/km and 0.3ns/km for step and graded-index fibres respectively. This corresponds to a fibre bandwidth-length product of approximately 1 to 5GHz km at 0.85µm due to modal delay spreading for a graded-index fibre; a substantial increase. The penalty is the extra manufacturing difficulty of retaining light control over the index profile, for even slight unplanned deviations in the index profile will cause a disproportionate reduction in the bandwidth-length product.

An alternative way to reduce the modal delay spread is to make the fibre core region much narrower than the multimode fibre core but still with a step index, Fig. 2(c). As the core diameter is reduced toward the wavelength of light, fewer and fewer of the higher order zig-zag modes can propagate and the fibre eventually becomes a monomode waveguide (HE₁, mode) when the core diameter falls below approximately three times the wavelength of the optical radiation. It is extremely difficult to make fibres with such a narrow diameter (2 to 3µm) and so usually diameters in the range 5 to 10µm are used and a few low-order propagation modes tolerated. (In contrast, a typical multimode step-index 50µm fibre may support several thousand propagation modes.)

The modal delay-spreading of a true monomode fibre must be zero, but there are usually several low-order modes present in a practical fibre, making it difficult to give meaningful figures. For a step-index monomode fibre modal delay spreading is not usually the restricting factor on the operational bandwidth-length product (it is probably well beyond 100GHz km). Instead, the practical restriction placed on the bandwidth-length is due to the second mechanism — that of fibre material wavelength dispersion and the spectral width of the optical source.

Visible red light rather than infrared is often used with the low-cost polymer fibre shown.

Material dispersion

Material dispersion refers to the variation in group velocity with wavelength of light in the fibre. The dispersion causes pulse spreading in fibres driven by optical sources with a finite spectral width; the greater the source spectral width the greater the pulse spreading and therefore the lower the bandwidth-length product. A typical 0.85µm i.e.d. exhibits a spectral width of around 0.05µm (50nm) in contrast to an injection laser diode whose spectral width is typically 0.002µm (2nm). These figures translate to bandwidth-length products of about 500MHz km and 25GHz km for i.e.d.s and
**OPTICAL FIBRES**

After a postdoctoral fellowship at Manchester University, Brett Wilson taught in Baghdad for a year and then returned to work on optical position detectors and sensitive non-contact current measurement. He then lectured at Nottingham University, where he's been concerned with novel uses of op-amps in addition to fibre optics, and from Easter returns to Manchester, this time at UMIST. His Ph.D. was on a high-speed laser stroboscope for magnetic bubble research. Hobbies include walking, cycling, climbing, motocycling, films, literature and photography.

### References

### Table 1. Principal limitations on fibre optic systems.

<table>
<thead>
<tr>
<th>OPTICAL SOURCE</th>
<th>MULTIMODE</th>
<th>FIBRE</th>
<th>MONOMODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.e.d.</td>
<td>λ=0.85µm, Δ=0.50nm</td>
<td>n=1.5, 6GHz</td>
<td>n=1.5, 6GHz</td>
</tr>
<tr>
<td></td>
<td>&gt;1000</td>
<td>GHz km</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>I.e.d.</td>
<td>λ=1.3µm, Δ=0.22nm</td>
<td>n=1.5, 2.8GHz</td>
<td>n=1.5, 2.8GHz</td>
</tr>
<tr>
<td></td>
<td>&gt;1000</td>
<td>GHz km</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>

i.e.d. respectively at 0.85µm.

Fortunately a material dispersion minimum has been discovered at 1.3µm which allows for wide bandwidth transmission over distances, >100GHz km, even with an I.e.d.8. Combined with the generally lower losses at 1.3µm, this has provided the impetus for much recent research at longer wavelength operations for future optical sources and detectors.

For any given fibre type and optical source there are therefore two main limitations on the maximum achievable bandwidth-distance product that can be achieved. Either the modal delay spreading or material dispersion will dominate depending on the fibre type, source type and operating wavelength. Table 1 summarises the points discussed so far in a convenient form, including figures for the highest modulating speeds so far achieved with I.e.d.s and i.e.d.s. Only there is much development to be done on source modulation before the bandwidth potential of the best fibre system is reached.

Step-index multimode fibres are best employed in short-haul medium bandwidth systems, probably with an inexpensive 0.8μm I.e.d. source as modal delay spreading restricts the performance to around 10MHz km. Graded-index multimode fibres are the natural choice for long-haul high data-rate links operating up to approximately 15GHz km at 1.3µm, probably using an i.e.d. source for faster modulation. Monomode fibres operating at 1.3µm with an i.e.d. source offer the best performance for ultra-high data rates. It may not always be possible to trade off the extremes of the bandwidth-distance product because of system power level restrictions imposed by fibre attenuation.

The only area in which present optical fibre systems are inferior to traditional metal cable systems is in the allowable power budget between the transmitter and receiver. It is presently difficult to launch more than several hundred microwatts of optical power into a fibre from an i.i.d. (less for an I.e.d.), whereas I.e.d. transmitters can inject many times this level of input power into ordinary copper cables. Similarly, optical detector-receiver arrangements are much less sensitive (+1 to 20W) than r.f. receivers.

The allowable power loss between transmitter and receiver in an optical fibre system is therefore restricted to a maximum of around 30 to 40dB for acceptable bit error rates or signal-to-noise ratios. This is much less than a conventional cable system. Fortunately, attenuation of an optical fibre is much less than that of traditional coaxial cables, resulting in potentially longer spacings (20 to 50 km) where there are few cable splices or optical junctions.

The problem of restricted power budget must be kept in mind when considering optical fibres for data network systems where there may be many junctions, couplers or splitters with attendant high losses. There is no optical equivalent of a high impedance tap.

A general comparison is made in Table 2 between the characteristics of twisted pairs, coaxial cables and fibre optics used as communication links. The many advantages of fibre optic link are clearly evident.

**Main benefits of fibre optic systems over metal cables:**
- higher system channel capacity
- lower bandwidth and small loss
- longer distance between repeaters
- electrical isolation of input and output
- almost complete immunity to e.m.i.
- almost complete freedom from signal leakage and crosstalk
- smaller size and weight
- lower system cost per channel km.

### Table 2. Comparison of major communication cable types.

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>TWISTED PAIR</th>
<th>COAX CABLE</th>
<th>OPTICAL FIBRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length-bandwidth product (MHz km)</td>
<td>1-2</td>
<td>50-100</td>
<td>1,000-5,000</td>
</tr>
<tr>
<td>Spacing between repeaters (km)</td>
<td>1-2</td>
<td>1-2</td>
<td>5-20</td>
</tr>
<tr>
<td>System cost</td>
<td>Low, small increase in future</td>
<td>Medium, small increase in future</td>
<td>High, large decrease in future</td>
</tr>
<tr>
<td>Crossstalk</td>
<td>High</td>
<td>Low</td>
<td>Negligible</td>
</tr>
<tr>
<td>Noise immunity</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Input-output isolation</td>
<td>No</td>
<td>No</td>
<td>Total</td>
</tr>
<tr>
<td>Weight, size</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Cable connections</td>
<td>Soldering, standard connectors</td>
<td>Soldering, standard connectors</td>
<td>Splicing, well aligned connectors</td>
</tr>
<tr>
<td>Fabrication control</td>
<td>Loose</td>
<td>Medium</td>
<td>Precise</td>
</tr>
</tbody>
</table>

In contrast to metal cable systems, fibre optics is a rapidly developing technology. It is obvious that fibre optics is currently superior in many respects to metal cable transmission techniques. But these advantages can only be strengthened as the technology matures. Over the next ten years or so we are likely to see the increased use of integrated optics in couplers, switches, modulators, sources and receivers further increasing the advantages of guided optical transmission over metal cable systems. Optical transmitters and receivers are discussed in part 2 of this article.
‘The report of my death was exaggerated’  
(MARK TWAIN)

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COMMUNICATIONS COMMENTARY

Tv hazards

The problems that can arise when a television mast, or aerial system, fails were underlined in the incident that put all four channels off-air at Durriss, near Aberdeen at the height of the appalling weather conditions on January 17. While it proved possible for IBA, BBC, Grampian TV and British Telecom riggers and engineers to restore service to most viewers in a matter of days, some viewers remained virtually without television until February 9. Although this incident is the first time that a very large number of UK viewers have lost all services for a matter of days, (the collapse of the Emley Moor mast in 1969 left BBC-1 unaffected) basically similar incidents have happened elsewhere.

Last October, for example, a 315-metre mast of Belgian television at Wavre, serving Brussels with a considerable number of radio and two television services, was blown down. While a temporary substitute for the 'Radio 21' service used a spare transmitter at the Palais de Justice, other services were lost over stations.

An electrical fire put an American tv transmitter WOWV-TV in West Virginia off the air in the afternoon of January 12. Before the station could be put back on the air that night a second fire broke out, completely destroying both transmitters. Finally a new transmitter was brought in, but the station was off-air for four days.

Satellites

Although the European Ariane launch vehicle scored a major success with the Intelsat V communications satellite launched on March 5, the problems for engineers have not been entirely overcome. The marine communications organization refused to accept the Intelsat V F7 spacecraft as unworkable and the March WIRELESS WORLD MAY 1984 satellite is to an earlier design still not entirely debugged. The F9 launch scheduled for summer 1984 has been put back to 1985. The problems with the booster engines on the Space Shuttle satellites has increased the demand for the Ariane, and production of the European vehicle may have to be stepped up from six per year. The sensitivity of the insurance market after the double failure with the Space Shuttle may be a deciding factor in the bright commercial future for the largely-French Ariane, despite the earlier set backs. It remains to be seen, however, whether the market for high-power DBS satellites will prove as large as forecast until recently. DBS, like multi-channel cable systems, are being subjected to a more realistic scrutiny. Many of the would-be cable programme providers in the UK have already merged or quietly vanished.

One of the last production jobs on a new scientific/educational/amateur type satellite, the second UOSAT satellite, was successfully into low earth orbit on March 1, 1984. Built, tested and launched in a few months, it represents a real achievement by the University of Surrey team.

Services and GCHQ

Among the millions of words that have been written about the banishing of unions at GCHQ, surprisingly few commentators have noted the implications of this badly-handled affair for other sectors of British and NATO defence communications or come up with a credible reason for the Prime Minister's determination to press ahead with this action at this time. The usual scenario has been to blame it on either American pressure following the Prime case (as for the introduction of the polygraph machines) or simple union-bashing.

There is, I would suggest, an alternative and inherently more likely explanation — the strong wish of the Services, particularly Navy chiefs, to reverse the post-war trend towards having defence communications and signals intelligence networks manned and controlled by civilians. The suggestion of de-unionisation, stemming from within GCHQ can, then logically be seen as a move to counter increasing Service pressures against the "demobilisation" of the defence communications set-up.

For many years, the monitoring and interception of the radio traffic of real or potential enemies was the responsibility of the Y-service at stations manned largely by the Services, though backed up by civilian personnel. This tradition changed following the war-time successes of Bletchley Park with the formation of the Composite Signals Organization as an inherent part of GCHQ. A typical example of the resulting changes can be safely quoted without categorising security since the station closed down several years ago. Flowerdean, near Winchester, was for many years a Y-service h.f. station of the Royal Navy. It became, under the GCHQ regime, a civilian-manned CSO station run from Cheltenham.

Although Service signals personnel still man some intercept stations, the direct role of the Services in this work, as in many other branches of Defence communications, has clearly decreased. The Royal Navy, always quick to take umbrage at any attack, real or apparent, on its assumed role as the 'senior Service' has consistently opposed such diminution of its responsibilities.

Stereo on tv

A further series of test transmissions of the BBC's digital stereo tv system suitable for use on terrestrial networks were carried out early in March in the London area, on the Crystal Palace high-power transmitter and its local relays. This followed earlier tests in the hilly South Wales area from Wenvoe where the main purpose was to check digital performance under multipath propagation conditions. The London tests concentrated on compatibility with the wide range of television receivers in use.

The system uses a phase-modulated second sound carrier at 6.55 MHz above the vision carrier phase modulated with a bit rate of about 700 kilobits/second.

If the system proves satisfactory in all types of terrain and does not cause interference problems with existing monophonic receivers, the BBC hope it will put it forward for European standardization, though this may not prove easy in view of the current use in West Germany of an alternative analogue tv-stereo system. These days it is not enough to develop a good system to ensure winning a standards battle!

A long struggle

Although political lobbying by the Services is usually conducted behind closed doors, in 1978 Admiral Sir Edward Ashmore, then a recently retired Chief of the Defence Staff, in a lecture to the Royal Signal Institution, made no secret of his vehement dislike of the command structure of NATO and the whole organisation of defence communications. He advocated strongly that defence communications should be securely in the hands and control of the Services, reversing the post-war trend towards a part civil, part Service, system, on the grounds that civilians might be provoked into industrial sabotage by hostile propaganda.

RN dislike of providing communications facilities for the civilian media was evident during the Falklands campaign, while the influence of the Defence Staff on the Prime Minister was underlined at that time, when she was persuaded by the then Chief of Defence Staff, Admiral Sir Terence (now Lord) Lewin, to agree that HMS Conqueror should sink the Argentine cruiser General Belgrano.

The hostility of the Services to Intelligence activities over which they have no direct control, by people not subject to Service discipline and traditions, is of long standing, particularly in the field of Sigint. It dates back at least to the period following World War 1 when the Navy's cipher-cracking operation passed from Room 40 at the Admiralty to the Foreign Office-controlled Government Code & Cipher School. It was reflected during World War 2 in the refusal of the Admiralty to agree to Ultra intelligence being distributed to the Navy by Mf6's Special Communication Units, as for
Here and there

In many major urban centres in the USA, broadcast listening on f.m. is now significantly ahead of a.m. with the Dallas-Fort Worth area showing f.m. with a 69.4 per cent share of listening. A few major urban centres, including San Francisco, still remain a.m.-orientated. The a.m. broadcasters hope to win back listeners with a.m. stereo. Meanwhile the f.m. broadcasters are being given greater freedom to use Subsidiary Communications Authorization (SCA) facilities, including the use of a second sub-carrier. The use of broadcast transmissions for area or nation-wide radio-paging based on the second SCA sub-carrier is attracting increasing interest.

The first part of the ITU conference on h.f. broadcasting, early this year in Geneva, seems to have gone smoother than expected, with even the Americans, often critical of ITU conferences, expressing satisfaction. Frequency allocations requested by countries are to be computerized and a check is to be made to establish the extent of deliberate jamming. However, the conference was concerned only with establishing technical parameters and the main problems may come next time in 1986. 615 delegates from 90 countries attended.

The Pentagon is planning to double its spending during 1985 on the protection of ground and airborne electronic command centres from the effects of e.m.p. (electromagnetic pulses generated by nuclear blasts). Also planned is the establishment of a world-wide network of five terrestrial electro-optical surveillance centres to detect and identify objects in deep space, for completion by 1988.

...}

the BT cable installation at Milton Keynes is normally regarded as a technically advanced system the problems that seem likely to arise as more and more television signals are distributed at frequencies within the amateur bands may prove severe.

50,000-plus

At the end of December 1983, the number of UK amateur radio licences was 50,635, of which 24,359 were Class A and 26,276 were Class B. During 1983 the number of Class A licences were, thus, for the first time overtaken by the 'no-morse-test' Class B licences (14.4 MHz and above). When the Class B licence was introduced in June 1964 it was for 420 MHz and above and was then intended to encourage the development of the U.H.F. bands by technically-minded experimenters. Unlike the FCC system, where radio amateurs voted 20-1 against the introduction of a no-code licence, the British Class B licence for first u.h.f. and later extended to v.h.f., resulted from closed-door discussions. The FCC state: "Morse code is a fundamental communications skill critical to the nature of the Amateur Radio service."

In brief

Dr Owen Garett, W5LFL, the radio-amateur scientist on board the STS-9 Space Shuttle took part in a London meeting of the Royal Society during February where the general scientific work of the mission was discussed. There are signs that future Space Shuttles are likely to have amateur radio equipment on board but most observers agree that it will be essential to achieve greater operational discipline and co-operation by those on the ground as well as a less noisy environment on board the Shuttle... .Japan is introducing 900 MHz c. with 80 channels and 25-kHz spacing. Automatic transmission of identification signals will be incorporated. Although Japan has supplied the world with c. equipment it is one of the last major countries to introduce c. Mobile rallies to be held during May may include an Anglo-Scottish rally at Kelso on May 6; Swanlton (Oakfield School) and Otley (Flower Show Hall, Harrogate) on May 13; Drayton Manor Park (near Tamworth) on May 20; and East Suffolk Wireless Revival (Suffolk Showground, Ipswich) on May 27...

The JTI have approved the setting up of the first five amateur-television repeater stations in the UK. They will use the 1.3 GHz band and accepting vision and sound a.m. or f.m. signals, located at Leicester, Bath, Luton, Stoke-on-Trent and Worthing, The Leicester (GB3GV), channel RMT 1, Luton (GB3TV), Channel RMT 2 and Worthing (GB3VR) channel RMT repeaters should be active by the time these notes appear. Aerial polarization both incoming and out-going is horizontal, RMT-1 has vision in 1276.5 MHz vision-out 1311.5 MHz, sound-in 1282.5 MHz and sound-out (a.m.) 1317.3 MHz, RMT has vision in 1249.0 MHz, vision-out 1318.5 MHz, sound-in 1255.0 MHz, sound-out 1324.5 MHz. The British Amateur TV Club has appealed to its members: "Since these are the first such licences to be issued in the UK, it is incumbent on us all to use the facilities in a responsible manner in order that the authorities may look favourably on any future expansion plans to the amateur-television network."

ATV repeaters

WIRELESS WORLD MAY 1984

COMMUNICATIONS COMMENTARY

Amateur Radio

Telephone and cable r.f.i.

The lack of attention paid to e.m.c. problems by those supplying electronic equipment for homes, cars, petrol pumps etc. is becoming ever more noticeable. The consumer-electronics industry assumes that very few of its products will ever be used in places subject to high levels of r.f. despite the many thousands of broadcast, amateur-radio, c.b. transmitters, cordless telephones, two-way car radios etc.

The latest problem is arising from the new telephone handsets and inserts that replace the traditional carbon-granule microphone with an electret transducer and integrated-circuit amplifier. As fitted, these telephones appear to be most susceptible to local transmitters, yet there is evidence that this can often be much reduced by improved r.f. bypassing, sometimes by utilizing components already fitted.

The RSGB reports that the interference to amateurs using the 144 MHz band at Milton Keynes has been traced by JTI to radiation by and feed-through at the British Telecom cable frequency translation units at about 120 points in the cable area, where a television channel centred on 134 MHz is changed to u.h.f. for distribution into homes. No significant leakage has been traced to the main distribution cable. Each translation unit feeds about 50 homes. The problem does not arise with television channels being run in metal cabinets but only when these are contained in fibreglass cabinets, where filters have to be fitted.

The JTI measured high levels of radiation at distances up to 100 metres from the translation units. JTI have stated that the local Radio Interference Service teams will fit suitable filters in fibreglass cabinets near the homes of radio amateurs, but only if complaints are received. Since...
PREFERRED HISTORIES

Mr Scott, in the January issue, has drawn quite the wrong conclusion for his final quotation, and his conclusion reflects his thinking throughout. The modern camel has been designed by a large committee of users, whose lives and livelihood have depended on their transport. Camels work for them, as horses work for Mr Scott and jorros. Horses one may recall, did not work for Captain Scott.

The appropriate quotation might be Belloc: "Only an aristocracy can be governed by committees". When the preferred number system and colour coding were standardized the light-current engineers had something of the character of an aristocracy. Tenuous links of common education or common experience extended almost everywhere, just as we can see the family links in the books of Anthony Powell.

The two basic factors were the almost universal use of carbon composition resistor, and the boom, highly seasonable, in the manufacture of wireless sets. There really were, every year, new ideas at Olympia, and one large manufacturer closed for six months each year because no-one bought in the early summer. The carbon composition resistor was not very stable, so that designers were forced to live with ±20% tolerance. The method of manufacture had a lot in common with the production of the stodgy school puddings which you can now get only at a decent London club. Two buckets of A, one of B, a shovelful of C and D to taste. Blend, mould to shape, place in a hot oven. Sort.

Sort in fact into bins, with 0.8-1.0-1.2, 1.2-1.44, 1.728:

As long as they were inside ceramic tubes the resistance could be printed on the tube. Changes of mix to make them fairly damp-proof gave a black body which did not need to be encased. Like the £1 coin it all made sense to have a set of values and a colour coding system. The trouble with answers which make sense is that no-one likes them. In the 1945 edition of Langford Smith the Radio Manufacturers Association (US) has a long list of popular values, few of which are our preferred number. Colour coding yes; E6 or E12, no.

One important trick, and a jolly good one, was to link value and colour. The use of 3.3 instead of 3.2 means more colour contrast, and as it means 2.7 to 3.9 anyway, how does it matter. To use the full colour range we can pick either 4.7, 6.8 or 4.6, 6.7. But 4.7, 6.8 gives us a double colour contrast. The committee, in fact, lifted its collective eyes from the slide rule and looked at the real world, as they knew it.

Full acceptance of the system came only with the War, with the drafting of specifications and lists, and with pressures on designers like the ruling that even 10% tolerance could only be used if application and justification were made in writing.

The functional nature of the preferred number series was discussed in a series of articles in Wireless Engineer nearly 40 years ago. The initial problem was to produce simple band-separating filters, the sort the PO used to provide if a local embassy transmission in the f.1 band interfered with your Band I television, subject to the condition that the capacitor should have preferred values. The usual method was to design conventionally and wonder what the effect of 220 instead of 270 would be. Using as an example the typical equation

\[ C = \frac{1}{2\pi f R}, \]

we have

\[ \log C = - \log(2\pi f) + \log f + \log R, \]

If 2\pi = 6.8 we can choose f, and R as preferred numbers. Then logC is an integer and so C is a preferred number. We have defined the design limitations at the beginning, not fudged them at the end.

For equations containing a square root, \( \log X \) will be n/2, and thus will be in the E12 range.

Mr Scott should ask himself what sort of people he thinks we are, not to have noticed that 10/9 is not 1.5. And then, what sort of a person do we think he is?

Thomas Roddam
Arundel
W. Sussex

DBX AND DOLBY

I am writing with regard to an article entitled "BSR clambers out of depression" in the January 1984 issue of Wireless World which states that "They (dbx, Inc.) have produced a neat little playback decoder, battery operated, for use with headphone cassette players for both dbx and Dolby B decoding."

If this statement is referring to the dbx PPA-1 decoder, it is incorrect, since this unit does not have a Dolby B-type decoding facility. In its dbx B mode, the PPA-1 does have static decode characteristics that approximate to those of Dolby B-type, but it does not have the dual path circuitry, the overshoot suppression, the dual-rate control circuit and other characteristics that it would need before it could be said to have "Dolby B decoding". I would appreciate it if you would advise your readers of this.

Ian Hardcastle
Vice president
Dolby Laboratories
San Francisco, LA

ELECTRIC CHARGE FROM A RADIO WAVE

In his letter (January 1984) Peter Hesketh gives a step by step method of changing Professor Jennison's apparatus to produce an ideal waveguide bent into a circle. I agree with him that no amplifier is in principle necessary to maintain a wave in such a guide, and so far, his assumptions are completely justified. However, I do not see how he can use this idealised equipment, even in his imagination, to support Professor Jennison's contention.

Is it true that the velocity in space of a guided electromagnetic wave is independent of the motion of the conductors that do the guiding? In other words, even in principle we cannot drive a waveguide backwards so that the wave it carries is arrested in space.

Now this objection does not apply to the discrete component machine described in the article. The waves associated with such a machine are not electromagnetic waves in space, but as I said in my earlier letter, more like the waves we find on a polyphase machine. As such they have a velocity relative to the hardware of the machine. Perhaps Mr Hesketh has raised unwittingly a more serious objection to Professor Jennisson's demonstration than at first occurred to me. We cannot use a machine that generates waves having a velocity which can be vectorially combined with the velocity of the machine to explain a phenomenon where the waves have a velocity that is independent of the machine velocity.

Perhaps in what I say here I am mistaken. I would certainly like to see Professor Jennison's defence of his apparatus.

Chris Parson
Department of Electrical & Electronic Engineering
Bell College of Technology
Hamilton

Letters to the editor

Letters for publication are always very welcome. Many more come in than can be published, since space in the journal is limited, and I would therefore ask that letters be short and to the point, so that heavy cutting need not be suffered. Letters on new subjects will now be printed on the Feedforward page, those referring to past topics, already mentioned in articles or previous letters, going in the Feedback section.
TELEVISION TECHNOLOGY

I think it is time something was done about Television. It has become rather nasty. I am referring not to video vice and violence, but to circuit technology. The whole science has, like Topsy in Uncle Tom's Cabin, "just grown". Well, what of it? one might ask, it works well enough, doesn't it?

Get yourself a circuit diagram of your own receiver, study it, and then ask yourself how you would like to track down an obscure fault in the heart of it. Logical, step-by-step fault tracing is not so easy.

The point. I wish to make is that it has all developed out of pre-war neon relaxation oscillator technology. If there had never been any television prior to 1900 say, then we would not have started from there, and we would not still be perpetuating that piece of non-ideal practice. At present I believe the following line standards exist, 405, 525, 625, 819, 929, and the Japanese are developing 1231 lines.

The advent of satellite television broadcasting gives the world a chance to make a clean break with the past, and to adopt a new, elegant and simple global standard. For a start, lack of bandwidth need surely no longer compromise and complicate system design. For instance, one could have three separate colour carriers, thus greatly simplifying everything. Since all receivers are likely to incorporate at least one frequency crystal, there is no need to transmit line as well as frame synchronizing pulses. Interfacing could probably be dropped in favour of some round number of lines, e.g. 1200, 1500, 1800, 2400 or 3000, and the nearer the shadow mask goes the better.

Modern tv receivers certainly are reasonably reliable. However, they do sometimes break down, and the involved circuitry around the line timebase (diagram) can give even experienced servicing engineers a great deal of trouble, wasting a lot of time. This results in heavy charges for customers to pay. Components in the line timebase are the most highly stressed in the set. Even the scanning coils may have a thousand volts across them.

If, instead of the present scan-and-flyback system, we had a zig-zag scan-scan system, the line timebase the would be much more wholesome, and far less lethal. It would be a simple matter to generate the e.h.t. by a separate oscillator and Cockcroft-Walton voltage multiplier. Synchronizing pulses and most of the other pulses at present supplied by the line output transformer could come straight from an internal crystal-controlled waveform generator. The crystal frequency and phase would be trimmed by a received frequency burst, which also serves as the frame sync. signal.

As tv receivers do not usually last much longer than 15 years, I submit that it is not essential to make the system for the future compatible with anything now in existence. Let's start again, and this time make it all elegantly simple, rational and straightforward, for in the end this will save everybody a lot of time, trouble and money. Many expensive items like colour cameras could probably be sent back to the manufacturers to be refurbished to the new system, only printed boards ending up on the scrap heap. Getting rid of fast flyback should also significantly reduce the fire hazard of tv receivers, and greatly increase reliability.

The prospects for international co-operation over programmes, and for tv "globe-trotting" would obviously be much enhanced if there was a single universal system. The co-operation of all nations is really needed in order to evolve the best possible system and to get it universally accepted.

H. G. May
Barton-on-Sea
Hants

* Double the line standard and you are likely to end up with twice the voltage across the deflector coils, unless you abolish flyback and have a zig-zag scan.

SHIFTING WAVES

I wonder if any of your readers could explain to me the odd behaviour of u.h.f. transmissions which I outline below?

To receive domestic television signals from the Sandy Heath transmitter, a simple half-wave dipole with a sheet balun is positioned at an anti-node in the standing-wave pattern which the transmissions set up in a rectangular brick enclosure of approximately 6X4X2 meters. (Sometimes referred to as a sitting-room.)

While the anti-node positions for BBC2, ITV and C4 are practically coincident, that for BBC1 displaced from them by nearly 50 cm. Since the point of transmission is the same for all four and the wavelength variation trivial, it is difficult to understand this.

An attempted analysis has postulated the irradiation of two of the enclosure walls by a plane wavefront travelling horizontally and then generated a Huygens wavelet construction from those walls. Mathematical iniquity prevented a rigorous solution of the expressions arising but they did not, in any case, appear to contain the seeds of an explanation.

H. C. Wright
Blisworth
Northampton

CODED TELEPHONE NUMBERS

May I suggest a simple method of removing one of the most frustrating and error prone activities of any business. This is, the dialing of unfamiliar telephone numbers.

By means of a simple decoder attached to a standard telephone this would use trade directories, visiting cards etc. carrying their bar-encoded telephone numbers. The reader would be a simple wand with possibly a slot to allow cards to be passed through.

This system would, of course, only be of use if a significant number of the business sector used it. Perhaps you would be good enough to raise the subject and help start by producing a suitable adaptor.

John Wikins
Somersham
Cambridgeshire
SC84 microcomputer continued from page 40

The signal at the start of the Schmitt buffers is (MREQ and not MEMDIS) and not (REFSH or ROMEN), i.e. unless MEMDIS, A15 is low, the bistable i.e. is set and enables ROM whenever A15 is low, i.e. during access at any address from zero to 7FF, the system clocks. On receiving a reset signal, the Z80 executes instructions from address location zero. This means that following reset, the Z80 executes instructions from system memory followed by a jump that area. This copied software is the machine code operating system whose first instruction is an i/o read which, due to the IORD line going active during its execution, resets the flip-flop and forces ROMEN to the inactive high state, disabling theEPROM and freeing the entire 64K-byte ram. The timing circuit on the reset monostable i.e. arranges for a much longer time constant to be applied during power-up, providing a long enough pulse to allow the board to be started up by all the system clocks. Eprom IC25 is as shown as 2764 or 27128 but the board may be modified to take 27256 or 27512 devices.

Prototypes of the computer have been made in wire-wrap and soldered wiring forms, the most recent version using Vero 03-2989L boards and wire and pin type 79-1732G. Suggested wiring layout and component placement diagrams for such boards can be obtained by sending a large s.a.e. to Wireless World’s editorial offices. Constructions using p.c.b.s is much easier and will be the assumed method. When using these boards the i.c.s should be soldered directly onto the boards with the exception of eqns which should be fitted in good quality sockets. Sockets may be used if required, but only good quality ones. Dynamic rams are best soldered in. The natural fear is that of removing i.c.s should faults occur. This is quite easy though, as the only requirement is to disconnect the i.o bus, pull off the i.e. body and remove them one by one. A system as complicated as this should not be repaired using the swap-and-patch technique for those who do not have the test facilities to trace a fault, a repair service will be available — for systems built on p.c.b.s! Standard pitches have been chosen for discrete components, details of which appear with each circuit diagram.

John Adams’ next article describes SC84’s input/output board. SciiDOS with utility software, extended Basic with graphics facilities and Basic with enhanced file manipulation, I/O control, numeric/constant string handling and 12-digit precision are available for £36, £22.50 and £31.50 respectively. These prices include vat and postage and will be the assumed method. Further discounts are available for those buying more than one software package at once. Write enclosing a.s.e. to J.H. Adams, 5 The Close, Radlett, Herts.

A set of three Eurocard-format plated-through hole boards for SC84 is available from Combe Martin Electronics, King Street, Combe Martin, Devon EX34 0AD. Price is £39 for the set including vat and inland or overseas postage. John Adams is considering producing a kit of parts for these boards and John Hodson - secretary of the Scientific Computer User Group - is organizing the SC84 user group. For further information send an a.s.e. to John Adams for kit details or John Hodson, 189 Trent Valley Road, Oakhill, Stoke-on-Trent ST4 5LE, for user group details.
**Combination lock with deterrent**

This electronic lock operates on entering the correct four-digit combination on a hexadecimal keypad but should an incorrect entry be made, a further entry is not permitted for one minute. Each subsequent incorrect entry increases the entry-inhibit period by one minute up to a maximum of 15 minutes, after which the delay period is reset.

Inputs A-H of shift registers IC11,12 are used to set the combination and A-D inputs of counter IC15, set the combination size (four in this case). Pressing the internal clear key resets the control-sequence counter IC12, and control-pulse generator IC14. On pressing the enter key, positioned externally on the keypad, outputs of decoder IC13 and counter IC15 are enabled through bistable IC15b. Activating X6 loads the combination size into counter IC15. Activating X7 loads the keyword into shift registers IC11,12, clears previously entered trials in registers IC3,4 and resets the open signal of bistable IC17. Activating X8 sets bistable IC17, which was reset when the internal clear key was pressed through IC6,10,11, to enable the hexadecimal keypad decoder IC2 so that digits entered are stored in IC4 sequentially. On entry of each digit, monostable IC1 generates a pulse which decrements counter IC1 by one. Following entry of the four-digit combination, the borrow output of IC1 goes low and disables IC10, inhibiting further entry of digits into encoders IC5,7. Keyboard activation is indicated by the i.e.d.

Activating X5 connects clock MCK to clock inputs of shift registers IC11,12, causing the internal keyword to be transferred serially through the Qn output of IC20 to one of the inputs of the exclusive-Or circuit comprising IC6,26,20,21,8. Also, activating X5 will put shift registers IC14 in shift mode due to IC3,4,8 outputs and connect clock MCK to inputs of both registers causing the entered keyword to be shifted in synchronism with the internal keyword to the second input of the exclusive-Or circuit. This permits a comparison which if untrue, will reject any one of the four entries, sending the error line high.

Note that MCK is 4n times the CK clock frequency, where n is the number of codeword digits.

If the comparison is true, IC10,11,12 will be cleared, and with the activation of X6, the 'open' line will go high and open the lock. Otherwise, IC4 will be set on the first low-to-high transition of the error line. Setting IC11,12 and clearing the open line on X6 activation to keep the lock engaged. The change of state in Error inhibits the sequence counter IC12, through setting of IC10, and activates a 10 Hz multivibrator IC18 with a duty cycle of 30%. Also, the delay counter is incremented by one and its contents loaded into counter IC15, which holds the control sequence for the specified delay steps; after this the borrow output goes low clearing IC10 and allowing sequence counter IC10 to continue.

At the end of each sequence, multivibrator IC21 is reset.
disabled and IC₁₃ clears, inhibiting sequence decoder IC₁₃ and the sequence counter IC₁₂. A further Enter signal restarts the control sequencer, permitting another trial entry. Upon activation of Open, delay counter IC₄₆ and the sequence counter IC₃₁ resets. Note that the MCK generator, not shown, can be realized with a 74123 (as shown in the delay section) or with an NE555 timer.

G.A.M. Labib
Heliopolis
Cairo
Universal crystal oscillator

Design of a universal crystal oscillator is hampered by the wide variation in crystal parameters — series resistance of low-frequency crystals can be more than 200 times that of h.f. types. This simple modified Pierce circuit works with crystals from 25kHz to 19MHz. Oscillation frequency is the parallel-resonant frequency of the crystal shunted by about 45pF; output is about 1Vpk-pk. The inductor, used only as a choke, is not critical and if the circuit is used below 100kHz it may be replaced by a 1kΩ resistor.

F. Brown
Lake San Marcos
California.

Simple digital music synthesizer

Musical notes of 32 instruments can be generated using this circuit. Basic sound patterns of the 32 instruments contained in a 2716 eprom are in 64-byte blocks which are sampled at 64 uniform intervals. Six lower address lines corresponding to a memory block of 64 locations are driven by a 7493 counter. This is clocked by a variable oscillator whose frequency is determined by nine non-locking push switches to control pitch. Five locking switches program the upper eprom address lines to select one of 32 memory blocks containing instrument patterns. Eprom data outputs feed a digital-to-analogue converter and loudspeaker amplifier.

K. Balasubramanian
NSS College of Engineering
Palghat
India.
Variable-speed video playback

The C-format broadcast video recorder uses helical scan on 1 in tape. This short series shows how servo-controlled head tracking and digital timebase correction allows playback of broadcast-standard video over a wide speed range.

C-format is a helical-scan system, using an omega wrap around the drum as in the sketch. A head on the drum traces a diagonal track across the tape, where one drum revolution corresponds to one video field. Because of the open base of the omega, the head will be out of contact with the tape for a short period once every revolution, which is timed to coincide with the vertical sync pulse where there is no visible picture information.

Vertical interval sync pulses can be easily taken from reference signals and, for this reason, storing the vertical interval is optional under C-format. Where vertical sync storage is implemented, a second, sync-only head, positioned 30° behind the video head, records in an area between the control and Audio 3 tracks. If vertical-sync recording is not implemented, a dummy head replaces the sync head, and a further audio track is available in the area vacated by the sync information.

Figure 1 shows the resultant pattern on the tape, and includes the linear audio and control tracks, the drum turns against the direction of tape travel and the video-head-to-tape velocity is the vector sum of the drum peripheral velocity and the linear tape velocity. Similarly the angle of the tape tracks is a function of the drum geometry and the tape speed. During playback the capstan and drum servos must phase lock to an external video reference, such that off-tape video has the same timing as the reference, which means that correctly timed playback can take place at one tape speed only. Furthermore, the video head will only accurately trace the tape tracks if drum and capstan turn in a fixed relationship.

For variable-speed playback, the capstan servo must be unlocked: thus the video head will no longer accurately trace the tape tracks, and the timing of the off-tape signal will no longer correspond to the reference.

Two systems are necessary to overcome these problems. A track-following video head solves the geometrical problems, and a timebase corrector restores the timing to that of reference video.

Video track following

Track following was originally applied to video recording in order to improve compatibility between machines. This technique will be discussed first, followed by the additional requirements of variable-speed track following. The principle appears under various trade names:

Cinewave, Cinewave II, Cinewave III, Timebase Corrector, Geometric Corrector, Timebase Corrector.

Cinewave is a (head-mounted) corrector for 1984 PAL systems, but does not improve compatibility between machines.

Fig 1(a) shows the essentials of PAL C-format. Tape is guided round drum at helix angle, but movement of tape against drum rotation causes track angle to be slightly smaller than helix angle. Tape speed is chosen to give video offset of 3.5 lines, which gives horizontal alignment condition (inset). Vertical interval storage is optional and a fourth audio track is an alternative.

Where optional sync head is used, vertical interval is recorded separately (b), without overlap. Effect of interface is to record two types of field. Two-field sequence repeats endlessly. Addition of chrominance to interlace sequence causes sequence to extend — see appendix.

by J. R. Watkinson, M.Sc., B.Sc.
VARIABLE-SPEED VIDEO

Fig. 2. Effect of tracking error on playback signal. Signal amplitude in (a) and (c) is identical, despite sense of tracking error. Maximum signal occurs with correct alignment as in (b).

Fig. 3. Simple single bimorph at (a) changes head contact angle. At (b) compound bimorph closely approximates parallel action. Tracking head mounted in video drum is shown at (c).

Ampex use the term Automatic Scan Tracking, whereas Sony's description is Dynamic Tracking. Essentially, the playback video head can move at right angles to the tape track, and forms part of a position servo and, as with all servo systems, a position error is required. The system used differs completely from those used in track following disc drives.

Figure 2 shows three configurations of head to track, and corresponding output. Video recorders use F.M. recording, to cater for the wide bandwidth of the signal, and the waveforms in Fig. 2 correspond to the r.f. envelope of the f.m. carrier. Case (a) and case (c) display the same output, although the tracking error is in the opposite sense. Simple processing of the r.f. level thus only provides the magnitude of the tracking error, not the sense. To extract the sense of the tracking error, a dither is superimposed on the tracking head, which is driven by a piezo-electric bimorph by positional feedback from the bimorph. A break is formed in the electrodes on the surface of the bimorph which apply the electrical field for deflection, and the small strip of electrode which is isolated in this way becomes a sense strip, which generates a deflection signal used for damping and feed-back during the vertical interval, when the head is out of contact with the tape.

If the capstan of the v.f.r. is made to run slightly slow, the drum speed will not change because it determines the field rate. Thus, the tracking servo will cause the bimorph to bend further and further down the drums as it attempts to follow tracks which are not passing quickly enough. Conversely, if the v.f.r. runs slightly fast, the bimorph will bend further and further up the drum to follow tracks which are passing too quickly. In both cases, if nothing were done, the bimorph would eventually run out of travel. To allow continuous operation it is necessary to make the tracking head jump as it crosses the base of the omega, reducing the bimorph travel. When running slow, the jump will be one track back, such that from time to time one field is passed twice to maintain field rate, whereas when running fast, the jump will cause a tape field to be missed periodically. The more the speed differs from unity, the more often will such jumps be necessary. Figure 6 shows several examples of jumping, and also shows the drive signal which will be sent to the bimorph (neglecting the dither signal). Note the dipoles which are needed to accelerate and decelerate the tracking head during the jump.

It is possible to stop the tape completely and maintain an output. In this case the bimorph can be made to follow one field continually by making a one-track reverse jump at the vertical interval, using the drive waveform in Fig. 7(a). An alternative is repeatedly to play one frame, where a two-track jump occurs every two fields, as shown in Fig. 7(b). If the tape is reversed at normal speed, the tracking head can still follow the tracks, but has to make a two-track reverse jump once every revolution.

From Fig. 8 it can be seen that the waveforms needed for -1x and +3x speeds are the inverse of one another. This is because the +3x speed is obtained by drum geometry, and the -1x and +3x represent an equal departure from it. This must be looked at in the context of head to tape speed. Because the drum peripheral velocity is the dominant factor, stopping or reversing the tape only reduces the head-to-

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tape speed slightly. Similarly, doubling or tripling the linear tape speed only slightly increases the head-to-tape speed. Note that in C-format, the drum turns against tape travel. In some formats, the drum turns with the tape travel, and many of the effects described here will be in the opposite sense.

When the tape speed exceeds certain limits, the bimorph does not have enough physical travel to stay on one track for a complete revolution of the drum. In this case jumping has to take place on the visible part of the scan, and guard band noise between tracks will be played back during the jump. There is no disturbance to H sync, phase caused by in-field track switching because the C-format, like most other video tape formats, is designed such that H pulses on adjacent tracks are aligned. This is achieved by choosing a linear tape speed which causes a 3.5 line shift between tracks. The half-line component removes the effects of interlace on the H/V sync. relationship, permitting the horizontal alignment condition. It is this constraint that results in video recorders having rather strange linear tape speeds. One revolution of the drum now plays back segments of various tracks to build up a field, the circumstances under which this happens are beyond the speed range where a broadcast quality signal is required, and the jumping within the field permits a picture to be seen which is not perfect but is of much more practical use than no picture at all.

The track-following head is in a drum which is of 67.31 mm radius, and turning at 3000 r.p.m., which means that it is experiencing a pull of about 700 times the force of gravity, which tends to keep the bimorph straight! Large excursions needed for variable-speed operation mean that an appreciable drive (several hundred volts) is needed to overcome the overall stiffness of the bimorph. As drive in a conventional feedback servo is proportional to the loop error, the tracking error would be greater at the excursion limits. This problem can be eliminated by using a feedforward technique. For any linear tape speed, it is possible to calculate the slope of the voltage ramp needed to keep the head on track by geometry. Figures 6, 7 and 8 show that the slope is proportional to the deviation from normal speed, i.e. slope is zero at +1X, and the slope at +3X is equal and opposite to the slope at -1X. The capstan drive circuit can determine the speed deviation, and if this is fed into an integrator which resets once per drum revolution, a predicted deflection signal can be

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Fig. 7. Still-field mode at (a) repeats one field endlessly. With tape stationary, one-track reverse jump is needed once per field. Still-frame mode at (b) repeats two fields endlessly. Two-track reverse jump once per frame. Depending on where tape stops, d.c. component may be needed.

Fig. 8. Single-track advance is obtained by normal tape movement. Two-track jump forwards adds to give X3 speed; two-track backwards subtracts to give -1 speed.

Fig. 9. Circuit arrangement at (a) shows feedforward signal predicting slope of bimorph drive derived from capstan speed deviation. At (b), correct choice of dither frequency enables interleaving of tracking-error spectrum and smalping. Obtained. The feedback system has now only to correct for difference between actual track position and predicted track position, and the tracking error will be independent of bimorph excursion. Figure 9 shows details of the system.

Stability criteria for a dither-based servo warrant a closer study. The tracking error is sampled at the dither frequency by the phase-sensitive rectifier. As it is a sampled system, then Nyquist's sampling theorem suggests that there will be no information above one half the dither frequency. It is essential to filter the tracking error to prevent aliasing components distorting the feedback. The presence of a low-pass filter in a feedback loop is undesirable in a servo system, since the overall response cannot exceed the response of that filter without instability.

One approach is to use a comb filter in conjunction with a carefully chosen dither frequency. Figure 9(b) shows that the harmonics of the tracking error are at multiples of 50Hz, the drum speed. If the dither frequency is set between multiples of 50Hz, the sampling spectrum will interleave the base spectrum. A comb filter with peaks at 50, 100, 150Hz etc. can recover the tracking error and reject the aliasing components, giving the highest possible response rate for a given dither frequency. Clearly an NTSC machine with 60Hz drum rate will need a different dither frequency.

The mechanism of track following has been discussed, but this can only function if it is correctly coordinated with jumping control. To reduce jerkiness in the picture, the jumps should be as small as possible, which implies that they will be as frequent as possible. The smallest jump possible is one track, and to give broadcastable pictures, the jump can only occur at the vertical interval. From stationary to +2X, single-track jumps are sufficient, their frequency varying from never at +1X to once per rev. at +2X where every other field is played back. This variation in jump rate is infinite, and therefore it is not easy to calculate when to jump by processing the tape speed. From 0 to +2X, a single-track jump will be made if the bimorph displacement exceeds 1/2track at the end of a field. This will cause the bimorph displacement to become half a track the other way, and if that track speed is maintained, the error will return to zero over a number of fields, and build up to half a track again, causing a further jump.

To be continued
Multi-standard modem

Suitable for any computer with an RS232-type serial port

Until fairly recently the average electronics hobbyist would have had little use for a modem. But now the situation has changed considerably, with the emergence of a multitude of dial-up information services accessible to anyone with a suitable home computer.

One of the UK's biggest databases, British Telecom's Prestel, can be reached from most parts of the country for the price of a local telephone call. Besides well-publicised services such as home banking and teleshopping Prestel includes thousands of pages for microcomputer users, with news and information and software to download.

The basic Prestel service is available to home users for £5 per quarter at present. There are other databases costing still less to use, or nothing at all. A number of electronic component suppliers, including Maplin Electronics, Display Electronics, Ambit International and STC Electronic Services, allow customers to search their stock-lists by microcomputer and place orders directly. In addition, there is a chain of privately-run 'bulletin boards' offering facilities such as software download and electronic mail.

One problem faced by would-be modem constructors (or buyers) has been in deciding which transmission standard to go for. Prestel follows the CCITT V23 standard, sending data to the subscriber at 1200 baud and receiving at 75 baud. Many other systems operate at 300 baud in each direction. There is also a 600 baud CCITT standard; and the situation is complicated further by the existence of yet other standards across the Atlantic, some of which are used by databases in Britain.

Multi-mode modems have tended to be complex and expensive; but the introduction by Advanced Micro Devices of a versatile modem chip capable of supporting all common standards has now made them a practical possibility for the home constructor.

The Am7910 is a 28-pin I.S.I. device signal processing through-
MULTI-STANDARD MODEM

Fig. 2. Block diagram of the AM7910. The mode control pins provide selection of a variety of common European and American standards. No external filters are required.

Viewfax 258 (right) is available through Prestel.

Browsers welcome: Distel (below) is soon to offer automatic mode selection to match the user’s modem.

Off-March 22:55  P.O.T. 14
Welcome to DISTEL
(C) Display Electronics 1985
Control: 'K' & 'L' can be used to slow down output for reading
'M' for HELP FILE - Recommended for first time users
'O' for DISTEL, including mailing list and topical info
'P' for DISTEL each menu
Enter Command 'K'
Use Control 'K' and 'L' to stop and start data output.
The DISTEL data base contains a lot of information. READ this help file to enable you to make the best use of it. Good luck!

All data from the DISTEL computer is selected by an 8 choice MENU
Menu explanations:
1. SEARCH data base by GENERAL part number. A lot of manufacturers make similar items and identify them by alpha prefixes. For example an Am7910 would be found by 7400. However the END numbers you enter the tip part number or all parts with the same part number will be found. Enter the BUR for the number of parts to be found.
2. SEARCH data base by TYPE of Product, for example: PRINTERS, DISKS, POWER SUPPLIES, TRANSMITTERS etc. The GENERAL search is then used if the same prefix is found. Enter the 5 digit category number to see all 500 categories under the chosen heading. Full names of PRODUCTS are NOT required. DISTEL will search from just a single character.
3. SEARCH by RS Components catalog number. Be sure to enter a lot of items that match or exceed the type of RS items. The only difference in the PARTS list is in the number of items. Be sure to enter the correct number of items, if not all RS items are found. Enter the RS part number to be listed.
4. SEARCH by RS Components catalog number. Be sure to enter a lot of items that match or exceed the type of RS items. The only difference in the PARTS list is in the number of items. Be sure to enter the correct number of items, if not all RS items are found. Enter the RS part number to be listed.
5. SEARCH by RS Components catalog number. Be sure to enter a lot of items that match or exceed the type of RS items. The only difference in the PARTS list is in the number of items. Be sure to enter the correct number of items, if not all RS items are found. Enter the RS part number to be listed.

The i.c. is the facility to operate what might be termed a reverse Prestel mode - in other words, receiving at 75 baud and transmitting at 1200 baud. This allows the user to communicate with the growing number of Prestel subscribers equipped with 1200/75 baud modems. In this condition, data to be sent is applied to the TD pin and the back-channel received data appears on BRD instead of RD.

In a full RS232 interface, the 25-pin connector has separate terminals for the main and back channels; but for home computers which do not, transmitted and received signals can be routed to the appropriate pins of the modem via switching logic governed by the setting of the mode switch.

The same switching must be applied to the handshake signals RTS and CTS. The computer sets the KTS (request to send) line to +12V to indicate that it is ready to receive data, and in response the modem drives RTS (clear to send) to +12V to signify that the computer may transmit. These signals are inverted by the RS232 buffers and are presented to the Am7910 as RTS and CTS, or BRTS and BCCTS in the case of the back channel. Note that the RS232 interface is governed by a negative logic convention and thus provides a good deal of scope for confusion.

To indicate that it is receiving a carrier from the telephone line, the Am7910 takes to 0V either its CD (carrier detect) pin or, for the back channel, its BCD pin. Again, in a full RS232 interface these signals appear on the separate pins. However, in the Bell 202 mode transmission in the back channel consists simply of keying a 387Hz carrier on and off. It follows that not all the modem's back channel signals are meaningful. BCCTS and BRTS are not used at all; and on the transmit side keying is applied to the BRTS line while BTD is held at +5V.

To complete the RS232 interface, the Am7910 has a DTR pin ('data terminal ready'), which acts as a sort of chip select line. Held at +5V, the DTR pin disables the internal logic and the inputs and outputs. It may be convenient to use this as a method of switching the modem on- or off-line. All digital inputs and outputs of the Am7910 are

Telephone interface

The transmit carrier appears on the TC output of the Am7910 at a level of about -3dBm into 600Ω.

In an acoustically coupled modu- rem it can be applied direct to the microphone of a telephone hand- set; but in a direct-coupled design

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MULTI-STANDARD MODEM

this signal must be fed to the
same connections from which the
received signal is to be extracted.
It is desirable to provide some
degree of separation between
transmitted and received signals,
and this can be achieved simply
with an op-amp duplexer (Fig. 3).
The impedance of the telephone
line is matched with the 600Ω re-
sistor, and the network introduces
a 6dB loss between the transmitter
and receiver. In practice, the line
is unlikely to match the resistor
perfectly and may even be quite
reactive; however, this should
not matter much.

Sensitivity of the receiver is
very high: the modem will accept
signals between 0dBm and
-48dBm, although the carrier
detect pin will not turn on unless
the level exceeds —43dBm.

A matching transformer pro-
vides coupling to the telephone
line and the necessary degree of
electrical isolation. On the line
side of the transformer the modem
must also include a d.c.
path to hold the telephone line
once it has been acquired.

To allow automatic an-
swering of calls, the Am7910 has a RING
input. This may be forced low by a
signal derived from a ringing tone
on the line, whereupon it will
switch the modem into an answer
sequence. If the modem is on-line
it responds with a period of sil-
ence at the TC output (1.9s under
European regulations) followed
by a few seconds of answer tone.
The call is then established and
data can be exchanged between
the computers at each end.

Table 1. Frequency assignments. In the Bell 202 back mode, a 387Hz tone corresponds to a mark, its absence to a space.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Data rate (baud)</th>
<th>Duplex</th>
<th>Transmit frequency</th>
<th>Receive frequency</th>
<th>Answer tone freq. Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell 103 originate</td>
<td>300</td>
<td>full</td>
<td>1070 Hz</td>
<td>2025 Hz</td>
<td>—</td>
</tr>
<tr>
<td>Bell 103 answer</td>
<td>300</td>
<td>full</td>
<td>2025 Hz</td>
<td>1070 Hz</td>
<td>—</td>
</tr>
<tr>
<td>CCITT V.21 originate</td>
<td>300</td>
<td>full</td>
<td>1180 Hz</td>
<td>1850 Hz</td>
<td>—</td>
</tr>
<tr>
<td>CCITT V.21 answer</td>
<td>300</td>
<td>half</td>
<td>1850 Hz</td>
<td>1180 Hz</td>
<td>—</td>
</tr>
<tr>
<td>CCITT V.23 mode 1</td>
<td>600</td>
<td>half</td>
<td>1700 Hz</td>
<td>1700 Hz</td>
<td>—</td>
</tr>
<tr>
<td>CCITT V.23 mode 2</td>
<td>1200</td>
<td>half</td>
<td>2100 Hz</td>
<td>2100 Hz</td>
<td>—</td>
</tr>
<tr>
<td>Bell 202</td>
<td>1200</td>
<td>half</td>
<td>2200 Hz</td>
<td>2200 Hz</td>
<td>—</td>
</tr>
<tr>
<td>CCITT V.23 back</td>
<td>75</td>
<td>—</td>
<td>450 Hz</td>
<td>450 Hz</td>
<td>—</td>
</tr>
<tr>
<td>Bell 202 back</td>
<td>5</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 2. Control pins on the Am7910 provide selection of nine operating modes and ten 'loopback' modes for testing. Optional equalisation is available to cope with long or poor-quality lines.

<table>
<thead>
<tr>
<th>MCA</th>
<th>MCB</th>
<th>MCD</th>
<th>MCE</th>
<th>MCF</th>
<th>Bell 103 originate 300 baud full duplex</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 103 originate 300 baud full duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 103 answer 300 baud full duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 1200 baud half duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 202 with equalizer 1200 baud half duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.21 originate 300 baud full duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 mode 2 1200 baud half duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 mode 2 with equalizer 1200 baud half duplex</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 103 originate loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 202 main loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Bell 202 with equalizer loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.21 originate loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.21 answer loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 mode 2 main loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 mode 2 with equalizer/loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 mode 1 main loopback</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CCITT V.23 back loopback</td>
</tr>
</tbody>
</table>

Regulations

Potential constructors should be
aware that the telecommuni-
cations authorities in Britain still
place heavy restrictions on what
may be connected to a public tele-
phone line. Direct-coupled
modems have to be approved by
the British Approvals Board for
Telecommunications, which
unfortunately can only examine
finished equipment. Even so,
many commercially-manufac-
tured modems available to
the home user are not approved,
even though they may include compo-
nents designed to meet the offi-
cial specifications.

What seems to worry British
Telecom is the possibility that
someone will accidentally
connect a telephone line to mains
electricity. This could happen in a
modem through faulty construc-
tion and might damage the tele-
phone network as well as being
dangerous for its users.

Constructional details of a
modem using the Am7910 will
follow next month.

WIRELESS WORLD MAY 1984

Fig. 3. Connection to the
telephone line can be via an
acoustic coupler, or (below)
through an op-amp duplexer
and an isolating transformer.

www.americanradiohistory.com
by A. E. Cawkell

The information society

1 — Technology, politics and infrastructures

A. E. Cawkell looks back at his 1978 piece “The paperless revolution” and forwards to the year 2000. In this first article, he considers the interactions of politics with technology and the infrastructures which influence, support and enable an information society.
In 1978 I wrote an article in this journal about forces controlling the introduction of new technology. At that time the arrival of the silicon chip, just introduced to the public, was being discussed with both optimism and foreboding.

The article was entitled "The paperless revolution" and featured a major case study of Consumers' Union, an information interface between man and the world outside, to become a reality, perhaps, by the year 2000. Universal data processing has no scope to be assumed to be in place. Reading this article again, I see that I took a rather gloomy view of the technological future.

Information is a curious and unique resource. It is unsatisfactory to call it a commodity. You cannot evaluate it until you have obtained it; once you have it it may be almost impossible to evaluate in monetary terms, but on other occasions there may be no doubt about its value — ask a demented patient, for example, about the value to him of timely, accurate information. The value of a train time-table to a man standing on Paddington station who wants to get to Penzance is obvious. It is equally clear that the same information displayed to a Martian is valueless. Information is destroyed when consumed and does not readily satisfy the usual sense, and yet the meaning of the phrase "there is a scarcity of information about the effects of video nasties on crime" is perfectly clear.

Information is obtained for pleasure and entertainment, for monetary gain or the acquisition of power, and is difficult to satisfy curiosity, but nearly always it has to be moved before it is changed from mere data into knowledge.

These days transference often involves transforming it into something rather than a paper-based system.

The idea of an "The Information Society" was implicit in Fritz Machlup's work in 1962. In 1974 Marc Porat, in an unpublished paper, analysed occupations in the United States and concluded that 50% of the labour force was engaged in information processing occupations. Parker and Porat discussed political issues and headed part of a 1975 article with the phrase "The Information Society".

The concept of an industry centred on a resource more important than oil — information — was developed. Telecommunication Technology Year (TT82) was launched to rub in the message 'Britain Needs Information Technology'. Before considering the outlook for the rest of the decade, let me establish my forecasting credentials, if any, by conducting a brief post mortem on the 1978 article.

Semiconductor technology has advanced and costs have dropped at about the rate predicted. Expectations for bubble memories and holographic storage have not materialised. The mismatch between the information processing capacity of the eye/brain and the amount provided by the c.r.t. screen is now being improved. Larger display devices will be available rather sooner than predicted. Teletext is successful but Viewdata/Prestel is slower to gain acceptance. Large computer systems are making progress. Teleconferencing is still in its infancy and so are electronic journals, but electronic publishing is advancing. Electronic mail was much discussed in 1978 and it is still today; implementation lags.

The rate of progress in speech recognition has been slow, also as predicted.

I think my end-of-term school report should read "Forecasting — very fair; Cawkell should try it. It is no worse than most other forecasts, and rather better than those mentioned below."

**Wild forecasting**

Before considering the likely rate of formation of a telecommunications infrastructure — the backbone of the Information Society — it is instructive to consider the development rate of other technologies contending mainly with technical problems. The telecommunications/service infrastructure will be containing mainly with political and social problems which will greatly slow down the growth.

In the July 1966 issue of *Datamation* it was stated that "economics of scale are swinging increasingly in the direction of the telephone line" and in a 1970 issue of *Computer Decisions* "Small businesses are not going to have small computers; it's not a practical way to go". In 1972 it was forecast that "40-60% of American homes will have cable tv by 1980", and at the end of 1979 a UK forecast of "100,000 Prestel sets in 1980, equally split between domestic and business" was made.

In 1979 it was anticipated that "By 1983 all the 220,000 telephone subscribers in the Ile et Vilaine department of Brittany will possess desk-top video terminals costing £33 each providing access to local and national database of telephone numbers".

All these forecasts were wildly off target.

As recently as late 1981 one predicted that the world total for all types of microcomputer in use by the end of 1983 would be 4 million units costing $350M. But another now thinks, with the considerable advantage of hindsight for most of the period, that the total would be 17 million units costing $79kM (79 billion dollars)!

**The delay factor**

Forecasters are often misled by manufacturer's announcements about development work which may or may not be followed by production, limited application, and more general application. The interval between these events, for technical and political reasons, may be many years, but new-technology announcements inspire speculative articles in the press which prompt discussion and awareness; and new products or services get talked into existence.

Euronet and a set of separate European PTT telecommunications networks were expected to become a unified network by about 1985 — 15 years after the pioneering work with ARPANET in the US. It took about 10 years before working local area network (LAN) systems were installed in any quantity following the development of the ALOHA network.

The next transatlantic cable will be the optical-fibre type. The idea of optical-fibre communications was first mooted in 1966 and the development of more efficient monomode cables accelerated their use. Such cables started to be installed in 1980 — an interval of 1 years after the early work.

Many years passed before Clarke's 1945 forecast that global communications using three geostationary satellites would be possible. By 1980 satellites were being routinely used as relay stations in the United States. In this case it took 18 years for the idea falteringly to be realised, a further 10 years before they became used as telephone relay stations in the Intelsat network, and several more years for TV relay satellites to become commonplace.

The Electronic Scientific Journal was suggested in 1976, pioneered with mixed results in 1979-1982, and is the subject of further experiments today. It seems unlikely that the final form will replace the scientific and social functions of the conventional journal for many years.

It has turned out to be extremely difficult to design an electronic device which can recognise continuous speech from any speaker. According to a classic 1976 article it will be many years before this becomes possible. A very large research effort seems to have produced rather limited results, but this simply reflects the difficulty of the problem. The interval between the first substantial research...
work in the '70s and the application of continuous speech recognition may well be 50 years.

A recent television programme described progress with synthetic speech — a much easier achievement — and then showed the recognition of single words and short phrases by a machine, which had almost certainly been preceded by a human/machine training session which was not mentioned. This led naturally to speculation and an interview, firstly with an equipment supplier about this 'here and now' technology, and then with a lay audience about how comfortable they would feel when conversing with machines. This kind of 'logical extension' from one thing to another against a background of impressive rows of knobs and c.r.t. screens encourages false expectations.

Very-large-screen displays may become generally available during the next 5 years, 60 years after the c.r.t., not much changed today, was first introduced by von Ardenne in the 1920s. Technical advances have been rapid in image processing systems and facsimile machines of rather low resolution have been available since the 1930s. After the war, machine compatibility was the problem. The interval between the introduction of the first usable machines, the evolution of standards, and fairly widespread use in business was 50 years.

The development of Teletex, a system for transmitting text rapidly between telex-replacement/word-processing machines, is progressing slowly, and microforms — around since the Franco-Prussian war — are still not widely used.

I conclude that a significant new development in information technology usually takes at least 10 years from point A in time to point B, where B is useful small scale application. Point A — the 'starting date' is hard to define. It is not so much that something significant actually happens on that date, but that a preliminary announcement about Widgetsor gets transformed into a report (not in this journal!) that "Colos-sal Systems Ltd are believed to be considering the construction of a new factory for the production of Widgetsor". The information-technology industry is skilled in convincing us that only fossilised people can afford to ignore 'imminent' developments which may still be a gleam in the inventor's eye.

### An exception

Technical developments, falling costs, and a combination of other circumstances may enable something new to be offered and applied rather quickly. If political, human acceptability, and economic factors are favourable, the offering will catch on faster — an exception to the ten year rule appears.

The microcomputer is such an exception, so its brief history is of some interest. The first commercially available machine to be produced in any quantity was the Altair 8800, provided as a kit by MITS in 1975, and ingenuity made that possible. The development of the transistor (first patent filed 1946); improvements in photolithography and diffusion techniques enabling transistors and other circuit elements to be manufactured as integrated circuits (Fairchild 1959); M. E. Hoft's invention of the Intel 4004 microprocessor containing over 2000 transistors on a chip in 1970, further developed into the 8080 in 1973; US government subsidisation of semiconductor developments amounting to about $1000M in 1958-1974; a large local computer market capable of absorbing and encouraging widespread circuit developments for a period the Altair and its successors were limited by small memories and the absence of disc storage to a market composed of enthusiast hobbyists. Software for useful applications was nonexistent. Demand increased with increasing software familiarity, better reliability, and falling costs but two further related developments may be singled out as major contributors to the explosive demand which started around 1975.

IBM introduced a terminal incorporating the FD-11 floppy disc in 1971. Competitors announced copies immediately, but in September 1972 IBM announced the 3740 data entry station incorporating a "diskette", and a host of competitors followed.

In 1974 Gary Kildall wrote some software for controlling files stored on a floppy disc. He was asked by IMSAI, a floppy disc supplier, to design an operating system for them, and the first version of CP/M, 1.3, became available. Hardware-dependent functions were concentrated in one section of it, enabling it to be adapted for use with microcomputers using the 8080 and later the Z80 c.p.u.s. Kildall founded Digital Research in 1976 and more versions were released later, including one for 16-bit machines, CP/M 86.

A parallel development started with the IBM Ramac "hard disc" introduced in 1956, but in 1973 IBM announced the 3340 "Winchester Disc" a sealed unit with the heads flying 20 micrometres above the disc surface. In 1978 Shugart announced the SA4000 Winchester for microcomputers, and in 1980 Seagate introduced a 5 Mbyte 5.25 inch Winchester. Imsai announced support for the Immac, and Microdia announced compatibility with the Winchester for M4000. These machines can deal with advanced information storage and retrieval, word processing, etc.

### Interactive infrastructures

In order to discuss some of the wider issues as we move into the Information Society it may be helpful to refer to Fig. 1 which shows the forces influencing an information services infrastructure.

Technical advances are a necessary but far from sufficient requirement for progressing towards an information society. The rate of advance will be much dependent upon the interplay of the factors shown in the figure. Exceptions like the microcomputer will arise in special cases where successful application can be independent of most of the delaying factors.

Two prime forms of information are shown — the "old technology", that is print-on-paper in the form of written letters, typed reports, printed newspapers, magazines and books, and the "new technology" for that is radio, television, tape or disc recordings, videorecorders, databases and information banks. Associated with each is a wide range of information channels is the hardware and software required to put the information into machine-readable form, process it, and convert it back into human-assimilable form.

The old technology is well entrenched. It has been developed by trial and error since 1455, when Gutenberg demonstrated the feasibility of movable type. A set of compromises in compilation, distribution, storage, display, aesthetics, convenience, accessibility and cost has emerged which serves us quite well.

The new technology has been developed during the last 50 years, but 90% of it during the last 15. In that time radio, television, automation and computers have been allowed in quick succession by pocket calculators, home computers, online systems, word processing machines, and video and optical discs, backed by a government technology proceeding at an unprecedented speed.

The general momentum of all
this encourages the belief that almost anything is possible by the introduction of more technology. There is no shortage of people with vested interests to foster this belief. However, application takes time, as has been discussed already. Ordinary people get in the way. They have contrary beliefs generated both by innate conservatism and, in some areas, by well-founded scepticism. This scepticism is in part a reaction to sales razzamatazz, to the observed general mismatch between men and machines, and to the fact that for every prediction which turned out to be an underestimate, there are several which turn out to be unduly optimistic or simply wrong.

Readiness potential and enabling infrastructure

Some years ago the phrases Readiness Factors and Enabling Forces were used with reference to teleconferencing. The similar phrases Readiness Potential and Enabling Infrastructure are apt in the context of the information infrastructure generally. For a new undertaking to be feasible the state of the ingredients needed for success must be considered. A readiness potential exists when the development of those ingredients, considered collectively, seems to indicate that the time is ripe for launching the undertaking. They include:

- appropriate telecommunications infrastructure
- appropriate telecommunication facilities
- appropriate experimental work
- accessible advocates and publicity
- optimist forecasts
- apparent economic viability
- apparent need (markets)
- adequate support organisations
- political reality
- organisational infrastructure
- human factors associated with the use of machine
- reliability
- standardisation/compatibility
- success momentum
- political reality
- service infrastructure

Success momentum continues if the earlier hot air can be backed up by success in practice, with circulation of the good word, favourable technical articles and reviews, further purchases with wider usage etc. Success breeds success.

Political reality means both concentration on the art of the possible and conducting operations which will take advantage of PTT or government policy instead of clashing with it. Current attitudes and actions in communications deregulation, particularly in the US and now in the UK obviously need close attention.

What should governments do and what will they actually do? You may take the view that the less a government does, the better, you may think it should have a limited role, or you may think it should intervene at all levels. I see little evidence that any government has had any success in intervening at the market level: it may result in a disaster. Witness the rise and fall of News. In this area of rapid changes and new emerging markets, bureaucratic involvement seems unhelpful.

All governments seem to be more or less involved with many of the areas shown on Fig. 1, that is, employment, control of telecommunications, and privacy and security. Involvement in communications, because of the importance of what is communicated, particularly news, spills over into topics like data protection, the flow of information across borders, and the concern of underdeveloped countries about this topic.

The government has a role in co-ordinating national and international standards. Perhaps it can best continue to do that by supporting organisations like NPL, British Standards and ISO in the UK, National Bureau of Standards and ISO in the US, and similar activities in other countries.

In the US, the IEEE has succeeded in establishing standards which have become international, such as the RS232 communications interface. Some manufacturers have established de facto standards such as Digital’s CP/M microcomputer operating system software and IBM’s SNA communications protocol. Europe—often follows the US in this field. In Europe German DIN standards have been adopted in some fields (not in information technology).

Telecommunications and the market

A service infrastructure will be the technological backbone of an information society. Digitized information (or, for the purists, data, which may be one man’s information but another’s noise) will flow from source to recipient.

---

Fig. 1. The information infrastructure and the forces which influence it.
I am not referring to "service" in the "maintenance" sense (although an efficient service network in these days of increasing dependence upon machines is extremely important) but services for supplying information.

The components of a service infrastructure are a communications network accessible to a large customer base offering cheap time, independent of distance; a customer base possessing a range of compatible machines using standardized processing and communications software; and a number of information providers feeding information to the network.

When compatible terminals connected to a growing network reach a critical mass, assuming that an adequate customer base for particular service also exists, the incremental cost to a supplier mounting the nth service will be low. His division of the infrastructure, so his direct investment involves only the injection of information.

The existing national and international PTT telephone network has the greatest service infrastructure that it exists. It is far from ideal for data transmission, but can be pressed into service for that purpose. Most PTTs have also created, or are in the process of creating, purpose-designed national data networks. They have also collaborated under EEC auspices in setting up Euroset, a network consisting of connected host computers, in different countries, running databases for information storage and retrieval (mainly scientific information); for terminal-connected users.

The private networks shown in Fig. 1 are composed of lines leased from the PTTs, or interconnecting the different sites of an organisation within a country, or may be to provide intra-organisation services for large companies such as Unilever, airlines, etc., requiring international satellite or cable links.

The commercial networks in Fig. 1 refer mainly to the Value Added Networks (VANs) developed by private telecommunication companies, in consequence of deregulation in the United States, to offer special services using lines leased from AT&T, or using satellite or terrestrial microwave communications. Some private companies have been accorded the status of 'common carriers', meaning that they are permitted simply to carry traffic for others without having to qualify as VANs. Some companies have 'nodes' (that is, connection points) in Europe and elsewhere.

If these three kinds of network were interconnected so that any service available on any of them was available to all in such a way that there appeared to be a single network, then a big step towards universal communications would have been made. The critical mass of customers needed to encourage more services would appear, the system would grow, costs would fall and home services would become viable.

There are some technical problems to overcome, but the main obstacles to this kind of common sense have been political. The PTTs have rigidly applied their carrier monopoly. Unlike the situation in the US, no other organisation has been permitted to arrange communication links between service and customers, for instance, so that people with terminals can obtain information from a database running on a remote computer.

In 1979 an electronic journal was running in the United States, and the organizers planned an experiment to connect terminals for editorial services and contributions from the UK to the system. British Telecom (BT) could not provide the interconnection, and it was planned to use the commercial network, Telenet, which had a node in the UK requiring connection to terminals via BT lines. The experiment had to be abandoned because of the participation of Telenet as a "third party" carrier. Note that if Telenet had been offering an electronic journal to UK participants — that is, if it had owned the journal's computer and facilities in the US, and was using its network to link its own customers to the system — then it would not have been acting as a third party and the veto could not have been applied.

The question is: can the existing networks be coalesced to provide the needs of the information society, and how long is it likely to take?

The 'critical mass' problem mentioned previously could of course be resolved by further separation rather than coalescence. In other words, new separate networks appear for interconnection of the PTTs with service providers, because this group regards the value of the particular kind of information received to be worth the relatively high price they have to pay to support the facilities. The services available to stockbrokers in the City of London are an example.

A possible compromise would be multiple interconnected networks, each free to innovate (a huge unified network would tend not rapidly to adopt communication new technology) but with common interconnection standards and a payments clearing-house mechanism.

To be continued
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WIRELESS WORLD MAY 1984
The roots of relativity

Dr Murray avoided criticising relativity theory in his recent Heretic's Guide series, but here he makes good that omission by drawing attention to one of Einstein's very rare but crucial mistakes.

It is not unusual to encounter references to the Special Theory of Relativity between the covers of *Wireless World*, either in readers' letters or in formal articles. One interesting feature of these contributions is that they are almost invariably critical of the theory, although it is so thoroughly established. Why so?

It is true the criticism comes from all sides, so that critics will refute each others' arguments as boldly as they refute Einstein's — for there exists as yet no singly-accepted or 'received' argument in denial of Special Relativity. Einstein's theory is in everyday practice used in modern physics and one is never (apparently) driven into error by employing it. Pragmatically, 'it works'. Nevertheless, the fact that now, some 80 years after its formulation, a large number, perhaps even a majority, of scientifically-educated people harbour nagging doubts about it may indicate that something, somewhere, might perhaps be wrong. Moreover, today's critics of Special Relativity are no longer die-hard, but well-informed, reasoning, and serious.

I am willing to wrangle with the best of them about the traditionally poor presentation of the clock paradox and the impossibility of drawing co-variant Minkowski diagrams, but to do so would only extend and support arguments that have been raised many times before: arguments which, characteristically, have never been refuted without begging the question, or even worse logical crimes, by any Relativist. (For a selection of such tricks see Professor McCausland's nicely-reasoned article in *WW*, October 1983.)

Criticism of this kind takes issue with the weird 'predictions' (consequences) of the theory, so that one is forced to refer to arguments, mathematical or otherwise, within the theory itself in order to criticise it. One can then always be accused of 'failing to understand the theory properly'. Naturally, no relativist would ever admit that his critic might understand the theory too well!

On this occasion I prefer to discuss the premises of the theory rather than its deductions; and I shall not invoke the opinion of any third party, but rely only on the written words of Einstein himself. By these means I hope to present my main contention as precisely as I possibly can. But first, by way of background, let me recall how the Special Theory of relativity arose in the first place, and what it was intended to achieve.

Origins of Special Relativity theory

Contrary to received belief, the idea of relativity was not a product of the early twentieth century. The concept of the relativity of uniform translational motion dates back two hundred years and more before 1905. It is directly associated with the truth of Newton's first law of motion, and there is nothing at all complicated about it. The following passage appears in Newton's *Principia* (1687):

"The motions of bodies included in a given space are the same among themselves, whether that space be at rest or moving forward uniformly in a right line without any circular motion... A clear proof of which we have from the experiment of the ship, wherein all motions happen after the same manner whether the ship be at rest, or be carried forward uniformly in a straight line."

From this quotation it is abundantly clear that Einstein did not invent the Principle of Relativity. He himself, in a passage that I shall quote later, said so in as many words. He had to re-state the Principle because, for reasons that we shall uncover shortly, his colleagues of those days had been led astray by a chain of false reasoning and had rejected the relativity principle of classical mechanics in favour of an 'aether' theory, in terms of which all motion must be specified absolutely. That theory was, of course, the Maxwell-Lorentz electromagnetic theory, also known as 'Maxwell's Equations'.

It is best to be frank and not mealy-mouthed about these historical facts. By the year 1905 electromagnetic theory had already failed on three separate experimental counts, namely,

1. The physical aether upon which it depended for its operations does not exist (Michelson and Morley, 1887)
2. The radiation of energy in the form of light is not a continuous process (Planck, 1899)
3. Light quanta — 'photons' — do not dissipate whilst in transit in vacuo (Einstein himself, 1905)

In addition it had become clear by the turn of the century, largely as the result of the brilliant work of H.A. Lorentz, that the theory had also failed internally, in that it could not handle even the simplest of situations involving relative motion.

Einstein was acutely aware of this problem. In his view, something was obviously wrong. In the preamblem to his Special Relativity paper 'On the Electrodynamics of Moving Bodies' he took it as one of his starting points. He wrote (1905):

"Customary electro-dynamics does not take into account the experimentally-corroborated lack of absolute motion. The description of a magnet moving relative to a conductor at rest is quite different from the description of a conductor moving relative to a magnet at rest. Yet the observed phenomena are exactly the same in both cases."

That last sentence again embodies the principle of relativity, but it is the first sentence in the quotation that provides the vital key: Maxwell's electromagnetic theory violates that principle. But there was, and still is, no doubt about the sheer power of the electromagnetic dogma among its adherents. Faced with this crisis the theory's protagonists held on adamantly to their all-dominating Faith. As I said in this connection in the third Heretic's Guide article (WW, October 1982 page 77), 'Human feelings at levels deeper than mere reasons were involved in this conflict.' Thus Einstein again, almost plaintively, the square brackets are my own sympathetic additions)

"Prominent theoretical physicists were therefore more inclined to reject the principle of relativity [than the e-m theory], despite the fact that no empirical data had contradicted that principle [and even though experimental data had contradicted e-m theory]."

by W A Scott Murray
B.Sc., Ph. D.

MODERN PHYSICS

WIRELESS WORLD MAY 1984
Here is as vivid a description as we are ever likely to read, by ‘that man on the spot’, of the innermost of a preconceived, established ideas.

P.0. Einstein! Like everyone of his generation he had been brought up on the great Faraday-Maxwell theory of electromagnetism, and he himself believed completely in the reality of electric, magnetic, and gravitational fields. He did his best to help by proposing what seemed to be a wise, balanced, and above all generally acceptable compromise. Here he is, writing about the crisis of 1905 retrospectively in 1952 (the italics are his own):

"Classical mechanics ... teaches the equivalence of all inertial systems ... for the formulation of nature's law. Electromagnetic-optical experiments taught the same thing with considerable accuracy. But the foundation of electromagnetic theory taught that one particular inertial system must be given preference, namely the notion of a luminiferous aether at rest. That aspect of the theory was most unsatisfactory. Was there no modification that, as in classical mechanics, would uphold the equivalence of inertial systems?"

"The answer to that question is the Special Theory of Relativity. This takes over from the theory of Maxwell-Lorentz the assumption of the constancy of the velocity of light in empty space ..."

Now it was precisely because the new theory 'took over the assumption of the constancy of the velocity of light' that modern physics became saddled with the three well-known mind-bending horrors of relativistic irrationality: (1) the assumption itself, together with the shortening of measuring-rods in the direction of motion of a clock, the slowing down of clocks due to relative motion, which are the inevitable mystical consequences of maintaining that assumption. Earlier, H.A. Lorentz had shown (somewhat apologetically, perhaps) that if those particular distortions of physical reality could conceivably occur in Nature, then all the internal discrepancies of the electromagnetic theory would disappear. He showed further, that such distortions were necessary if the electromagnetic theory were to be saved.* In direct and conscious support of Lorentz, although ostensibly from a new and independent standpoint, Einstein argued that if the velocity of light were universally constant, then those very same mathematicial distortions of reality (the Lorentz transformations) must actually take place: for that was the only way the velocity of light could be the same for all observers as he had assumed it to be. And in order to save the electromagnetic theory — which had already been disproved by his colleagues — he had the idea.

"That is how it all happened. It was a grand cover-up operation, and the people who pulled it off were acclaimed as heroes. The trouble was that their desperate and successful defence of the electromagnetic theory soon led (in 1925) to far worse difficulties. Perhaps someday we shall come to wonder if their success was really worth the troubles it has caused. In the meantime let us try to find out whether there is any possibility that the Special Relativity concept might be true ..."

Einstein's second postulate

The precedent that Einstein said he 'took over from the theory of Maxwell-Lorentz' was that the velocity of light is a constant of Nature. The electromagnetic theory statement was

\[ c = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \text{constant}, \]

where \( c \) is the velocity of light in vacuo and \( v \), \( k \) are artefacts of electromagnetic theory by which it seeks to attribute mechanical properties to a vacuum ('aether'). In e-m theory \( c \) is constant relative to this unique aether, and not universally. Thus the assumption of its universal constancy was not in truth 'taken over from e-m theory', with which it was actually inconsistent, but was introduced ad hoc in a curiously ambivalent attempt to reconcile \( c \) with the principle of relativity. Einstein's 'second postulate' was therefore suspect immediately. Whether or not we admit it to have been a failure, it follows from it that it leads consistently to paradox.

Nevertheless, Einstein indeed accepted that assumption without evidence (in 1905) as if it were, as he said, a "simple law" and a "natural law". Thus whatever my motion, light reaching me from any source whatever must always appear to approach me at the same velocity. For example, suppose that I am looking towards London from the hills to the north; light from the beacon on the Post Office tower at Heathrow shines towards me at velocity \( c \), which is fine. But you are a passenger in a southbound airliner, lining up for Heathrow. According to Einstein the light from the Post Office tower is also approaching you at velocity \( c \) (exactly), despite the fact that you are passing the beacon on the Post Office tower. This is the so-called twin's paradox, and it is the twin who is thrown off by the apparently foolish assumption. The argument is entirely circular. Whether or not it corresponds to the working of the physical world has never been put to the test.

At this point I should put in the routine reminder that the velocity of light from a moving source — had never been measured. What Michelson and Morley found was that if light was radiated from their light source at some velocity, presumably \( c \), its velocity remained \( c \) when it was reflected into any arbitary direction. (There were no moving parts of the apparatus.)

By writing down a group of mathematical equations (the Lorentz transformations), H.A. Lorentz was able to compensate for the failure of Maxwell's electromagnetic theory to cope with relative motions. In 1905 Einstein derived these same equations by postulating, without evidence, that the velocity of light was universally constant. The resulting Restricted or 'Special' Theory of Relativity, which required space and time to become distorted as a consequence of the observer's motion, preserved electromagnetic theory intact but at the expense of classical mechanics and common sense. Many paradoxes have ensued; the one examined here, which is less well known than some, shows that Einstein's 'relativity of simultaneity' is incompatible with his own Second Postulate.

The implication is that Einstein's arguments concerning the nature of time may be suspect and hence no longer capable, by sustaining the Lorentz transformations, of rendering the Maxwell-Lorentz theory plausible.\\

* 'Saved': 'Maintained, without the need for any further experimental appraisal and reformation from revised first principles'. There are good reasons for avoiding that extreme process.
assumed to be true because Special Relativity theory demands its truth, which is as circular an argument as you will find anywhere! There is no definitive evidence either way.

So now we have reached this situation: to save the Maxwell-Lorentz electromagnetic theory (which we already know by experiment to be wrong), we are asked to accept the 'Lorentz transformations' (which contravene all our long-standing experience of the nature of time and space), on the basis that the velocity of light is the same relative to all 'material' things, whatever may be their motions relative to each other (which certainly seems to deny ordinary logic). Perhaps there may be a higher logic? The whole thing begins to look like a confidence trick. One is always adjured to accept this theory simply on the grounds of the success of its predictions; but would it not be more convincing to get a line on the truth or otherwise of Einstein's second postulate from Einstein himself, if only one could find a way?

**Signal error at the trackside**

Einstein acknowledged that some physicists, as opposed to mathematicians, might have difficulty in swallowing these way-out ideas, so he developed an interesting argument about the nature of time and simultaneity. He envisaged a section of straight railway track running along an embankment from A to B, with M as its measure mid-point (see Figure 1). During a thunderstorm, lightning strikes the rails at both A and B simultaneously. "What does one mean by simultaneously?" he asks, and replies simplistically,

> "If the observer [at M] perceives the two flashes of lightning at the same time, then they are simultaneous."

This is Einstein's definition of what he means by simultaneity, and it is clear that it depends on what an observer perceives. But he is still being haunted by the aether-ghost of his own and his contemporaries' early training, and worried that the velocity of light might not be the same over the two equal but opposite distances A → M and M → B. After what, for him, is a longish discussion he concludes (his own italics):

> "That light requires the same time to traverse the path A → M as for the path B → M in reality neither a supposition nor a hypothesis about the physical nature of light, but a stipulation which I can make of my own free will in order to arrive at a definition of simultaneity."

**Now a 'stipulation', — arbitrary and subject to one's own free will in order to arrive at a definition — does not seem quite the same thing as a universal natural law. Is he not still talking about the velocity of light in vacuo? And incidentally, why should the definition (or fact) of simultaneity be associated so particularly with light signals? Could one not equally well send timing information through a vacuum by means of calibrated bullets fired from calibrated guns at velocity v? (Of course one could not use calibrated carrier pigeons because they fly relative to a medium, air). But since he needs to differentiate between the behaviour of photons and rifle bullets in order to bring c into his argument about time, and since it is the electromagnetic theory that he is trying to save, let us concede to him the light-based definition of simultaneity that he proposes, pro tem."

Einstein next puts a train onto his railway embankment, travelling in the direction A → B at velocity v, and puts a second observer M' into the train (Figure 2), so that "just when the flashes of lightning occur (as judged from the embankment)" this M in the train happens to be located exactly opposite M' on the embankment, half-way between A and B. If the observer M' were not moving "he would remain permanently at M', and the light rays emitted by the flashes of lightning at A and B would reach him simultaneously, i.e. they would meet just where he is situated." Good. But Einstein then goes on:

> "Now in reality (considered with reference to the railway embankment) M' is hastening towards the beam of light coming from B, whilst he is riding on ahead of the beam of light coming from A. Hence the observer will see the beam of light emitted from B earlier than he will see that emitted from A. Observers who take the railway train as their reference-body must therefore come to the conclusion that the lightning flash B took place earlier than the lightning flash A. We thus arrive at the important result:"

> "Events which are simultaneous with reference to the embankment are not simultaneous with respect to the train, and vice versa (relativity of simultaneity). Every reference body (co-ordinate system) has its own particular time; unless we are told the reference body to which the statement of time refers, there is no meaning in a statement of the time of an event."

Let us now without passion analyse that remarkable argument by which Einstein sought to justify both his assumption of the constancy of c and the consequent "dilation of time". Here we find his observer M' "hastening towards the beam of light coming from B while riding on ahead of the beam of light coming from A." But at the instant when the flashes occur the position of M' coincides with M (by scenario, see above); so at that instant the distance A → M' is equal to the distance B → M', in exactly the same way that the distance A → M is equal to the distance B → M. Therefore, if the velocity of light is the same for everyone (as assumed in the theory), its time of passage from A to M' must be the same as its time of passage from B to M' — exactly as it is over the equal distances AM and BM. Hence the light from both sources must reach M' at the same time, just as the light from both sources reaches M at the same time. But this is precisely the condition which Einstein himself has so carefully defined as 'simultaneous'!
I will paraphrase that result because of its importance: If the velocity of light were independent of the velocity of its source as claimed, then, as seen by two observers M and M' in uniform relative motion, the flashes which originated at points A and B when M and M' were spatially coincident at the mid-point of AB must arrive at the future positions of M and M' simultaneously. It would then follow that the times kept by observers M and M' must be identical in an absolute sense.

That is the exact opposite of the conclusion which we derived by Einstein in this, his own, scenario.

"Unbelievable", you will say: "there must be a mistake somewhere". There is, and we can locate it easily by transferring coordinates and joining observer M' in his 'moving' train, as we are entitled to do, since from them travelled the equal distance AM at velocity c and therefore reached the 'fixed' observer M at the same instant. According to his own second postulate the motions of the sources A and B relative to M are irrelevant; each light signal travels towards M' at the same universal velocity c. Therefore, since AM' is equal to BM' (so long as the Relativist does not change the rules!), these signals must arrive at M' at the same time — that is, simultaneously.

In the quotation above Einstein was actually arguing that M' was 'hastening towards' the light from B (relative velocity c + v) and 'riding ahead' of the light from A (relative velocity c - v), so that their times of arrival at M' must differ. But even the Master may not be allowed to keep his cake and eat it. According to his theory (second postulate) one cannot 'hasten toward' or 'ride on ahead' of a beam of light: its velocity relative to every observer is always and exactly c. If that is so, reception at M' is simultaneous by his own definitions and there is no case for denying universal time.

If the observations of M and M' differ it must be for the reason Einstein actually gave in the quotation rather than the reason he thought to give: not because the velocity of light is mysteriously the same for both observers but precisely because it is not the same — not universally constant, but relative. It adds up to this: one can maintain either the 'relativity of simultaneity' or the universal constancy of c, but not both.

"Please take your litter home"

In view of the simplicity of the logical error that we have been investigating, where Einstein fell so gullishly into his own conceptual trap, does it not surprise you that so many so-called Authorities have so blindly and uncritically followed him into it? Check me, if you please, by looking up the argument in any textbook of your choice, or in any popular presentation such as George Gamow's classic Mr Tompkins.4 (In the modern edition it is all done with rockets). Having checked, you may not be surprised to discover that very few people have heard of this counter-argument — which was not invented by me — nor even realised that the paradox existed. Those who wrote the textbooks did not want to know.

I suspect that most people will hold the same view about the present result as they do already about the other, better-known paradoxes of relativity theory. The established method of dealing with challenges to the logic of Special Relativity is to ignore them: and why not? For by using 'relativistic mechanics' (specifically, mass increase) the interpretation of physical measurements one can always bring one's experimental results into line with the predictions of electromagnetical theory, which is all that a scientific technician need be concerned to do. A natural philosopher, on the other hand, will go on trying, in the hope that he may in the end arrive at a logically consistent, paradox-free understanding of the physical universe. There are limits, intellectually, beyond which people of this second kind cannot be pushed.

It would be more in accord with the notion of science to make use of such anomalies rather than deny their existence. The lesson to be learned from this is that we, mere humans, are not entitled to define the fundamental physical apparatus TIME in an ad-hoc way simply in order to 'save' any particular theory. The demand that time 'must be' defined by the transmission of information to some observer by means of light signals is solely such that a definition, if accepted, permits an independent derivation of the Lorentz transformations. If that definition is rejected, many persistent physical and conceptual difficulties are immediately concentrated into the area where they properly belong — where also, once identified, they can be faced.

Up to and including the third quotation above (1905/1952) it is clear that Einstein's first intention had been to modify electromagnetic theory in such a way as to bring its erroneous predictions into line with the rest of physics rather than vice versa; the classical mechanisms of Galilei and Newton conforms with the relativity principle. As an intention it was wholly admirable, but alas, things did not work out as intended. The only compromise acceptable in the atmosphere of 1905 seemed to be one which left the already-disproved but sacrosanct eleventh century untouched but instead that the simple, natural world of energy and motion, time and space must become distorted in a manner that defies comprehension. The irrationality of that development was breathtaking, and the precedent it set was unfortunate: natural philosophers have had to put up with a lot of nonsense for a long time. Suppose we were to return to Einstein's original intention and try to put an end to the nonsense by correcting electromagnetic theory, rather than go on indefinitely riding roughshod over ordinary mechanics and common sense.

People working along these lines have made substantial progress recently, for example Professor Richard Waldron of the Ulster University. Only one or two more good, new ideas are needed in order to clear up this mystery, which dates back nearly a century to Michelson and Morley. If, at long last, we could get the "foundation of electromagnetical theory" right, we could take a deep breath and make a start on tidying up the mess.

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Terms of business: GWO. Postage and packaging valves and semiconductors 50p per order. CRPs £1.50. Prices excluding VAT, add 15%. Price ruling at time of despatch. Prices are exclusive of VAT and USA values will be higher than those advertised. Prices correct when going to press. Account facilities available to approved companies with minimum order charge £10. Carriage and packing £1.50 on credit orders. Over 10,000 types of valves, tubes and semiconductors in stock. Quotations for any types not listed. S.A.E.
WHAT RESOLUTION FOR ONLY £230.

Our RGB high resolution colour monitors (580 x 470 pixels) sell for £229.95 (excluding VAT)—a saving of over £100 compared to other leading monitors of similar specifications.

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For those who only require medium resolution we also have a model (370 x 470 pixels) at £179.95 (excluding VAT) which is equally excellent value for money.

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You can order by filling in the coupon below and posting to: Opus Supplies Ltd., 158 Camberwell Road, London SE5 0EE.或 by telephoning 01-7018 668 quoting your credit card number. Or, of course, you can buy at our showroom between 9.00-6.00pm, Monday-Friday 9.00-1.30pm, Saturday.

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I understand carriage per monitor will cost an extra £7.00 (N.B. A High Resolution Monitor including VAT lead, and carriage costs £229.95. A Medium Resolution Monitor including VAT and carriage costs £221.89).

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Please state the make of your computer:

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Name:

________________________

Address:

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Telephone:

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Opus Supplies Ltd.

WW11

CIRCLE 037 FOR FURTHER DETAILS.
**CIRCUIT BOARD REPAIR**

The salvage of just one complex p.c.b. assembly would pay for the repair kit used to do it, say OK Industries. Available in economy, standard and de-luxe versions, the kit includes repair tracks in most of the configurations likely to be required as well as setting tools. Additional to the standard kit are a number of consumables; epoxy resin, flux, cleaner, spatulas, abrasive sticks, tweezers, clamps and knives. The de-luxe kit has all that and an temperature-controlled soldering iron and five pairs of pliers. All items can also be purchased separately. OK Industries UK Ltd, Dutton Lane, Eastleigh, Hants. S05 4AA. WW 220

**P.C.B. C.A.D.**

Finding p.c.b. layout laborious and existing computer-aided design systems too expensive, Keith Ingham, a hardware and software engineer, designed his own c.a.d. system entirely in machine-code. This makes the system, Artwork plus, very fast and Mr. Ingham has managed to incorporate a number of very useful functions — curved tracks, for example, and a facility for dumping work in progress to a dot-matrix printer. At its simplest level, Artwork is a computerized analogue of a drawing board with 18 overlay sheets in register and the drafting pen replaced by a cursor. A p.c.b. designer with no computer experience could use the system with very little difficulty, claims Ingham.

The system compiles a list of all interconnections as the work progresses and if a component is repositioned, then the connecting tracks are reoriented to suit. A library of the user’s company standards may be kept on disc and the redrafting of a standard board is reduced to a minimum. Library space can also be given to a host of standard and non-standard pad layouts. Pads can be placed to an accuracy of 0.01mm and tracks to 0.6mm. Clearances between pads and tracks can be checked visually although an automatic clearance check is to be added to the system. Individual tracks or groups of tracks are initially given straight line connections and may then be moved using a ‘rubber-band’ control.

Output from the system may be on a precision drafting plotter to produce camera ready artwork. It will also send output information to a photo plotter, eliminating the camera stage. Each Artwork station is a complete stand-alone system with full design facilities. Further workstations when added can share a plotter. The basic price of the Artwork is £14,530 and this with a appropriate plotter is all that is needed for a complete in-house p.c.b. design system. Wayne Kerr, Datum Ltd., Woolborough Lane, Crawley, RH10 2UG. WW 221

**CONTROLLER FOR THE BBC MICRO**

A controller interface designed to plug into the 1MHZ bus socket of the BBC computer provides a number of useful facilities, including an eight-channel, eight-bit a-to-d converter, an eight-bit input port, eight-bit output port, four switch inputs, four relay outputs and a bus extender for further expansion.

The a-to-d converter is a single-chip device with a separate 2.45V precision voltage reference i.c. it gives 256-step resolution on all eight channels. A 5V regulator provides the supply for all the internal circuitry with a spare capacity of 80mA for external circuitry. Up to four switches can be connected directly to the switch inputs and the four internal relays can be used to switch devices of up to 12V at 1A. They could also be used to switch external relays for higher power requirements. The expansion connector uses its own configuration for add-ons designed by the makers. There is already an additional a-to-d pack which allows for high-speed operation, it takes 100K samples/s and is said to be ideal for use with an experimental digital storage oscilloscope or similar project. This is complemented by a d-to-a converter with eight-bit resolution (256 steps) which incorporates a high-impedance input buffer. The interface module, called Interbee, includes a power pack for £59.95 while the AD pack and the DAC pack cost £19.95 each. All prices inclusive. DCP Microdevelopments Ltd., 2 Station Close, Lingwood, Norwich NR13 4AX. WW 222

**MORSE RECEIVER FOR ZX81**

A program for the ZX81 computer can translate Morse code signal received from a radio or other source and translate them into text which is displayed on the screen. Two keys on the computer are programmed to adjust the reading speed and when this is correct, spaces appear between the words. The cassette program is loaded and a loudspeaker feed from the receiver is connected by coaxial cable to the cassette input of the computer. The instructions provide some useful hints and tips for the reception of signals including the use of a pair of back-to-back diodes to clean up the signal. This could be of use in cassette loading. The program has been successfully tested with both versions of the ZX81 r.o.m. Brian Bailey, Pinchest Data Studios, 69 Pinehurst Park, W. Moors, Wimborne, Dorset BH22 0BP. WW 223
COMPACT DIRECTION FINDER

A radio direction finding system, the DF2, gives an instant readout of the direction of a signal both as a digital display and as points around a compass. The signals are collected from four identical antennae mounted in a square array. These are combined in a head unit which phase-modulates the signal with a special waveform. The extra phase modulation carries the information about the direction of the incoming signal. In the unit this additional modulation is separated from any other modulation and processed to give two voltages; one proportional to the sine of the bearing angle and the other to the cosine. These voltages are digitized and the calculation to the bearing is handled by a Z80 processor, which is also used to drive the display. The phase-shift cause by signal delay through the receiver is automatically compensated for to give a superior performance than that in most Doppler-shift direction finders, according to the maker.

The DF2 is designed to be easy to install and use. In normal operation the unit instantly indicates the bearing of the received signal. If the signal fades the reading is held. Various operating modes give different selections of sampling and holding signals. The averaging time can be altered by a control but the processor control always ensures that the briefest signal will give an accurate bearing, whatever the setting. The unit may be used in conjunction with a separate receiver or may have a receiver incorporated into it. The coaxial feeder from the head unit also act as a d.c. power cable to the head unit. Although the system is designed to work with f.m. signals it will also operate with a.m. or s.s.b. signals which it will interpret as n.b.f.m. Other refinements include an offset so that the antennae especially on a mobile unit, do not have to be accurately aligned, since any misalignment can be compensated. It is even possible to reverse the directions entirely so that the system can be used with upside-down antennae, under an aircraft, for example. Suitable antennae, receivers and all ancillary equipment can be obtained from the Manufacturer; Datong Electronics Ltd, Spence Mills, Mill Lane, Bramley, Leeds LS13 3HE. WW 211

SINGLE-LENS VIDEO PROJECTOR

A new projector has been specifically designed to work with computer data output. The ECP 1000 differs from most other video projectors by combining the RGB images internally, working like a tv camera in reverse, and projecting the combined image through a single lens. This avoids the registration problems often encountered with three-lens projection tv and the system is capable of displaying high-resolution images with 600 lines of 1024 elements.

The input signal is fed to the three c.r.t.s which are positioned around a cube of dichroic mirrors. The mirrors within the cube have been aligned by laser light, and the dichroic coatings, up to 35 layers on each mirror, have been selected to match the wavelengths of the outputs from the c.r.t.s. This ensures that the brightest image is available for projection. The c.r.t.s. are also liquid-cooled to improve their efficiency.

The synchronization electronics can automatically lock onto an output operating frequency so that it will synchronize with the output of, for example, an IBM3279 terminal even though this uses a non-standard vertical frequency. The ECP 1000 can scan and hold frequencies between 15 and 33kHz horizontally and 45 to 100Hz vertically. This permits the projector to be used with many different output devices, from personal computers to high-resolution graphics terminals. With an optional adaptor and a tuner the system can be used to display broadcast tv or v.c.r. images, which benefit from the high resolution of the system. Electrohome Ltd, 7 Civic Way, Ellesmere Port, Cheshire L65 0AX. WW 213

MORE ON VISION

The MicroEye system for the BBC Computer has now been enhanced by the addition of two software packages. The standard MicroSight software will calculate areas and perimeters of an image and can be accessed from the Basic system. The additions are the Hi Res package which uses BBC mode 0 to give a 265 by 256 image which may be stored on tape or disc; and a Photo Graphics package which uses mode 2 and offers 'false colour' representation of different shades of grey. The system including tv camera, software and documentation costs £495. For an additional £39 it is possible to add an RGB filter system with the appropriate software to give a 'true' colour image in mode 2. Digithurst Ltd, Leaden Hill, Orwell, Royston, Herts SG8 5QH. WW 212

FLOPPY TAPES

We have received news of two very similar products which are both intended to improve the reliability and speed of tape storage for microcomputers for those who cannot afford disc drives. The Ultra-Drive from Ikon uses a standard cassette, offering a read/write speed of 1200 characters/s and a capacity of around 200k bytes on each cassette. A version compatible with the Dragon 32 computer is now available (£79.95) and others for the BBC, Nascom, Tandy, Orcy, Electron and Commodore computer are to be available soon. Ikon computer products, Kiln Lane, Lougharne, Dyfed. WW 214

A different approach is taken by Phi Mag Systems, who have produced Phloopy, which uses a continuous loop of tape about three meters long in an interchangeable cartridge. Tape speed is 15in/s and 0.25in instrumentation tape is used. Each cartridge offers a capacity of 100Kbytes and a transfer rate of 10Kbytes/s. Typically a file can be found and loaded in three or four seconds. The 'special secret' of Phloopy is that its records bytes in parallel, by using a nine-track head. The controller includes an on-board microprocessor which incorporates error-correction facilities and can take over many of the housekeeping and file-handling tasks of the computer. The system has been designed for the BBC computer, although other versions are on the way, and costs £99 plus £25 for an interface module which can handle up to eight drives. Phi Mag Systems Ltd, Tregonne Industrial Estate, Falmouth, Cornwall TR11 4RY. WW 215
If you need assistance in HiFi/audio service:

Here's all the help you need

Philips versatile PM5109 LF generator and unique combined distortion meter/oscillator, the PM6309, give you all the help you need for HiFi and audio service applications. They’re easy to operate – and economically priced.

PM5109 brings together all the high technology features you require from a test instrument. It offers symmetrical or asymmetrical outputs, pure sine wave signals, a wide 10 Hz – 100 kHz frequency range and switchable output impedances. A high 30 Vpp amplitude in the asymmetrical mode, with stepped and continuous attenuation; a 10 Vpp floating output in the symmetrical mode, and useful TTL or DIN loudspeaker outputs are further benefits. In addition, there is a choice of low-distortion or fast-settling modes.

PM6309 is a simple-to-operate distortion meter that can handle all types of audio equipment. It has been specially designed to provide appropriate signal generation plus an accurate distortion measuring capability within a single instrument.

It offers a built-in RC oscillator, total harmonic distortion (THD), 3rd harmonic distortion and rms measuring facilities. It not only measures distortion according to DIN-45500 – but also determines the distortion figure accurately when unstable audio signals are being applied.

Fully automatic operation means that all you do is connect the input, select the test frequency – and then read-out the distortion. Separate two-channel testing is also possible for stereo equipment.

Use the inquiry service to obtain further information.

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<td>PM 6309 distortion meter</td>
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Philips Test and Measuring
Pye Unicam Ltd
York Street, Cambridge CB1 2PX
Tel (0223) 358866 Telex 817331 GN13
**REQUIREMENT: AMPLIFICATION SOLUTION: CRIMSON!**

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### Modules

Power amplifiers bipolar type, incorporating full electronic protection, integral heatsink bracket, high slew/low distortion circuitry (< 0.01% THD TYPICAL)

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### New Low Power

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<td>MC2</td>
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### New Super CPR

Full details of our complete range including heatsink, toroidal power supplies, active crossovers etc. available on S.A.E.

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**FREQUENCY COUNTERS**

The brand new Meteor series of 8-digit Frequency Counters offer the lowest cost professional performance available anywhere.

- Measuring typically 2Hz - 1.2GHz
- Sensitivity <50mV at 1GHz
- Setability 0.5ppm
- High Accuracy
- 3 Gate Times

**PRICES (Inc. adaptor/charger, P & P and VAT)**

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**LOW COST LOW RELIABILITY**

- Illustrated colour brochure with technical specification and prices available on request.

---

**METAL FILM RESISTORS**

- 1% Tolerance, 1/4 Watt

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**SPECIAL OFFER**

- 5 each of 445 resistors
- £12.60

**SPECIAL 'POP' PACK**

- 50 pcs 100R, 1K, 4.7K, 10K, 47K, 100K, 1M
- 10% tolerance
- £11 extra
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**TRADE ENQUIRIES WELCOME**

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28 Bullfields, Sawbridgeworth, Herts. Tel: 0279-724425
STURDY CASSETTE RECORDER

Basing their efforts on a cassette recorder designed for use in schools, Bell & Howell and Leasalink Viewdata have combined their talents to produce a cassette recorder (3179CX) for use with microcomputers. Pointing out that the use of cassettes for computing accounts for much heavier use than with audio, the player has been manufactured with a heavy-duty case, mechanism and circuit boards, said to be hard wearing and shock resistant. All the usual facilities are provided including ‘cue’ and ‘review’ and a tape counter, while the recording level can be automatic or manually controlled. Frequencies up to 8kHz can be recorded which the makers claim is ideal for computer use. The recorder also doubles as an audio machine. Bell & Howell, Alerton House, Bridgewater Road, Wembley, Middlesex. HA0 1EG.

WW 216

PROGRAMMABLE MAINS SWITCH CAN SAVE ENERGY

A control system which uses mainsborne signalling, the Datapath, can switch up to 256 remote mains-powered appliances. The manufacturers see the main purpose of the system as switching heating and are therefore promoting it as an energy saver, though there are a number of other applications including the switching of security appliances and lighting. It can be used for controlling contactor or switchgear. The signals only provide for on-off controls but local, e.g. thermostat, control is possible for each remote site.

The control unit includes a microprocessor, a real-time calendar clock, and a transmitter for sending the f.s.k. signals into the mains supply. Each receiver has a frequency comparison decoder.

The frequency band used is 110 to 125kHz which is suitable for continuous transmission. Each Datapath installation uses one central frequency and all 256 remote switches are controlled from a single channel. Accuracy is ensured by including a redundant data byte at the end of each message. This is used as a check byte and prevents interruption or interference from any other source. The checking procedure introduces a delay which can be up to two seconds for switch-on or up to 30 seconds to switch-off. To prevent interference with neighbours, the signal is only 10mW, which ensures that it will not pass the metering point of the premises.

The main advantage of the system is that it needs no additional wiring. The control unit may be plugged into any convenient socket and may be easily moved. Each receiver outstation is about the size of a double-gang socket and is easily installed. The control unit can be used in an immediate mode to turn on or off any remote station. It may also be programmed to switch at specific times during the day or on specific days; off at weekends, for example. A c.r.t. monitor displays the status of all the outstations and the programmed times. Programs may be easily written to suit any requirements and although the system is self-contained it may also be programmed from a host computer. The distance at which the system will operate is restricted by the proposed standard for mains signalling equipment. In practice this has not proved to be a limitation and the system has worked in many large installations.

Different applications require different configurations of the control unit but an installation with 50 control units would cost about £7 500, or for 100 units, £13 000. FIDB Electrical Ltd, Reynard Mills Trading Estate, Windmill Road, Brentford, Middlesex. TW8 9NZ.

WW 218

TEST PATTERN

Two new colour bar and pattern generators have been announced by Advid. The Unachm EP690 is a bench instrument, intended for use by broadcasting stations, close circuit studios, laboratories, production test and service departments. It can produce colour bars, cross-batch, chequer-board, staircase and other patterns, all of which are available as composite video or r.f. modulated signals. The signals may be output in a frequency range from 35 to 950MHz. It costs £495.

The second instrument, Type GC081, is a small hand-held device for use by the service engineer in the field. It gives ten test patterns and colour bars as a modulated r.f. output in the range 47 to 65MHz, 175 to 217 MHz and 470 to 860MHz. It comes complete with leather case, NiCd battery and a mains adaptor/charger for £119.95.

Advid Electronics, 17a Mill Lane, Welwyn, Herts AL6 9EU.

WW 219
PEAK ENVELOPE POWER MEASURED FOR HAMS

A module is produced which can be added to a forward power meter to convert it to read peak envelope.

The common s.w.r. meter or the in-line wattmeter can often give misleading readings when used with s.s.b. transmission. According to Amateur Accesseries, the natural tendency of the operator is to increase the microphone gain or speak too close to the microphone in order to get some response from the meter. It is exactly these circumstances that the peak envelope reading is so valuable as it enables the user to operate within the correct parameters for the output stage.

The module consists of a p.c.b. with one integrated circuit and a number of discrete components. It has been adjusted for zero readings and then scaled. It comes with mounting hardware and may be fitted to an s.w.r. meter or an a.t.u. and needs no particular knowledge or skills to fit. When fitted to an s.w.r. meter, the module gives the same reading as it did before fitting and the meter will behave exactly as before when used with continuous carrier modes. £12 from Amateur Accesseries Ltd, Church Street, Glan Conwy, Colwyn Bay, Clwyd LL28 5LS. WW 205

FAST F.I.F.O.

For those seeking the speed of t.t.l. in spooler memories without the power consumption, they could look to the 67L401 from Monolithic Memories. The device has a maximum I of 110mA, about 30% lower than the standard 67401. The memory is organised as a 64K by 4-bit structure and may be cascaded to any width or depth. Typical applications for these first-in, first-out memories are for print spoolers, disc controllers, communications buffers, modems etc. Monolithic Memories, Lynwood House, 1 Camp Road, Farnborough, Hants GU14 6EN. WW 206

CUSTOM POWER SUPPLIES

A small projects division set up by Grenson Electronics was able to win a large contract by designing and providing prototype switch-mode power supplies in five days. Although they cannot guarantee to be so fast every time, they say that they are geared up to the rapid design and construction of prototypes. They achieve this by separating this division from the main manufacturing of production units. Grenson Electronics Ltd, High March, Daventry, Northants NN11 4HJ. WW 209

TRANSIENT PROTECTORS

A range of power-line and data-line protectors incorporate TransZorb silicon junction transient suppressors. mains-born transients can induce computer breakdowns and signal line interference may not be immediately detected but can cause downgrading of performance and may in the long term lead to damaged components. Hunter Electronic Components Ltd, Unit 3, Central Estate, Maidhead, Berks. SL6 7BN. WW 210

MICRO CONTROLLER

Built around the c.mos version of the 6502, a controller module may be programmed using a BBC computer. Programs are generated in assembly language on the BBC and then downloaded into the control board, where it may be stepped through or run. When development is complete, the program can be entered on an eprom for normal operation. As c.mos is used throughout, the controller may be battery powered. Applications include robotics, machine controllers, data loggers, automatic test equipment and any device requiring 'intelligent' control. The board may be purchased built and tested (£84.98) or as a bare board. The monitor eprom may also be purchased separately and the technical manual supplied with the assembled circuit can be bought for £2.50. Nikam Electronics, 25 Suffolk Drive, Lacey Green, Wilmslow, cheshire SK9 4DE. WW 207

MEMORY IN BULK

High density memory arrays can be provided simply and at lower cost by combining several 64K ram i.cs on to a single substrate. Mounted in single-in-line packages, these Texas memory arrays are available in several configurations, including 64K by 4, 5, 8 or 9 bits. as well as a device organized as a 256K by one-bit memory. Leadless chip carriers are bonded directly to the substrate which also includes decoupling capacitors. Mounted vertically, the devices offer considerable saving in board space and in board complexity and assembly time. The chips require a single 5V supply and have an access time of 150ns. They are refreshed 256 times every 4ms and have a protective coating against alpha-particle intrusion, which can cause errors. Available from Jermyn Distribution, Vesty Estate, Sevenoaks, Kent. WW 208

WIRELESS WORLD MAY 1984
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CIRCLE 075 FOR FURTHER DETAILS.

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A.M. Electronics
Wood Farm, Leiston, Suffolk IP16 4HT
Tel: 0728 831131

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CIRCLE 082 FOR FURTHER DETAILS.

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3. Tektronix 191 Constant Amplitude Generator .................................................. 1116
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5. Tektronix 2901 Time Mark Generator ........................................................................ 135
6. Tektronix 184 Time Mark Generator ........................................................................ 115
7. Tektronix MR501 X-Y Monitor for TM500 system .................................................. 165
8. Tektronix 087-502 Amplitude Calibrator .................................................................... 45
9. Tektronix 067-502-01 Amplitude Calibrator ............................................................ 40
10. Tektronix DF2 Formatte for Logic Analysers .......................................................... 400
11. Telequipment DMD10-100Mhz Storage Oscilloscope ........................................... 275
13. Marconi TF2401 50Mhz Counter ............................................................................ 45
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16. Tektronix 613 Storage Monitor ................................................................................ 295
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22. AVO Model 7 Mk. 7 & Mk. 2 .................................................................................. 50
23. Fluke 8020A DMM (Unused) .................................................................................. 60
24. Cases for above (New) ........................................................................................... 12
25. J. L. Lloyd PL100 X-Y Plotter ................................................................................ 195
26. DEC PDP 8 Computer ............................................................................................ 100
27. DEC PDP 81 Computer in rack with reader etc ...................................................... 195
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29. Sullivan AC Test Sets ............................................................................................. 150
30. Philips PM 2022A Digital Multimeter ...................................................................... 45
31. Hewlett-Packard 1901A Vertical Plug in ................................................................. 95
32. Hewlett-Packard 1921A Timebase Plug in .............................................................. 95
33. Ice Digital Multimeters ........................................................................................... 45
34. Tektronix 3533 Sampling plug in ............................................................................ 50
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WIRELESS WORLD MAY 1984
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The LEVELL TG302 is the lowest priced 2MHz function generator on sale in the UK. The LEVELL TG303 is a function generator together with a frequency counter.

- SINE, SQUARE, TRIANGLE, PULSE & RAMP
- 0.02Hz to 2MHz in 7 RANGES
- EXTERNAL SWEEP OVER 3 DECADES
- 20Vp-p from 50ohm SOURCE
- VARIABLE DC OFFSET
- TTL OUTPUT
- FREQUENCY COUNTER TO 10MHz (TG303)
- CMOS OUTPUT (TG303)

**CIRCLE 022 FOR FURTHER DETAILS.**

**VERSATOWER:**

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

Designed in accordance with CP3 Chapter V, part 2: 1972 for a minimum wind speed of 140 kph in conditions of maximum exposure and specified by professionals worldwide where hostile environments demand the ultimate in design, quality and reliability. Suitable for mounting equipment in the fields of:

- Communications
- Security surveillance – CCTV
- Meteorology
- Environmental monitoring
- Geographical survey
- Defence range-finding
- Marine and zero navigation
- Floodlighting
- Airport approach lighting

Further details available on request.

**STRUMEC ENGINEERING LIMITED**

Portland House, Coppice Side, Brownhills
Walsall, West Midlands WS8 8EX, England
Telephone: [0543] 4521
Telex: 335243 SEL.G

**CIRCLE 029 FOR FURTHER DETAILS.**
The VC1000L is a laboratory grade instrument with versatile microprocessor control. It includes a frequency (100 kHz - 60 MHz, 0.02 ppm), a period (0.1 s to 1 uS), and a pulse counter (0-999,999,999). TTL levels; a 9 VDC to 988 V range), a thermistor (remote sensor -290°C to +993°C) plus a precision timer (24 hour clock providing time, date, or period, 24-hour or 12-hour mode, and alarm function). Display is via 8 large fluorescent digits and/or the built-in 5X7 (20 characters line 2 line second) Dot Matrix thermal printer.

The VC1000L is designed for precision measurement and control applications in a wide range of fields, including education, research, and industrial process control.

SOUTH MIDLANDS COMMUNICATIONS
SALE of TEST EQUIPMENT
1/2 PRICE!

YHC1000L DATA PROCESSOR OBSERVE & RECORD FREQUENCY, PERIOD PULSES TEMPERATURE, VOLATAGES & TIMES £365 -15% VAT £312.50 +£5.00 Carriage

The VC1000L is a high-precision laboratory instrument designed for a wide range of measurement and control applications. It features a microprocessor control system that offers frequency measurement capabilities from 100 kHz to 60 MHz, with an accuracy of 0.02 ppm. The device also includes a period measurement range of 0.1 seconds to 1 microsecond and a pulse counter that can handle up to 999,999,999 counts. TTL levels are also supported, allowing for flexible interfacing with various systems.

The VC1000L's thermistor feature allows for remote temperature sensing with a range from -290°C to +993°C. It also includes a precision timer with a 24-hour clock, enabling time, date, and alarm function capabilities.

The display unit is large, fluorescent, and capable of showing 8 characters per line, along with 2 line seconds of Dot Matrix thermal printing.

The VC1000L is designed for precision measurement and control applications in various fields, including education, research, and industrial process control.

The unit is priced at £365, excluding VAT, with an additional £5.00 for carriage. The unit is available for sale at 1/2 price, bringing the final price to £312.50 after a 15% VAT deduction.

CIRCLE 056 FOR FURTHER DETAILS.
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UK ORDERS P&P 50p PLEASE ADD V.A.T. AT 15%
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**CIRCLE 053 FOR FURTHER DETAILS.**
Vigilant micon HF Communications Receivers

MICROPROCESSOR CONTROLLED RECEIVERS

Type SR 530 USB/CW/AM/Telex – 10 Hz Steps (Marine)
Type SR 532 USB/LSB/AM/CW – 10 Hz Steps (Static/Transportable)
Type SR 531 USB/LSB/AM/CW – 100 Hz Steps (Static/Transportable)

MICROPROCESSOR CONTROLLED RECEIVERS

NOW AVAILABLE AT HIGHLY COMPETITIVE PRICES

Send for Technical Brochure to:
Vigilant Communications Ltd.
Unit 5, Pontiac Works, Fernbank Road, Ascot, Berks SL5 8JH, England

DESIGNED AND MANUFACTURED TO HIGHEST INTERNATIONAL SPECS

Freq. Range: 50 KHz to 30 MHz
Increments: 10 Hz or 100 Hz Steps
Stability: ±1 Part in 10^7/°C
Tuning: Keypad and Spin Wheel
Power Supplies: 110/240V AC and 24V DC
FULLY MODULAR ‘PLUG IN’ CONSTRUCTION

Frequency Increments

200 Channels Freq/Mode/Filter
Full memory or discreet parts
Automatic or Manual Stop
Manual step on or Reverse

Dwell: Variable from Keypad 1 to 9 seconds
KEYPAD FUNCTIONS INDICATED BY DISPLAYS

NOW AVAILABLE AT HIGHLY COMPETITIVE PRICES

Send for Technical Brochure to:
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CIRCLE 027 FOR FURTHER DETAILS.

WRONG TIME?

MSF CLOCK is ALWAYS CORRECT — never gains or loses, SELF SETTING at switch-on, 8 digits show Date, Hours, Minutes and Seconds, 24 hour format, large digit Hours and Minutes for easy QUICK—GLANCE time, auto GMT/ BST and leap year, can expand to Years, Months, Weekday and Milliseconds, with parallel BCD output for computer and audio to record with commentary and show time on playback, receives Rugby 60KHz atomic time signals, only 15X5X8cm, superhet receiver, built-in antenna, 1000Km range, GET the RIGHT TIME, £72.70.

Fun-to-build kit (ready-made to order) includes all parts, printed circuit, case, instructions, by-return postage etc, list of all kits, SEND away NOW.

CAMBRIDGE KITS

45 (WE) Old School Lane, Milton, Cambridge. Tel. 860150

CIRCLE 045 FOR FURTHER DETAILS.

SOLDER FUME ABSORBER

Removes smoke and fumes from soldering area and absorbs harmful components, using activated carbon filter.
Free standing unit, adjustable for angle, with removable hood.
Supplied with 3 spare filters.
Price only £58.04.

Light Soldering

Developments Ltd
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Croydon CR0 2DN 01-689 0574

CIRCLE 045 FOR FURTHER DETAILS.

MICRO ENGRAVER

MICROPROCESSOR-CONTROLLED ENGRAVING MACHINE

NEW

STEPPING MOTOR XYZ MACHINE. Complete with microprocessor controller and software programmed to engrave alphabet and numbers. Also features three operator-programmable XYZ sequences to engrave, drill or cut out special shapes and logos. XY axis travel 100-107mm, Z 30mm. Mixed character sizes on a label from 1-99mm high. Qwerty keyboard, 24 character liquid crystal display. Machine supplied complete and ready to manufacture labels.

PRICE £2650.00

J.A.F. GRAPHICS

CIRCLE 017 FOR FURTHER DETAILS.

WIRELESS WORLD MAY 1984
Advertisements accepted up to 12 noon Tuesday, April 3, for May issue subject to space available.

DISPLAYED APPOINTMENTS VACANT: £17 per single col. centimetre (min. 3cm).

LINE advertisements (run on): £3.50 per line, minimum £25 (prepayable).

BOX NUMBERS: £5 extra. (Replies should be addressed to the Box Number in the advertisement; c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS).

PHONE: IAN FAUX, 01-661 3033 (DIRECT LINE)
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ELECTRONIC COMPUTER AND MANAGEMENT SERVICES LIMITED
Freepost, Barkway, Royston, Herts SG8 8BR

RESEARCH INSTITUTE
University of Petroleum and Minerals
DHAHRAN, SAUDI ARABIA

Needs Digital Electronics Repair Technicians for expansion of the facility for instrument repair, maintenance and calibration.

Candidates background should include:
★ Bachelors or associate degree in equivalent military/technical training.
★ Minimum 4 years hands-on digital experience on micro-mini computers, peripherals, data acquisition systems, micro-processor controlled test instruments.
★ Troubleshooting and repair capability to component level (experience with current micro model minis, micros and GPIB a big advantage).

Salary is competitive, benefits include annual reparation, housing and transportation allowances.

Candidates possessing the above requirements should only apply to the following address within one week of the release of this advertisement: furnishings details resume of their educational qualifications and experience, attaching copies of their degrees and transcripts, giving names and addresses of four references, including their present employer, if possible, and the present position held.

Mr Ali A Jaman, Director General, Financial and Admin Affairs, Research Institute – University of Petroleum and Minerals, P.O. Box 7177, Dammam – 31462, Saudi Arabia

BRIGHTON POLYTECHNIC
LEARNING RESOURCES

Senior Audio-Visual Technician £6,264 - £7,896

To be responsible for the organisation and operation of the audio-visual equipment loan service which supports teaching at the Moulsecoomb site of the Polytechnic. The equipment includes production standard colour video cameras, 3/4" and 1/2" video recorders and multi-standard video replay, production quality sound equipment including Revox and Uher recorders, along with film and slide projectors. Candidates must have experience of the operation and maintenance of equipment of this kind, and be able to work with a wide range of academic, media production and engineering staff. Candidates must also have good organisational skills. City and Guilds First Certificate or TEC qualifications in a relevant area of electronics an advantage.

Further details and application forms available from the Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton BN2 4AT. Tel (0273) 690655 Ext 2536.

Closing Date: 4 May 1984 (2560)

LOGEX ELECTRONICS RECRUITMENT

Specialists in Field & Customer Engineering appointments, all locations and disciplines.

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0453 882064 & 01-359 8077 (24 hours)

BRIGHTON POLYTECHNIC
COMPUTER CENTRE

TECHNICIAN

(DATA COMMUNICATIONS) Salary up to £8,712

To help maintain an extensive communications, terminals and microprocessor service comprising 350 terminals, and well over 50 microprocessors.

There is a small team dedicated to this task. Additional development activities are undertaken, improving the network by designing, building and servicing various system components.

A progression scheme is provided for accelerated remuneration commensurate with the applicant's development skills.

Application forms and job description can be obtained from the Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton BN2 4AT. Telephone Brighton (0273) 690655 Ext 2537. Closing date 4 May 1984. (2541)
Appointments

CUT THIS OUT!

Clipping this advert and you can stop hunting for your next appointment! We have a wide selection of the best appointments in Digital, Analogue RF, Microwave, Microprocessor, Computer, Data Comms and Medical Electronics and are here to serve your interests.

Call us now for posts in Design, Sales, Applications or Field Service, at all levels from £5,000 to £16,000.

Genius Wanted

To join our technical department at Utopia recording studios. SSL, Studer, Neumann and Neve experience an asset, to work with our young and enthusiastic team of Utopians.

Call Phil Wainman now on 01 586 3434.

Test and Service Technician required for Electronics Company to undertake the running of a small service department.

Duties would include test and repair of electromechanical devices and associated microprocessor based electronics along with the administration of spare parts stock control.

Although formal qualifications would be recognised, mechanical aptitude and a working knowledge of microprocessor electronics and digital circuitry are considered more essential.

Good conditions of employment, BUPA participation etc.

Apply in writing to: Personnel Manager Roxburgh Electronics Ltd., 22 Winchelsea Road, Rye, East Sussex TN31 7BR

BORED?

Then change your job!

1) VDU and Peripherals Senior service engineer required to support and train with O.E.M. sales oriented personally required - Medics. To £11,500 + car.

2) Data Communications 1 year experience in servicing PW Tele or message switching equipment for customer support - Berks. £5,000 + car.

3) Naval Weapons/Communications Support Engineer for managing logistics of installation and maintenance - Berks £4,000

4) Service Personnel (Navy, RN, ARMY) We have many clients interested in employing ex-Service officers and technicians at sites throughout the U.K. Phone for details.

5) £500 per week We pay very high rates for contract design and test engineers who have a background in RF, Microwave, Digital, Analogue or Software, all sites throughout the U.K.

University of Leeds

Applications are invited for the posts of Senior Technician (Grade III) and Junior Technician (Grade II) in the Electronic Workshop of the Department of Electrical and Electronic Engineering. The workshop staff are responsible for the maintenance of electronic instruments and for the development and construction of electronic equipment for both teaching and research.

Applications are expected to have a good degree in electrical engineering or a considerable experience of electronic engineering, particularly with the use of computers. The salary scale is currently £579 - £727 plus. Applications giving full details of present employment and qualifications are required together with the names and addresses of two referees, should be sent to Mr. W. G. Black, Department of Electrical and Electronic Engineering, Leeds University, Leeds LS2 9JT.

Mid-Warwickshire College of Further Education

Faculty of Technology

L.E. in Electronics/Microelectronics

Applications are invited for the above post for appointment from 1st September 1984. Applicants should possess a relevant degree or professional qualification with some relevant industrial experience. Applicants will be required to teach on a range of Technician and Craft courses, particularly on the Diploma in Electronics and the Foundation Degree in Engineering.

Applications forms and further details may be obtained from the Principal’s Secretary, Mid-Warwickshire College of Further Education, Bedworth, Warwickshire. Tel: 0203 3459469. Closing date 14th May 1984.

Plymouth General Hospital

Department of Medical Physics and Biomedical Engineering

Applications are invited for two posts at Greenbank Hospital -
Post A Technician (electronics)
Post B Technician (mechanical)

The person appointed to Post A will be a member of a team of eleven people, fully equipped and expanding, offering support services in many aspects of the management of clinical electronic equipment in hospitals and health centres throughout the Plymouth Health District.

The person appointed to Post B will be a member of a team of five people, fully equipped and expanding, dealing with the maintenance and development of a wide range of electronic clinical equipment (mainly in theatres and special care units) in hospitals throughout the Plymouth Health District.

Hospital experience is not essential as further training will be given.

H.R. O.N.C., O.C. and Guilds Final Certificate or equivalent qualification is required. The work involves frequent travel and necessitates a current driving licence. There is a requirement to be prepared to participate in a scheme to provide out-of-hours emergency cover.

Posts are offered in one of the following grades according to relevant experience.

£5,671 - £6,798 per annum

£6,132 - £7,926

Further information:
Post A Contact Mr. A. Dawson 0752 834276
Post B Contact Mr. Barritt 0752 834279

Applications forms available from and returnable to:
Unit Personnel Office
1 Belvedere, Greenbank Road, Plymouth


Satellite Reception Research Assistants

For the BBC’s Monitoring Service at Caversham, near Reading, Berkshire.

With the advent of satellite communications, broadcasting and news agency organisations are switching from conventional means to satellites for their transmissions. Satellite Reception Research Assistants will be involved in the Monitoring Service’s work in this field. Duties include frequency scanning and the compilation of transmission schedules. Extensive experience in communications with C and G Intermediate Telecommunications Technicians Certificate or equivalent qualification and a thorough grasp of satellite communications are essential. Knowledge of major broadcasting systems, familiarity with new agency transmissions and the ability to recognise a range of languages an advantage.

Applicants will be required to take written tests and appointment will be subject to satisfactory health tests. Shift working involved.

Salary £7,867 - £9,761 plus a 10% shift allowance.

Relocation expenses considered.

Write or telephone immediately for application form (quote ref. 3222/WW and enclose stamped, addressed foolscap envelope) to Senior Personnel Officer, BBC Monitoring Service, Caversham Park, Reading, Berks., RG4 8TZ. Tel. (0734) 472742 Ext. 212.

We are an Equal Opportunities employer.

Stereophonic Television

B.B.C.

WIRELESS WORLD MAY 1984

2552
Design Engineers & Materials Supply Control

Farnell Instruments and the Electronic Engineering Department at Huddersfield Polytechnic have together established a Teaching Company Scheme.

This has provided a rare opportunity for Associates to work on industrial projects in:

1) Test and measurement instruments design
   Digital signal processing
   Digital storage oscilloscopes
2) Materials supply and control

Applications are invited from Honours graduates in an appropriate discipline and ideally with some industrial experience. Associates have the opportunity to register for a higher degree. Three posts are based at Wetherby and are initially for a two year period.

Salary range £6516-£7692

Find out more by ringing Andy Lamming on Wetherby 81961 or Harrogate 870543 after 7.00pm

Further details also available from Personnel, Farnell Instruments Ltd., Wetherby LS22 4DH

Careers in Electronics Research

The Laboratories at Redhill, Surrey, are the UK research centre of the international Philips Group of Companies. The facilities and resources rank alongside the most technically advanced in the world today. The total environment is completely conducive to the wide range of research projects which continue to achieve the successes for which we carry world recognition.

There are vacancies in two teams for people qualified at least to HNC or HTEC level and having relevant experience in:

DIGITAL TELECOMMUNICATIONS

This team is involved in an advanced Integrated Services Digital Network embracing subscriber access through digital transmission. The task will involve exploitation of both Digital and Analogue Signal Processing.

As a key member of this team you will be directly concerned with construction, testing and evaluation of hardware systems.

If you believe that your experience and qualifications would equip you for either of these positions we would be pleased to hear from you. Conditions of service and rewards reflect those of the parent group, renowned for their forward thinking and enlightened policies. Assistance with relocation is available if required.

Please apply to: Chris Nye, Appointments Co-ordinator, Personnel Department, Philips Research Laboratories, Cross Oak Lane, Redhill, Surrey RH1 5HA. Tel: Horley 5544.

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Appointments

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CHELSEA COLLEGE
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Electronics workshop technician required for interesting work for electronics and physics research and teaching. Includes prototype instrument design, development and construction and the servicing and repair of commercial electronic equipment.

Experience and qualifications in electronics (particularly digital) at an appropriate level are essential. Inclusive salary Grade 5 — £7529 to £8582 p.a.

Further details and application forms from Mr M E Cane, Chelsea College: Department of Electronics, Pulton Place, London SW6 5PR.

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Appointments

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£9561
Communications Design in High Tech Country

At H.M. Government Communications Centre we're using the very latest ideas in electronics technology to design and develop sophisticated communications systems and installations for special Government needs at home and overseas.

With full technical support facilities on hand, it's an environment where you can see your ideas progress from initial concepts through prototype construction, tests and evaluation, to the pre-production phase, with a chance to influence every stage. Working conditions are pleasant, the surroundings are attractive, and the career prospects are excellent.

Ideally we're looking for men and women who have studied electronics to degree level or equivalent and have had some experience of design, whether obtained at work or through hobby activities. Appointments will be made as Higher Scientific Officer (£7149-£9561) or Scientific Officer (£5682-£7765) according to qualifications and experience.

For further details please write to the address given below. As our careful selection process takes some time, it would be particularly helpful if you could detail your qualifications, your personal fields of interest and practical experience, and describe the type of of working environment most suited to your career plans.

The Recruitment Officer, HMGCC, Hanslope Park, Buckinghamshire MK19 7BH.

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* Short or Long Term
* Installation

Marconi Communication Systems, world leaders in the design, manufacture and installation of advanced electronic communications equipment and systems require experienced field staff.

Contract employment
North Africa and Middle East
Maintenance of HF or Tropo, LOS, MUX and associated equipment.

Demanding assignments await adventurous Engineers/Technicians with an electronics qualification or HM Forces training and a minimum of three years' relevant experience (current UK driving licence required) as follows:-

Permanent employment
Worldwide
Installation and Maintenance of satellite earth stations or broadcast transmitters or Tropo, LOS, MUX or PCM and digital or HF equipments.

We offer excellent salaries, living allowances and overseas benefits where applicable. Skilled and dedicated Engineers and Technicians seeking permanent employment will find excellent scope for career advancement within our highly successful company.

Please telephone for an application form or send a full c.v. to Gordon Short, Marconi Communication Systems Limited, New Street, Chelmsford, Essex, CM1 1PL. Telephone: Chelmsford (0245) 353221, extension 498.

Marconi
Communication Systems

WIRELESS WORLD MAY 1984
COMMUNICATIONS ENGINEERING

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In every sphere of its operations, Aramco relies heavily on the most sophisticated communications links. The following appointments offer invaluable experience of advanced data and voice networks, together with all the tangible rewards of working for the world’s largest oil producing company:

**PROJECT PLANNING/CO-ORDINATING ENGINEERS**
(3 posts) Circa £19,500-£25,500 net

Will be involved in the planning and coordination of all types of telecommunications projects. One post requires at least 10 years’ experience covering Transmission Systems Engineering, Systems Design and UHF/VHF Radio Networks, and Microwave and Multiplex Applications. The other 2 posts require at least 7 years in the planning, engineering and implementation of telecommunications projects. Experience of drawing up engineering standards and of technical writing would be advantageous for one of these posts.

Ref: PPE/139.

**DOCUMENTATION ENGINEER**
Circa £19,500-£22,500 net

Will head the technical writing group and must have experience in the development, preparation and editing of communications-related standards, specifications, procedures etc.

Ref: DOCE/140.

**STANDARDISATION ENGINEER**
Circa £19,500-£22,500 net

Will determine specifications etc and technical acceptability of substitutions. Must have in-depth knowledge of communications materials, equipment and spare parts. 8 years’ experience is required in design, research, maintenance or a related area.

Ref: STE/141.

**SENIOR COMMUNICATIONS TECHNICIANS**
(6 posts) Circa £15-17,000

Will carry out the maintenance and repair of a variety of communications and electronic equipment, including UHF/VHF radio-systems and radio-data systems. One post will include the monitoring of the quality of the technical and administrative performance of contractors plus cost verifications for statistical purposes. Candidates should have a minimum of 10 years’ post apprenticeship experience in the maintenance and repair of communications and electronic equipment.

Ref: COMT/142.

For the Engineering posts a relevant degree, HNC or equivalent is required and for the Technician posts an apprenticeship, plus the experience specified above.

These single status appointments offer open-ended contracts with the usual tax advantages. The excellent range of benefits include low-rental accommodation (fully furnished and air-conditioned), regular UK leave with company paid air fares, free medical care and good sports and recreational facilities.

Please write with full career details quoting relevant ref. no. to: Webb Whitley Associates Limited, International Recruitment Consultants, 45 Kensington High Street, London W8 5ED.
Maxell (UK) Ltd is a subsidiary of one of the world's largest and most respected tape companies. Maxell's research and development efforts have brought very high performance tapes to both the amateur and professional user and to supply the European market for video tape. Maxell have recently completed construction of a video tape factory in Telford, Shropshire. The company has achieved considerable success as a supplier to broadcast duplication and video facilities companies and to support these clients Maxell now wish to appoint a Sales Engineer. The products mainly involved will be VHS, Beta and U-matic video cassettes and the position will involve sales and technical liaison with existing and potential users of these products.

The successful candidate will ideally be educated to degree standard and have experience in consumer and professional video systems. The company offers a future in an industry which is developing rapidly and which will present an interesting and challenging working environment.

The position is based in Harrow, Middlesex and benefits include free membership of the company BUPA scheme and a company car.

If this position would interest you please send a CV and any additional information you feel relevant to:

Maxell (UK) Ltd, 1 Tyburn Lane, Harrow, Middx HA1 3AF.

Senior Technical Assistant
from £9,300 p.a.

The Purchasing and Supply Department of the Independent Broadcasting Authority, based at Harrow, now has an opportunity for a Senior Technical Assistant to lead its small Technical Services Group.

Provision of technical services includes goods inwards inspection, storage environment, component testing, repairs to electrical equipment and maintenance of office equipment held at Harrow.

Candidates require a good secondary education to 'O' level standard and TEC or City and Guilds in Electrical/Electronic Engineering or equivalent knowledge and experience at a similar level. Considerable experience in a technical stores environment of a large organisation dealing with a wide range of complex technical equipment, will not only have furthered technical knowledge of electronic components and equipment, but brought an appreciation of stock control, purchasing systems and procedures, and of computer usage in stores and stock control.

An excellent working environment and conditions of employment are offered.

IBA INDEPENDENT BROADCASTING AUTHORITY
* An Equal Opportunities Employer *

For further details of the vacancy and an application form, please telephone 01-564 7011 ext 390 (9am to 5pm weekdays).

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Project Managers £18K
Technical Managers £16K

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S.E. ENGLAND

Several unique opportunities affording excellent career prospects with a large, expanding, performance orientated company exist for engineers with a degree or HNC in Physics or Engineering (preferably Electronics or Systems Engineering, but possibly Mechanical Engineering). Candidates should have acquired good systems experience whilst working in the Electronics or Defence Industries as a team leader or group leader and ideally will have acquired practical knowledge of prototype production or trials.

Your task will be to assist our client, who has developed an enviable secure base in the development and manufacture of complex weapons systems, to develop new business areas for high technology systems in both the defence and commercial sectors. The number of persons ultimately involved in a project will vary from 20 to 750 and the development costs will range from £20M to £200M and consequently there will be tremendous opportunities for you to progress to the control of the running of very large projects as well as to higher levels of management. By proposing, developing and evaluating systems and design options, producing prototypes and arranging for all necessary trials and tests, your team's objective will be to produce complete technical and cost proposals for complex, state-of-the-art systems whose technical excellence and competitiveness will ensure that large contracts are secured. To have acquired the necessary skills and experience to meet this formidable challenge you will probably be at least 30 to 35 years old, have management experience especially of dealing with people outside your direct control; have experience of customer liaison and project planning; and will have developed commercial and business awareness.

These important new positions offer excellent rewards and conditions with first class future prospects in the thriving division of a leading company in the High-Technology and Defence Industries that is part of a highly successful, major international group. The division has an order book which takes them potentially beyond the year 2000, is committed to developing several new business areas, and is poised to move into the world market in a big way.

TO FIND OUT MORE and to obtain an early interview, please telephone FRED JEFFRIES C.Eng., MIERE in complete confidence on HEMEL HEMPSTEAD (0442) 212655 during office hours or one of our duty consultants on HEMEL HEMPSTEAD (0442) 212655 evenings or weekends (not an answering machine). Alternatively write to him at the address below.

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THE INTERNATIONAL SPECIALISTS IN RECRUITMENT FOR THE ELECTRONICS, COMPUTING AND DEFENCE INDUSTRIES
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Experienced Graduate Engineers

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