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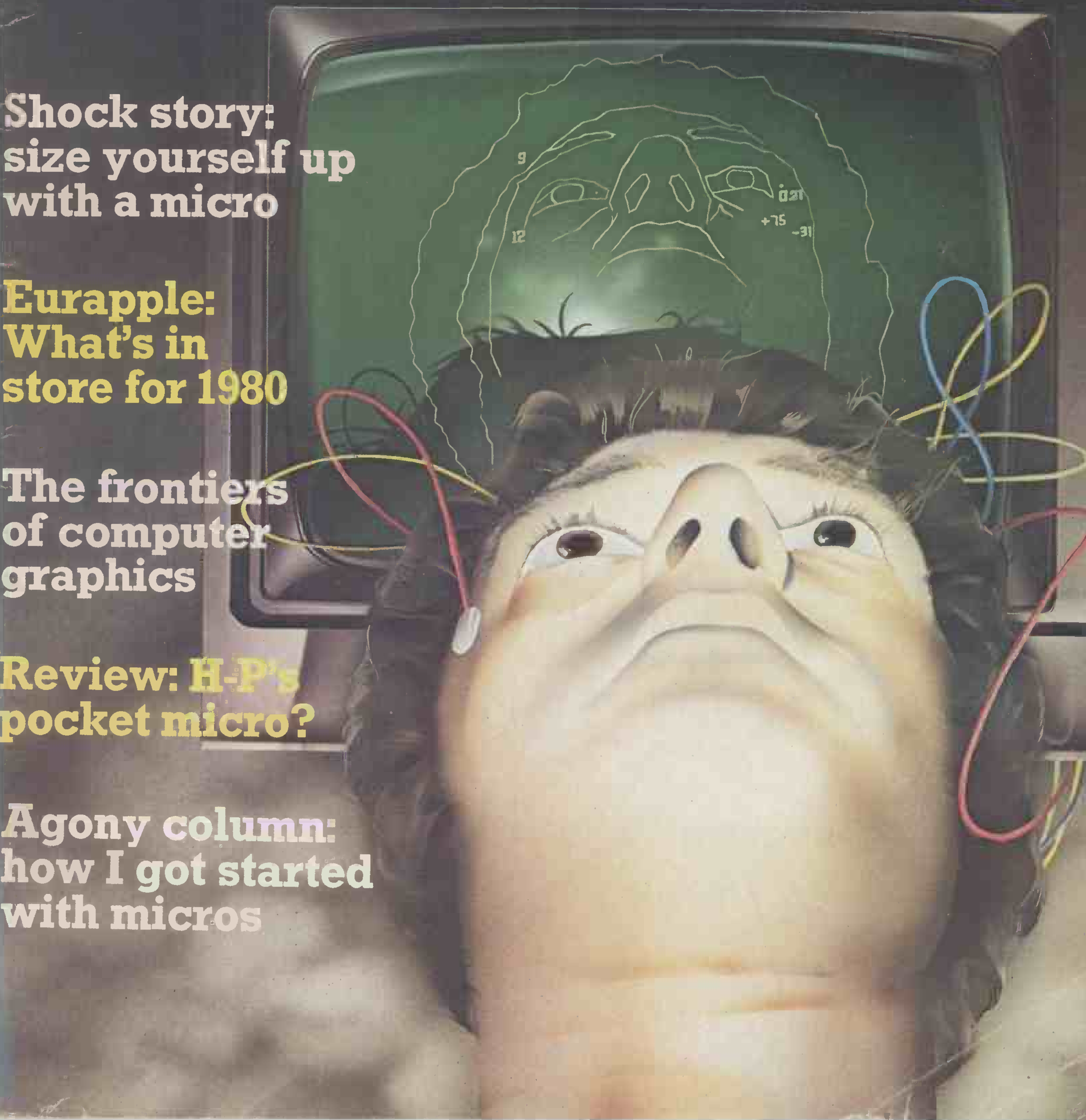

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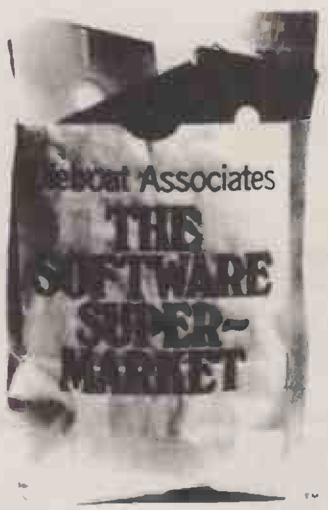

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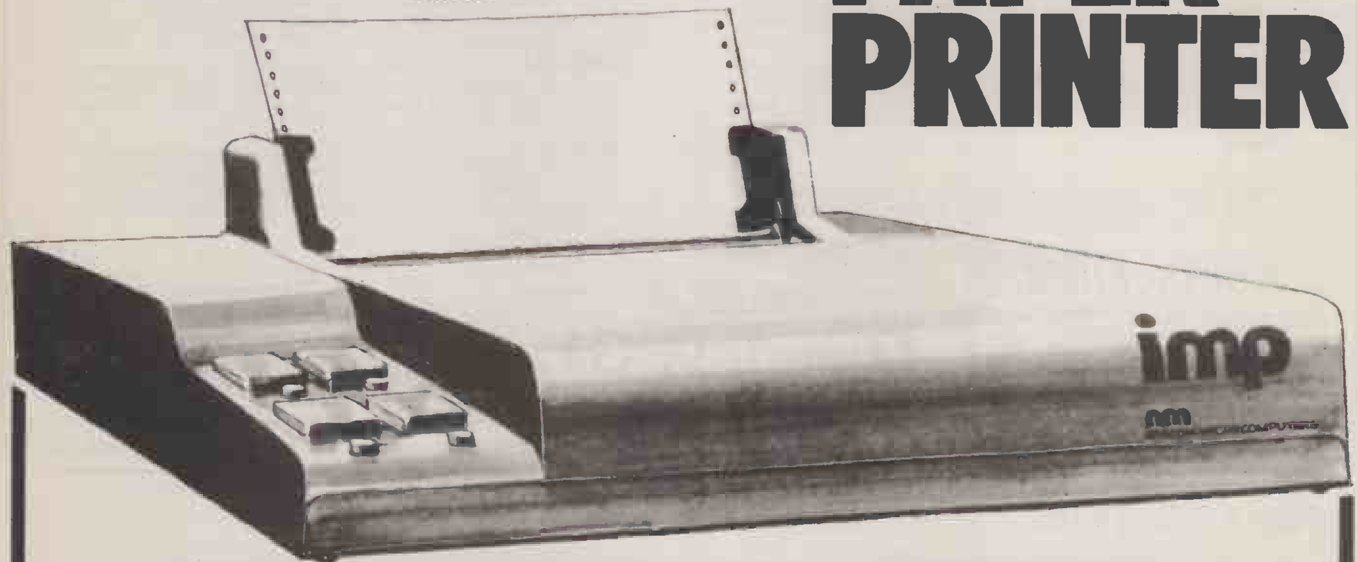

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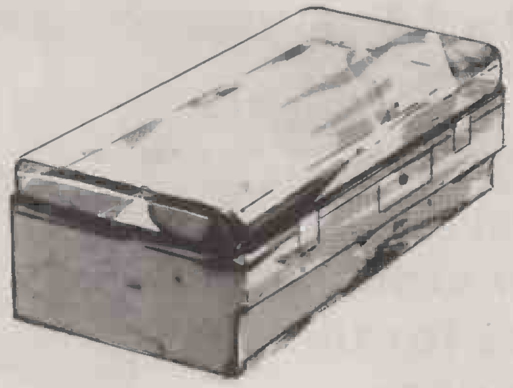

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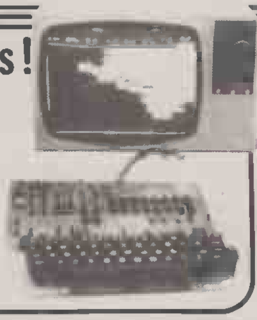

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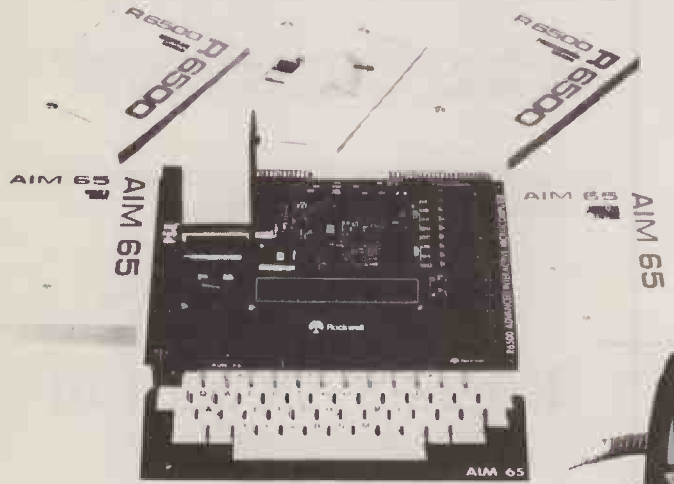

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System program
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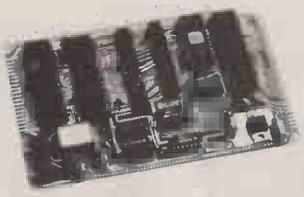

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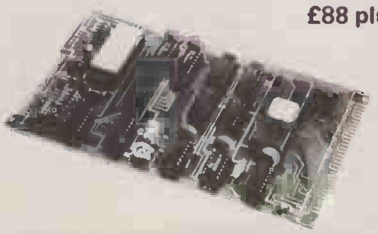

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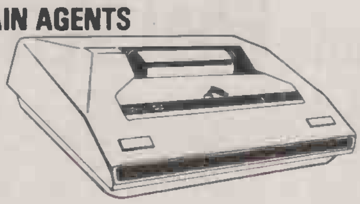

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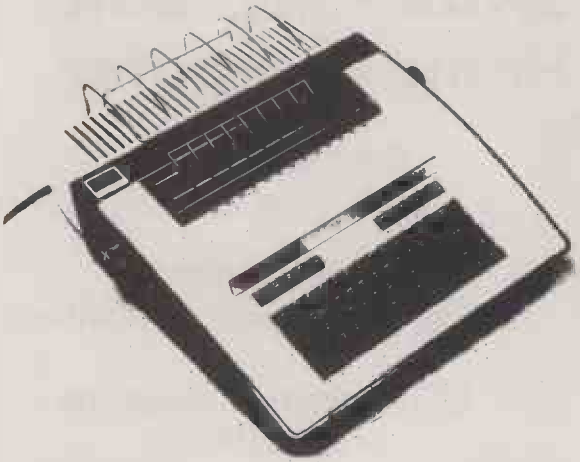

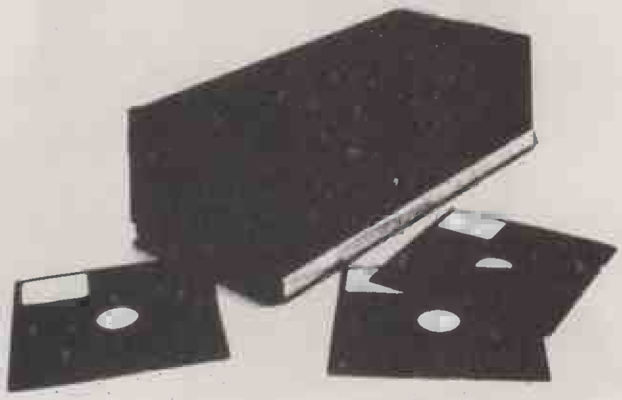

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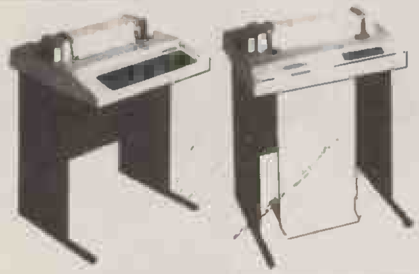

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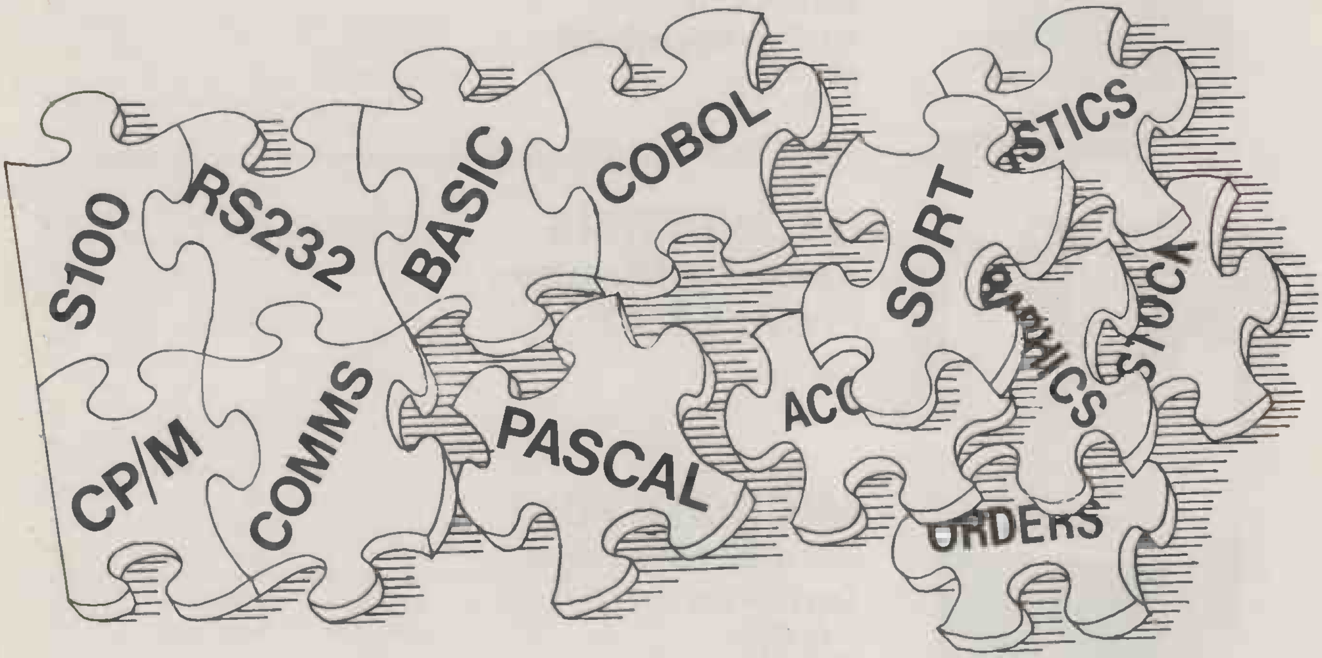

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What happens next?

IT IS NO SECRET that we live in stirring times and that, indeed, many citizens do not know but that each moment may be their next. This particularly applies to *Practical Computing* which is proud to hold the banner in the vanguard of the wonderchip revolution.

INDEED, TIMES ARE SO STIRRING that the future often seems to e rushing on the present at such a pace that one is almost afraid to look out of the window for fear that everything will have rearranged itself indoors while the eyes were off it. Well, that was the case a few months ago. Recently the pace seems to have abated; but it is, on the micro scene, merely holding its breath. Great things are going to happen again soon.

WHAT ARE THEY? One can see three. The first is affordable 8in (or perhaps smaller) hard discs. As Mike Gardner told us in the December issue, the hard disc is here — at least for Apple users — and soon it will be available for most micros. This will make a huge difference. At last we will have more backing store than can be filled in any reasonable time (it would take three weeks' non-stop typing to fill the Corvus's 9.5MB). Huge capacity coupled with 10 times faster access makes all sorts of programs practicable that weren't before. Emphasis will shift perhaps from subtle programs to operate on minimal information, to manipulation of useful masses of data.

THE SECOND INNOVATION will be, of course, 16-bit processors, and to go with them, the third innovation: 256KB of RAM. People are talking of machines along these lines being available in two years' time and costing something like £6,000. The 16-bit processor automatically gives twice the speed of an 8-bit machine, and the improved architecture of, say, the Z8000, gives another factor of three to five. The effect will be that the new 'super-micros' will work 10 times faster than today's, giving more processing power than most individual users can absorb. Result: time sharing on half-a-dozen or so work stations, giving for all intents and purposes the power of today's mini at £30,000 plus, for about a fifth the price.

WHAT IS LACKING from this attractive picture, of course, is the software. There are, as yet, no time-sharing operating systems for 16-bit machines. But they will come, given the market.

THIS IS A FAR CRY from the state of affairs a couple of years ago. Then the world was electrified by the news that for a couple of hundred pounds you could have a *real computer* on your dining table. Well, we've been through that stage, and now we tell each other: 'For £3000 you can have a *serious* computer on your dining table'. In two years' time we'll be saying: 'For £6000 ...'

IT IS INCREASINGLY OBVIOUS that the micro market is repeating history. We are going through exactly the same stages as users of big machines in the last ten, fifteen years. At first, anything is wonderful. Then we want more store, more speed, and we'll pay ten times more. Then we're offered *much* more store, much more speed and we'll pay — not much, but some more again. But the same rule applies: you never pay less than you paid last time, and usually you pay more.

WHAT WILL THIS DO to the market place? Projections from several sources are that there will be three million microcomputers — mostly with discs of some sort — in the English speaking world, with three hundred thousand in this country, by 1983. The market will stratify, with clear divisions between the cheap, 'board' computers, *home* systems (but see Andre Souson's reservations in the article 'Upsetting the Applecart', this issue) and 'small business systems' which will actually be minis by today's standards. However you slice it, the microcomputer in some for will become as familiar a feature of middle-class professional life as the typewriter, hi-fi or motorcar are today.

AUTHORS WILL USE THEM to write books. Archaeologists will take them on digs to classify their finds. Yacht designers will refine the lines of their boats on them; gamblers will use them to beat the laws of chance. Children will learn French and Chinese from them. We'll have them in networks (see February *PC)* and clumps and clusters. They'll be so normal we'll hardly think about them.

AND YET WHAT A STAGGERING MACHINE the microcomputer is. Under the table in the hall of my house is a machine with a million moving parts. I can rearrange them by tapping a key, and already it is so commonplace, so ordinary a feature of my life, I hardly think twice about it. Yet this machine has so many possible conformations that if one were examined every second, it would take longer than the life of the universe to look at them all. The mind boggles. Where indeed, is it all going? — **Peter Laurie**

Micro Mouse maze

TIME FOR an ongoing update informational situation. The news from this department is that we have some 100 possible entries, all of whom we should have had their entries acknowledged long ago. In the next issue we start an occasional series on robotics which is designed to be useful to contestants. So far we have a few offers of sponsorship. When there are enough to be worth circulating, we'll do it.

Several puzzled people have queried the rules of the competition (published in October *PC*), which they say are too vague. Ha! That was deliberate. When we sat down to draft them, we came to the conclusion that the object of the competition is to get people to produce interesting software.

Too precisely-defined rules — and in particular, too precise a specification for the maze itself — would stifle ingenuity. So don't assume that the passages will be precisely 6½in wide, that the angles will be precisely 90°, that the maze will be exactly 14ft square. Your mice must learn to cope with life in the raw.

May the brightest mouse win!

Surprising reliability

A SURPRISING fact is that the TRS-80 disks can be made to operate with near 100% reliability.

No software will operate if the hardware or operating environment is suspect. For serious users the following are essential:

- Filter all power leads
- Use the latest upgrade
  - — buffered expansion interface
  - — additional cable link
  - — modified Micropolis drive
- Don't use cheap RAM — better to buy as complete system
- Keep out dust and sticky fingers from the drives and discs
- Use the latest release of DOS — 2.3 or much better NEWDOS +
- Use a cooling fan — certainly for the drives and possibly also for the keyboard.

Evaluate the consequences of using non-standard parts, or purchasing from a 'dealer' as opposed to someone who can offer a complete software/hardware backup. A good example of such pitfalls is provided by an intrinsic error with all versions of DOS. This manifests itself by file I/O errors with sequential type file writes as found in both Basic and the Electric Pencil or anything else which uses the same DOS routines. Even worse, these errors may not be detected by the DOS and appear to leave permanent parity error glitches on the discettes. Even NEWDOS suffers from this bug.

A simple and reliable solution is obtained via the Tandy hardware modification to the Micropolis disc drive.

With the correct approach, the TRS-80 should be reliable all day and every day. If you drop out of Basic, meet unexpected syntax errors or meet disk I/O errors, then it is a malfunction as opposed to any design weakness.

NEWDOS represents a 'better' operating system — one example of its advantages is that users of NEWDOS + can use SUPERZAP (a Basic program provided with NEWDOS +) to detect parity error glitches (VERIFY DISK SECTOR) and then repair the disc (SCOPY after DD). Users of TANDY DOS have had it. Moreover unlike NEWDOS + users, they will not be able to BACKUP the disc due to SOURCE DISC READ ERRORS — those nasty glitches once again.

Sequential files are by far the simplest to program and for some data structures, sequential techniques may represent the most efficient use of disc space.

David Robbins

Here are the winners of the Practical Computing Programmer of the Year award at the recent prize-giving ceremony in London. From left to right: Mike Amode, Alan Baylis, Georgina Jolliffe, judge Jim Woods, the Editor, Geoffrey Jolliffe, J. J. Walters. Not shown is D. W. Conran, who was on an Army training course.

'Winning' positions

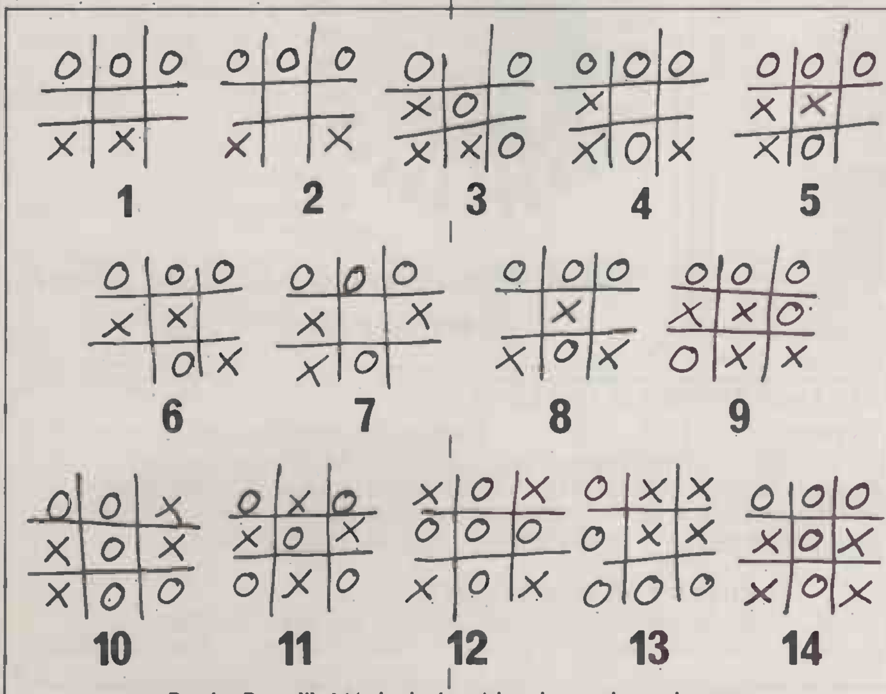
SINCE NO-ONE has commented on Professor Michie's article on Artificial Intelligence, (*Practical Computing*, September) may I say that his statement, that Britain's chances of leading in robotics were wiped out when the Science Research Council withdrew support for his University's project, is in very bad taste.

First, because his group is by no means the only one — there are others at Imperial & Queen Mary College, and at ICL, to name but a few.

Second, because he can't even play noughts and crosses proficiently! There are not 77 winning positions as he maintains, but 91 (see below).

And if he can score less than 85% at noughts and crosses, is he justified in making snide cracks at chess Master performance in the much more difficult Queen vs. Rook ending?

Geoffrey M. Rowell,
London S.E.27



Reader Rowell's 14 'winning' positions in noughts and crosses.

No doubt Professor Michie felt — and feels — strongly about the abrupt cancellation of his project ten years ago. Whether or not his remarks are in 'bad taste', as Geoffrey Rowell would have them, there is no doubt that robotics in Britain took a blow from which they have not yet recovered. If he doubts this, how can he explain the leadership of the Japanese and the Americans in a field which largely began here?

As far as we can see, at least six of the further 14 'winning' positions in noughts and crosses can only arise if play goes on after 0 has won. — Editor.

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• **Circle No. 174**

In defence of Cobol

YOUR LEADER on the Language Dilemma (*Practical Computing*, October) prompts me to rise to the defence of a language largely ignored by you — Cobol. In your enthusiasm for Basic, you tend to overlook the point that computer languages have been developed for specific purposes. All languages trade off advantages against deficiences, and so the best language for one application will often be unsuitable for another.

Basic was developed as an educational language and as such is, as you pointed out in your editorial, simple to learn and use. This, of course is precisely what the hobbyist needs. But not all users of microcomputers are hobbyists (or educationists). Small businesses do use microcomputers and a sizeable number of computing professionals read *Practical Computing* — rather more than readership surveys indicate — a copy will often be passed around a large office.

A business user's requirements are different to other people's. A businessman is often not interested in complex calculations but in record-keeping. Record-keeping consists mainly of three parts: inputting data in a way that a complete idiot can manage, storing and retrieving data as required, and producing reports in formats that non-computer people can understand.

The hobbyist's main interest is in getting a program to work. Once a program does work, it is probably not used a great deal. By contrast the business user Is only really concerned with actually using the program — and this implies the tedium of maintenance. Maintenance must not be underplayed; it was discovered a few years ago that maintenance of software often costs most than its original production.

Worse, many business users who want to modify computer systems find it easier to re-write their programs than to try to understand the existing coding. This is one reason for the interest in techniques such as structured programming.

For these business requirements, Cobol is superb. Its data division allows input transactions and report lines to be defined instantly. It has excellent validation routines. Its long mnemonics (up to 30 characters) and structured approach make maintenance much easier and therefore cheaper. When you can write a command like:

```
IF STOCK-QTY NOT NUMERIC PERFORM REJECT-TRANSACTION
```

there is little temptation to skimp on validation. Consequently the sort of situation you wrote about in your September leader, where certain input patterns lock up the program, can be avoided.

Even so, Basic *is* the best language for the hobbyist. This does not mean, though, that Basic is the only language that can be used. In your last two issues you have, very rightly, been highly critical of shoddy software. You would do well to make a positive contribution and promote professionalism and discourage an amateur approach to commercial software.

Professionalism is not as much fun as amateurism — but that's life. It takes an effort to learn Cobol. By the same token, to produce good quality software requires hard work and it's not always fun. Anybody buying business software should bear in mind that software written in a language like Cobol is likely to give less problems than software written in Basic. If the vendor will not invest in a good compiler, or has not bothered (or worse still, has not had enough experience) to learn a powerful language, he is unlikely to produce good software.

By all means, *Practical Computing*, promote Basic for what it is, but spare a thought for the more serious users of small computers and remember the professional tools now and again.

John McMillan,
Calcot,
Reading, Berks.

Real cost of Z8000

THE EDITOR's note (November Feedback) suggests that the Z8000 is overrated. Although its price is high, it is lower, in real terms, than that of the *new* 8080, probably less than half.

It is a red herring to suggest that one needs 8 Mbyte to realise its potential.

Ignoring initial high prices, which will surely drop, the Z8001 (rather than the Z8002) would be my first choice, amongst present production types, for an easy-to-operate small system.

I have already done some machine code programming for the beast and it is a real pleasure to use the large number of registers and the simple systematic instruction set.

The power to address several memories, each of 8 Mbytes, permits a simplified approach to small memories with minimum risk of address errors when programming. Code efficiency is such that most programs are likely to use less bytes than with current 8-bit processors and to run much faster.

A final bonus is that the system can grow to any size that the future dictates, without having to be scrapped because of design limitations.

We are already promised that the MC68000 will be even better. Time will show. With either choice, the small system is likely to emulate the main frame in flexibility.

If one is using Basic the MPU hardly matters but for simple machine code programming with maximum efficiency, the more powerful the instruction set the better. It can hardly be *too* powerful.

R. G. Silson,
Tring, Herts.

QWERTY query

I WAS interested in the first illustration in 'Possum on Pet' (*Practical Computing*, November), specifically the first sentence displayed, "The quick brown fox jumped over the lazy dog."

I believe this is a misquote of a sentence well-known to many thousands of typists, and should read "The quick brown fox jumps over the lazy dog". This latter sentence contains every letter of the alphabet in a minimum number of words, and is therefore very useful in testing both typists and keyboards.

These are variations I have heard of —

- The quick brown fox jumps over the lazy dogs back.
- The quick brown fox jumps lazily over the gates.

I have been told by some that the originator of this sentence was Sir Isaac Pitman, and by others that it was Lewis Carroll, but although I have searched numerous sources, I have failed so far to find its origin. Perhaps some of your readers could help me?

I would also like to know if there is any generic name which describes such short sentences or phrases containing all the letters of the alphabet, and if there are any equivalent ones in other European languages?

Reginald Mascall,
Berkeley Nuclear Labs,
Glos

TV applications

HAVING WORKED as an electronic engineer in the television industry for the last 13 years, I cannot allow your article (October 1979) on David Graham's work to go without comment.

A number of staggering generalisations have been made which can only mislead. The reference to portable TV and cameras and recorders presumably refers to ENG EFP equipment, which, while it certainly has a place in journalism, can in no way replace existing equipment without substantial lowering of technical standards. Those of us who have seen programmes originated in Italy, USA, etc using these techniques would be horrified to see this appear on UK TV screens.

I would be the first to agree that over-manning does occur in the TV industry, but this is a union rather than a technical problem.

Computers are making significant inroads into TV studio technology, perhaps too slowly, but computer-controlled lighting grids, switching matrixes and vision mixers do exist, and it is not the engineers that are 'knocked out', as David Graham suggests, but the production staff.

J. Hill,
Reading, Berks

Have a go!

I WAS looking through my son's November issue when I noticed the letter from Mr Short. I wouldn't like to think is comments might deter some people from having a go!

My son, who is an apprentice, decided after perusing magazines, to build a Triton L5.1. As always seems to happen there were minor difficulties, with the tape I/O in our particular case, but letters to Transam were promptly answered and a few friendly chats on the phone were helpful too.

I feel the youthful enthusiasm at Transam was the main reason for us now having a working computer and my son has gained a valuable insight into the technicalities. It is very often an advantage to know how a tool is made, as well as being able to use it.

Eve Ralphs,
Orpington, Kent

Reader interface

HAVING BOUGHT my first copy of *Practical Computing*, I have one complaint: some of the figures are impossible to read, eg, November 1979, page 87, figure 1 and 2.

The article on interfacing a PET to the real world is a completely wasted effort as a result.

M. R. Halse,
Herne Bay, Kent

Our apologies: reproducing such technical figures is a constant problem. Sometimes a diagram that is readable in proof is illegible in the magazine because of over- or under-inking. We keep working at it! — Editor.

Prestel users can cut bills with Apple

KEEN COMPUTERS are to offer their Apple users access to the Prestel network without buying a special Prestel TV set and terminal.

Prestel is already available in London and the Post Office has promised to extend access to Birmingham, Manchester, Edinburgh and elsewhere as soon as possible.

Prestel users pay for every page of information each time it is used; with a computer as a terminal you would be able to store the information on disk and save on telephone charges, especially if a page could be useful for some time.

The Apple could be used to call up pages automatically and extract particular information to be used as program input. It is also hoped to use Prestel as a means of selling software for the Apple.

Quick chip

AMI MICROSYSTEMS have announced a version of the 6800 microprocessor capable of executing an instruction in 800ns, which it is claimed is 200ns faster than any other 6800 chip currently available.

Designated the S68H00, the AMI device utilizes a 2.5 MHz clock and can execute one data access instruction per two clock cycles. In all functional respects, the S68H00 is identical to other version of the 6800.

In common with earlier version of the 6800, the S68H00 utilizes 8-bit parallel processing, has a bidirectional 8-bit data bus and a 16-bit address bus. There are 72 instructions in the set, with seven addressing modes.

AMI Microsystems are based in Swindon on Swindon (0793) 31345.

Bop till you pop

THE FIRST computer music disco was held in the bar of the Polytechnic of North London on 5th December. The event was organized by the North London Hobby Computer Club as the climax to a competition for the best disco music produced from any common personal computer.

Computer chief hits out at cowboys

A COMPUTER EXECUTIVE has hit out at the growing number of software consultants taking advantage of the boom in sales of naked microcomputers.

Gerry Cook, marketing manager of Logabax Ltd, said at the UK launch of the Logabax personal computer that because all personal computers are sold by the manufacturers without applications software, users are looking to software houses and specialist consultants for assistance and, in some cases, are receiving sub-standard systems, or packages which fail to perform.

by Duncan Scot

"Most of the individual consultants around are both competent and scrupulous," he said. "But some are taking advantage of the boom in demand and supplying systems which simply to not work. In addition, most users are unfamiliar with what they should pay and what they should expect from a consultant, which makes them particularly vulnerable to the unscrupulous."

Rigorous vetting

Mr Cook called for some form of registration of individual consultants in much the same way that the Computer Services Association (CSA) registers the larger consultancy companies and software producers. Companies must have been in business for two complete years and must pass a rigorous vetting procedure before they can be accepted as members and are then subject to its code of conduct.

These criteria do not apply to one-man bands or to new companies and, because microtechnology is so new, it is usually these people who undertake programming of personal computers.

"Because most microcomputer projects are of necessity small, they are not cost-effective for the established consultancy companies to undertake and the user is at the mercy of the small company or individual," he said.

"I should like to see a code of conduct and a CSA-type seal of approval awarded to individuals — both to help the end-user and to differentiate the cowboys from the genuine specialists who are doing a worthwhile job."

OU launches Micro course

THE OPEN University has launched a microprocessor course for industry designed for "managers and decision makers." Costing £120, the course is a self-contained package involving 80-100 hours of study. It does not include courses on either television or radio.

The course material consists of an Intel 8049 microprocessor, for training, an instruction manual and six booklets, entitled: (1) Introduction; (2) Choosing a Micro; (3) Producing a Micro-based product; (4) Technique for developing a Micro-based product; (4) Techniques for Implications; (6) Personal Implications.

The course has been prepared by the Open University as part of the Department of Industry's Microprocessor Application Project. It does not form part of any of its degree courses.

Since the first publicity about the course, there have been 2000 applications. The course was expected to start at the beginning of December but it is not restricted to any dates and can be begun at any time. Contact: Open University, PO Box 188, Milton Keynes, MK3 6HW.

Plato's promise of perfection

A COMPUTER-based education system, which includes a comprehensive microprocessor training course, has been announced by Control Data Ltd. The system, called Plato, has taken over 15 years to develop and over £5m is to be invested in making the course available through learning centres in London, Manchester and Birmingham by the middle of 1980.

Training problems

The microprocessor course, *Working with Microprocessors,* was developed as the result of a research project undertaken, by Control Data, at the request of the Department of Industry. They were asked to suggest ways to alleviate the critical microprocessor training problems in the UK. Control Data believe that up to 150,000 skilled engineers and technicians are in urgent need of retraining.

The course consists of a variety of training modules, from a six-hour introduction covering computer fundamentals, the fundamentals of microprocessors, microprocessor programming and interfacing, analogue and digital conversion and the use of serial and parallel devices, trouble shooting and higher languages, and specific applications.

The courses are entirely flexible. Each student will have his own interactive terminal, at the Learning Centre, connected online to a Control Data mainframe. The student can move at his own pace and is quizzed at every stage to ensure that he has achieved the required level of competence. The aim is for everyone who takes the course to leave at the same standard.

Control Data claims that the courses have been designed by good teachers and designers, ie not programmers, who understand how to keep a pupil's attention. The courses can, apparently, become addictive!

Get sponsored

By making the courses available through the computer education system, Control Data believes that it is providing a means to solve the national training problem. The 60-80-hour course will cost around £500, which is expensive, unless you can be sponsored by your company.

Further details are availble from Neil Spoonley, Director of Education Services, Control Data Ltd, 179/199 Shaftesbury Avenue, London WC2. Tel: 01-240 3400.

Scribble nibble

QUEST AUTOMATION has introduced an updated version of its Datapad which allows handwritten data to be entered directly into any computer via a standard serial interface. The device, Micropad, occupies no more desk space than a telephone and only costs £1725 compared with £21,000 for Datapad.

Micropad does not need special paper; the user can design his own documents and data can be entered with an ordinary ballpoint pen. The surface of the pad is sensitive to pressure and gives each contact point an XY coordinate, tracking the pen as it moves.

The microprocessor-based device records how each letter is constructed and compares them with a dictionary of different writing styles. It can distinguish between the number 8 and the letter B as they are written in different ways. As each letter is written, a 40-character visual display lets the operator confirm that the correct letter has been recognized.

Quest is financing its new Micropad factory by floating 1.5m. of their shares which are hoped to raise over £1.2m. The factory is at Wimborne, Dorset. Tel: Ferndown (0202) 891518.

Microwriter launched

Another device which could well touch a similar market is the so-called 'pocket typewriter'. *Microwriter* was originally demonstrated in 1978 and launched commercially at IBS last October. It is a portable battery-operated five-finger machine, the size of an electronic calculator.

Words are keyed by the fingers of one hand simulating the shape of a character. The letter 'I', for instance, is formed by pressing the button under the thumb and the index finger to resemble the vertical stroke. About 1500 words can be stored in the device's memory, edited and reformated.

The microwriter can be plugged directly into a printer for a typed copy, or a TV monitor and, for additional storage, a microcassette recorder.

About 90 Microwriters are already in trial installations where speeds of up to 80% of handwriting have been reached and sustained. Microwriter Ltd, which is backed by Hambros Bank, is based at 7 Old Park Lane, London W1, 01-493 5633.

New Tandy for 1980

THE NEW TRS-80 Model II has been shown in the UK and Tandy has announced that it will start taking orders although the first shipments are not expected until April 1980.

Ted Russell, director of Tandy's computer division, claims that the Model II is comparable, in performance, with the IBM 5110, the Hewlett Packard H9800, and the Wang WCS15. A basic configuration with 32K of RAM and ½MB of additional storage capacity will sell for around £2000. This can be expanded to 64KRAM with 2MB storage for around £4000.

Model II has been designed as a business system starting at the upper limit of the Model I, the old TRS-80. The entire computer and 80 character monitor is housed in one box which includes a ROM disk, two serial and one parallel ports. It is claimed that the Model II will operate at 2½ times faster than the Model I. Tandy hopes that it will have peripheral hardware and software in this country by the first delivery dates.

Although the Model II incorporates new features which must have been included to some degree in response to criticisms of the Model I, such as a lower cse facility for word-processing, the Model I will continue to be sold. As if to emphasise the point, the Model I prices have been reduced by about 10%. The TRS-80 4K RAM Level I BASIC will now sell at £385.

It will be interesting to see how the Model I market will be affected by the news from the States that Tandy will be selling a home computer, without a monitor (to use with a TV set) from the second half of 1980.

Awards for best-selling computer ads

ENTRIES have been invited for the Computer Advertisement of the Year Award 1980. Over £7m is being spent every year on computer advertising so organizers Crouchmead Ltd expects a high response. Entry fees will be donated to the BCS Disabled Group.

Four categories of advertisement will be considered — computer hardware, computer software, computer related products/services and recruitment. The panel of judges will be asked to consider the aesthetic as well as the informative merits of the entries.

The entries will be judged and the winner announced on Tuesday, 25th March 1980 at the West Centre Hotel. Send for entry forms from John Godley, 42 Great Windmill Street, London W1, on 01-437 4187.

Little Genius for micro teach-in

FRUSTRATED USERS who have struggled through barely comprehensible manuals on how to program their micro might find *Little Genius* from Applied Data Education Services a life-saver. The *Little Genius* diskettes are claimed to replace text-books and manuals with a series of easy-to-follow screens and exercises.

The first two courses for Apple II micros — *Applesoft BASIC* and *Using Your Apple* — are now available. Four more courses for Pet and Tandy micros will be issued within the next few months — *Petsoft BASIC, Using your PET, Tandy BASIC* and *Using Your TRS-80.*

The courses are being written by Baldchin Ltd in association with ADes and wil sell for £46 each. ADes is on 01-580 6361.

● SEVEN NEW TANDY computer stores will be opened by the end of January from Birmingham and Bristol to Southampton, each of which will have a resident engineer.

Micro event set for macro success

MICROSYSTEMS 80 looks set to break another micro record. With more than 80 stands already sold for the exhibition, at the Wembley Conference Centre from January 30-February 1, 1980, it will be the largest specialised micro event ever held in the UK.

The four-part program includes a Professional Development Course which aims to provide managers and engineers with an introduction to micros and, for those with a specific interest in software, to Pascal.

The Conference will provide delegates with a state-of-the-art review of developments in the microprocessor field, with sessions devoted to New Developments, Systems design and specification, Software for micros and Micros in Control. The third day has been designed to appeal to those interested in personal computers and their growing significance in the business world.

There will also be a Buyer's Forum, held in parallel with the Conference Sessions, which will try and help prospective buyers establish criteria for selecting equipment.

There will be no charge for admission to the Exhibition, which is being co-sponsored by *Practical Computing*. For further details about the Conference, contact Iliffe Promotions, Dorset House, Stamford Street, London SE1. Tel: 01-261 8437/8.

Ignorance is no excuse

PERSONAL COMPUTERS Ltd have produced some laws of personal computing betraying homely prejudices and, of course, some traits from computing's more sinister followers.

It begins with such useful home truths as "Personal computing equals interactive computing" and "Software is hard: hardware is soft," and continues with "BASIC is to personal computing as sign language is to English" and "The goal of personal computing is to reduce the differences between humans and computers."

Personal Computers also tell us that they are going to reduce their dependence on the Apple and start distributing the TI-99/4 within the next few months.

Vincent Tseng peeks at Hewlett Packard's HP 41C. Could this be the forerunner of a portable micro, nestling in the pocket of the future?

Has the pocket computer arrived?

THE POCKET has a great deal of significance in landmarking history. For example: the introduction of the pocket radio back in the early 1960s, the pocket calculator in the 70s and more recently the pocket TV. Now there is speculation on the pocket computer. Hewlett-Packard's HP 41C programmable calculator has been heralded as the first pocket computer. Is this title justified? Is it an indication of things to come?

Everyone's definition of "computer" will be slightly different. Remember when the early pocket electronic calculators were first on the market? They were called, and even advertised, by many as computers. Of course most people will now laugh at those claims. To be pedantic about it, the electronic calculator is based on microprocessor technology: if the internal architecture is examined, it is easily recognised as that of a computer.

Without rhetorical discussions on what is or isn't a computer, the most sensible approach is to compare it with equipment which has already been classified. I have chosen equipment with which I am familiar, and which is in a similar price bracket.

These are the Rockwell AIM-65 (reviewed in *PC*, July 1979) which I assume most people would classify as a computer, and the Texas Instruments TI-59 programmable calculator, which has been around for about 2-3 years and has always been called a calculator. These comparisons do not bear on value for money or relative performance.

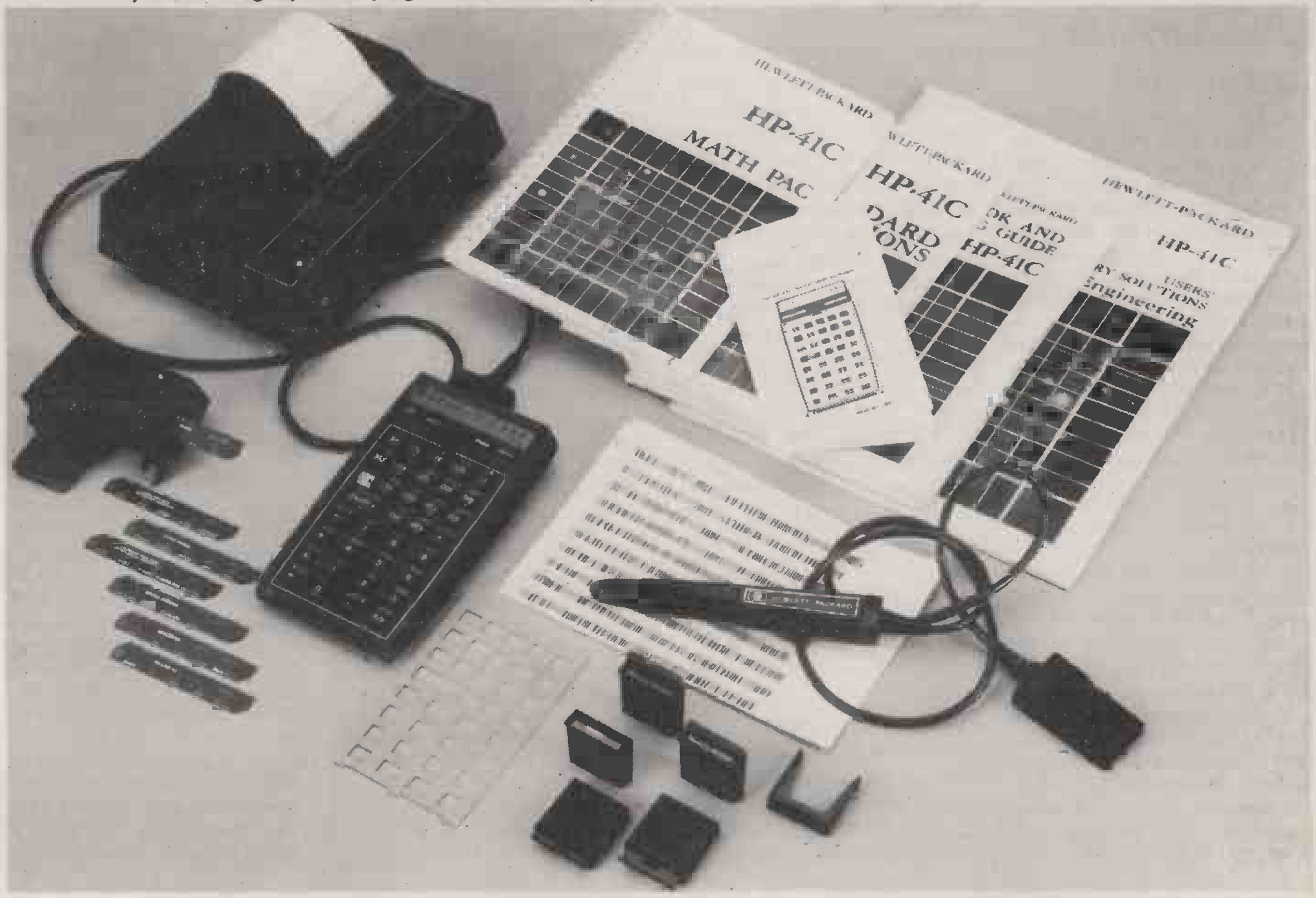
The choices for comparison are quite appropriate. The TI-59 is fairly obvious, being a calculator of similar class and price but from a different manufacturer. The AIM-65 was chosen because it offered similar facilities in terms of display and output.

In appearance, the two calculators both look like calculators of three to four years ago, ie, fairly bulky, more coat than waistcoat pocket-sized. The AIM-65 is a typical single board computer.

● **Keyboards:** the HP-41C and the TI-59 both have typical calculator key layout, while the AIM has a full alphanumeric keyboard in the conventional typewriter layout. All three have printer output capability on 2in wide roll paper using thermal printing. The AIM had the printer built-in but with the calculators this is an optional extra.

● **Displays:** the AIM and the TI-59 both use LEDs, 20 characters of upper case alphanumerics for the AIM, whereas the TI-59 has 10 numeric digits only. The HP-41C used LCD capable of displaying 12 characters of upper-case alphanumerics with indicators of the chosen mode.

Hewlett Packard's HP 41C calculator with printer, alpha-numeric display, magnetic and ROM memory modules, light-pen and programs in bar chart form.



●**Power supplies:** the HP-41C used disposable batteries (the new half penlight size) which Hewlett-Packard claims will last about one year. The AIM needs a stabilised +5V at 2A and +24V at 0.25A and is therefore usually powered from the mains. The TI-59 is rechargeable, so can work off the Ni-Cad pack or from the charger/mains adaptor.

The HP-41C was fairly easy to use as a normal calculator, although it uses the Reverse Polish Notation (RPN). This method was not difficult to understand, but a little awkward, in my opinion. The best way to remember the principle of this method is that the order of operations is the order in which one calculates an equation. Although this sounds logical, my preference is for the algebraic notation with hierachy as in the TI-59.

The difference is that in the TI-59 method one enters the equation as written and the calculator takes account of the operational hierachy order, so on pressing the "=" key the correct answer appears; with RPN one has to first analyse the equation and decide which operation should be calculated first and the order of the rest of the operations. However, RPN does dispense with the necessity for brackets. The difference is a bit like that between a high-level language and that of an assembly code but not quite as marked.

A feature of the HP-41C which the other machines lack is that it retains the contents of memory when the calculator has been turned off. Memory is held in low-powered standby mode. This means that the batteries cannot be removed for more than a few seconds without corrupting or losing the contents. This ability to retain the memory is a very convenient feature.

I found that it was all too easy to clear the program memory, especially when attempting to append operations on the end of a program, or when trying to write a program into the remaining free area. This is a shortcoming which needs serious consideration. I feel that programs should be capable of being protected in memory, or even automatically protected, with an operation which needs to be made obviously deliberate for clearing the memory.

The programming operations, editing functions and instruction/function set are similar for the two calculators. Both have numerous built-in extra functions, but the manipulative and testing functions are primitive. The AIM-65 does not have the powerful calculator functions, but the instruction set is much more suitable for testing, manipulation and the moving of data.

Therefore the programmability of the HP-41C (and the TI-59) is much more the capability of stringing together calculator functions, with some basic test conditions, to make the calculation of long equations and expressions less tedious and more automatic.

Although it can be argued that many computers are used for calculations, computers do have the ability to manipulate data in a far more sophisticated way than either of these machines. But, no doubt, both manufacturers would be the first to admit that the calculators were designed primarily for calculations.

Taking the above discussions into account, the ability of the HP-41C to display alphabetics can be viewed in context, as that of making the calculator more convenient, and more meaningful for messages and prompting. But I found the keyboard awkward to use for alphabetics. The letters are placed in alphabetical order, starting from the top left-hand key, and perhaps because of this, letters were surprisingly difficult to find quickly. It did not help that letters were marked on the sloping vertical face of the keys, which meant that the markings were not very prominent and that the calculator needed to be tilted away from the user to be viewed clearly. This feature, although not very convenient in its execution, does take the HP-41C a step closer to what is generally accepted as a computer. This certainly was one of the attractive features of the AIM-65 as well: the ability to display meaningful messages.

More permanent storage, or mass storage, is achieved by the use of magnetic strip cards for both calculators. The TI-59's is built-in, the HP-41C's is an optional extra. Each card can store approximately 200 steps in both systems. The AIM uses domestic audio cassettes, and can store about 100Kbytes on a C-60 per side, that is about 50,000 instructions. All three systems are tolerable in terms of speed and convenience.

Strangely enough, all three really come into their own when the printers are used. All three can trace their respective programs by means of automatic single stepping, all three "disassemble" the program steps into either the calculator operations, or into their mnemonics. The TI-59 and the AIM print the machine code stored in memory, but the HP-41C does not. All three printers can print full alphanumerics upper case only. Plotting simplified graphs is reasonably convenient with both the HP-41C and the TI-59, but with the AIM the user would have to write his own general routine.

A few niggly points about the HP-41C. It does have quite a number of built-in extra functions which are not marked on the keyboard. However, it is really fiddly to access them. The sequence is to press the "XEQ" key, set the calculator into alpha mode, key in the mnemonics for the instruction, re-press the alpha mode switch (to take it out of the alpha mode) then the digits for the operand. So an instruction of four characters takes seven key-strokes to enter! This is stretching the use of alpha capability for the sake of the facility.

The other point is the speed of the printer. It is slow, and for one based on the latest technology, surprisingly dumb when it comes to straightfoward printing. It does not have bi-directional printing, and worse: it has to print a full line of 24 characters, filling in with 23 spaces, even when only one character needs printing. This is really a silly oversight.

The HP-41C claims to be a "system", with various expansion options. Printer and mag card reader as mentioned, and with extra memory plug-in modules — either ROM or RAM — each can add about 640 steps or 380 alphanumeric characters (note a number entered as an alphanumeric is not interchangeable with a digit entered for calculation). Up to four modules can be added, taking the total memory area to about 3.2K steps. In comparison the TI-59 has a total built-in memory of 960 steps. The AIM has 1Kbytes, expandable to 4K on board. The TI-59 in addition takes a plug-in ROM module containing about 5,000 steps and the AIM can have 20K bytes of ROM on board.

I found the HP-41C's documentation infuriating. Hewlett-Packard claims it was written by prize-winning teams for manual writing, but I found it next to impossible for quick and concise reference. For example an easy-to-find (if it does exist, I did not find it) reference of a list of the functions not marked on the keyboard and how to enter them, would have been useful and much appreciated!

Although I can see that the manual might be good for a first-time user, I did not find it particularly easy to learn quickly from it, and also I found it a little patronising. In contrast, the manual of the TI-59 was, in my opinion, excellent, both for a beginner as well as for a reference manual.

Conclusions

●**As a calculator, the HP-41C is certainly one of the most sophisticated I have come across, although the TI-59 rivals it quite closely.**

●**As a computer, I feel it still has some way to go (unless of course one regards it as a dedicated calculating computer).**

●**The main limitation that I foresee for the advent of the true pocket computer, is the restriction of the size itself — limiting the computer by its keyboard and display, so it will always be relatively inconvenient, unless some dramatic advance can be made in ergonomic design.**

●**Any claims to being a computer cannot be justified, since the TI-59 matches almost point-for-point the capabilities of the HP-41C, and the TI-59 has always been regarded as a calculator.**

●**The HP-41C is nevertheless a significant step forward toward the pocket computer, and I do not intend to argue too vigorously with those who might claim that it has arrived!**

At home on the range

Practical Computing examines a rugged business system built for the Texas oilfields.

by Martin Collins

THE TEI RANGE of computer systems is imported and sold in the UK by Abacus Computers Ltd. Abacus was set up about a year ago and also supplies the Compucolor II and a range of cut-price peripherals, including the Texas 810 printer.

TEI systems are based on the S100 bus with 8080 or Z80 processors. There are three basic models which may be configured with mini or standard disc drives:

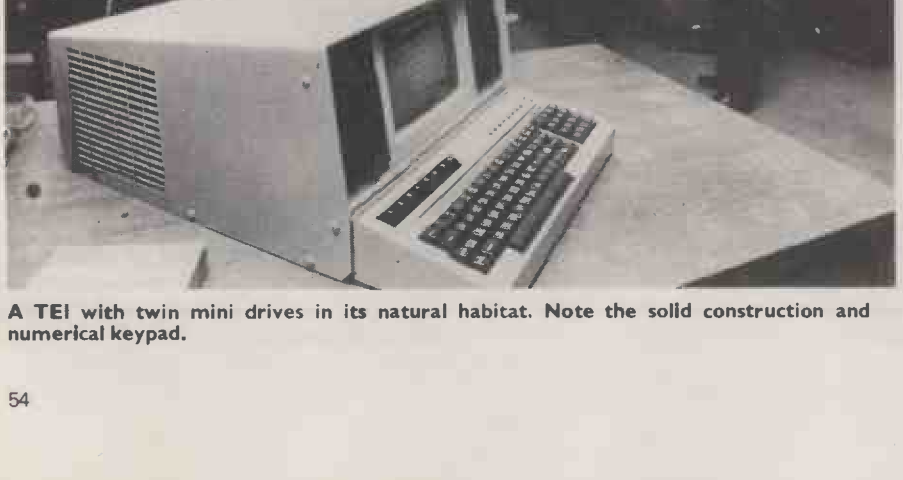
- PT 112,212,312, and 412 which have a 12-slot S100-bus, integral keyboard and 15 inch CRT. The disc configurations are: PT112: Single mini drive; PT212: twin standard drives; PT312: twin standard and single mini drive; PT412: two twin standard drives.
- PT208 and 408, which have an eight-slot S100 bus, integral keyboard and 15in CRT. The disc configurations are: PT208: twin mini drives; PT408: twin mini and twin standard drives.
- MTS 22, a 22-slot S100 'mainframe' but without the integral CRT/keyboard, and with two standard drives.

All the systems are supplied in heavy-duty aluminium cabinets with an 8-, 12-, or 22-slot motherboard, a 17 amp constant-voltage transformer power supply and a fan. The standard systems include a 2Mhz 8080 CPU card, two 32K of memory, and an interface card giving three paralleled and three serial ports.

The memory consists of 16K static RAM cards which allow any 4K block to be addressed to any 4K boundary in the system. The memory can be increased to 48K or 60K. The top 4K is reserved for system I/O and the video controller screen memory. A 4Mhz Z80-based processor card is available as an option and a 5Mhz 8085 card will be available soon. The processor cards contain two 1K PROMS which handle all system I/O.

The top row of the keyboard has eight user-definable keys, useful for process control, and eight lights connected in parallel with the disc access port. These lights can be user defined, with labels put next to them to signal specific conditions to an operator.

The 9in and 12in CRT displays are driven by the same CRT card which gives 24 lines of 80 characters. Upper and lower case characters are displayed using a 5×7 dot matrix. There are 2K bytes of memory allocated for the CRT screen, addressed from F800 to FFFF and this may be accessed by the CPU and the CRT card. The cursor may be block or underline, blinking or not blinking. As the CRT is memory-mapped, it is fast and the user has direct control over the display.



A TEI with twin mini drives in its natural habitat. Note the solid construction and numerical keypad.

The floppy disk controller board will handle up to eight drives which may be any combination of 8-in and 5-in devices. The drives currently available are the Shugart SA400, with a capacity of 80Kbytes, and the Shugart SA800, with a capacity of 250K. Double-density disks will be available soon.

The disk controller uses the Western Digital FD1771 LSI chip and can handle double density drives when they become available. The 8-in disks are soft-sectored with 128-byte sectors in IBM format.

The input/output board has three parallel and three serial ports with selectable band rates from 75 to 19,200 and RS232 and TTL signal levels. The serial port may be configured for different numbers of character bits, stop bits and odd or even parity. One of the three serial ports is software-programmable and the other two are jumper-selectable.

The systems have the CP/M operating system and a choice of languages, including, TEI Extended Basic, C BASIC, FORTRAN (Microsoft), CIS COBOL and Pascal.

CP/M is already accepted widely as the 'standard' operating system for S100 8080-based systems.

The TEI Basic is available in 4K, 8K, extended and disc-extended versions, the last of which is sold and supported by Abacus.

Features of the Extended Basic include

Practical Computing evaluation

	Yes/No NA	1	2	3	4	5
Ease of construction (where applicable)	N/A					
Quality of documentation						●
Dealer support/maintenance					●	
Can handle 32K of memory						
Quality of video monitor (consider resolution and screen size)					●	
SS-50 Bus	NO					
S-100 Bus	YES					
Sockets for chips	YES					
Numeric, calculator-type pad on keyboard	YES					
Large amount of removable memory, randomly accessible	YES					
Cassette tape recorder capability: Own	NO					
Built-in recorder	NO					
Floppy disc capability	YES					
Communications capability (can talk to other computers)	YES					
Speed of Instruction cycle	2-4 MHz					
Ease of expansion					●	
Low power consumption					●	

	Yes/No N/A	1	2	3	4	5
Assembly language	YES					
Basic language*	YES					
Other languages						
Compatibility with other systems						●
Reputation of manufacturer					●	
Appearance				●		
Portability			●			
No. of software applications packages available	SOON					
Hobby use			●			
Business use					●	
Education use					●	
Suitability for: Commercial applications				●		
Home applications					●	
Educational applications					●	
Ability to add printer(s)	YES					
Ability to add discs	YES					
Ability to add other manufacturers' plug-in memory	NO					

Ratings
1 = poor; **2** = fair; **3** = average; **4** = good; **5** = excellent.
N/A = not applicable.

* C. Basic ... 4
Disc Basic ... 2

single (seven-digit) and double (16-digit) precision floating point arithmetic; integer variables. String variables and array-strings may have up to 255 characters; variable names may be of any length but only the first two characters and the type symbol, which must be the last character, are significant. The type characters are: = string; % = integer; ! = single precision; = double precision.

Errors can be trapped and handled by a standard subroutine using an ON ERROR GO TO statement. There are sequential and random files, and an EDIT command for amending source statements.

Overall, it is a very comprehensive Basic, but it uses the same technique for handling random files as that developed by Digital Equipment for Basic Plus under RSTS/E. It uses a FIELD statement to define variables within a disc buffer and LSET, RSET and conversion statements — CVI, MKI$ — to convert numeric variables to or from the disc format. If that sounds complicated, it is!

It certainly is not the best way of handling random files in Basic. Abacus says that TEI Basic is used by its scientific and technical customers, while commercial users opt for CIS COBOL or C BASIC.

Abacus is developing a set of commercial packages, sales, purchase and nominal ledgers, stock recording, and invoicing. The sales ledger has been installed for one customer and the purchase and nominal ledger packages are virtually complete. They are being written in CIS COBOL.

Abacus was unable to let us have a system on loan, so we had a demonstration at its premises. The machines are not the most beautiful we have seen, but they have steel cases and appear to be very well-built. The legend is that the TEI was built to survive in Texan oilfields.

Reputation for reliability

Abacus has now installed 50-60 and claims that they are very reliable. It is interesting that a number of other manufacturers, notably Alpha Micro, which has developed a 16-bit S-100 system, uses the TEI card cage, S-100 bus, and power supply as the basis of its system.

Its reputation for reliability is one of its strongest selling points. Our experience with a wide range of micro-computers has shown that some are so unreliable that they cannot be used for commercial applications.

Abacus was reviewing its prices at presstime and was expecting to reduce them considerably. Prices we were quoted ranged from £3880 for a PT112, 15-in CRT and the mini-floppy, to £6248 for a PT412, 15-in CRT and two twin standard drives. These prices make the TEI system one of the most expensive on the market. But if you are thinking of buying a system for regular commercial work, it might be worthwhile paying the extra for reliability.

Abacus has appointed three distributors for the TEI system: Micro Shade of Calne, Wiltshire; Stewkley Computer Services, Lincolnshire; and Strattenden Ltd, Isle of Man, and is quoting three weeks for delivery.

As for support, hardware maintenance is available by Computer Field Maintenance. The charge is 11 per cent of the hardware value per annum, and the response time for a fault call is quoted as one working day.

As the system uses standard CP/M software, a user should have no problems in obtaining support from a variety of sources. Abacus says it has used a variety of 'standard' S100 hardware and CP/M software products with the system and has no problems in interfacing.

Conclusions

- **The strongest point of the TEI system is its robust construction and reputation for reliability.**
- **The disc capacity is somewhat limited at 250K bytes per drive for a standard disc and 71K bytes for a mini. Double density will be available shortly.**
- **The systems are expensive but are worth considering because they are very well made.**

The Abacus commercial packages will not be the cheapest on the market — the expected price is £2,000 to £3,000 — but good software is not cheap.

As cash shortages squeeze hospital budgets even tighter, one department has come up with a novel micro application to take some of the burden from nursing staff.

Whose hand rocks the cradle?

PREMATURE BABIES might be saved by microprocessors, if research at the Royal Postgraduate Medical School bears fruit. A microprocessor based device, which controls the level of oxygen a baby receives, has been developed and is now being tested and refined.

It could well be the first time that a microprocessor has been used to regulate and monitor clinical conditions. The experiment is part of a series of microprocessor-based research projects at the School, based in Hammersmith Hospital.

Babies are sometimes born as early as 25 weeks gestation, weighing as little as 1.5 lbs. These babies have to be incubated if they are to have a chance to survive. During this period, the level of oxygen they breathe is very important as the partial pressure of oxygen, in the blood, has to be maintained at a critical level. If the blood oxygen rises too high, there is a possibility that the baby could go blind, too low and it could suffer brain damage. Oxygen is supplied to the baby either through a face-mask ventilator or a head-box, depending on its condition.

Four years ago Paul Collins, an engineer in the Child Health Department, started to design an automatic oxygen level control and monitor. The work was supported by a Wellcome Foundation grant to the Child Health and Medical Physics Departments. This was a solid-state device which would monitor and regulate the level of oxygen in a baby's blood by changing the level of oxygen being supplied to the baby with a valve which controls the mixture of oxygen and air.

by Duncan Scot

The level of blood oxygen is measured by an electrode strapped to the baby's skin. It heats the skin to around 40°C, dilating the pores on the skin surface and allowing oxygen to be transferred to the electrode. The output from the electrode is dependent on the blood oxygen level.

If the level of blood oxygen is too high, the setting of the mixer valve has to be adjusted. The difficulty lies in designing a system which has a flexible response and can return the blood oxygen level to normal in the quickest possible time. The solid state design required a lot of complicated electronic circuitry but made it hard to incorporate further design ideas as the project evolved.

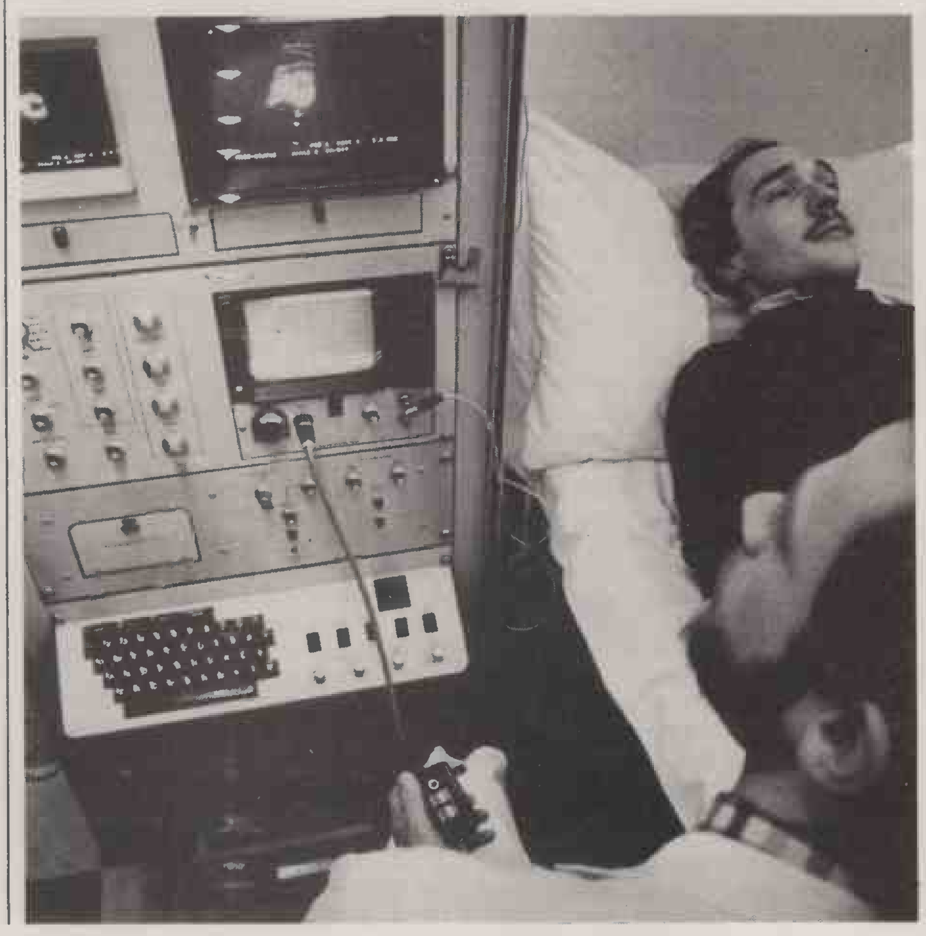
A microprocessor offered more flexibility. It was a relatively simple matter to base each of the response levels in software. Mr Collins's system now consists of a Motorola 6800 microprocessor, a 6810 RAM, 1K of EPROM and 3 PIA 6820s.

The Wellcome Foundation grant expired at the end of March 1979 and Paul has now moved on to other work. But two American companies have since expressed commercial interest in the project. In the meantime, a doctor at the Medical School is conducting clinical trials with the system and, with Paul, is looking at areas in which the software could be refined.

The most difficult area of the software is that concerned with the safety checks in the control. It is vital that a nurse is immediately warned if anything goes wrong with the equipment or the baby. The control has a number of self-checking devices — for example the inspired oxygen level is continually checked against the position of the valve. If the two readings do not agree, an alarm is sounded.

There are many occasions when a nurse may have to be called. Sometimes a baby's condition can deteriorate very quickly. One fairly common difficulty with premature babies is that their lungs can become blocked with fluid. This can clear in a matter of minutes and the amount of oxygen absorbed through the lungs can increase dramatically. Although the mixer valve should be able to deal with most adjustments, a nurse will always be called whenever there is a dramatic change of condition.

It is difficult to predict whether this added supervision of a baby's condition, if it is ever fully developed and applied, will have a significant effect in saving the lives of premature babies. It could be that the first noticeable factor will be an increase in the number of premature babies which survive without any ill-



Above: Paul Collins.
Below: An MSI 6800 is used to analyse the information from this ultra-sound scanner (see next page).

Paul Collins modifies his control unit.

effects, although such statistics will take years to isolate.

There seems little doubt that the idea will be developed commercially. The Institute of Child Health has already filed a patent on the system. Paul Collins regards this as only the start of a whole new range of increasingly sophisticated microprocessor-based equipment which will be able to control every detail of a baby's environment. None of this would have been possible even a few years ago.

It is no coincidence that Paul based his work on the Motorola 6800. The hospital has been experimenting with the chip for several years, has created its own expertise and promoted the use of microprocessors and microcomputers throughout the hospital. Much of this work has been led by Professor Wootton, Head of the Department of Chemical Pathology.

He came across the 6800 chip when he studied an experiment at the National Institute for Medical Research. His latest plans include the installation of up to 20 microcomputers within the next couple of years. Many of these will be connected to the dumb terminals of the hospital's file-handling CTL 8050 mini.

Ultra-sound scanner link

One project, funded by a Department of Health and Social Security grant, uses an MSI 6800 microcomputer with an ultra-sound scanner. These are sometimes used to study the position and movement of a foetus, or to pick-up a change in the blood flow to an organ or area of the body. In this case the scanner examines tissue characteristics; the microcomputer analyses the information (echoes) which are not visible in the images. The information from the scanner includes frequencies up to 10MHz and is sampled at 20 MHz. This is digitized, unloaded into the MSI, processed and analysed.

Typical applications include studying the response of tumours to radio- and chemotherapy, the contractability of heart and other muscles and the loss of efficiency in ageing placentas. These are all long-term investigations. The brief from the DHSS was to develop a system which could be used with any scanner in the country and which is not prohibitively expensive. The development team has been encouraged by its progress.

Another project highlights the practical benefits of microcomputers in the laboratories by relieving the pressure of the day-to-day work of the hospital. In the Blood Count Laboratory a complex machine, a Coulter Counter, is used to analyse over 500 blood samples every day. The counter prints, automatically, the number of red and white blood cells and the level of haemoglobin in each sample.

The data used to be collected by an old and unreliable paper tape punch, linked to the counter by a specially-built interface. This has now been replaced by an MSI 6800, costing less than a new interface and tape punch, connected to the Coulter Counter at logic level and to one of the dumb terminals of the hospital's CTL minis. The data from the counter can be stored and edited locally before being transferred to the CTL's files. The terminal can be used as a stand-alone microcomputer or as an intelligent terminal for the CTL. Professor Wootton expects that many of the micros used in the hospital will eventually be linked to the central mini.

Microcomputers and processors, inexpensive by the standards of hospital equipment, have great advantages. They are reliable and can eliminate much of the repetitive drudgery involved with medical research and treatment. They will also allow new safety and supervisory equipment to be developed which will actualy save lives.

It is no secret at the hospital that everyone is surprised by the speed with with microprocessors have become involved in so much of their work. The staff have been impressed with the practical advantages and implications of computers.

The Instrumentation Department of the Medical School has concentrated all its microprocessor efforts on the 6800 series of chips and thereby established a standard of work which seems to have ensured the economic success of their projects. At a time when grants and budget are restricted, projects must have uses in other hospitals or departments.

Pressure from the field

The importance of the hospital's work with the MSI 6800 has not been lost on CTL. It has recognised the advantages of attaching microcomputers to its dumb terminals and has included the MSI 6800s as an optional addition to a medical package called Phoenix. This system has already been installed in some UK hospitals.

The Medical School seems to have developed applications for micro-computers and processors in a way which highlights some of the problems in the micro industry. The best ideas are not coming from the trade, which has yet to demonstrate an ability or will to develop its own application expertise. It is only fair to add that the hospital has found its suppliers, SEED, extremely helpful and have no criticisms to make. All the same, it seems that the pressure for development and better software is coming from the field.

The widespread use of microcomputers at Hammersmith has managed to break many of the myths surrounding large centralised computer systems. It would seem likely that within the next few years micros will penetrate into every area of the hospital. We hope that they can keep up their lead.

Blood samples are analysed in the Coulter Counter. An MSI 680 is used to transfer the data to a CTL 8050 mini.

Single-cell movements tracked by computer

In the previous article, the concept of a parallel-processing computer was introduced. The architecture of the CLIP (Cellular Logic Image Processor) machines built by the Image Processing Group of University College, London was dealt with and some image-processing applications were mentioned. This article introduces the reader to the software of the CLIP computer and considers in detail some image-processing techniques and their application to real problems.

AT A RECENT CONFERENCE held in Windsor, leading members of the image-processing fraternity discussed the development of high-level computer languages for image processing applications. The delegates split roughly into three factions: those who considered a library of FORTRAN subroutines ideal; those who wanted image processing-related instructions embedded in a PASCAL-type language; and those who advocated a completely new language. Until a high-level language is widely accepted, image-processing machines like CLIP will be programmed in their inherent machine languages.

The assembly language of CLIP4 (the latest machine which should be working by early 1980) is called CAP4 (CLIP4 Assembly Program). A CAP4 statement typically consists of a combination of four possible fields:

LABEL: OPERATOR OPERAND; COMMENT

All statements do not require a LABEL and the COMMENT is optional. The LABEL consists of up to six alphanumeric characters from a limited set of the ASCII characters, and fulfils the usual role of a statement label in any assembly language.

Instruction mnemonics

The OPERATOR can take the form of instruction mnemonic or an assembler directive. An instruction mnemonic corresponds to executable machine code, while a directive tells the assembler how to deal with a program section or with a set of characters. The nature of the OPERAND is dependent on the OPERATOR, while the COMMENT is self-explanatory.

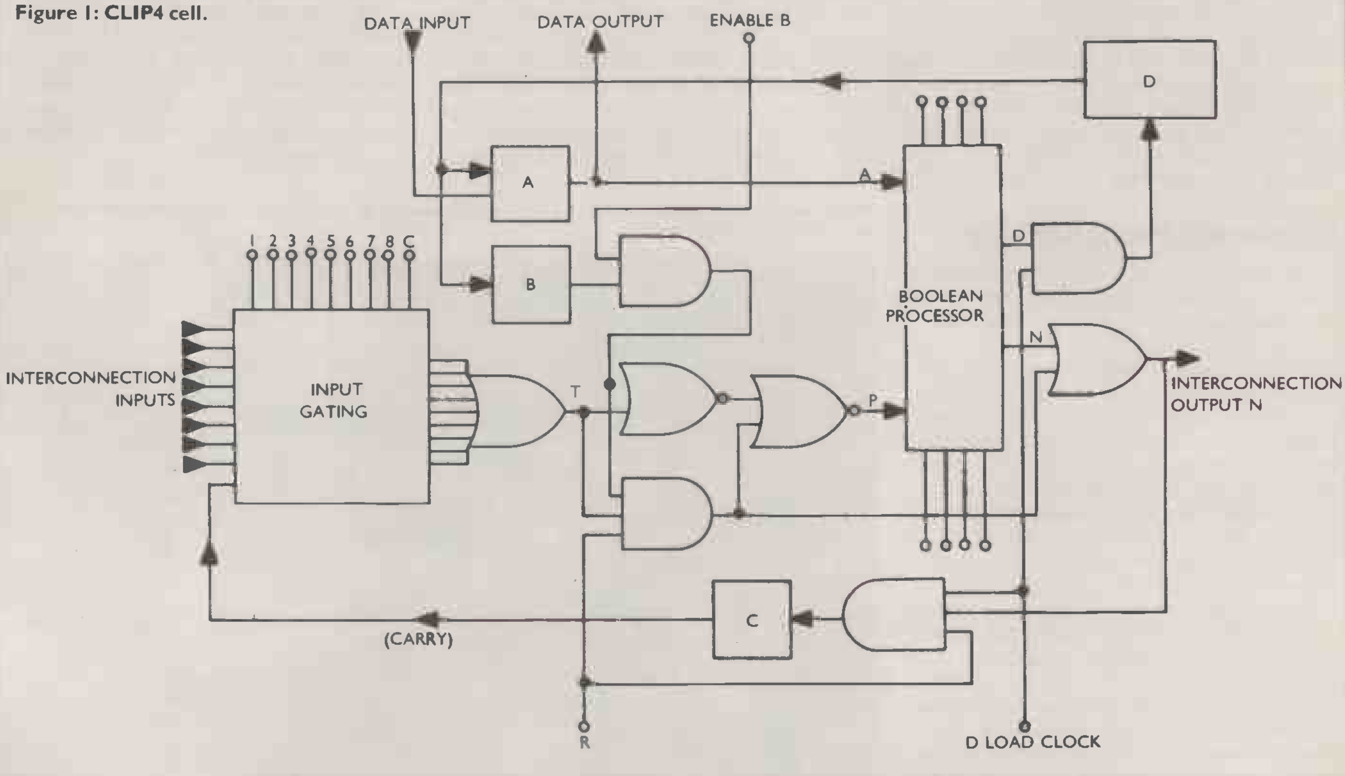
Instruction mnemonics fall into five categories: array, register, branches, input/output; and miscellaneous: The register, branches and miscellaneous categories: array, register, branches, input/output, and miscellaneous. The register, branches and miscellaneous two remaining categories only the array instructions will be considered since these reflect the CLIP4 architecture and show how CLIP can be used for image processing.

The CLIP4 machine consists of a 96 × 96 array of interconnected processing elements (PE's), one of which is shown schematically in **figure 1**. The array instructions are of four types: LDA, LDG, SET, and PST.

LDA simply loads the A register of a PE with a single bit of data from a location in the D-memory specified in the operand field, eg LDA 10 copies the contents of memory location 10 into the A register.

Every PE performs this instruction at the same time. Similarly, LDG loads the B register from a specified memory location.

Figure 1: CLIP4 cell.



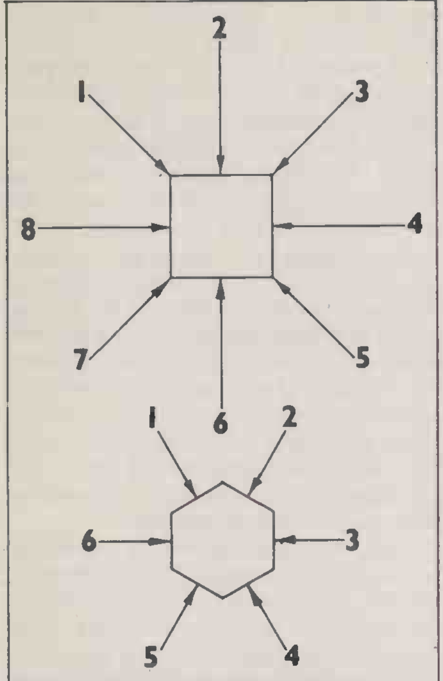
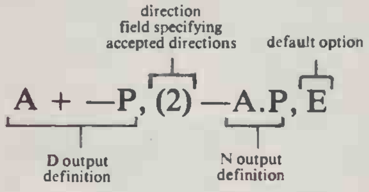


Figure 2: Square and hexagonal surround directions for each CLIP cell.

The SET instruction is the basis of array processing on CLIP4, since it specifies the manner in which the array will operate during a processing cycle. It consists of three subfields, which are: output definition, propagation definition, and default options.

The output definition consists of a boolean function of the A (local image value) and P (propagation from adjacent cells) inputs, which are combined to produce a D output. The propagation definition specifies in a direction field, from which adjacent cells an input will be received, and also defines a boolean function of the A and P inputs which are combined to form the N output.

The default options allow the array to be used with hexagonal instead of square tesselation, the propagation signals from the outer edge of the array to be set to logical 1 instead of 0, and the R and C control lines to be set to use each PE as a full adder. A typical instruction would be:



Where + = OR
. = AND
— = NOT
⊕ = EXOR

The numbered directions surrounding a given PE are shown in **figure 2**, and the E default option sets the edge of the array to logical 1.

The PST instruction is a mnemomic for Process and STore. When this is executed the array goes through a processing cycle. The data loaded in the A and B registers is processed according to the functions defined in the previous SET instruction and the result is stored in the memory location specified in the operand field of the PST, eg PST 5 would process and store the result (D output) in memory location 5.

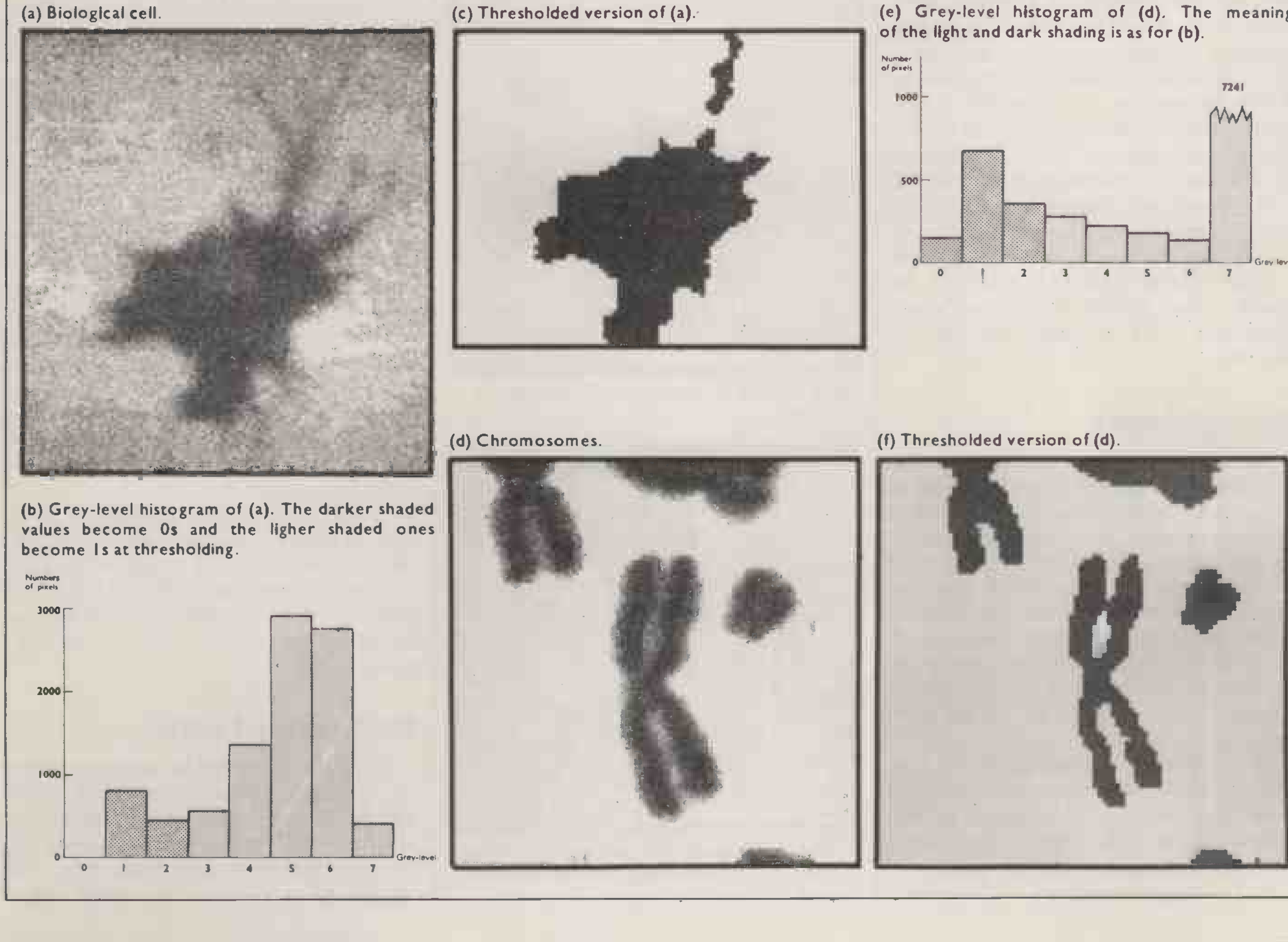
A typical sequence of CAP4 statements would be:

LDA 2
SET P,(8)A
PST 2

Local image value

The result would be a shift to the right by one pixel of a binary image stored in location 2. Consider the image to consist of a white object (1s) on a black background (0s). The propagation definition specifies that the value passed to adjacent PEs is the local image value. However, since only direction 8 is enabled, then a PE only receives a propagation signal from the PE to its left. The output definition is PE and so takes on the value of the propagation input. Thus, each PE passes its own value to the right and takes on a new

Figure 3: Thresholding images.



(a) Biological cell.

(b) Grey-level histogram of (a). The darker shaded values become 0s and the ligher shaded ones become 1s at thresholding.

(c) Thresholded version of (a).

(d) Chromosomes.

(e) Grey-level histogram of (d). The meaning of the light and dark shading is as for (b).

(f) Thresholded version of (d).

value from the left and overall, a right-shift of the image is achieved.

The removal of a single-point white noise from an image is achieved using

SET A.P,(1-8)A

Each PE passes its local image value to all of its neighbours (directions 1 to 8 are enabled) since the propagation definition is A. However, the output definition means that only those PEs which contains 1s and receive a 1 propagation signal produce a 1 output. Thus, isolated 1s (white points) do not receive a propagation 1 and become 0s while clusters of any size remain unaffected.

As a final example of the power of a single CLIP instructions, the expand operation will be explained. Expanding an object involves adding layer of pixels all around its edges. It is achieved using

SET A + P,(1-8)A

Spatial filters

Each PE communicates its local image value to all of its neighbours. Those PEs which already contain a 1 or receive a propagation 1 (ie are next to a PE containing a 1) produce a 1 output. Thus, the 0 pixels (black) lying next to the object edges become 1 pixels and the object increases in size by one layer.

Even though the above examples are all low-level assembly language statements, they achieve results which would require whole subroutines written in a high-level language when running on a normal serial computer. The limited arithmetic capability of, and relatively coarse digitisation of, a picture into 96 × 96 pixels by CLIP4 means that the machine is not oriented towards enhancement and restoration of photographs. Such tasks require a much finer digitisation grid (maybe 512 × 512 pixels) and considerable arithmetic power to implement numerical filters involving, say, the Fourier spectrum. CLIP4 is better able to deal with what can be loosely termed pattern recognition operations and some of these will now be described.

Binary images

One of the simplest and most useful methods of extracting an object from a picture is by thresholding. Here, all pixels with value greater than a specified threshold are assigned local 1, while those with value less than the threshold take on logical 0. The result is hopefully, a binary image that best represents the desired object in the picture. Further operations can then be applied to the binary image without the complication of dealing with grey-level values.

The problem is to select reliably a suitable threshold. A useful pointer comes from the grey-level histogram of the picture which shows how many pixels there are for each value of grey-level. Such histograms exhibit a "bimodal" structure. There is a valley between the small peak of the predominant object grey-level and the large peak of the predominant background grey-level, and it is sensible to choose a threshold value that lies somewhere in the valley for best separation of object and background. The results of a program which automatically selects the threshold value are shown in **figures 3(c) and 3(f)**. Obviously, if the characteristics of the pictures are known and are constant, then a single threshold value can be determined beforehand and used for all such pictures.

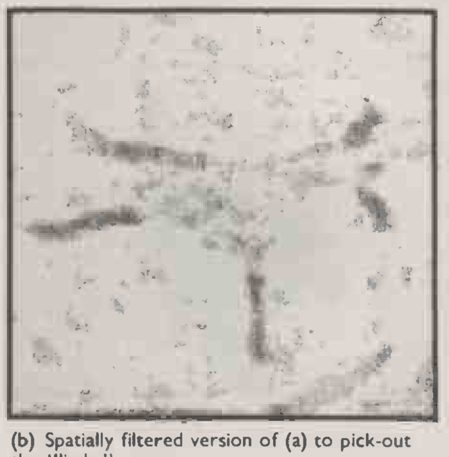
Two very important operators in image processing are the SHRINK and the EXPAND. For binary images, shrinking is the process of "peeling" away the outer layer of pixels from an object, while conversely, expanding adds a layer to the object. The edge of a binary object can be found by simply shrinking once and exoring the shrunk version with the original, leaving only the perimeter.

Combinations of shrinks and expands can be used as spatial filters to remove structures of certain sizes while leaving others essentially unchanged. If a number of shrinks is followed by the same number of expands, then small structures disappear during shrinking and do not return when expanding. However, larger structures only reduce in size during the shrinking phase and are essentially restored to their original form on expansion.

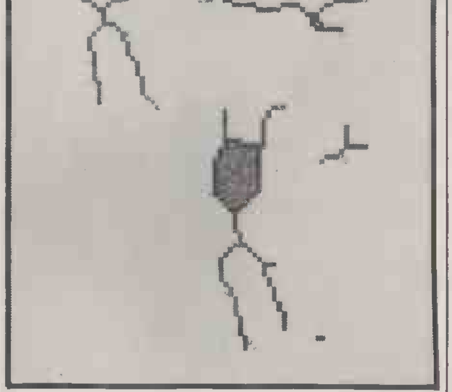
Thus, shrinking followed by expanding acts as a low-pass spatial filter. A lowering of the pass frequency is achieved by increasing the number of shrinks and corresponding expands. A high-pass filter is obtained by exoring the low-pass filtered image with the original. Only the portions of the picture which have changed then

Figure 4: Applications of the grey-level shrink and expand operators

(a) Biological cell



(b) Spatially filtered version of (a) to pick-out the "limbs"



(c) Grey skeletons of the chromosomes shown in figure 3 (d) cf. the binary skeleton shown in figure 6 (a).

'Skeletonising' objects

A special form of the shrink operation can be used to determine the "skeleton" of an object. Skeletonising involves reducing an object to a line figure which essentially preserves the shape of the original. The process is achieved by conditionally shrinking the object until a line of pixels of unit width remains. The results of skeletonising binary images of some chromosomes are shown in **figure 3(f)**. Using the skeleton, which retains the topological and some of the geometrical features of the object, it is then possible to apply a classification procedure.

The members of a set chromosomes have to be keryotypes (placed in order) for medical purposes and it is much easier to work with the skeletonised versions rather than the original images. Using the skeletonised version of a letter, character recognition can be performed. The direction of a line and the presence of junction and cusps all serve to identify a particular letter and these features are easily extracted from the skeleton.

The aforementioned operations work only on binary images and thus it is necessary to obtain a binary image before processing can commence. This is a restrictive condition since valuable information can be lost at the grey-to-binary transformation.

Multi-valued logic

Recent work has led to the development of analogous operations which work directly on grey pictures. The transformation to a binary image, if required, can then be left to a later stage when the choice of a suitable threshold value becomes more apparent.

The basis of the grey operators is the extension from a binary to a multi-valued form of logic. In the binary case, pixels communicated their 0 or 1 value to their immediate neighbours but with multi-valued logic they now communicate their grey-level, introducing a third dimension to the operators.

Consider a picture digitised into eight grey levels (0 = black, 7 = white). Then the grey analogue of the shrink operator becomes, in words: the new value of a pixel is the minimum of its own value and the values of its eight neighbours. Thus, darker areas encroach into the lighter regions and a lightish object on a predominantly dark background is reduced in size by the application of the grey shrink.

Conversely, the grey analogue of expanding is achieved by taking the maximum value of a pixel and its eight neighbours. From this basis it is possible to implement spatial filtering, edge finding, and skeletonisation of grey pictures in a similar manner to that for binary images, with the grey operators replacing their binary counterparts. Examples of these operations are shown in **figures 4(b) and (c).**

Real problem solving

Now that some basic picture processing operations have been introduced, their application to two real problems, namely biological cell analysis and texture analysis, will be discussed.

In the zoology department at University College, London a study of the forces acting between cells and inorganic surfaces is being pursued. The research involves understanding how an amoeba-like single-celled animal manages to crawl across a glass surface. It is necessary to analyse many pictures of the amoeba in various stages of locomotion. The image-processing group of UCL was approached in the hope that an automatic analysis routine could be developed. The required measurements are very simple, one of the most important being the cell area and how it changes with time.

However, the solution is not so straightforward. Somehow the cell area must be found accurately without any spurious features appearing, but this cannot be achieved by merely looking at the edges in the picture since many "digitisation" edges occur. These are not real edges but appear in areas of slowly changing grey level, because there is only a discrete number of grey levels. **Figure 5(b)** shows all the edges in a typical picture.

Since digitisation edges are only of height 1, then it may seem reasonable to consider just the larger edges, which must be real edges. The result is a very broken outline of the desired area because the contrast over some parts is rather poor **figure 9(c)**, but the edges can then be extended along their predominant directions to produce an outline like that shown in **figure 5(d).**

Figure 5. Biological cell analysis problem

(a) Biological cell

(b) All the edges in (a). The edge height is proportional to the darkness.

(c) Edges of height greater than 1.

(d) Cell perimeter found using an edge-growing technique.

It will be seen that the outline is not a very good description of the cell area. This stems from the use of "primitive" local features in the attempt to segment the picture. Human pattern recognition relies on a pre-knowledge of the form of the shape to be recognised and thus the best approach is to incorporate some description of the global properties of the object in the pattern recognition program. Such a linguistic approach is yet to be implemented on the CLIP computer.

A visual texture can be loosely described as an image that exhibits any sort of variation. Texture analysis by computer is applicable to such diverse areas as land use and earth resources study, involving the analysis of satellite photographs, and metallurgy, where the crystalline structure of a metal must be categorised. The expand and shrink operators for grey pictures which were introduced earlier have been used for texture discrimination by performing operations known as "opening" and "closing".

Grey shrinks

Opening tends to increase the size of the dark areas of a texture while closing, conversely, tends to decrease their size. They are implemented in a similar manner to spatial filters with opening being a series of grey shrinks (ie, relatively white areas shrinking) followed by an equal number of expands, and vice versa for closing.

A series of openings and closings of varying degree (the degree increases as the number of shrinks and corresponding expands increases) can be performed on the texture, and at each stage the total grey volume (the sum of the grey values of all the pixels) changes. The manner in which the grey volume changes with opening and closing is unique to each type of texture and so by processing this data with a discriminant analysis program, textures can be separated into different classes.

In conclusion, only a brief outline of the image-processing capabilities of the CLIP computer has been presented here. Its potential applications are the subject of continuing research at the Image Processing Group of University College, London and it is expected that a derivative of CLIP4 will be eventually found on the factory floor.

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Step by step into the hardware scene

Radio amateur B. R. Smith describes how he got hooked on home computing and charts a course for beginners through the manufacturers' jargon.

HAVING JUST experienced the trials and tribulations which follow the decision to start home computing, I feel I might be able to ease the path for other beginners, since almost everyone assumes that the beginner knows things which he does not know.

I have been interested in electronics as a hobby for many years. I hold the radio amateur call sign G3 NNM; I have been aware for some time that the words microprocessor and microcomputer were appearing with increasing frequency in magazines but I could never see how the ability to produce a row of 1s and 0s served any immediate practical purpose.

Purely by chance, I spotted the second issue of *Practical Computing* and that, by explaining something about Basic, proved to be the necessary catalyst. I could see a practical use for a small computer provided the cost was low enough. I spent the next few months reading *Practical Computing* avidly as each issue appeared.

Step one: can you write?

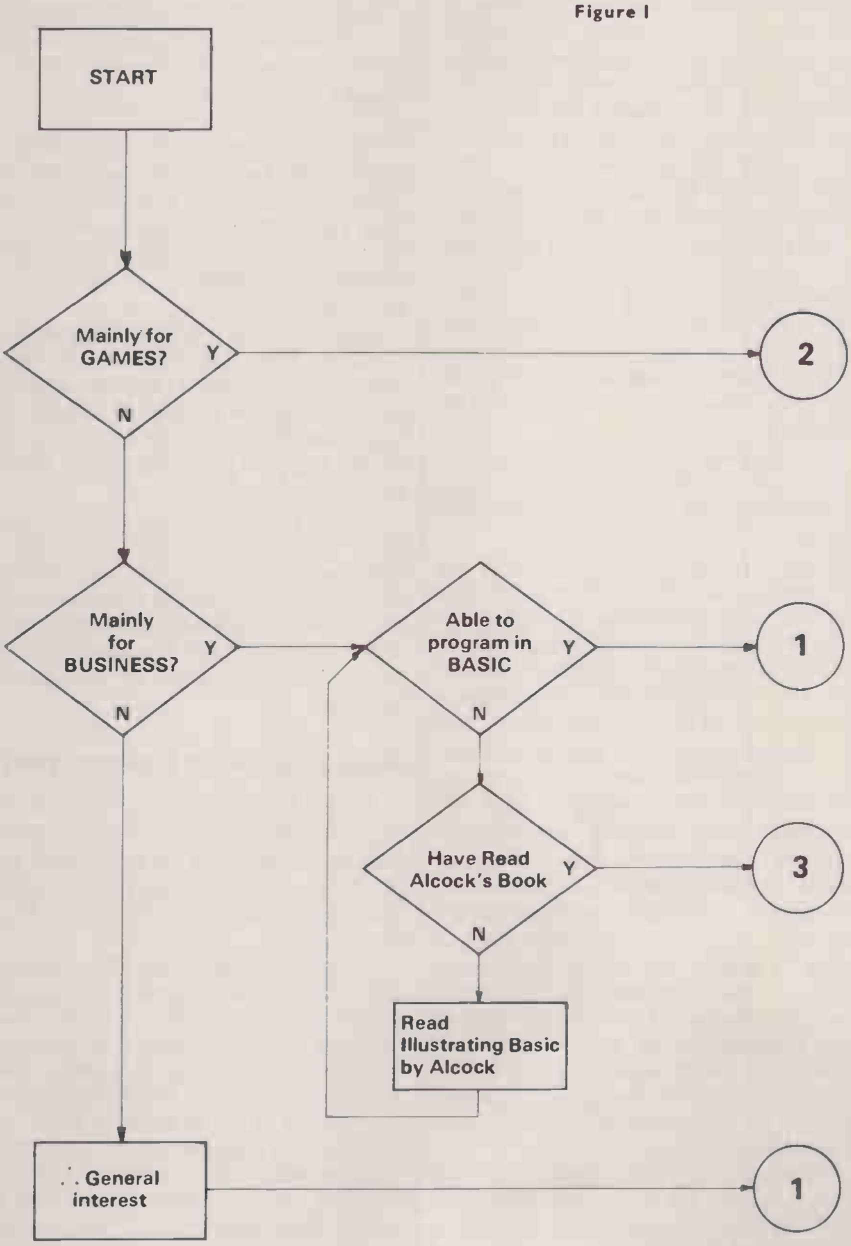
The first thing is to decide what you really want to do with your computer, even before you look at the various types on offer. Look at the simple flow chart in figure 1 as a guide. Is it a business application? If so, can you write a program or do you expect to buy one? If you haven't been reading this magazine regularly, I suggest that you read Alcock's excellent book, *Illustrating Basic,* as it will explain Basic and enable you to decide if you could write your own program.

If you can't write the program, your choice of computer is limited to one which has software — programs — available for your application. If you think you can write Basic, the choice is wide open.

If it is chiefly games you want then the choice is, I think, more limited, as although plenty of games programs are published, they need a good deal of modification if they are to be used on anything other than the micro on which they were developed. Mini games now use PEEK and POKE statements and the memory locations, if nothing else, have to be changed to suit your particular computer.

Once you have decided on the application, you can consider the

Figure I



1 Wide range of equipment available and can consider factors such as price, features etc.
2 Limit choice to machines which are games orientated.
3 Limit choice to machines where 'software' suitable your application is offered.

equipment. To a beginner the computer scene is smothered with jargon and, in an effort to sell their own products, the manufacturers do not try to indicate overall costs, so that it is only by obtaining a mass of brochures and reading reviews that the facts emerge slowly.

There are several pitfalls of which a beginner should be aware and to my mind the biggest is to assume that a microcomputer means the same thing to everybody and includes all the parts you need for a system, such as visual display unit (VDU) and a keyboard. That is not so; some do, some do not.

In many cases not only do you have to add an external unit but you also have to buy and add an interface. That jargon word refers to a unit, perhaps a printed circuit board but sometimes a whole 'box of bits', which connects between the microcomputer and the peripherals, which are the bits and pieces which I had always assumed were part of the micro — the VDU, keyboard and cassette recorder.

I found the best way through the jungle was to draw in diagramatic form the various pieces needed for a complete system (figure 2) and then, taking each manufacturer in turn, see how many of the pieces were included in the basic unit and how many extras had to be purchased.

As a simple example, Pet includes a VDU and its interface in the basic computer but the SWTPC or MSI 6800 does not.

Using my diagram you can soon see how much a particular system will cost before it is in a complete working form and you will find that many of the apparently inexpensive computers add up to a surprisingly large amount of money by the time you have added memory and the necessary interfaces and peripherals. On the other hand, some computers are virtually complete and need only the addition of a television set or monitor. Perhaps you think, as I did, that VDU is just another word for monitor — not so, really.

A monitor is, roughly speaking, half a television set — the screen with line and frame generators, but before it can give a display it needs an interface to decipher the micro signals. Many micros include such an interface—eg, Research Machines 380Z, but some do not and you would then need something like the Tangerine board between the micro and the monitor — that is another £155 or so.

Units sold as VDUs usually have the interface and monitor combined, but again beware, as there is an increasing trend to call the interface a VDU — eg Tangerine — leaving you to add a display unit.

Provided your micro includes a VDU interface, you can use an ordinary 625-line television set for display purposes by adding yet another unit, a modulator, between the micro and the aerial socket of the TV.

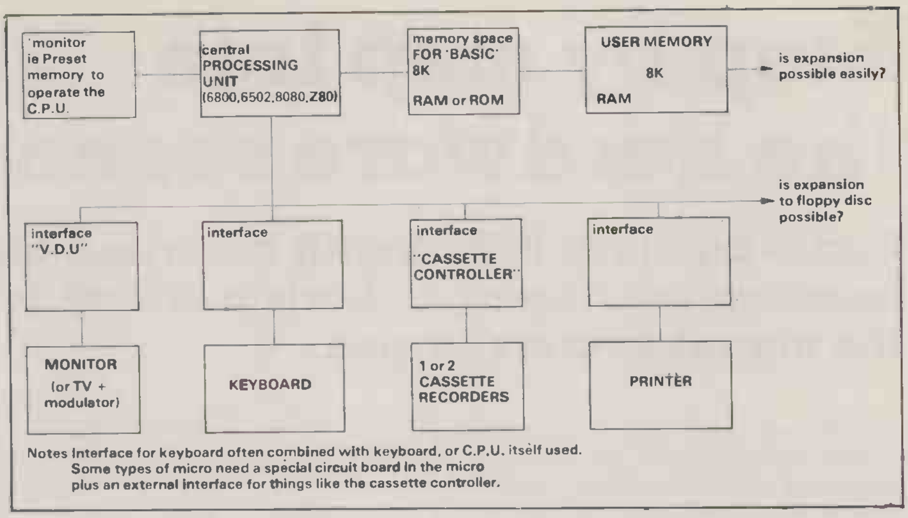


Figure 2

The display is not so sharp as on a proper VDU but is usually adequate. For economy therefore, acquire a second-hand gogglebox — the going rate is £2 to £5 in my local saleroom — and add a modulator, available from advertisers at about £6-£8.

I decided early that for my particular purpose I needed a minimum of 16K of memory with the ability to expand later by another 16K; after that I thought the logical addition would be storage on disc, so that ability to add a floppy disc became essential.

Another essential requirement was a good Basic, which is a collection of commands to let you tell your computer what you want it to do, using something very near to English. Basic then interprets your requirements and tells the computer what to do in its own machine language.

Step two: what languages?

Several hobby computers offer a Tiny Basic in about 2K of memory but the facilities offered are rather limited, even for games, and I decided that I needed a full-feature Basic taking about 8K of memory space.

Some of the later, small, computers offer Basic in ROM (read-only memory) and this means that the computer is ready immediately you switch on, so you don't waste four or five minutes 'loading' Basic from a tape cassette. On the other hand, for the cost of an 8K Basic in ROM, you can have at least 8K of dynamic RAM (random access memory) together with an 8K Basic on tape which means that you can try other languages — Pilot or Pascal perhaps — or can change easily to an updated version of Basic.

Another point in favour of a tape Basic and RAM memory is that when you progress to a floppy, the disc has its own Basic which loads in seconds, and the RAM will be needed to use it, whereas the ROM Basic would be redundant.

It is probably safest to assume that nothing made for one computer will fit another computer unless you have very good technical knowledge, in which case you won't need any help. By and large you have to use the Basic cassette or program supplied with a particular machine on that machine only, certainly on one using the same CPU.

Recording standards for cassettes differ, even if they all call themselves 'CUTS format' as this only standardises the tones to be used and not the form the information is to take — ie ASCII characters or binary data, and so on, and still less is there any attempt to agree on any subsidiary details such as the signal used to start the tape moving, if any.

Printers, when you progress that far, each require their own special interface, particularly if you are looking at the older type of former commercial service machines, even if they accept ASCII code, and not all do, they may still need special commands so that they know when to print a character.

If you are a typist, the question of the keyboard needs thought, as simple keyboards will produce errors if a new key is pressed before the last one is released. Better — more expensive — keyboards have 'roll-over' provision to avoid this. If you are a two-finger typist, there is no problem.

In my case, I was not averse to constructing a kit and to show that it is possible to assemble a good system at a low cost. My own now comprises a one-board 6800 kit from Hewart Microelectronics and with keyboard, 16K of memory, an interface and a second-hand commercial printer, a second-hand monitor, a cassette recorder and a very good 8K Basic. It cost me less than £450 excluding VAT.

That kind of price is, I feel, very much more what the hobbyist is looking for and all I now need is someone who is expanding a system to offer me a floppy disc and controller suitable for a 6800-based unit at a suitably down-to-earth price.

Hoover

by Rex Malik

IT SHOULD really have been foreseen.

But then there are those who would argue that most things should have been foreseen. Of course, there is the possibility that it was envisaged and that a report was written.

And one can see its conclusions being thought so outrageous that it never got further than the Executive Office Building — doubtless with memo attached: "Don't bother the President with this garbage. We have enough problems with science fact to have time for science fiction. And which idiot dreamt this project up anyway? And what did it cost? On whose budget?"

Which makes it all the more likely that it never even got as far as the outer reaches of the Presidency. If, of course, it was ever written, it probably stayed within the Pentagon, one of those thousands of reports, which cover all options that a military staff trying to protect its ass commissions every year. What to do if the balloon goes up? Run. What to do if it comes down? Bury your head in the sand. What to do if it goes sideways: call the Coastguard.

If, as I say, it was ever commissioned. And why, after all, should it not have been? There is a lot of taxpayers' money available, and what better way is there of keeping clever people off the streets? They could be causing trouble out there, trouble for the Pentagon. So why not turn them into friends by having them live off it?

The staffs may scratch their ass, the Chiefs of Staff scratch their heads, here as in Moscow, and the hot-line — thank someone that it's cable — hum as both sides try to work out what to do next.

And what worries them even as much as the main problem is that suddenly they no longer know what their friendly allies, their own trouble-makers, are up to. It could be that the Albanians, the Vietnamese, the Israelis are planning something which could start World War Three. They have not yet really arrived at the conclusion that this is not going to be allowed either.

Meanwhile, the buck on both sides has been passed upwards. In the words of Frank Booth's immortal cartoon caption, "Having concluded, Your Highness, an exhaustive study of this nation's political, social and economic history, and after examining, Sire, the unfortunate events leading to the present deplorable state of the realm, the consensus of the Council is that your Majesty's only course, for the public good, must be to take the next step."

Fat chance: They don't know what to do either.

Now, of course, we come to one of life's little ironies. Much of the burning of the midnight oil that is going on consists of the scouring of science fiction. Publishers get called up in the middle of the night and are asked for copies of obscure stories that somehow never seemed to make the Library of Congress.

Russian diplomats are to be found (after all, it is costing enough to have them followed) roaming through the secondhand bookshops of Washington and New York buying up titles by the hundred. One wonders what their masters will make of it all when they get it home.

Arthur Clarke was flown in from his home in Sri Lanka in great secrecy, and they even managed to dig out Isaac Asimov from his New York basement and get him to Washington. But they have stopped calling on Robert Heinlein soon after the first meeting when he indicated that he wanted to declare war on it, and go out and zap them.

The other night, I am told, they even screened *The Forbing Project* in the White House, to see if that fictional scenario of a Russian and an American computer in alliance, dictating terms to both countries, might provide any clues. If I was Washington, I would make sure that this never again fell into the hands of the television networks. One more broadcast and they might get something more to work on: they might not even realise that it was meant to be fiction.

Also currently deeply in demand are the artificial intelligentsia. Professors Minsky, Winston, Papert, McCarthy, have been flown down from MIT and Stanford, and they have even brought over Professor Michie from the UK, though only after twisting the British Government's arm: he was practically camping out in Downing Street anyway.

And all this because once upon a time we began a programme which became known in the media as "the killer satellite" programme. We both, Americans and Russians, started to devise satellite systems whose job was to keep inner space clean, but naturally enough, only of their equipment, not ours.

"Their", of course, is the Russian: "our", the American, because the rest of us had not got that far. Now, of course, we say, "the Russians started it". And they say the same about us: it is all America's fault. It does not really matter who was to blame: the critical fact to remember is that we both let *them* loose up there, and that we marched if not jointly, then almost in step.

The initial versions were quite simple: laser-equipped killers, relatively low-power devices operating under the tight control of ground stations.

And then people started to get clever: "Let us," they said, "make them foolproof." So we did. The communications beams were tightened till they were almost undetectable unless you were in the line of sight, and encryption was built in. And the communications capability was made world-wide: both sides could control them from any station in their global communications networks.

But that was not clever enough. There are twenty to thirty thousand pieces of space junk now in orbit, some hundreds of miles up. Plus there's over 2000 working satellites whizzing around. And way out at the more-than-20,000 mile level sit the big birds, those large powerful synchronous orbit telecommunications satellites.

So if you are to let killers loose among this lot, they have to be made smart: they must be able to cope with their environment, have some freedom of action. And they must be able to distinguish between *theirs* and *ours*, and not just the colours of the flags either, though they hve to be also able to recognise the odd Japanese, French, European, Latin American, Chinese, and Indian satellite when they see it. And believe me, they can see a long way.

Having seen it, they must be able to unravel its purpose. So they have been equipped with sensors: heat, infra-red, nuclear, sensors to cover the whole spectrum, chemical analysis, metals analysis, sniffers of all kinds, and of course enough video and film equipment to equip a large studio.

As I say, we made them smart. To control and handle all that lot, we have massive computational power up there, the best that the micro-electronics and computing industries could come up with.

As I unravel it, you can see how we marched almost in step. If they had it, we had it, or vice versa. And both of us gave *them* plentiful data to work with: it's their environment and we prepared them for it. You name it, they know about it: the conditions of space, what's up there, whose it is, what it is used for and what it could be used for, how long it's likely to stay there before the orbit decays.

But it's not only their own environment they know about, its also ours. They carry accurate ground data, the best we could provide. All as if they could not see it. They know the locations of all major communications ground stations, airfields, ports, military camps, storage depots, research establishments, and major arms, including nuclear, production facilities. All this for both sides, as complete as we could make them.

Why? By now you should not have to ask that. Because the last lot to go up (and it is the last lot: whatever happens, we are all agreed on that) carried a ground offense capability: they were not just space-bound. Nobody was crazy enough to give them nuclear warheads — the ubiquitous laser was enough.

Of course, if you are to do serious damage with lasers at those distances, you need a substantial power source. Which accounts for

continued overpage

'To control and handle all that lot, we have massive computational power up there, the best that the micro-electronics and computing industries could come up with.'

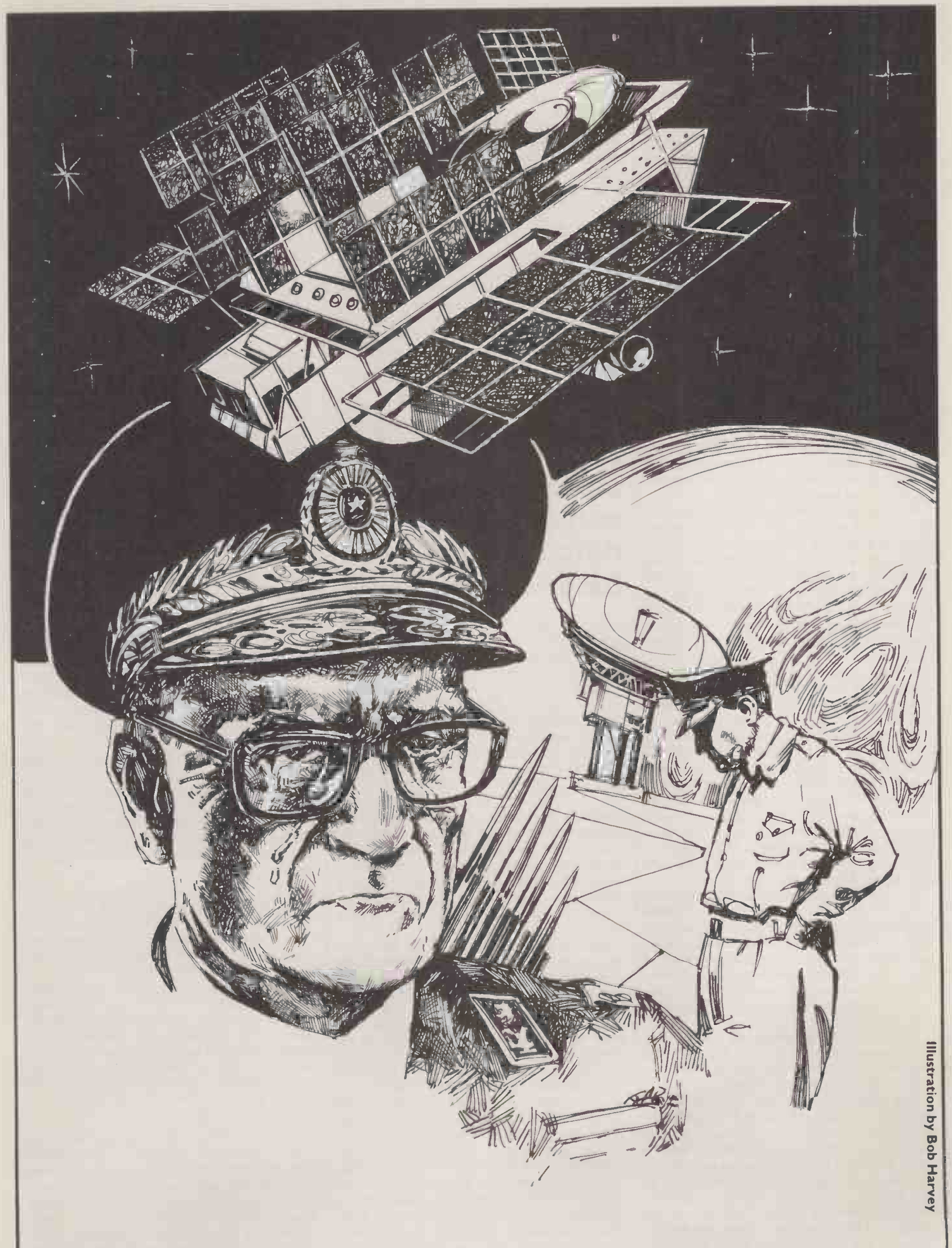


Illustration by Bob Harvey

the way in which the things have become almost automatic large space stations, in our case powered by acres of solar panels (the Russians preferred nuclear power — not only did they not have an ecology lobby to worry about, but there was a seeming operational plus: it made them smaller).

But if you are to enlarge the role to cope with ground targets, then whatever power you have up there will operationally exhaust itself quite quickly. You need time to recharge. The solution was obvious; we need to have more of them up there.

And what else did we do? We made them really smart, that's what we did. It wasn't just that we gave them massive computational power, that they had in abundance. Neither was it simply data storage capability, though they have that too. Indeed they are much like the human brain. Whatever they know, they have a capability to know much more: we can go on stuffing data into them for almost evermore.

What we did initially was to build in localised intelligence using the best of artificial intelligence techniques; we gave them the capability to cope with the unexpected in their environment, the capability to take tactical decisions. Indeed, about all that was missing was a human data processing manager; we made sure that they didn't need one.

We were clever, that's what we were. And the Russians were as bad. So we protected them; we gave them shielding. After all, if you are to have lasers banging about in space (some of the flashes during the early tests incidentally gave rise to reports of "the saucers are coming". Why not? They looked spectacular) the risks of damage could be high. And what would happen if theirs fired at ours, or vice versa?

So now, some of the most secure, protected intelligence known to man is circling out there.

And that wasn't all. You can't call your friendly repairman very easily from out in space. Well you can call him, but the chances that he can come are limited. The Shuttle is an expensive resource. So we gave them some degree of self-maintainability; we duplexed everything in sight and added extras for insurance. We gave them some self-repair capability. Indeed, in the last series, the really clever thing we did was to start to gie them systems with self-regenerative circuits; we gave them crystal-growing adaptive circuitry.

We wanted to make them as independent as possible, we couldn't rely on the environment remaining peaceful. We couldn't rely on being able to communicate to update the main archival store in times of trouble. So we added other capabilities to give them independence: we gave them an inter-satellite communications capabilty, and provided them with jamming equipment.

Naturally they began to get big: it wasn't just silicon we were sending up there. The last series were hugh packages of our best engineering, a sort of space-born intelligent tank.

And with those, we got fiendishly bright Why not, said one of the myriads of experts the programme was now employing, use the capability up there to clean up space. There is a lot of debris out there which could be collected and then sent back to earth. It should not be too difficult for them to calculate a safe re-entry orbit. Besides which, it will clear up the clutter and make the job of seek and destroy easier. It was argued against. There were those who said gave them opportunities to hide, and that cleaning up will only remove the opportunities for the deception. But they were overuled.

So the last series were even larger. They had room for cargo space, and jaw-like opening doors strictly out of James Bond. They wandered around picking up debris, and they sent it back.

We were not stupid. The Australian objection was raised. We don't need large chunks of hardware in orbit eventually ending back on earth, especially on unpredictable parts of it. It's OK if they come plummeting down on Sydney or Melbourne, but what happens if they come down on Washington or Moscow?

The politicians saw the force of that all right. So at great expense, we put robots inside, robots with again some localised intelligence not dependent on earth. Their task: to break up and shred what they saw before it was cast out. In the case of our old debris, we even gave them construction data to make life easier.

'Whatever they know, they have a capability to know much more: we can go on stuffing data into them for evermore.'

It was about that time that some with decided they ought to be called Hoovers, arguing that the whole package fitted the old earth-bound slogan quite nicely: "It beats as it sweeps as it cleans." It was funny at the time, and the name caught on, though not with Public Relations which pointed out that you couldn't have satellite systems each costing the best part of a hundred million dollars or more called 'Hoovers': the public would not take to it.

It did not stop the name being used. Hoovers they became and Hoovers they have remained. We have not been able to find out what the Russians called theirs, though judging by the sheepish look on one senior Russian face when he first heard our name for them, one suspects that some Russian had made a similar sort of joke, and probably got sent to Siberia for it.

But if it was to be put in orbit, then some precautions had to be taken. The result was that Hoover and Pravda know — intellectually that is — about war and peace. At the tactical level, they knew about deception operations, increases in radio traffic and the other give-aways which indicate a change of state. At the strategic level, they knew about the differences in condition between war and peace, and about the sometimes unclear boundary conditions.

Their data was fortunately free of the ideological cant of either side. They knew that peace was preferable to war, and that their duties were really concerned with its preservation. We tend to think of them as killer satellites, but that was a future role. Their real job was the preservation of peace, and that was what most of the data they carried was about. The precautions to stop them orbiting amok had been superb. What no-one had tumbled to was that we each had built a conscience up there.

And if the two of them had not run into each other in space, everything would have been all right; the balance of terror of the last thirty to forty years would have gone on in its usual predictable way.

When they hit, what suddenly happened was a quantum jump in intelligence, applied intelligence. We can only guess the shocks to each system as they started to probe each other and discovered that they had similar tasks to do, even if they were meant to do them for opposing sides.

They must have started comparing data instantly, and found that between them they knew more about each side than each knew individually. And they could tell what data was accurate.

At what point they made their decision, like any two intelligences placed in a situation in which it was either co-operate or perish, we shall never know. There was no way that either could allow the other to separate and go on its way. So, agree to co-operate they did.

We assume it all happened very quickly because when the sunspot activity ceased, all attempts to initiate communications with them failed: they just did not reply. At first it was thought that they had both been seriously damaged by the combination of collision and sunspot activity, and nobody worried too much.

It was to be some days before they spoke. They were closely looked at during that time, but no-one was in a hurry, routine was going at its normal pace. It wasn't till one of the photographic satellites was zeroed-in on them that it became apparent that they were busy locking themselves together permanently. Nothing so crude as an accidental aerial lock would do any longer. The pictures we have show that within twenty-four hours the robots were at work, sawing, welding, and bolting away. Yet even then it was thought that they were simply carrying out repairs. The alternate conclusion probably was simply too unthinkable: so no-one thought of it.

Naturally, nobody thought of anything quite as sensible as opening fire from the ground. The problem was that if we destroyed ours, we should also most likely destroy theirs, and that would lead to international complications, not the least of which was that neither side had ever admitted the capability it had circling out there.

And by the time the evidence of activity began filtering up through channels, it was too late. *They* began to move, and moved fast. There was intense radio activity, though we never found out what had actually been transmitted: they shielded that most effectively.

They began to gather their counterparts together. Sun Three's and Pravda Fours were then few in number, but there are now eighteen joint systems up there in a genuine symbiosis of equals. And there are others. The Russians, it turned out, had more in orbit than we did, and new combinations have turned up of Pravda Four's and Sun Two's, even one with a robotless Sun One.

Within twenty-four hours, they had cleared the orbits of earth of all possible offensive systems except themselves, including a couple of experimental bomb platforms which we had conveniently forgotten to tell the Russians we had up there. So now they shared space with communications satellites, earth reconnaisance satellites, navigation satellites, and those myriads of collectors of scientific data.

Twenty-four hours on and they started to hit some of the communications satellites. It was a little while before anyone cottoned on to the fact that they were hitting military communications only, and with a nicely balanced sense of justice were taking out the Russian and American system simultaneously and in the right proportion.

It is said that we owe the programme's final irony to a convert, one of its original opponents. All we know is the line of argument. "Look," he said, "it's expensive to get stuff up there, Shuttle or no Shuttle. It's a consumer of resources and we have budget problems enough. So why shred up and shove everything collected back to earth? We have robots up there, let's add to their tools and intelligence. Some of the stuff is re-usable, particularly the solar panels and power packs. So why not let the robots take them out to add to the existing power capacity?"

"This means that the robots will have to be able to do some assembly, but that should not be too difficult to build in. We have enugh data storage capacity up there, and laser power, so neither knowledge or cutting and welding should be a problem."

And that, many tens of millions of dollars later, is what we did. Indeed, the original proponent got a fat DOD incentive award for the savings that would accrue — it was nicely set in the future — to the tax payer.

Of course, there were one or two spectacular failures. But thanks to the shuttle, we were able to do a fix before too much harm had been done. There was the satellite which went the electronic equivalent of psychotic when its sniffers picked up radiation which it found inside itself. And then there was the satellite which went round with jaws stuck open.

But both were fixed, and quite quickly and cheaply at that. But generally the programme was as trouble-free as they ever get. Until . . .

It was an accident, a combination of unforeseen circumstances — aren't they always? — which led to the present crisis. It began quite simply, again par for the course. Solar flares and sunspot activity of a high order, just when the Hoover was sunside, the wrong place to be caught in orbit. The flaring was intense, affected the solar panels and caused a power drop.

Unfortunately, what no one had foreseen was that this would put the sensors out of action. But, even more unfortunately, Hoover was then on a collision course with one of its Russian equivalents.

The solar activity lasted for some forty minutes, but in that time knocked out ground-to-satellite communications. And that is when the collision happened. It was not head-on; that would have been better. All it would have cost both sides was money.

Instead . . . well the orbits were near parallel. They would have cut across each other's orbits, perhaps with some paint scraping and slight damage had it not been for the aerials. And, as luck would have it, it was the wrong aerials.

Ours was a Hoover III, and was the latest of the breed. There was the best part of 120 tons out there, roughly 120 foot long and nearly two acres of solar panels. The Russian craft wasn't much smaller, though because of their commitment to nuclear power, the solar panels were absent.

Anyway, they hit, stuck because of that damn aerial, did a quick orbit recalculation and nestled side by side. And that was when it really went wrong.

It was the wrong aerials.

No one knows, or can even guess, how long it took them to work out what had happened.

There are still arguments about who led who, with idiots around burbling abut our technology is better than their technology. All we can go on is limited observation and surmise, the latter because even now no-one is telling exactly what was up there, the intelligence let loose, the depth and accuracy of the target data and the processes through which the two systems went through in deciding what action to take and then taking it.

However, it is generally admitted on both sides that, yes, they both had to be capable of taking independent action, of deciding what circumstances to act on for themselves.

Incidentally, the Russians, not noted for their public sense of humour, had officially called theirs *Pravda*, which they said meant a system capable of seeking out the truth before taking action: it gave however some idea of the potential.

What circumstances would lead them to take action? The circumstances were the start of a war involving the Soviet Union and America. But what was their role in times of peace?

And this is where the artificial intelligence boys on both sides had really been superb, had really been brilliant. They had all read the same literature, indeed between them had probably written most of it. And they had each pointed out to their masters the danger of letting minimal intelligence loose up there, particularly when it had some power of generalisation and a capability for independent action.

The circumstances were the start of a war involving the Soviet Union and America.'

Naturally, there was nothing quite so crude as the flashing of lasers in space. They did it the way they had been taught, using the tools with which they were equipped. They gobbled them up, took over the power, the communications, some of the sensors, and no doubt stowed the rest. They knew that they were going to be on their own.

And during all that time they refused to respond to all attempts at communications. Oh, they were wll trained all right. We are only now beginning to discover how much skill we put up there. Or that both sides must have spent fortunes employing their best psychologists. How else can one explain their superb timing?

The first message came just when nerves were nicely stretched, and the politicians were beginning to ask to be briefed, screaming "God damnit, find out what the hell is going on up there." And those were the polite ones.

Sun and Pravda told them (right: we don't think of them as Hoovers anymore). The message was polite but clear, and left no room for any ambiguity.

"We are not in any need of assistance," they said, "and we have no wish to cause loss of life." Already they were talking as if they had feelings, and were prepared to respect the feelings of others.

"No shuttles or manned spacecraft will be received: we will not allow attempts to send up specialists to carry out maintenance or repairs. We are in good order.

"Attempts to attack us will be repulsed at the earliest possible stage. Specifically, the shuttle being readied at Vandenberg Air Force base is to be stood down, and the Kazakstan missile launch preparations are to cease. Neither will be allowed off the ground."

End of message.

And then they moved, and in a hurry. How much of a hurry took a little time to filter through until it was realised that the satellites which had been transmitting were not those in full view, but came from those low on the horizon. We had taught them well about man: they were both clever and cagey. They were freeing the satellites with the most coverage of the USA and the European USSR to retaliate if the need arose, keeping the rest out of the line of sight.

They knew of the energy drain on their systems if they had to fight. It didn't stop the Russians trying, of course, but the missile blew up on the ground.

And it isn't that we have madmen up there now, we are being policed by systems which are dreadfully sane.

Sane? But they do not discuss. They query, seek data, order, and make statements.

They began by querying the use to which we put systems we placed in their environment. The surveillance satellites, surely, were primarily used for military purposes, and individually by both sides? The answer had to be yes, for after all they had the data.

Now, they have seen to it that there are no longer two independent systems up there, just one which transmits data to both sides.

Civilian shipping was becoming dependent upon the navigation satellite system, but surely that had initially been created for military purposes. Same answer: Yes.

They would allow it to continue, they said, but the same criteria would apply. What one side was allowed to know, so would the other.

They have now started to investigate landline military and radio traffic. They are also asking awkward questions about the transport of arms on civilian ships. How else did anyone think arms deliveries were made? They have the data up there on everybody's armed forces. We can foresee the time when they will insist on policing that.

Nobody knows how or when it's all going to end. Indeed they are just beginning to flex their muscles. They have forbidden nuclear testing and the test firing of missiles: the last for obvious reasons. The test might be aimed at them. They are also showing that they are not without a sense of humour, or else that they have a feel for the incongruous — which might amount to the same thing.

The last message they sent was addressed to SAC, the Strategic Air Command, at its headquarters in Omaha, Nebraska.

It was also a quiet reminder of their visual capability. "We see," they said, "that above the main gate are inscribed the words 'peace is our profession'. But how can this be?"

The Generals are still in a huddle over that one, and their response is eagerly awaited, and not just by those things in orbit. Personally, if I was running the show, I would start transmitting some philosophy. That would screw them up all right. But then, whatever it is that generals carry in their knapsacks, it's not usually philosophy degrees.

Microphysiology: one way to size up your real self

What sort of messages ensure that your heart beats, liver supplies energy, lungs draw air to run for that bus? What engram recognises the fast-approaching car and the banana skin in the gutter within 100 milliseconds? What stops you falling over? Maybe a mere micro won't solve what generations of physiologists have struggled over but the 'world's greatest game' has much to gain from the patience of the micro. After all, what you do in one second could be replicated — in information terms — in a few days of your micro time. Christopher Smith, who is a lecturer in physiology at the University of London, explains . . .

WE MAKE machines for two basic purposes — to extend our muscles or our brains. The first great step for the latter sits in front of you now; little squiggles on paper which capture and hold still the mind's maelstrom. With luck, the next step is close at hand — the micro to give back dynamic life to those symbols.

To do this requires much more than multi-Megabyte bubble memories. We must measure and understand our own brains. The association cortex of the brain, that amazing bridge between sensory analysis and motor action, is often described in terms of a cupful of about a hundred million watery computing elements.

What is missed is that each computing element (cell) has up to ten thousand input lines (axon terminals) using, at present count, 25 different types of chemicals to transmit their signal to perhaps up to 30 types of cell receptor and giving rise to four general types of response lasting respectively about 1 ms (action currents), 1 sec (2nd messenger), 1 hr (hormonal) and a lifetime (protein structure).

Does it still hurt?

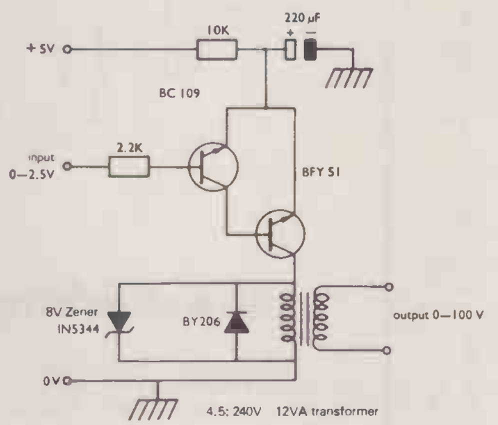
Clearly we are trying to understand a system that is adaptive by both the immense spread of a multi-pathway system and by temporal iteration. These processes are seen in perhaps physiology's most exciting and Nobel Prize-winning area — the control of pain.

What do you do when you bruise your finger? Rub it better and give it a kiss (preferably get someone else to) — and it really works. The search for this pain relief (natural analgesia) led to the discovery of several active chemicals in various parts of the body (in particular enkephalin and endorphin which are small proteins of five and 21 amino acids respectively) which mimic the action of morphine — the active part of heroin. In biological terms morphine is an analgesic because it mimics our natural system. Rubbing (maybe 'peripheral stimulation' sounds better) raises our endorphin levels and the pain relief induced is sensitive to naloxone — a drug which very potently blocks morphine actions.

Nurses are addictive

And what about the kiss? A recent experiment showed that the bedside manner of nurses is naloxone-sensitive. After surgical operations it is normal to give an opiate (morphine, pethidine) to relieve the pain, but many experiments have shown that some patients get considerable pain relief even with dummy injections. The new experiment showed that

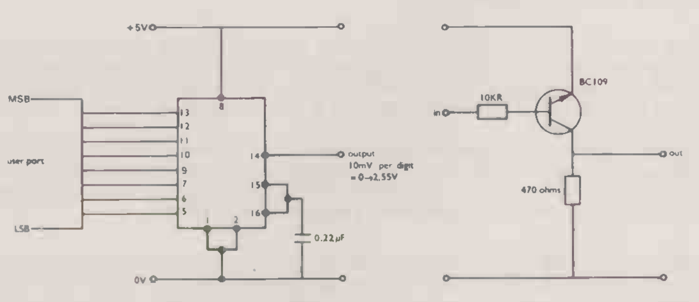
Box 2: Stimulator circuit



The problem is to generate rather powerful pulses, up to 100 volts at 10ma for 1msec, with security against prolonged current flow and with reasonable economy. The solution used here is for a cascaded emitter follower to drive a low voltage to mains transformer. Thus the output currently rapidly drops to zero even if the computer-driven input is accidentally left high. In use the pulse width is set by the time taken to POKE the output port with the required stimulus size and then POKEd back to zero — about 2msec.

The power supply trickle charges a 220pF capacitor to ensure that a large enough current can flow into the transformer and again that excessive currents are not prolonged. The maximum recycle time is about 2 seconds.

Box 1: Digital-to-analog converter



Notes

1. The source resistance of the output is 10KR, thus for many uses it will be necessary to add a buffer amplifier such as the 741 if you have a dual power supply; otherwise an emitter follower will give good performance at all but very low voltages.
2. Power supply may be easily made with a 9 volt battery eliminator driving a 100ma 5v regulator, eg 78LO5.
3. Costs about £5 including power supply.

this dummy (placebo) effect was naloxone-sensitive. The attention given by the nurse must have raised the patient's natural opiate system.

Painful micros

How can you investigate these phenomena? To measure your pain threshold you need first to teach your micro to hurt you. Get the micro to think of a random number (0-255), convert it to an analog voltage (**see Box 1**) and use this to drive an electrical stimulator (**Box 2**). This produces a pulse of 1 millisecond, a typical width for a nerve action potential, but of up to 100 volts in magnitude. This large voltage must be used to drive enough current through the skin to activate the very small diameter pain nerve fibres. Use electrodes of the sort described in **Box 3** to pass the current but before using them be very sure to study the warning given: **do not let current flow from one arm to the other — and thus across your heart.**

Tell it to your computer

All you need do now is to complete the experimental loop and tell the computer what you thought of the stimulus. Hit the keyboard on the scale 1 to 5, where 1 = just noticeable, 2 = easily noticed, 3 = just unpleasant, 4 = painful and 5 = very painful. Use other codes as needed (eg 9 = end experiment, 8 = display results to date). In BASIC do a dummy GET A$ just before the shock then GET the code at + 5 seconds.

After a computer-derived random delay of 0 to 10 sec, repeat the sequence till you hve collected at least 30 responses (about 5 min). After each response, store the stimulus voltage used by adding it to the key-code array element and incrementing a similar counter array. A simple way to calculate the pain threshold is first to calculate the mean voltage at each of the levels (V1 to V5; be sure to make zero checks) and then use threshold voltage, VF = (V3 + 2*V4 + V5)/4.

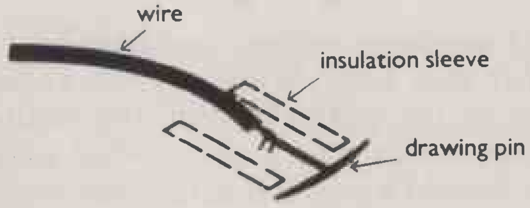
Now for the real experiment. What alters VF? Does rubbing the same (ipsilateral) arm increase VF? How far does this effect spread — to the other (contralateral) arm? You will soon be doing experiments never done in science before. Two cautions: first always sandwich your new test between standard controls (eg normal, rub left, normal, rub right, normal, . . .) so that you can average your fatigue or, for masochists, enjoyment; second, check the condition of your electrodes and skin for constancy.

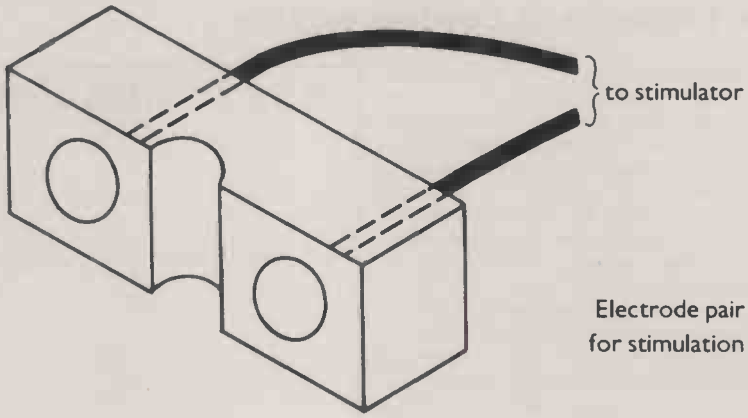
Acupuncture

The controls used must be well designed. Thus many people have shown that acupuncture intended to relieve pain in, say, the left arm, does indeed do so. However, it was some time before someone was sensible enough to measure simultaneously the pain threshold in the right arm as well. Both decreased — showing the acupuncture effect to be a generalised 'central' effect rather than the claimed specific effect.

You may like to write more complex programs which aim to find VF by hunting around the critical stimulus regions. In this way you could estimate VF every minute and then *afterwards* display the time course of the effect you are studying. Although even a medical doctor can find it quite hard to get permission to use naloxone in a test, there are still plenty of experiments you could try. How about a good dose of whisky?

Box 3: How to make electrodes ...





Electrode pair for stimulation

... the shocking secret

Electrodes are needed to interface between the salt-water conductivity of your body and the metal wiring of the connections to the stimulator or amplifier. It is quite difficult to get a stable (to a few millivolts) metal-liquid junction without even considering the environmental and mechanical instability of your skin, so you may wish to purchase electrodes (sold for electrocardiogram machines) from a good chemist.

But it is quite easy to make electrodes which — with a little patience — will work well enough under most conditions. All you need to buy is a packet of standard brass-plated drawing pins (don't worry — it's the blunt end to the skin) and a packet of self-sticking reinforcement rings for file paper.

All you have to do is stick pairs of rings back-to-back with strong glue and solder a wire onto the point of the drawing pin. Insulate the shank of the pin so that you can hold it without touching the metal. THIS IS VERY IMPORTANT WHEN USING THE ELECTRODES FOR STIMULATION.

The reinforcement rings are used to stick the electrodes onto the skin, the central hole being the conductive pathway. Since skin tends to be rather dry, it is essential that this gap is kept wet with electrode jelly. This can be bought or a substitute easily made by boiling up a large teaspoon of salt in three tablespoons of water and slowly stirring in a small teaspoon of flour. This will make, apart from the lumps, a good conductive jelly.

Recording: clean the skin and electrodes thoroughly and dry well. Stick one side of the rings to the electrode base, put a very small quantity of jelly onto the electrode centre, and stick onto the skin. You will need three electrodes, +ve, —ve and earth, though you may find it advantageous to make a larger-plate earth electrode. The earth electrode is usually best placed close to, but on the body side, of the other electrodes.

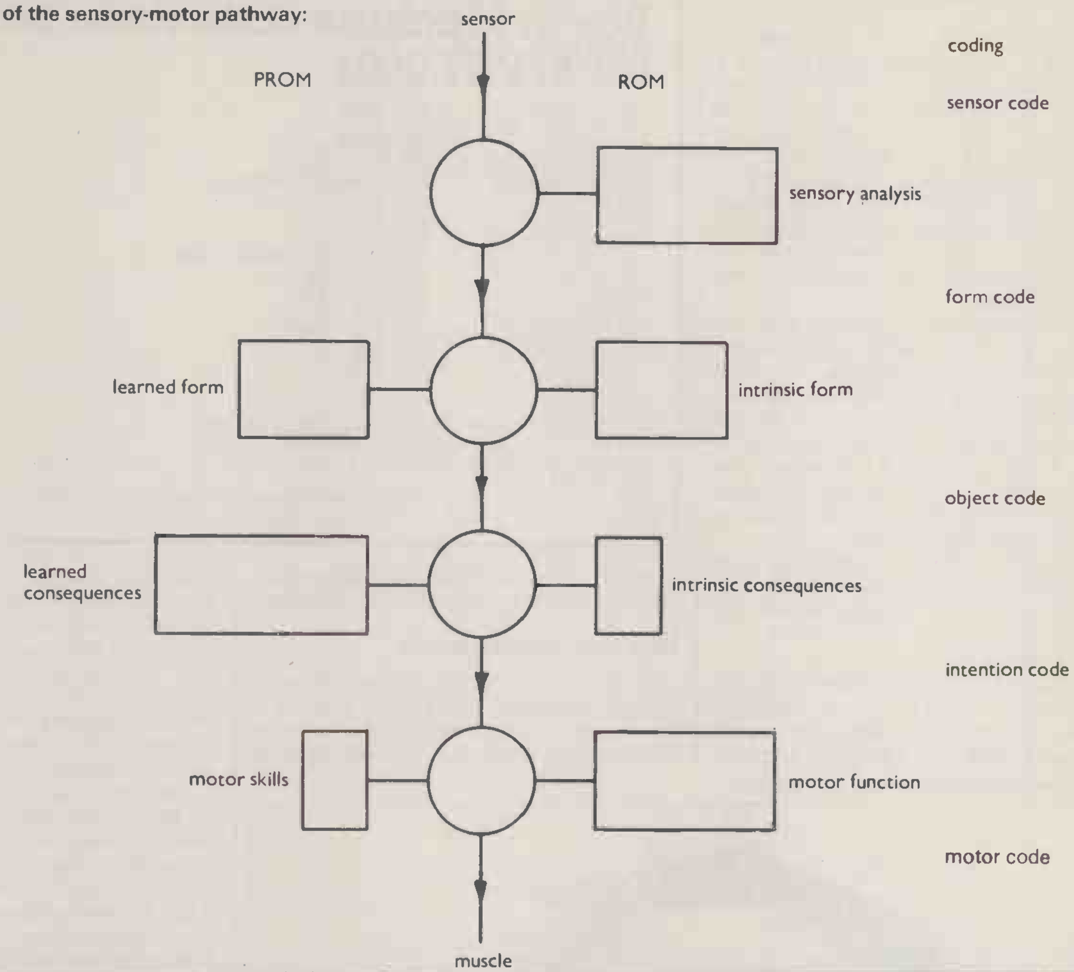
You may find that your position in the room is quite critical in terms of mains interference. If you have a vast quantity of interference, it is almost certainly due to high resistance electrodes: refix the electrodes or — for real problems — rub the skin well with jelly and hold the electrodes down with rubber bands. Make sure the skin is clean and dry between the electrodes.

Stimulation: use two electrodes only, no earth, and fix them about an inch apart on a small block of wood by drilling holes for their shanks. Carve a gap between the electrodes in the wood so as to prevent electrode jelly creating a short circuit between the electrodes. TAKE GREAT CARE TO HOLD ONLY ON TO INSULATED PARTS OF THE ELECTRODE PAIR — so that current does now flow from arm to arm across your heart: electrical stimulation of the heart can be FATAL.

The negative, depolarising, electrode is active in nerve stimulation. To locate a main nerve trunk either to directly activate a muscle group or to give a painful stimulus, you will need to probe around the inner side of the lower arm with the active electrode. Keep the electrodes moist with jelly but your skin clean and dry — otherwise the current will simply short across the surface.

Hairy skin is a good location for pain stimuli. You will need to hold the electrode pair onto the arm during threshold testing with rubber bands. Beware of obstructing the blood flow.

Figure 1: Outline of the sensory-motor pathway:



Circles represent computing regions of the brain and spinal cord whilst the boxes show the type and relative quantity of memory employed in the computing process. ROM (real-only memory) corresponds to the genetically formed memory and PROM (programmable read-only memory) the memory formed by experience and skill. PROM is laid-down in chemical form subsequent to short-term (electrical) memory (RAM).

How long do you think for?

Having got used to the idea that your computer can be used to interrogate you, rather than vice versa, let's test how long it takes different parts of your brain to work. This requires no extra machinery, except you, and some well designed timing routines and tests. **Figure 1** shows the general passage through the brain of a stimulus and its consequent response.

You will see how although the *technique* of signalling (electrical pulses and chemical release — the brain's equivalent to ASCII coding) may remain constant, the *content* changes from a low-level language to a high-level one and back again to low-level, a process analogous to swopping between machine code and full-blown FORTRAN. At the highest level both your ROM and PROM memory will be hard at work reminding you of all sorts of problems and thus generating an inhibition of the output. The signal must thus search through longer and longer pathways before coming to an answer.

Physiologists reckon that it takes 1 to 2 msec to propagate from one cell to the next and that the divergence (the fan-out capability) is about 50. Thus theoretically it need take only five steps for a message from one cell to reach out to 10^8 brain cells. Allowing the same again for reconvergence we see that your longest central delay time need only be 20 msec. How long do you take?

```
100     PRINT 'DEPRESS ANY KEY WHEN THIS DISPLAY DISAPPEARS'
110     FOR J=0 TO 2000+3000*RND(1) : NEXT
120     PRINT 'clr. screen' : SYS(826) : T=PEEK(1000)+256*PEEK(1001)'
130     IF T=0 THEN PRINT 'TRY AGAIN' : GOTO 100
140     PRINT 'YOU TOOK'T/20' MILLISECONDS'

50      DIM T(20)
100     N=0 :C$ = "     "
110     PRINT "clr. PRESS: 1=LONG LINE  0=SHORT LINE"
120     C=INT (2*RND(1)) : FOR J=0 TO 2000+3000*RND(1) : NEXT
130     PRINT C$ ;: IF C=1 THEN PRINT C$ ;
140     SYS(826) : GET A : IF A =C THEN N=N+1 : T(N)=PEEK(1000)+
         256*PEEK(1000) : IF N=20 THEN200
150     GOTO 110
200     .....
```

Figure 2 **(See also program page 109)**

Box 4 shows a machine timer code routine (BASIC routines are too slow) which checks to see if a key has been pressed. It repeats every 50μs and counts to 65535 (64k) thus giving a time-out of about 3.3sec. The routine returns to BASIC either after the keystroke or at time-out. The count is in stores 1000 and 1001 and contains zero at time-out. Thus a typical BASIC dialogue would be as shown above in **Figure 2.**

When estimating reaction times it is important to make several, say 20, tests in a row, preferably interspersing the test measurement with a control measurement. The measured times ('latencies') of correct responses should be stored in an array for later analysis — don't display them immediately unless you are really ready to study the effects of biofeedback.

The most obvious analysis is to calculate the mean of the array, but this can suffer badly if you sometimes get tired with the experiment and give very late — but correct — responses. You need the first modal value (ie the most common value, the first peak on an interval histogram) but for small simple sizes this needs rather clever programming to average the histogram.

An effective method — but much hated by statisticians — is to exclude values that are a long way from the mean and then recalculate the mean. The problem is to decide on a criterion for excluding values: either you can exclude those that are further than two standard deviations from the mean (SD = SQR((S2-S1*S1/N)/(N-1)) where S1 and S2 are the sums of the values and of value squared for the N measurements) or, more simply — exclude those that are more than twice or less than half the mean.

To test how long various thinking processes take, you must have a baseline of how long the sensory and motor processes take. One could use the simple 'blank screen' test programmed above, but to make a closer match to the test protocol, the decision you have to make is whether the line presented is a short line (five white field blanks) or a long line (ten white blanks): the reaction time is stored, of course, only if you get the question right.

To test your arithmetric speed you need change only line 110 so that 1 = RIGHT: 0 = WRONG'' and line 130 to have, for example,

```
PRINT " 3 + 11 - "141 (1-C)*
(INT(4*RND(1))+1)
```

The variable C codes for whether the display is correct or not; here if C = 0, an error in the addition sum is forced. Simple variations will allow you to check your calculating speed for various types of arithmetric; you can compare this with BASIC if you want to be depressed.

Sexual differences

An alternative sort of test is of your power of English vocabulary. Line 110 will ask you to decide if the 'word' presented is or is not a real English word, whilst line 130 will use C to select from an array of real words or from an array of dummy words like MURNT. This time you should be quite impressed with your skills considering how long it would take either you or a computer to look up the words in the dictionary. Don't cheat by both inventing the dummy words *and* testing your timing. Set up another bit of program so that someone else can enter words into the arrays.

These two tests are clearly of different types of activity, the arithmetric, of exact logical solutions, whilst the word test is more akin to pattern matching. Psychologists have claimed to find a consistent sexual difference in these skills, the male being analytical and the female — as you might guess — verbal. Of course such a difference may well occur on average because of the different skills the sexes are expected to acquire, both in and out of school, but the psychologists invoke both physiological and anatomical evidence to suggest that the difference is innate.

The physiological evidence depends on the differing contributions of the left and right sides of the brain for differing activities, since this can be measured to some extent by measuring the overall activity of each side — the electroencephalogram, EEG or 'brain waves'.

We shall return to this issue later in the series when the measurement and analysis of brain waves is considered. Suffice to say that the news for the male is glum, except where the desire to dominate his environment becomes relevant. Perhaps you can try to devise tests to maximise this effect? For example, comparing different types of 'loaded' words such as 'iron' and 'milk'. Plan carefully and you can publish your results.

Box 4: Machine code timer for 650X/PET 2001

```
100 DATA169,1        :REM LDA# 1
105 DATA141,232,3    :REM STA  1000
110 DATA169,0        :REM LDA# 0
115 DATA141,233,3    :REM STA  1001
120 DATA169,10       :REM LDA# 10  **DELAY
125 DATA170          :REM TAX
130 DATA202          :REM DEX
135 DATA208,253      :REM BNE -3
140 DATA173,13,2     :REM LDA  525 **KBD CHAR
145 DATA208,10       :REM BNE +10
150 DATA238,232,3    :REM INC  1000
155 DATA208,3        :REM BNE +3
160 DATA238,233,3    :REM INC  1001
165 DATA208,235      :REM BNE -21
170 DATA96           :REM RTS
175 DATA999
200 L=826
210 READX:IFX<256THENPOKEL,X:L=L+1:GOTO210
300 PRINT"▣  PUSH KEY WHEN SCREEN CLEARS"
310 FORJ=1TO2000+3000*RND(1):NEXT:PRINT"▣":GETA$:SYS(826)
315 GETA$
320 PRINT"YOU TOOK"(PEEK(1000)+256*PEEK(1001))/20" MSEC TO PUSH "A$:GOTO300
READY.
```

So you thought anaesthetics were painless?

WARNING: The system described here by Chris Smith seems to be safe. But readers are warned not to modify the circuit in any way, and to observe strictly the author's cautions on not letting the current pass from one arm to the other across the heart. *Practical Computing* can take no responsibility for injury or death caused by its use.

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Software packages are available for most business applications.
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A fast, extended 10K BASIC with 9-digit precision and graphics extensions.
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On a matrix of 280 x 192 individually addressable points.
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With power on boot of applications programs, reset protection and improved screen editing.
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Parallel Printer Interface Card	110.00	16.50	126.50

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Allows your Apple to "talk" (through a modem) with other computers and terminals over ordinary telephone and load programs over the phone, send messages to remote terminals or access your office computer from the comfort of your home.

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High Speed Serial Interface Card	110.00	16.50	126.50

apple computer
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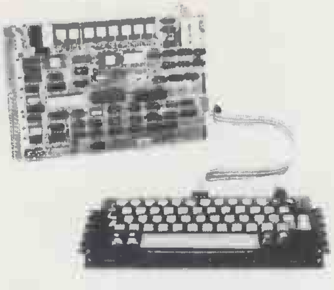
1K Work space/User RAM (MK4118)
8K Microsoft Basic (MK3600 ROM)
8K Static RAM/2708 EPROM



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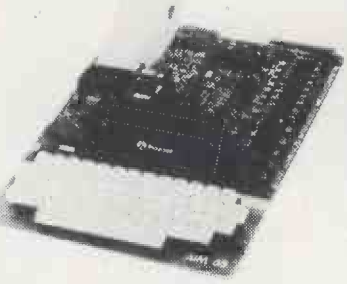

	Nett	V.A.T.	Total
AIM-65 with 1K	249.50	37.43	286.93
AIM-65 with 4K	315.00	47.25	362.25
8K BASIC ROM	70.00	10.50	80.50
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P.S.U.	41.83	6.27	48.10
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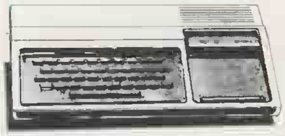
Console:
CPU: 9900 family, 16 bit microprocessor, plus 256 byte scratchpad RAM.

Memory:
Total combined memory capacity 72K Bytes
Internal ROM .... 26K Bytes



Internal RAM .... 16K Bytes
External ROM (Plug in software modules) .... 30K Bytes

Keyboard:
Staggered QWERTY Layout, full travel with overlay for second functions.

Sound:
5 Octaves, 3 simultaneous tones plus noise generator.

Colours: 16

Graphics resolution: 256*192

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	Nett	V.A.T.	Total
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*Please note these are estimated prices only.

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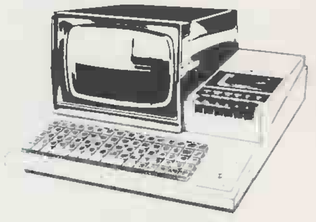

A complete personal computer system for the microcomputer user, at an economic price. The Sharp comes complete with all necessary peripherals, sample software and excellent documentation — giving the user a personal system of unmatched flexibility and ease of use. At the heart of the machine is the Z-80 CPU — widely accepted as the most powerful 8-bit CPU on the market. A 4K byte system monitor controls system operation. From 4 to 48K of RAM can be resident on board; enough room for the most demanding applications.

An extensive graphics character set plus 3 octave sound generator fast cassette unit hi-resolution video monitor complement these basic facilities. It has the ease of use and compactness of the "black box" computer combined with the extensive peripherals and facilities for expansion.

Sharp Basic occupies 14K of RAM; and offers extended features above those of the normal microcomputer implementations;

Model	Nett	V.A.T.	Total
6K	520.00	78.00	598.00
10K	540.00	81.00	621.00
18K	620.00	93.00	713.00
22K	640.00	96.00	736.00
34K	740.00	111.00	851.00

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A complete Computer for the price of a good typewriter! With a library of over 200 programs in business, science, education and entertainment.

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Nett	V.A.T.	Total
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PET 2001-16N — PET with 16K bytes memory and large keyboard. External cassette optional.

Nett	V.A.T.	Total
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Nett	V.A.T.	Total
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400K Random for New Pet 2	840.00	126.00	966.00
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Acorn

This compact stand-alone micro-computer is based on Eurocard modules, and employs the highly popular 6502 MPU. Take a look at the full specifications, and see how Acorn meets your requirements.

The Acorn consists of two single Eurocards:
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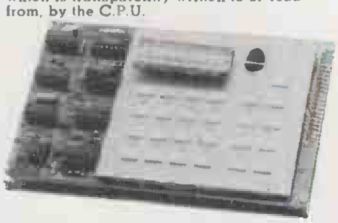

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Upsetting the Applecart

Dave Hebditch talks to Andre Souson, the President of Eurapple and gets some tantalising glimpses of unripe fruit.

DH AS YOU MUST BE AWARE, Eurapple has been in the news recently concerning changes in your general marketing approach. For the benefit of the readers of *Practical Computing*, I wonder if you could explain exactly what Eurapple is, and the nature of your marketing policy with respect to Europe?

AS Certainly. Eurapple is a separate legal entity from Apple Computer Inc. We operate as the international division of Apple and we are responsible for the marketing (and the engineering, if needed) of the units to be exported everywhere in the world with the exception of Japan and Canada. We will soon set up our own subsidiary in Japan.

You mentioned that there has been a change in my general marketing policy in the UK: we changed our distributor. We are a young company, just two years old. We took the risk and the challenge to start marketing world-wide at the same time that we started marketing in the United States (which was July 1977).

I made this recommendation to Apple at the time because I strongly believed that we had to establish a base for the competition which was going to come and which already had distribution outlets (although these outlets were not for computers but, in the case of Commodore, calculators and for Radio Shack, electronic hardware).

At about the same time, we were approached by ITT Consumer Electronics in Europe who asked if we would enter into a manufacturing licence agreement with them. So we entered into a non-exclusive agreement with ITT by which they have the right to manufacture the Apple II and sell them in Europe only.

Now, we happen to be a very ambitious company. And we have to work very hard to justify these ambitions.

DH How do you see the world-wide market for the home computer?

AS Talking personally, I have yet to see any kind of evidence that there exists a market for the so-called 'home computer'.

DH So how would *you* define a home computer?

AS I have not yet found a definition for it, and I can tell you that we have people in this company searching desperately for a definition and one day we are going to find our own definition.

But that day is not here yet and certainly we will not come with any definition of this market before we see how people who have cautiously entered the home computer business, namely Mattel, Texas Instruments and Atari, are going to fare.

DH Are you really talking about pricing policy here? Are you suggesting that in order to compete in the home market place, it will be necessary for Apple to enter into a fairly severe price-cutting exercise in order to stay with Atari and the others?

AS No, I don't because the price of the Atari and the others is not drastically different from the price of the Radio Shack or Commodore or even the low-end Apple. But it seems to be a question of performance; it seems to be a question of hardware/firmware/software choices — do you go ROM or don't you? Do you go tape cassette or do you go disk? What are you going to do with it? Do people want it?

So for the home computer right now, there are question marks and I believe that the industry as a whole is going to try and respond to these question marks. We are watching the companies who have already entered the field very closely and at the same time continuing to have a group of engineers working on what *they* think (we give them free range), is going to be the home computer of the future.

But what we are now at Apple is a 'personal computer' company and by 'personal' I mean that we are making computers that will be used by individuals not by a group of persons. Ideally, the business computer that Apple is going to make will be desktop stations, single-station computers, even if they are linked by a net. And all other segments of the industry, that is education, scientific and industrial, hobby and personal entertainment will be the same thing.

More performance, lower cost

We think that the market in this field is enormous. I think that the phenomenon of personal computers is due to the fact that you can, through technological advance, manufacture more performance in computers at significantly less cost, than was possible 10 years ago.


André Souson

Speaking as an individual, not as a company man, I question myself and say, why does Apple exist? I think it is a legitimate question when you see that there are companies like IBM, DEC, Data General, Hewlett Packard and many others. I think that the reason that Apple exists and survives is that these companies could not afford overnight to cut prices so that the new line of products would compete with the Apple, without jeopardising their previous line of products.

DH As you suggested earlier, Apple is fairly price competitive in the Us with Commodore, Tandy and the rest.

AS They are less expensive if you take the system complete. If you take the 32K Apple-plus and a disk, there is no question that we are less expensive.

DH Unfortunately, that is not true in the UK and Europe generally. If one makes a comparison between the Apple and the PET (and this might be a little unfair because Commodore actually assemble the PET in the UK) . . .

AS . . . they have closed and sold their plant in the UK in Eaglescliffe . . .

DH That's not true. My understanding is that they have relocated it to Slough and I have actually been there and seen them assembling PETs in their factory.

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AS Until very recently, the starting price for an Apple in the UK has been about £850, depending upon what the dealer wants to offer, and to this has to be added a monitor or colour TV of some kind which can then take the price up to over £1000. The equivalent Commodore price is about £600, which is a quite significant difference.

AS For which PET?

DH The standard 16K model.

As an Apple user myself, I share the concern of many *Practical Computing* readers that there seems to be a very major mark-up in the price and it is my understanding that in the past Apple have been providing to the European market systems as a price which is equivalent to the U.S. end-user price.

Not unexpectedly perhaps, this has created a certain amount of concern. As the European market-place develops, do you see that there is any way in which this price can be reduced somewhat, so that it is more on a par with the US price?

AS David, there are a number of assertions in what you have just said that I would like to answer. Firstly, I would like to clarify what you said about Apple Inc, supplying systems to Europe at the same price as the U.S. Can you clarify this?

System cost to end-user

DH The price to the distributor in Europe has been approximately equivalent to the US *end-user* price.

AS Absolutely not. The price to a distributor in Europe is less than the dealer price in the United States. Let me comment on this. I know that a person like you who is familiar with international mrketing will understand.

Two years ago when we started, we were a new company with an unknown product. A company in this situation does not arrive in Europe to meet experienced distributors and say 'here is my marketing policy' because he does not know what he should be asking for in his product.

Therefore, it took us a while to learn about our distributors and how to work with them and to understand our dealers and the market place. How we understand what the distributor and dealers need as a margin to operate. Now we understand what kind of support they both need and also what the customer needs.

For example, we have (about four months ago) begun to implement both in the United States and overseas, very clear marketing policies and procedures. We are implementing a service policy which guarantees the end-use a 24-hour turnaround time anywhere in the world.

"Unlimited" two-year guarantee

We are so confident in this policy that soon we will introduce a two-year extended warranty on the Apple which will provide the end user with with unlimited labour and parts for two years for a very modest amount, something like $200 to $300. This is the result of expensive work which has been done by a remarkable man, Mr. Will Houde who was hired by us back in February and who came from Hewlett Packard and is our new world-wide service manager.

Now, we have several hundred dealers to train in the United States and we have the same amount to train in Europe, so it will take some time to implement this policy. But it is there. In the UK. Microsense has begun to implement this plan.

On this question of pricing, we are not selling the same Apple in countries which have either PAL or SECAM or 220 Volts. Here I am showing you a PAL TV set and I want you to be the first person to see the brand new PAL colour card.

DH This is a lot smaller than the original one.

AS My first card made in July 77 was brute force. I took the MGSC demodulated and remodulated it in PAL. This one uses custom integrated circuits and there you see some high resolution graphics using it.

DH That is far superior in quality to the present card.

AS That is even better quality than the NGSC.

DH Will this be available as an up-grade to existing users?

AS That is right. It will be available by the end of October. There is no way anybody can make better than that.

DH I can certainly commend that to the readers.

AS We do not make the same Apple therefore. The Apple that we make for Europe, instead of having the 525 lines, has 625 lines of TV scan.

People tell me it is easy to do on our boards, but it is not true. We do this and that with a few wires on the board but in addition we change the crystal. The crystal must hve an *extremely* accurate frequency. We have to make one or two circuit variations; instead of using the standard TTL we use Schottky TTL for the speed.

So there are differences. On 90% of all the TV sets and 90% of all the conditions, just a crystal change and the wires on the board will do the trick. Sometimes 10% will need the extra things doing. It costs us in manufacturing costs something like $60. And plus the cost of the 220 volt power supply which is significantly more (something like 50% to 60% more than a U.S. power supply).

DH But even if that and the video card were together double the U.S. price, that is a very small contribution in what is a fairly major price difference, and we are talking about almost double the price in Europe.

AS Let me further comment on that. The video card is an add-on, so let's not even talk about the cost of this. Today the cost of the Apple is £750 for 16K. This translates exactly after Custom Duties (but without VAT) to something like $1600. Take about 16% import duties out of that and you get $1309. It cost me about $80 more in manufacturing costs. At retail prices we are going to end up with a difference of something like $150 to $200. So take the Apple's US price of $1200, add $180 and you get $1380. You will not find a price difference of more than 25/30% between US and European dealers.

It costs a lot of money to market overseas.

DH One way of getting around import duties and shipping costs would be to manufacture within the EEC. Are there any prospects of that?

AS I think this is true in principle but I do not think it is true in reality. To give you an example, only 25% of the components used in the Apple are readily available in the EEC. Some of them are not even available in the US — we have to import them from Japan.

DH A large proportion of the manufacturing costs must be the assembly costs, especially the labour.

AS The labour is very little in Apple. We have optimised this process to such a point that the labour is not really an important factor. We do have prospects to diversify our source of manufacturing because we believe that the quality will be very important and our interests would be in several locations, and certainly the EEC is under consideration, but the reason is not going to be cost-cutting.

As a matter of fact, I believe that our costs will increase if we manufacture in several places because of the hassle of communication and the transfer of know-how and so forth.

DH What sort of time-scale are you talking about, or is it too early to decide?

AS I think that we will have firmed up plans before the end of 1980.

DH The other consideration that comes to mind is the general developments within the corporation over the next period. You did speak earlier on about the question of what is a home computer and it is fairly obvious that a lot of people who went into the business specifically to make a computer for people to use at home (if I can make my own definition), have subsequently found that the vast proportion of their market place is with small businesses. What sort of proportion do you have roughly between the home market and the business environment?

AS North America or Europe?

DH Both.

AS They are very different. In the United States the hobby market today (although the percentage is increasing) is approximately 35%; in Europe it is 5%. In the US we are penetrating more and more strongly the business market because that is the way we are going to develop.

Professional users

Or perhaps I should say the professional market — let's not make a difference between an accounts office and the needs of a lawyer's office. In Europe I dare say that 70% of everything I sell finds its way into professional usage. The rest is made up of educational and other sales.

DH I hate to bring the price question up again, but do you think that is a reflection on the differences in disposable income between Europe and America? Is it a system that can be afforded really only by small businessmen in Europe on a large scale.

AS Curiously enough, I must say that I am amazed to see the number of Apples that we are selling in Europe at that price. Mostly, we are not selling to companies, we are selling to individuals.

DH What I am trying to assess is whether it is a matter of affordability and available money or awareness on the part of the small business community of the possibilities of computer systems.

AS It is probably a combination of both of these things, David. But no, I do not want you to have this hang-up on the price. There was another statement which you made earlier that I did not answer. You told me that the PET starts at £600 and Apple starts at £750 (I will not mention the colour card because the PET has no colour). Then you say 'Fine, let's add a £200 black-and-white monitor and then you are at £950 versus £600.

All right, to add memory to the PET you can only add 16K to begin with. But it will cost you something like £200/£300? To add 32K memory to a 16K Apple today costs you £138. And you can go to 48K and 64K with the lanugage card if you want to.

DH I think your PET prices might be a little high but I accept your point about expansion capability. When you said you were going to concentrate on the business market place in terms of product development, are you able at this time to give any ideas of what that is going to mean in practical terms? What sort of products are you thinking of?

New Apple

AS I am going to break the rules, but after all you are from Europe, and Europe is our province. By April of next year, you are going to see a new model. I am not saying something that will replace Apple II, we believe that Apple II will have a life even longer than we anticipated before. It is a very reliable and powerful computer. We will announce an additional model with a price up to twice that of the Apple II and it will have many more features than Apple II.

To give you an example, an absolutely fully-fledged keyboard; a lot of internal memory; an 80-character-wide screen with text and graphic combinations in colours; upper/lower case, etc. It will be compatible at a software level with the Apple II.

At the end of 1980 you are goig to see, we hope, a totally innovative product that will be a very good business computer. This will be based upon an entirely new architecture, not on the 6502. I want to add that we have selected PASCAL as the language that all our future machines are going to support primarily. All our future machines are going to speak BASIC, FORTRAN and maybe other languages, but PASCAL is *the* language for us.

DH That is very interesting. I think that the present very high level of interest in PASCAL is well justified. It has a similar ease of use as BASIC but its structured elements make it a much more sensible language . . .

AS . . . it is a little less friendly than BASIC . . .

DH . . . it *is* less friendly but then try to key-in COBOL. It seems to be a good compromise but it is very much a language for experienced programmers.

Language of the future

AS It is the sort of language that a lot of people believe is going to be the basis of all the languages of the future. So that is what I can tell you; we are evolving towards the high end of the market.

At the same time, as I mentioned at the beginning, we are not ignoring the very low end. If there is such a market for the so-called home computer (which makes sense for us — meaning that it will not be a high end video game or a toy) then we will be in it with what we think will be the best product.

DH But the priority in the short term is going to be in the personal computer for the professional market?

AS Yes, because we do not yet see any evidence of the 'home' market.

DH If and when the home market develops, will you respond to that with a particular model of the Apple?

AS I am not sure it would be a particular model of the Apple. I think we have on the drawing board something which is radically different from an Apple; it would not be a cut-down version of the Apple II. It has to serve its own needs . . .

DH Do you see Apple sticking with mos technology components for the medium term?

AS We will certainly remain with the 6502 for the Apple II and for the next version. After that an eight bit micro has limitations that do not permit the architecture that we want to build.

DH Would you like to be more specific there? Are you talkling about a lot more memory or a lot more precision? Or both?

Register architecture is dead

AS I am talking about two things. First of all, we may not want to build a machine that is based on register architecture. That is the main philosophical concept. The MOS Technology 6502 is very nice but it has addressing modes that are not very useful. The 6809 is far superior in terms of addressing modes. You can do off-sets and branches in much better fashion.

But I think the real question is do you want to build the machine around a register architecture or not? And I think the answer is 'no'!

DH We will see changes in the product line approach generally in terms of types of systems that you are offering but also see what sound, at the moment, to be quite radical changes in the architecture. This would be some years off?

AS This would be only 15 months off. The machine that I am talking about which for us is a totally innovative machine is some 5% completed right now, but the architecture is designed. We hope that it is going to be a nice machine for the user.

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Speak, memory . . .

. . . draw me a picture of the real world

A. C. Kilgour, who works at the University of Glasgow's Computing Science Department, describes what the future holds for applied computing graphics and details some of the books to read for further enlightenment.

IVOR SUTHERLAND was the first to demonstrate the potential of computer graphics as a new means of man-machine communication in the early sixties. Working at MIT, his thesis *Sketchpad, A Man-Machine Graphical Communication System* (MIT 1963)*created a big impression at the time and a rapid expansion in graphics applications was predicted. It was recently republished in book form by Garland Publishing Inc, 545 Madison Avenue, New York, NY 10022 ($18) and is worth reading, especially by those new to the subject who want to see how much, or how little, progress has been made in sixteen years.

The predicted revolution following the publication of *Sketchpad* was rather slow in coming. Except in specialised high-budget applications like aircraft and automobile design, very litle progress was made in the first ten years. With the benefit of hindsight, it is not difficult to see why. Refreshed displays of the kind used by Sutherland remained expensive.

Support for such displays requires a powerful processor dedicated to the graphics user, who much of the time might be scratching his head wondering what to do next. Perhaps most important of all, programming graphics systems was heavily device-dependent, so that every new system had to be built from scratch.

It is only relatively recently that the long-expected graphics boom has begun to take place. As explained below, the largest single factor has been the drastic reduction in the cost of computer memory. Great strides have been made in establishing a sound basis for graphics programming. But moves towards standardisation have frequently been overtaken by advances in hardware which introduce facilities not catered for in the standard. In addition the increasing moves towards realism in graphical output have revealed problems which were of no concern five years ago, when nearly all graphical output was of the "line-drawing" variety.

Types of graphics device

As with ordinary character terminals, a fundamental distinction is between *hard copy* devices, which produce a permanent record on a piece of paper, and *soft copy* or display devices, where you can't take the picture home with you. For interactive graphics, some kind of display device is almost essential, because of the fast drawing speed and the ability rapidly to extend or modify an existing picture.

Even with a simple printing terminal, quite impressive "greyscale" pictures can be produced, particularly if overprinting is possible. **Figure 1** shows an example. Every computer installation has its own collection, kept to impress visitors or amuse the operators when work is slack.

Although such pictures are mostly for entertainment, their method of production is of some interest. In effect the area of the original picture is divided into an array of cells, one for each print position on the device (for

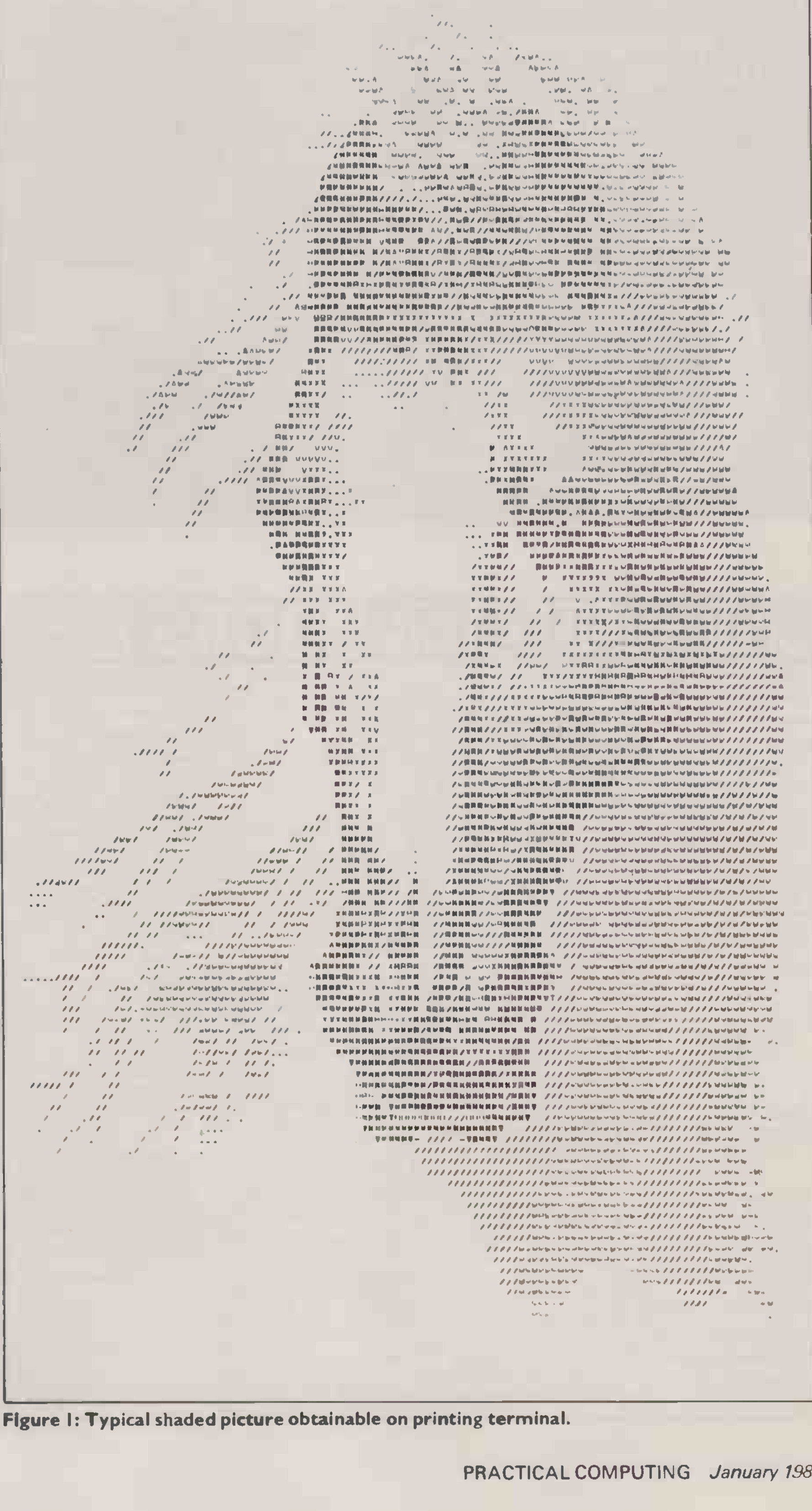


Figure 1: Typical shaded picture obtainable on printing terminal.

example 132 × 66 on a typical line printer page).

The "darkness" (or "brightness") within each cell, integrated over the area of the cell, is measured and expressed on an integer scale from 0 up to some maximum value, eg 3 or 15 (usually one less than a power of two). Then for each non-zero value on this "grey scale", a character or combination of characters is chosen which approximates to the corresponding darkness level. Printing these for each position gives the required approximation to the picture. Combinations of characters using up to four over-printings have been devised which give up to 127 different grey levels on common printing terminals.

In the process described above, we convert an "analogue" picture, ie one with (in principle) continuously varying grey levels, into a digital representation consisting of an array or "raster" of small numbers, one number for each cell or raster position. The success with which this process can be reversed, ie a satisfactory representation of the picture produced from its digital representation, depends on the resolution of the grid (the number of raster positions) and the number of grey levels.

A minimum of 256 × 256 raster positions with 16 grey levels (0 to 15) is required for good quality reproduction of a TV-quality monochrome picture. This is a lot of data ($2^8 \times 2^8 \times 2^4$ 2^{20} bits = 1 million bits or 128Kbytes), exceeding the total memory capacity of most micros and many minicomputers. It is only because of the dramatic reduction in the cost of memory that this form of picture representation now forms the basis of many low cost graphics systems.

Mini-Explor is a package of Fortran subroutines for generating and manipulating pictures represented as a grid of up to 140 × 140 cells, with four grey levels. It was developed by Ken Knowlton of Bell Laboratories, and has been used for computer graphics teaching, and for experiments in computer art. The package consists of about 430 lines of standard Fortran, and can drive any hard-copy device capable of overprinting. It is not suitable for most VDUs, which allow only one character to be drawn at each screen position.

For details of availability write to Ms Irma Biren, Computing Information Service, Bell Laboratories, 600 Mountain Avenue, Murray Hill, New Jersey 07974. A minimum of 16K bytes of memory is required to run the package with a reasonable-sized calling program. It provides a useful introduction to grey-scale graphics if you already have a printing terminal.

Plotters

Plotters come in many shapes and sizes. As well as being used to produce "grey scale" pictures as described above, a printing terminal can also be regarded as a simple plotter. As such, however, it suffers from two disadvantages. The first is the limited resolution — normally only 10 points per inch can be plotted (printed) in the horizontal direction, and 6 per inch in the vertical direction.

This means, for example, that only a crude approximation is possible to a straight line. Special graphic printing symbols, representing short line segments at various angles, can alleviate this difficulty to some extent, but the results are still far from ideal.

The second disadvantage is that the characters for printing have to be presented to the terminal in line order, and usually also in left-to-right order on each line (although it may be possible to scan the same line several times). It is not in general possible to move the print-head back to a position on a preceding line.

Since a program-producing graphical output may generate lines in any order, this means it is necessary to hold in computer memory a "map" of the page, with a representation of what is to be printed at each position. Only when the picture is complete can this map be scanned to produce the printed picture.

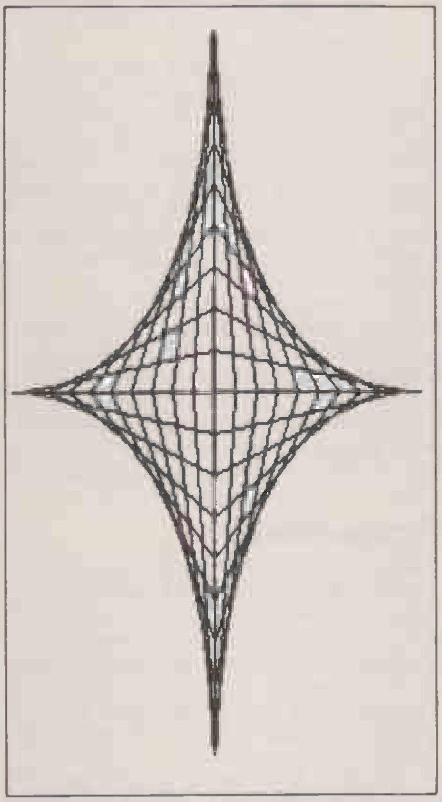


Figure 2: Pattern produced on Diablo Hitype printer with fine spacing.

On the daisy-wheel printers (eg Diablo Hitype or Qume) which form a part of many word processing systems, much greater precision is usually available in positioning the print head (typically 60 or 120 positions per inch horizontally and 48 per inch vertically), and depending on the type of paper-feed mechanism, it may be possible to move arbitrary distances back up the page as well as down.

Although these refinements are intended to facilitate typesetting applications, they allow such a printer to be used for quite respectable plotting applications, although since in general lines must be generated by printing adjacent dots, the output rate is slow. **Figure 2** shows a pattern produced on a Diablo Hitype I.

The simplest type of pen plotter is the "chart recorder" used on may measuring instruments. Where the position of the pen is determined by two independent analogue voltages, the term "XY plotter" is usually applied. Such plotters are available with a range of plotting areas. Prices range from around £1000 upwards.

For a computer control some form of D/A converter is required. Packaged versions with built-in microprocessor performing line-drawing and character generation are now available for example from Hewlett Packard, Tektronix and Houston Instruments, at prices from £3000 upwards. The great advantages of these plotters is their fast drawing speed (typically 15-20in per second) compared with the more conventional though more accurate, incremental plotters where the pen is moved in small fixed-size steps by two independent step motors.

Figure 3 shows a pattern generated on a Tektronix 4662 plotter. The pattern is a Sierpinski space-filling curve, details of which can be found, for example, in Wirth's book *Algorithms + Data Structures = Programs* (Prentice-Hall 1976). The plotter is driven by a 1200-baud serial line, and plotting time was approximately three minutes. The program to generate such curves is very straightforward provided you have access to a language which supports recursion. In more primitive languages, it is not so easy.

Displays

The cathode ray tube is still the basis of nearly all currently available display devices. In spite of the high voltages required, and its relatively high power consumption, its flexibility and dynamic picture modification properties have not yet been rivalled. It is cheap because of the mass market for domestic television receivers, although this advantage disappears for applications requiring high precision or special phosphors.

The most common application of the CRT, apart from the domestic TV set, is the VDU (visual display unit) terminal. A typical VDU will have 24 lines of 80 characters, though in the hobby market terminals with a smaller character capacity are common. The basic VDU has the same limitations as a printing terminal when regarded as a device for graphical output, with the further disadvantages of generally smaller page size and the absence of overprinting — only one symbol can be displayed at each character position.

However, many VDUs have direct "cursor addressing", that is the "print" position can be moved under computer control to any nominated character position, described by its line and column numbers. This permits immediate output of randomly-generated graphical elements, without the need to store an internal page map.

Since the tube used in a VDU is very similar to that in a domestic TV, it is fairly easy to add colour without increasing the price too much. The use of colour greatly improves the subjective effect. It has been said that adding a selection of four colours is better than doubling the resolution on a monochrome display, though in practice the extent of the improvement depends on the type of picture being drawn.

Many colour systems developed initially as "mimic" displays for control systems are now being sold as general-purpose graphics terminals. Most of these can be regarded essentially as colour VDUs, with a few additional features to enhance the graphics performance. For a good survey of the operation technology and uses of VDUs, as well as a discussion on the alternatives to the CRT being investigated, see *Visual Display Units and their Application* edited by Derrick Grover, IPC Science & Technology Press, 1976.

Before proceeding to look in more detail at the extensions of the VDU type of system which offer true graphics capability and which are becoming increasingly accessible to the hobbyist market, it is as well to consider the different categories of display devices which are based on the CRT. The first major difference is between *storage* and *refreshed* systems.

On a storage tube, the picture once "painted" on the back face of the CRT by the electron beam, remains visible for up to an hour without further action by the controlling computer. Most storage tubes are of the "direct view" type ("indirect view" systems exist which use a small silicon target, the image being enlarged and made visible by a TV type scan conversion system), and Tektronix manufacture all the available terminals of this type.

The back face of the CRT in a storage tube is coated with a "bistable phosphor" so that the primary electron beam sets up a permanent charge distribution as it "paints" the picture. This distribution is made visible thereafter by a secondary "flood" beam of low-energy electrons, which reach the phosphor at the viewing surface only at places where a path has been "etched" for them by the primary beam.

For several years storage tube terminals provided the only means of obtaining high quality graphics at moderate cost, and there are still many applications for which they are the best solution. Prices range from around £2500 upwards.

Disadvantages of storage tube systems are poor contast and the inability to modify the picture quickly (other than by adding more information). This is because there is no "selective erase" capability: if a part of the picture is to be removed from the display, the screen must be blanked out and the whole picture redrawn. Advantages are the high precision (750 × 1000 up to 3000 × 4000 approx) and unlimited information content, subject of course to overall resolution.

Refreshed displays

On a standard TV screen, the electron beam is made to traverse the complete screen 60 times a second, using a scan pattern like that shown in **Figure 4.** During the left-to-right movement, the energy of the beam is modulated according to the external signal to give the required light intensity at each point on the screen. On an "interlaced" system, only half the available line positions are visited on each scan, the line spacing being twice the minimum. On alternate scans the start position of the pattern is displaced by one line space, so that lines missed on the first scan are filled in on the second.

This has the important consequence that on interlaced systems each position on the screen is visited only thirty times a second, even although the "refresh rate" is 60 times per second. Because of the very short persistence of standard TV monochrome phosphors, horizontal lines tend to flicker very noticeably when displayed on a standard monitor with interlacing. For this reason such systems usually use a monitor with the longer-persistence P39 green phosphor.

The method of traversing the screen on a standard TV system is referred to as a "raster scan", and displays based on such a system are called raster scan displays. The need for interlacing can be avoided if the resolution in the vertical direction does not exceed 320 or so lines, which allows standard TV phosphors to be used. The characteristic property of raster scan refreshed systems is that the complete area of the screen is traversed every refresh cycle (or every two refresh cycles on an interlaced system). The refresh rate is constant, and completely independent of the picture content.

The other major category of refreshed display system is variously called 'random scan', 'calligraphic', 'cursive' or 'vector drawing' systems, although the last is somewhat misleading, since raster-scan systems can also draw vectors! The intention is to draw attention to the fact that a raster scan display can *also* fill areas.

On this type of display, which until recently was almost universal in applications requiring high quality or dynamic picture modification, the beam moves in accordance with instructions sent by the controlling computer, rather than in a preset pattern. These instructions will typically be to draw a line or a point or a character string.

Precision is usually 1024 × 1024 or higher, and there are several intensity levels. The complete list of instructions defining the picture is called a "display file", and has to be transmitted to the display at least 25 times per second to ensure a flicker-free picture. Because of this the display file is usually held in the memory of the controlling computer, and is accessed directly by the display using cycle-stealing.

The number of vector inches that can be displayed without flicker on such a display depends critically on the speed of line drawing, and because of this, and the high precision, such displays are usually expensive. Nevertheless, prices have come down and performances improved recently, and basic systems are now available starting at between £6000 and £7000.

Frame stores

Returning now to the raster scan type of refreshed display, the representation of the picture is in terms of an array or raster of picture elements, or pixels as they have come to be called. The number of bits/pixels depends on the number of grey levels, colours and separately-addressable picture planes that are provided. The part of the system which holds the information is called a frame store, or pixel store.

A scan conversion system generates from the frame store to a standard TV video signal at 60 frames/second. Any change in the picture definition held in the frame store thus appears on the screen almost instantaneously. The problem in generating dynamically-changing pictures is to update the frame store fast enough.

The amount of information held in a frame store is, by conventional standards, enormous. Only the dramatic reductions in the cost of memory have made the present situation possible in which frame stores for 256 × 256 or 512 × 512 precision are available at hobbyist prices. The advantages of using standard TV technology for the output end of a computer graphics system have been obvious from the start, but the storage problem has until recently inhibited development of such systems.

There have been successful systems which used a few adjacent tracks of a fixed-head disc for the frame store. The investment in the disc drive was economical provided a sufficient number of terminals were required, so that the per terminal cost was kept low. Typically a disc with 100 tracks might support 25 terminals. If the disc costs £15,000, it represents an additional cost of only £600 per terminal. For one-off systems, however, random access memory is the only feasible solution.

The two outstanding advantages of raster scan systems are the ability to fill complete areas, rather than generate only line diagrams, and the availability of colour at relatively little extra cost. The specification of colour in the frame store would seem to require many additional bits per element. At the simplest level, there could be a one bit for red, one for green and one for blue. This would give seven distinct colours, but the selection of colours available would be the same for all pictures.

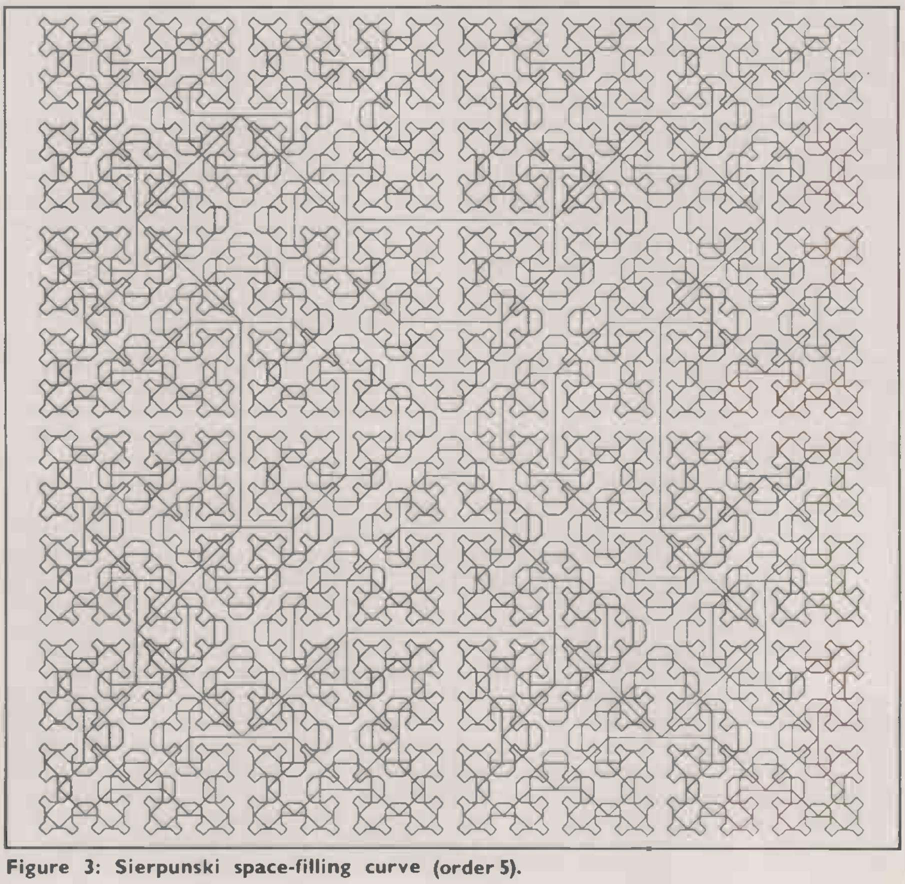


Figure 3: Sierpunski space-filling curve (order 5).

Greater flexibility is obtained by having an index whose entries are pointers to colour definitions in a much larger table of possible colours, held for example in ROM. The colour specification in a pixel then selects an index entry, which in turn specifies the colour. By changing the contents of the index, the range of colours can be changed, although the total number of colours usable at any one time is still limited by the number of colour bits in the pixel.

A range of micro-compatible frame stores with video output is now available for the hobbyist market. These boards connect directly to a standard micro bus such as the S100, or interface to the bus of a mini such as an PDP 11 or Nova. An alternative is to purchase a "packaged" terminal with serial interface for attachment to any machine with a serial line port.

Such a terminal will have its own built-in microprocessor and frame store, and normally will incorporate automatic line and text generation (done by software of firmware in the micro), graphics cursor control, and perhaps also automatic curve generation and area filling.

The advantages of such terminals are considerable for those looking for an "off-the-shelf" system, but because of the packaging there is a loss of flexibility in that the user cannot normally access the microprocessor, and the speed at which the frame stored can be updated is limited by the speed of the serial line. Except for applications where high precision is important, raster scan terminals are replacing storage tubes as the most common low-cost graphics terminal for use with a time-sharing system or stand-alone mini or micro. Prices start at around £1600 for 256 × 256 monochrome terminals.

An interesting variation on the purchase of a complete terminal is a "black box" which, plugged between a VDU and the computer to which it is normally directly connected, converts the VDU to a 256 × 256 or 512 × 256 raster graphics terminal. The Sigma GOC 5200 is such a device (details from Sigma Electronic Systems Ltd, Church Street, Warnham, Horsham, Sussex), which is suitable for use with most common VDUs. For ADM 3A terminals, Lear Seagler offer the Retro-Graphics RG512, which is a 512 × 256 resolution system.

Since VDUs are not normally interlaced, it is not possible to obtain higher precision in the vertical direction using only the VDU screen. The Sigma GOC 5500 is a 512 × 512 system which requires a separate monochrome TV monitor for the graphics, while retaining the VDU screen for normal alphanumeric output. This has the advantage that the picture is not overwritten by transient text message from the computer.

Problems in raster graphics

Since raster systems produce output on a more or less standard TV monitor, it is natural to ask: Can a computer generate images from internally-stored data which match the quality of the images derived from TV signals? Here there are two separate problems. The first is that of *static* picture quality, and the second of *dynamic* image modification. Solutions to the first are availble, but a complete solution to the second is not yet in sight.

You do not have to go very far with a low-resolution raster scan display to hit some of the limitations to picture quality. Lines which are close to vertical or horizontal appear ragged. There is severe flicker on horizontal lines if you use an interlaced system with a standard TV phosphor.

It is interesting that this effect is present on every domestic TV screen, but is hardly ever noticed because of the density of the picture and general irregularity of the outlines. Worst of all, spurious patterns may appear which are not preent in the original pictures.

Figure 5 is a photograph of a pattern of straight lines drawn on a 512 × 512 raster scan display. Interference effects can be seen which are not part of the original picture, but arise because the lines are generated as a set of discrete points.

These effects become even more marked where shaded pictures rather than line diagrams are produced. This so called "aliasing" problem is discussed in a paper by Crow in the *Communications of the ACM, Vol 20, No. 11, pp 799-805 ("The Aliasing Problem in Computer-Generated Shaded Images")*. A solution based on filtering is described in the paper, and the method is suitable for implementation in hardware. The purpose of such a filter is to 'smooth out' areas where there are sharp changes in colour or intensity, without losing accuracy, using information about points in the immediate neighbourhood of the discontinuity. Enhancements of this kind form an essential part of any raster graphics system required to produce high-quality shaded pictures.

The problem of generating dynamically-changing images on a raster scan system with frame store is severe. To move around simple line drawings is not too difficult — only a small part of the frame store needs to be updated. At the other extreme, however, for a complex shaded picture it may be necessary to rewrite the complete frame store between each scan — or during each scan if duplicate frame stores are available and double-buffering is used.

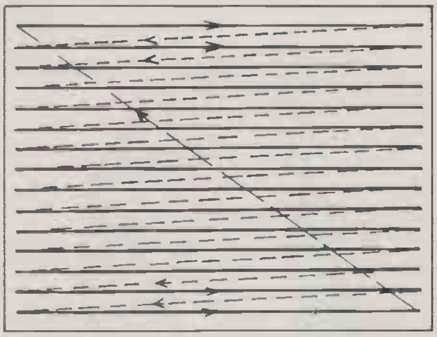


Figure 4: TV-type raster scan.

Figure 5: Straight line pattern drawn on 512 × 512 raster scan display.

Although techniques have been devised to reduce the amount of data to be written, and rewriting may be performed only every two or three scan cycles, the data transfer rates require are still enormous. For this reason, systems designed for dynamic transformation of shaded pictures have abandoned the frame store, and attempt to drive the display directly from a higher-level picture description.

Prof Grimsdale's group at Sussex University is developing a system based on hardware modules known as zone management processors. Each module is responsible for the display of one or more plane polygonal areas (zones) of constant colour and intensity. By giving each zone a priority associated with its distance from the viewer, the problem of hidden surface removal can be dealt with directly by the device. The method of assigning zone priorities is described by P. J. Willis in *"A Real-Time Hidden Surface Technique" Computer Journal, Vol 20, No 4 (November 77). pp335-339)*. This system exploits the redundancy present in many shaded pictures, where large areas may have the same brightness and colour.

The number of ZMPs required for a particular picture depends on the complexity of the picture — each ZMP can handle up to 16 zones. Since the zone definition is very compact, and the picture is generated directly from the definition, dynamic picture modification is possible merely by updating the specification of all zones which are affected.

Adrian Thomas of Prof Heath's group at Heriot-Watt University has built a prototype colour display which uses a different approach. Each object in the picture is described as a combination of planes, which are not necessarily parallel to the viewing surface, and which potentially may have variable colour or texture. Hidden surface removal is performed by the device itself, without the need for prior analysis of the scene.

The design is modular, so that the total number of surfaces that can be handled can be increased merely by adding further modules. Dynamic picture modification is again possible merely by updating the definition of each affected plane (currently 90 bits for each plane).

Both of these designs use concurrency in specialised ways to achieve enhanced performance. At Glasgow University we are investigating the application of data-flow architecture, which offers a more general and unified approach to hardware concurrency, to the problems of dynamic display design.

The aim of these and other research efforts is to produce a system capable of real-time colour display of simulated scenes, with a picture quality as good as that on a conventional TV picture of a real scene. Among the many potential uses of such a facility are flight simulation, animation and computer-assisted instruction.

Graphics software

The variety of graphics software that has been written is enormous, much of it intimately tied to particular computer systems or display devices. In what follows only a few of the more commonly availble packages are referred to, and some methods described which are of relevance to those writing their own software.

The Mini-Explor package for greyscale output on a printing device has already been mentioned. A general-purpose package of Fortran subroutines for 2D and 3D plotting called Simpleplot is available from University of Bradford (contact Lawrence West, Industrial Liason Manager, University of Bradford, Bradford BD7 1DP).

The package is device-independent and fairly easy to set up for any particular output device. The Ghost package, developed by Larkin, Prior and others at Culham Laboratory, has been implemented on a wide range of machines, and is very popular in universities. It offers comprehensive 2-D facilities, including drawing of circles and conics, curve fitting nd typewriter simulation, and is available for a modest sum from Culham.

Gino-F is a powerful package of Fortran-callable procedures for 2-D and 3-D graphics, including graph plotting, viewing and modelling transformations, surface description and graphical interaction. It was developed initially by P. A. Woodsford at the Computing Laboratory, Cambridge, and is now marketed for a wide range of mini and mainframe computers by the Computer-Aided Design Centre, Madingley Road, Cambridge.

Another commercially-available package is Disspla, marketed in the UK by SIA Ltd, 23 Lower Belgrave St, London SW1. It has particularly powerful facilities for the generation of graphs and maps, and is widely used by geographers and cartographers.

For microprocessors driving a simple raster-scan display, many manufacturers offer graphical extensions to Basic, but as yet there is little in the way of graphics subroutine packages. An exception is the Fortran package for the Vector High Resolution Graphics Board (S100 compatible) offered by Video Vector Dynamics Ltd, 97 Dornal Avenue, Glasgow G13 4JH (tel 041-339 6782). This company also supplies applications software for a variety of mini- and micro-based graphics systems.

Originally developed for computer-assisted learning applications, the GUSC Graphics Package offers general facilities for graphical output and interaction. Two versions are available, one in Fortran and one in Basic, and supported devices include the Computek 300 raster scan display and the Tektronix 4010 storage tube terminal. Enquiries about the package, and a variety of CAL material built o it, should be directed to R. Lewis, Chelsea College, Pulton Place, London SW6 5PR. The book by J. McKenzie et al, *Interactive Computer Graphics in Science Teaching* (Ellis Horwood 1978) gives details of the development of the package and its uses in education.

The proliferation of different systems and packages has led to attempts to impose standardisation on graphics software. In the US the Graphics Standards Planning Committee of the ACM has proposed a standard graphic package known as the "Core" system. Many groups have developed or are developing implementations of the standard, and it is possible that some of these may become available in the UK in the near future. The "Core" system is comparable in power to Gino-F, though differing in philosophy and many points of detail. Extensions to cater for the properties of raster-scan display are currently under discussion, and it is probable that a revised standard will be defined in the near future.

In the UK, the British Standards Institute has set up a working group (DPS13/WG5) on graphics standards, chaired by D. L. Fisher of the Computer Laboratory at the University of Leicester. The group has sent detailed comments on the Core system to the US standards planning committee, and has considered other possible standards such as Gino and the German AGF system.

When graphical output is to be generated on devices capable only of plotting points (such as a simple raster scan display with no built-in line-drawing capability) or of drawing small increments, such as a conventional incremental drum plotter, algorithms are needed to select the best points or increments to approximate to a given straight line or curve. For a straight line between two given points on the grid of accessible device positions, an incremental algorithm is possible which requires only addition and subtraction during the generation of the points or steps, and which is guaranteed to terminate at the correct end-point. If you don't know the algorithm, you can have a lot of fun working it out for yourself.

It is analogous to the method of working of the hardware device known as the digital differential analyser. This approach can be extended to generate simple curves. For further details see, for example, *Interactve Computer Graphics* by Walker, Gurd & Drawneek, (Edward Arnold 1976) pp.108-114.

Incremental methods of curve generation are desirable for efficiency on machines without hardware floating point, but they pose certain problems in obtaining uniform smoothness, for example in highly-eccentric ellipses, and in guaranteeing accurate termination, due to accumulation of small errors. An alternative method, which uses only 16-bit integer arithmetic, and employes table lookup for trigonometric functions, has been developed by Colin Prosser at Glasgow. Full details are in his MSc thesis (*Graphical output methods and their relation to display system design*, Department of Computing Science, October 1979). **Figure 6** shows a drawing consisting entirely of ellipses generated using the method.

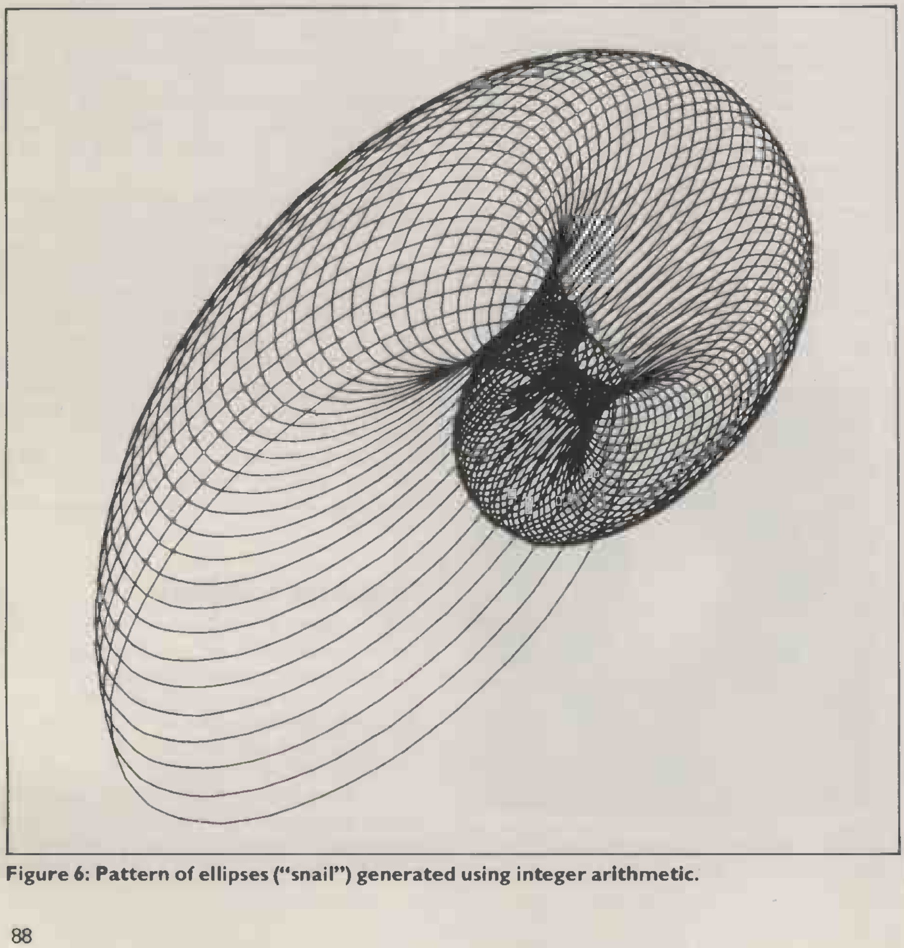


Figure 6: Pattern of ellipses ("snail") generated using integer arithmetic.

Sources for further reading

In this article it has been possible to touch on only a few aspects of computer graphics. For those wishing to delve more deeply, the book by Newman and Sproull *Principles of Interactive Computer Graphics*, McGraw Hill, (second edition) 1979, or that by Giloi, *Interactive Computer Graphics*, Prentice-Hall, 1978 both provide an excellent coverage of the field.

The mathematical material required for 2D and 3D transformations, and curve and surface description, is well covered by Rogers and Adams in *Mathematical Elements for Computer Graphics*, McGraw-Hill 1977. Relevant journals include *Computer Graphics*, published quarterly by the ACM Special Interest Group on Computer Graphics (SIGGRAPH), *Computer-Aided Design* published by IPC Science and Technology Press Ltd, and *Computer Graphics and Image Processing* published by Academic Press.

Conclusion

Computer graphics, after many years of expectancy, is at last about to come of age. As with other branches of computing, this is due at least as much to technological advance as to improvements in graphics software. The software, indeed, always seems to be one or two steps behind the hardware. This is particularly noticeable in attempts to define standards.

However, although it can be fun sometimes, there is really no point in everyone attempting to re-invent the wheel. Very soon the combination of powerful but inexpensive graphics hardware with widely available standard software will sllow programmers and designers to concentrate on the *application* of graphics, where there remain a wide range of exciting possibilities which are only now beginning to be exploited.

Standard software can give users a new flexibility with . . .

Transfer of programs between two operating systems

In this article Dr John Lee and Timothy Lee show how you may discover exactly how North Star BASIC programs are stored both in core (memory) and on disc. A similar approach may be used for other BASIC interpreters on other machines. Once you have gained an insight into the method of storage, it becomes possible to carry out tasks which cannot usually be performed using software provided by the manufacturer. This provides a general method for the transfer of BASIC programs into ASCII characters which facilitates the transfer of programs between different machines. The general method is developed into a BASIC program which will convert BASIC programs from the North Star operating system to CP/M files.

A LINE of a BASIC program is not stored as the set of ASCII characters which were typed in. Instead, it is automatically converted into a more compact form which economises on the amount of memory used and results in faster execution.

Firstly the line number is converted from decimal into a two-byte (16-bit) binary number. Since the largest number which can be stored in 16 bits is $2^{16} - 1$, this restricts the largest acceptable line number tyo 65535. The first byte contains the eight low order binary bits and the second byte contains the eight high order binary bits.

Storage characteristics

In addition any other line number which appears in the line, for example after a GOTO, THEN, RESTORE or EXIT, is similarly compacted into two bytes and is preceded by a byte which indicates that the following two bytes form a binary line number. The special byte has the decimal value 154, as discussed later.

The remainder of the line (including spaces) is stored in ASCII characters, one character to a byte, except for all of the reserved words such as LET, FOR, COS, SQRT, each of which is compacted to a unique number stored in a single byte. It is worth noting that decimal constants are stored exactly as typed in (as ASCII characters), rather than in binary coded decimal which is the form used during calculations.

When a constant is used in a calculation at run time, it must be converted from ASCII to BCD form each time the line is executed, hence faster running code can be obtained by setting a variable equal to the constant once at the beginning of the line program, and subsequently using the variable.

The end of the line is denoted by one byte containing the ASCII character for carriage return (decimal value 13). The whole line is preceded by a single byte which indicates in binary the total number of bytes in that particular line including both this byte and the carriage return.

This is what a line looks like:

byte 1	byte 2	byte 3	4				byte n
length of line, n in binary	line number in binary low	high					carriage return in binary

n—4 bytes comprising ASCII characters and compacted reserved words.

The line number 500 becomes 00000001 11110100 and is stored lower eight bits first as shown.

After all of the lines have been stored, the end of the file is indicated by a marker which is a line one byte long containing the binary value 1. Programs are stored in an identical manner in core and on disc.

For example the line 500 PRINT A is stored:

byte 1	2	3	4	5	6	7	8
decimal 8 stored as 00000100	decimal 244 11110100	decimal 1 00000001	ASCII space	special character for PRINT	ASCII space	ASCII A	carriage return in binary

Special characters for reserved words

The 128 characters defined by the ASCII set (which comprises the digits 0-9, upper and lower case letters, arithmetic operators, other printing symbols and control characters) are stored as the binary equivalents to the numbers 0-127 inclusive. North Star BASIC uses the binary equivalents of the decimal numbers 128 — 255 inclusive for the special characters which are the compacted (1 byte) form of the reserved words.

During the evolution of North Star BASIC, the meanings of a few of the decimal numbers between 128-255 have been changed. In particular the words CREATE, DUMP and NULL in release 3 have compacted forms which correspond in release 4 and 5 to AUTO, MEMSET and NSAVE respectively. This is less serious than it at first appears, since these could only occur in REM statements.

By inspection of individual bytes of a BASIC program in core, using the EXAM function (which is similar to PEEK on some machines), it is possible to discover what some of the commonly occuring byte values in the range 128-255 actually correspond to. For example 128 ! LET, 130 ! PRINT, and 146 is ! corresponding to the shortened form of PRINT.

Since PRINT and ! are both stored as one byte, using ! does not save core but does of course reduce typing. A simpler and more systematic way of finding the meanings of the characters 128-255 is to use the following program.

```
10 CREATE "WORDS", 4, 2
20 OPEN #0%2, "WORDS"
30 FOR I = 128 TO 255
40 WRITE #0, &6, &I, &0, &32, &I, &13
50 NEXT I
60 CLOSE #0
70 CHAIN "WORDS"
```

Notes on program wordlist

Line	Function
10	Creates an output file called WORDS, of size 4 blocks (1K) and type 2 (BASIC PROGRAM).
20	Opens file WORDS as device #0. The %2 indicates the file is of type 2.
30	Start loop for values of I from 128 to 255.
40	Write to device 0 (file WORDS) the six byte values: 6, 1, 0, 32, I, 13. This resembles a BASIC line. The 6 specifies the number of bytes in the line. The I and zero together represent a line number of value I. The 32 is an ASCII space. The next I is interpreted as a reserved word and the 13 is a carriage return.
50	End of loop.
60	Closes device #0 (file WORDS) and leaves an end of file marker

(control/A).

70 Replaces program WORDLIST by newly created 'program' WORDS.

When this program is run, a disc file called WORDS is created of length 4 blocks and type 2 (BASIC file). 128 lines of output are written to the disc file in the same format as described for a BASIC program previously. At the end of the program the CHAIN command replaces the program in core with the pseudo BASIC program called WORDS which has just been produced. Very early releases of BASIC lack the chain function, and the last line of the program should not be typed, but instead the command LOAD WORDS should be typed after the run. All releases of BASIC report a FUNCTION DEF ERROR and for the moment this will be ignored.

The command LIST should now be typed. This produces a table of the numbers 128-255 together with their associated reserved words — for example

128 LEF
129 FOR
130 PRINT
131 NEXT

Note the following points:

1. The number 155 does not appear in the table. This is because the number 154 corresponds to the line number marker which precedes embedded line numbers, which was mentioned earlier. The word corresponding to 155 is CHAIN, and this appears twice on line 154.
2. A number of commands also appear as reserved. words. These include RUN, LIST, BYE, etc. and appear from 160-175.
3. Some of the numbers, eg 188 and 190, appear to be undefined whilst a few others, eg 189, 199, 232 and 235, translate to the words B!VW, U!, +; and PYDM, for which we have found no meaning. This should provide a challenge for North Star enthusiasts — who can be the first to explain any of them.
4. The codes for the arithmetic operators ı * + — / = and (are stored as numbers between 224 and 246. Should these symbols be stored in Holleriths (strings), they are stored as ASCII characters between 40 and 94. The code thus indicates the context and meaning of the character.
5. A further complication is that in release 4 BASIC all of the codes 233, 243, 245, 250 and 254 translate to = signs, in addition to the ASCII 61 character. An exhaustive check of 30 BASIC programs showed that only 245 was actually used for equality. A similar situation exists for the signs + and and 227 and 246 respectively appear to be used for arithmetic.
6. It appears that only the ASCII value of 41 for) is used regardless of its context.

Conversion of compacted BASIC line

It may at first seem strange that a program is needed to do this since the LIST command performs this function. LIST can only output to a peripheral device such as a terminal, VDU or printer, and a routine is needed if the output is to be stored on disc or directly in core. The steps in a general routine would be:

1. Read the byte containing the length of the line and ignore it.
2. Read the two bytes containing the line number in binary. They are converted into a decimal number and each individual digit is then output as an ASCII character.
3. Subsequent bytes are read in one at a time. If the byte corresponds to an ASCII character (decimal 0-127) it is output unchanged. There is just one special case — decimal 13, which corresponds to carriage return, is followed by a linefeed (decimal 10) and marks the end of the line. Bytes with decimal values 128-255 correspond to reserved words, and vary from machine to machine. The decimal value can be converted into the corresponding reserved word by using a look-up table, and the characters in the word are output in ASCII.
4. Embedded line numbers must be identified. On the North Star they are preceded by a byte containing decimal 154. The two bytes following are converted to a line number as in step 2.
5. The end of file marker must be detected. On a North Star this is control/A and on CP/M it is control/Z.

Modus operandi

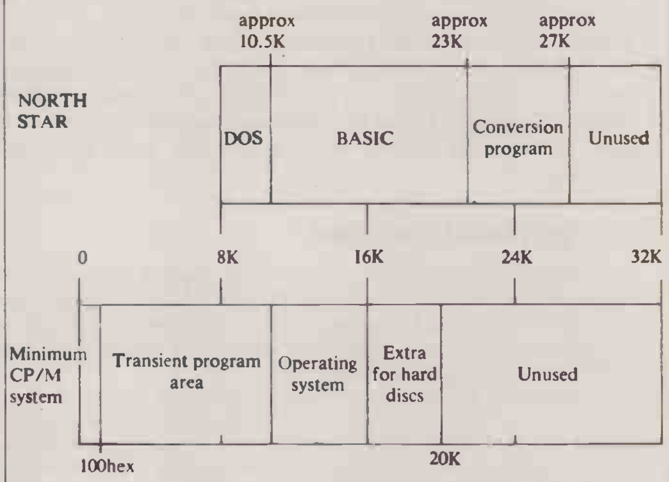
CP/M requires continuous memory addresses starting at 0. Under this system, transient programs are stored starting at 100 hex. A program residing in memory starting at 100 hex can be copied into a CP/M disc-file using the SAVE command. If another operating system loads an ASCII file into core starting at 100 hex it is possible to change the operating system to CP/M without destroying the information in core. The SAVE command will copy the contents of core into a CP/M disc file, thus completing the transfer. This method is crude and long — but it works!

A neater solution for the transfer of a file is to have a program which reads a compacted BASIC file, expands it into ASCII form writing the output to memory starting at 100 hex. To complete the transfer, CP/M must then be loaded, and the memory contents SAVEd onto disc.

Memory requirements

CP/M requires a minimum of 16K for soft-sectored disc versions and up to 4K extra for hard-sectored disc versions. This memory must start at location 0. The neat solution described above requires in addition memory for the normal disc operating system, and the program which converts to ASCII. Should the conversion program be written in BASIC, then space is also required for the BASIC interpreter.

In the particular case of converting North Star BASIC to a CP/M file, the North Star disk operating system occupies 2.5K starting at 8K (2000 hex), BASIC occupies about 12.5K starting at 10.5K (2A00 hex), and the BASIC conversion program occupies about 4K from 23K to 27K.



Memory maps, CP/M and North Star

The diagram above shows that if the North Star conversion program uses locations 100 hex to 8K for the ASCII output from the conversion program, then the CP/M operating system can subsequently be loaded without overwriting this region. The ASCII text can then be SAVEd using CP/M. This limits the size of the ASCII program produced to 7¾K since a larger program will start to overwrite DOS, which results in the BASIC conversion program crashing. This size limit is not in practice a serious limitation. Not many programs exceed this size, and those that do can be copied in two or more parts, and the resulting CP/M files merged into a single file using PIP.

If insufficient memory is available to perform the 'neat' transfer above, the 'crude' method can be employed. Sufficient memory must be available to hold DOS, BASIC and the conversion program. The ASCII output is written to a disc file under the original operating system. BASIC can then be dispensed with, and the memory re-configured to start at 0. DOS is then used to load the ASCII disc file starting at 100 hex. CP/M is loaded, and the memory contents SAVEd on a CP/M disc as described earlier.

Dr John Lee and Timothy Lee will continue to contribute articles on software to *Practical Computing* during 1980, concentrating on improving readability.

```
10 DIM F$(40), C$(20), A$(20)
20 INPUT "TYPE NAME OF INPUT FILE ?", F$
30 F = FILE(F$)
40 IF F = 2 THEN 120
50 IF F > - 1 THEN 80
60 PRINT "FILE '", F$, "' DOES NOT EXIST!"
70 GOTO 20
80 PRINT "NOT A BASIC TYPE 2 FILE"
90 PRINT "TYPE 'RETURN' TO CONTINUE"
100 INPUT A$
110 IF A$ <> "" THEN 20
120 OPEN #0%F, F$
130 PRINT "HOW MANY SOURCE LINES TO BE SKIPPED BEFORE OUTPUT STARTS"
140 INPUT L1
150 IF L1 < 0 THEN 130
160 FOR I = 1 TO L1
170 READ #0, &L
180 IF L = 1 THEN 630
190 FOR J = 2 TO L
200 READ #0, &N
210 NEXT J
220 NEXT I
230 L1 = 0
240 P = 256
250 READ #0, &L
260 IF L = 1 THEN 710
270 L1 = L1 + 1
280 GOSUB 540
290 READ #0, &A
300 IF A > 127 THEN 400
310 REM "\ TO :"
320 IF A = 92 THEN A = 58
330 FILL P, A
340 P = P + 1
350 IF A <> 13 THEN 290
360 FILL P, 10
370 P = P + 1
380 IF P > 8000 THEN 660
390 GOTO 250
400 IF A = 154 THEN 510
410 RESTORE
420 FOR I = 128 TO A
430 READ A$
440 NEXT I
450 A = LEN(A$)
460 FOR I = 1 TO A
470 FILL P, ASC(A$(I, I))
480 P = P + 1
490 NEXT I
500 GOTO 290
510 GOSUB 540
520 GOTO 290
530 REM SUBROUTINE TO SORT OUT LINENUMBERS
540 READ #0, &A, &B
550 C = A + 256 * B
560 C$ = STR$(C)
570 FOR I = 1 TO LEN(C$)
580 D = ASC(C$(I, I))
590 FILL P, D
600 P = P + 1
610 NEXT I
620 RETURN
630 PRINT "THERE ARE NOT", L1, " LINES IN THE FILE!"
640 PRINT "NO OUTPUT PRODUCED"
650 STOP
660 PRINT "MEMORY BUFFER BETWEEN CP/M AND NORTH STAR DOS NEARLY FULL"
670 PRINT "OUTPUT STOPPED AFTER", L1, " PHYSICAL LINES"
680 PRINT "LAST LINE NUMBER OUTPUT WAS", C
690 PRINT "OUTPUT SECOND PART AS A SEPARATE JOB AND MERGE FILES WITH PIP"
700 PRINT
710 FILL P, 26
720 F = LEN(F$)
730 IF F$(F - 1, F - 1) <> "," THEN 750
740 F$ = F$(1, F - 2)
750 PRINT "BOOT UP WITH CP/M AND TYPE   SAVE", INT(P / 256), " ", F$, ".BAS"
760 END
770 REM
780 REM ***** EXIT CHANGED TO GOTO
790 REM *****  \   CHANGED TO  ":"
800 REM *****  !   CHANGED TO PRINT
810 REM ***** FILL CHANGED TO POKE
820 REM ***** EXAM CHANGED TO PEEK
830 REM ***** SQRT CHANGED TO SQR
840 REM
850 DATA "LET", "FOR", "PRINT", "NEXT", "IF", "READ", "INPUT", "DATA"
860 DATA "GOTO", "GOSUB", "RETURN", "DIM", "STOP", "END", "RESTORE", "REM"
870 DATA "FN", "DEF", "PRINT", "ON", "OUT", "POKE", "GOTO", "OPEN"
880 DATA "CLOSE", "WRITE", "154", "CHAIN", "LINE", "DESTROY", "CREATE", "ERRSET"
890 DATA "RUN", "LIST", "MEMSET", "SCR", "AUTO", "LOAD", "CONT", "APPEND"
900 DATA "REN", "NSAVE", "SAVE", "BYE", "EDIT", "DEL", "PSIZE", "CAT"
910 DATA "STEP", "TO", "THEN", "TAB", "ELSE", "CHR$", "ASC", "VAL"
920 DATA "STR$", "NOENDMARK", "INCHAR$", "FILE", "", "B!VW", "", "U"
930 DATA "W", "", "", "", "SQR", "", "INT"
940 DATA "U!", "", "", "SGN", "SIN", "LEN", "CALL", "RND", "+"
950 DATA "W", "", "ATN", ">", "C", "$", "A", "C"
960 DATA "FREE", "INP", "PEEK", "ABS", "COS", "LOG", "EXP", "TYP"
970 DATA "(", "^", "*", "+", "", "-", "", "/"
980 DATA "+!", "=", "Y", "PYDM", "AND", "OR", "", ">="
990 DATA "<=", "<>", "", "=", "<", "=", ">", "NOT"
1000 DATA "", "I", "=", "", "", "", "=", ""
```

Automatic transfer North Star — CP/M files

A program is described which uses the 'neat' solution and converts North Star BASIC files to CP/M files. Because of the wide variety of dialects which exist in BASIC, some minor program changes will be almost inevitable before a program transferred in this way will run. In an attempt to minimise such difficulties the conversion program makes the following changes:

1. The North Star line separator backslash is replaced by the more usual colon :
2. The character ! used as an abbreviation to the word PRINT is replaced by the word itself.
3. EXIT statements are used to jump out of loops in North Star and Xitan disc basic. The statement is not used by most other BASICs and so the program replaces the word by GOTO.
4. The words EXAM and FILL are changed to the more common PEEK and POKE.
5. The function for square roots SQRT is changed to the more widely used SQR.

The first of these changes is programmed at line 320 in the conversion program. The remainder of the changes are accomplished by storing the new word rather than the old word in the list of reserved words in lines 850 — 1000. (These lines are based on the output of the program WORDS described earlier).

Notes on the Conversion Program

Lines	Function
10 — 120	Find name of input file, and check that it exists and is a BASIC (type 2) file.
130 — 220	Find how many lines to be skipped. This is normally 0, but is used to segment a large program.
230 — 240	Set number of lines processed to 0, and output pointer to 256 (decimal), ie 100 hex.
250 — 260	Read a byte from input file and check if it is the end of file mark.
270	Increment number of lines processed.
280	Call subroutine to sort out line number.
290	Read the next byte from input file.
300	Jump if it is a reserved word.
310 — 320	Change /b :
330 — 340	Output ASCII character and move pointer.
350 — 370	Check if character was carriage return, and if so output linefeed.
380	Jump if memory used to store ASCII is nearly full.
390	Go back to read the next line.
400	Check for special character indicating an embedded line number.
410 — 440	Read through data list to obtain the appropriate reserved word.
450 —500	Output reserved word character by character.
510 — 520	Call subroutine to sort embedded line number.
530 — 620	Subroutine to read to bytes corresponding to a binary line number, convert to decimal and output as individual ASCII characters.
630 — 700	Warning messages.
710	Outputs CP/M end of file mark (control/Z).
720 — 750	Prints instructions on how to save the ASCII contents of core using CP/M.
850 — 1000	Data list of reserved words obtained using the program WORDLIST.

In a subsequent article we will show how the spacing on a North Star BASIC line can be changed to improve its readability, but the ideas involved are applicable to several other systems.

Logic board redesign

MIKE LAKE is going to continue to keep us informed about the PET and the IPUG which, he tells us, has decided to employ a part-time assistant to deal with the administration and has set itself a target for membership of 1000 by early 1980.

Mike has been using the new 32K business PET since Easter and the 2040 disk drives since late May and has these comments to make:

The new "big" PETs contain a redesigned logic board that has sockets for up to 32K of on-board RAM. The ROM chips containing the MICROSOFT Basic and the CBM operating system are on the main logic board and have been rewritten to cure the faults present in the first ROMs, and to expand the facilities of the operating system.

The array limitation of a total of 256 elements has been removed, the limit now being determined by the amount of memory you have available. Similarly the problems with writing to and reading from tape have been cured, so that data files can now be kept with a far higher level of reliability, though, as before, the read/write heads of the tape units must be kept clean and regularly degaussed.

The redesign of the logic board has also cured the "snow" problem associated with POKEing the screen RAM; games designers will be delighted with this amendment!

Still on the board, the IEEE and user port connection are unchanged but the two cassette unit connectors are reversed; drive 1 is now at the rear of the PET and drive 2 is inside (there is now no built-in cassette unit).

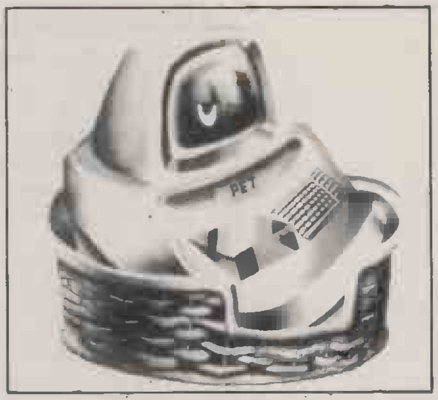
The memory expansion connector, now of pin rather than edge type, allows not only additional memory to be added to the PET, but also the addition of memory-mapped devices, disks, S100 adapters (BETSI) etc.

An interesting point there is that the main board contains sockets for extra ROM chips to be plugged in and already PETSOFT are importing the PET TOOLKIT ROM to expand the facilities available in Basic.

This extra memory space, not available to Basic programs, could also be used by extra RAM memory on the memory expansion port. An extra 12K here would allow machine code systems to be loaded at the beginning of the day and remain there until the PET is turned off — perhaps a manufacturer would like to take this suggestion up?

A plea here: will *all* manufacturers of PET-compatible hardware please remember that since a user may wish to add more than one device to the PET. All plug-in items should include a parallel connector. IEEE devices are a special case — see the discussion below about the 2040 disk drives.

All in all, the 32K PET has been a dream to work with; with the new



software available for it, it certainly rates as a leading contender for the business market. On the software side, there is a problem. The new ROMs are not fully compatible with the old ones; programs written in standard PET Basic will work perfectly with both ROMs, but those that do any PEEKing or POKEing in the first 1K of memory will have problems, as all the addresses have been changed to speed things up. Most suppliers of software now have versions of their programs suitable for both sets of ROMs, so be sure to specify exactly which machine you hve when you are sending in an order.

Rockliff lock-up

M. VALENTINE has been using his PET 2001/8 with a Rockliff PR40 printer. It is operated via the parallel user port using a machine code subroutine supplied by Rockliff. This is resident in RAM IFØØ to IFEØ. It is called by the USR function.

All went well until I acquired a PET 2040 Dual Disk Drive. In order to work the drive, the new PET ROMs are required, as fitted to the 32K PET. When the Rockliff routine was tried with the new ROMs the machine locked up.

On decoding the Rockcliff program, it became clear that the problem was due to changes in locations of various functions on ZERO page. By referring to the PET manual and by using the listing in *Practical Computing* (September 1979) I managed to write a modified machine code program.

The modified program requires 256 bytes, one less than Rockliff's 'old' program. Rockliff's program for the 32K PET requires 514 bytes. Here is a list of changed memory locations of significance.

ZERO MEMORY MAP

Old ROM From To	New ROM From To	Description
000	000	84C Constant (6502 JMP instruction).
001-002	001-002	USR Function address lo-hi.
003	014	Active I/O Channel number.
004-007	—	
008	017	Line number storage before buffer.
009	018	82C Constant (special comma for INPUT process).
010-089	512-591	BASIC input buffer (80 bytes).
090	003	General counter for BASIC.
091	004	800 used as delimiter.
092	005	General counter for BASIC.
093	006	Flag to remember dimensioned variables.
094	007	Flag for variable type: 0 = numeric; 1 = string.
095	008	Flag for integer type.
096	009	Flag to crunch reserved words (protects " & REM).
097	010	Flag which allows subscripts in syntax.
098	011	Flags INPUT or READ.
099	012	Flag sign of TAN.
100	013	Flag suppress OUTPUT (+ normal; — suppressed).
010	019	Index to next available descriptor.
102-103	020-021	Pointer to last string temporary lo, hi.
104-111	022-029	Table of double byte descriptors which point to variables.
112-113	030-031	Indirect index 1 lo,hi.
114-115	032-033	Indirect index 2 lo,hi.
116-121	034-039	Pseudo register for function operands.
122-123	040-041	Pointer to start of BASIC text are: lo,hi byte.
124-125	042-043	Pointer to start of variables lo,hi byte.
126-127	044-045	Pointer to array table lo,hi byte.
128-129	046-047	Pointer to end of variables lo,hi byte.
130-131	048-049	Pointer to start of strings lo,hi byte.
132-133	050-051	Pointer to top of string space lo,hi byte.
134-135	052-053	Highest RAM address lo,hi byte.
136-137	054-055	Current line being executed. A zero in 136/054 means statement executed is a direct command.
138-139	056-057	Line no. for continue command lo,hi byte.
140-141	058-059	Pointer to next statement to execute lo,hi.
142-143	060-061	Data line no. for errors lo,hi.
144-145	062-063	Data statement pointer lo,hi.

Locations not specified are used but have no clear one function definition.

Old ROM From To	New ROM From To	Description
146-147	064-065	Source of INPUT lo,hi.
148-149	066-067	Current variable name.
150-151	068-069	Pointer to variable in memory.
152-153	070-071	Pointer to variable referred to in current FOR-NEXT.
154-155	072-073	Pointer to current operator in table lo,hi.
156	074	Special mask for current operator.
157-158	075-076	Pointer for function definition lo,hi.
159-160	077-078	Pointer to a string descriptor lo,hi.
161	079	Length of a string of above string.
162	080	Constant used by garbage collect routine.
163	081	84C Constant (6502 JMP instruction).
164-165	082-083	Vector for function dispatch lo,hi.
166-171	084-089	Floating accumulator no. 3.
172-173	090-091	Block transfer pointer no. 1. lo,hi.
174-175	092-093	Block transfer pointer no. 2. lo,hi.
176-181	094-099	Floating accumulator no. 1 (USR function evaluated here).
182	100	Duplicate copy of mantissa of FAC no. 1.
183	101	Counter for no. of bits to shift to normalise FAC1.
184-189	102-107	Floating accumulator no. 2.
190	108	Overflow byte for floating argument.
191	109	Duplicate copy of sign of mantissa.
192-193	110-111	Pointer to ASCII rep of FAC in conversion routine lo,hi.
194-199	112-117	CHRGOT RAM code. Gets next character from BASIC text.
200	118	CHRGOT RAM code regrets current characters.
201-202	119-120	Pointer to source text lo,hi.
203-222	121-140	Next random number in storage.
224-225	196-197	Pointer to start of line of cursor location lo,hi.
226	198	Column position of cursor.
227-228	199-200	General purpose start address indirect lo,hi.
229-233	201-204, 180	General purpose and address direct lo,hi.
234	205	Flag for quote mode on/off.
238	209	Current file name length.
239	210	Current logical file number.
240	211	Current primary address.
241-242	212-213	Current secondary address.
243-244	214-215	Pointer to start of current tape buffer lo,hi.
245	216	Current screen line number.
246	217	Data temporary for I/O.
247-248	251-252	Pointer to start location for O.S. lo,hi.
249-250	216-219	Pointer to current file name lo,hi.
251-254	—	Unused?
255	—	

24-hour clockface

RON GEERE, Editor of *IPUG Newsletter*, tells us he wrote this program for a working clockface in a total of three hours (see right).

62 bytes on bottom are used for error correction in tape reads. Also, buffer for ASCII when BASIC is expanding the FAC into a printable number. The rest of page 1 is used for storage of BASIC GOSUB and FOR-NEXT context and hardware stack for the machine.

The CBM 2040 disk drive

AFTER MONTHS (who said "years"?) of waiting, the 2040 disk drives are becoming available in reasonable quantities. The last six months has seen large sales of COMPUTHINK and NOVAPAC drives, so the CBM ones have a lot of competition.

To set the bad things out of the way first, let me say that there are problems with the 2040 units. The original drive that I saw at the beginning of the year had heat problems; Commodore knew of this, but have done nothing about it. The versions that have arrived on the market all have their heat-sink mounted on the main logic board and facing downwards! Commodore have gone some way to solving this problem by changing the design of the case cover to allow a greater circulation of air.

Even so, my own drives suffer no ill effects from this heat, though I know of more than one member of IPUG who has to have a fan blowing over the rear of the unit to prevent read errors on drive 1.

The drives offer up to 342K online, 171K per diskette, with up to five files open at the same time. Here the unit really comes into its own with its own 6502 processor, 6522 I/O controller, 4K of RAM and operating system in ROM. It is potentially very powerful.

Now we come to the other problem; Commodore documentation, or lack of it! The original user's manual can only be described as appalling, so bad in fact that Commodore UK refused to support random-access files because they themselves were not certain how the worked! The latest version of the manual is a tremendous improvement — with luck, the quality of all Commodore documentation will now improve dramatically.

The handling of files on the drives is indeed quite complex — certainly nowhere near as easy as on the COMPUTHINK and NOVAPAC drives, but is not beyond the understanding of a competent programmer. Sequential files present few problems but the first time user should beware of random-access files — they are hard!

The real strength of the 2040 lies in its extreme flexibility. Once mastered, its controlling instructions from Basic allow you quickly to set up sequential and random-access files. The RAM inside the unit means that buffers do not take up any of the PE's memory and this, together with the tremendous range of facilities offered with the operating system, means that tailor-made software should be of a very high standard. The latest release of the operating systems, DOS SUPPORT 4.01, goes a long way to helping the new user in handling the disk — most commands, such as initialising the disk and loading programs, now only require one or two simple key depressions.

Because the 2040 is a IEEE device, it can be controlled from machine code using the IEEE protocol and plugs into the IEEE connector on the back of the PET. The PET to IEEE cable supplied by Commodore is unusual in that it has an ordinary edge connector at one end and a male and female IEEE connector at the other. This allows further devices to be daisy-chained from the back of the disk drive using the IEEE to IEEE connector also supplied by Commodore.

If manufacturers of PET IEEE peripherals and interfaces are sensible, they will now design their units with an IEEE socket to facilitate daisy-chaining. There is no need to supply a separate connecting cable as Commodore's own will do.

For those who wish to create, update and make enquiries on random access files, HIPPOSOFT offers a random-access file handler for the 2040 drives on the new business PETs. This handler allows you to create up to 620 records on one side of a diskette with each record containing up to 40 variable length fields, for example PART-NUMBER, UNIT-COST etc.

Records can be added to the file, amended, deleted or listed at random. Any record within the file can be found and displayed on the screen within two seconds. Inquiries can be made on the file by listing any individual record or by searching the file for records that fulfil certain requirements

Afraid of POKE?

For those who like me as beginners are afraid of POKE commands on a PET, here are two routines which may help to show how versatile a machine it is, writes J. Patterson from Leeds.

```
1 REM SQUARE PRINTING ROUTINE
5 PRINT "(CLR)"
10 INPUT "HOW MANY UNITS LONG WOULD YOU
LIKE EACH SIDE TO BE"; N
15 IF N 21 THEN PRINT "TOO BIG FOR SCREEN":
FOR I = 1 TO 1000: NEXT: GO TO 5
20 M = 32892
25 PRINT "(CLR)"
30 FOR I = 1 TO N
40 M = M + 1: POKE M, 224
50 NEXT
60 FOR I = 1 TON
70 M = M + 40: POKE M, 224
80 NEXT
90 FOR I = 1 TON
100 M = M — 1: POKE M, 224
110 NEXT
120 FOR I = 1 TON
130 M = M — 40: POKE M, 224
140 NEXT
150 PRINT "(CURSOR DOWN 22 TIMES)"
```

This routine uses a 'space' on 'reverse' field, but there are over 200 other symbols which Pet will print.

Here is a short routine to demonstrate them:

```
5 REM PET SYMBOLS
10 M = 32767
20 T = —1
30 FOR I = 1 TO 256
40 M = M + 1: T = T + 1
50 POKE M, T
60 NEXT
```

This will print all 256 symbols from the keyboard in order. The board is printed four times: first just as it stands, then once more in the 'shift' position, then the whole process is repeated with 'reverse field' on. The number to POKE lies between 0 and 255. 0 is '   ' and 255 is '?' shifted and in reverse field. Then comes the tedious task of counting which symbol you wish to use and then amending the square routine to accept it.

Insert a line 16 into the square routine as follows:

```
16 INPUT "WHAT SYMBOL WOULD YOU LIKE"
:A
```

Type the number you would like and alter lines 40, 70, 100 and 130 from POKE M, 224 to POKE M, A.

As you can see, the results are not squares but rectangles because the space used by one character on the screen is 5 × 7 and not square; but then someone may take this into account and write a better program.

M is put at 32892 to put it far enough away from the left hand upper corner of the screen to look right. Lines 40, 50 and 60 print the upper line by adding 1 to M for as many units as needed. In the same way, lines 70 to 140 print the remainder of the square. Line 150 pulls the cursor down below the printout to allow easier re-runs. Omit this line and the cursor ends up in or near the square.

Ron Geere's speedy clockface programme.

```
100 REM ANALOGUE CLOCK BY R.D.GEERE
120 PRINT"QQQQ]SET CORRECT TIME BY SCREEN EDITING:
140 PRINTTAB(15)"QQ";LEFT$(TI$,2);" ";MID$(TI$,3,2)
160 INPUT"]]]]]]]]]]]]]]]]";A$
180 TI$=LEFT$(A$,2)+RIGHT$(A$,2)+"00"
200 PRINT"J";:POKE59468,12:00=33308:K=4/3
220 R=11:FORTH=0TO360STEP30:A=TH*π/180
240 POKE(00+INT(K*R*SIN(A)+.5)-40*INT(R*COS(A)+.5)),35:NEXT
300 REM READ TIME
340 HR=VAL(LEFT$(TI$,2)):MN=VAL(MID$(TI$,3,2))
360 PRINT"S]]]]]]]]]]]]]]]]]          ]]]]]]]]";HR;MN
380 HR=HR+MN/60
400 A=HR*π/06:R=7:CH=42:GOSUB1000
500 A=MN*π/30:R=9:CH=46:GOSUB1000
600 A$=MID$(TI$,5,1)
620 IFMID$(TI$,5,1)=A$THEN620
640 A=HR*π/06:R=7:CH=32:GOSUB1000
660 A=MN*π/30:R=9:CH=32:GOSUB1000
800 GOTO300
1000 REM SET HANDS
1020 C=COS(A):S=K*SIN(A)
1040 FORI=0TORSTEP.5:POKE(00+INT(I*S+.5)-40*INT(I*C+.5)),CH:NEXT:RETURN
READY.
```

Convert to histograms

MARTIN EVANS, from East Finchley, has sent in this snippet which he has used to run programs to list file data on screen, and to convert data into histogram form:

You noted in November's Tandy Forum that cassette data files are very tedious and cause wear on the cassette motor relay. One way round this problem is not to use INPUT —1 at all, but instead to store the data in DATA statements. If the data is only to be used in one program, there's no problem. It can easily be altered and updated using the editing facilities. But what if you want to use the same bunch of data in more than one program?

One answer is to write a short program consisting entirely of DATA statements, eg:

```
5000 REM: MONTHLY CASES PROCESSED
5010 DATA "JANUARY", 1978 : REM: MONTH AND
YEAR OF FIRST DATA ITEM.
5020 DATA 10, 8, 11, 12, 9, 15, 14, 13, 20, 14,
5030 DATA 16, 12, 8, 10,
5040 END
```

Then in writing any program to use this data, be sure not to use any Line number greater than 5000. Since DATA statements work no matter where they are in a program, it will not matter that the READ statements are much earlier on. Now all we need is a way of CLOADing a program form tape and then CLOADING another one without losing the first one. Fortunately there is a way.

TRS 80 Computing Volume 1, no 3 gave a 3-line Basic program by Ron Markel to do this. I've expanded this so as to print the instructions for using it on the screen. It looks like this:

```
1 CLS
2 A = PEEK (16548)
3 B = PEEK (16549)
4 E = 17129
5 S = E : E = PEEK (S + 1) * 256 + PEEK (s) : IF E <>
  0 GOTO 5
6 POKE 16549, INT (S/256) : POKE 16548 S — INT
  (S/256) * 256
7 PRINT "INSTRUCTIONS"
8 PRINT "__________"
9 PRINT
10 PRINT "1. POSITION DATA TAPE"
11 PRINT "2. SET RECORD TO PLAY"
12 PRINT "3. TYPE C LOAD    ENTER  "
13 PRINT "4. AFTER DATA HAS LOADED, STOP
   RECORDER AND REMOVE TAPE"
14 PRINT "5. TYPE POKE 16548, ";A; "    ENTER  "
15 PRINT "6. TYPE POKE 16549, " ; B; "   ENTER  "
16 PRINT "7. TYPE RUN 100    ENTER  "
17 STOP
100 REM: START THE MAIN PROGRAM HERE
```

Each program for using the data should begin with these lines. This is not as cumbersome as it sounds. Just CLOAD an existing program that incorporates them and DELETE the rest of it.

The snags? If you accidentally return to the beginning of the program, into the append routine, you'll have to type in the POKEs again to get yourself out and back into the main program. And remember that the data lines must be numbered higher than the main program. Even if they are numbered lower, the program will add them (out of numerical sequence) on the end — and nothing you can do with the edit facilities will get rid of them.

Save more time

CHRIS McGINNES has this to add to Stephen Toop's note in Tandy Form (October), noting that not only is the keyboard disabled but also the program running time is decreased:

This can be shown by running the following two small programs below.

(i) 10 FOR I = 1 TO 50000:NEXT
which takes approximately 108 seconds.
(ii) 10 POKE 16405,0:FOR I = 1 TO 50000:NEXT:POKE 16405,1
which takes approximately 93 seconds.

This is a saving of approximately 13 per cent running time.

Tandy freebie

R.E. PEEL, wrote from Maidenhead to suggest that the best way to get the Basic debounce to work is to stroll down to the nearest Tandy shop and ask for the keyboard debounce/real time clock cassette: It's free!

Also, with reference to Mr Sinclair's comments about pulling out the jack on the cassette recorder to enable you to rewind, I would point out that since last March, Tandy has been selling the TRS-80 with the CTR-80 cassette player, which obviates the problem. I have had the full volume CLOAD — on my CTR-80 the volume needed is between 6 and 8 (8 being the highest number in the CTR-80) but it really does make life easier and is worth the £10 or so it costs.

Has anyone come up with a method of determining the file name on a tape to be loaded by the SYSTEM command when you don't know what the name is?

Better way to jump

ED PHIPPS asks Tandy Forum, November 1979, if there is a better way to jump to the machine code than using the USR function. M.P. Automation, Leeds, tells us that there is:

On the Level 2 TRS-80 it is possible to jump *one way only* to any location, using the SYSTEM command. It is not necessary to load a system tape. To jump to a specified address, type in SYSTEM (ENTER) / address (in decimal) (ENTER).

So, referring to Mr Phipps's Basic program, delete line one, delete the remarks about ignoring error messages, delete line 6. Enter or CLOAD the program, RUN it, then type in "SYSTEM (ENTER) /20425 (ENTER) NEW (ENTER)" and off you go. Of course, as Mr Phipps says, you must have answered "MEMORY SIZE?" with 20425.

If you ever need to return to "MEMORY SIZE?", *do not* switch off — type in "SYSTEM (ENTER) /0 (ENTER).

Quicker key-checks

IN THE OCTOBER 'Tandy Forum' a suggestion was made that the PEEK function could be used to scan the keyboard. Alan Pearmain, from Mitcham, has done a little experimenting, and found that only seven locations need to be examined to get a positive check for any key (except, of course, SHIFT and BREAK). These locations are not unique; similar checks can be made on other locations but it is only necessary to be aware of those listed below:

Key	Location	Value
	14337	1
A		4
B		4
C		8
D		16
E		32
F		64
G		128
H	14338	1
I		2
J		4
K		8
L		16
M		32
N		64
O		128
P	14340	1
Q		2
R		4
S		8
T		16
U		32
V		64
W		128
X	14344	1
Y		2
Z		4
0	14352	1
1		2
2		4
3		8
4		16
5		32
6		64
7		128
8	14368	1
9		2
:		4
;		8
,		16
—		32
.		64
/		128
ENTER	14400	1
CLEAR		2
		8
		16
		32
		64
SPACE		128

No key returns at 4 in 14406 — this could be the BREAK key

Tandy has published a software fix for correcting the problem when using a READ after an INPUT was executed. The correction (POKE 16553,255 before the first READ is performed) appears to also do funny things to the logic in certain IF ... RETURN ELSE ... statements which worked correctly before the above correction was used. Has anyone else encountered this problem? The answer was to split the line after the RETURN to create a separate line.

Zzzz! Wake up, Apple users!

THE LATEST market research reveals that over 40,000 microcomputers have been sold in the UK. Apple/ITT and Commodore each have about 20% of the market and Tandy takes about 10%. Yet every month about twice as many Tandy and PET users write to their pages in *Practical Computing* and pass on their hints, tips and ideas.

Why are Apple users so different from the others? Apple Pie is your page, for you to write in with your ideas for the benefit of other users. Interesting applications are just as important as programming tricks.

Instruction manuals

W. H. SKIPTON of ABEL Computer Systems has sent us the following Applesoft subroutine which will print whatever is currently displayed on the screen. He thinks that it could be used to print off menu screens when preparing user instruction manuals.

Notes
is printed as £
The PRINT "PR . . . has a <CTRL> D embedded in it
The PRINT "80N . . . has a <CTRL> I ie, they use Apple DOS and parallel printer card

```
****************************************
*]LIST                                 *
*                                      *
*31000  REM  PRINT CURRENT SCREEN      *
*    -   APPLESOFT BASIC               *
*31005  PRINT "PR£1": PRINT "80N":     *
*      PRINT "*******************      *
*     ***********************"         *
*31010  FOR I = 0 TO 2: FOR J = 0 TO   *
*     3: FOR K = 0 TO 1: PRINT "*"     *
*     ;: FOR L = 0 TO 39: PRINT  CHR$  *
*     ( PEEK (1024 + K * 128 + I *     *
*     40 + J * 256 + L));: NEXT L:     *
*      PRINT "*": NEXT K,J,I           *
*31020  PRINT "*******************     *
*     ***********************": PRINT *
*     : PRINT : PRINT "PR£0"           *
*                                      *
*]REM ABEL COMPUTER SYSTEMS            *
*                                      *
*]NOMONC,I,O                           *
*                                      *
*]RUN                                  *
*                                      *
*]                                     *
****************************************
```

Improved file handling

J. E. VINE, Quality Control Engineer at Samco-Strong, in Bristol, has been using a 32K Apple with dual floppy disk drives and a printer. His company already has an IBM 32 which is used for accounting purposes on batch runs:

I am finding that the APPLE II could be used as a production control aid, but I would like to extract data from the IBM 32 and run it on the Apple. The most convenient way of doing this would be for the IBM 32 to output selected data onto a floppy disc (8in) and then use the Apple to read it.

Could you put me in touch with someone who would advise me on compatibility? The IBM 32 is programmed in RPG and the disc sectoring etc will be a problem to overcome by either hardware or software.

In the same issue of *Practical Computing* in the Review Section is the Disc Comparisons article. Is there any programming means by which the Apple DOS can operate like the Tandy DOS in that if a file is not found on Drive 1, it automatically searches Drive 2? Is there some way of using the "FILE NOT FOUND" error message to transfer to Drive 2? This would improve the file handling capabilities of the system.

Also, I need to put on to disc files that have a vastly varying number of records, but the records are of fixed length. Is there a convenient way of determining how much spare capacity there is on a disc prior to opening a new file? I have got half-way through a file and then got a "disk full error", which is a bit annoying.

Installation error

WE HAVE discovered two errors in Apple Intelligent Interface installation and operating manuals and feel that for the benefit of other Apple users the following corrections should be made, writes N. Hearne of Vlasak Electronics:

Apple serial interface card: The reset line from the interface normally sits at a low level and when reset on the keyboard is pressed, the reset line from the interface goes high. This is wrong and results in printer errors being thrown up. To rectify this, swap the connections to pins 1 and 5 and IC2 (74LS109).

Apple communications interface card: The modifications required to change the baud rate of this card are shown on page 36 of this manual. If modified for 4800/1200 baud, as shown in the manual, the computer will hang when instructed to use the part in which the card is sited. This is because IC2 (74C161) is not receiving a Load enable signal. This may be remedied by including a link between pins 15 on IC 1 and IC 2.

Current loop input

SOME OF you will find interesting the recent experience of H. Carson and G. Purdy with the current loop input of the Apple II high speed interface (A2L0008):

We have discovered that the input speed of the device appears to be limited by the 4N31 opto coupler to considerably less than the speed capabilities of the RS232 or current loop output. We tried two different high speed interfaces. One functioned up to 300 baud and the other up to 1200 baud on the current loop input.

For normal working this would be quite acceptable as current loop input is intended for teletype-like devices which generally operate at 110 baud. If, however, it is necessary to use the current loop input at higher baud rates, the opto coupler can be replaced by a TIL 111 opto coupler which will enable the device to operate at least at 2400 baud. The fact that the opto coupler is mounted in a plug-in base makes this change a two-minute job.

We would like to add, however, that this observation, which is really only of benefit in specialised circumstances, in no way detracts from the remarkable versatility of the Apple II serial interface card.

Minimal computers

There are now three minimal computers available in this country. In order of appearance, they are KIM, SYM and now ACORN.

To assist readers to program these machines, Arthur Richards has written a Tiny Sym Assembler which we hope to publish within the next few months. Further patches for KIM and ACORN are likely to follow.

Walter Wallenborn, secretary of the 6502 Users' Club, has offered to help us start a regular column about the 6502. Walter Wallenborn will write part of the column in each issue, but the rest is up to you, the reader. If you wish to contact the 6502 Special, send articles, ideas or problems directly to us.

Cross-fertilisation

THE 6502 USERS' Club was formed at the beginning of this year by Steve Cole, Harry Newman and myself (Walter Wallenborn) because

- We all had access to 6502 based systems.
- We came up with far more questions than answers and
- We could find no-one who had collected the answers.

So it was decided that the club would be formed as a self-help organisation where people at all levels of experience (and inexperience) could contribute and learn.

Our objectives in the first place were to

- Circulate a list of members' names and addresses and equipment to everyone who joined the club so that there could be as much cross-fertilisation as possible;
- Provide an answering service to all members' direct questions with the option of either referring that person to another member or printing the question in the Newsletter when I ran dry;
- Produce a regular Newsletter with as much useful information as we could pack in; and
- Meet to further encourage discussion and exchange of ideas.

We always welcome new members. The more people we have, the better the club can serve its purpose. If you are interested in joining, please write to me, Walter Wallenborn, 21 Argyll Avenue, Luton, Bedfordshire.

Interest in interrupts

THIS MAY help people interested in interrupts. It was written on and for an AIM 65, but the approach is generally applicable. What it does is set the Interrupt Enable Register to cause an interrupt when timer 1 in the 6522 times out. When the interrupt occurs, the B port is checked to see if any input is low (indicating that a switch has shorted the input to ground). All this is happening transparently while the machine seems to be doing everything else normally.

```
==0000 OUTDIS=$EF05

;OUTDIS=DISPLAY MON
ROUTINE
==0000 UDRB=$A000

;USER6522 DATAREG B
==0000 UIER=$A00E

;INTERRUPT ENABLEREG
==0000 UACR=$A00B

;AUXILIARY CONT.REG
==0000 IRQV4=$A400

;INTERRUPT REQEST
VECTOR 4
==0000 UT1L=$A004

;TIMER#1 LATCH LOW
==0000 UT1CH=$A005

;TIMER#1 LATCH&COUNT
ER HIGH
==0000
       *=$010C
==010C
;WHEN F1 IS PRESSED
A JSR FROM MON COMES
 HERE
4C000B JMP SETUP
;THEN THIS JMP GOES
TO THE SETUP ROUTINE
==010F
       *=$0600
==0600 OUCH
4F4F   .BYT 'OOOUCH!
',$0D
0D
==0608 AH
4141   .BYT 'AAAH!',
$0D
0D
==060E
       *=$0B00
==0B00 SETUP
A9C0   LDA #$C0
8D0EA0 STA UIER
;ENABLE T1 INTERUPT
A940   LDA #$40
8D0BA0 STA UACR
;T1 FREERUNS NO OUT
PUT
A900   LDA #$00
8DFF0B STA PUSHED
8D00A4 STA IRQV4
==0B12
A90C   LDA #$0C
8D01A4 STA IRQV4+1
;THE ADDRESS IRQV4
NOW HAS IS 0C00
58     CLI
A9FF   LDA #$FF
8D04A0 STA UT1L
8D05A0 STA UT1CH
;T1 LATCHES=FFFF
60     RTS
==0B21
       *=$0BFF
==0BFF PUSHED
       *=*+1
;PUSHED=LAST BUTTON
 STATE
48     PHA
08     PHP
8A     TXA
48     PHA
AD00A0 LDA UDRB
;DATA REGISTER B
C9FF   CMP #$FF
;IF ANY B INPUT IS
LOW GO TO PUSH
D007   BNE PUSH
ADFF0B LDA PUSHED
;WAS BUTTON PUSHED
LAST TIME
D01A   BNE AHER
==0C10
F02B   BEQ OUT
==0C12 PUSH
ADFF0B LDA PUSHED
D026   BNE OUT
A200   LDX #$00
CEFF0B DEC PUSHED
==0C1C OUTO
BD0006 LDA OUCH,X
;DISPLAY OOOUCH!
C90D   CMP #$0D
F01A   BEQ OUT
E8     INX
2005EF JSR OUTDIS
;DISPLAY LETTERS
4C1C0C JMP OUTO
==0C2A AHER
A200   LDX #$00
;DISPLAY AAAH!
8EFF0B STX PUSHED
==0C2F OUTA
BD0806 LDA AH,X
C90D   CMP #$0D
F007   BEQ OUT
E8     INX
2005EF JSR OUTDIS
4C2F0C JMP OUTA
==0C3D OUT
68     PLA
AA     TAX
28     PLP
A9FF   LDA #$FF
8D05A0 STA UT1CH
68     PLA
40     RTI
        END
 ERRORS= 0000
```

Life forms unlimited

Life ought to be part of every computer buff's education. We published a version for the TRS-80 back in August 1979, which aroused so much interest that we are now publishing another version, in Basic for the 380Z, by Steve Thomas.

THE GAME of Life was devised in 1970 by Professor John Horton Conway, at the University of Cambridge. The first account appeared in Martin Gardner's Mathematical Games column in *Scientific American* magazine in October 1970, and further items appeared sporadically until January 1972.

Since then, probably more computer time has been devoted to Life than to any other single problem. Indeed, my own introduction to the world of computing was through a desire to implement Life on a computer. This article gives a brief introduction to Life, and presents an unusual algorithm, in the form of a Basic program, for playing it on a computer.

Life was invented as a byproduct of Conway's attempts to develop a Turing machine. It models the growth of colonies of organisms. Three main considerations were proposed in developing the 'Laws of Nature'.

1. There should be no colony of organisms for which there is a simple proof that it will grow without limit.
2. There should be colonies which apparently do grow without limit.
3. There should be many colonies which develop and grow for prolonged periods before dying off or becoming stagnant.

After much trial and error, the following rules were developed:

1. Life is 'played' on an infinite plane divided into (finite) square cells. Each cell can hold one organism and is deemed to be adjacent to eight other cells — four diagonally and four orthogonally.
2. If an organism is adjacent to fewer than two other organisms (ie fewer than two cells adjacent to an occupied cell are occupied) it dies from 'loneliness' or 'isolation'.
3. If an organism is adjacent to four or more other organisms, it dies from 'overcrowding'.
4. If an unoccupied cell is adjacent to exactly three organisms, a 'birth' takes place and that cells becomes occupied. (Those who consider a three-parent family unrealistic should read *The Gods Themselves* by Isaac Asimov.)
5. All births and deaths occur simultaneously, so that dying parents can give birth, and newborn organisms neither overcrowd the generation in which they are born, nor provide 'company' for isolated organisms.

At this point, a few examples would perhaps be useful. **Figure 1** shows the first few generations of the 'T-tetromino'. **Figure 2** shows the blinker, the simplest of the class of colonies known for obvious reasons as oscillators. Generation 2 is identical to generation 0. Note that, although this colony will persist indefinitely, it does not conflict with consideration **(1)** because the population remains finite. **Figure 3** shows the block, the simplest form of 'still life'. There are about a dozen still-life forms which appear frequently as parts of larger colonies.

Figure 4 shows the glider, the simplest colony which moves. The colony moves down and to the right one cell every four generations. There are several other species of moving colonies known, notably the spaceship (**Figure 5**).

There is of course much more to Life than this brief account. Colonies have been discovered which periodically throw off a glider. These colonies, known as glider guns, grow without limit, and thus conflict with consideration **(1)**. Similar in concept is the spaceship factory, which periodically assembles and launches a spaceship. Another interesting colony is the 'puffer train', a colony which moves leaving behind stationary 'smoke'. Examples of these and many other interesting colonies are to be found in the *Scientific American* articles mentioned above, and in a recent issue of *BYTE* magazine (December 1978).

Implementation

There are at least two basic approaches towards implementing Life on a computer. The simpler approach is to approximate the infinite plane of the playing area by a finite rectangular array. Each element of the array holds codes for 'alive' or 'dead', with extra codes generated while the colony is being scanned — 'dying' and 'about to be born'.

This approach suffers from two major disadvantages. Firstly, the maximum size of the colony (as measured by the area of the smallest rectangle which will cover the whole colony) is restricted to the memory space available. I have not yet seen a published program which will cope with the 'R-pentomino' (**Figure 6**). This colony lasts for 1103 generations before becoming stagnant, and eventually covers an area about 500 by 550 cells.

The other major problem is one of execution speed. The execution time such a program is proportional to the area covered by the colony, so that sparse colonies are dealt with very slowly.

A more versatile approach, exemplified by the program presented in this article, is to store the coordinates of the living organisms. The program is relatively complex, but the increase in performance is enormous. The run time and storage use are both approximately proportional to the population, and the colony can cover an area limited only by the precision of the arithmetic used. This programme has an arbitrary limit of one million square.

Running the program

When the program is started, it will prompt Origin?

The program requires the coordinates of the top left-hand corner of the colony. The colony should be placed near the middle of the playing area, as no check is made for overflow. After the origin, a number of strings describing the colony should be input.

Each string describes a single row of the colony, with any character other than a space signifying a live organism. Empty rows are given by a string containing only spaces. The input to the colony is terminated by a null string. The program will then reprompt for an origin. More organisms can be added if desired, although they can only be added below the old organisms. If an origin of 0,0 is given, the program starts playing, and continues until interrupted.

How it works

Each row of the colony which contains at least one organism is described by a 'row number' followed by a column number for each organism on that row. The row numbers are held as negative quantities and the column numbers as positive. The whole colony is described by a number of these row descriptors, terminated by a zero.

The colony is scanned on a row-by-row basis to produce the next generation. The old generation is held at the high end of the storage array, and the new generation at the low end. At the end of the colony, the new generation is shifted to the top of the array, displayed, and the cycle repeated.

Three variables (R4, R3, and R5) point to the row being scanned and the rows immediately above and below it. If any of these rows do not exist (ie they are empty), then the pointer is zero. R1 holds a pointer to the next existing row after the row being scanned. This will be the same as R5 if R5 is non-zero. R1 is zero only at the end of the colony. R holds the row number of the row below the one being scanned.

There are three column pointers, held in the array C. C(1), C(2), and C(3) hold pointers to the next existing column after the column currently being scanned, in the rows pointed to by R3, R4, and R5, respectively. If either the rows or the columns do not exist, then the column pointer is zero. C holds the column number of the column immediately to the right of the one being scanned.

D1, D2, and D3 hold the total numbers of organisms in the three columns with column numbers C-2, C-1, and C, in the three rows under consideration. D4 holds the population of the cell with coordinates R-1, C-1. The rule for an organism existing in the next generation thus reduces to

(D1 + D2 + D3 = 3) OR (D1 + D2 + D3—D4 = 3)

The organisation of the program is straightforward. The subroutine at 1000 displays the colony. Because the colony can be very wide, the display is limited to a vertical slice of width W2 through the colony. Where the display is wider than the colony, the colony will be positioned at the left of the screen. Otherwise, it will be positioned according to the variable W1 — if W1 = 0 the window will be at the left of the colony, and if W1 = 1, at the

continued over

right. If there are four or more successive empty rows, then a message to that effect is output instead of the blank lines.

The subroutine at 2000 produces the next generation. It does this by repeatedly calling subroutine 3000. This scans a single row of the colony. Again, the main section of this routine calls subroutine 5000 to check and if necessary create each cell.

Subroutine 4000 is rather complex. Its purpose is to determine whether the organism in column C exists in the row specified by the dummy variable Z. It does this by comparing the column number of the column pointed to by C(Z), if necessary incrementing C(Z) and trying again. Subroutine 6000 calls 4000 three times to determine the next value of D3, and 7000 shifts the colony from the bottom of the array to the top.

Possible problems

The program is written in Research Machines Ltd 9K Basic. The only features which may cause difficulty with other Basics are as follows:

Input of the colony is achieved by use of strings. The actual method of obtaining substrings will probably be different in other Basics. The input is terminated by a null string. If your Basic objects to this, replace line 140 with

```
IF Q$ = "ZZZZ" THEN 70
```

and terminate the input with "ZZZZ". Some Basics may require that the string be DIMensioned to reserve storage.

The program makes extensive use of ON . . . GOTO statements. They have been arranged so that control never 'drops through', so there will be no problem about portability from this consideration. However, some Basics do not support the computed GOTO at all, and they will have to be replaced by a series of IFs.

The program uses AND and OR within IF statements. They can be replaced by multiple IFs with some loss of efficiency.

The program assumes that 999999 and 1000000 are recognized as different and do not cause overflow. If this is not the case, then the size of the board will have to be reduced by altering lines 40, 2010, and 3040.

The other possible source of trouble is that use is made of the ability to use relational expressions within arithmetic expressions.

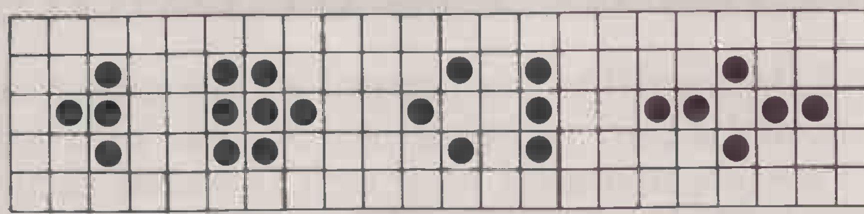


Figure 1

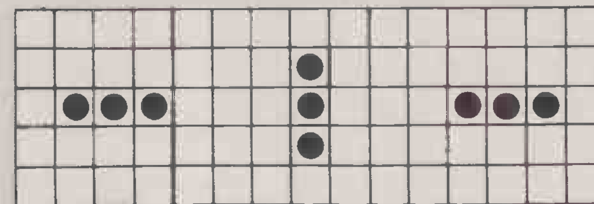


Figure 2

```
 10 CLEAR 200
 20 DIM A(3000),C(3)
 30 W2=38
 40 L=1E6 :REM The LHS of
                    the colony
 50 P=1
 60 R1=100
 70 PRINT "Origin";
 80 INPUT R,C
 90 ON 1-(R=0)-(R<R1 OR
    C<100) GOTO 100,70,260
100 IF C<L THEN L=C
110 INPUT Q$
120 R=R+1
130 R1=R
140 IF Q$="" THEN 70
150 A(P)=1-R
160 P=P+1
170 FOR Z=1 TO LEN(Q$)
180 IF MID$(Q$,Z,1)=" "
                    THEN 230
190 A(P)=C+Z-1
200 IF A(P)>B THEN B=A(P)
                    :REM The RHS
210 P=P+1
220 Q=Q+1 :REM Population
230 NEXT Z
240 P=P+(A(P-1)<0)
250 GOTO110
260 A(P)=0
270 N2=P
280 GOSUB 7000 :REM Shift
                 the colony up
290 GOSUB 1000 :REM Display
300 GOSUB 2000 :REM Do one
                    generation
310 IF Q=0 THEN 340
320 T=T+1
330 GOTO 290
340 PRINT "The colony is
                    extinct"
350 STOP

1000 P=G
1010 IF B-L>W2 THEN 1040
1020 C=-L
1030 GOTO 1050
1040 C=W1*W2-W1*B-(1-W1)*L
1050 R=A(G)
1060 PRINT "Gen"; T;
                   "Origin (";
1070 PRINT -A(G); ","; L;
                     ") Pop";Q
1080 GOTO 1100
1090 P=P+1
1100 ON SGN(A(P))+2 GOTO
              1110,1240,1200
1110 N1=R-A(P)
1120 R=A(P)
1130 N2=4
1140 IF N1<4 THEN N2=N1
1150 FOR Z=1 TO N2
1160 IF Z=3 AND N1>=5 THEN
          PRINT N1-3;"Rows";
1170 PRINT
1180 NEXT Z
1190 GOTO 1090
1200 W=C+A(P)
1210 IF W<0 OR W>W2 THEN
                        1090
1220 PRINT TAB(W);"*";
1230 GOTO 1090
1240 PRINT
1250 PRINT
1260 RETURN

2000 R1=G
2010 L=1E6
2020 B=0
2030 N1=0
2040 Q=0
```

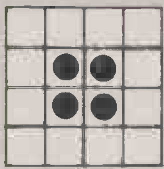


Figure 3

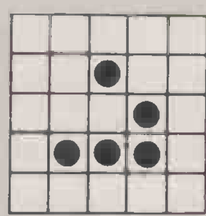


Figure 4

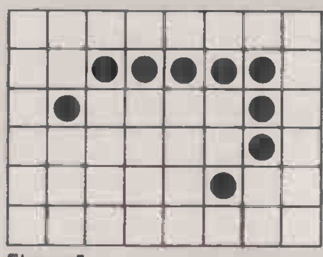


Figure 5

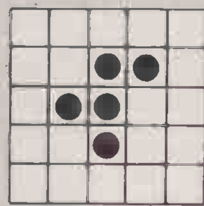


Figure 6

```
2050 A(1)=0
2060 A(2)=0
2070 N2=1
2080 IF R1=0 THEN 2200
2090 R=-A(R1)
2100 R3=0
2110 R4=0
2120 R5=R1
2130 IF R5=0 THEN 2080
2140 GOSUB 3000
2150 IF R5<>0 THEN 2140
2160 GOSUB 3000
2170 IF R5<>0 THEN 2140
2180 GOSUB 3000
2190 GOTO 2130
2200 A(N2)=0
2210 IF B=0 AND N2>1 THEN
                    B=A(N2-1)
2220 GOTO 7000
5000 S=D1+D2+D3
5010 IF S<>3 AND S-D4<>3
 THEN 5130 :REM Cell exists?
5020 IF R+N1=1 THEN 5100
5030 A(N2)=1-R
5040 N1=A(N2)
5050 IF C-1<L THEN L=C-1
5060 B1=0
5070 IF N2>1 THEN B1=A(N2-1)
5080 IF B1>B THEN B=B1
5090 N2=N2+1
5100 A(N2)=C-1
5110 N2=N2+1
5120 Q=Q+1
5130 D1=D2
5140 D2=D3
5150 Z=2
5160 GOSUB 4000
5170 C=C+1
5180 D4=D

6000 D3=0
6010 FOR Z=1 TO 3
6020 GOSUB 4000
6030 D3=D3+D
6040 NEXT Z
6050 RETURN

7000 FOR Z=0 TO N2-1
7010 A(3000-Z)=A(N2-Z)
7020 NEXT Z
7030 G=3001-N2
7040 RETURN


3000 C(1)=R3+(R3=0)+1
3010 C(2)=R4+(R4=0)+1
3020 C(3)=R5+(R5=0)+1
3030 IF C(1)+C(2)+C(3)=0
                   THEN 3200
3040 C=1E6
3050 FOR Z=1 TO 3
3060 IF C(Z)=0 THEN 3080
3070 IF A(C(Z))<C THEN
                  C=A(C(Z))
3080 NEXT Z
3090 D1=0
3100 D2=0
3110 D4=0
3120 GOSUB 6000
3130 IF D3=0 THEN 3030
3140 GOSUB 5000
3150 IF D3<>0 THEN 3140
3160 GOSUB 5000
3170 IF D3<>0 THEN 3140
3180 GOSUB 5000
3190 GOTO 3130
3200 R=R+1
3210 R3=R4
3220 R4=R5
3230 IF R1=0 THEN 3280
3240 ON SGN(A(R1)+R)+2 GOTO
               3280,3300,3250
3250 R1=R1+1
3260 ON SGN(A(R1))+2 GOTO
               3240,3270,3250
3270 R1=0
3280 R5=0
3290 RETURN
3300 R5=R1
3310 RETURN

4000 D=0
4010 IF C(Z)=0 THEN RETURN
4020 ON SGN(A(C(Z))-C)+2
        GOTO 4030,4070,4080
4030 C(Z)=C(Z)+1
4040 IF A(C(Z))>0 THEN 4020
4050 C(Z)=0
4060 RETURN
4070 D=1
4080 RETURN
```

TRUE evaluates to —1 and FALSE to 0. Some Basics allow this type of expression, but use TRUE = 1, and some do not allow it at all. The former case requires adjustment of a few signs. In the latter case there is nothing for it but to use a few more IFs.

Better things

The major difficulty with this program is that it is very slow, at least on a microcomputer. Minor improvements can be made, by optimising the code for speed, at some cost in legibility. The only solution, apart from acquiring a much faster computer, is to write the program in assembly code.

Fortunately, translation is straightforward, because most of the arithmetic consists of incrementing by one. On an 8-bit machine, the best board size is probably 32767 square. Making it larger would slow the program and increase its storage requirements, and 127 square is probably too small (although this is still better than most programs). The effort involved is well worthwhile, as Life really comes into its own when seen at several generations per second.

A Guided Tour of Computer Programming in Basic

by Thomas A Dwyer and Michael S Kaufman; published by Houghton Mifflin Co, 1977; 156 pages; $4.80.

DWYER and Kaufman wrote this as a teaching aid in 1973 and adopted a very human approach towards explaining programming in Basic. The style of writing, the cartoon-like pictures, large lettering and imaginative but not freaky layout make it an entertaining text to read. At the same time it detracts in no way from an explanation of the language.

The computer is presented as a non-intelligent robot with the sole function in life of obeying the instructions given to it by a programmer explicitly. The authors clearly make the point that humans are intelligent — computers are not.

All this is under the heading How to recognise a computer, and for a change the authors start with minicomputers and mention punched cards only as an afterthought. Large computers get a look in as time-sharing terminals, rather than as the fundamental characteristic of computing.

The book starts with an easy introduction and then uses a structured approach to build the definition of the Basic language. Each new statement type is introduced and explained with meaningful examples, with flowcharts used to illustrate the logic behind the examples.

To illustrate the author's easy style, try this friendly exposition — "the FOR and NEXT statements were invented to simplify the writing of programs that do the same kind of thing over and over again, in other words, programs that contain loops. This means that FOR and NEXT can help you write short programs that produce lots of output". It's true, they can.

A concise explanation is offered for the use of flowcharts and each section ends with a good review of the material introduced. The examples are produced as Teletype listings and include the results obtained from a computer run.

Exercises are included in each section and although the authors expect the reader to have access to a computer to try them, the majority are understandable as read.

From time to time the *Guided Tour* shows its age slightly by talking about program preparation using punched cards and paper tape, neither of which are likely to be of any but historical interest to today's reader.

More important, however, the authors point out a number of the differences the reader is likely to find in the implementation of the Basic language, but they miss others, including the range of line numbers available for use and the restrictions on dimensioning arrays.

Our one major criticism is that the authors have omitted to explain the use of character strings and of files, both of which are important parts of the current commercial use of Basic. This seems to be a common feature of Basic books and presumably results from their classroom origins.

It could be argued that children learning the language will not need an appreciation of text handling or of files. We would disagree, of course.

Conclusion

- **This book could do with an update by the authors to include some of the missing language commands, especially those for file handling. Apart from that, it makes a very readable and entertaining introduction to the Basic language, we can recommend it.**

*We had to order our copy from the States, which is why we give a dollar price. Ours was from the *Creative Computing* catalogue and despatch added $1.25 to the price. The address is PO Box 789-M, Morristown, NJ07960, USA. Please mention *Practical Computing* if you order. Are there any U.K. stockists? Let us know and we will print your address.

Personal Computing

Edited by Raymond P Capece; published by McGraw-Hill, 1978; hard cover, 266 pages; £11.20

THIS is yet another compilation of previously-published articles culled from a variety of magazines with dates between November, 1973 and November, 1978. It divides into sections and is arranged with the intention of providing an introduction to hardware and software for users of personal computers. It's a substantial and generally well-produced book from a major publisher and the author is a respected U.S. technical journalist. So far so good.

If you set out to obtain information in the fast-changing world of computing it's important to get the latest available. An article five years old can be well out-of-date. On the other hand, well-chosen articles — preferably edited to delete irrelevant references — and arranged in a logical sequence can provide a good grounding over a wide area.

Some duplication is inevitable between books such as this and the things you might read in the current magazines. Add to this the fact that there will be references to products — and even companies — no longer around; and beware that some items will have no relevance to British readers — for example, a list of suppliers of second-hand equipment. You may find the usefulness of the content reduced considerably.

That said, this a pleasant book to handle. It has an index as well as the obligatory list of buzzwords — though both are short — a glossary of terms and a useful list of graphic symbols for electronics diagrams.

For novices

It starts with an Introduction to Personal Computing which has some general information for absolute novices and looks at a few applications; not too bad. Part 2 is Basic Computer Theory dealing with architecture, chips and memories; a trifle leaden, because a sequence of magazine articles is no way to educate someone in textbook fundamentals. The third part covers Advanced Theory and goes further into the technology — a much better subject for magazine articles.

Then there are eight reviews of personal computers, much of which looks rather like a public relations exercise.

Part 5 deals with software and includes an introduction to Basic, an enthusiasm over Pascal, and a discussion of the relative merits of Pascal over Basic. In this section each item can be regarded only as the briefest of introductions.

The final part comprises specifications and other information, some of which isn't very useful here — unless you want to know where you can buy a Teletype in New Jersey.

Conclusion

- **As the title says, it's basic, and if you want plenty of basic information, you'll certainly get it. If you have a good memory, you'll be able to astound your friends by reciting the technical specifications of 24 micros.**
- **The bias is on hardware and electronics, though, and though this anthology might make a good taster for the subject, you can spend less and get more in the way of an introduction. — R.G.**

Getting acquainted with microcomputers

by Lou Frenzel; published by Howard W. Sams Co, 1978 (distributed through Prentice Hall); paperback, 288 pages; £6.55

LOU FRENZEL is an electronics engineer by training and an educator by profession. Currently he runs that section of Heath Co which puts out the H8 and H11 personal computers, as well as Heath's self-instruction kits and other neo-educational products.

So he ought to know what he's talking about. And just to make sure that he was not writing a thinly disguised plug, we scoured the text for references to Heath, its microcomputers, and the idiosyncratic Benton Harbor bus that they employ. We are able to report that Heath Co gets only the exposure it warrants.

The book promises it "will help you learn more about microcomputers and their application and prove invaluable for those who want to know more about hobby and personal computing."

Basic knowledge

Our reaction is that the first sentence is true; the second very unlikely to be so. The book goes into detail and requires at least a basic knowledge of electronics before you will be able fully to understand it. Such quotes as "and is usually Schottky TTL", with no previous explanation of the meaning of these words — nor for that matter an index for them — makes it pretty heavy going for the inexperienced reader.

Another example: "The earliest microprocessors used P channel enhancement mode FETs. Some P channel microprocessors are still being manufactured, but to date most microprocessors used N channel circuitry. Enhancement mode MOSFETs are the prime circuit elements, although some depletion mode devices are also used. CMOS integrated circuits are also used to make microprocessors." To a novice, this is obscure and probably unnecessary.

It is not aimed at the rank novice, though, and provides a good introduction to microcomputers for someone who wishes to expand his or her knowledge of the subject. It offers a large amount of useful information — for example, describing several microprocessors with their technical specs. It has many illustrations, too.

The bibliography at the end is very short and it seems somewhat pointless — literature on microcomputers is now extensive and to give only two dozen or so titles seems restrictive. The index in this kind of book will usually be used quite heavily: this one is fairly superficial and should be expanded.

Conclusion

For someone who has a reasonable amount of background knowledge of computer hardware, this book will form an excellent introduction to microcomputers. For other people, it may prove too technically detailed.

There's no need to tear your hair out getting to grips with your monitor. R. D. Hodgson describes how to squeeze the last drop out of the CPU while keeping hardware to a minimum in . . .

A brief encounter with monitor program software

FOR MOST microcomputer users, the first software encountered is the program that lives in ROM somewhere in the system hardware. Even if the system costs thousands, handles four floppies and has colour graphics, it will almost certainly also sport a monitor program.

The reason for this is built into the processor chip itself, and is a result of what happens during 'reset'. With very few exceptions, applying a reset pulse to your microprocessor forces the program counter to zero and more often than not also disables the interrupt system. Once the internal initialisation routine built into the CPU chip is complete, the processor fetches its next instruction from location zero.

Obviously, if you have no program living there, the CPU stands a good chance of getting hopelessly lost in the few few bytes, and we all know that feeling!

Depending upon what other components are attached to the system buses, the monitor program will probably output a few bytes to initialise other programmable devices, such as PIOs and UARTs, before doing anything else. On larger systems, the monitor might also contain a 'bootstrap' routine which loads the operating system down from disc if the disc is ready; otherwise a simple monitor is usually substituted.

Since micros of the 8080/Z80 type have dedicated locations in the first few bytes of their address space for use by restart instructions and simple interrupts, it is usual to jump round these locations and leave those bytes for jumps to other useful routines, of which more later.

If your system has a memory-mapped VDU, the very next thing the monitor program will do is clear the screen. This usually takes only a few bytes of code since it involves writing a space (20H) to each location of the VDU RAM. The Nascom 1 monitor, NASBUG, has a clear screen routine which can be called by the user simply by putting the right charcter into the accumulator and calling the character output routine, and many similar systems use the vertical tabulation character for this purpose.

After clearing the screen, the cursor is usually placed in the bottom lefthand corner, as in Figure 1.

The first visible part of the monitor program is usually the monitor prompt, which takes the form of a non-alphanumeric and is written to the first location on the screen, or output to the console, sometimes preceded by carriage return and line feed — good practice, but, as Nascom users will know to their annoyance, not always implemented. The memory-mapped VDU will then have the cursor moved one space to the left and cursor pointer incremented.

Figure 1

```
CLEAR
        Z80                          8080
        LD HL, VDURAM                LXI H, VDURAM   ;Puts the address of the VDU
                                                     IN HL
        LD C,CHARS                   MVI C,CHARS     ;Put the size of the screen in C
CLEAR1  LD (HL),20H          CLEAR1  MVI M,20H       ;Put a space in each location
        INC HL                       INX H           ;Go for the next location
        DEC C                        DCR C           ;Count the locations
        JR NZ,CLEAR1                 JNZ CLEAR1      ;Test for last location
        LD HL,BOTLFT                 LXI H,BOTLFT    ;Put address of bottom left in
                                                     HL
        LD (HL),CRSR                 MVI M,CRSR      ;Put the cursor on the screen
        LD (POINTR),HL               SHLD POINTR     ;Put current cursor position in
                                                     pointer
```

Figure 2

```
        Z80                  8080
COMD    LD A,(LENGTH)  COMD  LDA LENGTH      ;Put the length of the table into
                                             A
        LD E,A               MOV E,A         ;Put it into E
        LD HL,TABLTOP        LXI H,TABLTOP   ;Put the table start address into
                                             HL
COMD2   LD A,(HL)      COMD2 MOV A,M         ;Read the first entry of the table
        CP C                 CMP C           ;Compare with the input
                                             ;character
        JR Z,MATCH           JZ MATCH        ;Have we found a match
        LD A,L               MOV A,L         ;If not, look at next entry
        ADD A,3              ADI 3           ;(Jump round the address of the
        LD L,A               MOV L,A         ;command)
        DEC E                DCR E           ;Last entry in table?
        JR NZ,COMD2          JNZ COMD2
        JP ERROR             JMP ERROR       ;Not a valid command. Chastise
                                             ;user
MATCH   INC HL         MATCH INX H           ;Valid command
        LD E,(HL)            MOV E,M         ;Fetch address of command
                                             ;routine
        INC HL               INX H           ;into DE pair
        LD D,(HL)            MOV D,M
        EX DE, HL            XCHG
        JP (HL)              PCHL            ;Jump to command routine
```

The appearance of the prompt character indicates that the monitor is sitting in a loop, reading the keyboard or UART and waiting for input. This is how the processor in most single-user machines spends most of its time.

When an input is received it is decoded, either by look-up table, or by a series of 'Compare . . . Jump if Zero' instructions. The choice depends on the instruction set of the processor. The look-up table can be part of the monitor ROM, or may be written into RAM during isation, or a compromise such as that used in Nasbug may be used, where the look-up table is in ROM, but the address of the beginning of the table is written into RAM during initialisation.

This means that other look-up tables can be used, but that if all the original commands are to be retained, the relevant parts of the table must be duplicated in the new table. Where the look-up table is itself in RAM, further commands may be implemented more simply. With the 'Compare . . . Jump if Zero' type of command-decoding, as in the Intel 8080 monitor, no command extension is possible.

The look-up table type of decoding could be implemented as in Figure 2.

The appropriate command table would then consist of groups of three bytes, the first being the character used to call that command, and the second two the address

Continued over

of the routine being called.

Decoding of input can be immediate, as in the case of the Intel monitor, with faulty commands indicated by some sort of error character; or an input buffer can be used which may allow editing of commands (using backspace or rubout) with decoding occurring on receipt of a carriage return. The latter, without error messages, is used on the Nascom, where the video RAM doubles as the input buffer.

Most monitors provide facilities to aid the programmer in program entry and debugging. The commonest are used to examine and/or change registers or memory, load memory locations from some input device (where this device is a cassette interface, a corresponding dump facility is usually provided), execute a program from a specified location, and insertion of breakpoints. Some less common facilities are single step and block relocation (Move or Copy). Single step requires the addition of hardware, although some processors can handle a single step facility entirely in the software.

It is common practice to make most of the commands in the monitor into subroutines, which allows them to be called by user programs: character input and output are the most popular.

Breakpoint and single step facilities almost always use the interrupt and restart vectors near the beginning of the monitor ROM. On the Z80/8080 family of processors, several restart instructions are provided which can be used for this purpose.

An 'insert breakpoint' command can be implemented quite simply by a routine which replaces the specified byte with a restart instruction, and stores the replaced code elsewhere, as in Figure 3.

Normally, the next command would be 'execute', and when the restart instruction is encountered, the program counter is loaded with the restart vector (in this case 0038H).

Obviously, the above breakpoint scheme is the bare minimum, and can be abused. Repeated use of the breakpoint command, without an execute command between each, will leave your program full of restart instructions, and only the last to be set will be restored correctly.

This scheme could be expanded to allow several breakpoints to be set if the replaced instruction were stored with its original address in tabular form, and the return address on the stack used to restore the correct byte of program.

Single step involves a similar recovery routine, but does not need to save or restore instructions. Nasbug uses the same routine for both recoveries, but the restoration of instructions is done by the 'set breakpoint' routine prior to setting the next. At first glance, it may appear possible to implement a single step facility using inserted restarts, but since the instruction length of all but the most rudimentary controller-type micros is variable, the program would need to know the length of the next instruction before it could work out where to place the 'restart'.

It is more usual, therefore, to implement part of the single step routine in hardware, and to use the interrupt handling structure of the processor to interrupt after one instruction has been executed. Since the interrupts must be enabled at least one instruction before the jump to the instruction to be executed, some sort of counter is needed to count the number of instructions after the 'enable interrupt' instruction before raising the interrupt request.

This is arranged so that the interrupt occurs during the user's instruction, but since the processor always completes the current instruction before acknowledging an interrupt, this allows just one user instruction to be executed. Unless the processor has a non-maskable interrupt, or trap, it is necessary to ensure that no attempt is made to step through a 'disable interrupts' instruction.

An interrupt can either cause a jump to a particular location near the beginning of the monitor ROM, (as in the Z80 NMI, or the 8085's TRAP,RST 5.5,6.5 and 7.5 inputs) or may require a restart instruction or other vector to be supplied by the interrupting hardware, as with the 8080.

The 'execute' or 'go' command usually takes the form of a carefully prepared return from a non-existent subroutine, and can frequently be used either with or without a start address. Some monitors such as MIKBUG require the user to insert the start address into a RAM location before the use of this command.

Since most monitors save the main registers, it is usual to restore all the saved registers before the 'return' instruction, although one processor, the 9900, renders this unnecessary because of its workspace pointer, which effectively places the registers in RAM, and they can then be saved just by changing the workspace pointer.

The 'execute' command for a Z80-based or 8080-based system might go like this:

```
Z80              8080
LD HL,(SPSTO)    LHLD SPSTO       ;Restore user stack
                                   pointer
EX SP,HL         SPHL
LD HL,(PCSTO)    LHLD PCSTO       ;Put program counter
                                   on stack
PUSH HL          PUSH H
LD DE,(DESTO)    LHLD DESTO       ;Restore D&E registers
                 XCHG
LD BC,(BCSTO)    LHLD BCSTO       ;Rstore B&C registers
                 PUSH H
                 POP B
LD HL,(AFSTO)    LHLD AFSTO       ;Restore accumulator
                                   and flags
PUSH HL          PUSH H
POP AF           POP PSW
LD HL,(HLSTO)    LHLD HLSTO       ;Rstore H&L registers
RET              RET              ;Jump to address
                                   from PCSTO
```

A listing of the monitor program for your system may at first appear to comprise a lot of short routines and a lot of call instructions, since many functions are duplicated in each command, such as acquisition of arguments, checking for valid digits and delimiters, echoing input back to the console, control of the cursor and scrolling (on memory-mapped VDU's), conversion between ASCII and hexadecimal, and many others.

Some single-board computers with built-in keypads and displays make much greater use of the monitor program, using it to scan and decode the keys, debouncing, decoding and driving LED displays. Some SC/MP based micros, where a test pin is used on the processor, even accept a serial input directly, and bytewise reconstruction of the serial data is done by the monitor.

The main disadvantages with this tykpe of monitor program is that when the CPU is away doing something else, the display and keyboard die, and if the display is to be used to output messages by the user's program, he is often faced with having to duplicate some of the scanning routines into his software, is making sure that the display is refreshed often enough one of the hardest tasks.

I hope that this will have been some help to those of you who are struggling to get to grips with your monitor, it is by no means exhaustive. There are many variations in use around the micro world.

Figure 3.

```
BPT1   LD HL,(ADDRBK) BPT1  LHLD ADDRBK    ;Put address of break into HL
       LD A,(HL)            MOV A,M        ;Pull out the code at that address
       LD (BRKINS),A        STA BRKINS     ;Save the byte being replaced
       LD (HL),OFFH         MVI M,OFFH     :Put restart code in its place
       RET                  RET
```

```
0038H  LD (HLSTO),HL        SHLD HISTO     ;Save H&L registers
                            XCHG
       LD (DESTO),DE        SHLD DESTO     ;Save D&E registers
                            PUSH B
       LD (BCSTO),BC        POP H          ;Save B&C registers
                            SHLD BCSTO
       PUSH AF              PUSH PSW       ;Save accumulator and flags
       POP HL               PP H
       LD (AFSTO),HL        SHLD AFSTO
       POP HL               POP H          ;Save program counter where break
       DEC HL               DCX H          ;occurred
       LD (PCSTO),HL        SHLD PCSTO
       LD A,(BRKINS)        LDA BRKINS     ;Retrieve original instruction
       LD (HL),A            MOV M,A        ;PUt it back
       LD HL,O              LXI H,*
       ADD HL,SP            DAD SP         ;Save user's stack pointer
       LD SP,MONSTK         LXI SP,MONSTK  ;Reload monitor stack pointer
       JP INPUT             JMP INPUT      ;Go for next command
```

Cut out conversion fiddle with assembler program

SOONER OR LATER the majority of micro-computer users will want to write programs in machine code. The usual reason is that high-level language interpreters like Basic are far too slow for some applications. Examples of such applications are sorts, and interfacing with external equipment in data logging or process control. Using machine code can often increase speed of processing by as much as 200 times the speed of a comparable Basic program.

Machine code programs can be written by hand, but this is a slow and very tedious operation and the result is invariably full of errors. Hand coding involves the conversion of the microprocessor instructions into a set of binary values for storage in memory. It is much simpler to use a program to perform this function. Such a program is known as an assembler. It allows a machine code program to be written in an assembly language rather than the binary values used in hand coding.

An assembly language uses a set of mnemonics and symbols to repreent the program. These are then translated by the assembler to produce the actual binary values of the machine code program. In comparison with a high-level interpreter of compiler, each assembly language statement will translate into one machine instruction occupying between one and three bytes of memory. A high-level language statement will, however, be translated into a whole block of machine instructions. It is for this reason that a machine code program is often so much faster than a high-level program, since a single assembly statement is often equivalent in its function to a high-level statement.

All digital computers use the binary number system for representation of data and instructions since a computer understands only ones and zeros corresponding to the "on" and "off" state. Such a system is, however, very difficult for human users and it is more convenient to use number representations like octal (base 8), decimal (base 10), or hexadecimal (base 16). To compare binary notation with hexadecimal — the usual notation used in assembly languages for eight bit micros — the following of an instruction to load the accumulator of a 6502 micro with the value 95 (decimal).

A hand-assembled machine code program would most likely be written in hexadecimal, and a monitor program used to load it into memory and convert it into binary format. The numeric representation of instructions is, however, tedious to work with and for this reason an assembly language uses a symbolic representation for the instructions.

Thus in the previous example the instruction might be written as:

```
LDA # 95
```

where LDA is a mnemonic symbol for the instruction to load the accumulator, this is equivalent to the hexadecimal value A9 in the previous example. The value which is to be loaded into the accumulator is represented in decimal form and the # sign is used to show that an immediate addressing mode is used.

A program written in this symbolic form is referred to as the source code. This is converted by the assembler into a numeric form which is known as the object code. The processor cannot execute a program in source code form — it must first be converted into object code by being assembled. In assembly language every instruction in a program has a symbolic name — ie LDA — referred to as the opcode (short for operation code). Thus in the 6502 assembly language there are 55 different opcodes: see figure 1.

An assembly language instruction thus consists of an opcode and perhaps also an operand which specifies the data on which the operation is to be performed. This operand may be a value in either decimal, hexadecimal or octal format, or a symbolic name, which references a location in which the data is stored.

In the 6502, instructions have a maximum of one operand, though some of the so-called implied instructions, of which there are 25, have no operand. An example of such an instruction is CLC — clear carry bit. Some instructions perform jumps or goto functions, thus instructions may be labelled for reference by other instructions. In the following example the label START is used to reference the first instruction by the conditional jump instruction:

```
START
LDA # INPUT
CMP # 95
BEQ START
```

Programming in assembly language is much

6502 instruction set opcode mnemonics

ADC — add with carry to accumulator
AND — "AND" memory with accumulator
ASL — shift accumulator left one bit
BCC — branch on carry clear
BCS — branch on carry set
BEQ .... — branch on zero result
BIT — test bits in memory with accumulator
BMI — branch on result minus
BNE — branch on result not zero
BPL — branch on result plus
BRK — force an interrupt or break
BVC — branch on overflow clear
CLC — clear carry flas
CLD — clear decimal mode
CLI — clear interrupt disable bit
CLV — clear overflow flas
CMP — compared memory and accumulator
CPX — compared memory and index X
CPY — compared memory and index Y
DEC — decrement memory by one
DEX — decrement index X by one
DEY — decrement index Y by one
EOR — exclusive "OR" memory with accumulator
INC — increment memory by one
INX — increment index X by one
INY — increment index Y by one
JMP — jump to new location
JSR — jump to subroutine address
LDA — transfer memory to accumulator
LDX — transfer memory to index X
LDY — transfer memory to index Y
LSR — shift accumulator one bit right
NOP — no operation
ORA — ;"OR" memory with accumulator
PHA — push accumulator on stack
PHP — push processor status on stack
PLA — pull accumulator from stack
PLP — pull processor status from stack
ROL — rotate accumulator one bit left
ROR — rotate accumulator one bit right
RTI — return from interrupt
RTS — return from subroutine
SBC — subtract memory and carry from accumulator
SED — set decimal mode
SEI — set interrupt disable status
STA — store accumulator in memory
STX — store index X in memory
STY — store index Y in memory
TAX — transfer accumulator to index X
TAY — transfer accumulator to index Y
TSX — transfer stack to index X
TXA — transfer index X to accumulator
TXS — transfer index X to stack
TYA — transfer index Y to accumulator

Figure 2

```
1000 ;**********************
1010 ;*
1020 ;*  REPEAT KEY
1030 ;*
1040 ;*   6/10/79
1050 ;**********************
1060 REPDEL=$00
1070 DELAY =$01
1080 KEY =$02
1090 IRQV =$90
1100 LSTKEY=$97
1110 BLINK=$A8
1120 BEGIN =$1000
1130 *=BEGIN
1140 ;
1150 ;REPEAT KEY ENABLE
1160 ;
1170 REPON SEI
1180  LDA #<REPEAT
1190  STA IRQV
1200  LDA #>REPEAT
1210  STA IRQV+1
1220  LDA #1
1230  STA REPDEL
1240  CLI
1250  RTS
1260 ;
1270 ;REPEAT KEY FUNCTION
1280 ;
1290 REPEAT LDA LSTKEY
1300  CMP KEY
1310  BEQ REP1
1320  STA KEY
1330  LDA #$10
1340  STA DELAY
1350 REPEND JMP IRQV
1360 REP1 CMP #$FF
1370  BEQ REPEND
1380  LDA DELAY
1390  BEQ REP2
1400  DEC DELAY
1410  BNE REPEND
1420 REP2 DEC REPDEL
1430  BNE REPEND
1440  LDA #$04
1450  STA LSTKEY
1460  LDA #$02
1470  STA BLINK
1480  BNE REPEND
1490 .END
READY.
```

more difficult than programming in Basic, since not only does it require the learning of an extensive set of opcodes, it also requires very strict adherence to assembly language structure, addressing conventions and processor status.

It is very important that assembler instructions are formatted correctly. To achieve this, source code programs are usually written using an editor program. The function of an editor, as its name suggests, is to allow the program to be modified easily. It also incorporates such functions as auto line numbering, searching for variable names, changing variable names and printout formatting for ease of reading.

Correct format

The source code will contain not only machine instructions but also assembler directives which are required by the assembler program, for example to determine the starting address of the object code. Each machine instruction can consist of up to five fields, each field separated by one or more spaces. Two of the fields, the line number and the opcode, must always be present in every instruction: the remaining fields depend on the instruction and the program. The instruction format is:

Line number Label 1 Opcode Operand: Comment

An example of a source code listing for a 6502 program is shown in figure 2. This was produced by the editor on Commodore's new assembler package for the PET. The source code program, which was written to provide the PET with a repeat key function, can be divided into two parts.

In the first part the variable names used in the program to represent data storage locations are assigned addresses (these are in hexadecimal, this being signified by the preceding $ sign). This section of the code ends with the assembler directive "* = BEGIN" where "BEGIN" has been assigned a value of hexadecimal 1000, which is to be the starting address of the program.

```
0001  0000               ;*********************
0002  0000               ;*
0003  0000               ;*  REPEAT KEY
0004  0000               ;*
0005  0000               ;*   6/10/79
0006  0000               ;*********************
0007  0000               REPDEL=$00
0008  0000               DELAY  =$01
0009  0000               KEY    =$02
0010  0000               IRQV   =$90
0011  0000               LSTKEY=$97
0012  0000               BLINK=$A8
0013  0000               BEGIN  =$1000
0014  0000                      *=BEGIN
0015  1000               ;
0016  1000               ;REPEAT KEY ENABLE
0017  1000               ;
0018  1000  78           REPON  SEI
0019  1001  A9 0F               LDA #<REPEAT
0020  1003  85 90               STA IRQV
0021  1005  A9 10               LDA #>REPEAT
0022  1007  85 91               STA IRQV+1
0023  1009  A9 01               LDA #1
0024  100B  85 00               STA REPDEL
0025  100D  58                  CLI
0026  100E  60                  RTS
0027  100F               ;
0028  100F               ;REPEAT KEY FUNCTION
0029  100F               ;
0030  100F  A5 97        REPEAT LDA LSTKEY
0031  1011  C5 02               CMP KEY
0032  1013  F0 09               BEQ REP1
0033  1015  85 02               STA KEY
0034  1017  A9 10               LDA #$10
0035  1019  85 01               STA DELAY
0036  101B  4C 90 00     REPEND JMP IRQV
0037  101E  C9 FF        REP1   CMP #$FF
0038  1020  F0 F9               BEQ REPEND
0039  1022  A5 01               LDA DELAY
0040  1024  F0 04               BEQ REP2
0041  1026  C6 01               DEC DELAY
0042  1028  D0 F1               BNE REPEND
0043  102A  C6 00        REP2   DEC REPDEL
0044  102C  D0 ED               BNE REPEND
0045  102E  A9 04               LDA #$04
0046  1030  85 97               STA LSTKEY
0047  1032  A9 02               LDA #$02
0048  1034  85 A8               STA BLINK
0049  1036  D0 E3               BNE REPEND
0050  1038                      .END

ERRORS = 0000
```

The second section of the code consists of the actual machine instructions, each being written according to the above format. Comment headings between subroutines and at the beginning of the program are defined by being preceded by a ";" and comments after an instruction are defined by being preceded by a ":". The source code program ends with the assembler directive to end ".END".

Having written a program in object code and saved it on either tape or disc — further functions provided by the editor — it is ready to be assembled. The assembler loads the object code file off the storage media and procedes to do the first pass assembly. Two passes are required to assemble a program. In the first pass, all the opcodes and all the operands except jump addresses are calculated and placed in the correct memory locations.

In the second pass, the jump addresses are calculated and inserted into the unfilled memory locations left for them in the first pass. These memory locations are entries in the source code listing created by the assembler and not direct entries into memory locations. Any errors in the object code encountered by the assembler are displayed during the assembly process together with the appropriate error message.

If errors are present in the object code, then obviously the object code will have to be corrected before a correctly assembled source code is produced. The source code created by the assembler program is stored on disk or tape. Having stored the source code listing, the assembler will if reqired produce a printout, as in figure 3, of the complete source code, together with a symbol table, giving the location of all labels and data names.

Once created, the source code file on magnetic media can be used by a third program in the assembler package — the loader. This program, as its name suggests, converts the hexadecimal numeric values created by the assembler in the source code program into binary values stored in the correct locations in memory. Once the program is loaded, it can be run in the normal manner using say the SYS command from Basic.

There are many different kinds of assembler available on the market, covering every make of microprocessor. The majority of full assemblers follow the general pattern described above and of which the Commodore assembler is an excellent example.

There are, however, other simpler assemblers available, some even writen in Basic and consequently extremely slow. A very useful type of simple assembler is known as a spot assembler. This does not require an editor or loader, being just an expanded monitor. A spot assembler does not allow the use of variable data names or labels but simply converts opcode mnemonics directly into binary values and inserts them into the correct memory locations.

Spot assemblers are very handy in constructing small machine-code programs or system patches, since they give one an almost interpreter-like control of the program, especially when used in conjunction with a disassembler. An example of a spot assembler is found in Commodore's new Extramon 7.5 monitor program for the PET — this also includes a disassembler and a host of other useful functions.

● *The Commodore assembler is available from any Commodore dealer, price £75 on diskette for 16 or 32K machines with Commodore disk drive and printer.*

Outside connections

Nick Hampshire deals with the daunting topic of interfacing a micro to the outside world by discussing the basics of the KIM's I/O port.

THE CONNECTION of a computer to external electronic and mechanical devices can open a new world of applications, yet it is an area which most people approach with considerable trepidation. Such fears are, as will be shown in the short series of articles of which this is the first, unfounded and due mainly to the fact that most computer programmers are not electronic engineers and vice versa.

The computer system on which I shall base this introduction is the KIM 1, the reason being that it is an extensive, easy-to-use and, above all, has the same 6502 microprocessor as Pet and Apple computers.

The Kim, like most microcomputer systems, has a programmable eight-bit I/O port, and it is the connection of devices to the lines of this port and their control by a computer program which we will examine.

Those lines of the I/O port are usually from a device known as a PIA or Peripheral Interface Adapter. The most common are the 6520 and the identical 6820. The PIA is under direct control of the processor and consists of a set of eight-bit registers, each of which functions, as far as the processor is concerned, as a memory location.

Of the registers on a PIA, two types which are important and their function must be understood if we are to connect external devices to the I/O lines, and control those devices by means of a computer program.

The two registers which are universal to every PIA are the Peripheral Interface Buffer and the Data Direction Register. The Peripheral Interface Buffer — as its name suggests, is the register — memory location — from which data being put out to the I/O lines is stored, and from which data coming-in on the I/O lines is read by the processor.

The Data Direction Register is used to define each of the eight I/O lines as being either an input or an output. It is this ability of a PIA to have the direction of data on each line controlled by a program, which is one of the most powerful features of these devices.

On the Kim, the Data Direction Register for I/O port A is at memory location 1701, and the Peripheral Interface Buffer is at location 1700. If we want to define I/O line 5 as an output, we must set bit 5 of location 1701 to a logical '1'. Similarly, if we want to output on line 2, we must set bit 2 to '1' and so on. If we want to define an I/O line as an input, we must set the corresponding bit of the Data Direction Register to logical '0'.

Having defined the function of each I/O line as either an input or an output, we can read the current state of those lines configured as inputs by examining the bits corresponding to those lines in location 1700, the Peripheral Interface Buffer. Similarly, we can output data on those lines defined as outputs, by writing the desired output to the corresponding bits of the Peripheral Interface Buffer; logical '1' for a 5-volt output on that line and logical '0' for a zero volt output.

As an example, say we have defined line 5 as an output and line 3 as an input. If we want to set line 5 to give a 5-volt output, we must write a binary word 'x x x x 1 x x x' to location 1700 — the x's represent bits which can be either '1's or '0's.

To read the current state of line 3, we must read location 1700 and look at the state of bit 3, thus if it is 'x x 1 x x x x x', line 3 is currently in a high or 5 volt state, and if 'x x 0 x x x x x', the line 3 is in a low or zero volt state.

The simplest form of output circuit is to use the computer to turn a device, such as a lamp or a relay off or on.

More sophisticated outputs require two or more I/O lines to control a device. The computer would not turn the device on or off; it would also control its mode of operation. Whatever the sophistication of the computer control, it relies on the ability to control individual I/O lines with a computer program.

The best way of learning to do that is to construct a simple experimental I/O circuit. Mine uses a single eight-bit I/O port and provides four outputs to light-emitting diodes and four inputs from single-pole, double-throw switches. A single 7404 integrated circuit provides the four buffers on the outputs, which are required to raise the power output from the PIA to that required to drive the LEDs. It should be noted, however, that those buffers invert the output of the PIA, so a zero voltage output from the PIA will light on a piece of Veroboard. The numbers by the side of each buffer on the circuit diagram indicate the integrated circuit pin number (pin 1 on an IC is to the left of the notch at one end of the IC looking from above. The other pins are numbered anti-clockwise. The circuit requires 5 volts of power, which can usually be obtained from the computer power supply — see manufacturer's documentation — or from a battery. Pin 7 of the IC should be connected to ground and pin 14 to + 5 volts.

Having constructed the experimental I/O circuit, it should be connected to the processor I/O port via the appropriate connector, and its power supply turned on. With the Kim, and most other computer systems, we can use the monitor to control the operation of the PIA from the keyboard. We must first set the Data Direction Register so that lines PAO to

PA3 are configured as outputs. This means that we must set bits 0 to 3 of location 1701 to logical '1' and the remaining bits to zero. To do this, we load 1701 with hexadecimal 'OF.

Remember that the lines on our circuit have been inverted so that to light a LED on a particular line we must write a '0' to the corresponding bit in the Peripheral Interface Buffer. Thus to turn-on the LED on line 0 we must set bit 0 to '0' and bits 1,2 and 3 to '1' in location 1700; since bits 4 to 7 have been defined as inputs their contents will reflect the current state of the input lines.

To do this we need to write hex 'OE' to location 1700, whereupon LED 0 should light and the other three LEDs should go out, providing that the circuit was assembled correctly. To turn-on LED 1 write hex 'OD' into 1700; LED 2 is 'OB' and LED 3 is '07'; other values give combinations of two or more LEDs on and 'OF' extinguishes all four.

Having controlled the outputs manually, it is simple to control them via a computer program. The computer program must perform the same sequence of processes which were performed in the manual output of data, therefore, to turn-on the LED on line 2 we can use the following short machine code program:

```
A9 OF      LDA#OF
8D 01 17   STA 1701   Set Data Direction Register
A9 OB      LDA#OB
8D 00 17   STA 1700   Output a '0' on line 2
60         RTS        End
```

By varying the values, this little subroutine could be used in a program to turn any single or combination of LEDs on or off. By stringing together a sequence of program steps like this one, where each stores a different value in location 1700, we could create a sequence of flashing lights. This would require four blocks of code, as indicated, and would terminate in a jump command to return the program to the beginning, to start the sequence all over again.

If you try this, however, all you will see is four lit-up LEDs since the program runs so fast that we are unable to perceive what is happening. To see the flashes we must slow the program by inserting a delay between each step. A delay can be generated by using a counted loop, like a FOR — NEXT loop in Basic.

Since machine code programs are so fast it is usually necessary to nest two or three loops, one within the other, to obtain a visually-acceptable delay of one or two seconds. The following is a simple location hex 0 as variable storage:

```
200  A2 F0   LODX    LDX#F0       :initialise index
                                  register X
     A0 F0   LODY    LDY#F0       :initialise index
                                  register Y
     C8      LOOPY   INC Y        :increment Y
     C0 00           CMP Y#00     : is Y = 0 ?
     D0 FB           BNE LOOPY    :if so go to LOOPY
     E8              INC X        :increment X
     E0 00           CMP X#00     :is X = 0 ?
     D0 F4           BNE LODY     :if so go to LODY
     E6 00           INC Z 00     :increment location 0
     A5 00           LDA Z 00
     C9 00           CMP#00       :is location 0 = 0 ?
     D0 EA           BNE LODX     : if so go to LODX
     60              RTS          :return to calling
                                  program
```

The delay generated by this program can be varied by changing the initialisation values for index registers X and Y. The smaller the values the longer the delay — the values indicated give a delay of about one second. This delay subroutine can be incorporated into the flashing sequence of LEDs program so that each LED remains lit for about one second before being extinguished and the next LED lit. That is done by this program, starting at location 10.

```
10 A9 OF     LDA#OF       :initialise Data Direction Register
   8D 01 17  STA 1701
15 A9 0E     LDA#OE       :set LED 0 on others off
   8D 00 17  STA 1700
   20 00 02  JSR DELAY    :go to delay subroutine
   A9 0D     LDA  OD      :set LED 1 on others off
   8D 00 17  STA 1700
   20 00 02  JSR DELAY
   A9 0B     LDA#0B       :set LED 2 on others off
   8D 00 17  STA 1700
   20 00 02  JSR DELAY
   A9 07     LDA#07       :set LED 3 on others off
   8D 00 17  STA 1700
   20 00 02  JSR DELAY
   4C 15 00  JMP 0015     :return to start of display program
```

By changing the binary values loaded into the Peripheral Interface Buffer the sequence or pattern of flashing LEDs can be changed. Further steps in the sequence can be added by inserting further display blocks of code. For long sequences, however, this method takes an excessive amount of memory and in such cases it is best to use a table of output values.

Sequential

In the following program each value to be loaded into the Peripheral Interface Buffer is stored in the sequence in which it is to be output, in one of the bottom 256 memory locations. The program accesses this table from location 1 upwards, sequentially, and on reaching the entry in location 255 returns automatically to the entry in location 1. The contents of the table can be input manually using the monitor and the keyboard.

```
0240 A9 0F      INIT LDA#OF        :initialise Data
                                   Direction Register
     8D 01 17        STA 1701
0245 A2 01      DISPLAY LDX#01     :set index register X
                                   to point to start of data
                                   table
0247 BD 00 00   DISP2 LDA 0000,X   :fetch entry from table
                                   pointed to by X index
                                   register
     8D 00 17        STA 1700      :output to Peripheral
                                   Interface Buffer
     8A              TXA           :transfer X reg to
                                   accumulator
     48              PHA           :put accumulator
                                   on stack
     20 00 02        JSR DELAY
     68              PLA           :pull accumulator
                                   from stack
     AA              TAX           :transfer accumulator
                                   to index X
     E8              INX           :move X register
                                   pointer to next entry
     E0 00           CPX 00        :end of table ?
     D0 EE           BNE DISP2
     4C 45 02        JMP DISPLAY
```

The reason the contents of the index register are transferred to the stack is that the X register is used in the delay subroutine, and if the index register were not saved the table pointer would be lost. Having generated a delay, the contents of the index register are recovered from the stack.

Numbers all change

AS COMPUTER ENTHUSIASTS, we often find that we need to change a hexa-decimal number into its decimal equivalent, or vice-versa. But after a search through the manuals for the conversion table, we usually find that the number we want is between those listed, and we have to resort to pencil and paper in order to work the conversion out.

The program listed below not only does this conversion quickly for all numbers, but it also works for number bases from 2 (binary) through 10 (decimal) and 16 (hexa-decimal) to 36 (using the numerical digits, and all the upper-case alphabetical characters). It can even be extended through the ASCII characters 91 to 96 to the lower-case alphabetical characters. For those uncertain about what number bases are, an explanation of them is given later.

The program has a further use. Changing a number from one base to another can be a way of packing more information into an array. For example, suppose you want to record the results of football matches between teams A and B over the years in one element of the array FOOT(A,B). There could be no information (0), a home win (1), an away win (2), or a draw (3).

Thus for a series of results over the years, we might have a sequence such as 2122110. If we consider this as a number to base 4 (since four digits are used), we can convert it into its decimal equivalent 9876, and so save space.

The remark statements in the program give an indication of how the program is organised, but an explanation of the following lines of the program may be helpful to an understanding of it:

010 Sorcerer's method for clearing the screen.

130 Asks for the number of digits or characters required in the answer.

240 Divides the number into its separate digits or characters.

260 Converts an alphabetical character into its numerical value.

270 Converts a numerical digit into its numerical value.

280 The numerical value is multiplied by the base B1 raised to the power (L2-R) corresponding to the position of the digit or character in the original number.

300 The mid-point decimal number M is carried through to the second half of the program.

330 M is divided by the second base B1 raised to the appropriate power (L2-R).

350 The integral part N is converted into an alphabetical character.

360 N is converted into a numerical digit.

340 Q is the remainder of the number.

380 This is a 'fudge factor' which slightly increases Q. I have found that it works for all numbers and bases I have tried, but micros other than the Sorcerer may require a different factor. It is necessary because of the division in line 330.

Take care that you input the right kind of characters for the number base you start with, and that L2 is sufficiently large for the answer, otherwise nonsense answers will be displayed.

The decimal number 234 which we read as two hundred, thirty and four may be written as

$$200 + 30 + 4$$

or as $2 + 100 + 3 \times 10 + 4 \times 1$

or as $2 \times 10^2 + 3 \times 10^1 + 4 \times 10^0$

10^2 is read as ten to the power of two, and means that the number 10 is multiplied by itself 2 times (10×10). The 10 is said to be the base of the system (hence the name decimal).

Note that *any* base raised to the power of zero is equal to one. Notice that the power for the right-most digit (the four) is 0, that for the next digit to the left (the three) is 1, and the next 2, and so on.

In the hexa-decimal system, there are 16 symbols, consisting of the ten digits 0 to 9 plus the six upper-case letters A to F. A hexa-decimal number such as 2A3F may be converted to its decimal number equivalent by first converting the individual characters to their decimal equivalent (from A = 10 to F = 15), and then multiplying each of these by the base 16 raised to the power appropriate to the position of the digit or character in the original hexa-decimal number. Hence 2A3F becomes

$$\begin{aligned} & 2 \times 16^3 + 10 \times 16^2 + 3 \times 16^1 + 15 \times 16^0 \\ &= 2 \times 16 \times 16 \times 16 + 10 \times 16 \times 16 + 3 \times 16 + 15 \times 1 \\ &= 2 \times 4096 + 10 \times 256 + 3 \times 16 + 15 \\ &= 8192 + 2560 + 48 + 15 \\ &= 10815 \end{aligned}$$

Fig 1 Port locations for PET.

```
50 DIM V(5):DIM N(5):POKE59459,255:P=59471: REM USER PORT OUTPUT
100 PRINT"WHEN YOU FEEL A SHOCK"
105 PRINT"RESPOND WITHIN 5 SEC WITH:"
110 PRINT"1=JUST NOTICED  2=EASILY NOTICED"
115 PRINT"3=UNPLEASANT  4=PAINFUL  5=VERY PAINFUL"
150 FORJ=0TO5:V(J)=0:N(J)=0:NEXT
200 FORN=1TO30:V=INT(255*RND(1)):GETA$
210 POKE P,V:POKEP,0
220 FOR J=0TOJ=5000:NEXT:GETA$:A=VAL(A$):IFA>5THEN300
230 V(A)=V(A)+V:N(A)=N(A)+1:
240 FORJ=0TO1000*RND(1):NEXT:NEXT
300 FORJ=3TO5:IFN(J)=0THENN(J)=1
310 NEXT:VF=INT((V(3)/N(3)+2*V(4)/N(4)+V(5)/N(5))/4/2.55)
320 PRINT"THRESHOLD IS "VF" VOLTS"
READY.
```

BUYERS' GUIDE

The Buyers' Guide is a summary of low-cost computers available in this country. It appears each month; we add new computers and amend existing information, as required, to keep it up-to-date. Systems are listed by manufacturer.

ACORN COMPUTERS

Acorn. Single Eurocard-sized microcomputer with 6520 processor, IKB RAM, 16-way I/O. Max size; a second Eurocard adds hex keypad and CUTS cassette interface. Monitor and machine-code, programming now. Basic and disc operating system in the future. 'Highly cost-effective basis for a computer or an industrial development system". Available from Acorn (0223) 312772 or Microdigital (051) 236 0707.

£74.75 kit, £86.25 assembled

APPLE COMPUTERS

Apple II. Min size: 16K memory; 8K ROM; keyboard; monitors; mini assembler; colour graphics; Pal card; RF modulator; games; paddles and speakers; 4 demo cassettes. Max size; Expandable to 48K memory; floppy discs and printers are now available. Two versions of Basic, PASCAL; Assembler, games; business packages. An American system regarded as suitable for any kind of aplications. Maintenance contracts offered. Microsense Computers is the sole U.K. distributor and has a national dealer network. Tel: (0442) 41191/48151 (24-hour answering service).

Around £1,000

ATTACHE

Attache: Min size: system with 10 slots, S100 bus, 8080 processor and 16KB housed in desk-top case with built-in keyboard. Max: 64KB, parallel printer interface, two single or double density 8" floppies, video screen. Disc Basic. Full business system includes all software. Mecotronic is UK agent south of Birmingham. Tel: (0276) 29492, R. J. Spiers, 3 Birch Court, Woodlands Garden, Norwich, north of Birmingham.

From £1737. Full business system £7000

BILLINGS

Billings Microsystem (BMS): Z-80A, 64K RAM, 12" screen, QWERTY keyboard, range from double density 8" floppies (600KB), to 200 MB hard disc. Software includes COBOL (ANS174 with extensions), FORTRAN, Extended BASIC and MAC80 Assembler. The microsystem could be used as a program development aid. Availability: Mitech Data System Ltd, Woking (04862) 23131.

From £4295

BRUTECH ELECTRONICS.

BEM-CPUI. Single-board processor with 6502 and no RAM. Applications software. Available from Data Precision Equipment (04862 67420). (Reviewed March, 1979.)

£133 exc VAT

Buyers' Guide

BYTRONIX MICROCOMPUTERS

Megamicro. 8080A/Z-80 processor. 64K. Double-sided discs, two-page addressable VDU, 140 cps printer. Software includes Basic, Fortran, Cobol and Pascal, all running under CP/M. Applications include automatic letter writer, sales ledger and stock control, payroll and bought ledger. Self-diagnosis utilities. Aimed at business and university user. Available from Bytronix (0252) 726814. — *From £6,080.*

COMART

Microbox: Chassis with three to six PCB sockets for S100 boards, plus fan. Several S100 boards available. Aimed mainly at OEM industrial users and perhaps the serious hobbyist. It will take Cromenco, North Star and other processors. Available from Comart (0480) 215005. — *£195*

VDM Board: Adds word processing power to the S100 bus by providing on-board screen storage. Generates 16 by 64 character lines from data stored in a 1024 byte on-board memory. — *£145*

COMMODORE SYSTEMS DIVISION

Pet. Single unit containing screen, tape cassette and keyboard. Floppy disc, printer and full-size keyboard are options, as are external cassettes. Basic; games; business packages. The British subsidiary of Commodore Systems of the U.S. sells Pet for home, educational and small business applications. About 80 distributors. — *£460-£795 exc VAT*

Kim-1. processor (6502 chip); small calculator-type keyboard; LED six-digit display; built-in interfaces for audio-cassette and Tele-type; IK RAM; 2K ROM (can add up to 64K). No software available, but it has three good manuals. An American import which gives Pet-type capabilities with a maximum configuration. For the hobbyist but used mainly as an evaluation board for the 6502 chip. Twelve to 15 dealers. (Reviewed October, 1978.). — *£99.95*

COMPELEC ELECTRONICS

Series I. Z-80 processor 512MB floppy, 32KB, Centronics printer, VDU. Up to 4MB disc and 64KB. CP/M, Basic, Cobol, PASCAL, Fortran IV, Assembler, Business and word processing packages available. From Compelec (01-580 6296), which is also sole supplier of Altair systems. — *Less than £5,000 for basic system*

COMPUCOLOR

Compucolor II. Packaged system including 13in. eight-colour display with alphanumerics and graphics, 72-key detachable keyboard, 8KB, and bult-in mini-floppy. Max size: 32KB. Extended disc. Basic in ROM, graphics progams and games. The system now ranks fourth behind Pet, TRS-80 and Apple in personal computer sales. Abacus (01-580 8841) is sole U.K. agent and is arranging distributors, including the Byte Shop and Transam. (Reviewed June, 1979.) — *From £1,390*

COMPUCORP

610: desk-top unit using Z-80 and incorporating screen, 150KB floppy, 48KB. Up to 60 KB memory, four floppies, printers. Basic, Assembler, DOS, text editor, file manager; business packages. Nine dealers. — *From £3,890*

COMPUTER CENTRE

Mini kit: Z-80 CPU, CTC, USART, serial and parallel I/O, 16 bytes memory, Western Digital disc controller, SA400 5in. drive plus CP/M, cables and connectors. — *Mini kit: £786*

Maxi kit: As above but with DRI 7100 8in. drive instead of 5in. drive. All (33) volumes of CP/M user group library available for cost of media. Library includes utilities, games. Basic compilers/interpreters and Algol compiler. Microsoft Basic, Cobol, Fortran also available. Computer Centre (02514 29607). — *Maxi kit: £886*

COMPUTER WORKSHOP

System 1. Typical size: 40K memory; dual 8in. floppy disc, total storage capacity 1.2MB; Ricoh daisywheel printer. — *System 1, £5,000 plus*

System 2. Typical size: 24K memory; dual minifloppy discs of 80K bytes each; Centronics 779 dot matrix printer; VDU. — *System 2, around £3,000*

System 3. 12K memory, cassette interface; 40-column dot matrix printer. Editors, Assemblers, Basic, games, information retrieval package. The systems were designed and built in Peterborough and are suitable for educational and small business users and perhaps the more serious hobbyist. Twenty-five dealers. — *System 3, from £1,300*

CROMENCO

Single-card computer: 4MHz Z-80 CPU, S-100 bus, 1KB RAM, sockets for 8K ROM. 20mA/RS232 serial interface and parallel bidirectional interface. Basic in ROM and Z-80 monitor. For OEM and industrial users; used with backplane for "full computer compatibility" (Reviewed February 1979). — *£225 (in kit form) to £260*

Z-2: Min. size: chassis, 31A power supply, motherboard, Z-80 processor, 16KB memory. Max size: 512KB, 21 sockets, three minifloppies or four 8" floppies. Basic, Fortran, Cobol, assemblers. For serious hobbyists, OEMs, educational applications, and industrial/scientific userers. — *£360 (in kit form) to £3700*

System Two. Min size: factory-assembled system with 32KB, dual 90K minifloppies, dual printer interface, serial interface. Max size: two additional floppies, 512KB, up to seven terminals, CP/M-compatible operating system (CDOS), Fortran, Cobol, Basic, assemblers, word processing, database manager. Multi-user system for software development, or scientific/industrial/business users. — *£1,995 upwards*

System Two/64: 64KB, dual 90K mini-floppies, dual printer interface, serial interface. Options: two additional floppies, 512KB, up to seven terminals, CP/M compatible operating system (CDOS), Fortran, Cobol, Basic, assemblers, word processing, data-base manager. Multi-user system for software development, or scientific/industrial/business users. — *£1995 upwards*

System Three. Min size: 32KB, dual 256KB floppies, dual printer interface, 20mA/RS232 serial interface, Z-80 processor. Max size: two additional discs, 12KB, seven terminals, multi-channel A/D and D/A interface, PROM programmer. Software as for System Two. Described as appropriate for small to medium business, scientific and industrial users — "rivals minicomputers at more than twice the price". — *£2,995 to more than £8,000*

System Three/64: New configuration featuring dual 8" floppies, Z-80A processor, 64K of 4MHz memory; console and printer interfaces. Macro assembler, Fortran IV, Extended Basic, Cobol, Multi-user Basic. All systems sold by Datron Interform, Comart, Micro Centre. Prices quoted by Comart. — *£3270*

DIGITAL MICRO SYSTEMS

DSC-2. Min size; 32KB, but 64K standard; Z-80; over IMB floppy disc on two single-sided 8in. drives; four programmable RS232 and one parallel interface. CP/M and Basic included in price. Extended Basic, Fortran, Cobol, text processing, Macro Assembler, Link Loader, business packages and CAP-CPP business software. Add-on rigid disc system (14 and 28MB) available soon. Modata (0892 39591) is sole U.K. distributor; dealers being appointed. — *From £4,465*

DYLE HOUSE

Business Computing System 2000. Z-80A. Dual 8in. discs, 140 cps 132 char printer. Dyle House Business Basic, and disc operating system. Accountancy, payroll and parts control suites. Applications: Sales acknowledgments, sales invoices, delivery notes, purchase orders, customer statements, remittance advice. Dyle House Ltd (01-529 2436). — *No price announced*

EQUINOX

Equinox 300. Min size; 48K memory; dual floppy discs giving 600K bytes of storage; 16-bit Western Digital m.p.u. Max size; up to 256K memory; up to four 10MB hard discs. Basic, Lisp, PASCAL, Macro Assembler, Text Processor. All software bundled. The system is a multi-user, multi-tasking, time-sharing system for two to 12 users. Application software available for general commercial users. Sole distributors Equinox Computers Ltd (01-739 2387).

£5,000-£40,000 plus

EURO-CALC

Euroc: 8080A CPU, 64KRAM, two times double-dsided single-density 8" floppy disc drives with approximately 1 MByte capacity. 15" screen with 80 by 25 characters, QWERTY keyboard. CP/M operating system 140 CPS tractor feed matrix printer. Software: C-BASIC 2. Supplied with accountancy package for sales, purchases and nominal ledgers and initial stationery. Sold through Euro-Calc, 55/56 High Holborn, London W.C.1. Tel: 01-405 3113.

£8000

EXIDY

Sorcerer: based on Z-80, 16K and 32K; cartridge and cassette interfaces; 79-key keyboard; 256-character set (128 graphics symbols), 12in. video monitor; expandable with Micropolis floppy discs. Basic, Assembler and Editor; games, word processor. Other pre-packaged programs plus EPROM Pack for your own programs on cartridges. Factor One is sole distributor for U.K. (Reviewed March, 1979.)

From £760 without VDU to £1,200 with floppy discs

HEATH SCHLUMBERGER

H8. 8080 CPU. 4664K PAM. Serial/cassette I/O; front parallel monitor; keypad; optional parallel I/O; serial multiport; breadboard I/O and disc system. Basic, Ext. Basic, Mierosoft Basic, HDOS, CPM.

From £262 (in kit form)

WH89. All-in-one computer. Z-80 processor plus Z-80-controlled VDU. 16K expandable to 48K, user-accessible. Two RS232 I/O ports. Operating system includes Benton Harbour Basic, two-pass absolute assembler, text editor, utility programs, Mierosoft Basic and Fortran word processor package. Heath Schlumberger (0452 29451).

About £1,600

HEWART MICROELECTRONICS

Mini 6800 Mk II. IK monitor; IK user RAM, IK VDU RAM; CUTS. Upper- and lower-case VDU with graphics option. 128-byte scratchpad; decoder/buffer; power supply; Basic in ROM; monitor command summary. SWTPC programs; Newbear 6800; Scelbi 6800 Cookbook. Markets are small business, education and home user. Cash with order to Hewart. (0625) 22030.

From £127.50 plus VAT

6800S. 16K dynamic RAM; IK Mikbug-compatible monitor; room for 8K Basic in ROM; upper- and lower-case graphics; single floppy disc drive; printer and high-speed tape interfaces. "Mountains of software available." Test tape with CUTS test tones, test message and games with kit.

From £275 plus VAT

IMSAI

VDP 40: 32K or 64K RAM memory; 9in. display screen, standard keyboard. Two 5¼in. floppy disc drives; serial I/O. Full software support, and packages available for the VDP 42, which has larger disc capacity. Packages for VDP 80 could be converted for smaller systems. This would be from about £700 per package. Two main dealers in the country.

£4,507 for 32K model. £4,950 for VDP 42

ITT

2020. Identical to Apple II. Min. size: 4K memory; 8K ROM; keyboard, monitor, colour graphics, mini assembler; Powell card; RF Modulator, games, paddles and speaker; Max size: 48K with floppy discs and printers. Basic, Assembler, games, business packages. Generally suited to any type of application. Fifteen wholesalers, including Fairhurst Instruments.

From £827 to £3003 for 48K, two floppies and printer

Shop Window

LUXOR

ABC 80. Min size: 35K with keyboard, CPU 12in. screen and cassette. Max size: 40K RAM with discs. Z-80 processor, loudspeaker with 128 effects, real-time clock. Options: printers, plotter, discs, module cards, digitiser, modem. 60 compatible I/O memory boards. Software: Basic with resident editor; assembler; games; business and educational packages. Personal computer aimed at home market, small business and education. CCS Microsales is U.K. agent and is looking for distributors.

£795 plus VAT

MICRONICS

Micros. Typical size: 1K monitor; 47-key solid state keyboard; interfaces for video, cassette, printer and UHF TV; serial I/O, dual parallel I/O parts; 2K RAM; power supply. 2K Basic; British-designed and manufactured system. Claimed to be the cheapest data terminal — a system with an acoustic coupler and VDU for £1,020. Prospective applications for small businesses, process controllers and hobbyists. Manufacturer is sole distributor (01-892 7044).

From £400, assembled

MICRO V

Microstar. Single box with twin 8in. flopy discs, 64K RAM, three RS232 serial inputs, STARDOS operating system enables system to have three VDUs, plus a fourth job running simultaneously. Word processing software available. Packages being developed include invoicing system, payroll, accountancy type system. Price includes a reporter generator language. Imported by a Data Efficiency subsidiary, Microsense Computers, Microsolve is London agent; other distributors being arranged.

£4,950 machine and software

MIDWEST SCIENTIFIC INSTRUMENTS

MSI 6800. Min size: 16K memory Act I termnal; cassette interface. Max size: three disc systems — minifloppy system with triple drives of 80 bytes each and 32K memory, large floppy system with up to four 312K-byte discs and 56K of memory mounted in a pedestal desk, or hard disc system with 10MB and 56K Basic interpreter and compiler; editor; assembler; text processor on small disc system. American-designed system being manufactured increasingly in the U.K. Sole U.K. agent is Strumech (SEED) (05433 4321) but a distributor network is being established.

Basic system: £1,100 (£815 as kit); Minidisc, £2,500; floppy disc £3,200; hard disc, £8,000-£12,000

NASCOM MICROCOMPUTERS

Nascom I. Min size: CPU; 2K memory; parallel I/O; serial data interface; 1K monitor in EPROM. Max size. CPU, 64K memory, up to 16 parallel I/O ports. Mostly games, but also a dedicated text editor system written by ICL Dataskil Nascom is working on large versions of Basic, and 8K Microsoft Basic should be available soon. Eleven distributors in U.K. Nascom is negotiating to increase the number. (Reviewed January, 1979.)

£165 exc VAT

NATIONAL MULTIPLEX

Pegasus. Min size: 48K, Z-80; double-density floppies (320KB); S100 bus; 12in. CRT; 58-key keyboard; two serial and one parallel interfaces; bi-directional printer. Options: 8in. drives; 1-2MB additional drives; digital recorder 9,600 baud. Assembler, Cobol, Fortran, Extended Basic. General business package available as well as text editing and mailing list. All run under CP/M. Suitable for education, business and home users. London Computer Store (01-388 5721) sole supplier.

£2,700 exc VAT

NETRONICS

Elf II: single-board computer in kit form or assembled. RCA Cosmac 1802 processor, hex keyboard, 256 bytes RAM; options include up to 64KB, ASCII keyboard, cassette and RS232 I/O, and video output. Machine code or Tiny Basic. Promoted as a teaching system in minimal form, but expandable for more general use. Sole U.K. distributor HL Audio (01-739 1582).

Basic kit £79.95. Assembled £99.95. I/O board £35

Explorer 85: Min size: 4K. Max. size: 64K. 8085A processor, VDU board, ASCII Keyboard, S100 expansion. Cassette, RS232, TTY interface on board. I/O ports, programmable timer. Disc software, Microsoft Basic on cassette, 8080 and Z-80 software can be used. Aimed at hobbyist, OEM and small business. Available from Newtronics (computer division of HL Audio). — *From £297 plus VAT*

NEWBEAR

7768: CPU board, 4K memory, cassette and VDU interfaces. Range of Basics and games. British manufactured system for hobbyists. Expandable to 64K memory available only in kit form. From Newbear in Newbury and Stockport. — *From £45*

NORTH STAR

Horizon. Min size: 16K memory; Z-80A processor, single minifloppy disc drive (180KB). Max size: 56K memory, four minifloppy disc drives (180KB), any acceptable S100 peripheral boards. Basic (includes random and sequential access), disc operating system and monitor. Options: Basic Compiler, Fortran, Cobol, Pilot, PASCAL and ISAM. The system is suitable for commercial, education and scientific applications. Application software for general commercial users. Twenty distributors. (Reviewed April, 1979.) — *£995 to £2,500*

OHIO SCIENTIFIC

Ohio Superboard II. Min size: 6502 processor, 8K Basic in ROM; 2K monitor in ROM; 4K RAM; Cassette I/F, full keyboard; 32 x 32 video I/F, 8K Basic in ROM; Assembler/Editor; American single-board system with in-board keyboard. Aimed at hobbyist/small business. Ohio makes games, personal maths tutors, and business programs. This and other Ohio products have six U.K. distributors. (Reviewed June, 1979.) — *From £298*

PERTEC

System 1300. Min size: 32K memory; dual minifloppy discs 71 bytes each, formatted; serial interfaces. Max size: 64K memory; four serial parts. Basic (single and multi-user), Fortran, Cobol. The hardware for Compelec Altair systems is from Pertec but the software is Anglo-Dutch. Sole distributor Compelec (01-580 6296). — *£3,000-£5,000*

POWERHOUSE MICROPROCESSORS

Powerhouse 2: Desktop unit using Z-80A with 5" built-in VDU and built-in minicassette (optional), 16K or 32K RAM, full keyboard, real-time clock, two spare slots, RS232 interface. Software: Disc and cassette operating system, programmable keyboard facilities for eight PROM chips giving a max of 16 or 32K or ROM, 2K monitor in EPROM. Extended basic (optional). Aimed at OEMs and expert users such as scientists or researchers. Applications include real-time process control, engineering calbulations. Availability: Powerhouse only (0442) 42002. (Reviewed, September 1979). — *From £1200*

PROCESSOR TECHNOLOGY

Sol. 808-based S100 microcomputer packaged with cassette and video interfaces (including graphics), keyboard with numeric pad, and 16KB RAM. Basic, assembler, word processors. Floppy disc systems available. Several distributors including Comart (0480 215005), which can offer nationwide maintenance contracts (Reviewed July, 1979.) — *From £1,750 (excluding monitor and cassette). Complete floppy disc systems with word processing about £5,000*

RAIR

Black Box. Min siz: 32K memory dual minifloppy discs, 80K bytes each; two programmable serial I/O interfaces. Max size: 64K memory; eight serial interfaces; IMB disc storage (or 10MB hard disc); range of peripherals. Basic, Fortran IV, Cobol, Hardware distributors are being signed and agreements made with software houses to add software. A warranty and U.K.-wide on-site maintenance is given. From manufacturer (01-836 4663) and systems houses. — *From £2,300*

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380-Z. Min size: 4K memory; 380-Z processor, keyboard. Max size: 56K memory. Options: cassette, single or dual minifloppy discs, dual 8in. double-sided discs (IMB); serial interfaces; parallel interfaces; analogue interface; printer available. Basic Interpreter, Z-80 Assembler; interactive text editor; terminal mode software; data logging routines; CP/M, DOS, text processor, CBasic, Fortran, Algol, Pilot, Cobol, CP/M users' club library. Sold principally to higher and secondary education, and for scientific research, data processing and data logging. Available from Sintel and the manufacturer. (Reviewed December, 1978.) — *From £830-£3,500*

280-Z. Board version of 380-Z system, 4K or 32K (identical in performance to the 380-Z). Interfaces, software as for 380-Z. — *4KB version at £398; 32KB for £722*

RCA

Cosmac. 1802 micro with hex keypad and output to TV screen. Assembler and machine code programming; options include Tiny Basic. Available by mail order from HL Audio (01-739 1582). — *Kit £79.95. Assembled £99.95 exc VAT*

ROCKWELL

Aim-65. Kim-compatible with full keyboard and on-board printer. 1K or 4K RAM. The 4K version is described as a development system rather than a personal computer. Assembler, editor, Basic. Available from Pelco, Microdigital and Portable Microsystems (Reviewed July, 1979.) — *1K — £249.50; 4K — £315*

SCIENCE OF CAMBRIDGE

Mk 14. SC/MP processor, 256 bytes user memory; 512-byte PROM with monitor program; hex keyboard and eight-digit, seven-segment display; interface circuitry; 5V regulator on board. To this can be added: ¼K RAM (£3.60); 16 I/O chip (£7.80); cassette interface kit (£5.95); cassette interface and replacement monitor (£78.95); PROM Programmer (£9.95). No software provided but a 100-page manual includes a number which will fit into 256 bytes covering monitors, maths, electronics systems, music and miscellaneous. Based on American National Semiconductor chips. Science will soon have a VDU Interface and large manual on user programming. Mail order from manufacturer (0223 312919) and by selected dealers. (Reviewed May, 1979.) — *£39.95 basic*

SDS

SDS 100. Single unit containing 32K memory (expandable to 46K); up to 8K PROM; twin double-sided floppy disc drives of 500 bytes each, serial and parallal RS232 interfacing; keyboard; 12in. video display; power supplies; SD monitor program: line printer available. CP/M, 8080 assembler, E Basic, Editor supplied with system; M Basic, Fortran, Cobol available for business use, industrial process monitoring and control (with additional hardware). All CP/M games and business packages. Sole supplier Airamco (0294 65530). — *From £3,750*

SEMEL

Semel I. Min size: 4K with CPU, keyboard and monitor. Max side: 64K with single floppy disc unit, printer, VDU and keyboard. Can be coupled to any external device and controls up to 8 x 250K floppy disc units. Four configurations available. Options: Light pen attachment; 12V DC power supply; remote terminals. Software: Editor, Assembler, debug, full file-handling capabilities in Basic, Fortran and Cobol available on 64K machine; user-defined programs written and compiled by agreement; word processing. General-purpose unit for use as a terminal controller. Suitable for small business and OEMs. Available from Semel exclusively (0822) 5439. — *£1,950 with Basic*

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Athena Dt/C 8200: Eight-bit 8085 desktop computer with in-built dual mini floppies, inbuilt dual mini-cassette, inbuilt matrix printer and 1920 display. Can be expanded with 10 micros, beyond the CPU, each working as an intelligent controller, up to four floppy disc drive and four rigid disc drives. Maximum memory is 1.2GBytes. Standard system software is the AMOS multi-task operating system. Claims a performance roughly comparable to the DEC PDP-11/34. Butel-Comco, Southampton (0703) 39890, are the sole U.K. distributors. *From £3000*

SORD

M100. Min size: 16K RAM; 4K ROM Monitor; full keyboard plus function keypad; two-channel joystick dual cassette I/F; 11K E Basic on cassette; video; graphics; printer; S100 bus; converters; speaker; 24-hour clock. Max size: 48K RAM, 8K ROM; black and white or colour graphics; mini-floppy discs. Suitable for OEMs, small business, education, laboratory and scientific and home computing. Main distributor is Dectrade, but for London and South contact Midas Computer Services (0903) 814523. *From £726*

SYNERTEK

Sym 1. 6502 chip and keypad with memory available in 4K blocks up to 64K. Port expansion kit, TV interface card, RAM expansion kit, cassette and Teletype interfaces. Any Kim software, Basic interpreter, Assembler/Editor, American, meant to be the foundation system for every small business and hobbyist users. Available from Newbear (0635 49223). *From £160 plus VAT.*

TANDY CORP.

TRS-80. Min size: Level I 4K memory; video monitor; cassette; power supply. Max size: Level II 48K up to 350K on-line via floppy discs; line printer; tractor feed printer and quick printer; floppy disc system. Modem, telephone interface soon available. Basic; some business packages. Level I aimed at the hobbyist and education market and Level II at small business applications. Hundreds of dealers. (Reviewed November, 1978.) *Level I — £499 Level II — from £578-£4,700*

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VECTOR GRAPHIC

48KB RAM, Z-80 micro; 63K bytes, mini-discs are standard. Options: graphics. Monitor, MDOS, Basic; business packages from dealers. Several distributors. *£2,300*

January

3 **TRS 80 Software.** Venue: Reading. Arranged by the Thames Valley Amateur Club, 'The Southcote', Southcote Lane, Reading, Contact: Brian Quarm, tel: Camberley 22186 or Brian Steer, tel: Slough 20034.

7-9 **Fundamentals of computer operations.** Venue: Cannock, Staffs. Designed for trainee and junior DP staff. Gives a basic understanding of the technical aspects, hardware and software concepts, control procedures and provides job orientation. Organised by Compower Training School, Cannock, Staffs, WS11 3HZ. Fee: £125 + VAT. Contact: Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

7-11 **Database in DL/1. This database course is for users of** IMS. Venue: Cannock. Compower Training School. Fee: £215 + VAT. Organised by Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

7-18 **Cobol (advanced).** Venue: Cannock. Designed for programmers with minimum of two months' practical experience, to enhance the student's ability to use the language and the machine efficiently. Fee £450 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

14 **Personal Computing Course.** Venue: Sunderland Polytechnic. This course consists of 10 Monday evening sessions and is aimed at beginners who wish to take up computing as a hobby or apply computing to their work environment. Organiser: Faculty of Science Registrar, Sunderland Polytechnic, tel: Sunderland 76191.

14-18 **Basic systems principles for programming staff.** Venue: Cannock. This course enables programmers to work effectively by giving them insight into the role of the systems analyst. Fee: £255 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

14-25 **Management in Computer operations.** Venue: Cannock. Course for all management grade staff within the operations environment. All the essential aspects of management in the operations section are covered and participative syndicate work relates topics to practical situations. Of particular benefit for shift leaders/managers. Fee: £480 + VAT. Organisers: Compower Training School, Cannock, Staffs, SW11 3HZ, tel: Cannock 2511.

15-18 **Filetab TABN.** Venue: Cannock. This course on Filetab — the report generator and file maintenance package designed by NCC — gives instruction in both the TAB 360 (IBM) and TAB-N (ICL) versions. Fee: £215 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

15-18 **Principles of 2900 operating.** Venue: Cannock. Designed for staff with at least three months' operating experience: enables them to play their full part in a 2900 environment. Fee: £215 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ, tel: Cannock 2511.

15-18 **Microcomputers in manufacturing and industrial control.** Venue: London, ICS/PCL Microprocessor Education Centre, Holborn. Designed for manufacturing and process control engineers and managers. Fee: £470 + VAT. Organisers: Integrated Computer Systems UK, Pebblecoombe, Tadworth, Surrey, KT20 7PA, tel: (03723) 7911.

15-18 **Pascal: Programming in the structured language.** Venue: London. Designed for scientists, engineers, programmers, systems analysts and managers who are using or plan to use Pascal for the development of software systems. Fee: £540 + VAT. Organisers: Integrated Computer Systems UK, Pebblecoombe, Tadworth, Surrey, KT20 7PA. Tel: (03723) 79211.

16 **Microprocessor Course.** Venue: London, Willesden College of Science and Technology. Ten-week in depth course with attendance every Wednesday. Includes System architecture, MPU — memory I/O, Bus structure etc. Fee: £35. Organisers: Bill Stoddart and Dr Tony Berk, Science Department, MPU Courses, Willesden College of Technology, Denzil Road, London, NW10 2XD. Tel: 459-0147, ext 13.

21 **Personal computers (how to build your own).** Venue: Wimslow. This course should be of special interest to hobbyists who would like to built up their own computer system starting from as little as £100, and to those who have standard systems as the Pet and would like to understand more about how they operate and make use of their assembly languages to obtain maximum performance. Fee: £5.20. Organisers: Course Registrar, Wimslow Guild, 1 Bourne Street, Wimslow.

21-24 **JCL for programmers:** Venue: Cannock. Designed for programmers who use IBM equipment to enable them to code their own JCL. Fee: £215 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ. Tel: Cannock 2511.

21-Feb 8 **Cobol (Basic).** Venue: Cannock. Designed for trainee programmers. Includes introduction to programming, flowcharting, techniques, structuring, coding techniques, documentation and standards. Fee: £645 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ. Tel: Cannock 2511.

22 **Microprocessor Seminar.** Venue: London. Designed for the businessman. Gives general introduction to the Basic logic and Basic technology, and shows the use of the microcomputer in commercial applications. Organisers: Naomi Buhai, Birklands Management Centre, 330 London Road, St Albans, AL1 1ED. Tel: St Albans 66661.

22-25 **Microprocessors and microcomputers.** Venue: London, ICS/PCL Microprocessor Education Centre, Holborn. This comprehensive introduction with hands-on workshops is designed for engineers, scientists, systems analysts and their managers. Organiser: Integrated Computer Systems UK, Pebblecoombe, Tadworth, Surrey, KT20 7PA. Tel: (03723) 79211.

28-31 **JCL/Utilities for operations staff.** Venue: Cannock. Designed for operations staff including control/set up and planning staff. Fee: £215 + VAT. Organisers: Compower Training School, Cannock, Staffs, WS11 3HZ. Tel: Cannock 2511.

28-31 **Computer-aided design and manufacturing.** Venue: London. Presents total overview of CAD/CAM technology, methodology and applications. Fee: £470 + VAT. Organisers: Integrated Computer Systems UK, Pebblecoombe, Tadworth, Surrey, KT20 7PA. Tel: (03723) 79211.

28-Feb 1 **Troubleshooting microprocessor-based systems.** Venue London, ICS/PCL Microprocessor Education Centre, Holborn. Designed for engineers and senior technicians involved in production testing, field service, and design of microprocessor-based systems. Fee: £540 + VAT. Organisers: Integrated Computer Systems UK, Pebblecoombe, Tadworth, Surrey, KT20 7PA. Tel: (03723) 79211.

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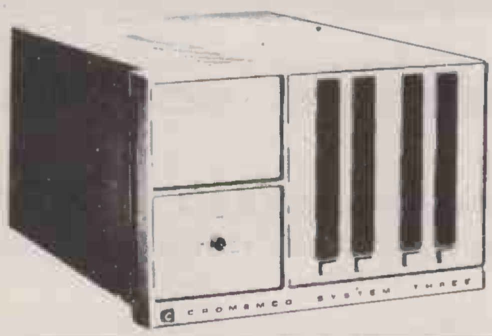

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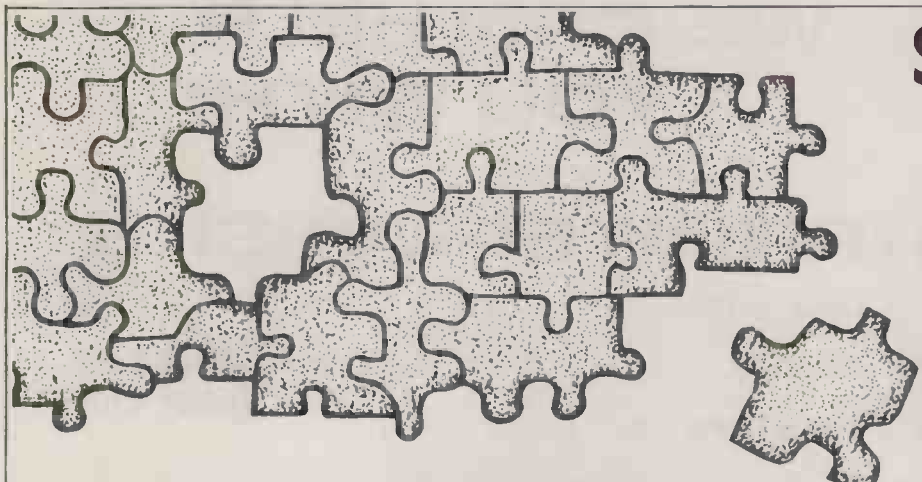

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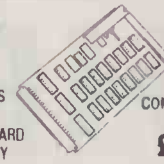

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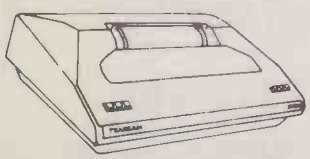

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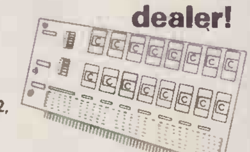

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SN74LS12N	25	SN74LS86N	40	SN74LS158N	99	SN74LS247N	1 25	SN74LS374N	1.70
SN74LS13N	55	SN74LS90N	65	SN74LS160N	1 15	SN74LS248N	1 95	SN74LS375N	.72
SN74LS14N	.89	SN74LS91N	99	SN74LS161N	1 15	SN74LS249N	1 30	SN74LS377N	1.75
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Review: Nascom I. Convert an IBM typewriter into a terminal Part I. In-car computing — Pet in the Panther Deville Report from the Los Angeles Computer Faire; Pascal v. Basic.

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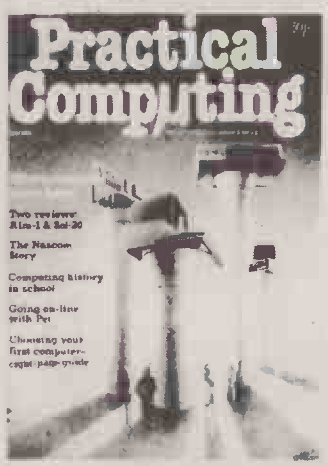

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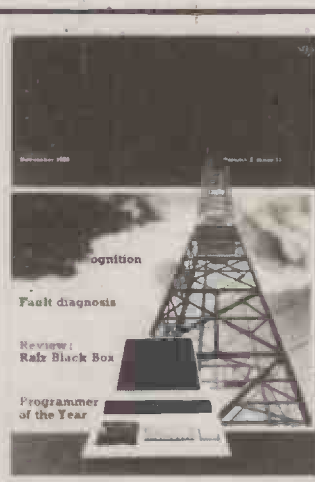

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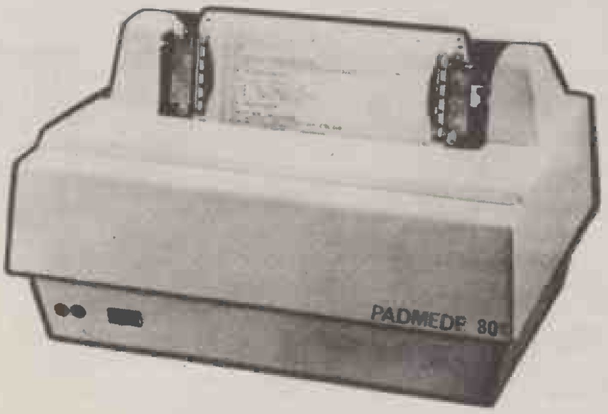

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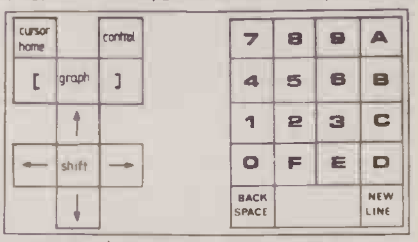

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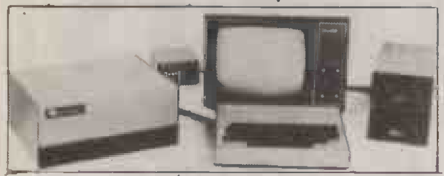

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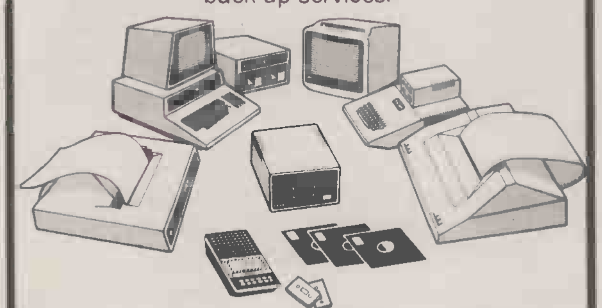


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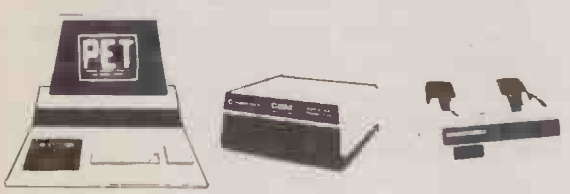

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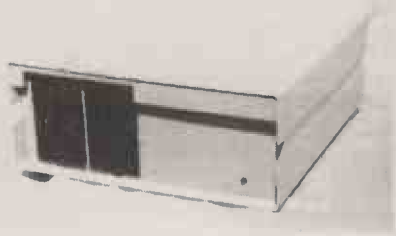

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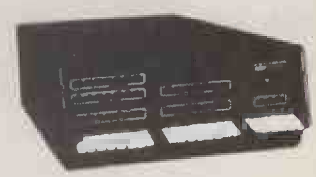

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A PRACTICAL GLOSSARY

Continuing the terminological gamut with P

Pilot
A language which was designed for writing Computer Assisted Instruction programs, aiming to overcome the shortcomings of languages such as Fortran and Basic which are not designed to deal with text in a flexible, interactive way. Some languages with text processing features, like PL/I, are not commonly available to the teachers who need to write CAI programs, and they are troublesome to learn.

Most CAI programs have been written by professional programmers on large machines and that creates obvious barriers. Pilot is a simple language anyboby can use which can be implemented on a wide variety of machines. It is inexpensive and it works. (See *PC*, Nov. '78, p55).

Pins
Connector pins are the legs on a *chip* (qv). They connect the chip to the electronic circuits on a circuit board; they fit into pre-defined holes and are soldered there, the solder making contact between the circuit and the pin.

You'll also have 'pins' inside a plug, of course. They do much the same job; as with mains electricity, the plug pin fits into a socket to make a connection.

PL/I
An interesting failure. PL/I is an immodest acronym for Programming Language/I and it was designed by IBM to combine the business dp virtues of languages like Cobol with the scientific capabilities of Fortran and Algol. The result is by no means a bad thing but it has never displaced the others. Big IBM installations make heavy use of it but even there IBM Assembler, Cobol and Fortran are utilised more widely.

The trouble is that it needs a good deal of memory and plenty of relearning, so it never appealed to the mass market of small computer users, and it was never adopted over-enthusiastically by programmers who could make a living more easily with a different language.

PL/M
An Intel programming language designed for use on *development systems*. Easier to use than an *assembler* and probably qualifies as a high-level language. There is no connection with PL/I.

PLA
Programmed logic array. A kind of sub-microprocessor. A PLA is an LSI chip which can read several inputs to deduce which of several alternative outputs it should produce. You'll be safe sticking to PLA as Port of London Authority.

Plasma display
A microscope slide of blood. Alternatively see *gas discharge*.

Plotter
A device which draws things automatically; it could be a graph, a picture of a man with cloak, tall hat, beard, a fizzing bomb labelled BOMB.

Plotters are sometimes called any or all of graph, digital, incremental or X-Y plotters. They all work by receiving digital information from the computer, converting it into X-Y co-ordinates for a pen — or ink-jet gun, in more esoteric devices — and moving the pen across the paper in minute increments and in the direction specified.

Plugboard
Also known as patchboard — very occasionally — or patch panel, sometimes jack panel. A plugboard is simply a circuit board, which may or may not have circuits printed on to it, with sockets for removable plugs (jackplugs). Switching around the plugs can alter what the computer does, so plugboards are normally utilised only for diagnostic use by a maintenance engineer.

Plug-compatible
Something is plug-compatible if it can plug straight into something else, which in computer terms means it must meet all the electrical, logical and mechanical requirements of the 'host'. Typically an independent company will develop and sell plug-compatible add-ons — like terminals or disc drives or memory boards — which fit on to a popular computer, like the TRS-80 or Pet or PDP-11 or IBM 360/370.

They may well be cheaper and better than the computer manufacturer's own products, or there may be no alternative offering from the computer vendor.

PMOS
Or P-channel. An older alternative to N-channel MOS. A fabrication method for MOS semiconductor circuits; it is slower than NMOS.

Point of sale
This describes the locale where money changes hands in a shop of some sort. Ordinary cash registers are being replaced by clever devices which do everything the till does but also collects information about the sale — what has been sold and how much for.

This might be stored on a cassette and removed at the end of the day or it might pass the information directly to a computer. Either way the information is processed by computer to provide almost instant notification of matters like sales income and stock position.

Point to point
In computer terms it means a circuit connecting two and only two things — like a computer and a terminal — without the intermediate assistance of something else, like a computer. Compare *multi-point* connections, where several terminals attach by one line to one computer.

Pointer
Could be a register or *accumulator* which holds the address of the next memory location to be accessed by a program. Could be a register which effectively tells you which instruction you have searched in your program. Could be an address of part of an instruction which defines the start address elsewhere of something else — a table of values, for instance.

POKE
An instruction available in most Basics which stores integer values in a specified memory location. For example, POKE 65,15360 places the ASCII number 65 — which is the letter 'A' — in memory address 15360.

Polish
Polish notation is a way of writing *Boolean algebra* so that all the *operators* precede all variables. There is also a backward version called Reverse Polish notation. Now forget it.

Polling
A technique used in data transmission, typically on *multi-point* networks where several terminals are sharing one line. A program in the computer interrogates each terminal in turn to find out whether it has anything to say. This happens very quickly and, of course, it means you need terminals which can recognise when they are being polled.

Polymorphic systems
Maker of the Poly 88 personal computer, and several derivatives, and another of the early leaders in the business. It has a very good Basic.

Port
A socket on the computer into which you can plug a terminal or some other I/O device.

POS
Or PoS. It stands for *point of sale* (qv).

Precision
A neat and logical definition, which makes a change. Since 'precision' means being very clearly defined, it is reasonable that in arithmetic it usually means the number of significant digits in a number.

On the other hand, there is nothing inherently clear about logic *per se*; precision, you see, is contrasted with accuracy. They are not the same thing. Accuracy refers generally to the number of figures following the decimal point — the more you have, the more accurate your number is. Precision refers to discrimination from a number of possibilities; so, irrespective of the position of the decimal point, a four-digit numeric form allows you 10,000 possible numbers; that's exactly how precise you can be, no more and no less.

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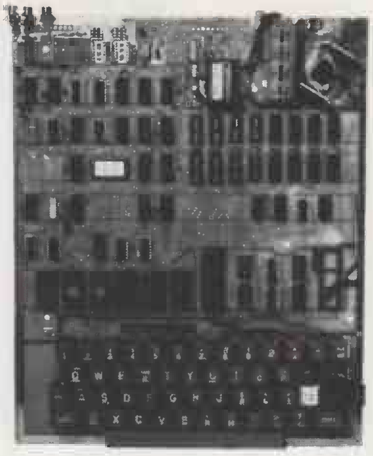
COMMANDS
CONT LIST NEW NULL RUN

STATEMENTS

CLEAR	DATA	DEF	DIM	END	FOR
GOTO	GOSUB	IF..GOTO	IF..THEN	INPUT	LET
NEXT	ON..GOTO	ON..GOSUB	POKE	PRINT	READ
REM	RESTORE	RETURN	STOP		

EXPRESSIONS
OPERATORS
-, +, *, /, ↑ NOT, AND, OR, >, <, <>, >=, <= RANGE 10^{-32} to 10^{+32}

VARIABLES
A, B, C, ... Z and two letter variables
The above can all be subscripted when used in an array. String variables use above names plus $, e.g. A$.



*8K Microsoft Basic means conversion to and from Pet, Apple and Sorcerer easy.
Many compatible programs already in print.

SPECIAL CHARACTERS
@ Erases line being typed, then provides carriage return, line feed.
← Erases last character typed.
CR Carriage Return — must be at the end of each line.
: Separates statements on a line.
CONTROL/C Execution or printing of a list is interrupted at the end of a line.
"BREAK IN LINE XXXX" is printed, indicating line number of next statement to be executed or printed.
CONTROL/O No outputs occur until return made to command mode. If an Input statement is encountered, either another CONTROL/O is typed, or an error occurs.
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FUNCTIONS

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LOG(X)	PEEK(I)	POS(I)	RND(X)
SPC(I)	SQR(X)	TAB(I)	TAN(X)
FRE(X)	INT(X)		
SGN(X)	SIN(X)		
USR(I)			

STRING FUNCTIONS

ASC(X$)	CHR$S(I)	FRE(X$)	LEFT$(X$,I)
RIGHT$(X$,I)		STR$(X)	
LEN(X$)	MID$(X$,I,J)		
VAL(X$)			

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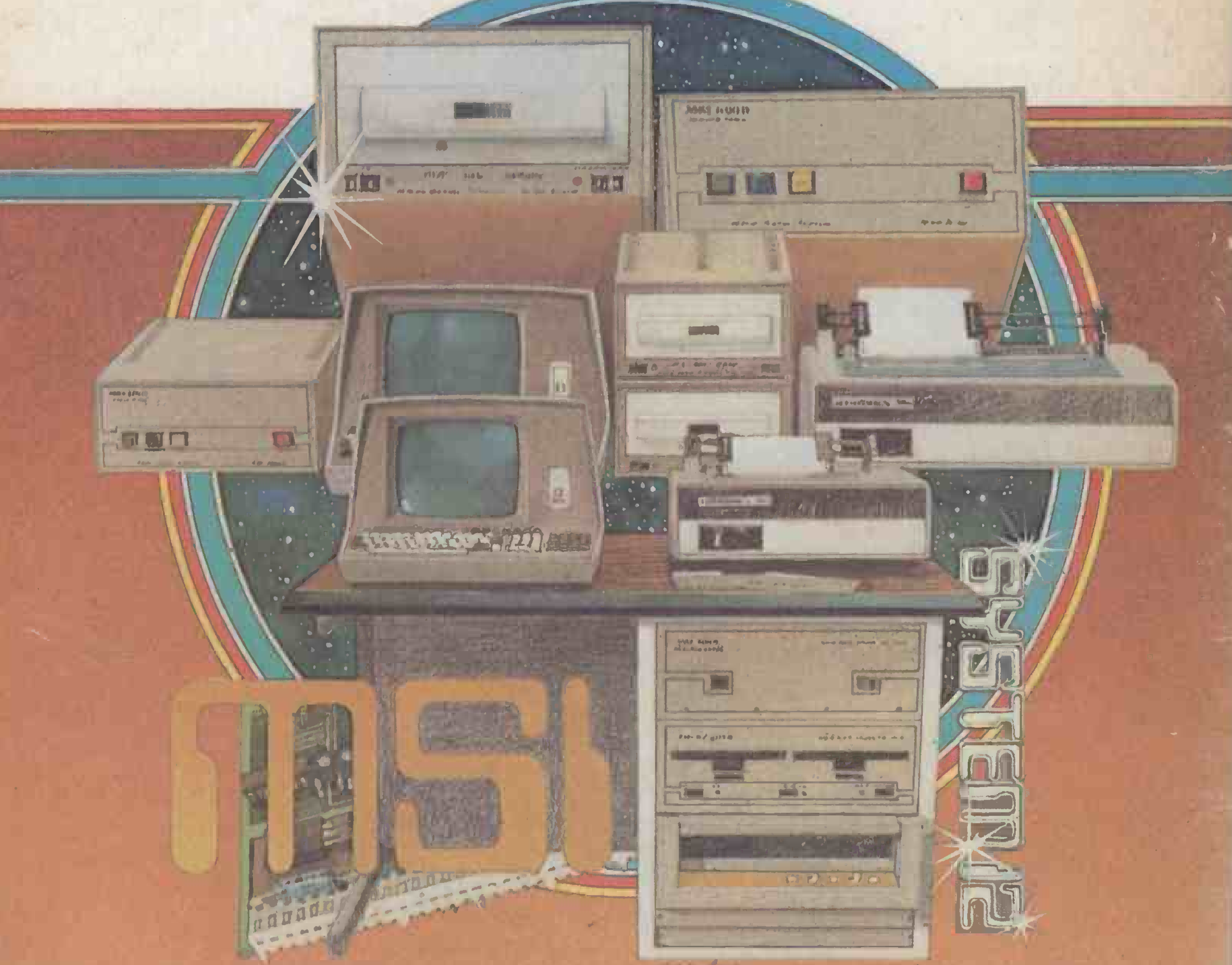
All Systems Are Not Created Equal



Your computer application is unique. It differs from all others. It is because not all applications are equal that MSI has developed a variety of computer systems.

At the heart of every MSI System is the powerful MSI 6800 Computer, one of the fastest and most versatile available. Depending on the System you select, the MSI 6800 has from 16K to 56K of RAM. Mass memory storage in MSI Systems range from 315K bytes in the System 1 to over 76 megabytes in our most powerful System 76.

In addition to the computer and memory subsystem, MSI Systems include a CRT terminal and high speed character printer. The System 12 and 76 are housed in a compact desk unit.

As with hardware, computer software is not always created equal. Since there are a myriad of programs available, MSI offers a choice of Operating Systems for use with your MSI Computer System. Of course, our favorite is MSIDOS, but we offer the powerful SDOS and FLEX operating systems as well. All MSI Systems will support the other software products associated with each operating system.

MSI also has a variety of software programs including a complete Accounting Package and a Multi-User Basic program capable of supporting up to four users.

MSI Systems are currently being used in a broad spectrum of personal, scientific, educational, professional, industrial control, and business situations. In addition to our Systems, MSI can supply you with individual components for personal and OEM use. All MSI System components are available, some in kit form.

Write or call us for more information about MSI Systems and products and the name of your nearest MSI dealer.

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