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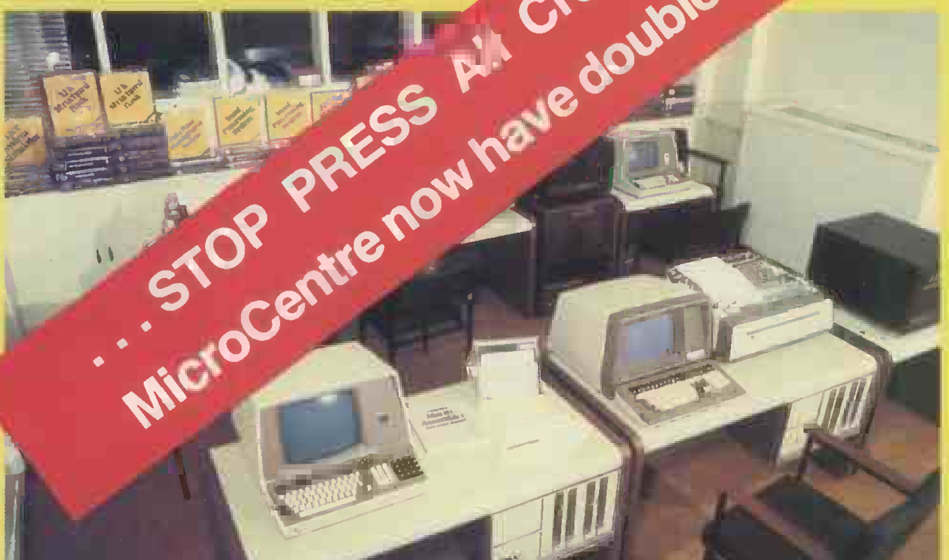

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Cover photography Ian Dobbie

Freedom for the PET... and the busy user.

Now PET users can achieve previously 'impossible' configurations without recourse to tedious machine code routines.




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It assists busy or inexperienced programmers with ten new SERIAL BASIC commands, enabling them to achieve previously 'impossible' configurations without hours of tedious machine code routines.
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More Powerful. In short it makes the PET a more powerful beast...bringing electronic mail and data retrieval systems like Viewdata, multi-access and user applications and inter-office data transfer within the range of PET users.

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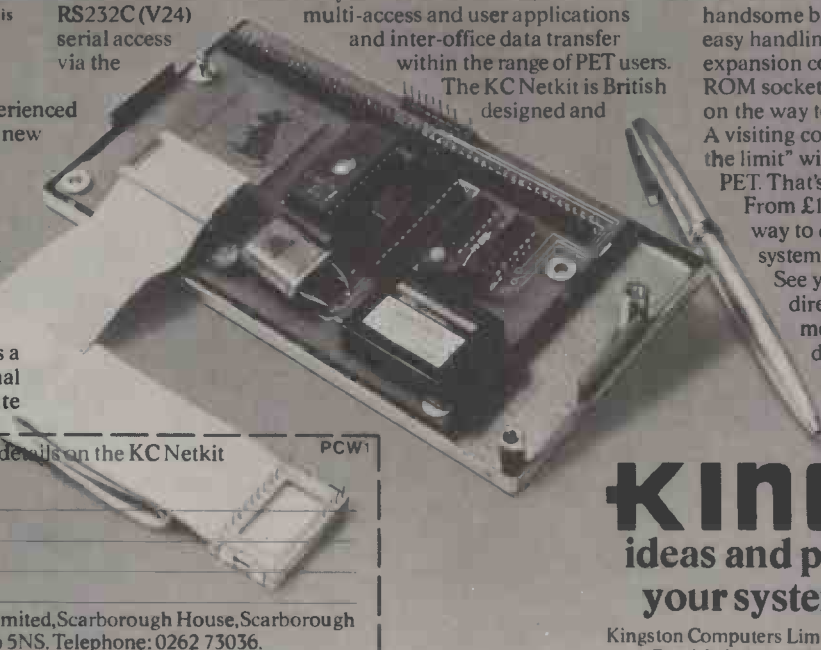

The KC Netkit is British designed and developed by the manufacturers, Kingston Computers, part of the £25m Dale Electric Group, who make standby power systems for industrial-type computers.
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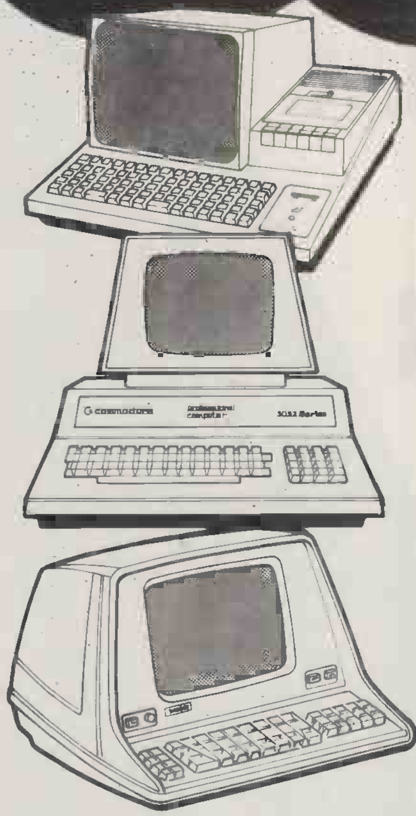

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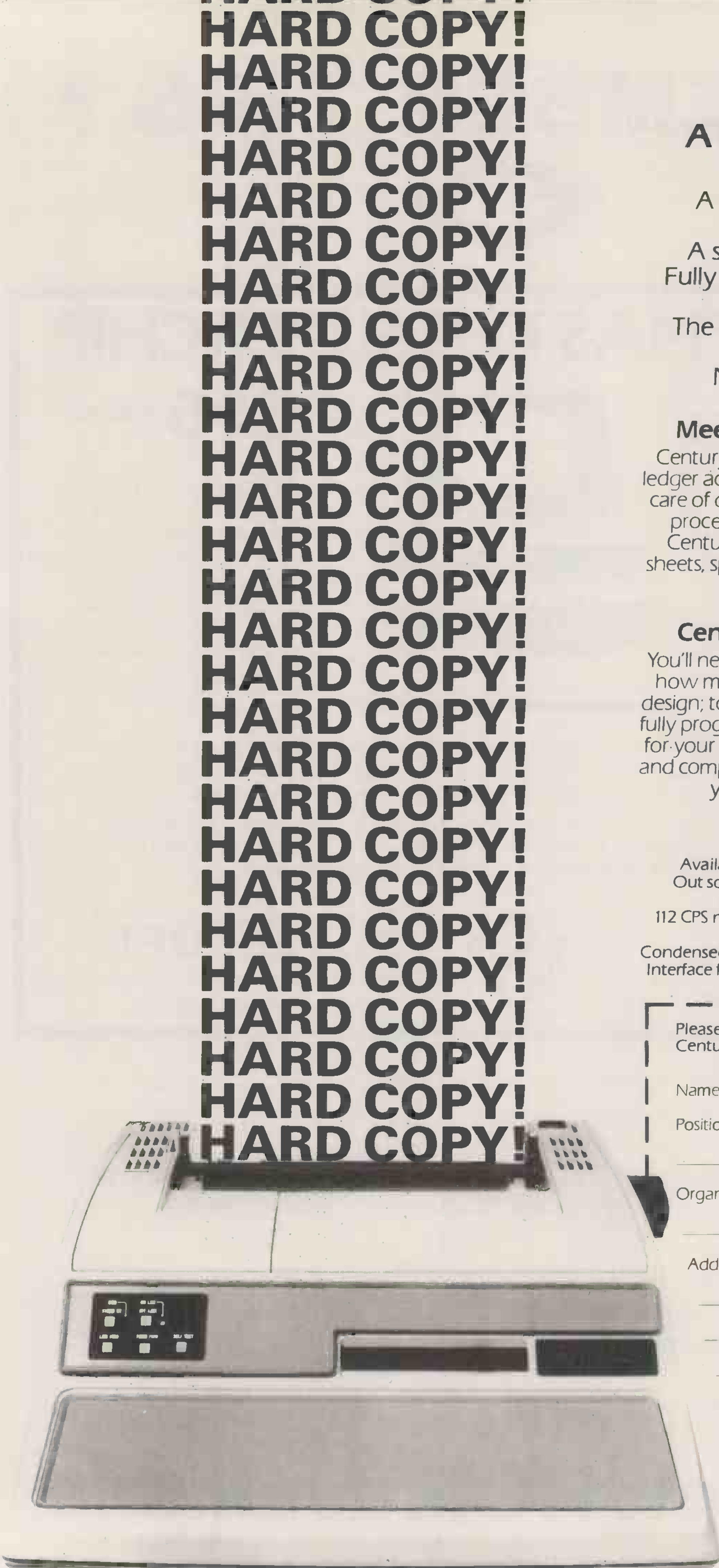
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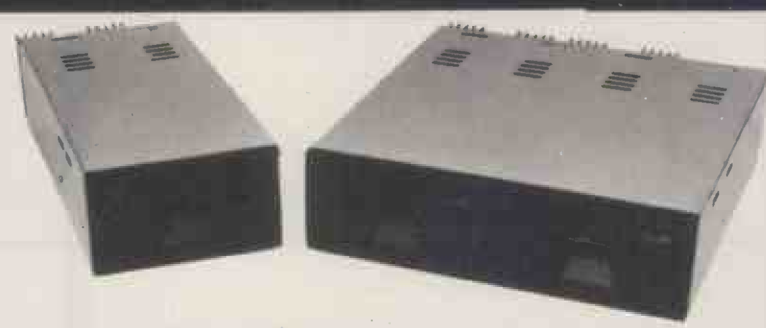

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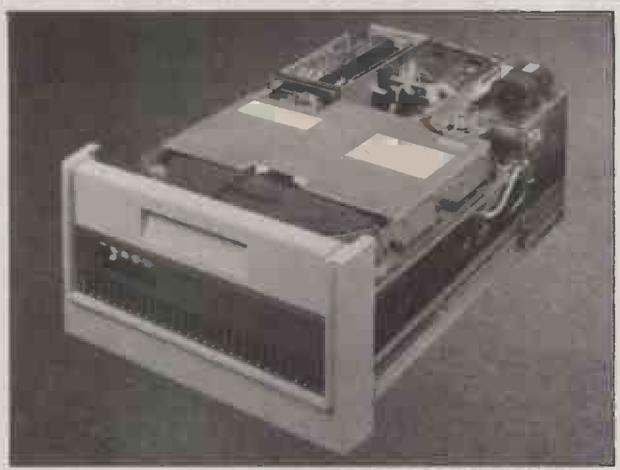

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11 = Numerous reports may be generated (eg: sale ledgers up to 30).
12 = Invoice produces immediate stock update + double journal entry.
13 = Reference on invoices enable cost centre build-up on ledgers.
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03=*ENTER PURCHASES . . . .
04=*ENTER A'C RECEIVABLES . . . .
05=*ENTER A'C PAYABLES . . . .
06=*ENTER' UPDATE INVENTORY. . . . .
07=ENTER' UPDATE ORDERS . . . .
08=*ENTER' UPDATE BANKS . . . .
09=*REPORT SALES LEDGER . . . .
10=*REPORT PURCHASE LEDGER . . . .
11=*INCOMPLETE RECORDS. . . . .
12=*EXAMINE PRODUCT SALES . . . .
13=*PRINT CUSTOMERS STATEMENTS . . . .
14=*PRINT SUPPLIER STATEMENTS. . . . .
15=*PRINT AGENT STATEMENTS. . . . .
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19=PRINT YEAR AUDIT . . . .
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21=ENDMONTH MAINTENANCE. . . . .
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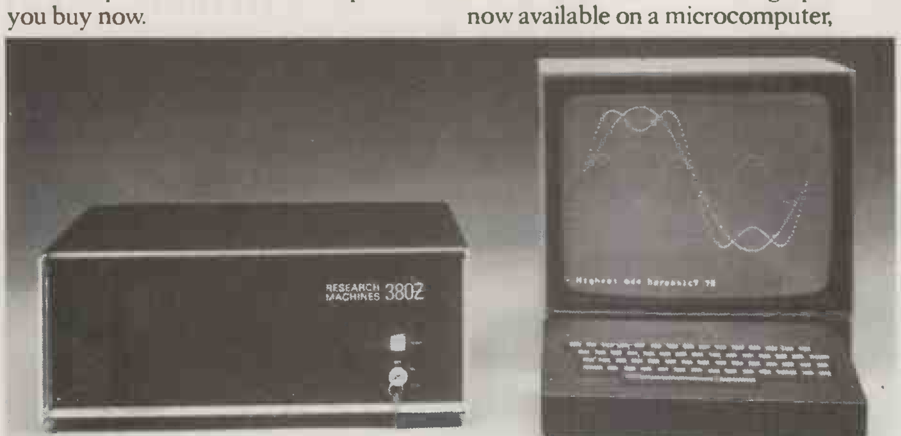


Might you want to add disc storage in the next few years?

If you do:

Given good hardware, software availability completely determines the flexibility and usefulness of your system. There is absolutely no question that a Z80 based micro-computer which uses the industry-standard CP/M* disk operating system has several times more software on the market available to it than non CP/M computers.

Today you can purchase a mature CP/M BASIC, FORTRAN, COBOL or Text Processor for the 380Z. Soon there will be CP/M Pascal and Database Management systems.

CP/M software is several years ahead of software available for non CP/M family machines.

If you don't:

Remember that professionals writing packages for your cassette system will themselves often use a disk 380Z, and the power of their tools will influence what they produce.

For many people a disk machine is too expensive – but at least the 380Z approach will allow your students to advance.

380Z BASIC is not frozen in ROM. An enhanced BASIC could be loaded in mid 1980 and a BASIC with structured features sometime later.

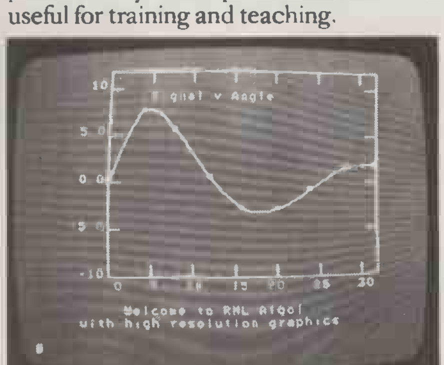
On the 380Z the memory used by a BASIC interpreter can also be used for other software.

Does our research-oriented design pay off in classroom hardware?

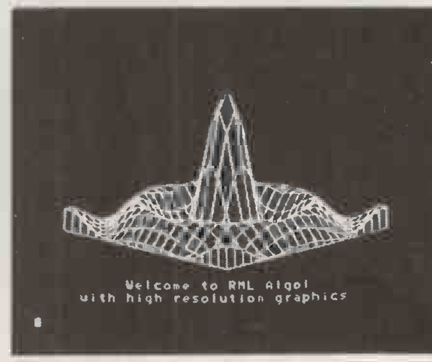
Our scientific graphics was produced for the professional user. Interest in it for classroom use has been surprising.

The 380Z has the best graphics now available on a microcomputer, allowing multiple resolutions, multiple paging, fading and accurate control over colour. All these features help bring excitement to efforts in computer assisted learning.

Our standard machine comes with low resolution graphics and support for this from BASIC allows you to plot a point directly with a plot command – useful for training and teaching.



It is worth remembering too that neither our low resolution graphics nor our optional scientific (high resolution) graphics has any limiting effect on your memory usage, and in both you can



freely mix upper and lower case text and diagrams.

Mains noise can cause system crashes which result in loss of programs and data. All current 380Zs include a mains filter which significantly reduces the chances of this happening.

Don't buy a 380Z on patriotic grounds.

Please only buy it if you would have bought it anyway. But remember, because it is designed and manufactured here you are bound to have better access to us for influence and help than if we were on the other side of an ocean.

Prices range from a 16K cassette 380Z @£897 to a 56K Dual Full Floppy Disk 380Z @£3322.

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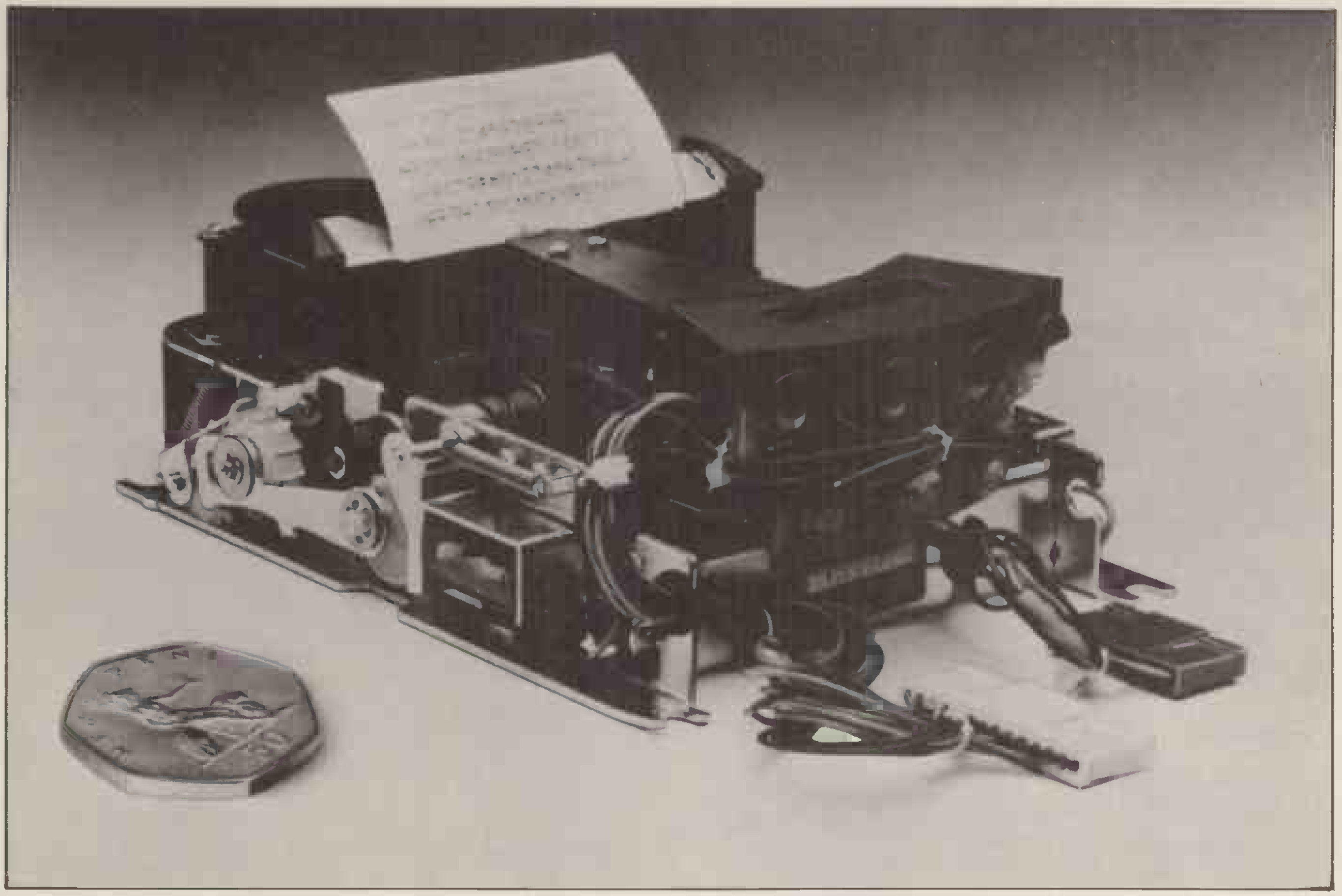

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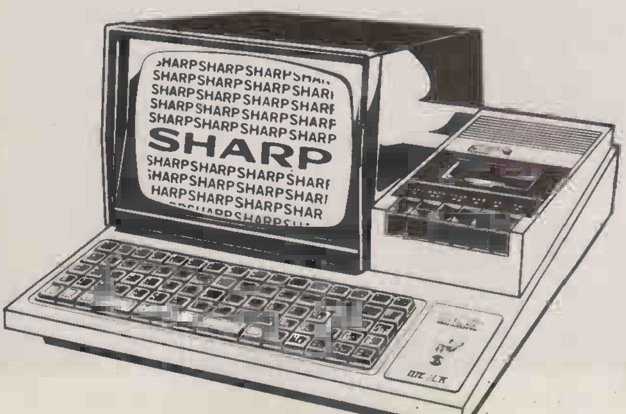

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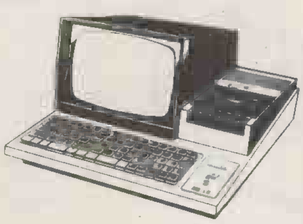

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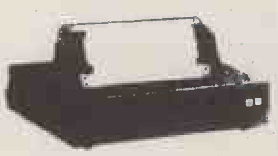

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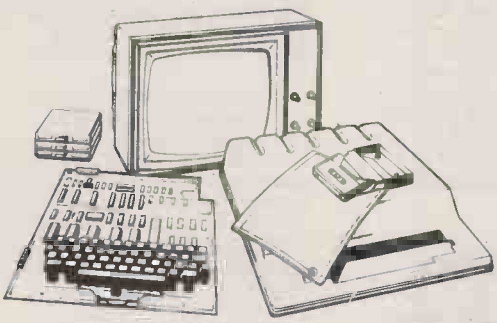

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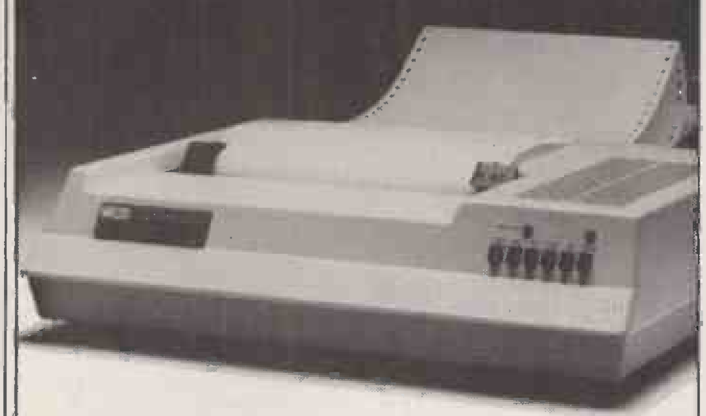

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WH14

You'll be pleased to hear that, despite his recent elevation to the Editorship of trade rag Datalink, *Guy Kewney has decided to stick with PCW. Here he is with his latest crop of news, rumours and gossip.*

PO on the prowl

Today, anybody can hire a microcomputer from the Post Office. Next year or maybe the year after, you'll be able to hire a Post Office microcomputer — which is not quite the same thing.

For users, the news must be good: another supplier in the market can only mean a better choice. And once the Post Office's National Data Processing Service starts building its own microcomputers — which is what this is all about — it'll have a direct interest in using its resources to make its own micros easier to use. And that means all sorts of good things.

The good things will include very cheap software, distributed down the phone lines. The people designing the PO micro are bright enough to know that software is free; anybody smart enough to borrow a disk or tape and copy it can have a program, in the same way that anybody smart enough to tape a radio broadcast can have free music. The current pricing level puts software at three different cost points: cheap (£5 or so), reputable (£100 or so) and quality (with stars and a nice, hard-to-understand manual, at £300 or so) — all for very similar programs. This is a very temporary trend. In five years' time, software will cost £50 (by then, I'm assuming, £50 will buy an LP or a round of drinks) or £50,000 in a dealer pack, allowing you, the dealer, to sell off copies for £50.

The PO, with Telecom's wires to distribute, can transmit software direct to a user machine for the cost of the phone call — and that's at a profit. Now while all this may be some way in the future, it's the sort of thing we can expect the PO to work towards once it gets into the micro market: and the move is much closer than many people suspect.

The biggest surprise has been for the people who already make micros and who supply them to the PO for rental to its customers. They're finding that sales to internal PO departments are suddenly being blocked off.

It is not easy to do this, of course, and the trend will evaporate quickly once internal departments twig that permission to buy a Rair Black Box, or Research Machines RML 380Z, or Casu, is likely to be refused on the grounds that "you'd better wait until our own product is announced," which is what's happening now. Instead of asking permission, they will fall back onto the many tried and trusted dodges — buying 'process control equipment,' or 'office storage systems' or 'automatic monitoring devices' out of adequate special budgets set aside for these things. "Microcomputer?" they will say innocently, when asked to explain a North Star Horizon on the desk, "is that a microcomputer? We bought it as a sophisticated staff clocking-on registry device and all it does apart from that is Star Trek and a few other games — cost accounting, and that sort of thing..."

But the PO's own microcomputers, for there are two, will be eye-openers when they come. For a start, they'll be multi-user: the designers are not limiting their vision to today's slow eight-bit micros but are looking wistfully into the next five years, when any competent micro will be a 16-bit mini.

Second, they will not be built by the automatic PO choices for the past few decades — the branches of Plessey, Standard Telephones and Cables, and GEC — but by the company which tenders successfully for the licence to build them. And they will be built by a second source, the PO's factories division. Few people know that the PO has a factories division — they tend to think of a specialist outfit, making £2000 transistors for undersea cables. They can forget it: Sir Keith Joseph has decided that the PO must face competition, because it will be healthy for the PO.

Actually, what he meant was that it would be healthy for the rest of industry, which could march into the PO territory and take over from the fat slugs. But it won't work only one way. It will be healthy for the PO, which will respond to the cold wind of competition by waking up and flexing its muscles ... don't say you haven't been warned.

Hard Diskussion

Impressive though it may be to say that one particular manufacturer of computer back-up store can boast Bill Schneider "who was director of product planning for the Memorex Corporation", it is time that suppliers of imported US products realised that they had one little problem: when they say "the product I am importing is the best in its field," they are laying themselves just a teeny bit open to charges of bias.

Rack Data imports mini-winchester disk drives made by Priam (who boasts Bill Schneider, etc) and "regards Priam as being the best of the independent suppliers" of these disk-drive sized storage devices. Really? Did Rack Data have the option of Shugart and turn Shugart down?

INMOS-the late news

How much is £25 million, if you are building a chip factory? It depends, doesn't it, on whether you got it two years ago or now; Inmos was promised the money to set up a British chip-making plant more than two years ago.

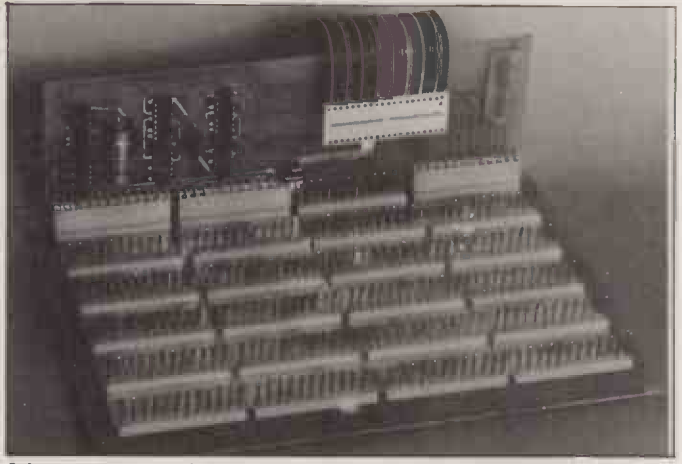
Last month, the Prime Minister announced that the money was available after all (after the long pantomime of deciding whether chips would sell, of wondering whether GEC could do it better, and of agonising over whether a Tory Government could actually do *anything*, especially if it had been started by Jim Callaghan) and Inmos started making plans.

Well, the plans are rather less grand than the original ones were; £25 million may be more money than I will see this decade (next decade it'll be the price of a house, I dare say) but it doesn't stretch to the sort of plans that Inmos made when they first started drawing lines on paper.

The Bristol factory has been moved to South Wales. Originally, that would have helped some 200 school leavers in South Wales but wouldn't have done anything for Inmos. Catch-22 says that if you set up shop in a development zone, you get a Government grant but that if you already have a grant, the second grant is deducted from the first. Inmos was set up under a Government grant.

That has been changed: now it looks as though Inmos will gain £3 million or more

These ain't pins, they's probes. Vero has produced them for automatic board testing, before or after components are loaded. One part is spring loaded and fits into the other part, which is fitted to the board to be tested; you put the board on a bed of pins which are all wired to your test rig — which may be as simple as a volt meter or as complex as a signature analyser — and contact is made. Details on 04215 66300.



It's not easy to plug extras such as data storage disks, or extra memory, or printers, into the typical Ohio Scientific computer at the single board level of the Superboard (or the imitation, Chris Cary's Compukit UK101) — for the simple reason that the machine is a single board, without a nice standard bus to plug things into.

A product which offers such a plug-in bus has been released by Zen Computer Services of Sale in Cheshire. It comprises two boards with a 40-wire connection to the main computer board. The first board plugs into the second which is a motherboard, taking up to five other expansion devices) and merely boosts the electrical signals, providing a 'buffer'. Details on 061-962 3251.

by getting Government assistance to set up in South Wales, a high unemployment area. Even with that, the plans for a corporate headquarters at the factory have had to be scrapped. Instead, it will keep its rented office space in Bristol for a headquarters and will only build a factory in Wales. The saving will be enormous but necessary.

Ah well, it still doesn't bring the magic day any nearer, the day when products with Inmos chips inside will be sold. Inmos is designing a microcomputer, no secret about that, and it will be available sooner than its competitors expect. But it isn't going to be a challenge for anything we now use; for the Zilog Z8000, yes, but only far, far in the future.

¿Qué?

You may think these translation calculators are a joke. You wait until some foreigner tries to pronounce a simple phrase such as "Do you have the right time?" from the anti-phonetic spelling of the English language, as provided by his pocket phrase book, and you will realise why the only firm with a chance in this business is Texas Instruments.

The Texas translator talks. It may sound like a machine talking, and it may be monotonous but when it speaks French, it sounds like a monotonous machine *with a French accent*, a very important point.

Panasonic has introduced a translator which doesn't talk: "Designed for use by the travelling businessman, tourist, or student," says the announcement sent to me recently, "it is ideal for vocabulary practice..." I bet. "Hello = bonjour," it says. It even detects spelling errors.

The reason for mentioning it is that this one (costing £105) can also be used as a calculator for simple arithmetic, plus a converter from imperial miles, feet, pounds and pints to metric kilometres and so on. So, even if the translator turns out to be useless, you haven't wasted your money.

Worth a Try

Second-hand computers — 650 of them — have been sold to UK buyers by CFL, a Coventry based systems house which also sells new Honeywell and General Automation minicomputers. So far the company is not into used micros but bigger machines. If you've got one to sell, this company is now moving into the Middle and Far East and on the strength of this has boosted its income by 60% over last year (the new figure is £1.2 million turnover).

If you have one to buy, it sounds from these figures as if the average used-computer price must have been (at the outside maximum) £10,000, assuming that all 650 used machines — and no new ones — were sold last year; in fact, that obviously isn't the case and it looks like CFL can sell £5000 used machines. Check it out on 0203 58318.

Amusing Jobs

Smart lad/lass wanted: one of the most fascinating jobs one could ever imagine has just been set up by the Government as part of its £9 million project to boost computers in education.

The project is one of the jobs to be done by MUSE — minicomputer (and micro) users in secondary eduction — and it involves working out a way of transferring software written for one machine onto a different one.

John Coll, chairman of MUSE, hopes to appoint two school-leavers as research assistants for this project. "With a relatively small number of different makes of micro computers in schools," Coll observes, " it seems sensible to have a team making programs available for all."

The two assistants will be appointed to Oundle school, where Coll works, and to Birmingham, which will be a part time job. MUSE is hoping to get something like £30,000 out of the Government project, to be spent over the next academic year. It isn't clear what happens next year, however. The same applies to MUSE's other project — a central information service offering expert advice for teachers struggling with the new technology and discipline of data processing.

MUSE should approach the National Research Development Corporation and ask for a further £30,000 to actually develop a machine-based system for software conversion. Not only would this be of much more long-term use to MUSE and the schools it serves, but it might also make MUSE some money, enabling it to hire its assistants for rather more than a year.

But I bet there's some civil service regulation which says you can't finance good ideas like this. Anyway, MUSE can be contacted through Bob Coates, Netherhall School, Cambridge on 0223 42931.

On the Buses

People who buy a computer with a bus inside it do so because they intend to plug extra boards into the computer, not because they think the actual bus itself (the pattern of wires and the signals they carry) is intrinsically good. Yet Zilog has launched a new bus family and justifies the move on the grounds that the bus is intrinsically good.

It's competing with the S100 bus, which will take micro users well into the

When a manufacturer talks of moving 'up-market', ask the executives how their video output compares with HP's 2626A terminal.

As the photograph shows, it's clear enough to register on film in normal light. It's divided into four independent work areas; each area can be on the screen, or off the screen and moving one around doesn't affect any of the others. Hewlett-Packard calls this multi-window, which describes the process quite well once you understand it. Don't ask how much it costs unless you're going upmarket yourself — price is not its selling point. Oh, all right: it sells for £2275. Also it can talk to two computers at the same time. Details 9734 61022.

1980's and 16-bit computers, and it's competing with Intel's own, rather more expensive, Multibus, which is starting to look as if it won't. Zilog hopes that its Z-bus Component Interconnect (ZBI) will do so.

The reason the Intel Multibus may not last as long as the S100 bus (the one which most computers advertised in this magazine are based) is the ironic one that it was always more ambitious.

Systems using the Multibus as the method of connecting component modules have always tried to go faster, be more sophisticated and more reliable than systems 'thrown together' on the much cheaper S100 bus.

The logic may have a flaw: granted, there are always people who want a superlative product rather than an adequate one but are there enough of them? Intel's Multibus has appealed to many customers but these have been relatively small-volume people compared with the numbers sold on the S100 system. And they remain picky which means that while the people who used the S100 will be able to get by for the next decade by making a few adjustments, the people who wanted the Multibus are now saying that it is running out of steam. It may still be better than the S100, but it isn't good enough.

Zilog say its ZBI is good enough to move into the days of the 32-bit micro. For those of us who need a 32-bit micro, this must be good news...hullo, I seem to have lost my audience. Surely somebody here wants a 32-bit micro? Not this decade? I understand, sir: sorry.

Wiping Up

Most recent addition to a whole range of cleaning aids for the computer room (the range is called Texwipe) is this packet of Bluewipes, a multi-purpose wiping cloth made from non-woven fabric (like J-cloth) which is durable and absorbent, yet is unaffected by water, detergent and alcohol and contains no additives.

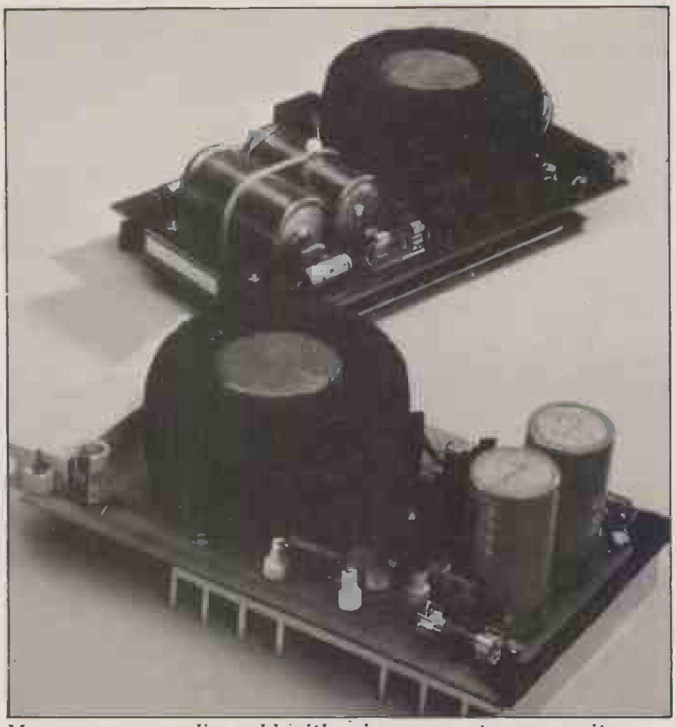
What Mike Brewer of Microsense's parent company (Data Efficiency) doesn't say — but ought to — is that normal tissues do contain additives and they aren't funny. In order to pamper the mucous membranes of the human nasal and anal orifices, tissue paper and bogroll is crammed full of talc. And you know what talc can do for a disk...details on 0442 57137.

Catching the Bug

It's some while since I went into print with news of problems on the Anadex DP9500 printer. The problems then were that it was supposed to be available 'off-the-shelf' which should mean immediately, and yet people were waiting months for them; it also misbehaved when asked to run at its higher speed.

It's a very nice printer on paper (sorry) and when the bugs are proveably out and the price drops a trifle, it will sell well. It has nice features, such as being able to print a dot anywhere the program specifies along a line, not just in character positions defined by the character generator chip; that means it can draw very detailed pictures. It'll print across 132 characters per line, and at full speed, will print a line in under a second — making it pretty fast.

Its speed, however, is currently the only thing it has over the Oki Microline-80 which sells for half the price and seems to be rather more reliable. It may be that by the time this gets into print, Anadex will have traced the fault, and told me what caused it but until they do, make sure the printer will actually run at its fast speed *on the computer you will be using.* On some, it doesn't. Details from Midlectron, on 077 382 6811, or from Anadex direct.



Many power supplies sold with microcomputers are quite powerful enough to drive the computer, but tend to run out of capacity once the user expands. Vero has introduced a supply which provides the standard five volts — but at nearly twice the normal power. It's a 25 watt supply, capable of providing five amps without cooking the wax out of the transformer or turning off the regulator. Either eventuality is what you expect from an inadequate supply. Details 0703 440611.

Siriusly Now

For £60, you can add a board to any SS50 based computer an use it to generate the sound of a raspberry tart (rhyming slang) directed at me.

The board is the latest product of the famed Sirius Cybernetics outfit — *not* Corporation, outfit — in Leamington Spa. It's a programmable sound synthesiser (the board not the outfit) which can be programmed from either assembler language or Basic programs to produce "a vast variety of sound effects and music from a combination of three independent sound channels which can produce a tone and a white noise."

With the publication of this item, we come to the end of the long-running saga, wherein Sirius Cybernetics and its very existence were the subject of considerable Kewney scepticism. I will admit that I still find it hard to tell people, with any real conviction, that a company was named Sirius Cybernetics roughly at the time when the radio programme *Hitch Hiker's Guide to the Galaxy* was so successfully entertaining Britain with its Sirius Cybernetics Corporation — by people in Leamington who had never heard of the radio show. Stranger coincidences have happened, I know; but I find some of those a bit hard to swallow, too.

However, since my personal scepticism is not a marketable item, I have no shame or hesitation in telling you that I was proved wrong in extending it from a disbelief in coincidences. I was wrong to conclude that Sirius Cybernetics was merely a practical joke, being perpetrated on the world's press.

The company really exists and really has computer

It hurts to admit it, but I can't really say that my old friend Graham Barrat has picked a winner with his £4500 microsystem from Sanyo of France.

His machine looks to stand comparison with the Intertec SuperBrain, which KGB of Slough is now offering at £1500 or so (64 kbytes, minifloppy, nice screen and keyboard all in box and starting to look like a serious rival to the Apple II). For the extra money, the Memory System 7000 (as the Sanyo machine is called here) seems to offer rather more disk capacity, plus whatever quality is built into the software.

Mind you, I have little doubt that the software will be good — Barrat used to run a big computer bureau and should know what users like — then again, at £400 to £500 each, these programs really better be good. Details of Memory System 7000 on 01-836 5342.

NEWSPRINT

In tests, eleven out of ten PCW staff were unable to tell the difference between Tandy's new hand-held micro and the Sharp PC1211. To confuse things yet further, Tandy's new offering is called the TRS-80 Pocket Computer — I really wish Tandy would think of a TRS-something else. It will be on sale here in October and will cost £119 inc VAT; the cassette interface is priced at £17.95. Tandy says that software packages will also be sold at prices between £8.95 and £13.95.

boards for sale. And it now includes a telephone number on its letterheading: 0926 87342.

But don't mention my name when you ring. Or, if you do, spell it Em You Dee.

Texas Talk

Making a computer talk in an American accent is now possible for the home builder as well as the built-system buyer. A guide to designing speech circuitry with Texas Instruments chips, such as the set in the home 99/4 computer, is available. It's the *Solid State Speech Products and Services Brochure*, and details are available on 0234 67466.

The Soft Sell

The biggest potential competitor in the market for ready-cooked software, the market currently dominated by Petsoft, has yet to really show its paces.

Microtrend, set up by our own contributor David Hebditch with Dutch money, has announced an initial range of various packages for several micros but still hasn't made the impact that it may do once it gets the distributors to stock its products. In the meantime, it's extended its range of machines with a deal, signed with a Swedish micro company's UK agent, to cover the Luxor ABC—80.

This micro is marketed in the UK by Dr Frank Taylor, once a consultant with the NCC and now working for himself. He's a standards expert, and his company, Microtech, distributes the Luxor machine — which he claims is "currently a best seller in the discerning Scandinavian marketplace."

So far, the ABC—80 has proved to be a slightly expensive rarity in this country and has relatively few devotees. It doesn't use the S100 system, nor any other American-designed standard bus, and software for it is therefore hard to come by.

If Microtrend gets itself right off the ground, this situation may change. Microtech will handle the work of converting Hebditch's software to run on the Luxor computer, but Microtrend will help distribute and market the programs.

I wish I knew how well Hebditch's chess playing program, Gambiet 80, did in the PCW championships (I'm scribing this just before the event). That was written for the Z80 micro (which is in the Luxor machine) and Hebditch made impressive claims for its playing ability before the games. He said it had beaten Sargon, among a great many others. If it's that good, Taylor's lot will want to convert it quite quickly.

Details from Microtech on 0565 52911 and from Microtrend on 0423 711878.

S100 Graphics Boost

Now that we have a cheap British machine with S100 standard slots, the Transam Tuscan, devices like the high resolution graphics board built to this standard by Digital Devices' supplier become more directly relevant to the less affluent users.

The board is the Matrox ALT—256**2, which is a daft name for something you have to ask for over the counter. It provides an 'image' for a video output and ensures that whenever the computer alters that image, the resulting flashes don't get transmitted to the screen, thus avoiding the common snowstorm effect of less careful systems. Some 256 x 256 dots are covered; that fills around 8 kbytes of 'image memory' which is higher resolution than many, even if not the highest on the market.

No price is available yet, from which you can deduce that it isn't the price which sells it. Details on 0892 37977.

Approved PET Food

A catalogue of Commodore-approved software for the PET computer is available, It's a list of dealers, each starring a favourable item or a few items of code under various headings, such as Business, Medical, Education and so on. Some 50 programs are described in enough detail that you can tell whether they will run on your machine; memory size, type of PET, type of peripherals needed and so on, are given in most cases.

Less interestingly, the catalogue also includes PET peripheral products. While it's nice to know that there are products which carry the Commodore seal of approval, evaluation of a printer is a much simpler matter than the problem of finding out whether you actually *like* the way a particular program runs.

The catalogue is available from Commodore's London information centre on 01-388 5702.

KGB Swoop

The list of dealers for the SuperBrain, given in this column by the Editor last issue, has just been over-trumped. An independent operator, KGB Microcomputer Systems, has set up in Slough High Street, flogging them at £400 off for around £1500.

At that price, these nice machines should start to sell. So far there are only some 500 to 700 SuperBrains in this country, the same order of magnitude of the number of dealers in America.

KGB isn't the approved dealer, or even *one* of the approved dealers. The company is not saying where it gets its supplies, or how... just in case the angry authorised dealers move to have them cut off, perhaps, or in case it turns out to be the manufacturer, trying to put a bomb under the market. Either way, it looks like the beginning of a good slanging match, because I'll bet that the next thing the authorised dealer network says is "He can't support them at that price."

The machine that plays with itself

Chess master David Levy has announced his very own chess-playing micro and has been inconsiderate enough to tell me about it for this issue. This means that the World Chess Championships for microcomputers will be over and done by the time you read this but I have to write about it beforehand. What a shabby trick!

(Don't worry — it's not competing — Ed).

The micro is unique, claims Levy, in eight ways. First, it's a sophisticated game, not just a plug-in program for a video ping-pong set; it displays the chess board and pieces in full colour on a TV (a colour one, of course).

Second, it includes a built-in video cassette recorder (not admittedly, one which can record Starsky and Hutch) to record up to 1000 full games on ordinary audio cassette tape. The player can add his own commentary: "This is where the machine made a fatal error," or "That error the machine made earlier now turns out to have been less fatal than I originally thought."

Third, each game comes with a free audio cassette to teach you how to operate the machine. There are other cassettes, including all the tournaments and match games ever played by Bobby Fischer, all Karpov's games (about 800 each) and all named opening variations, about 300.

Intelligent Chess, the new chess computer from Optim Games. See 'The Machine That Plays With Itself'

BASF gives a Good Deal

To an entrepreneur building up his own business, or to a company needing to distribute its data processing, the BASF 7120 gives a good deal.

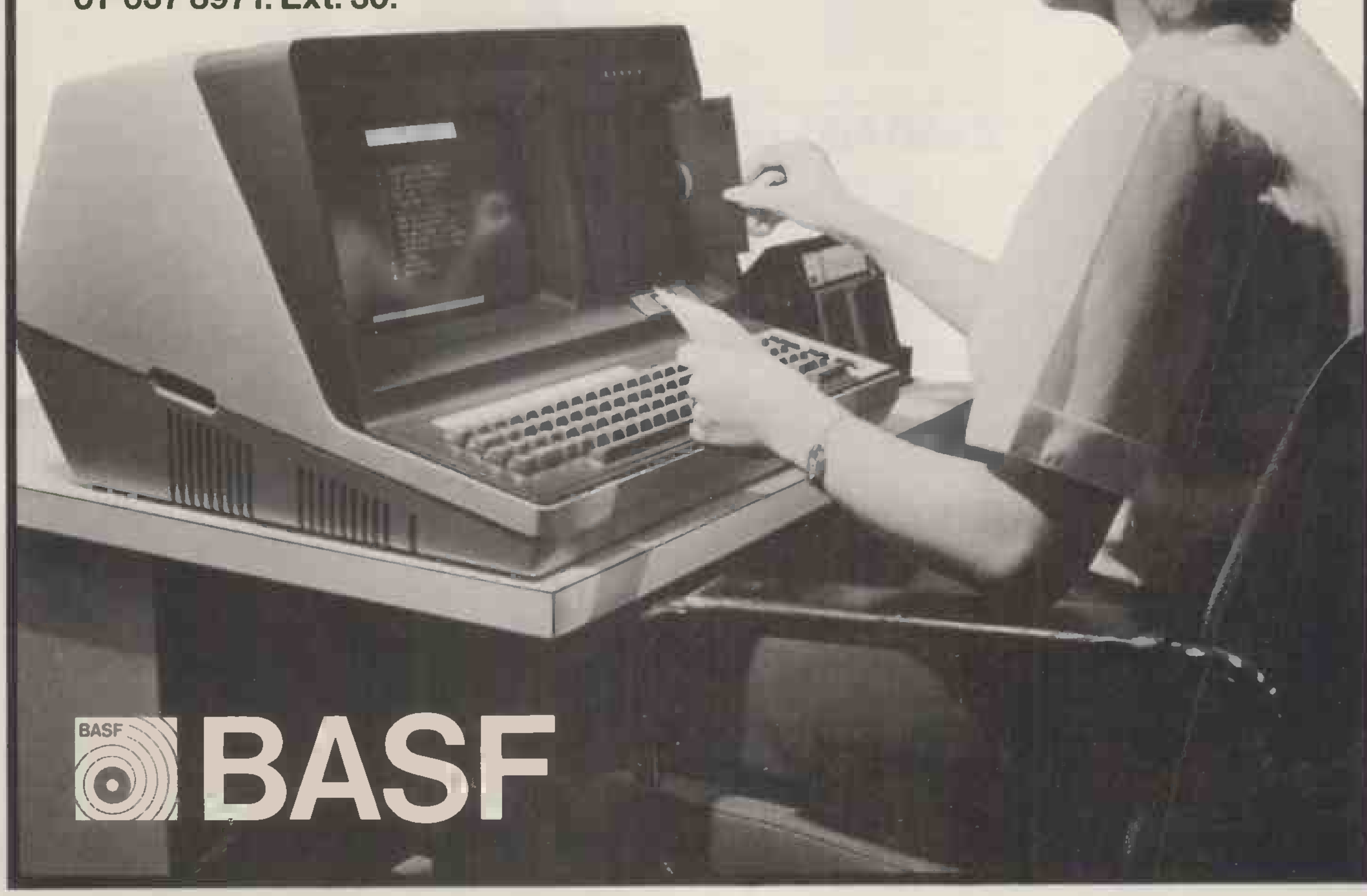
Our 7120 is basically a stand-alone microprocessor giving high performance at low cost. It's a powerful desk-top computer for around £5,500.

The main features include:
* Main memory of 64 K bytes
* File control system memory of 24K
* Dual Z80 microprocessors
* Extended BASIC for business applications
* CIS COBOL and CIS FORMS 2 for interactive programming
* Specially designed keyboard to ease operator interface
* Free word processing package.

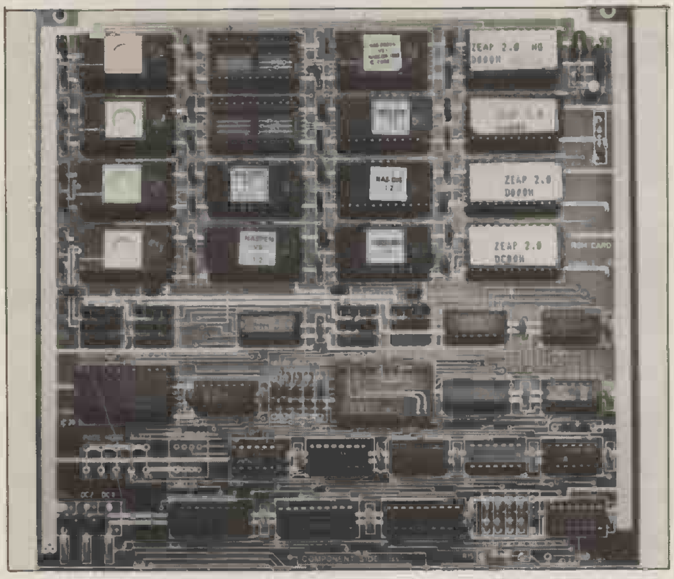
The whole deal is offered by BASF, whose computer interests also include supplying media, CPU's, add-on memory and plug-compatible peripherals for large mainframes.

Finally the deal is completed by selected dealers providing sales and technical support where you need. Including Computer Services in Canterbury, Dataforce in Bristol, Dataview in Colchester, Davies & Brown in Shoreham, HB Computers of Kettering and Verles in Birmingham.

For more information and the name of your nearest dealer, please contact: BASF Computers, Haddon House, 2-4 Fitzroy Street, London W1. 01-637 8971. Ext. 30.



BASF



If nobody else likes Nascom, its founder does. John Marshall's new company is Interface Components and just about its first announced product is a board to hold Nascom firmware — up to 40 kbytes of it. The board will attach to both Nascom 1 and 2 and has room, for example, for the Naspen letter writer, the Zeap assembler and editor, the Nas-dis disassembler and Nas-debug and still you can plug your own programs into another six sockets. Details on 02403 22307.

Fourth, any square on the board (or squares) can flash. This may be useful in teaching chess, I suppose.

Fifth, the computer can be tortured into revealing what its next best move would have been, and compelled to play that move. And the next best, and the next, right down to the only move left.

Sixth, the machine can be stepped through a pre-recorded game move by move.

Seventh, it can unplay a game to the point where you want to play something cleverer.

And finally, it can be left alone to play games with itself, in a shop window or at an exhibition.

It costs a mere £295 including tax, and will be available from October. Mike Johnson, winner of our first championship, wrote the software, and Barry Savage, designer of the Softy PROM programmer, designed the circuits. Levy provided the blueprints. Details: Optim Games on 0279 54547.

Motor Control Chips

A chip to build into any system that must control electric motors has been released by Motorola. It's a complex type of chip, using the magnetic characteristics of the alternating current series motor to provide information feedback to a triac (which slices the power up into fat or thin pulses to run fast or slow) — which drives the coils. Details on 0908 610035.

Info Happenings

Nobody would ever bother to report all of the 400 conferences, seminars, tutorials, briefings and other happenings organised by Infotech for the rest of 1980 — except, of course, Infotech itself. The booklet runs to 25 pages, and is available free from Maureen Nichols at Nicholson House, Maidenhead. Details on 0628 39101.

ZX80 Add-ons

It was quite cheeky of Clive Sinclair to claim that his ZX80 microcomputer could be used to control a power station or run a business but for those who took this statement at face value, help is on the way: it may be able to control a toy train. Extra components to add on to the ZX80 can be expected to appear from several outside suppliers, now that the original machine has passed the 20,000 sales mark (at the time you read this, that is). First to appear are an add-on memory board, which also offers some control over external devices, and a power supply.

The add-on memory looks like a much better bargain that Uncle Clive's own product which provides a mere 4 kbytes of RAM. This one costs £79 (built assembled and tested) and provides 16 kbytes; for an extra £10, the board will include 24 parallel input and output lines "for controlling music synthesizers, model train layouts, or whatever you wish," says the maker, Timedata. The power supply will drive the memory board and will also drive the ZX80 itself. It costs £29. and if used to drive the ZX80, takes the heat-producing job of voltage regulation out of the micro's own case, cooling it down somewhat. All these prices include tax. . details from 57 Swallowdale, Basildon, Essex.

Well I never

Amateur computerists are putting memory chips to uses that their makers certainly never planned. One of the strangest of these is the harnessing of EPROMs as tapes.

Amateurs who have written long programs tend not to like waiting the quarter-hour or so that it takes to read the code into their systems from a cassette tape. Instead, they load it into a blank EPROM with a PROM programmer. Then, when they have tired of it, they erase the chips with ultra-violet light.

All of which explains why Newbear is happily selling EPROM-erasing cabinets, not just to big software houses which retail software in chip form but also to people who can't even afford a disk. Details from Jon Day on 0635 30505.

Nascom Lives!

At the time of writing, Nascom (Britain's first and biggest computer kit company) appears saved. The deal had not been signed but was looking certain.

The deal was between Manas Heghoyan, who runs a printed circuit board company in Watford and the receiver of the company (accountant Cork Gulley) and all that remained to do was to take stock and make sure the books were straight.

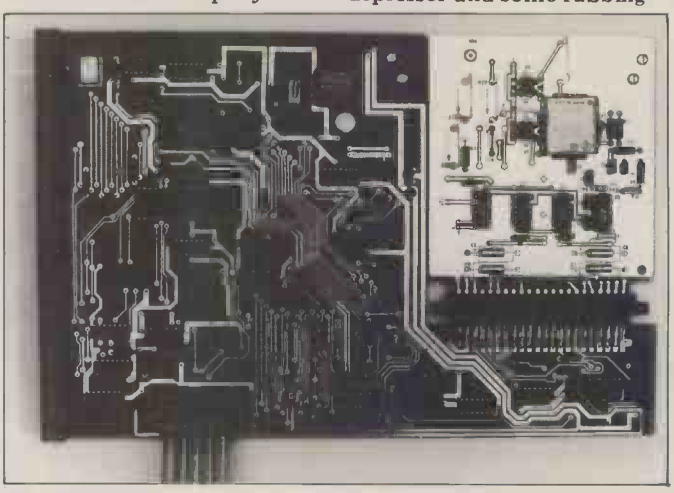
Heghoyan won't say what he paid for the company, but sources indicate that it was quite a bit less than the half million sterling which the company owed when it was originally put into liquidation. Grovewood Securities, the backer which backed out, is therefore presumed to be paying for its timidity in dropping the company just as it was starting to make money.

The new boss is quite a different person from John Marshall, the founder. He started his career as a computer designer, putting together the high technology of English Electric's 1965 vintage System 4 mainframes which were killed off when the ICT 1900 range was selected by ICL as 'the way to go'. He built up his PCB factory in Kington, Hertfordshire, literally from the ground, acting as architect, builder, and financier and obviously plans to build future Nascom products himself.

One thing he is not (at the time of writing) is an expert on Nascom. Unlike many however, he did not try to cover ignorance when I met him. Instead in a determined drive to pull the company back into good shape he was busy hiring the consultancy services of Tony Rundle, one-time software director of Nascom, and now working for Systec consultants. If I were one of the 19,000-odd users of the Nascom design, I would be pleased to see him take over.

Clean Sweep

Any gonzo with a tongue depressor and some rubbing



The first British micro kit to have a bubble memory may be your Nascom. A new board has been announced by Microdata Computers which offers a small storage capacity of 92,304 bits (that is, around 10 kbytes) which will never evaporate, even if you turn the power off by my own favourite method of tripping over the power cable. The bubbles are in that square tin can in the white section of the board — which carries a little map of Texas, indicating that they are Texas Instruments bubbles. Details and prices from 01-848 9871.

NEWSPRINT

alcohol can set up in business cleaning disks. Cleaning the drive which holds the disks when in use, isn't so easy and if you think it isn't necessary, you haven't seen the sort of disaster I saw recently at the offices of Commodore's publicity agency. There, the simple process of putting in a new window in a partition wall had filled the drive with enough dust to ruin four disks.

To clean the drive, you put a special cleaning disk into it. Some 20% of its surface is wet with a special cleaning fluid, the rest is dry, and as the drive tries to read it, the cleanser alternately wipes the heads with the solution and then with the dry surface. Neat, isn't it? Details on 01-941 4066, from BFI Electronics.

PL/Z Revealed

Zilog makes the Z80 micro; everybody uses it and yet they don't use Zilog's own very special language for programming it, PL/Z. Learn the language through Software Architects, authorised course-runners for Zilog, in a three-day course at the Holiday Inn in North London; get details on 01-734 9402.

Making Light

Draw on the television screen of your Apple computer by using the £34 light pen announced by Bill Unsworth's company, U—Microcomputers of Warrington. A simple PEEK instruction checks the light pen's photoelectric sensor, to see if the part of the screen it's pointing at is emitting light and then software follows the pen around the screen. There is a sample program available (which comes free with the pen) on cassette, in case you think it's too complex. Details on 0925 54117.

YANKEE DOODLES

Tom Williams reports from California with some thoughts on the future

This is by way of being a gadfly, a bubble-popper, indeed little short of a wet blanket. There are a lot of illusions and tacit assumptions afoot about the future of microcomputers, which, while not impossible, do tend to gloss over many of the problems standing in the way of all those delirious dreams.

"...compromises have been made which turn out to be quite inefficient."

Computers are getting bigger as they grow smaller. We are now witnessing the spectacle of galloping hardware development outracing the ability of the software industry to keep up — let alone to fully utilize the enhanced capabilities of the newer processors. Not only have newer operating systems come along which try (not always successfully) to be compatible with existing applications programs but in trying to adapt existing operating system software to newer hardware, compromises have been made which turn out to be quite inefficient.

A classic example came with the introduction of hard disks to micros. Existing operating system software was not able to efficiently handle the increased capacity because the sector size was geared to floppies and required too great a percentage of disk space to keep track of directory and other housekeeping. In a couple of instances the hard disk itself was not treated as a physical entity, but was divided up into "virtual disks" that appeared to the programmer just like a large number of floppies. This may at first seem to be a convenience from the user's point of view, but it's really just a patch and terribly wasteful of space on the hard disk.

So what are people going to do with 16-bit micros, and (saints preserve us) the 32-bitters? No doubt there'll be a great many fascinating things that can be done with them, but it will be a shame if the software proves to be an impediment. The increased speed and capacity of the new machines could really bring about the level of simulation — colour, real time, complex parameters, etc. that have been in the dreams of educators but which are not yet really possible on today's 8-bitters. It's well to realize that hardware alone won't do the trick.

Another popular myth, prevalent in one form in Britain and another in the States, is that access to huge data bases will instantly give us all that information we need to make our lives simpler and more productive. Yes, data bases *will contain* a great deal of information, but *getting* to that information and getting it in a form we can easily use is not a problem that's seen a lot of attention.

"...a shame if the software proves to be an impediment."

The shape and organisation of a data base tends to reflect the interests and priorities of the people who created it and not those of a broad and general public. We often walk into a library to research a problem that we've only vaguely defined in our minds. It's only after interacting with the 'data base' *and* with human resources (librarians and bibliographers) that we are able to focus the direction of our search. This direction may take us on an entirely different path than we originally anticipated. The point is that in a library — a social institution — we're dealing with more than just structured information. In today's data bases, the user is left on his own to find a way through the maze, or, worse yet, is led along a narrow path wearing blinkers which prevent him from seeing things that might aid his quest.

At the risk of sounding downright reactionary, I'll allow myself the following analogy. It's been said of microcomputers that they represent to the human mind what steam engines of the Industrial Revolution meant to human muscles. Human production did take a quantum jump as a result, but there's another side to the analogy . . . over-reliance on machines caused some people's muscles to go flabby. I submit that the same can be said of micros.

I'm thinking, for example, of the newer cash registers, which instead of numbers on the keys, have pictures of the sandwiches, drinks, etc. served by the establishment. Theoretically, one could train an orangutan to operate such a machine (the only impediment being the unions) but what if something goes wrong? It's here that I cease my ravings and turn to substantive items.

There's long been talk of a new Radio Shack computer with colour capability and despite Tandy's efforts, it hasn't been able to hide the fact that it has been working on it. The recent introduction of the Videotex terminal indicates that it might have the same screen configuration — 40 characters —, 16 lines, and relatively low resolution graphics. This would be in keeping with Radio Shack's arrangement with MicroNET, by which the network service will change its display format to be compatible with the new terminal. If these suspicions turn out to be true, the long awaited new TRS-80 may turn out to be something of a disappointment.

"...hardware alone won't do the trick."

On a more business orientated front, however, look for something new from Germany in the near future. A certain company there is preparing to market a machine put together out of the German Kontron system, a very sophisticated maching with high resolution black-and-white graphics and the new 5¼" Winchester disk drive by Shugart Technology (not to be confused with Shugart Associates, the original company). This should mark the first instance of a consumer/personal computer using the new, small Winchester.

For much more sophisticated systems, National Semiconductor has introduced a new family of 16-bit microprocessors, the NS 16000 line. One member is especially adapted to handle high level languages, and another can, in combination with a memory management chip (MMU), be used to construct a computer with virtual memory capabilities.

"...the user is left on his own to find a way through the maze."

In virtual memory, the processor generates 'virtual addresses' and the memory manager then translates these into physical addresses which can be either in RAM or on disk. The important thing is that to the programmer, all addresses appear as if they are part of one, continuous memory. It may well be said that such capabilities are beyond the abilities or needs of users of personal computers. But, bearing in mind my earlier tantrum, if proper software is developed to take advantage of the power — software that is a *superset* of existing software — then human imagination will do the rest, and we needn't worry about our brains going flabby.

PCW welcomes correspondence from its readers. Be as brief and concise as possible and please add "not for publication" if your comments/questions are to be kept private.
Address letters to: "Communications", Personal Computer World, 14 Rathbone Place, London W1P 1DE.

Talkers wanted

I am trying to organise a series of talks for the Kirklees Computer Club on the following subjects:
Monitors, assembler languages (particularly 6502), error-handling techniques, disk operating systems (particularly CP/M), Pascal, Forth, Fortran. The audience will comprise people ranging from those with little or no knowledge or experience of personal computers to those who have owned one for some years.

Can I appeal for anyone who is willing to come to Huddersfield on a Monday night to talk on one of the above subjects for about two hours to write to me or phone Dudley Stilton on Huddersfield (0484) 652862.
A Starkey, 46A Mill Moor Road, Meltham, Huddersfield

Animistics 1

I found Mr Frude's article on Animistics fascinating and it is all too possible that 'your plastic pal that's fun to have around' will one day be introduced by, who else, the Sirius Cybernetics Corporation. However, I feel that people's attitudes to computers are changing in such a way that many will cultivate relationships with straight off-the-shelf micros despite their inhuman, technical appearance. Microcomputer operating systems are becoming so complex that each machine has a 'personality' all of its own; indeed, here in Oxford the computer freaks talk of 'getting to know a new software release' or 'discovering a quirk in the video output' of their favourite machine. This does not mean that the computer is thought of in human terms; the relationship is of a completely different kind. Perhaps a 'hard' relationship with a flashing box is more appropriate to today's mechanised, computerised society than one with a cuddly pet/companion or even with another person: one is master of one's personal computer and the reward for a continuing, successful relationship is greater mastery and control over it — the machine needs no reward in the form of considerate treatment and behaviour towards it, unlike pets and humans. The more one becomes involved in the hardware/software specifics of one's machine (the things animistics tries to hide behind 'user friendliness') the more it will assume a character, and the more uses one finds for it the more indispensible it becomes. For those of us not spending our time exploring the intricacies of CP/M subroutines it is unlikely that we could have a close relationship with anything which does not involve friendship, trust and caring, but to youngsters brought up with TV games instead of teddy bears, shunning the company of other children to play with hand-held Astro-Invader games, it might well prove to be a natural development. It is hard to decide which is the more daunting prospect: a society which prefers the company of life-size friendly androids to the real thing, or a society which rejects the real thing, preferring to gaze intently at a screen and occasionally tap at a keyboard.
Stephen Page, St Johns College, Oxford

Animistics 2

I read with fascination Neil Frude's article 'Animistics' (July PCW).

While we are running barefoot through the outer fringes of technology, how about a replacement of the blow-up female simulcra advertised in *Playboy* and such like. The blow-up doll market would collapse like a pricked balloon under the onslaught of a computer controlled responsive 'Randy Raquel'. Slot-in ROM pacs can cater for whatever perversion is your bag of beans and vocabulary pre-programmed from murmers to howls of appreciation.

You may not like the idea but to extend Frude's criteria of probability, 'there is money here, so no doubt they will be built'. No doubt readers will view it as prostitution of technology but this will not stop it (remember $E = MC^2$?).

This is not a new concept. Anyone remember a film called *The Stetford Wives?* Anyhow whatever the final outcome I am sure that it will give a new nuance to the phrase 'dolly birds'.
J D Swift, Surrey

Viatron System 21

In reply to Mr Dion's letter in the August issue of PCW, I have a manual entitled *Information for Operators 2111 Data Management Station* which I would be pleased to loan to Mr Dion. This gives no technical information about the circuits or connections on the back of the brute. I understand that there is no microprocessor chip in the system and that it is basically a stock keeping system, and that
1. the company making them has ceased to exist;
2. most of the chips were purpose made;
3. the British agents for the system are Data Design on 01-207 1717 who have the circuits but want about £600 for a copy of the set.

The magnificent keyboard is a mechanical opto system with a nasty tendency to jam up or rather for a key to stay down and corrupt the coding. The keyboard coding does not seem to conform to any of the recognised systems involving 13 bits.

My own feeling is that unless the built-in operating system is what one wants, the best use of the brute is as a case, power pack and a VDU. With a little bit of adjustment I have found the VDU will resolve 32 lines of 64 characters. If Mr Dion has information on the chips, I would be very grateful if he would make this available.
J H Whittaker, Tonbridge, Kent.

LA users

My department has recently acquired a PET microcomputer and I would be interested to hear from any Local Authority user or other interested body of their experiences with microcomputers.

In particular I would welcome observations on the level of support for the establishment of a user group for the interchange of experience and software related to design/administrative/management information systems within a technical department.
A J R Evans, Director, Engineering Services, Dudley Metropolitan Borough.

Rip-off ?

Time and again when software crosses the Atlantic to this country it seems that the $ sign is directly replaced with a £ sign for the price. Just what sort of a rip-off is being made by the so-called 'software houses'? While it is understandable that some markup is necessary to pay for import charges of a master copy and for the licensing agreement with an American software house, a 120% increase in the price appears ludicrous.

Surely it is time for someone like yourselves to help micro owners by giving the breakdown in costs of importing a piece of software; this should be done independently as I expect UK software traders can justify any price hike.
Mike Gettings, Wantage, Oxon.

Unfair tape tax

The national press (Guardian, 22 Aug) has reported that the Government is to impose a £1 surcharge on blank cassette tapes to benefit the British Phonographic Industry by offsetting losses caused by record piracy.

I regard this as unfair and an imposition on personal computer owners who owe nothing to the BPI. Perhaps readers who agree will lobby or write to their MPs as I have done.
J R Handford, Gosport, Hants.

We agree that personal computerists should not be penalised in this way and we certainly advise readers to lobby their MPs. We might, however, feel a little differently if the £1 surcharge on cassettes sold for computers could be forwarded to programmers whose work had been ripped off — Ed.

No jobs for the boys

I am writing to you in connection with the shocking unemployment figures that exist at present in this country especially relating to the younger group of people.

I would like to know if your magazine could help by setting aside half a page for any companies or businesses who wish to acquire the services of young and keen computer users to train to the level that will be of service to them.

This letter was prompted by my own experience when I tried to obtain a 26 week training period in a field related to computers/electronics. At present I am at South Bank Poly on an HND Elect.Eng. course and in the course of trying to obtain this training (and I stress training not sponsorship) I wrote to over 65 companies in London and the south-east.

The reply was consistent, no training for students given, however if I contacted them again when qualified, they could guarantee a job for me.

Business is out of touch with reality, they do not seem to realise that no training by a company means no qualification as the diploma/certificate is with held until this training has been done. Catch 22!!!

I finally got a job in a local government department teaching degree qualified officers how to program in Basic on a 32k PET. The trouble is that I am the one who is supposed to be trained.

Thank you for letting me air my thoughts, keep up the good work in your excellent tome.
Graeme Caselton, Orpington, Kent.

PET pranks

I thought you might like to see the enclosed photo of an 8k PET screen after power-on. It seems to prove that even micros have a sense of humour or perhaps it had just had a good night's rest previously. Anyway, I can deny it represents my efforts at getting a small foothold in the add-on memory business.
R D Eberst, Edinburgh

North Star GETting

There's an easier way of GETting characters in North Star Basic ('Computer Answers', August PCW). Version 6 Basic, which comes with Version 5 DOS and is probably what Mr Kirby is using, provides the INCHAR$( ) function. This waits for input from the specified device and then returns the character. CTRL—C will interrupt the program as usual, unless it has been disabled in the way Sheridan describes. The sample program thus becomes:

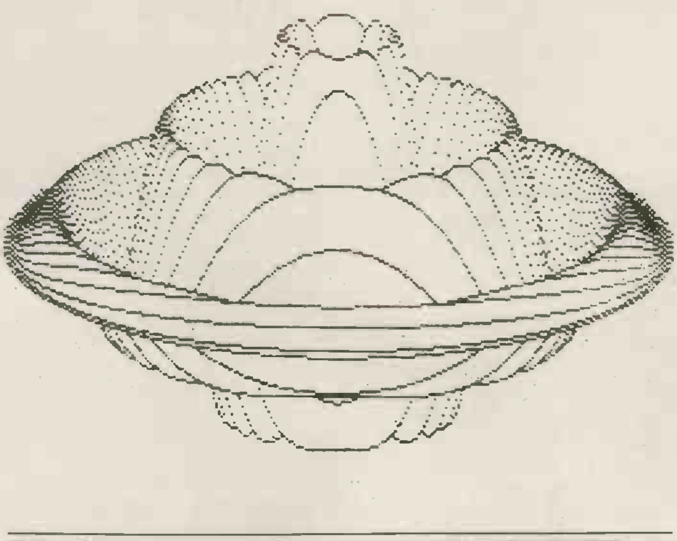
```
10 PRINT "TOUCH A KEY PLEASE",
20 B$=INCHAR$(0)\REM ASSUME CONSOLE IS DEVICE 0
30 PRINT B$
40 GOTO 10
```

S Withers, University of Warwick.

3D improvement

I was interested in Malcolm Banthorpe's article on 3-D plotting in your July issue. With slight modification, his program is very suitable for use on the HP85. It is possible, by adding a couple of lines, to show also the visible underside of the surfaces and this I believe improves the picture. Enclosed, with program listing, is an HP85 plot of a variant of his second figure, with visible underside shown.
Professor R H Macmillan, Cranfield, Bedford

```
10 SCALE 0,255,0,191
20 X1=128 @ X2=X1*X1 @ Y1=96 @
   Y2=96
30 FOR X=0 TO X1
40 X4=X*X
50 A=SQR(X2-X4)
60 FOR I=-A TO A STEP 6
70 R=SQR(X4+I*I)/X1
80 F=(R-1)*COS(18*R)
90 Y=I/3+F*Y2
95 IF I=-A THEN M=Y @ M1=Y @ Y=
   Y1+Y @ GOTO 120
100 IF Y<=M THEN 160
110 M=Y @ Y=Y1+Y
120 PENUP @ PLOT X1-X,Y
130 PENUP @ PLOT X1+X,Y
140 NEXT I @ NEXT X
150 END
160 IF Y>=M1 THEN 140
170 M1=Y @ Y=Y1+Y @ GOTO 120
```



Genie graphics

Research Machines 380Z users will of course be aware of two particularly useful graphics commands, these being GRAPH 1 and GRAPH 0. The former restricts the scrolling of data and instructions to the bottom four lines of the screen, while leaving the graphics intact. The latter command simply reverts the screen to its full scrolling format.

Since changing systems to my own Video Genie (which uses TRS-80 Level II Basic), I have felt the loss of these two commands. Even though Level II Basic is very similar to RML 9k Basic, the graphics on the 380Z are without doubt far superior, but are much easier to use. I would be grateful if you could print two subroutines which perform the functions described above, and I am sure that all TRS-80/Video Genie users will find them very useful and will save a lot of frustration.

A word of warning for all those who own, or planning to own a Video Genie: while it's an excellent system (I prefer it to the TRS-80), it does have one drawback concerning software compatibility. Since the Genie lacks two TRS-80 keys, the right arrow key and the clear key, any program which relies upon these keys cannot be used to its full potential without modification. However, in using Tandy's excellent new 'Cassette Scripsit' word processing package, I have not found this much of a problem.
R N Braybrooke, Keston, Kent

Anyone out there care to offer the subroutines — Ed.

Ohio quickie

In response to your call for short programs, I'd like to offer the following for an Ohio Superboard:

```
1 S=53692+Y :
V=PEEK(S)=49 : POKE
S,49+V : Y=V—V*Y :
GOTO 1
```

Note that V=PEEK(S)=49 is *not* an error.
P Smith, Middlesbrough, Cleveland.

We haven't tried this and we've no idea what it does, so you're on your own! — Ed.

Personal Computer World

FEATURE INDEX

Index to current volume, up to, and including, last month. (Previous volumes were indexed in March and April 1980 issues)

SOUND ADVICE

Adding sound to your micro computer opens up a whole new range of possibilities but until recently it tended to keep the CPU rather busy. Now there's a simpler way, using the easy-to-interface GI AY-3-8910 programmable sound generator chip, as David Harper explains.

The 8910 is well-suited to such tasks as adding sound effects to computer games, or generally giving your micro the power of whines and groans, if not indeed of speech itself. It has 16 programmable registers which control three independent tone generators, a white noise generator, three logarithmically-tapered output level controls, a set of mixers and an envelope shaper with a variety of profiles and variable repetition frequency. As a bonus, the chip also provides two user-defined 8-bit input/output ports. The whole device, which comes in a 40-pin DIL package, draws a modest 60 mA from a single 5 volt supply and is available at around £8.25 + VAT. There's also a 28-pin version, the AY-3-8912, which is identical to the 8910 but provides only a single 8-bit port; this IC, however, does not appear to be as readily available as the 8910 at the time of writing.

With all these facilities at the call of a micro, you can create from software an almost infinite variety of sounds from explosions, gunshots, whistles and whines to piano notes, clock chimes, and even drum beats and cymbals. The 16 independent registers can be easily and efficiently controlled from Basic via PEEK and POKE commands and the device is also extremely economical of CPU time. Even for fairly complex sounds such as a repeated chime or piano note, it is only necessary to set the registers once at the start of a sequence and the PSG will continue to produce sounds until the CPU resets it. This of course gives it great advantages over less sophisticated sound generators which can monopolise the CPU completely during sound output.

Interfacing

The 8910 was designed for compatibility with the CP1600 CPU and since the latter device uses a shared address and data bus, the 8910 cannot be directly hooked up to CPUs such as the 6502 or Z80, whose buses are separate. The easiest way to interface these CPUs to the PSG is to connect the CPU data bus more or less directly to the PSG's shared bus and to use software to generate data which the PSG can use either as an address or as true data depending on the state of its control lines. All that is then required is to create the appropriate set of control signals, which inform the PSG whether the data on its bus is to be used as an address or as true data and whether data is to be read or written.

Figure 1 gives a circuit which does just this; it was evolved for use with the Compukit UK101 and because this machine has no parallel port the circuit was designed to connect to its expansion socket; with very little

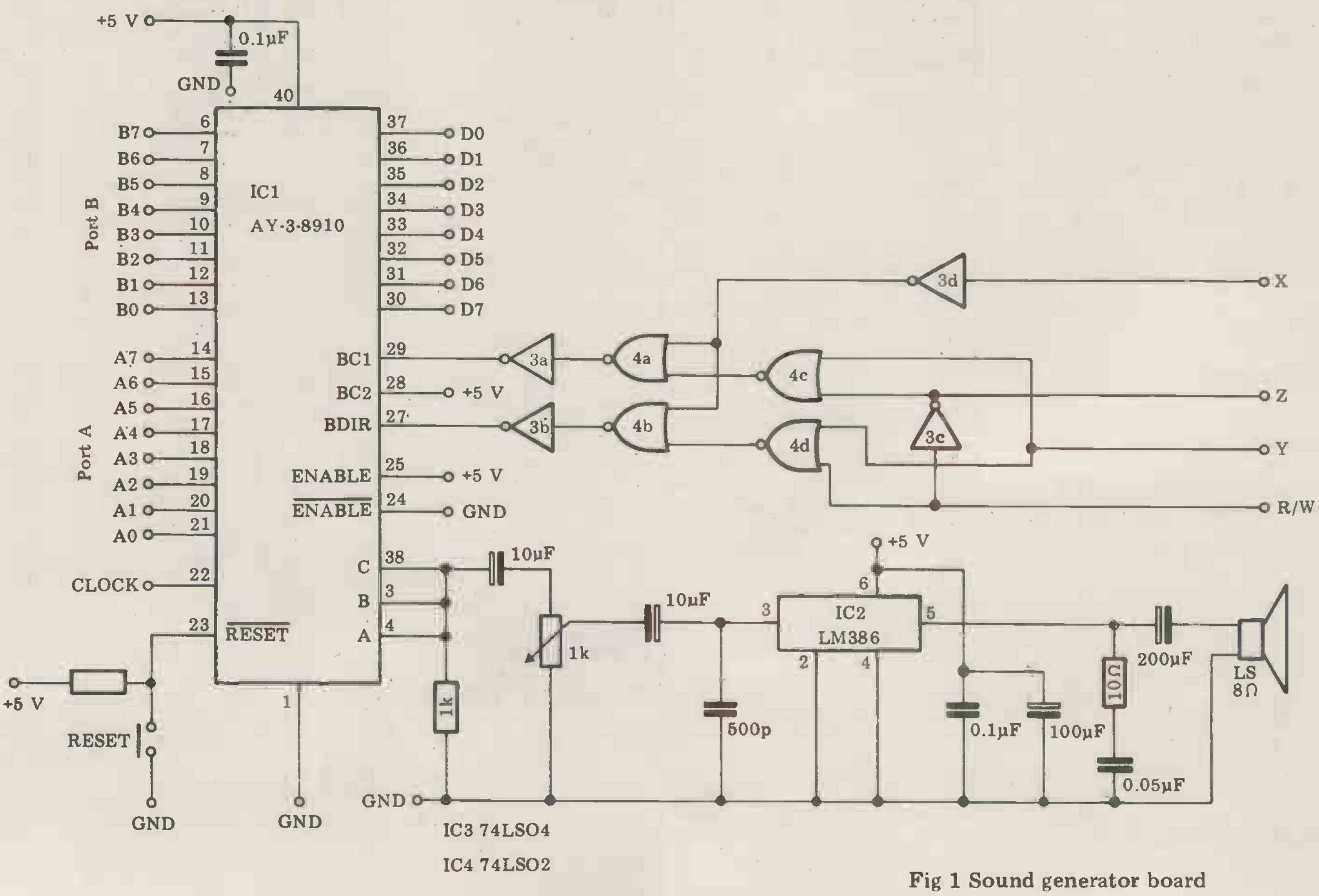


Fig 1 Sound generator board

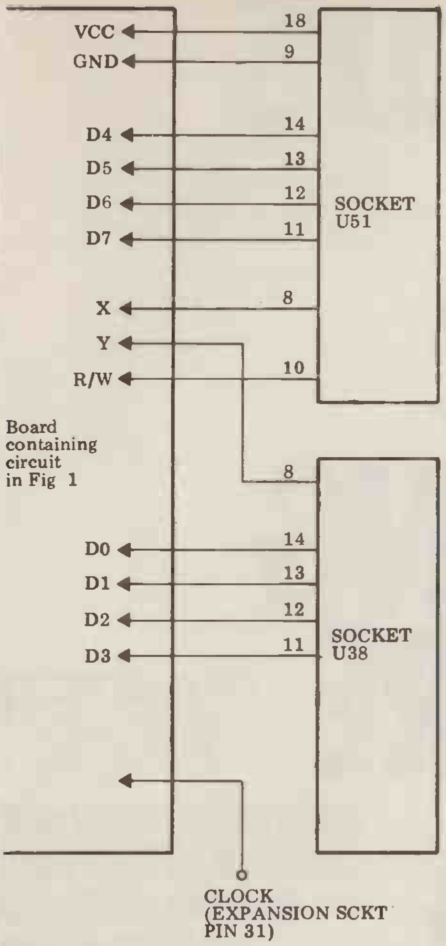


Fig 2 Sound generator board connections to top 2k RAM sockets on UK101. Note that all four 2114s of the top 2k must be unplugged — sockets U37 and U52 must be empty.

modification it should function satisfactorily with almost any 8-bit micro which has separate data and address buses. It is also possible to interface the 8910 to 10 lines of a parallel output port such as is found on many micros and details of this method will be given later. It should be noted, however, that although the hardware for this latter interface is much simpler than for the former, it does suffer from a number of disadvantages. Not the least of these is that it ties up 10 lines of an output port with a device which, because of its great utility, will quite probably be permanently connected to the micro. It also requires rather more complex software, as will be clear later, and of course the ports must be initialised each time after a reset, and between read and write operations. The proposed circuit suffers from none of these disadvantages and achieves the generation of control signals using only two 14-pin DIL packages.

The full circuit for the interface is given in Figure 1. It will be seen from this that pins 30-37 of the PSG carry its shared bus and this should be wired to the CPU's data bus. The chip also has two chip-select pins (24 and 25), though these have been hard-wired since this function is performed via the BC1 and BDIR lines whose operation is explained below. The RESET line is wired to a separate push-button; closing this zeros all registers. Alternatively this line could be wired to the CPU's RESET circuitry (it is 6502-compatible). Pin 22 requires a clock pulse of between 1 and 2 MHz from which the various tone outputs will be derived, after division by the data held in the PSG's note control registers. It operates well from the UK101's Φ2 1 MHz clock, although for production of an equal-tempered chromatic scale I suggest you use a clock frequency of 1.78977 MHz. This is half the standard colour crystal frequency; for further details see GI's 8910 data manual.

Audio output from channels A, B and C appears on pins 4, 3 and 38 respectively. The three signals may be combined directly as in Figure 1, or, preferably, via separate manual mixers, since although the three output levels are individually controlled when the PSG's envelope shaper is not in use, all revert to maximum volume when put under envelope control! Inserting a variable resistor of about 50 or 100k between pins 3 and 38 gives control of the level on channel C and this has proved most useful in some simulations.

The audio output from the chip is considerable (about 1 volt p-p at maximum volume) so that almost any audio amplifier may be used with it. That shown in Figure 1 is based on the circuit suggested by GI; it has the great advantage of operating from a single 5 volt supply and was found to perform well.

The function of the circuitry to the right of the PSG chip in Figure 1 is essentially to simulate the status signals that the PSG would normally receive from a CP1600 CPU along its three control lines BDIR, BC1 and BC2. Table 1 gives the states of these lines during PSG operation and since BC2 may remain high in each case, it has been hard-wired. The gates shown in Figure 1 serve to produce the states on BDIR and BC1 appropriate to the four functions of Table 1. The states are generated in response to the CPU READ/WRITE line (high READ, as for the 6502) and to the two address-decoded, low-enable lines X and Y. When X goes low, the PSG will take data on its bus to represent a register address, while when Y is low it will use the bus for data associated with the last selected register, and will either write into that register if the R/W line is low, or read from it if R/W if high. Thus suppose that line X was enabled by address 35,000, while line Y by 35,001, then the following Basic commands would place the value 254 into register 7 of the PSG:

```
POKE 35000,7
POKE 35001,254
```

Changing the contents of register 7 to 250 immediately afterwards would simply require the statement: POKE 35001,250, since register 7 of the PSG has already been called up. Read operations are performed in a similar manner. Thus in order to read the contents of register 8 for example, it is necessary to POKE the pseudo address 8, before PEEKing 35001:

```
POKE 35000,8
PRINT PEEK(35001)
```

Now let's look at the production of the two Enable lines from which the circuitry of Figure 1 is controlled. If your machine is a Compukit and you are not at present using more than 6k of RAM, then you can plug the circuit in Figure 1 directly into two of the unused 2114 sockets in your machine. The wiring of the two 18-pin DIL plugs required is given in Figure 2. For address X, any number between 6144 and 7167 will suffice, while for address Y the range is from 7168 to 8191. The easiest to key in would be 6666 and 7777. Thus:

```
POKE 6666,2
POKE 7777,15
```

will put 15 into register 2 of the PSG, while

Function	BD1R	BC1	BC2
Inactive	0	0	1
CPU read from PSG	0	1	1
CPU write to PSG	1	0	1
Latch address of PSG register	1	1	1

Table 1 8910 control line functions

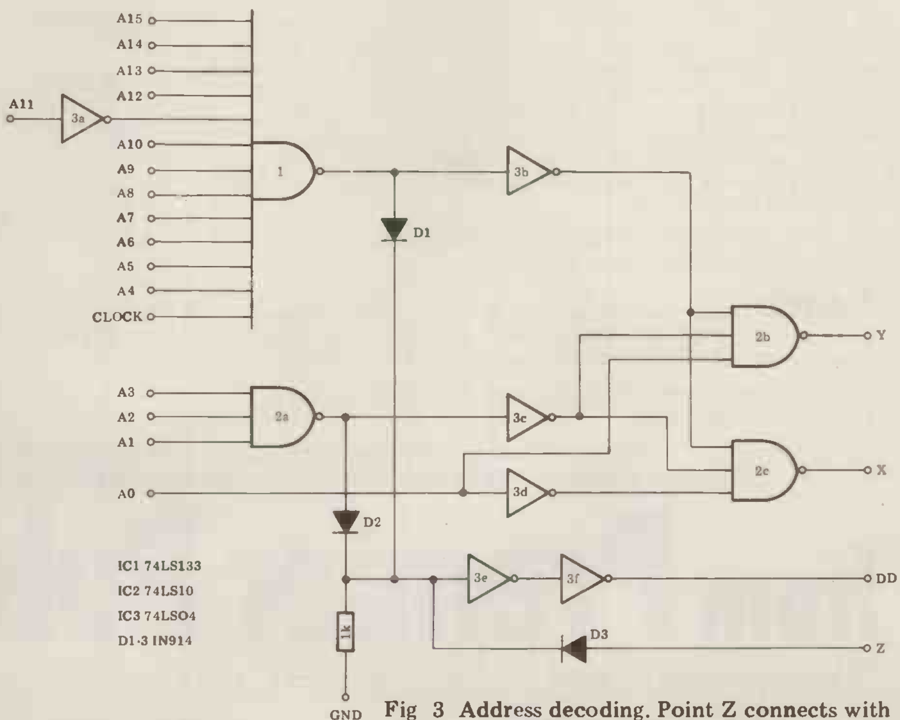


Fig 3 Address decoding. Point Z connects with the circuit of Fig 1 to pick up a R/W line.

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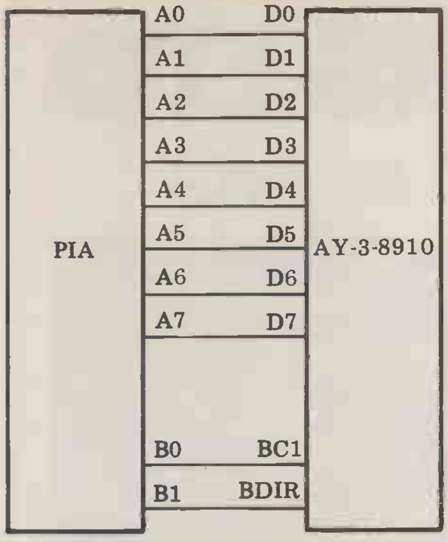

Fig 4 Interfacing the PSG to 10 lines of a parallel port.

POKE 6666,5
PRINT PEEK(7777)

will print the contents of register 5.

If your machine is not a Compukit, or if you are not prepared to sacrifice the top 2k of the Compukit's RAM space, then you will need to decode two appropriate addresses from the CPU's address bus. Figure 3 gives a circuit which does this with a minimum of components; three diodes and three ICs are used. As it stands, the circuit will decode the addresses 63486 and 63487. These fall in an unused area of the Compukit's address map, just below the 2k monitor. For use with other machines the circuit may need to be modified so that the two addresses decoded are not ones used for other purposes. This can be done by changing the position of the inverter on address line 11 to a different line (or by adding inverters to other lines. Note in this context that IC3 of Figure 1 contains two unused inverters). Moving it from A11 to A12 would decode the addresses 61438 and 61439.

The circuitry involving the three diodes in Figure 3 produces a Data Direction signal, required by all interfaces plugged into the Compukit's on-board expansion socket involving a Read operation. The DD line must be forced low for the bidirectional data buffers in the machine to allow the CPU to read data at the expansion socket. If this part of the circuit is not included, or fails to function, then it will only be possible to write to the PSG — which will be sufficient for many purposes.

It should be a fairly simple matter to modify the circuit of Figure 3 to suit the needs of individual machines. As suggested, however, there's a much simpler way to interface the PSG if your machine possesses 10 bits of parallel port which you are prepared to devote to sound generation and do not object to extra software complexity. The remarkably simple circuit for this, based on one suggested by GI, is given in Figure 4. In this approach the BDIR and BC1 status lines are controlled directly, by two lines of the output port.

Using this circuit it will obviously take several POKE commands to fill one of the PSG's registers with data or to read from it, since the control lines must be made inactive before the port A lines can be changed. Thus in order to put the number 16 into register 6 of the PSG, the following sequence of data must be put through ports A and B:

B 0 Begin with control lines in inactive state
A 6 Place pseudo address on port A
B 3 Latch the address register of the PSG
B 0 Return PSG to inactive state
A 16 Place data on the bus
B 2 Cause data to be written
B 0 Return PSG to inactive state

Thus from an initially inactive state, six POKE commands would be required to change the contents of any PSG register, and since programming the 8910 for a particular sound effect can involve anything from three to 14 registers, it is clear that this simple hardware solution is not without its cost. Note that if you do use this method, port B should not be left in the non-zero state for more than a fraction of a second; in testing this circuit, this caused random data to be written into the registers. Once the software was modified to return to port B to zero immediately after each operation, no further problems were encountered with this interface.

Register layout

Table 2 shows the 8910's 16 registers. The device contains three independent audio channels, and the register pairs 0 & 1, 2 & 3, and 4 & 5 determine the time period of the notes produced on channels A, B and C respectively. The second of each register pair, the coarse tuning, is only four bits wide and together with the 8-bit fine tuning

Register	Function	BIT 7	6	5	4	3	2	1	0
R0	Channel A tone period	8-bit fine tune A							
R1						4-bit coarse Tune A			
R2	Channel B tone period	8-bit fine tune B							
R3						4-bit coarse Tune B			
R4	Channel C tone period	8-bit fine tune C							
R5						4-bit coarse tune C			
R6	Noise period				5-bit period control				
R7	Enable (inverted)	In/out (inverted)		Noise (inverted)			Tone (inverted)		
		I/O B	I/O A	C	B	A	C	B	A
R8	Channel A amplitude				Envelope enable	4-bit amplitude			
R9	Channel B amplitude				Envelope enable	4-bit amplitude			
R10	Channel C amplitude				Envelope enable	4-bit amplitude			
R11	Envelope period	8-bit fine tune							
R12		8-bit coarse tune							
R13	Envelope profile					4-bit control			
R14	I/O port A	8-bit parallel port							
R15	I/O port B	8-bit parallel port							

Table 2 8910 register layout

```
 99 REM AY—3—8910 SOUND ROUTINE
100 FOR S=0 TO 15: PRINT : NEXT S
110 PRINT, "AY—3—8910 POKE/PEEK ROUTINE"
120 PRINT, "USING ADDRESSES 6666 & 7777"
124 PRINT, "(NOTE DATA > 255 CAUSES A READ)"
125 PRINT : PRINT
130 A = 6666 : D = 7777
140 REM ZERO ALL REGISTERS
150 FOR X = 0 TO 15
160 POKE A,X
170 POKE D,0
180 NEXT X
200 REM POKE/PEEK ROUTINE
210 INPUT "   REGISTER"; A1
215 IF A1>15 THEN PRINT, "TOO LARGE, TRY AGAIN":GOTO 210
220 POKE A,A1
230 INPUT "   DATA";D1
240 IF D1 >255 THEN 300
250 POKE D,D1
260 GOTO 210
300 PRINT, "CONTENTS OF REG"; A1; "="; PEEK(D)
310 GOTO 210
```

Fig 5 Program for experimenting with the PSG

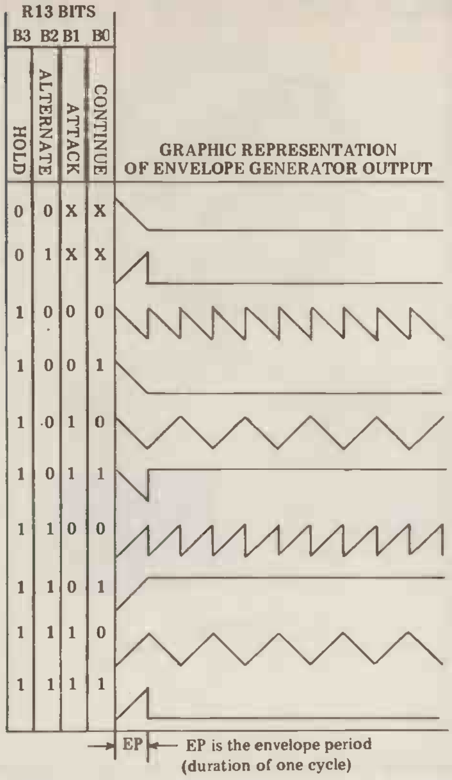

Table 3 Envelope profile control at register 13.

provides a 12-bit number which is divided into a constant frequency source obtained from the clock input. A high number in any pair of registers will therefore give rise to a low frequency note, and if both coarse and fine registers of a particular channel are at zero, then the tone generator for that channel will produce a square wave of one sixteenth of the clock frequency (62.5 kHz for a 1 MHz clock). Register 6 is five bits wide and controls the tonal characteristics of the white noise generator. Here again a large number results in a low frequency. Register 7 is the most difficult to use and actually requires some degree of thought. Its lowest six bits control mixers on all three channels, determining whether each should carry tone and/or noise or neither, while the highest two bits control the direction of the two ports. You need to be good at converting binary to decimal if you are POKEing this register in Basic, and the problem is slightly aggravated by the fact that a 1 disables rather than enables. To give an example, the number 180 (10110100 binary) in register 7 will have the following effect: port A will be set to input, port B to output, Channel A will carry tone and white noise, B will carry tone only, and there will be no output from channel C.

Registers 8, 9 and 10 control the amplitude of the outputs of the three channels; data can range from 0 to 15 (15 represents maximum volume) and the digital to analogue conversion is arranged logarithmically to suit the human ear. Placing a 1 in the fifth bit of registers 8, 9 or 10 (or any combination of them) causes channels A, B or C to come under the control of the envelope shaper rather than giving a continuous tone or noise output.

Registers 11 and 12 exercise fine and coarse control over the time constant of the envelope, while the lowest four bits of register 13 control the envelope shape and determine whether it is one-shot or repeating. Table 3 gives the range of options offered here.

Experimenting

The listing in Figure 5 is a simple program for experimenting with the sound generator appropriate for interfaces of the type in Figure 1. To make it run on different machines it should only be necessary to change the two addresses A and D in line 130. If the parallel port method of Figure 4 is used, the program will need to be modified to initialise the ports and to set up the appropriate outputs on port B, as suggested earlier. The program first zeros all registers and then proceeds to ask the user for a register number and then the data to be put into it. It's so arranged that if a value greater than 255 is entered as data, then the program will cause a Read to be carried out at the last entered register, in place of a Write, and the result printed. As an example of the use of the PSG, Table 4 gives lists of data for two different sound effects which may be set up using this program.

Controlling the PSG

Once the CPU is used to vary the contents of the PSG's registers under program control an almost infinite range of sounds can be produced. FOR... NEXT loops can be used to particularly good effect on the tone frequency registers and of course when just a single register is being varied in this way it is only necessary to POKE the register address once at the beginning of the operation. When using the generator in games and other programs, the most straightforward approach is to use a series of subroutines to control it placed at the end of the program. This method is useful for adding sound effects to programs already written. The first routine encountered should be one which resets all PSG registers to zero and which designates variables to be used as shorthand for the two CPU addresses used for the device. And of course if you're using the parallel port method, this would also be an appropriate point to set its control registers. A suitable subroutine for zeroing the registers is:

```
8000 REM AY-3-891Ø ZEROING
8010 A=6666
8020 D=7777
8030 FOR X=ØTO 15
8040 POKE A,X
8050 POKE D,Ø
8060 NEXT
8070 RETURN
```

If you intend to use only one register configuration in a given program, then it is probably easiest to insert extra lines into the end of this routine which will set up most of the registers required for sound generation but which leave one vital register set for zero output (eg register 7 could be set to 255). When sound is actually required at a given point in the program it can then be turned on or off with a single command. But if a variety of complex sounds are involved that are produced in different ways, then it's probably better to set up the PSG from scratch each time a sound is produced, to avoid any subroutine leaving the registers in a state inappropriate for the next.

Sound effects for dodgems

As an example of the use of the 8910 under program control let's look at the way in which sound effects may be added to Dodgems, a nicely-written games program for the UK101 by N E Berry (PCW April 1980).

The first problem in adding noise subroutines is to identify the point in the program at which they are to be called. In games such as Dodgems there are two useful clues to look for: the easiest is the score-change statement associated with the event that you are using as a cue. Thus in Dodgems, sounds have been added both when the player crashes and when he hits a beacon; the relevant position in software was found by visually scanning the program for an SC=SC-100 (for a crash) and an SC=SC+200 (for a beacon). This task was made much easier because in writing the original program, Mr Berry used the mnemonic SC for the score variable. Tracing further changes in SC led to the discovery of the insertion point for a statement which produces two types of 'blips' during the game.

A second way to track down appropriate insertion points is to scan the program for statements containing relevant character codes. Thus one

1

Register	Data
7	248
8	16
9	16
10	16
12	20
13	8
0	200
2	201
4	100

2

Register	Data
6	31
7	7
8	16
9	16
10	16
12	20
13	0

Table 4 Two sound effects:

1 Electronic piano note: changing the data on register 2 to either 66 or 101 adds a 'twang' to the quality of the note.

2 Explosion: entering another zero into register 13 will reproduce the effect and replacing the zero with 8 will cause it to repeat.

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could tell in Dodgems when the player hits a beacon because there will be a look-ahead PEEK statement testing for the beacon's character code, which is 9. A visual scan of the program immediately identifies the line:

```
1155 IF PEEK(I)=9 THEN
SC=SC+200:FOR LL=1 TO 2000:
NEXT
```

In this case of course SC=SC+200 serves as a much more obvious marker to the line.

Figure 6 lists the modifications and additions to Dodgems to produce these four sound effects. The additions consist largely of three subroutines: the first zeros all registers, and then partially sets them up for sound production. This is possible because different channels of the PSG have been used for the different noises. Channel A gives the beacon noise, B the two types of 'blip', and C the crash, this latter using the envelope shaper. For the sake of economy of timing, the 'blips' are handled within the program itself with a minimum of POKE commands. Line 1154 decides the tone of the 'blip' and activates it, while line 1005 turns it off. The beacon and the crash noises provide examples of the use of FOR loops on the PSG's registers to produce two very different sounds and are handled in the subroutines at lines 4000 and 5000 respectively.

Finally

The options available of course do not end here. Sounds could well be added to accompany the 'GAME LOST' and 'YOU WIN' messages. The appearance of a beacon and direction changes of the robot would also make good cues, or to really hot things up a second PSG could be added to give a stereo effect. There is no end to the possibilities that the exceptionally versatile 8910 offers the programmer and the complete transformation of previously silent programs which can be brought about using this device must, as they say, be seen and heard to be believed.

```
6     GOSUB 3700
1005  H=E : POKE GD,0
1154  POKE GA,2:POKE GD150: IF PEEK(I)=213 THEN
      SC=SC + 10: POKE GD,100
1155  IF PEEK(I)=9 THEN SC=SC + 200 : GOSUB 4000
2004  GOSUB 5000

3700  REM AY—3—8910 INITIALISATION
3710  GA = 6666 : GD = 7777
3720  FOR GE = 0 TO 15
3730  POKE GA, GE
3740  POKE GD, 0
3750  NEXT GE
3760  POKE GA,7 : POKE GD, 248
3770  POKE GA,8 : POKE GD, 15
3780  POKE GA,9 : POKE GD, 11
3800  POKE GA,10 : POKE GD, 16
3810  POKE GA,2
3820  RETURN

4000  REM BEACON HIT NOISE
4001  POKE GA,2 : POKE GD,0
4003  POKE GA,0
4005  FOR GG = 1 TO 10
4010  FOR GH = 255 TO 50 STEP —10
4020  POKE GD, GH
4030  NEXT GH : NEXT GG
4050  POKE GD, 0
4060  RETURN

5000  REM CRASH NOISE
5010  POKE GA, 12 : POKE GD, 30
5020  POKE GA, 13: POKE GD, 0
5025  POKE GA, 4
5040  FOR GH = 255 TO 40 STEP —1
5050  POKE GD, GH
5055  POKE GD, 100
5060  POKE GD, 40
5070  NEXT GH
5075  POKE GD, 0
5080  RETURN
```

Fig 6 Sound effects for 'Dodgems'

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ANOTHER DIMENSION

Complex, moving three-dimensional computer graphics displays are still the preserve of big mainframe computers, yet there's plenty of scope for producing 3D images with microcomputers. Maurice Shepherd describes the maths involved and gives ideas for experimenation.

Points in three-dimensional space can be uniquely described by their Cartesian coordinates (x y z). The unit cube shown in Figure 1 can therefore be described by a set of eight (x y z) coordinates plus information about which points are joined by straight lines.

Since the 'joining' information remains constant even if the coordinates are altered by, for example, moving or rotating the cube, we can neglect this aspect for the moment and concentrate on the coordinates. Having defined the coordinates of a 3D object, we may want to transform these coordinates in various ways corresponding to, for example,

a Translation — moving the object in 3D space

b Scaling — making the object larger or smaller

c Rotation — rotating the object about an axis

and obtain a set of transformed coordinates (x' y' z'). Ultimately these transformed 3D coordinates have to be represented on a 2D surface such as a video screen, X—Y recorder or graph paper. This requires a two-dimensional projection of the points (x' y' z') onto some plane, say the z=0 plane, to give a set of (x" y") coordinates. (Note that Figure 1 is a 2D projection!) It would also be useful, in some circumstances, to have a perspective view of the object.

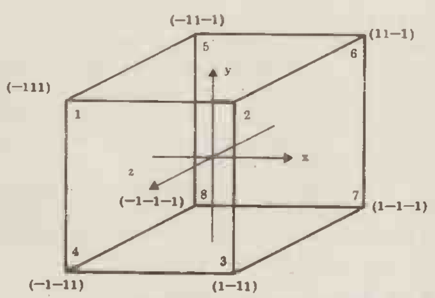


Fig 1 Cartesian coordinates of the vertices of a cube centred on the origin.

Although the above may appear to involve a great deal of complicated 3D geometry, it can all be done remarkably easily and elegantly using matrix algebra. Enough detail is given in the following sections to allow those reasonably familiar with matrix multiplication to develop programs for their own purposes; the material is also incorporated in the Basic program IMAGE and the associated subroutines described below.

Homogeneous co-ordinates

The necessary matrix algebra requires the use of homogeneous coordiantes instead of the more familiar Cartesian coordinates. Four homogeneous coordinates (X Y Z H) are necessary to define a point in 3D space. For our present purposes it is sufficient to know that the point with normal coodinates (x y z) can be represented by the homogeneous coordinates (x y z 1) or any one of the set of homogeneous coordinates (nx ny nz n) where n is not zero. In reverse, the Cartesian coordinates of a point represented by the homogeneous coordinates (X Y Z H) are (X/H Y/H Z/H). These conversions are easily programmed.

The transformation matrix

A set of n points in 3D space can therefore be described by an n X 4 matrix of homogeneous coordinates. Coordinate transformations and projection either with or without perspective can then be done, either individually or in combination, by multiplying this n X 4 matrix of the original coordinates by an appropriate 4 X 4 transformation matrix to give a product matrix of the transformed homogeneous coordinates, as shown in Table 1.

This is a straightforward operation particularly if you use a Basic which includes a MAT operation for matrix multiplication. Since MAT instructions are not usually available with the smaller Basic interpreters a suitable subroutine is given in the program IMAGE. However since the multiplication of an 8 X 4 and a 4 X 4 matrix, which would be necessary for the simple cube in Figure 1, is likely to take at least a second with a micro Basic interpreter, don't expect to obtain rapidly changing complex displays — they must still be left to the larger main-frame computers.

Rotation, scaling and translation

So, on to the 4 X 4 transformation matrix. We will first look at some specific coordinate transformation matrices and then at the central projection technique. Individual transformation matrices for rotation, scaling and translation are given in Table 2. The three matrices R(α),R(β) and R(γ) produce rotations through angles of α, β and γ about the x, y and z axes respectively and are therefore special cases of a more general but also more complicated rotation matrix. A position rotation angle causes a counter-clockwise rotation of point(s) about the relevant axis when viewed along the negative-going direction of that axis.

Also shown in Table 2 are the matrices for scaling (local and overall) and translation. It may seem that

$$\begin{bmatrix} x_1 & y_1 & z_1 & h_1 \\ x_2 & y_2 & z_2 & h_2 \\ \cdot & \cdot & \cdot & \cdot \\ x_n & y_n & z_n & h_n \end{bmatrix} \begin{bmatrix} \text{The} \\ \text{4 X 4} \\ \text{TRANSFORMATION} \\ \text{MATRIX} \end{bmatrix} = \begin{bmatrix} x'_1 & y'_1 & z'_1 & h'_1 \\ x'_2 & y'_2 & z'_2 & h'_2 \\ \cdot & \cdot & \cdot & \cdot \\ x'_n & y'_n & z'_n & h'_n \end{bmatrix}$$

n X 4 matrix of original coordinates — n X 4 matrix of transformed coordinates

Arrays:
OC(N,4) — T(4,4) — TC(N,4) (See IMAGE)

Table 1

ROTATION

Rotate by angles α, β and γ about x, y and z axes respectively.

$$R(\alpha) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R(\beta) = \begin{bmatrix} \cos\beta & 0 & -\sin\beta & 0 \\ 0 & 1 & 0 & 0 \\ \sin\beta & 0 & \cos\beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R(\gamma) = \begin{bmatrix} \cos\gamma & \sin\gamma & 0 & 0 \\ -\sin\gamma & \cos\gamma & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

LOCAL SCALING

Multiplies x, y and z by a, b and c respectively.

$$S(a,b,c) = \begin{bmatrix} a & 0 & 0 & 0 \\ 0 & b & 0 & 0 \\ 0 & 0 & c & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

OVERALL SCALING

Multiplies x, y and z by 1/d.

$$S'(d) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1/d \end{bmatrix}$$

TRANSLATION

Translates x, y and z by u, v and w respectively.

$$T(u,v,w) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ u & v & w & 1 \end{bmatrix}$$

Table 2 Transformation Matrices
(Continued over)

Table 2 (continued)

CENTRAL PROJECTION

Projects onto the xy plane with viewpoint at z=Z.

$$CP(Z) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1/Z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

CONSECUTIVE ROTATIONS

About the x, y and z axes : see text

$$R(\alpha\beta\gamma) = \begin{bmatrix} A & B & C & 0 \\ D & E & F & 0 \\ G & H & I & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where

$A = \cos\beta.\cos\gamma$
$B = \cos\beta.\sin\gamma$
$C = -\sin\beta,$
$D = \sin\alpha.\sin\beta.\cos\gamma - \cos\alpha.\sin\gamma$
$E = \sin\alpha.\sin\beta.\sin\gamma + \cos\alpha.\cos\gamma$
$F = \sin\alpha.\cos\beta,$
$G = \cos\alpha.\sin\beta.\cos\gamma + \sin\alpha.\sin\gamma$
$H = \cos\alpha.\sin\beta.\sin\gamma - \sin\alpha.\cos\gamma$
$I = \cos\alpha.\cos\beta$

these particular operations could be more readily done by conventional multiplication and addition but the advantage of the matrix multiplication becomes evident when, as is usually the case, several consecutive transformations are required.

A series of consecutive transformations can be done using one 4 X 4 matrix which is the product of the individual 4 X 4 transformation matrices. Suppose, for example, that one requires consecutive rotations by angles α, β and γ about the x, y and z axes respectively. This can be done using the single matrix $R(\alpha,\beta,\gamma)$ where

$R(\alpha\beta\gamma) = R(\alpha)$ X $R(\beta)$ X $R(\gamma)$

This matrix is given in Table 2. Going a stage further one may derive the transformation matrix, RST, required to give the above rotation sequence followed by local scaling, followed by translation,

RST = $R(\alpha\beta,\gamma)$ X S(a,b,c) X T(u,v,w) and show that

$$RST = \begin{bmatrix} aA & bB & cC & 0 \\ aD & bE & cF & 0 \\ aG & bH & cI & 0 \\ u & v & w & 1 \end{bmatrix}$$

where A to I are the corresponding elements of the $R(\alpha\beta,\gamma)$ matrix. It is essential that the individual matrices are multiplied in the order in which the transformations are required. For example, a rotation followed by a translation does not give the same result as the same translation followed by the same rotation — or put another way, matrix multiplication is not commutative.

In the local scaling transformation it is apparent that the overall shape of the object is altered if a, b and c are not equal. The local scaling factors also allow reflections through the xy, yz and xz planes to be made eg a=b=1 and c=−1 cause a reflection of points through the xy plane — it changes the signs of all the z coordinates. if a=b=c=−1 then all points are inverted through the origin.

The transformation matrix RST has nine input parameters (α,β,γ,a,b,c,u,v,w) — remember A—I are functions of the rotation angles. The transformed 3D coordinates obtained using RST must now be projected onto a plane to give a set of 2D coordinates.

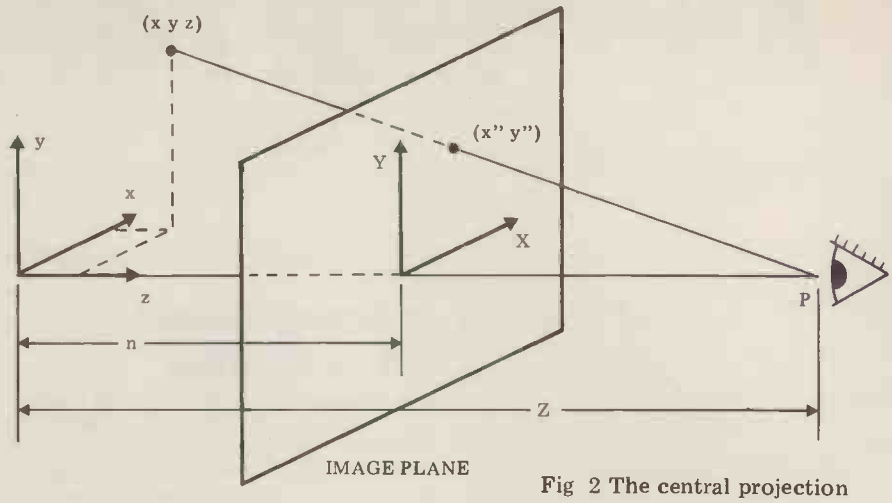


Fig 2 The central projection

The central projection

The central projection method, illustrated in Figure 2, also allows perspective to be introduced. In this relatively simple projection method a viewpoint, P, is selected on one of the orthogonal axes and the 3D points are projected onto the image plane which lies normal to this axis.

In Figure 2 the viewpoint, or centre of projection, is on the z axis at z=Z and the image plane is the z=n plane. The straight line passing through coordinate (x y z) and P intersects the image plane at the image point (x" y"). From elementary geometry it may be shown that for a projection onto the z=0 (or xy) plane,

x" = xZ/(Z—z) and y" = yZ/(Z—z)

The effect of perspective decreases with increasing Z until in the limit of Z being infinite (1/Z = 0) we have what is known as an orthogonal projection, ie x" = x and y" = y, in which all lines which are parallel in the 3D object are also parallel on the image plane. Orthogonal projections are often used in mechanical drawings.

The transformation matrix for central projection onto the z=0 plane, CP, is given in Table 2. Rotation, local scaling, translation and central projection can therefore be done using the transformation matrix, RSTCP, where

RSTCP = RST X CP

$$= \begin{bmatrix} aA & bB & 0 & -cC/Z \\ aD & bE & 0 & -cF/Z \\ aG & bH & 0 & -cI/Z \\ u & v & 0 & 1-W/Z \end{bmatrix}$$

Original coordinates are transformed by the RSTCP matrix, as shown below

(x y z 1) X RSTCP = (X Y 0 H)

and the points in the image plane (x" y") calculated by dividing X and Y by the corresponding H ie a homogeneous to Cartesian coordinate conversion. Strictly this is not necessary with orthogonal projections because H is always unity. Now a Basic program to do all this.

Image

The Basic program IMAGE illustrates the use of the transformation matrix, RSTCP, derived above. The starting Cartesian coordinates are stored, for convenience, as DATA and the program requires 10 input parameters (α,β,γ,a,b,c,u,v,w,1/Z) and prints the image coordinates (x" y"). At the expense of some extra programming it may be worth setting default values for these parameters of (0,0,0,1,1,1,0,0,0,0), ie an orthogonal projection of the starting coordinates.

Some typical results produced by IMAGE are plotted in Figure 3 for a series of transformations with and without perspective. Some care must be taken in choosing the value of 1/Z; if the viewpoint is too close to the origin then a very distorted and unrealistic perspective view is obtained. Similarly some experience with using the other parameters will probably be necessary before you can readily achieve the desired views.

If a different sequence of transformations is needed then it is necessary to derive the appropriate transformation matrix by multiplication of the individual transformation matrices in the appropriate order as described above and by making the relevant substitutions in subroutine 300.

Although the image plane coordinates from IMAGE can be manually plotted they are not suitable for direct input into most graphics displays.

Videographics

Most micro video graphics systems allow individual points on the screen to be addressed by using an instruction such as PLOT(p,q). The display coordinates p and q are usually positive integers with machine-dependent ranges of, say, $0 \leqslant p \leqslant P$ and $0 \leqslant q \leqslant Q$, where P+1 and Q+1 are the number of rows and columns of addressable points on the display. These general principles also apply to X—Y recorders. For so-called high resultion micro graphics, P and Q are generally of the order of 300 and 200.

It's not a particularly difficult problem to take the IMAGE coordinates and convert them into a suitable form for a video display. Figure 4 illustrates a mapping of coordinates onto the display plane — x" y") → (p q) — with the origin of the image plane being mapped onto the centre of the display plane (P/2 Q/2), and in this case,

p=x"Q/YD+P/2 and q = y"Q/YD + Q/2.

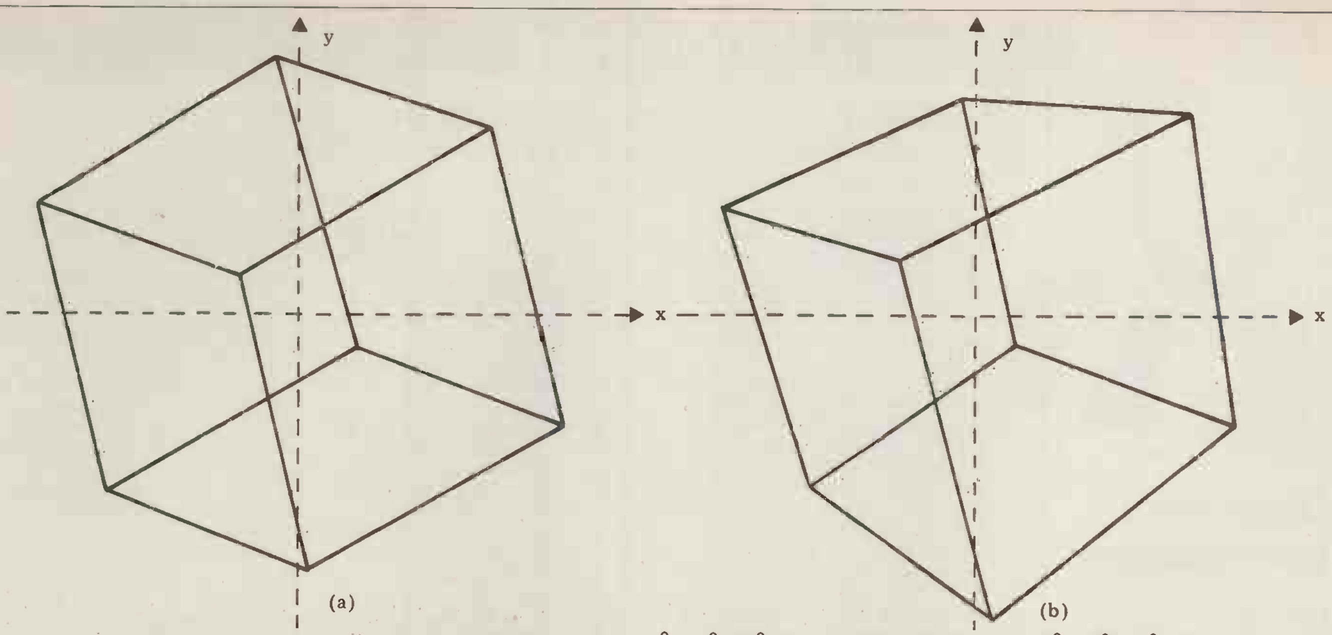


Fig 3 IMAGE results plotted for input parameters of (a) (30^0,30^0,30^0,1,1,1,0,0,0,0) and (b) (30^0,30^0,30^0,1,1,1, 0,0,0,0.2) using the cube coordinate set.

The values of P and Q are obviously machine dependent but the value YD (or the starting coordinates) must be chosen with care to ensure that all image coordinates map onto the display plane. This is a common problem in computer graphics and offers scope for ingenious programming. It is also the problem you solve every time you successfully draw a graph!

The program IMAGE can be easily modified to give screen coordinates using the two equations above. The optional subroutine 700 given after the IMAGE listing will do this and could replace subroutine 600 in IMAGE — but remember to value P, Q and YD appropriately.

This image plane to display plane coordinate conversion involves an overall scaling and a translation. In view of the above, a much neater and faster means of doing it would be to incorporate these transformations in the transformation matrix. The appropriate transformation matrix, VIDEO, is derived from

VIDEO = RSTCP X S'(d) X T(U,V,0)

where d= Q/YD, U = P/2 and V = Q/2, ie an overall scaling of the image coordinates followed by a translation. The elements of VIDEO, although fairly complicated, are easily programmed following the general example of IMAGE.

$$\text{VIDEO} = \begin{bmatrix} A'+UC'/d & B'+VC'/d & 0 & c'/d \\ D'+UF'/d & E'+VF'/d & 0 & F'/d \\ G'+UI'/d & H'+VI'/d & 0 & I'/d \\ J'+UL'/d & K'+VL'/d & 0 & L'/d \end{bmatrix}$$

where A' to L' are the corresponding elements of RSTCP.

Joining information

The program IMAGE does not deal with the problem of joining the appropriate coordinates on the video screen. Most graphics systems however include an instruction to draw a 'straight' line joining two points on the screen, such as JOIN(x_1,y_1,x_2,y_2). The framework of the cube in Figure 1 for example, is defined by twelve specific lines and the drawing of these lines can be done with a Basic routine similar to that given in subroutine 800.

If a JOIN or similar instruction is not available then a separate routine must be written.

Further extensions

The information and example above give sufficient background to allow quite powerful graphics programs to be written. There are several areas which can test programming skills. For example, in order to allow transformations to be done in any order the individual transformation matrices could be stored and multiplied in the program as required. Defining the coordinates of a given object can be tedious and full use could be made of the symmetry properties, if any, of the object in order to reduce this problem. Judicious use of subroutines would speed up the matrix multiplication and the line drawing, both of which can be relatively slow using an interpreter. This would be especially useful if fairly rapidly-moving displays

The types of programs discussed here produce 'wire-frame' pictures. These pictures result in objects like cubes having the annoying tendency to turn inside out as you look at them, presumably the brain is struggling because it has no 'z' information. The problem of suppressing the 'hidden' lines to give an artist's drawing with hidden surfaces is however a difficult one and beyond the scope of this article.

One not totally flippant approach to recovering the missing 'z' information would be to produce two stereoscopic images. After all stereoscopic images are only 2D perspective projections with different viewpoints, an extension of the above discussion. Then, with the aid of colour graphics, display each stereoscopic image in a different colour, put on suitable viewing spectacles and you have real 3D graphics!

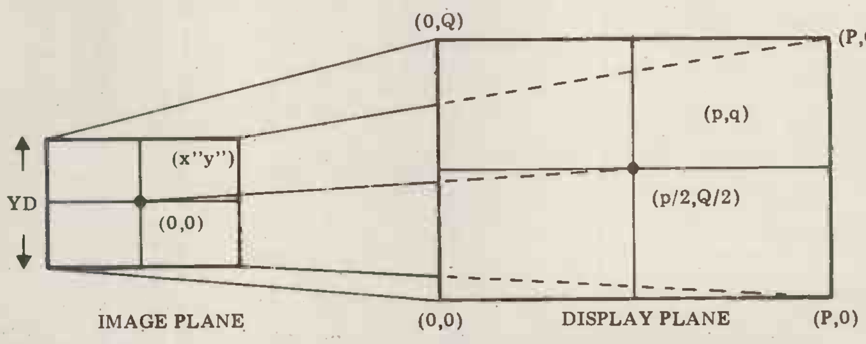
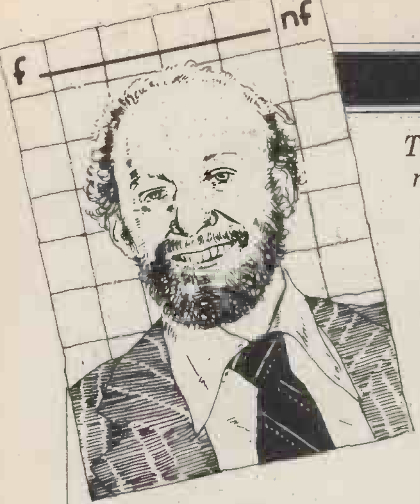


Fig 4 The image plane coordinates (x'' y'') mapped onto the display plane coordinates (p,q).

IMAGE Listing

```
10 GOSUB 200
20 INPUT"Rotation Angles";ALPHA,BETA,GAMMA
30 INPUT"Local Scaling Factors";A,B,C
40 INPUT"Translations";U,V,W
50 INPUT"Reciprocal Viewpoint";RZ
60 GOSUB 300
70 GOSUB 500
80 GOSUB 600
90 END
```

GOTO page 123 for remainder of listing.



BOOKFARE

This month Malcolm Peltu takes a look at the latest enticements for the microcomputing novice, the way the French deal with 'telematics', and the human side of computers.

Beginners bandwaggon

Like J Worthington Foulfellow and Gideon (the fox and cat) in Pinocchio, publishers around the world have spotted a fresh-faced innocent stepping out on the road of knowledge with a few quid to spare. Pinocchio was on his way to school when he was waylaid by Foulfellow and Gideon; the likely lads and lasses who interest modern publishers are off on the road to micro enlightenment.

At least Pinocchio had the wisdom of Jiminy Cricket and magic of the Fairy Queen to guide him; the seeker of computing truth is faced with a confusion of temptations, each claiming to be the ideal starting point for the computer beginner.

Personal Computer World led the populist computing bandwagon in this country, following on the growth of the personal computing publishing scene in the States which first took the mystique out of the technology.

In book publishing, the late Chris Evans' *Mighty Micro*, published last year, became the hallmark for books about computing aimed at a non-technical audience. Since then the floodgates have opened to a rush of introductions to the micro/mini/information revolution/Basic/Pascal/microetcetera. Many of these intros have already been covered in Bookfare but this month the postman has been huffing and effing under the weight of the latest and largest wave. Of these, two British books emerge with distinction, *Living With The Micro* by Martin Banks and Robin Bradbeer's *The Personal Computer Book*. In addition, Uncle Howard Sams has launched a bunch of Stateside books in our direction. Other recent intros will, I am afraid, have to remain outro for the time being.

Before proceeding with the Banks and Bradbeer reviews, I should declare my prejudices. I know Martin well — in fact I employed him on *Computer Weekly* to run the Micro News section. I don't know Robin that well but, except for his mate Guy Kewney, he does not seem to like *Personal Computer World*, which he claims is "still looking for a real role to play in the developing hobby market".

You, dear reader, will have made your own judgement on this comment. Fortunately for me, the Bradbeer and Banks books are aimed at sufficiently different markets to avoid forcing me to make a direct comparison.

Bradbeer's *Personal Computer Book* is a straight-down-the-middle introduction to the technology of personal computers, the systems on the market and possible home applications. Although it lacks the laid-back West Coast style of many US hobbyist books on the same subject, it gains in strength by sticking to the basics without any frilly writing.

He has based the contents on his experiences at the North London Polytechnic, teaching electronics and running the local hobby club where he has had to answer the initial questions of computing innocents. He explains the components which comprise a computer lucidly with the help of cartoony diagrams and covers all the kinds of software and I/O capabilities that would be expected in a book of this ilk. There are also almost 50 pages containing product specifications, which seems an excessive amount of space for information that is bound to become out of date very quickly. Anyone wishing to purchase equipment would obviously look in magazines like PCW for the latest news.

It's a pity that there is no index to the book although there are many helpful appendices providing information on computer clubs, books, manufacturers and a reasonable little glossary.

Martin Banks' *Living with the Micro* covers a wider spectrum than just the personal computer market. As a survey of the way microelectronics fits into overall developments in information technology, it is one of the fullest, most rounded and gentlest of the many books on the subject.

Gentleness might seem a strange description to apply to a book about a new technological 'revolution' but it's the best way I can find of identifying the quality Banks has of offering the reader a touch of humanity and humour at those points in the book where the technological road might seem a bit harsh and rough, like describing software as "anything you can't kick". This gentle style infuses the book, making it an easy and relaxed read without ever becoming too loosely informal and enables a broad spectrum of technologies and applications to be covered in a way which never becomes hard-going.

The topics covered include the usual things — what is a micro, what is software, the impact of the technology on business and on society at large, the micro in industry, and so on — which have been dealt with in other books. What makes *Living with the Micro* something special is that all developments are placed within the context of Information Technology, the subject which has been identified by governments around the world, starting with the Japanese in the late 1960s, as the strategic framework that brings together otherwise disparate developments in microelectronics, computing, telecommunications and other information sciences.

This coherent framework, coupled with the gentle writing style, means that Banks offers the reader a full, easily assimilated picture rather than the partial views which come from looking at one segment of the market or giving undue weight to any one of the information technologies.

But emphasising the need for any innocent abroad to retain a healthy degree of scepticism, Banks makes at least one major booboo when he says that information retrieval and dissemination does *not* require any knowledge of programming. I think he meant that from the user-end it is not necessary to know how to retrieve information from a pre-programmed system, but that would be true of any user application. He does, however, provide a very useful Appendix called *Where do you go from here*? which gives reference to books on particular subjects that would clear up any misconceptions.

Just one point of direct comparison between the Banks and Bradbeer books: the large, clear type of the *Personal Computer Book* is far more attractive to a novice reader than the smaller typeface of *Living with the Micro* and is a point that should be taken into account by publishers, even if the larger type adds to the cost.

Now to the bundle of Uncle Sams books. Howard W Sams has been one of the most prolific personal computing publishers. This summer, Prentice Hall made available a number of new Sams books in the UK.

They include two computer dictionaries by Charles J Sippl, *A Crash Course in Microcomputers* and *Introduction to Microcomputers for the Ham Shack*. The cheaper (paperback) *Computer Dictionary* has a comprehensive coverage of relevant words with a strong American flavour and spelling; first published in 1966, it has been fully revised since then. Although Sippl claims that it is a 'browsing' dictionary designed to be read as a kind of educational tutorial, the dense definitions and type would become a bit mind-blowing very quickly if they were 'browsed through'.

The technical depth covered by the *Dictionary* means that it is more likely to be of use to someone deeply into computing — as a hobby or for business — rather than the kind of newcomer targetted by the Banks and Bradbeer books. The hardback *Computer Dictionary and Handbook* by Sippl includes the paperback dictionary in full plus an introduction to computing, operational research techniques and mathematical and statistical definitions, which I do not feel warrants the extra £11.00. The *Crash Course* is a self-tutorial book in which the student follows through a sequence of 'lessons' with blank spaces at key points for him to fill in before proceeding to the next lesson; at the end of each section there's a self-test quiz. If this type of approach grabs you, the book might appeal but I find it irritating and unhelpful and nowhere near as educationally appropriate as the self-instruction *Computer Programming in Basic* course from Cambridge Learning Enterprises which I reviewed in a previous Bookfare.

The *Ham Shack* introduction by Harry L Helms Jr is a more hardware-oriented version of the Bradbeer-type of book but does not contain the breadth of coverage or the useful local information obtainable from *The Personal Computer Book*.

French lesson

Britain needed a TV programme to alert its Establishment to the micro-inspired 'information revolution.' The French went about it differently.

In April 1975 the French Council of Ministers decided it was necessary to appoint an official to examine the potential impact of computers on society. Over a year later (I wonder why the delay?), Simon Nora, an Inspector General of Finances, was asked by President Giscard to undertake an 'exploratory mission' with two aims: to stimulate thinking on how the computerisation of society should be carried out, and to define the nature and scope of the strategic policy decisions that will need to be taken. In January 1978, about the time Jim Callaghan initiated a British study into the impact of semiconductors and shortly before the BBC Horizon *Now the Chips Are Down* programme, Nora and a colleague who helped him on his study, Alain Minc, presented their report, which became an immediate best seller.

As a result, the French launched their telematique programme which includes giving a micro to every school, developing a cheapo mass facsimile device and putting a VDU into every home, starting with experimental uses of VDUs as electronic telephone directories. Meanwhile, Britain has thrashed about in a policy-making vacuum.

The Nora report has now been published by the Massachusetts Institute of Technology in a semi-English version under the title *The Computerization of Society*. The poor translation makes the book heavy going and difficult to understand in parts. The whole subject has also had such a mass media and book publishing bashing since Nora that the arguments now appear old hat. But it is still worth reading, both to provide an historical perspective on the way government intervention can play a positive role in directing developments and as an insight into the areas of technological impact which will have to be resolved during the 1980s.

The human view

The personal computer industry gave computing a human face: colour, graphics, voice and sound synthesis, etc are standard parts of the 'user friendliness' of personal computers.

The traditional business computing market, however, has been noticeable for its lack of concern shown for human factors in computer use. One reason why viewdata has proved attractive to businessmen is that it has colour displays whereas it was less than a year ago that IBM introduced the first colour business VDU.

Concern about the possible damage to the health of computer and word processor users through poorly-designed systems, particularly VDUs, first surfaced in the late 1970s when printing workers claimed that prolonged operation of VDUs damaged their eyesight. I remember running one of these stories when I was editor of *Computer Weekly*; by chance, it appeared on the same page as a VDU advertisement. When the irate manufacturer complained about the juxtaposition I said I would publish any evidence that contradicted the claims against VDUs; the manufacturer replied that he knew of no research that proved that VDUs did *not* damage health.

As a result of the fears expressed in the printing industry, the International Research Association for Newspaper Technology commissioned a study into the human view of VDUs. The findings of that study is now published in the *Visual Display Terminals Manual*, which should be essential reading for anyone involved in managing or using computer systems.

The book looks far beyond just the question of potential damage to eyesight. It examines how methods of work organisation — for example giving operators suitable rest periods — can be used to increase productivity and job satisfaction. Detailed descriptions are provided of hardware characteristics and the best ergonomic designs that should be expected from suppliers. The way in which VDUs are located, the disturbing effects of screen reflections, glare, legibility and readibility of characters, lighting, noise and positioning of VDUs in relation to windows are all factors which are discussed.

Psychological factors discussed include alienation at work, job design, fatigue and workload pressure. Many of the observations and recommendations are based on surveys of staff who have been using VDUs.

Ergonomic considerations of VDUs are becoming an intrinsic part of industrial relations negotiations because unions are asking for the specification of minimum health and safety standards as part of technology agreements which cover the conditions under which new technology is introduced. In Norway there is a Health and Safety Law which requires that new technology does not adversely effect the quality of the working environment and in Scandinavia in general it is becoming difficult to sell equipment which does not meet ergonomic considerations.

The subject of ergonomics, so long the Cinderella of the computer world, is therefore coming onto the centre stage. And about time too.

Sci-fi

The way in which a few science fiction writers have predicted future developments, like Jules Verne's submarines and Arthur C Clarke with communications satellites, has led to much discussion about how much sci-fi can be used to gain an insight into science reality.

Computer manufacturer Sperry Univac thought there was sufficient meat in this discussion to fly out a load of British journalists and sci-fi writers to Nice last year to chew the sci-fi cud in the sunshine. The proceedings have now been brought together in a book called *Future Imperfect*. It contains some interesting ideas from sci fi masters such as A E van Vogt, Harry Harrison and Clarke himself. Unfortunately, the editor of the book hasn't tightened up the text, some of which looks like verbatim transcripts of speeches which ramble a bit. It also assumes a knowledge of a lot of sci fi work as there are frequent references such as, "as Joe Lueker wrote in *Star Crinkles* . . . . ."

But for sci fi freaks and others interested in the subject, it should provide an interesting read. And Sperry Univac is donating its royalties to The Save The Children Fund, so at least give *Future Imperfect* a chance.

This month's Bookfare featured:
Living with the Micro by Martin Banks (Sigma Technical Press, £4.50)
The Personal Computer Book by Robin Bradbeer (MCB Publications, £5.25)
The Computer Dictionary by Charles J Sippl (A Howard Sams publication, paperback, £8.40)
The Computer Dictionary and Handbook (A Sams publication, hardback, £19.45)
The Howard W Sams Crash Course in Microcomputers by Louis E Frenzl Jr (A Sams publication, £11.40)
Introduction to Microcomputers for the Ham Shack by Harry L Helms Jr (A Sams publication, £3.20)
Visual Display Terminals by A Cakir, D J Hart and T F M Stewart (John Wiley & Sons, £17.50)
Future Imperfect edited by Rex Malik (Frances Pinter, £4.00)
The Computerization of Society by Simon Nora and Alain Mic (MIT Press, £7.75)
All the Same publications mentioned are published in the UK by Prentice/Hall International.

TECHNICAL REVIEW

by Peter Rodwell

6502 Software Design
Leo J Scanlon (Howard W Sams, £6.85)

While the Basic/Pascal/etc debate continues among high-level programmers, down at the low level there's a quieter, more fundamental rift between, on the one hand, those programmers working with the 8080/8085/Z80 family of register-orientated processors and, on the other, those used to the 6800/6502 memory-orientated CPUs.

I'll make no secret of my allegiance to the former group and I suppose that, like most Z80 freaks, I've tended to look down somewhat on the 6800/6502 camp, a prejudice which, in my case at least, was based more on ignorance than any specific facts for there are good and bad points about both approaches to CPU architecture.

This book arrived just as I'd decided that I ought to make a serious effort to learn more about 6502 programming; after all, the damn thing is used by people like Commodore, Atari and Apple, so it can't be all bad news.

6502 Software Design is typical of books of this ilk, offering a basic grounding in the processor's architecture and its instruction set and then progressing to cover all the elementary aspects of assembler language programming which you'll need to get started on anything useful.

After the preliminaries, Scanlon goes on to discuss subroutines, time delays, lists and look-up tables (which get a whole chapter) and then looks at mathematical routines in some detail, including integer arithmetic and, more briefly, BCD (the 6502 has a handy BCD mode, unlike the Z80 which requires a special decimal adjust instruction after each arithmetical operation) and floating point number-base conversion is covered quite well, as are interrupts and resets. Frequent reference is made in the book to the Aim 65 and that machine's assembler mnemonics are used throughout, although you certainly don't need an Aim 65 to make sense of the book.

Having thus covered most of the useful things (although the use of the stack is dealt with a little cursorily), the book then goes into hardware with a handy section on 6502 compatible I/O devices. This is very useful because, of course, the assembler language programmer must have an intimate knowledge of the devices hooked up to the CPU in order to make them work. The book ends with a chapter on I/O in general, covering switches, software-scanned and encoded keyboards, Teletypewriters and seven-segment displays. Two appendices contain the apparently compulsory hex-ASCII look-up table and a 6502 instruction set summary.

I'm still not converted away from the Z80 but at least I'm now more aware of the 6502's potential, having read the book. On the whole it's a useful introduction to the subject, although I think you'd need at least some idea of what low-level programming is about before you started to read it as a certain basic level of knowledge is assumed.

Personal Computer World

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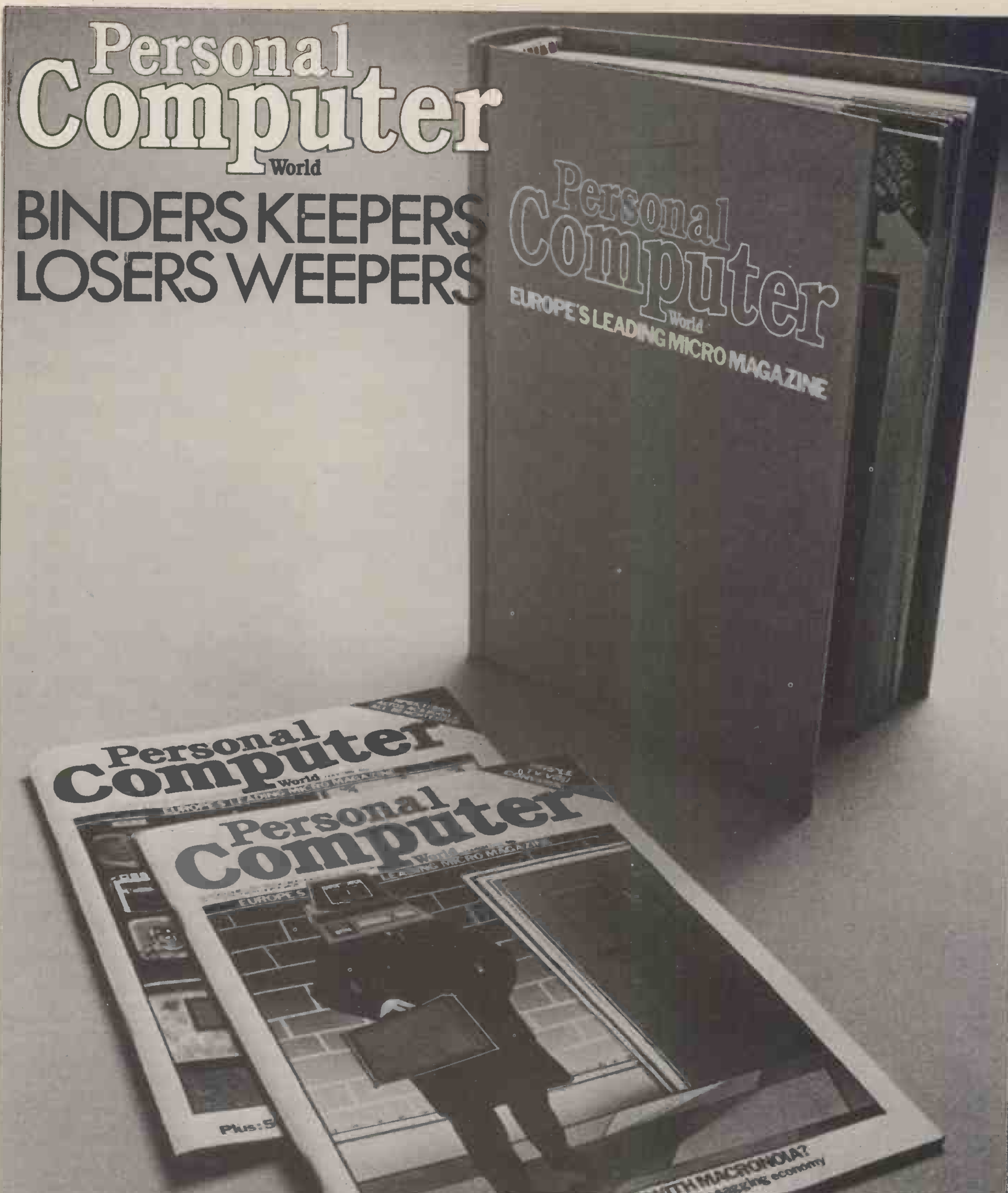

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ATARI 400 & 800

Once again PCW brings you an exclusive Benchtest — this time it's of two exciting computers to be be launched early next year. By offering TV games and audio-visual education capabilities as well as normal computing, Atari says it has created the first machine to be aimed at the true home market. The easy-to-use computers plug into the domestic TV and through it provide a wide range of graphics, colours and sounds; David Tebbutt reports.

Atari claims its 400 and 800 series computers are the first of a new generation of home/personal computers. They are primarily aimed at the home user who will be able to play pre-packaged games, learn all manner of things with audio-visual educational packages, sort out his finances or simply compute. No doubt people running small businesses will be interested in this machine and many of them will find it suitable but at the moment it does have some limitations — all Atari printers use paper rolls as opposed to sprocket fed fanfold paper and few business packages are available. It's quite possible that this will change so don't rule it out completely.

We've all been scratching around for years now wondering if and when the home market will ever exist — I think that Atari will create the market with the home education packages on this machine. One thing is very clear — as the rate of change in our society increases, so we shall have to learn new skills to cope with this change. It is well known that enjoyment goes hand-in-hand with learning — people learn more when they're having fun — so Atari has quite sensibly latched on to this and, bearing in mind the social climate, sees its educational packages being used by children and adults alike. The consumer education market is a big one; the Atari machine is well suited to it and it has the potential to do extremely well.

Both machines are well made and look quite pretty — a glance at this month's cover will tell you far more than any words I write. The 400 differs from the 800 in that it has a flat touch-sensitive keyboard and limited expansion capabilities. It is capable of doing everything that an 800 of the same memory size can do and anyone buying a 400 and then wishing to upgrade to an 800 will be able to run all their existing programs on their new computer.

Both machines plug into the domestic TV (colour or black and white) and are very easy to use. Programs can be loaded from a cassette recorder (Atari), disk or they can be run from a plug-in cartridge. It's interesting to note that the cassette recorder is used for audio as well as digital information which means that the audio channel can be played back through the television speaker under program control — no doubt this feature forms the basis of the audio-visual packages mentioned earlier. The 800 contains a socket for a video cassette recorder — imagine the potential for this machine when video disks come along — it will be possible to access about 12,500 Mbytes of digital information on just one such disk.

Other peripherals available are disk drives, printers, an RS232 interface — necessary for talking to non-Atari devices (other printers perhaps) — games paddles (three types) and a light pen. Given the right marketing, the right price and right level of support Atari could do very well.

Hardware

I was supplied with a 16k model 400, a 48k model 800, a 90k single disk drive, a 40-column impact printer, two joystick controllers, a cassette recorder and a selection of disks and cartridges. The only problems encountered were with the TV display and the cassette recorder. The television display problem was caused by interference from one of the power supplies — a prototype made up for the review. This was quickly cured with the addition of a few smoothing capacitors which will now be incorporated in production models. A more serious problem occurred with the cassette recorder which would only work properly about five percent of the time. We tried three different recorders, all of which worked before leaving Atari but none of which worked properly on arrival. My own mains power is the main suspect but at the time of writing the cause has not been found. Once it is, then I am quite confident that Atari will modify the equipment design to overcome similar problems in the future. Atari itself has had no problems with the recorders and a software house I know has been using the recorders (eight of them) for nine months now without any problems.

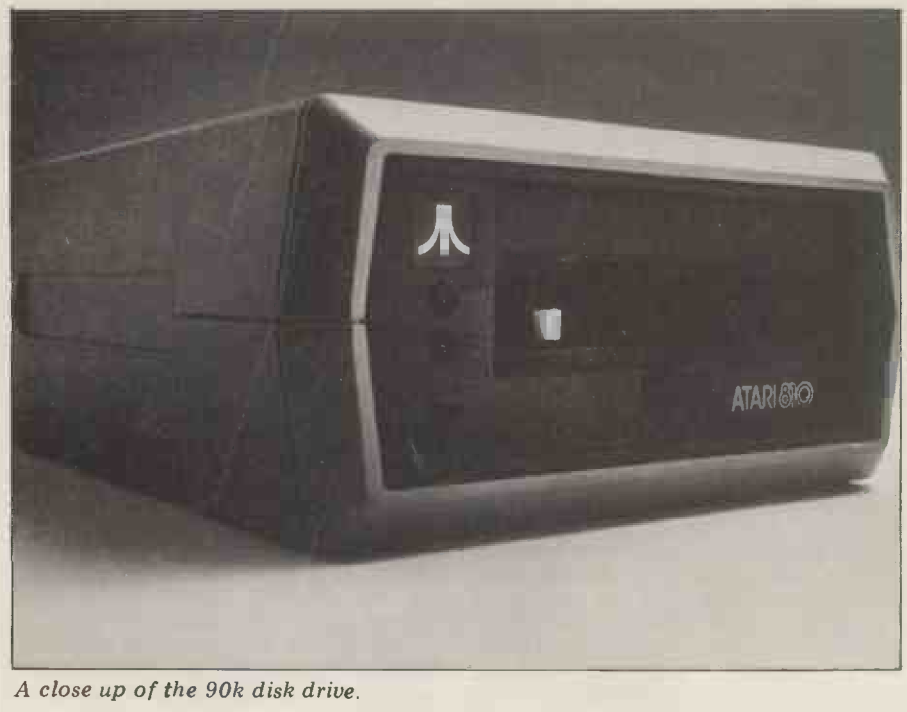
The model 400 measures 13½" x 11½" x 4½" and weights 5¾ lbs. It has a flat keypad with each 'key' having raised edges, which makes for a much better feel than the more common totally flat keyboards. Having spent a week switching backwards and forwards between this and a conventional keyboard with real keys I definitely prefer the latter. In theory the 400 should only be connected to a printer and a cassette recorder but, in view of my cassette problems, I hooked up a disk drive and it worked. The disk operating system gobbled up rather a lot of memory with the result that I was left with just 4238 bytes for program storage. It is possible to reduce the DOS requirement by about 5 kbytes leaving just the bare minimum of routines to keep the disks running. Really, the 400 isn't a disk machine but you could probably get away with it — just.

Finally the 400 has one slot for exchangeable cartridges. I was supplied with a Basic cartridge and three games: Basketball, Star Raiders and Alien Invaders. It was very tempting to spend the week playing Star Raiders rather than preparing this review.

The 800 is clearly a more grown-up machine. It has a normal keyboard which came as a great relief after stubbing my

A useful configuration comprising an Atari 800 with disk drive, forty column printer, cassette recorder and a couple of joysticks.

Two views of the 800 showing the locations of the various plug in modules.



A close up of the 90k disk drive.

fingers on the 400 for a few days. The reset button is protected by a plastic surround which stops you pressing it inadvertently. For those buying a 400, don't worry — the reset doesn't clear your program. Two cartridge slots are provided: the left one is the equivalent of the one in the 400 while the other's a bit of a mystery. Somebody did mutter something about bubble memory but I think it was speculation rather than a fact. It seems to me that some cartridge programs will exceed the 8k limit and the second slot will enable them to overflow. The 800 has a DIN socket for connecting a VCR or an external monitor — see my earlier notes about video disks.

The 800 can be expanded using either 8k or 16k expansion memory modules. (Rumour has it that the 8k will be dropped and that a 32k is on its way.) Three slots are available giving a maximum of 48k if you use 16k modules. A fourth slot contains the 10k operating system. The fact that this occupies a plug-in slot must mean that the operating system can be easily upgraded. All these modules may be installed by the home user in about 30 seconds flat.

The cartridge slots occupy memory locations from 32k to 48k so if you have a 48k system you will lose 8k if slot A is in use and 16k if both are being used.

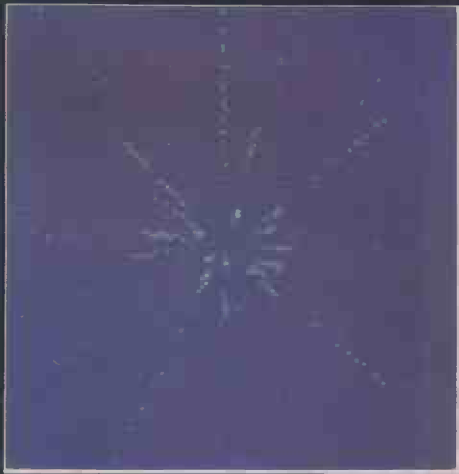
Like the 400 the 800 is compact measuring 16" x 12½" x 4½" and it weighs in at 9¾ lbs.

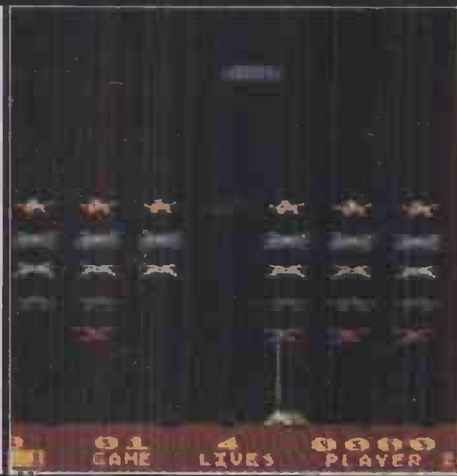
I have now covered all the main differences and the rest of the review relates to both machines. For convenience I shall call the machine the Atari.

The keyboard is arranged in the standard qwerty format with the addition of a number of control and special function keys. Each key may be used in three or four different modes: control, upper case, lower case and graphic character. With 57 keys this means that over 170 different characters can be generated. In addition to this, each character may be displayed in normal or inverse video giving a true range of over 340 choices. Each time a key is pressed the keyboard (not the television) 'peeps', very useful on the 400 when you can't always be sure you've made contact.

Cursor movement is as flexible as you're likely to need with up, down, left, right, clear screen and tab controls provided. It is possible to set and unset tabs anywhere along a single line on the screen. The manual suggested that tabs could be set anywhere in a logical line (up to 120 characters); if it's true I'd like someone to explain how. All keys repeat after they have been held down for about a second, which is especially useful when screen editing. All character modes — upper case, lower case, inverse video and graphics — may be 'locked' until changed. When the machine is in lower case mode, upper case characters can still be obtained by pressing the shift key just like a normal typewriter.

The screen format can be any resolution from 12 x 20 to 320 x 192 with up to five colours. In normal text mode it is 24 lines of 38 characters although the line may be altered to any length between one and 40 columns. A logical line is three times the physical line length and when nearing the end of a logical line the keyboard 'peeps' a warning. Character insertion and deletion is

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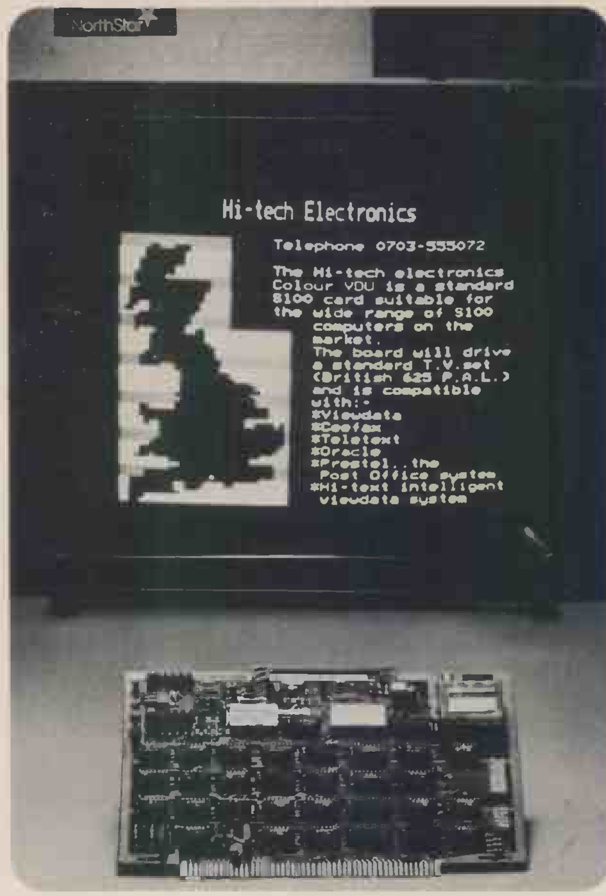

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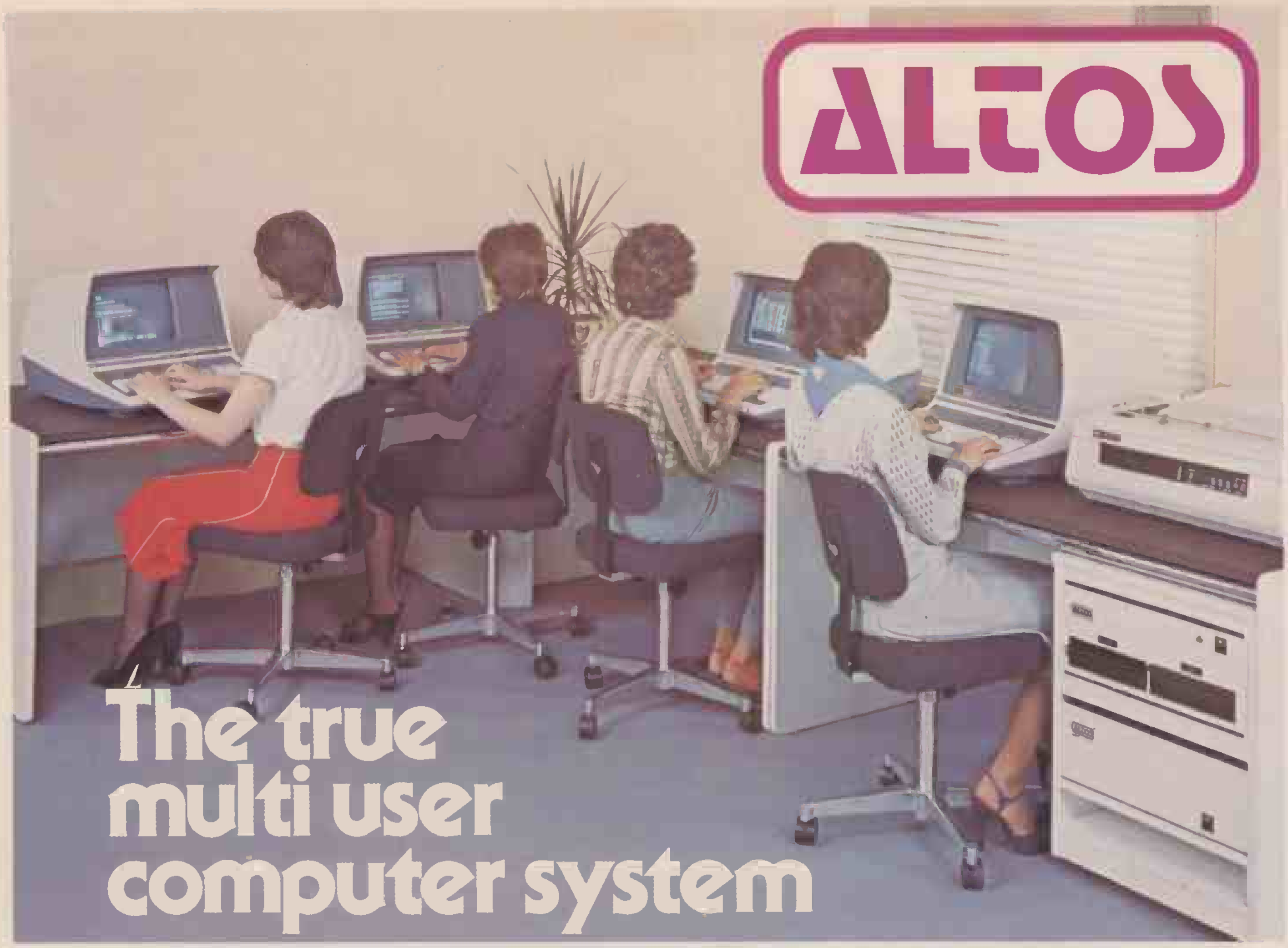

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provided as well as line insertion and deletion. Line delete removes a whole logical line from the display but not from memory (if you're keying a program) whereas line insert makes space for a single physical line.

Four remaining keys on the right of the keyboard allow for system reset, select, option and start. Apart from reset these keys relate to the selection and initiation of functions in a cartridge.

The processor used is the 6502, the same as that in the PET, Apple and others. It runs at 1.8 MHz and gives benchmark timings which are a little slower than PET or Apple. The real time clock runs at 50 Hz, unlike the American version which runs at 60Hz so some US packages will run a little slow in the UK.

Four ports are provided at the front of the machine for attaching controllers — either knobs, joysticks or keypads. Up to eight controller knobs may be attached (in pairs) each returning a value from one to 228 depending on the knob's position. The joystick is a nine-position controller and up to four may be attached. As well as the positional controls, each device contains a trigger button. Up to four keypads may be attached, each containing keys 0 to 9, * and #.

One input/output port is provided on the side of the machine. Each device which can be attached has two sockets to enable others to be 'daisy chained'. The printer, disk drives, cassette recorder and RS232C expansion unit may all be connected in this fashion. A light pen plugs into one of the front controller ports.

The cassette recorder can be used with any high quality audio tape and reads from two channels — one audio, the other digital. It transfers digital information at 600 baud and is very sensitive to speed fluctuations. Sound is output through the television. The recorder has a tape counter to give the approximate position of a program and, as each recording has an 18 second leader, the precise location of the program start is not too critical.

The printer supplied was a 40-column impact machine with 5 x 7 matrix. With its on-board 6502, I reckon it could do more than I could find out. I managed to get the standard character set but no graphics. The documentation gives tantalising hints of more features, mainly to do with the ability to print horizontally and vertically but I couldn't get it to work.

Two other printers are available, a thermal 40-column device and an 80-column machine. All three printers use a paper roll which limits the scope of the machine a little.

The disk drive supplied was a 5¼" 90k single sided device whose origin appears to be Atari. I had a little peek inside and could find no manufacturer's references other than Atari itself. Up to four drives may be attached or, if you need more storage, a double density dual drive is available, giving about 160 kbytes per disk. Again, up to four of these drives may be attached, giving a total over 1.2 MBytes.

I consider the hardware to be very well made and certainly attractive enough to have in the home.

Software

The main operating system occupies a

A close look at the 400 keyboard and cartridge slot.

The special Atari recorder.

Outside and. . .

. . . inside the 40-column impact printer.

10k ROM slot, the disk operating system is loaded from disk and takes up almost 9k of user RAM and the Basic cartridge occupies the RAM from 40 to 48k. At the moment games and other package modules occupy the same slot as the Basic cartridge.

Every package comes with an instruction booklet which can be quite substantial: a 12-page booklet explains the Star Raiders game for example. To digress for a moment, the Star Raiders game is similar to many of the Star Trek type games *except* the television screen gives what appears to be a three-dimensional view of space. In fact it creates the illusion of being the window of your spaceship. Believe me it's quite addictive and there are several levels of play, each rewarding you with a whole series of grades depending on your performance in your mission. It could take weeks, months even, to reach the highest rank of star commander.

I've been told by someone who knows about these things that the programs available now are nothing compared with what's coming along.

Two program libraries exist, one for 8k programs and the other for 16k. The latter contains this new generation of games as well as new programming languages and business information processing packages. An enormous amount of Talk and Teach courseware is being prepared, such as Basic Psychology, Basic Sociology, Effective Writing, Counselling Procedures, Supervisory Skills, Principles of Accounting, Principles of Economics, Spelling, History and so on. . .

A terminal emulator and an assembler/editor look like interesting cartridges to get hold of as well.

Basic

It would be impossible to give a full description of Atari Basic in this review. Instead I shall restrict my comments mainly to those aspects of the language which are different to the Basics normally encountered.

First of all a couple of points relating to program input and editing. Atari Basic checks command syntax quite carefully at the time of input and, if it detects an error, highlights it with a marker at the part of the line at fault. Unfortunately this admirable approach stops when programs are run. The user is presented with an error code number which has to be looked up in the manual. It's possible to use a reserved word as a variable name although Atari doesn't recommend it; I tried LET LET=10: GOTO LET, yes, you can GOTO a variable name. Finally CTL 1 allows you to freeze the screen (and program) and unfreeze it at will. This is great if the doorbell rings while you're in the middle of a fast moving game for example.

Saving and loading programs on cassette is quite neat; the keyboard 'peeps' once if you're to press PLAY and twice if PLAY and RECORD are to be pressed. A number of commands are available for these functions, LIST, CLOAD, LOAD, ENTER, CSAVE and SAVE. SAVE or LIST can record programs for later merging by the LOAD and ENTER commands. CSAVE saves a more compact version of the program.

Memory map

Operating system	FFFFH
Floating point routines	DFFFH
Hardware registers	D7FFH
Not used	CFFFH
Slot A or RAM	BFFFH
Slot B or RAM	9FFFH
Basic & RAM	7FFFH
DOS & RAM	2A7FH
System controls & RAM	12FFH
	0000H

The string functions are adequate but hardly exciting. For a start all strings must be defined using a DIM statement, thus turning each string into a single dimension array, as in Cromemco's 16k Basic. No string arrays (in the normal meaning of the term) are allowed, which can be a bit of a nuisance. On the bright side, there's no limit on the length of a string although substrings are limited to a maximum of 99 characters. Substrings may be concatenated but not with the usual '+'; on the Atari it is necessary to devise an expression such as Z$(LEN(Z$)+1)=A$; this adds A$ to the end of Z$. All string variables can be subscripted either with a single number or with two separated by a comma. A single character means 'from this character position to the end of the string', while two characters define the start and end positions within the string.

The INPUT instruction will accept commas as part of the string, unlike so many other Basics. Unfortunately the machine gives no warning if the string is too long for the space available to accept it — the poor thing is simply truncated. Another oddity about Atari Basic is that you can't include a prompt in the INPUT statement and it's necessary to precede it with a PRINT.

ADR returns the memory address in decimal of the start of any given string.

A matrix has a maximum of two dimensions as opposed to the more usual three. Unlike the ZX80 which can only work with integers, it is impossible to define integer variables on the Atari machine.

A nice feature is TRAP; this allows you to define an address to which program control must pass when an error is encountered — very useful. This must be reset with a new TRAP instruction following each error trapped.

Sensibly, Atari has included a POP instruction which enables you to remove the top entry from the stack, essential if you decide not to RETURN from a subroutine.

Disk handling is somewhat crude but nevertheless effective. It comprises three useful commands — NOTE, POINT and OPEN. I only mention OPEN because a file may be opened in append mode which is quite useful. The other two commands give direct control over where the disk is to be accessed. NOTE saves the current sector/byte combination while POINT sets internal pointers to the next sector/byte to be accessed. Think about it. Sadly I didn't see a DOS manual but I have been led to believe that file handling software is fairly non existent at present.

GET and PUT read or send one character to a specified device and the location pointer is then incremented by one.

Many instructions are quite lengthy so an XIO command has been provided to give a sort of shorthand. The required function is accessed by issuing an XIO with a command number selected from a table. It has one extra function not provided by any other command and that is to FILL a previously defined graphics area.

Surprisingly, user defined fuctions are not allowed in Atari Basic. There are, however, a number of functions, among which are RAD, DEG and CLOG. RAD or DEG selects whether results are to be in radians or degrees — the mode won't change until another RAD or DEG instruction is encountered. CLOG gives logarithms to base 10. Mathematics are to nine-place accuracy except for EXP which will be at least six.

The graphics on this machine more than make up for any minor deficiencies in the other departments. It is possible to select from 128 colour/luminance combinations and 17 different screen arrangements. Up to five colours may be displayed, depending on the particular graphics mode in operation. Table 1 gives the range of options together with their RAM requirements.

Two of the more useful commands are DRAWTO which draws a line from the last location plotted to the coordinates defined and SETCOLOR which is used to set each of the five possible colours. Mixed text and graphics are allowed, so it's necessary to move an 'invisible cursor' around the screen. This is done using the POSITION command; text sent to the graphics area will then appear at that position.

The graphics commands take a lot of effort to master but they are definitely worth it. You may even find a few modes that are not in the manual, as I did.

One look at the Basketball or Star Raiders games tells me that there are far more graphics facilities locked away inside the machine. Atari isn't telling though, so it will be left to some bright programmers to get inside the software and then to spill the beans. (To PCW perhaps?) For now I would suggest you go to a pub or an arcade where Atari machines are installed to get some idea of their potential. One of the interesting features is the 'simultaneous' movement in different directions of large graphic figures (people, spaceships etc).

Up to four sounds may be played simultaneously; the pitch of each may be varied from one octave below middle C to two octaves about it. Special

Basic Reserved Words

+	—	*	/	Λ	NOT		
BYE	CONT	END	LET	LIST	NEW	REM	RUN
FOR. . .TO. . .STEP. . .NEXT			GOSUB. . .RETURN		GOTO	IF. . .THEN	STOP
ON. . .GOSUB	ON. . .GOTO			POP	RESTORE	TRAP	
CLOAD	CSAVE	DOS	ENTER	INPUT	LOAD	LPRINT	NOTE
OPEN	CLOSE	POINT	PRINT	PUT	GET	READ/DATA	SAVE
STATUS	XIO						
ABS	CLOG	EXP	INT	LOG	RND	SGN SQR	USR
ATN	COS	SIN	DEG	RAD	ADR	FRE	POKE
ASC	CHR$	LEN	STR$	VAL		PEEK	SQR
DIM	CLR						
GRAPHICS	COLOR	DRAWTO	LOCATE	PLOT	POSITION		
SETCOLOR							
SOUND	PADDLE	PTRIG	STICK	STRIG			

distortion effects and separate volume controls may be applied to each voice, using the SOUND command, and once a sound is initiated it will continue until stopped by a reset, END or another SOUND instruction for the same channel.

You will see from the Basic reserved words table that there are many commands not even hinted at here. In my view it's a good Basic with just the one or two limitations mentioned above.

The disk operating system (DOS) must be booted in before programming starts, which is very important, not least because the machine has to be switched off before DOS can be loaded. It was difficult for me to evaluate the DOS properly as I didn't have the DOS manual; all I can say is that it worked for me — I had no disk problems at all and I was saving and loading both programs and files. A menu can be displayed which shows that DOS offers the usual functions such as file copy, delete, rename, lock, unlock as well as disk level commands such as copy, write DOS to disk, format disk and duplicate disk. I was disappointed not to find mention of any file handling procedures as this would save each user reinventing this particular wheel.

Benchmark timings (all times in seconds)	
BM1	2.35
BM2	7.41
BM3	19.89
BM4	23.16
BM5	26.78
BM6	40.75
BM7	61.51
BM8	43.08

Potential use

Without doubt this machine is aimed at the home user and education in its widest sense. The audio visual facilities will find a place in the home, in commercial training establishments as well as in the school. The games will be an attraction to those already interested in computing while at the same time involving those who wouldn't normally touch a computer with a barge pole. The home computeer will have a whale of a time while the more serious may reconcile their household accounts and taxes on it. The businessman may use it but probably only the smallest, the architect or engineer perhaps. The 400 should be ruled out for serious computing although it is ideal for games/computing/education. The 800 offers a more grown-up option with plenty of growth capability; disks and the RS232C interface will ensure that some quite serious users will buy.

Both machines are friendly, they have the solid backing of Atari and, behind it, Warner Brothers Communications.

This machine is probably the strongest contender for the home computer market in Britain today.

Documention

A lot of effort has gone into the preparation of the documentation. It has been well produced although there is still some room for improvement. The operator's manuals are very clear as are the instructions for operating the various cartridges. A Basic manual written by Albrecht, Finkel and Brown was also quite excellent.

Aimed at the absolute novice, this book takes you through most of the various features and functions of Atari Basic. All except our friends the I/O commands, that is. Experienced programmers will probably dip into this book but I would recommend a beginner to work through it carefully. The Atari Basic reference manual is quite good for the experienced programmer but not a lot of use to the beginner except for the appendices which give all sorts of interesting information such as the derivation of mathematical functions in terms of Atari Basic, memory maps, useful POKE & PEEK locations, error codes and the various graphics modes.

I'd like to have seen more in Atari's own manual; I did feel that they skimped a bit on explanations, especially with regard to printer and disk operation.

Prices

Prices in the UK have not been finalised so I shall give Atari's "approximate anticipated retail" figures which include VAT.

16k 400	£395 -300
16k 800	£695 -600
Cassette Recorder	£55
90k Disk Drive	£525
80 column printer	£500
16k RAM	£145

My guess (not Atari's) is that the cartridges will range from £20 to £50.

Conclusion

I've said it all earlier in the review but for the benefit of those busy people who only read the introduction and conclusion, I think that Atari is doing a very professional job. The machines are clearly aimed at the home market where, as well as satisfying a demand for sophisticated games and Basic computing, they might spawn a completely new 'consumer education' boom. Self improvement is rapidly becoming a necessity and Atari seems set fair to help/capitalise depending on your viewpoint. Some small business owners may buy but they are unlikely to form a major part of the installed base. The official UK launch isn't until early next year so Atari has time to fix the odd hardware problems encountered during the review.

TECHNICAL SPECIFICATION

CPU:	6502, 1.8 MHz
Memory:	8-48k (16k limit on 400), 8k ROM Basic (40-48k RAM location) 10k ROM operating system.
Keyboard:	Full qwerty + special keys. (61 keys including controls).
Screen:	Domestic television. 12x20 to 320x192 resolution. Up to five selected from 128 colour/luminance combinations, 4-channel sound
Cassette:	Digital, 600 baud. Audio channel. Tape counter.
Disk drives:	5¼" 90k. 5¼" twin 160k drive. Up to 4 drives per system.
Printers:	40 col impact or thermal, 80 col impact.
Ports:	Interface module gives RS232C. VCR socket on 800 (can be used for a monitor). 4 games controller/light pen sockets.
System S/W:	10k operating system. 9k (almost) DOS in RAM.
Language:	8k Basic (others coming)

	Graphics mode	Columns	Rows: Full	Rows: Split	No. of colours	RAM required
Text	0	40	24	—	2*	993
	1	20	24	20	5	513
	2	20	12	10	5	261
mixed text/graphics	3	40	24	20	4	273
	4	80	48	40	2	537
	5	80	48	40	4	1017
	6	160	96	80	2	2025
	7	160	96	80	4	3945
	8	320	192	160	1*	7900

* 2 luminances may be defined for one colour

4 text lines are provided at the foot of each split screen.

Table 1 Graphics options

At a glance

***** excellent, **** V. good, *** good, ** fair, * poor.

FIRST IMPRESSIONS	
Looks	*****
Setting up	*****
Ease of use	*****
LANGUAGES	
Basic	****
System software	**
PACKAGES	
Business	not reviewed
Education	not reviewed
Home	****
PERFORMANCE	
Processor	**
Cassette	see text
Disk	**
COMPATIBILITY	
Hardware	**
Software	*
DOCUMENTATION	****
VALUE FOR MONEY	****

BENCH TEST

DAI PERSONAL COMPUTER

Continuing this month's special look at home computers, Sue Eisenbach tests a new machine from Belgium.

Rumour has it that when Texas Instruments was designing its personal computer, it knew that producing a colour signal for English and European TV would cause difficulties and so it approached a Belgian firm, Data Applications International (DAI), to design a European microcomputer. The brief was wide — using Texas components, produce a personal computer with sound and good colour graphics that may be used with domestic televisions. By the time the DAI personal computer was developed, TI had had a change of heart: it decided to market the 99/4 in Europe with an American colour monitor — which increased its price but solved the 'European problem'. DAI was left holding a computer, the design of which had been funded by TI. . . and it is this machine that Data Applications [UK] Ltd has now launched onto the British market.

Hardware

The DAI personal computer is a single board based around the 8080A microprocessor. It's contained in a smart white lightweight case, which also holds the keyboard and is held together by four black plastic pins which can be pushed in or out by hand.

For mass storage the DAI expects an ordinary audio cassette recorder; two audio cassette interfaces with motor control work at 600 baud. The machine produces sound (more on this later) which can be output in mono through the loudspeaker of a domestic TV or through a stereo system for full stereo.

There's a socket on the PCB for the AMD 9511 maths chip, which the review machine contained. Benchmark 8 tests the speed of mathematical functions; I disabled (by software) the AMD 9511 and ran benchmark 8 a second time and it ran eight times slower.

The DAI plugs into a domestic TV and produces an excellent colour picture. According to the manual, it can also be plugged into SECAM and NTSC televisions or a colour monitor. The ASCII keyboard is fairly standard with cursor control keys on the left. On booting the system, the keyboard produces only upper case letters but there's a control key that toggles in a full typewriter-style keyboard. (The Basic does not accept lower case commands so this is a feature which may have limited use.) The reset button in the top left hand corner is recessed and requires pressure from a hard object (eg a pencil point) to activate. The computer contains a software keyboard scan and encoder.

The DAI has an external connector for a flat cable to the DCE bus — the bus used by Data Applications' other bus-based computer. According to the manual this bus can also be used for connecting up to a parallel printer. There's also an RS232 connector on the back of the computer.

The dynamic RAM is divided into three separate memory banks which can contain 0, 4k or 16k of RAM. The RAM is seen by the program as a continuous memory block starting at 0000H. The first RAM bank (which may not exist) is for programs, while the second two are used for both programs and display data. The second two banks contain the low order and high order bits of the 16-bit words needed for the display. The RAM configurations allowable are 8k, 12k, 32k, 36k and 48k.

The Basic and other system software sits in ROMs starting at address C000H and extending to EFFFH. Addresses E00H through EFFH have four switchable banks of program address space giving a total ROM address space of 24 kbytes. Static RAM occupies the address range F800H to F8FFH which is used by the 8080A for stack space while the top of the address space is used for memory-mapped I/O.

The DAI has five programmable interval timers, two external interrupts and two serial I/O interrupts. According to the manual, it has the appropriate circuitry for connecting two games paddles as input devices. Each paddle contains three variable resistors whose positions are read as values and one on-off event.

Basic

On power-up, DAI PERSONAL COMPUTER appears in large white letters on a bright green background; hitting any key clears the screen and puts BASIC V1.0 in small black letters on a white screen. The Basic occupies 24k and although written by DAI, shows a strong Microsoft influence, as can be seen from the table of Basic reserved words.

DAI variables can be up to 14 characters long. Both integer and floating point numbers are recognized; integers are 9 digits whereas reals are in the range 10^{-18} to 10^{18} (4 bytes) with 6-digit printout. All numbers are assumed to be floating point unless declared with a % sign after the variable name or by means of an IMP statement. IMP INT I-N declares all variables that start with I—N as being integer variables. Not only are there no rounding errors when using integers but there can also be a substantial improvement in speed. When I changed the variables in benchmark 1 to integers, the program ran in 0.68 seconds, or 73% of the floating point version of the program.

Leaving aside the graphics and sound commands for fuller treatment later, the commands that don't look like Microsoft include:

CALLM N, [V], which calls a machine language routine located at N. If the second parameter is included in a CALLM statement, then the HL register pair will contain the address of variable V. Upon return all 8080 registers and flags are restored to their original state;

A = INP (#N) reads a byte off the Nth Port into A;

OUT #N, A puts A into Port N;

A = PDL (I) sets A to the position of the Ith paddle potentiometer;

UT calls the machine language monitor;

CHECK scans a cassette tape (or disk) and examines all files to see if their checksums are correct;

LOADA loads an array (or machine language program stored as an array);

SAVEA saves an array on cassette (or disk);

STEP allows single-stepping through a Basic program;

A = VARPTR(B) variable A is set to the address of B;

HEX$(I) returns a string of characters representing the hex value of the number I;

LOGT(X) calculates the logarithm base 10 of X;

RND(X) for which the user has the choice of a hardware or software generated random number.

Typing EDIT does not have the same effect as in Microsoft Basic. Rather, EDIT calls the editor, loads the current program into it and displays the first 24 lines of text. Once in the editor, a program can be easily altered by either moving the cursor (using the cursor keys) around to the appropriate place and retyping or by moving the text around (shift and cursor keys) and retyping. Up to 255 characters may be stored in a line and viewed by 'panning' the screen. Carriage returns are visible within the editor. If only a few lines are required then the editor can be called with EDIT N-M, EDIT N, EDIT N- or EDIT -N. The editor is very easy to use and can be left by pressing BREAK, followed by space (to keep the changes) or BREAK, BREAK if the edit is to be disregarded. I found the editor convenient and very easy to use.

DAI Basic is 'semi-compiling' — after each line is typed in, it is translated into an intermediate code that is faster to execute than the Basic statement typed in. Usually a 'semi-compiling' Basic will not accept a line if it contains errors since it cannot translate it into intermediate code. This can be quite irritating if you have to type a long line again because of a silly typing error but DAI Basic has got around this problem. When an incorrect line is typed in, an error message immediately appears. When the program is listed, the erroneous line is there but has *** in front of it. These can be easily edited out when the line is corrected in the editor.

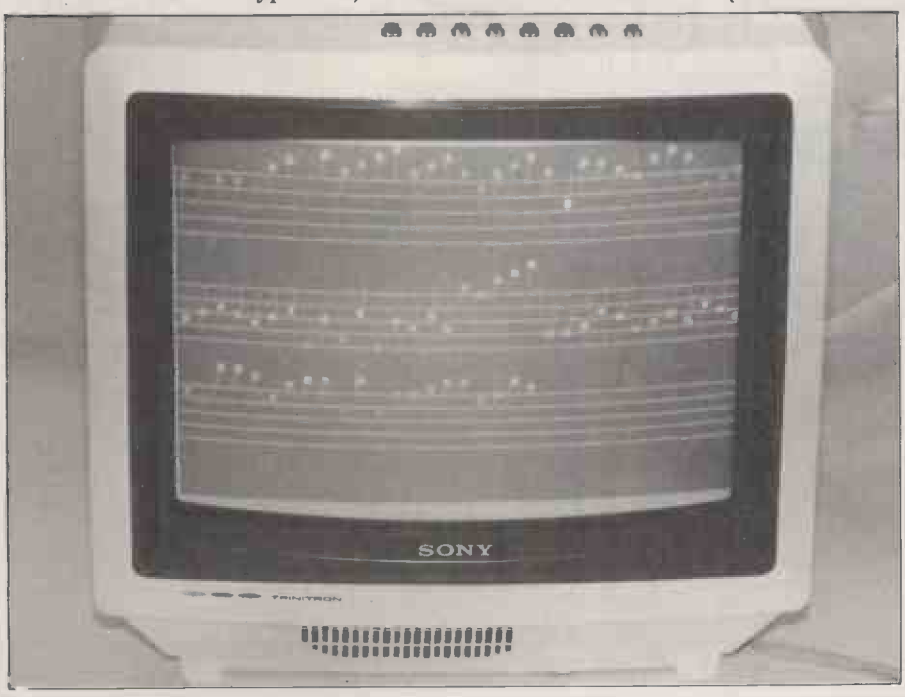
Every effort has been made in DAI Basic to help the user debug a program easily. As well as the debugging statements STEP, TRON, TROFF and the listing of error lines with ***, there are 25 distinct error messages. These are more helpful than the usual SYNTAX ERROR and are in English (eg COLOUR NOT AVAILABLE IN LINE 200).

Graphics

The DAI personal computer has three graphics definitions available (low, medium and high resolution) as well as an all character mode. The character mode displays 60 by 24 characters. The graphics definitions are: low — 65 x 88 pixels; medium — 130 x 176 pixels; high — 260 x 352 pixels.

At each level of definition the user has the choice of all graphics or four lines of text on the bottom. If an executing program uses a graphics only mode and the user breaks in, the DAI will move the picture up, switching into graphics and text mode. On typing CONT the picture rolls back down and the program continues.

The graphics takes up user RAM (see memory map) so you need at least 32k to use the high resolution graphics. The DAI provides 16 colours; if all of these were usable without restrictions, far too much of the user RAM would be occupied with the screen image. Instead, DAI has two modes, a full-colour mode and a restricted 16-colour mode for each graphics definition. In four-colour mode the user choses four colours out of the 16 available (which can be changed at will, and the existing picture changes colour immediately) and can use any of these colours anywhere on the screen. In a 16-colour mode, the screen is divided into vertical fields 8 pixels across. Within each field only two colours can be used.



A demonstration program was provided with the machine that followed a place through a full 24 hours. It started with a crescent moon in the left hand corner on a dark blue screen. As time went by, first stars came out and then the sky faded into light blue. After the horizon became visible the (perfectly round) sun slowly rose. When it was high in the sky a Dutch flag was raised on a flagpole. This was followed by the playing of the Dutch national anthem. When this was completed, clouds passed across the screen and night descended.

The colours were clear and the resolution seemed fine. The graphics can be accessed through machine code or by the following commands in Basic:

COLORG A B C D for graphics mode — this sets up the four colours to be used in four colour mode.

COLORT A B 0 0 for text — this sets up A as the background colour and B as the character colour.

DOT X, Y, A. This places a pixel of colour A at point X, Y.

DRAW X1, Y1 X2, Y2 A. This draws a line of colour A between X1, Y1 and X2, Y2.

FILL X1, Y1 X2, Y2 A. This fills a rectangle with opposite corners at X1, Y1 and X2, Y2 with colour A,

XMAX. The maximum allowable X value for the current graphics mode.

YMAX. The maximum allowable Y value for the current graphics mode.

SCRN(X, Y). The colour coordinates X, Y.

CURSOR X, Y. In text mode this moves the cursor to the Xth character in the Yth line from the bottom of the screen.

CURX. The Xth coordinate of the cursor.

CURY. The Yth coordinate of the cursor.

I found the graphics easy to use and impressive. My criticisms are twofold. Firstly, I'd like to see a set of subroutines for drawing characters in graphics modes (graphs do improve with labels on their axes), and it would be nice (especially with the 48k machine) for there to be low and medium resolution modes that allow the use of 16 colours anywhere on the screen.

Sound

The DAI can generate sound using three independent programmable oscillators and a random noise generator. Each of the oscillator channels can be programmed to produce sound in the frequency range 30 Hz to 1 MHz at whatever amplitude is required. The noise generator which produces random frequencies is designed to simulate white noise and to provide a random sequence for random numbers. Oscillator channels one and two are used to produce sound for the left stereo output while channels two and three are used for the right stereo output.

A music program 'Music Tutor' came with the review machine. When run, staves appeared on the screen and the

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typing keyboard became a musical keyboard. Hitting a key produced both a sound and a note on the screen. Although not a sophisticated piece of software (all notes were crochets) it did demonstrate some of the potential of the DAI's sound capabilities. The bottom row of keys became a piano's white keys while the next row up contained the black keys. Pressing a key in the next row produced a chord while the top row was used to alter the quality of the notes produced. By pressing a key in the top row the volume could be increased or decreased or the duration of the notes hit could be altered from normal to either staccato or an organ-like (filled with overtones) legato.

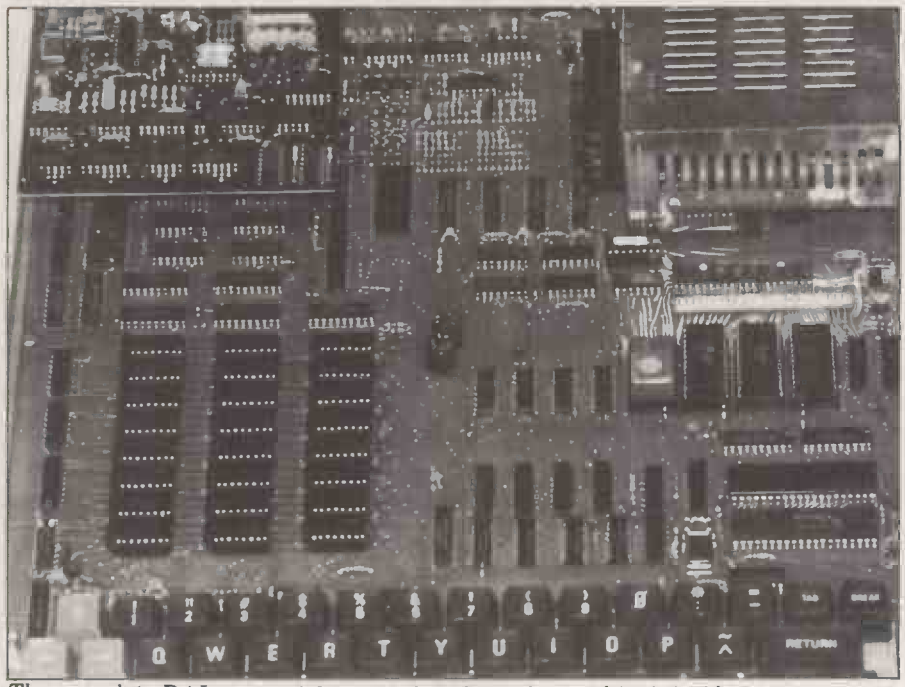
The sound can be generated from either Basic or machine code. In Basic the commands are:

A = FREQ(N) — sets A to a number that can be sent to a sound generator channel to result in an N hertz rate.

ENVELOPE <ENV> [<V>, <T>;] ENV selects which of two envelopes is being defined, V is a volume level (0 to 16), and T is a time length in the range 1 to 254 (where each unit lasts 3.2 milliseconds). Anything in [ ] brackets is optional and can be repeated any number of times.

NOISE ENV VOL
NOISE OFF
These commands turn the random noise generator either on or off.

SOUND <CHAN> <ENV> <VOL> <TG> FREQ <PERIOD> SOUND <CHAN> OFF
SOUND OFF
CHAN selects programmable oscillator 0,1, or 2; ENV selects which of two previously defined envelopes should be used; VOL selects a volume for a sound which is multiplied by the volumes in the ENVELOPE command; TG is an expression in the range 0 to 3 which selects tremolo/no tremolo and glissando/no glissando; PERIOD sets the period of the required sound in units of ½ microseconds.



The complete DAI system (above) and (below) the machine's insides.

Documentation

The documentation comprises two books — a general introductory text designed for someone with no knowledge of computers and one entitled *Personal Computer Manual* which is more technical.

The introductory text is not a manual: it starts from unpacking the computer and introduces both hardware and software ideas slowly by solving the problem of getting colours on the screen. Solutions are reached but each solution except the last throws up more difficult problems to be tackled. This book takes quite a good approach for teaching a beginner about computing in general and the DAI in particular. Unfortunately, its tone is so patronising as to easily put off any novice.

Fortunately the manual is free of the textbook's tone. It's quite comprehensive about both hardware and software and even includes 40 pages of programs. Although there are ambiguous sections, overall it's quite clear and most features have limited examples. The manual is paginated and has an excellent table of contents (eg 'How to get Restarted if Accidental Reset During Program Keying or at End of Program'). The hardware sections contained justifications for design features (such as the graphics resolution) which make for interesting reading.

Expansion

The minimum system is an 8k black and white version with low and medium resolution graphics. This can be expanded to a system like the review machine; and with 48k and full colour graphics the single board is fully populated. There's a DCE bus connector which can be used to attach a DCE backplane and any number of DCE Eurocards, which include EPROM, RAM and a wide range of I/O cards.

Potential

In common with the other European machines that I have reviewed, the DAI personal computer has rather nice system software but no applications packages. At this stage the DAI micro is only interesting to programmers or people who want to learn to program.

As the DAI personal computer has a Data Applications DCE bus, it can be connected to those cards. Using an expanded system should enable the development of process control systems for example.

As a machine for educational purposes the DAI has advantages and disadvantages. For teaching Basic it has many fine features: the Basic is large (although missing ELSE) and the graphics and sound capabilities are not only impressive but are accessed via sensible Basic commands. The machine is light and portable but unfortunately the box is too fragile for school use. Being limited to Basic makes this machine unsuitable for teaching programming at a higher level, yet it may have a place in higher education as a machine for monitoring and controlling experiments.

Both the sound and graphics capabilities could be put to good use in games programs, assuming that it's acceptable to tie up the TV and stereo for extended periods of time. With DAI real world cards a user should be able to wire up a home so that everything may be remotely controlled!

Assuming price is not a deterrent, the major disadvantage of the DAI machine as a home computer must be its lack (both current and proposed) of home application packages. I think if I bought a computer to play with I'd want arcade games and personal finance packages at least.

Conclusion

I found the DAI personal computer an entertaining machine to play with. With its range of add-on boards, its potential as a computer for process control is good. Both its colour graphics and sound capabilities are impressive and would make an interesting proposition for someone who wanted to produce and record computer music.

I'm curious whether a machine with rather limited software will be able to compete with either the Apple or the current offerings from Texas and the American game manufacturers — such as the Atari machines reviewed elsewhere in this issue.

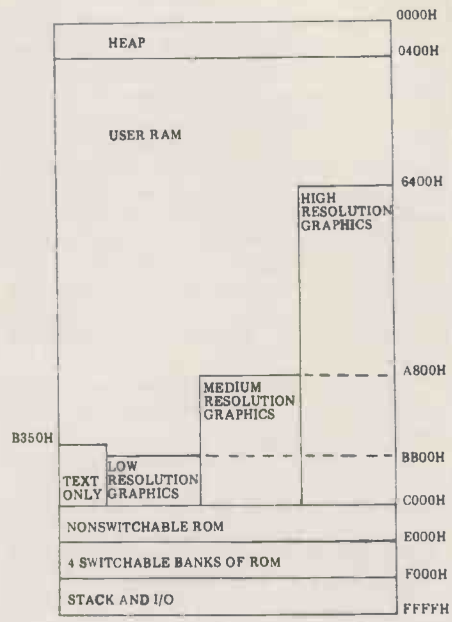
Prices

48k — £795, 32k — £725, 12k — £595, Hardware Maths Module £149. All prices are exclusive of VAT and delivery charges.

Machine Language Utility Commands

LOOK
DISPLAY
GO
FILL
SUBSTITUTE
MOVE
EXAMINE
EXAMINE REGISTERS
VECTOR EXAMINE
VECTOR EXAMINE BYTES
READ
WRITE

Memory map



Technical Data

CPU:	8080A, 2 MHz
Memory:	48k dynamic RAM, 24k ROM, 262 bytes static RAM
Keyboard:	56 keys
Screen:	Any colour TV, 60 x 24 char., 260 x 352 pixels
Cassette:	Any audio cassette, 600 baud
Disk Drives:	N/A
Peripherals:	N/A
Bus:	DCE-bus
Ports:	Input: 2 paddles, RS232; output: 2 stereo channels, RS232
System software:	Machine language utilities
Languages:	Basic, 8080 machine code

Benchmark Timings (in seconds)

1	0.93
2	4.78
3	10.05
4	9.78
5	11.20
6	18.12
7	30.11
8	2.14

Basic reserved words

EDIT	SAVEA	ASN
IMP	CONT	ATN
LIST	REM	CHR$
NEW	STEP	COS
RUN	TRON	EXP
END	TROFF	FRAC
FOR . . NEXT	CLEAR	HEX$
GOSUB	DIM	INT
GOTO	FRE	LEFT $
IF . . THEN	LET	LEN
ON . . GOSUB	VARPTR	LOG
ON . . GOTO	MODE	LOGT
RETURN	COLORG	MID$
STOP	COLORT	PI
WAIT	DOT	RIGHT$
CALLM	DRAW	RND
INP	FILL	SGN
OUT	XMAX	SIN
PDL	YMAX	SPC
PEEK	SCRN	SQR
POKE	CURSOR	STR$
UT	CURX	TAB
DATA	CURY	TAN
GETC	SOUND	VAL
INPUT	ENVELOPE	IOR
PRINT	NOISE	IAND
READ	FREQ	IXOR
RESTORE	TALK	INOT
CHECK	ABS	SHL
LOAD	ACOS	SHR
LOADA	ALOG	AND
SAVE	ASC	OR

At a glance

FIRST IMPRESSIONS	
Looks	****
Set up	***
Ease of use	****
HIGH LEVEL LANGUAGES	
Basic	****
Fortran	N/A
Cobol	N/A
Pascal	N/A
System Software	N/A
PACKAGES	
Business	*
Education	*
Home	*
PERFORMANCE	
Processor	**
Cassette	***
Disk drives	N/A
Peripherals	N/A
EXPANSION	
Memory	***
Cassette	***
Disk drives	**
Bus	**
COMPATIBILITY	
Hardware	*
Software	**
DOCUMENTATION	****
VALUE FOR MONEY	***

***** excellent
**** very good
*** good
** fair
* poor

GATEWAYS TO LOGIC

Derrick Daines continues his unique series on teaching others the basics of microcomputing.

CHAPTER 4: BINARY ARITHMETIC

At the most fundamental level, all computers, silicon chips and allied gadgetry work with binary arithmetic. Tell most people this and they throw up their hands in horror: "I don't know anything about binary!" they exclaim and give up there and then. Of course they know about binary — far more than they realise. How many hands have they got? How many legs, arms, eyes, ears, nostrils and knee caps? In every case the answer is two, unless accident or surgery has deprived them. If you know that two halfpennies make a penny, then you know almost everything that there is to know about binary.

Thinking about it, binary is the simplest and most natural kind of arithmetic there is. Of course, we are more familiar with decimal (counting in tens), but only through many years of practice. In fact we count in tens simply through an accident of nature — we all have ten digits on our two hands. Had we all been born without a little finger, we'd have counted in eights — which, by the way, is more useful than decimal.

For evidence that binary is better, I refer the reader back to a previous chapter. Something possesses an attribute, or it does not. That dress contains silk or it does not. Only two conditions prevail — yes or no, on or off, true or false; halfpenny or no halfpenny.

When introducing binary for the first time, a good plan is to present the following problem: a certain grocer had a set of scales but a limited set of weights— 1 ounce, 2 ounces, 4 ounces, 8 ounces (½ lb), and 16 ounces (1 lb). Substitute grams if the spirit moves you. The question you ask is, how can he weigh all weights up to 31 ounces? If he wishes to weigh out 1 ounce then of course he uses the one ounce weight; if two ounces, the two ounce weight, while if he want to weigh out 3 ounces, then he must use both the one and the two ounce weights (Table 1). Give the students the first five or six examples and then let them finish the table on their own.

To Weigh	WEIGHTS AVAILABLE 16oz	8oz	4oz	2oz	1oz
1oz					*
2oz				*	
3oz				*	*
4oz			*		
5oz			*		*
6oz			*	*	
7oz			*	*	*
8oz		*			
9oz		*			*
10oz		*		*	
11oz		*		*	*
12oz		*	*		
13oz		*	*		*
14oz		*	*	*	
15oz		*	*	*	*
16oz	*				
17oz	*				*
18oz	*			*	
19oz	*			*	*
20oz	*		*		
21oz	*		*		*
22oz	*		*	*	
23oz	*		*	*	*
24oz	*	*			
25oz	*	*			*
26oz	*	*		*	
27oz	*	*		*	*
28oz	*	*	*		
29oz	*	*	*		*
30oz	*	*	*	*	
31oz	*	*	*	*	*

Table 1 Binary weighing

00001
00010
00011
00100
00101
00110
00111
01000
01001
01010
01011
01100
01101
01110
01111
10000
10001
10010
10011
10100
10101
10110
10111
11000
11001
11010
11011
11100
11101
11110
11111

Table 2
Binary notation

If a new table is drawn up from the first, putting the figure 1 in place of the cross and inserting 0s in all the blank spaces, we have the binary representation of the first 31 numbers — or 32, if you count zero as the first (Table 2).

Any handiman can wire up a few lamps and switches as in Figure 1 and although the battery drain can at times be quite heavy, I personally find it far safer than a mains-powered board — particularly for school use. Many useful and happy hours can be passed using this tool, transmitting decimal number values in binary form. To begin with, have each lamp labelled with its decimal value but as the students get better you should remove the labels. In school, I ask various children to take over transmitting a decimal number; the class has to speak up if a mistake is made.

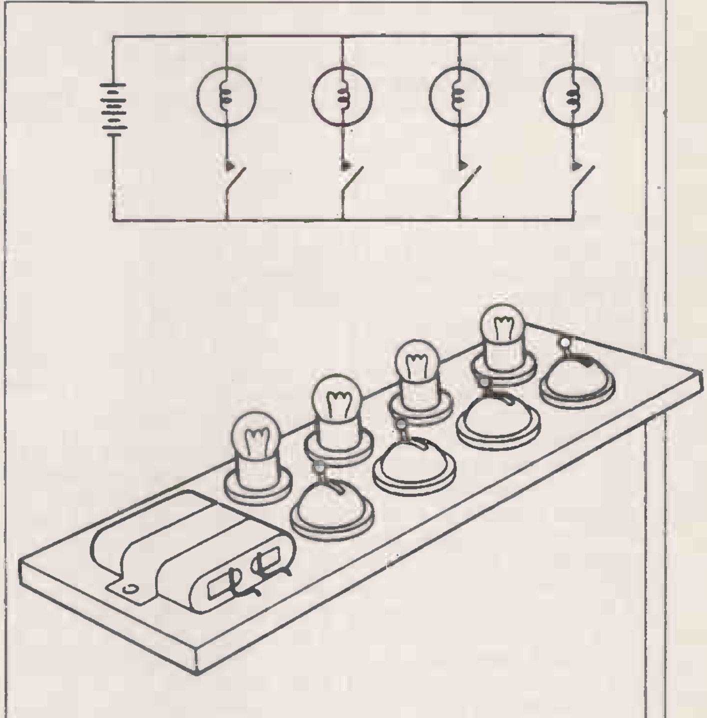


Fig 1

Binary to decimal

Starting from the right, jot down the value of each column. Each column has of course twice the value of the one to its right. If a 1 is present, add it in; if a 0, ignore it. The total value is the decimal count.

Decimal to binary

Divide the decimal number by 2. If there is a remainder, write 1 in the least-significant place of the binary equivalent (Figure 2). If there is no remainder

```
            Start
2 | 17
2 |  8 rem. 1
2 |  4 rem. 0
2 |  2 rem. 0
2 |  1 rem. 0
  |  0 rem. 1
        1  0  0  0  1
```

$\therefore 17_{10} = 10001_2$

Fig 2

write 0. Divide by 2 again, putting any remainder in the next least-significant place. Continue in this way until nothing is left to divide.

Simple binary arithmetic operations are best begun by adding or subtracting 1 (Figure 3). One way to show this would

1	11	111	1000	111111
1+	1+	11+	1−	1+
10	100	1010	111	1000000

Fig 3

be to ask the students to add 1 to a decimal value transmitted through the binary lamps. What will happen is that they will translate the binary number to decimal and then add the 1 — a method which can be cross-checked by working in binary before translation into decimal. A useful little gadget to be introduced here is the binary counter (see Appendix). Several types are available; some work by means of a pawl that actuates the next column if a carry is generated, while others require that the carry is noted by the user. You can see that adding any two binary digits must result in one of only four possible conditions: (i) 0 and no carry, (ii) 1 and no carry, (iii) 0 and carry, (iv) 1 and carry. The last condition is generated only when there has been a carry from the previous column.

Surprisingly, simple binary addition helps people to understand decimal addition a little better. The reason for the carry is better understood, particularly in relation to the base of the arithmetic — ie, 10 or 2. Once this point is grasped, the student is beginning that transition from hard slog with numbers to looking for and utilising their underlying beauty and pattern. Obviously from a classroom point of view this transition is of vital importance if a student is ever to understand thoroughly, let alone enjoy, mathematics. I find one road into this enjoyment is to insist on working in binary and encourage the chortles of delight when carry after carry is generated.

Adding three or more numbers in binary format requires care and is not really recommended. For one thing, there's a tendency to err and for another it's not necessary. No computer or microprocessor adds three numbers at once — they work on a series of operations on two binary numbers at a time and there is no reason why this should not be done by us as well.

Neither is there any special virtue in adding or subtracting enormously long binary numbers. It may be attempted of course and students frequently get pleasure from such strenuous (and useless) activity; in general it's best to confine efforts to six or eight digits. Nor do I advocate binary multiplication or division. Again, though quite possible, for the same reason they're not necessary. Computers complete these operations by multiple additions or subtractions — either of the mantissa or the exponent or both — points that can well be made to the students. It's a good exercise to set a problem such as 3 x 4 to be worked out by multiple addition in binary before final translation of the product into decimal.

I find few children under 12 to be very familiar or comfortable with the values of decimal digits above 1000. They start off very confidently — units, tens, hundreds, thousands, er — millions? (Million is a much-bandied word — see later). When working in binary, the value of each column is easily calculated by doubling the previous (Table 3) and

Power of 2	Decimal Value	Power of 2	Decimal Value
2^0	1	2^{12}	4096
2^1	2	2^{13}	8192
2^2	4	2^{14}	16384
2^3	8	2^{15}	32768
2^4	16	2^{16}	65536
2^5	32	2^{17}	131072
2^6	64	2^{18}	262144
2^7	128	2^{19}	524288
2^8	256	2^{20}	1048576
2^9	512	2^{21}	2097152
2^{10}	1024	2^{22}	4194304
2^{11}	2048	2^{23}	8388608

Table 3

students do derive enormous pleasure from repeated doubling — both to see how far they can progress without error and to see how big the numbers get.

In this context, several stories are worth telling. The oldest concerns the mythical inventor of the game of chess. The story goes that the Emperor of China was so delighted with the game that he offered the wise old man a prize. "I am a modest man," wheezed the wily old devil, "Just give me one grain of rice for the first square, two for the second, four for the third, then eight for the fourth and so on until all the board has been dealt with." Since there are 64 squares on a chess board, had the Emperor been able to comply with the request, he would have needed the entire world production of rice since the dawn of time!

Tear a sheet of newspaper across, thus doubling its thickness, then tear it again. Continue in this way as far as you can ... you'll be surprised how few 'doublings' you can make. If it were possible for you to carry out just a few more, the wad of paper would be so thick that you'd be able to stand on it and reach the moon.

Tower of Hanoi

Binary arithmetic crops up in the most unlikely places and this ancient game or puzzle is one of them. The equipment is easy — a few books of different sizes will do, or a child's set of nesting bricks; a de luxe model can be made from a set of plywood discs of increasing size and three nails in a block of wood (Figure 4).

The problem is simply stated. Moving one disc at a time, the object is to move the stack to one of the other pegs, with the sole proviso that at no time is a disc to be stacked above one smaller. Six or eight discs are enough.

The first few moves can be demonstrated — disc 1 to spike B, 2 to C, 1 to C, 3 to B, 1 to A, 2 to B, 1 to B, 4 to C. After that you're on your own! People can play this game for hours, especially if there's a prize going on for the one who does it in the least number of moves. I guarantee that unless the user is in on the secret, he or she will expend many unnecessary moves. It's reasonably easy to see what to do when dealing with the smallest discs (thinking in pictures again!), but when it comes to dealing with the larger discs, that's where the problems start.

The clue to the solution is to realise that it's binary in nature. As with the grocer and his weights, so it is with the discs. What is the pattern? Well, the grocer utilised his smallest weight every alternate weighing and in the current problem the smallest disc is moved every alternate go. Easy though it may be to spot this, it's not so obvious that the smallest disc has a pattern of movement, from spike A to B and C; A, B, C, A, B, C, ... it never varies. If these two simple rules are followed then the smallest number of moves will result; that's

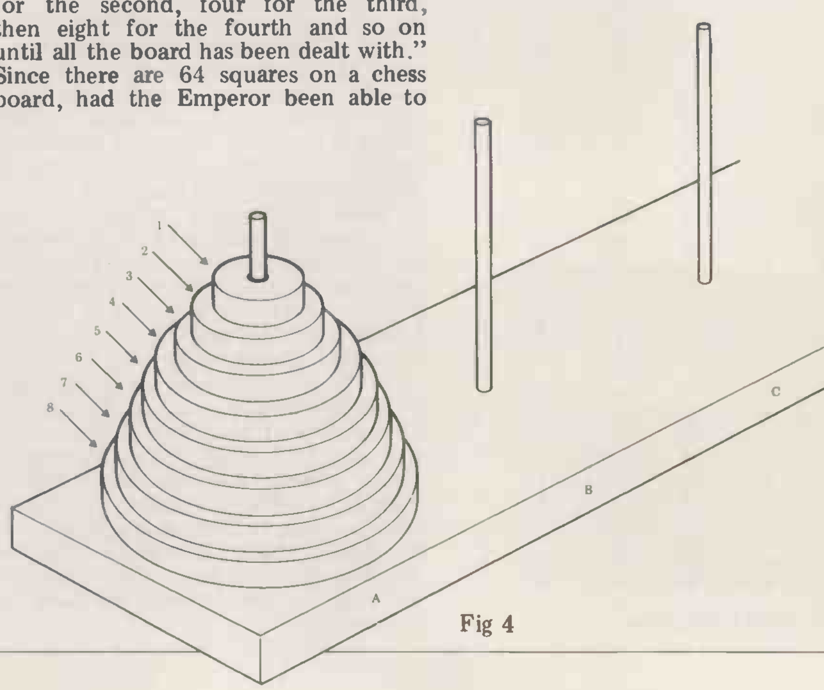


Fig 4

RED	Y'W	BLUE	SQ	RecT	CIRC	TRI	LGE	THK	
0	0	0	0	0	0	0	0	0	— no block applicable
0	0	1	0	0	0	1	0	0	Note that last three digits are used to count 0 — 3 in binary.
0	0	1	0	0	0	1	0	1	
0	0	1	0	0	0	1	1	0	
0	0	1	0	0	0	1	1	1	
0	0	1	0	0	1	0	0	0	Repeated for circle
0	0	1	0	0	1	0	0	1	
0	0	1	0	0	1	0	1	0	
0	0	1	0	0	1	0	1	1	
0	0	1	0	1	0	0	0	0	
0	0	1	0	1	0	0	0	1	
0	0	1	0	1	0	0	1	0	
0	0	1	0	1	0	0	1	1	
0	0	1	1	0	0	0	0	0	
0	0	1	1	0	0	0	0	1	
0	0	1	1	0	0	0	1	0	
0	0	1	1	0	0	0	1	1	— completing the blues
0	1	0	0	0	0	1	0	0	
0	1	0	0	0	0	1	0	1	

— and so on for all the yellows and finally the reds.

Table 4

because, of the two spikes other than that occupied by the smallest disc, there is only one legal move. If the game is interrupted, it's only necessary to remember whether or not the smallest disc was moved last time.

To find the minimum number of moves necessary we work from the top down. If there was only one disc of course there would only be one move; two discs — three moves; three discs — seven moves; four discs — fifteen moves. Spot the connection? The number of moves needed is the binary series of Table 3, less 1. If you follow the table, you will see that 63 moves are needed for six discs, while for eight discs the figure rises to 255 moves. Masochists might like to make themselves a set of ten discs — and be happy in the knowledge that they will require a minimum of 1,023 moves.

The story, you might like to hear, is that in the ancient city of Hanoi there is a team of Buddhist monks dedicated night and day to the task of moving one disc a minute and that when they've finished the puzzle, the world will end. Since there are 32 discs in their set, should we worry? Not on your life! Apart from the fact that I secretly doubt a Communist regime tolerating such a useless pursuit, with that number of discs and at that steady speed of operation, the puzzle will take over 8000 years to complete! Incidentally, the fastest computer in operation, moving a million discs a second, would take over 3 days to complete the job.

Binary coding

The great advantage of binary coding — and the reason why computers are good at keeping track of things as well as crunching numbers — is that anything can be coded in binary form. Think back to those logic blocks. A piece is either thick, or it is not (and if, for instance, it is *not* thick, we have no need to enquire whether it is thin.) The possession of such an attribute can be assigned the binary number 1, while of course absence of the attribute is indicated by 0. This provides us with a very powerful tool for computer classification.

But of course you'll soon be asked the question, "If we have 1 for red, 0 can't be blue, since it could be yellow!" Quite right. In circumstances where one attribute does not necessarily exclude another, there have to be separate binary bits for each attribute. In Table 4 I give one method of binary coding for a set of logic blocks. There are of course several acceptable methods, depending upon the order in which the attributes are considered.

Tear up a mail-order catalogue and distribute the pages. Each student takes one type of product — ladies' fashions, watches, bicycles — and devises a simple series of questions, answerable by yes or no that will differentiate one product from the next within the category in which he is dealing. The set of questions is then applied to each product in turn, yielding a multi-digit binary number that becomes the code for each product. If two products turn out to have the same code, then another question must be devised to differentiate them. In order to eliminate ambiguity absolutely, the choice of questions requires considerable thought; the number of questions asked has also to be kept to the very minimum. With minor variations, this is essentially the method used in mail-order houses, a point which should be made to the student. Ask questions like, "If Mrs Smith writes 7F on her order form instead of 7E, what product will she get?" The answer to this question will do much to explain the irritation of modern computerised shopping!

For display purposes, it's worth cutting out some attractive pictures and mounting them on card to illustrate binary coding. (See a previous chapter for a method of turning binary into hexadecimal.)

Exactly the same method will yield a pattern of 1s and 0s for use in a binary selection box. Both boxes and suitable cards are available commercially. When purchased, the cards are of course blank but with a series of holes punched along the top and bottom edges. A hole represents a binary 0 and to change it into a binary 1, the user simply turns the hole into a slot with two quick snips of the scissors (Figure 5). Cut-out pictures from the

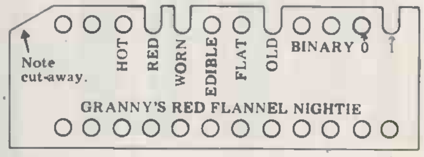


Fig 5

mail order catalogue are stuck onto the faces of the cards and of course the questions must be matched, hole for hole. I recommend that, to avoid confusion, the bottom row of holes be ignored for now; later it will be possible to use them with a different type of product, pictured on the back.

Having assembled a collection of pictures coded in this way, the student may then put the stack of cards in the box for easy selection with the aid of a knitting needle (Figure 6). For example, a range of dresses may be sorted to see which have a vee neckline; put the needle through the vee neck slot and shake. Since the box has no bottom, those cards bearing a yes answer — binary 1 — will not be held by the needle and will fall through.

Perhaps a more exciting method is to imagine a widely disparate selection of objects such as the Sahara Desert, the sea, a fire engine, a two-ton Xmas pudding, a Chinese penny and so on, including a few fun objects like granny's red flannel nightie, a bloodstained concrete slab or a pair of prehistoric knickers. This can be coded as before, posing such questions as, "Are you red?", "Are you near?", "Are you hot?" and so on. Note, by the way, that the cards all

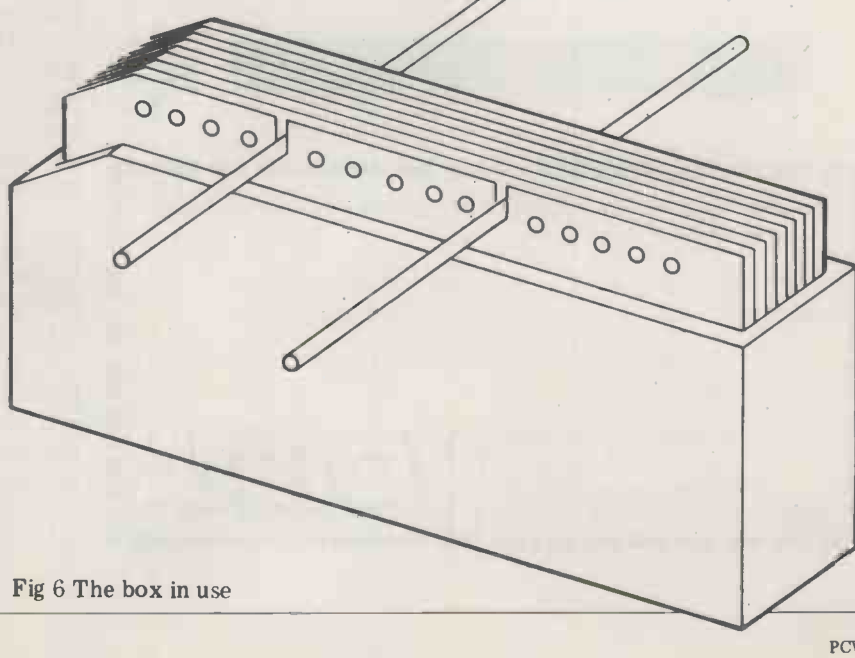


Fig 6 The box in use

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Multi-User PET (Mu-pet) links 3-8 PET computers to one Commodore disc drive and a printer.

Mu-pet is very good news indeed for those PET users wanting a multi-user computer system and who, up until now, have run up against a budgetary brick wall.

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All machines have access to the disc drive and printer. The hardware which all runs via the IEEE bus has been so well designed that each PET thinks the disc is its own, and priority depends on who gets there first.

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Yes, I want to see the Mu-pet show – please advise me on my nearest dealer.

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____

____

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come with one corner snipped off; this is simply to ensure proper alignment within the box....all cut corners must line up.

The method of extracting all cards carrying an object with a given attribute has been described already — we put a needle through the hole and shake. Those cards with the attribute drop through and, conversely, those without it stay in the box, suspended by the needle. But operations may easily be combined. If for example we wish to find all objects that are RED AND OLD AND WORN, we put needles through RED, OLD and WORN simultaneously. The OR operation is slightly different. If we want objects that are RED OR OLD OR WORN, three operations are needed to shake out first those that are red, then those that are old and lastly those that are worn.

Combinations can get quite complicated. If, let us say, we're asked for objects that are RED AND OLD OR RED AND WORN, we must be very careful. Does it mean (RED AND OLD) OR (RED AND WORN), or RED AND (OLD OR RED) AND WORN? Read that again — they really are different! Let's suppose that what is required is (RED AND OLD) OR (RED AND WORN). Two operations are needed; first a shake with needles through RED and OLD, then a shake with needles through RED and WORN.

The NOT attribute is useful too. Suppose we want articles that are OLD AND RED AND NOT WORN then again two operations are necessary. The first shakes out those that are OLD AND RED by means of needles through both at once. Now, discard those cards that remain in the box and put in their place the OLD AND RED. Insert the needle again, this time, through WORN. Those that fall out are of course WORN and therefore not wanted.

We may summarise the operations as follows:

(i) Positive attributes drop through
(ii) Negative attributes remain in the box
(iii) AND operation — two or more needles at once
(iv) OR operation — two or more needles in different operations

Sooner or later students will notice that the questions are ambiguous. This will happen when the result of the operation produces an unexpected result. "That's not near!" they will protest, and they'll be right. Just what do we mean by near, anyway? How hot is hot? We could perhaps stick to unequivocal questions and decisions when devising the cards — as for example the vee neck question — but it's better to deliberately allow ambiguity to creep in so that the teaching point is made a little more forcibly. Now is the time to start introducing the idea of standards and precision.

Make up a set of cards so that the binary numbers 0—111111 are represented (0—63). It's easy to select any particular number in one or more operations. At first it may seem possible for any number to be selected in one operation, but a little thought will show that this is not true. Suppose for example we wish to select binary 1. To do that we put a needle through the first position; half the cards will drop out and will require further operations upon them. Several more operations are needed because the 1 required is (NOT 32) AND (NOT 16) AND.... etc. to (NOT 2). It follows therefore that we put needles through 32, 16, 8, 4 and 2 in turn. Each shake will drop out some cards that have that attribute, leaving behind the one that we want. This is a rather important concept and one I shall return to when dealing with computer gating.

Many of the computers that check batches of products are programmed to accept a range of tolerances and a good type of question to pose with binary selection cards is to ask students for a series of operations that will select all cards between, say, 8 and 12 — a question that will cause some considerable head scratching.

The old parlour game of Twenty Questions is a good lead up to binary coding of products, since of course acceptable questions must be answerable by yes or no.

A practical use of the binary selection box is a school filing system. Such systems were widely used commercially before the advent of the computer. One card could be made out for each pupil, with questions relating to birth date, colour of eyes and hair, games played, academic achievements, languages studied and anything else considered relevant. Immediately, a multiplicity of logistic questions are solvable in moments. "How many red-haired children have we got that ride bikes? Hang on a minute." A steel rod through the hundreds of cards at the spot marked RED HAIR, another through the spot marked BICYCLE, a shake, and the answer is there in the number of cards that drop out. Compare that with the time taken by the usual method of going to each class in turn and counting heads after explaining what is wanted.

I find that students will happily and easily apply the method to their own class grouping and will soon spot the weakness in the system, that of addressing. If the school sits in the middle of an estate for example, how do we set about dealing with the question, "How many children live in Farnsfield Road?" We could have a binary bit for Farnsfield Road, but that would also mean that we would need a binary bit for every other road, street, avenue, lane and close. Clearly, we would soon run out of available space on the cards. The system is inefficient and luckily it is also unnecessary.

Before I go on to consider the solution, however, I would recommend a simple game. One player announces, "I am thinking of a number between 0 and 9. What is the number? You have three guesses." To each guess the reply is given, "Too high," "Too low," or "correct."

How would you tackle the problem? One way would be to hop about wildly at random, hoping to hit on the answer. This is the most inefficient method, although it might result in a stroke of luck. Another way would be to start at 0, then 1, then 2 — by then you would have run out of guesses. This is like having one binary bit for every street on the estate. The best method — and one that results in the correct answer every time — is to *divide the margin of error.* At the start, one knows only that the number sought lies between 0 and 9, so we divide the error and guess 5. Suppose that's low. We now know that the number lies between 6 and 9, so again we divide the margin of error, guessing 7. The next time we are certain to get the answer right, save solely in the extreme case of 9, which will require one more guess (Figure 7). This game,

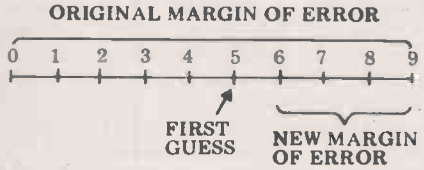

Fig 7

by the way, lends itself admirably to loading as a program in even the simplest computer.

And it gives us the clue we need to tackle the addressing problem; we must divide the margin of error. The first question to ask is if the chosen address is North or South of a line drawn through the school; then if it is East or West of a similar line at right angles to the first, Hence in two binary bits we are able to describe four areas. By now I expect you're beginning to see the start of a Carroll mapping.

We cannot move on from the binary selection box without mention of the sorting sequence. Shuffle the pack of coded number cards and place them in the box. Now the question is, what is the minimum number of moves needed to put them all back into correct order? Those who have studied the binary sequence will know that the number is surprisingly small; with 64 cards, only 6 moves are needed. Starting with the least-significant bit, insert one needle and shake. All the cards that drop out are retained in their original order, but placed carefully behind those that remained in the box. Repeat, using a needle in the next least-significant bit, and the next, and the next. With this done up to the sixth bit, all cards will be in the correct binary-coded order. I'll leave the reader to sort out why this is so. Children are of course very intrigued by the process — as they are by everything connected with the binary selection box.

The physical operations performed by pushing needles through the holes in cards has its close analogy in the way that the computer searches through data. As we'll see later, all data consists of binary digits, so that if the computer is searching for a bank account number, fingerprint match or what-have-you, deep in its electronic heart it carries an image in binary of whatever it is that it's looking for and it compares that image, bit by binary bit, with all relevant store contents. It's only the terrific speed of operation that tends to conceal from us the painstaking way in which it searches.

The binary selection box is therefore an excellent teaching aid at several levels, having much to offer for the teaching and understanding of binary arithmetic, the organisation of data and the understanding of logic; it's also a handy model of computer operation.

Suppliers

Invicta Plastics Ltd., Oadby, Leicester.
Supply Binary Counters

PARKINSON'S PEP-UP

Is your microcomputer sluggish? Do your programs stroll instead of RUN? Here's a tonic to get things moving more quickly, from David Parkinson.

Microchess is a small chess program written by P Jennings and T O'Brien. The version I have was written in 1977 and is in 8080 machine code. From a passing reference in *Byte* (March 1978 p166) I believe my version of Microchess may be a translated version of the program originally written for the KIM1 in 1976. The current versions for Apple, PET, TRS-80, etc may well differ in internal structure so all references to Microchess here refer to the early 8080 version.

The program offers three levels of play and runs in about 3.5k of RAM. I wanted to transfer the program to an 8080 system which had only 1k of RAM but sockets for 8k of ROM. Having reverse assembled it I altered and moved certain sections of the code in order to produce a 'ROMable' version. While doing this it became apparent that once the program had been written and debugged no real attempt had been made to tidy up the remaining code. Among other things I found a conditional jump around an unconditional call and several conditional jumps that terminated in an unconditional return. It seemed it might be possible to gain a noticeable decrease in the program's response time by removing redundant coding such as this.

Running at the 'normal' speed setting, Microchess takes about 90 seconds (Z80 at 2.5 MHz) to decide on its move. During this period it is going through a repetitive process of generating a move, saving the board position, moving a piece, evaluating the new position, exchanging sides, restoring the previous position and trying a new one. All the routines had at least one small (or not so small) possible modification but which were worthwhile? Saving a single 10-cycle instruction from a routine that was only executed 100 times would not be noticeable, but if it were repeated 1,000,000 or more times it would. The evaluation routine could well be one worth attention (cf David Levy, PCW May 1979).

The way to find the critical routines is by measurement rather than by inspired guesswork. By regularly sampling the microprocessor's program counter, a histogram or similar record can be built up showing the level of activity in various areas of the executing program, the areas of highest activity being the ones offering the possibility of the best return for any recoding effort.

Luckily we already possess the tool necessary to do this — the processor itself — so there's no need to beg borrow or steal expensive and complex analysers to connect to the address bus. The sampling can be done by the processor in response to a request through its interrupt system.

The interrupt system

The way to use this approach depends on your particular microprocessor and its hardware configuration. In my system the interrupt system is unused and so it was a simple matter to connect the circuit shown in Figure 1 to the system. Those whose interrupt systems are already in use should be able to find a suitable way to connect a similar circuit to their system, or be able to generate a regular interrupt with existing hardware such as a counter-timer.

A full description of interrupts and interrupt systems will not be discussed here but for those unfamiliar with them here's an outline of the Z80's (mode 1) interrupt behaviour: at the end of each instruction cycle (if the interrupt system is enabled) the Z80 samples the state of the $\overline{INT}$ line. If the line is high the Z80 continues with the program it is executing. If the line is low the Z80 does not fetch the next instruction but outputs an acknowledge signal by taking $\overline{M1}$ and $\overline{IORQ}$ low simultaneously and then executes an 'RST 56' instruction. In other words, taking the $\overline{INT}$ pin low automatically causes a CALL to address 38H provided the interrupt system is enabled.

Why interrupt?

The interrupt effectively inserts a CALL instruction into the program flow. As a result of this CALL the current content of the program counter is pushed onto the stack; so, to discover which section of the program was executing, all the interrupt routine has to do is to examine the return address on the stack. By arranging for the interrupts to occur on a regular basis the interrupt routine can build up a table which shows where it found the program executing. The more often a section of code is executed, the more likely it is to be 'caught' by an interrupt, and, if we take a large enough sample, we should have a representative picture of the activity within the program.

But beware! For this approach to be possible the interrupted program must use the stack pointer in a hygienic fashion. At any time, if an address is suddenly pushed onto the stack as a result of an interrupt it must not overwrite valid data. Also, on return from the interrupt routine, all internal CPU registers must contain the values they held at the time of the interrupt. (Microchess does switch the stack pointer back and forth between two areas, but these are two normal stacks; data is PUSHed on and POPped off, the stack pointer always pointing to the bottom of the current saved data/addresses and never into the middle.)

The software

In building up the table we are only interested in certain sections of the program. (There is no need to speed up the first section of Microchess because nearly all the time is spent waiting for the player to type in his move.) There are two possible approaches to ensure

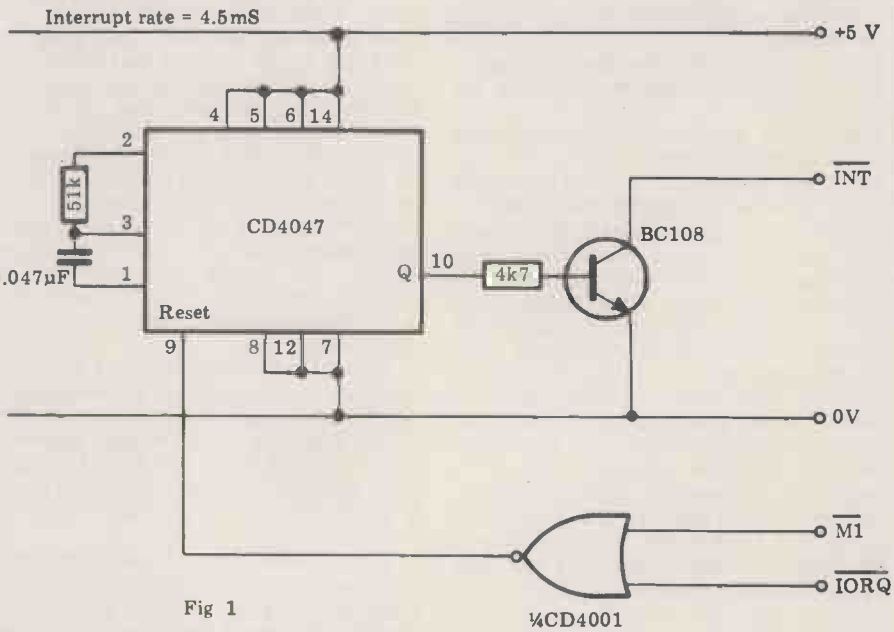

Fig 1

The CD4047 monostable is wired to run in its astable mode. When the Q output goes high it switches on the transistor (any small signal NPN transistors will do) which pulls the INT line low. The Z80 acknowledgement (if it occurs) is detected by the NOR gate and is used to clear the 4047. This removes the interrupt request and starts the 4047 timing period off again. If the Z80 interrupt system is not enabled the 4047 free runs and the INT line (which goes alternately high and low) is ignored by the Z80.

Alternatively the 4047 Q output, (or the output of a baud rate generator), could be connected to the strobe input of a parallel I/O port such as a Zilog PIO or Motorola PIA if such a device is already connected into the interrupt system.

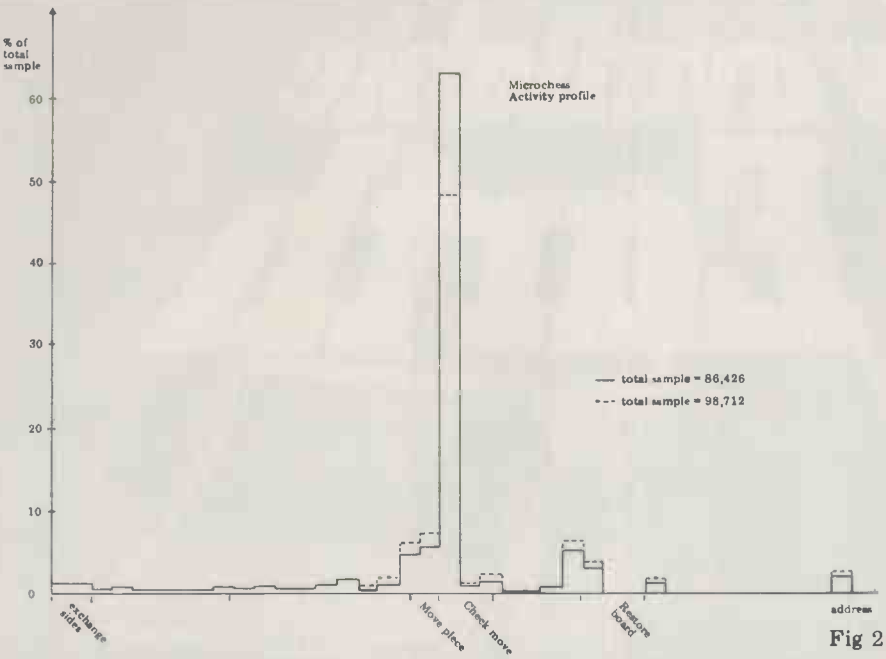

Fig 2

that only useful data is recorded: the first is to enable the interrupt system only while the program is within the area of interest; the second, applicable to those whose interrupt system cannot be inhibited, or where the analysis is more complex, is to make the routine ignore any addresses that lie outside the range of interest.

The interrupt routine used on Microchess is shown in the listing. The complexity of this routine will depend on several factors, the primary one being the amount of free memory left in the system after the program under investigation has been loaded. Ideally it should be a simple 'data collection' type of routine which leaves the basic data to be analysed by another program. This allows the analysis program to be run several times, the analysis criteria being changed between runs in order to amplify any interesting points revealed by the earlier runs. With too much preprocessing the interrupt routine would have to be changed and the whole sampling process repeated, but this cannot be avoided if there is only a small amount of free memory left after the program under analysis is loaded.

Application to Microchess

Within Microchess the main program flow is:

Player makes move
Call Display
Call Microchessmove
Print move
Call Display

and so to control the range analysed by the interrupt routine 'enable interrupt' and 'disable interrupt' instructions were inserted before and after the call to Microchessmove. The interrupt routine (see listing) used one 16-bit counter per two addresses within Microchess.

The table area was cleared and Microchess started running. A game was then played against Microchess until the interrupt routine dropped back to the monitor (automatic when any 16-bit count reached 32,512). Having generated the data table it was analysed by a simple Basic program. The USR function was used to access the table, although PEEK or DEEK could be used equally as well. Assembler language programs can of course be used, or even a manual examination of memory from the monitor, but a Basic program is the simplest approach, assuming there's still room to run it. The program summed the samples to produce a total and then printed out the percentage occupancy (to two significant figures) per 16-byte block of code; with graphics facilities you could produce a more readable display. From these figures the activity profile of Figure 2 (solid line) was plotted. The program apparently spent 63% of its time in just 16 bytes of code!

After checking the hardware and software and repeating the measurement, I accepted this as fact and examined the code of those 16 bytes. This is also shown in the listing and related to Microchess's internal representation of the chess board. Microchess does not hold an image of the board, but instead has a 'piece table'. This table, which contains one byte per chess piece (ie 32 entries), holds the board position of each piece. If a piece has been captured its board position is greater than 77H, the board coordinates being 0,0 (00H) to 7,7 (77H). Thus the program, having generated a move to a particular square, has to search the piece table to see if anything is actually standing on that square. It was only after realising that the five lines of the loop are often repeated at least 32 times per move (5x32=160 lines of program) that I began to accept the figure of 63%. (If the routine finds the square is occupied it may already be well down the table. If the piece is of the same colour it immediately generates a new

GOTO page 123

```
Activity Profile for Microchess

0000                  ;
0000                  ;  Mode 1 Interrupt Patch
0000                  ;
0000                          ORG   56          ;RST 56 address
0038  C3 10 50                JP    INTRTN      ;Transfer to  Interrupt routine
003B                  ;************************************************************
003B                  ; USR function for MITS BASIC V.4.0
003B                  ;************************************************************
003B                          ORG   $5000
5000  CD 38 07        ACCESS: CALL  DEINT       ;Get parameter in call
5003  21 00 50                LD    HL,$5000    ;Base of RAM table
5006  19                      ADD   HL,DE       ;Index into it
5007  46                      LD    B,(HL)      ;Get lo' byte
5008  23                      INC   HL
5009  7E                      LD    A,(HL)      ;Get hi' byte
500A  C3 E5 0D                JP    RETV        ;Return value to Basic
      0738            DEINT:  EQU   $738
      0DE5            RETV:   EQU   $DE5
500D                  ;************************************************************
500D                  ; Interrupt routine for Activity Profile
500D                  ;************************************************************
500D                  ;  One 16-bit count per two addresses
500D                  ;  Expected range of addresses $442B to $493C
500D                          ORG   $5010
5010  08              INTRTN: EX    AF,AF'      ;Save registers
5011  D9                      EXX
5012  E1                      POP   HL          ;Copy return address....
5013  E5                      PUSH  HL          ;.....to HL
5014  11 00 10                LD    DE,$1000    ;Offset to RAM table
5017  19                      ADD   HL,DE       ;Address now $5XXX
5018  CB 85                   RES   0,L         ;Make $5XXY where Y is even
501A  34                      INC   (HL)        ;Bump counter there
501B  20 08                   JR    NZ,EXIT     ;Leave if no carry
501D  23                      INC   HL          ;On to the high byte
501E  34                      INC   (HL)        ;Add the carry in
501F  7E                      LD    A,(HL)      ;Check it
5020  FE 7F                   CP    $7F         ;Full?
5022  CA 39 F2                JP    Z,$F239     ;Yes, drop back to monitor
5025  08              EXIT:   EX    AF,AF'      ;Restore registers
5026  D9                      EXX
5027  FB                      EI                ;Turn on interrupts again
5028  ED 4D                   RETI              ;Done, continue with M.chess
502A                  ;************************************************************
502A                  ; Section of code from Microchess
502A                  ;************************************************************
502A                          ORG   $46A0
46A0  0E 1F                   LD    C,31        ;No. pieces in table (0-31)
46A2  21 9C 49                LD    HL,PTABLE   ;Top of piece table
46A5  BE              LOOP:   CP    (HL)        ;Do coordinates match?
46A6  CA B1 46                JP    Z,FOUND     ;Yes,skip
46A9  2B                      DEC   HL          ;Next entry
46AA  0D                      DEC   C           ;Next piece
46AB  F2 A5 46                JP    P,LOOP      ;Loop if more in table
46AE  C3 B9 4C                JP    EMPTY       ;Not in table
46B1                  ;
      499C            PTABLE: EQU   $499C
      4CB9            EMPTY:  EQU   $4CB9
      46B1            FOUND:  EQU   *
                              END
```

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SHARP COMPUTER APPLICATIONS

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COMPUTER GAMES

David Levy continues his historical survey of the most important milestones in mainframe chess programming.

The first program of the modern generation was written at MIT by Richard Greenblatt, a student, and two colleagues. Work on the program began in November 1966 and by April the following year it had scored two wins, two draws and no losses in a tournament with human players. Based on statistics given in Greenblatt's paper, I would estimate that his program, at that time, was stronger than any commercially available chess machine currently on the market. The name of his program was MacHack VI.

MacHack employed a plausible move generator containing some 50 heuristics. The program was intelligent enough to know that certain heuristics were not always applicable, but depended on the nature of the position. In this way, moves selected by the plausible move generator were not always exactly the same set of moves as those which would have been chosen by a linear evaluation function. From this aspect of MacHack's decision process the microprogrammer can learn an important trick — it is often useful to use one evaluation mechanism (or set of heuristics) to select the plausible moves for the tree, and another one for performing the evaluation of terminal nodes.

The plausible move generator made its decisions by considering the moves themselves, rather than the positions arising after the moves were made. For example, if a move is bad because it blocks the line of attack of another of the player's pieces, the program would recognize the fact rather than look at the resulting position and say to itself "Hey! This position is bad because my bishop is blocked." By accepting or rejecting moves for the plausible move list in this way, the program saved a great amount of computation.

During the plausible move computation, each square of the chess board was assigned a measure of importance, corresponding roughly to the estimated value of having an extra piece attacking that square, or the cost of moving away a piece which currently attacked that square. The most important criteria used for assigning these values included how near the square was to the centre of the board or to the enemy king, and whether or not the square was occupied by one of the program's pieces under serious threat.

The value of a piece in strategic terms (as opposed to its actual material value) was related to the number of squares it attacked ie its mobility, and to the number of enemy pieces that it attacked. These strategic values were computed for the piece in its old and new locations and a strategic gain was taken as an indication that the move should be on the plausible move list. In other words, if a move appears to put a piece on a better square, that move is worth further examination.

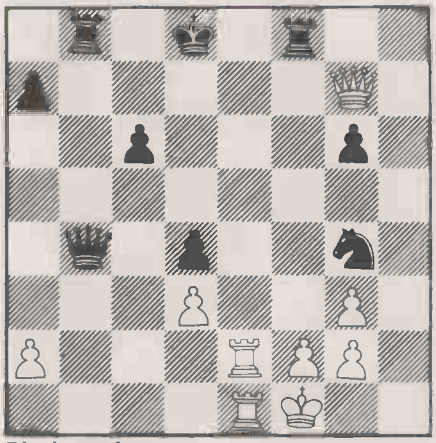
The program encouraged certain types of attack on squares that were considered possible weak points, for example weak pawns, pinned pieces, and pieces defending other pieces. Moves which fell into these categories were also added to the plausible move list.

MacHack performed an alpha-beta search, with forward pruning. The plausible move generator would select a number of moves at each level of lookahead, and add to this number any moves which satisfied certain conditions: all safe checks were examined; at the first and second plies all captures were investigated; the moves of a certain number of distinct pieces are examined, so that the program would not ignore most of the board if all of the moves of a single piece were highly plausible. The minimum number of moves selected by the plausible move generator was normally six at each level of lookahead, but in tournament mode, ie when playing at a rate of 2-3 minutes per move, the program would examine a minimum of 15 moves at the first two ply, nine moves at the next two ply, and seven moves at each subsequent level. Only when the minimum number did not exist (for example when one side was in check or had only its king on the board) would the search be narrower, though of course the alpha-beta algorithm would often prune away branches on which there were plausible moves.

One of the few advantages that mainframe programmers have over those writing for a micro, is the availability of enormous backing store. This enables a program to employ transposition tables, which are advantageous in preventing the program from evaluating the same position more than once. In chess, as in many other games, it is frequently possible to reach the same position by different routes, and we call this phenomenon transposition. As a simple example, if White makes move A, Black makes move B, and White then makes move C, we shall reach the same position as if White had made his moves A and C in the reverse order. MacHack produced a hash value for every position evaluated in the tree search, and together with this value the program stored the score for the position and a note of the depth of search at which the evaluation took place. If the position is created again during the search, the program would not recompute the score for the position but would take it from the value scored together with the hash for that position. Even though MacHack stored only 32,000 positions in hashed form, it was able to save considerable computation time and as a side benefit, it was quickly able to detect draws by repetition.

The MacHack program represents the first really significant milestone after Shannon's paper because it was the first program to make good use of the Shannon-B strategy. The strength of the program in 1967 was extremely impressive and created considerable publicity for computer chess among the computing and chess fraternities. This publicity served as the impetus for many of the groups which started programming around 1967 or 68, for example the Slate/Atkin/Gorlen group at Northwestern University and Newborn at Columbia University. In fact Greenblatt and his colleagues probably did as much for computer chess in 1967 as Shannon had done almost 20 years earlier.

I should like to offer you two examples of the playing strength of the Greenblatt program. The first is a position which was shown to several strong American chess players, including Masters, and defeated a number of them.



Black to play

This position is a win for Black, who has an extra knight for a pawn. But the task is to find a quick win. If White is allowed to survive he might conjure up counterplay based on the exposed position of the black king and the weakness of Black's pawns on g6 and a7. How can Black force a quick win?

MacHack discovered the correct continuation:

1 . . . f8-f2+

For the program to play this move it must have been able to see 9-ply ahead, in the crucial variations.

2 f1-g1

The alternative was 2 e2-f2 g4-h2+ 3 f1-e2 (or 3 f1-g1 b4-e1+ 4 g1-h2 e1-f2, when Black is a rook ahead) 3 . . . b4-b2+ 4 e2-d1 b2-b1+ 5 d1-e2 b8-b2 mate.

1 . . . f2-e2
3 g7-h8+ d8-c7
4 h8-f6 e2-e1+
5 Resigns

To show that a computer program is a good chess player, it is not enough to give an example of its tactical prowess. The very best programs are extremely adept at tactical combinations but are often let down by their poor strategic understanding. So the proof of the whole pudding must lie in an examination of complete games. The following is the first game ever won by a computer program in a chess tournament. Its opponent was rated 1510 on the USA rating scale, equivalent to a weak club player. The game was played in the Massachusetts State Championship, 1967.

WHITE: MacHack VI
BLACK: Human

1 e2-e4 c7-c5
2 d2-d4 c5-d4
3 d1-d4

MacHack knew no openings at that time and plays very much as many of today's commercially available machines. This type of opening is bad for White because it allows Black to bring out his pieces 'free of charge', by using developing moves to harass the white queen.

3 . . . b8-c6
4 d4-d3 g8-f6
5 b1-c3 g7-g6
6 g1-f3 d7-d6
7 c1-f4 e7-e5

A dubious decision. The human was obviously worried about the possible advance of the white pawn from e4 to e5, but Black should have continued 7 . . .f8-g7, and if e4-e5, then f6-h5, attacking White's bishop.

8 f4-g3 a7-a6
9 e1-c1 b7-b5
10 a2-a4 f8-h6+ ?

An ineffective move that weakens an important central pawn. One gets the impression that the human felt he could take risks against MacHack.

11 c1-b1 b5-b4
12 d3-d6

Black, when making his tenth move, almost certainly overlooked the fact that on the d6 square, White's queen or rook will fork the two black knights on f6 and c6, thereby rendering harmless Black's threat to the white knight on c3.

12 . . . c8-d7
13 g3-h4 h6-g7
14 c3-d5 f6-e4
15 d5-c7+

Black may have overlooked this response, but in any event his position was hopeless.

15 . . . d8-c7
16 d6-c7 e4-c5
17 c7-d6 g7-f8
18 d6-d5 a8-c8
19 f3-e5 d7-e6
20 d5-c6+

MacHack spots a simple queen sacrifice that forces mate.

20 . . . c8-c6
21 d1-d8 mate

A benchmark chess program

It is perhaps worth mentioning in passing the work performed by Jim Gillogly during the early 1970s on a program designed as a benchmark for other chess programs. Gillogly's program, which he named TECH, had a very simple program structure which could easily be emulated by anyone using a micro. Rather than perform strategic evaluation on all terminal nodes in the tree, the TECH program only took a close look at the nodes at the first level of look-ahead. It evaluated all these positions, sorted them into order and only changed this order if a full-width search revealed the forced win or loss of material for a root move. Programs with such a structure can play perfectly recognisable chess and are tactically quite satisfactory but they are hindered in their overall playing performance by a lack of strategic depth.

Those of you wishing to start writing chess programs for your own machines could do a lot worse than employ Gillogly's approach. Because strategic evaluation is only carried out on the (say) 30-40 root moves, the program can perform quick full-width search, using the alpha-beta algorithm, to detect forcing variations that affect the material status of the board. Such a program is relatively easy to write and should perform at roughly the same level as a Chess Challenger, provided that your strategic evaluation function is well thought out.

Gillogly argued that to be of any real merit, a chess program must be able to play better than a TECH type program, given the same amount of time, because the TECH program did not do anything clever. A really good programmer could probably write a TECH type program in little more than 2k of code (assembler) and I would not be surprised to see a program of that size playing better chess than some of the 8k and 16k cassette programs available to personal computer users today.

Deep or shallow search

Not entirely unconnected with the previous section is the question of how essential it is to search the game tree as deeply as possible. There are two distinct schools of thought on the subject: programmers usually prefer to search as deeply as possible, on the grounds that they are more likely to notice neat tactical possibilities; but a minority believe that shallow search, with more attention being devoted to each node, can lead to equally good play. Since human chess players look at a very small tree, this second approach is clearly endowned with some merit, but most chess programmers prefer the exhaustive search technique, possibly because of a lack of confidence in their own ability to create an advanced evaluation function that would be sufficiently sophisticated to perform drastic forward pruning.

Up to now almost all of the world's strongest programs have been the 'brute force' type — searching enormous trees but performing relatively little sophisticated evaluation at the terminal nodes. The TECH program is possibly the supreme example of this genre, performing only a material evaluation at the terminal nodes. We do not yet have sufficient experience with intelligent chess programs to be able to determine which approach is superior but I hope that the following game, despite exhibiting rather passive play by Black, will convince the reader that brute force is not the only possible route to a master strength chess program. For those programming chess on a micro, the intelligent approach offers much scope for original research and I would like to hear from readers who have any interesting or fresh ideas on this subject.

This game was played in a computer tournament in Dortmund in 1975.

WHITE: Schach MV 5.6
BLACK: Fischer/Schneider

1 b1-c3 d7-d5
2 d2-d4 c8-g4
3 f2-f3 g4-f5
4 e2-e4 d5-e4
5 f3-e4 f5-d7
6 g1-f3 b8-c6
7 e4-e5 e7-e6
8 c1-g5 f8-e7
9 d1-d2 g7-g6
10 f1-d3

So far Black has played rather passively, but White has developed its pieces on sensible squares. White's latest move is, in fact, a mistake, which should lose a pawn to 10 . . . c6-d4 11 g5-e7 d4-f3+ 12 g2-f3 g8-e7, but Black was unable to see this far.

10 . . . b7-b6
11 g5-e7 g8-e7
12 e1-c1 e8-g8
13 d2-h6!

Immediately beginning an attack against the black king. The threat is f3-g5, followed by h6-h7 mate.

13 . . . e7-f5
14 d3-f5 g6-f5
15 f3-g5 d8-g5+

Giving up the queen was the only way to prevent mate. If 15 . . . f8-e8

16 h6-h7+ g8-f8 17 h7-f7 mate.
16 h6-g5+ g8-h8
17 g2-g4

A fine move, opening up other lines of attack to the black king.

17 . . . f5-g4
18 g5-g4 f7-f5
19 g4-h4 f5-f4
20 c3-e4

Here comes the other knight.

20 . . . f4-f3
21 e4-g5 f8-f7

Again the only way to prevent mate on h7.

22 g5-f7+ h8-g8
23 h4-f6 f3-f2
24 f7-h6 mate

It would be reasonable to deduce, having played over this game, that the program playing the white pieces had a very good idea of what it was doing; that it planned a king-side attack from early on and then executed this attack in a well planned manner. In fact, White did not employ any look-ahead whatsoever. All of its moves were found as a result of a one-ply search. Its king attack feature was obviously well designed but there was no tree search — the planning was all implicit in the evaluation function. This should provide some idea of just how much *can* be achieved without a deep look-ahead and I hope it will encourage some of you to write intelligent programs rather than programs which perform brute force searches of large trees.

The northwestern program

To conclude this survey I shall give a brief description of the famous program, witten at Northwestern University, by David Slate, Larry Atkin and (in the beginning) Keith Gorlen. This program has won most of the important computer chess tournaments of the 1970s, and the interested reader would do well to read a more detailed account of this program, which may be found in Peter Frey's outstanding book *Chess Skill in Man and Machine*.

The Northwestern University program, whose successive generations have been named CHESS 2.0, . . . CHESS 3.0, . . . CHESS 4.0, . . . CHESS 4.9 (the first digit represents a working generation, the second digit is a version within that generation), was born in 1968. When the first computer chess tournament took place in 1970, the program proved itself to be the strongest and it maintained this reputation for most of the decade. Occasionally another program would win an event ahead of the Northwestern program but such occurrences were the exception rather than the rule. At the time of writing, this program holds the title of World Computer Champion, which it took from the Russian KAISSA in 1977. The forthcoming World Championship contest in Linz, Austria (25-29 September 1980) will probably be the toughest event in which the program has participated and we may even see a new title holder.

Much of the program's power is due to its great speed. The programmers have devoted much effort to the speeding up of essential processes such as legal move generation and to this end the program maintains a data base which includes, among other things, a list of every square attacked by each piece. This list is updated whenever a move is made in the game tree, and by updating it rather than recreating it, the programmers reduce the time taken to provide the attack and defence lists for the newly-created position. The program also uses a hash table for transpositions, as described in the section on Greenblatt's work.

For some time, the Northwestern program employed a plausible move generator to restrict the number of nodes in the game tree but various reasons prompted the programmers to change to a full width search. One of the prime reasons for doing so was the fact that they noticed certain moves, which appeared good when examined to a depty of (say) 5-ply, but which ranked too low at the root of the tree to be included in the first plausible move list. Chess masters are not faced with this problem because their plausible move generator is much more sophisticated and accurate and I suspect that the chess programs of the future may return to the plausibility approach, unless brute force searching produces an electronic chess master within the next 2-3 years.

The program's evaluation function contains a number of terms which quantify the best known chess heuristics. Material is measured in such a way as to encourage the side that is ahead in material to exchange where possible and to discourage the exchange of material if the program is losing. Another feature gives a bonus for attacking enemy pieces and this bonus is enhanced when an enemy piece is doubly threatened.

Pawnstructure is an important feature of the game of chess at higher levels of skill and any program which aspires to master strength must understand the finer points of pawnstructures. If your pawn formation is rotten your whole position is eventually liable to crack under pressure. This program considers doubled pawns (two or more pawns of the same colour on one file); isolated pawns (pawns that cannot be supported by pawns of their own colour); backward pawns (pawns which do have adjacent friendly pawns, but which are less far advanced than its neighbours); passed pawns (those which have no enemy pawn impeding their progress to the eight rank); and advanced pawns.

Knights, bishops, rooks and queens are given bonuses according to the values of the squares they attack, particularly if the squares are near the enemy king or the centre of the board. Rooks are given bonuses for being situated on open files or on the seventh rank (a rook on the seventh rank usually poses a serious threat to enemy pawns which have not yet moved). The kings are discouraged from moving towards the centre of the board, except in the endgame, and there is a safety feature which determines whether or not a king is well sheltered by its own pieces.

The tree searching routines employ all of the techniques that we have encountered in previous articles: the alpha-beta algorithm, with a 'window', killer moves, etc. In fact the Northwestern program provides us with an excellent illustration of the power of all these neat tree searching tricks — it plays better chess than more than 99.5% of the world's chess playing population and has even won some quick games against International Masters and Grandmasters. These outstanding results have been achieved more through the effects of a cleverly programmed brute force search than as a result of the program's chess knowledge, which is still primitive. The success of the program shows good programming is even more important than an advanced knowledge of the game, when producing a program of the strength currently being exhibited by microcomputers. Certainly it will be necessary for a human chess expert to be involved in the programming of an electronic Grandmaster but there is absolutely no reason why the readers of this column should not write a program that can play respectable chess.

To illustrate the prowess of the Northwestern program I shall offer you the following game, which was its first ever win over a human Grandmaster. The game was played at blitz speed, which requires each player to make all of his moves within five minutes. In fact the rules were slightly different for the two participants — Stean was playing in real time but the program was permitted a total of five minutes for CPU time and satellite transmission time, with no penalty for the time taken by its human operator to move the pieces.

WHITE: CHESS 4.6
BLACK: Stean

1 e2-e4 b7-b6
2 d2-d4 c8-b7
3 b1-c3 c7-c5
4 d4-c5 b6-c5
5 c1-e3 d7-d6
6 f1-b5+ b8-d7
7 g1-f3 e7-e6
8 e1-g1 a7-a6
9 b5-d7+ d8-d7
10 d1-d3 g8-e7
11 a1-d1 a8-d8
12 d3-c4 e7-g6
13 f1-e1 f8-e7
14 c4-b3 d7-c6
15 g1-h1

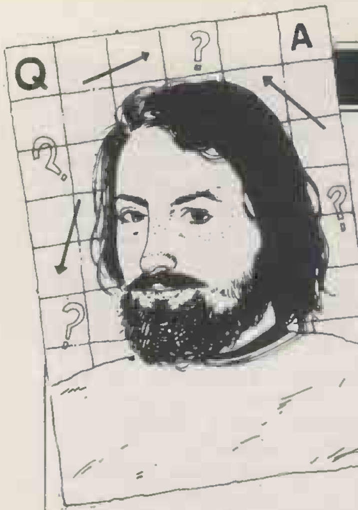
It is peculiar moves such as this one which make it possible to recognize the play of a computer. A strong human player would never move his king onto a diagonal occupied by his opponent's queen and bishop, unless it was forced.

15 . . . e8-g8
16 e3-g5 b7-a8
17 g5-e7 g6-e7
18 a2-a4 d8-b8
19 b3-a2 b8-b4
20 b2-b3

If we sum up what has happened so far, it is clear that Black has a dominating position. His pawns control the centre while White's e4 pawn attacks only one central square. Black's pieces are active, White's are passive. But the program has one important advantage — its opponent thinks that to all intents and purposes the game is over and he tries to take the program's position by storm. This is exactly the opposite of the way one should play against a strong program — the tactical search will reveal tricks that the human misses, especially at this breakneck speed.

20 . . . f7-f5?

GOTO page 123



COMPUTER ANSWERS

I need consultants to answer questions on the TRS-80 and Compucolor, with thorough experience of machine code programming, the disk operating systems and the hardware of these machines. Please write to me, Sheridan Williams, at 35 St. Julian's Road, St. Albans, Herts, stating your experience. A reminder to readers that personal replies can only be given to Computer Answers if an SAE is enclosed. Send your questions to me at the above address.

Lab system

We need a micro computer in our laboratory which could run any of 20 or so fairly simple (but not necessarily short) programs at short notice and frequent intervals during the day. At the same time we would like to use it to teach people to program in Basic in preparation for the time when we have a terminal running into our in-house mainframe. Ideally the microcomputer could then be used as a terminal. We could find £1000, or maybe up to £1200 for the complete micro-system (excluding printer). Have you any suggestions as to suitable equipment?
Name and address supplied.

It's a great pity that you can't afford another £1000, for the Hewlett Packard 85 is almost what you are looking for, except for the ability to use it as a terminal! And even that might come by next year. Short of the HP 85 I would think, from your need to change from one program to another frequently and at short notice, that cassette storage would not be very suitable. That's a pity, for faster means of loading are much more expensive, generally speaking. Providing even one 5¼" floppy disk drive and controller is probably going to use up the best part of half of your £1000. Which doesn't leave much for the computer itself, let alone a VDU, monitor or TV set. An Apple with a single drive would just about do it, but if you needed to buy a TV set or monitor you would be well into your upper figure of £1200. An Ohio Challenger C2 with disk would work out at about the same kind of figure. You could get a 16k TRS-80 model 1, level II, with expansion interface, single disk drive, and monitor at about the £1000 level. This would certainly be capable of later upgrading for use as a terminal, albeit at extra cost. Another approach would be to concentrate on the eventual situation and start off by getting a VDU terminal with keyboard and RS232 interface. This would again take about half of your available funds. As you would still need both a computer and fast storage and retrieval facilities, how could it be done with disks access at £500? The answer could lie in the Stringy Floppy, made by Exatron in the USA, which has only just come to notice in the UK. By using a special cassette with an endless tape this device gives much faster, and apparently more reliable, program loading than ordinary cassettes, although it's not as fast as disks (see PCW Vol 3 No 6). A single drive and controller for a TRS-80 costs about £200 in this country and you might be able to get a 16k TRS-80 for the remaining £500 or so. Alternatively, you could think of an expanded Microtan 65 with the Tanex board to give the RS232 interface, or wait until September when the Newbrain is scheduled to be available — this will include the necessary RS232 port as standard, and, like the Microtan 65, should be able to interface the Stringy Floppy.

There are bound to be other permutations and combinations, and there is also the large field of second-hand equipment, not only microcomputers, but also possibly oldertypesof mini-computers.
P McIlmoyle

US PET

I am going to the USA for a short trip and at the same time feel like getting either a 16k or 32k PET. I will be staying in New York — could you advise on the possibility of getting a PET there and an alternative (if any). I am planning to take $ 1500 for the PET — should this be enough?
Tunde O Osibubi, Chatham. and I Harwood, Welwyn Garden City

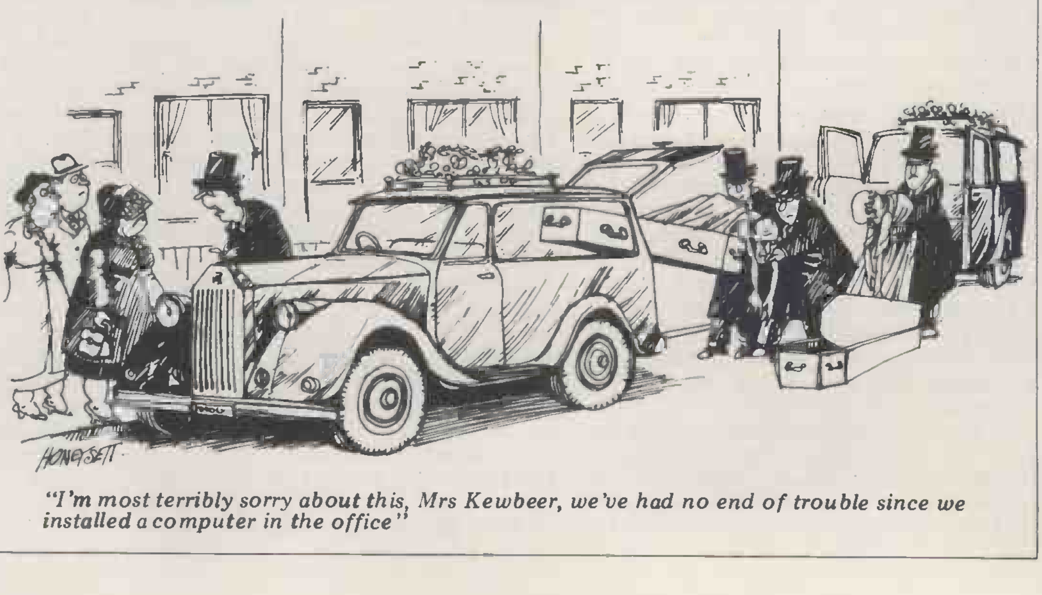
You should have no difficulty at all in getting a 16k or 32k PET in New York, but you may have difficulty in getting it back to the UK! Not only is it fairly heavy, due to the built-in screen and metal case but the box is an awkward shape to carry very far. $ 1500 should adequately cover the price, bearing in mind the very much lower prices current for personal computers in the US and assuming that you just want the PET itself without expensive extras such as disk drives or a printer.

Alternatively, you could consider the Apple II, the Tandy TRS-80 Model 1, level 2, and the Exidy Sorcerer. The first and last of these don't include a screen or monitor as standard so would be easier to carry; the TRS-80 Model 1 usually includes a monitor screen. In this country it is also sometimes available as just the keyboard unit, without the screen. I'm not sure if it can be bought in the States in this form, but this could be worth looking out for.

Apart from the problems of actually carrying your computer home there are a number of other points to bear in mind. Equipment sold in the US is designed to operate on 110 volts, 60 Hz mains supply. The voltage is fairly readily taken care of by using a transformer to reduce the British 240 V to 110, but the frequency is another matter entirely. The difference is unlikely to stop your computer from running, but it often leads to a very unsteady display on the monitor screen. Talking of screens, it's worthwhile bearing in mind that the American colour TV system is very different to ours (they use NTSC, we use PAL), and an Apple II from the States will not give true colours when used with a British colour TV as monitor.

Don't forget that there will also be a number of other costs: there's the transformer, mentioned above, a TV set or other monitor, and probably a cassette recorder, unless you make use of existing equipment. But there will be more to pay before you ever get your computer home: there could well be an excess baggage charge from the airline, assuming that they will be prepared to carry the extra baggage, and, whatever model you have chosen, there will be not only VAT (at 15%) to pay before you can get the machine into the UK but also Customs duty at about seven percent. And please don't try to take a computer through the Green Channel; it's very likely to be spotted and you run the risk of not only a hefty fine but also of having your computer permanently confiscated!

If you end up having your purchase sent on to the UK rather than carrying it over



"I'm most terribly sorry about this, Mrs Kewbeer, we've had no end of trouble since we installed a computer in the office"

yourself you will also have to pay for a freight agent to clear it through Customs for you.

If it were me, I would certainly look for something more portable than a PET, quite possibly an Apple. But, bearing in mind that you can buy a 32k PET in this country for under £680 (plus VAT), which is very close to $ 1500 (plus VAT), I would be very inclined to buy my machine here. At least it would make servicing much easier and avoid the electricity supply problems. Of course, if you were to find that PETs were very much less than $ 1500, that would be another matter.
P McIlmoyle.

Sorting references

Please will you give me references for further study of the 'Quicksort' that you mentioned several months ago? The whole area of sorting fascinates me.

I had dozens of letters asking this question so here goes: Knuth, D E: *The Art of Computer Programming Volume 3*, Addison-Wesley, 1973, pp 86-95, 289; Lorin, H: *A Guided Bibliography to Sorting*, IBM systems journal 10, No 3 (1971) pp 244-254; Van Emden, M H: *Increasing the Efficiency of the Quicksort*, Comm ACM 13, No 9 (1970) pp 563-566, 693; Wirth, N: *Algorithms + Data Structures = Programs*, Prentice Hall, Ch 2.

Probably the best starting point is the last book, which I used. Both this and Knuth are very expensive (over £14) ask your local library to get the books for you — use your library more as they are only too pleased to help.
Sheridan Williams

Unadventurous games

I'm bored stiff with computer games that involve killing Klingons, Robots, Piranhas, Space Invaders, Androids, and who knows what else. I'm also bored with computer versions of chess, Othello, draughts, pontoon etc. What's next, other than suicide?
J James, Slough

How about a game called 'Adventure'? There are dwarves, dragons, trolls, pirates, snakes and other nasties in this game and it's up to you whether you kill them or not. As you have this aversion to killing perhaps you could try 'stroking' them instead.

Adventure is a totally different type of computer game, unlike any that you will have seen already. Before you get too excited, there might not be a version available for your machine, and even if there were it would not be worth getting unless you had disks. Still we can dream; let's assume that it is available for your machine. Here's an analogy: If you think of most computer games as 'films' then Adventure can be likened to a 'book'. In a film you are given very little chance of fantasising, but with a book you can conjure up your own mental pictures. Adventure is like that. It is an adventure story that you can control, the object being to find your way into a cave system and collect lots of hidden treasure. The more you collect the greater your score. Along your journey a great many things can happen and you must find the correct course of action to proceed. Before you think 'yawn' I must tell you that when I tried Adventure it totally ruined a whole weekend. I started playing at 10am on Saturday and apart from about six hours' sleep, I was still playing at 1130pm on Sunday night! And I still only scored 200 out of 380. In other words, I had only covered just over one half of the cave system and this was only a small version of the game. The versions I have used are on a PDP11 and an RML 380Z. If you can get a copy then jump at the chance.
Sheridan Williams

ZX80 chips

I have ordered a Sinclair ZX80 in kit form and I am slightly confused regarding RAM memory. I have found out that the ZX80 uses 2114s, which I have seen priced at under £5. Sinclair is quoting £16 for his RAM memories. I have seen 4027s (4k) and 4116s (16k) at more reasonable prices — could these ICs be used with any success in the ZX80?
G S Dawson, Glasgow

2114s of your own source are quite suitable provided they are of sufficiently fast speed. Don't forget that 'Uncle' Clive is quoting for two 2114s, and possibly even an extra decode chip.

4027s and 4116s are dynamic RAM chips, and so are non-compatible with the ZX80 because the Z80's refresh line is used to drive the video display; extra circuitry would be needed.

This information and a great deal more should be available to all those who join the National ZX80 Users club. Send an SAE to Tim Hartnell, 44-46 Earls Court Road, London W8 6EJ. They are publishing a newsletter (already in its third issue) and offering 10% off

COMPUTER ANSWERS

computer books, cheap RAM chips, low-priced software and a membership list. They have over 500 members to date.
Sheridan Williams + Comp Shop, Barnet

Jumping about

The 6502 microprocessor does not have an indexed indirect jump instruction, so what is the next best way to handle a 'jump table'?
L Meddock, Peterborough

This is a common problem in programming, where we want to select one case from many. For example, a sales ledger system may present a menu on the screen from which the user can select:

1 Account setup
2 Transaction
3 Statement etc

High level languages provide special verbs, such as 'CASE N OF' in Pascal or 'ON N GOTO' in Basic. A solution in a low level language will depend on the architecture of the processor and so will be less well-known. Here's an interesting and particularly simple solution which I have not seen mentioned elsewhere.

The general principle is to index along a 'jump table', pick up the address of the desired routine by conventional programming, then push the address onto the stack and 'return' as if from a subroutine. The processor will go to the chosen address. There are a few items to watch out for:

— remember to double the index (shift left one) to allow for the 16-bit addresses in the jump table
— beware of the order in which the low and high bytes of the address are pushed onto the stack
— study the 'return' instruction for your microprocessor; the 6502 for instance always adds 1 at the end of the RTS operation, so you could put a NOP as the first instruction of the selected routines.

The idea can be extended in some interesting directions. Try these:

— add a byte before each address in the jump table, then look for a match with the input byte. This permits a mnemonic code letter
— use the address of an error routine in the jump table to simplify input validation
— use the first (or last) address to point to a default routine
— implement a computed 'GOSUB' by pushing the real return address before using the jump table.

R Ross-Langley, Mine of Information

Small micros

Could you advise on microcomputers in the £200 range, suitable for serious use by students studying computing? Has the Acorn Atom been reviewed anywhere? Has it any real competitors apart from the Sinclar ZX-80? How is the ZX-80's 1 kbyte of RAM "roughly equivalent to 4 kbytes in a conventional computer"?
D S J Hargreaves, Halifax and A J Moorhouse, Blackpool.

There are now several machines in this price range, although, if you want a ready-built machine with a high level language like Basic, your choice will probably at present be made from among the Sinclair ZX80, the Acorn Atom, the Nascom 1 and the Microtan 65, with the Ohio Superboard II a bit above your range. If you can build from a kit you can save some £20-£50, and this would bring the UK101 nearly into your range, on a VAT-inclusive basis. If you are content to limit your activities to machine coding in hex, then the Elf and original Acorn can be considered. If you wait till the autumn there may well be some more choice in this range. One computer already announced for introduction then is the Newbrain, which in its simplest form would offer a ready built machine with a lot of I/O and an extended Basic well within your price limit. There is also the Sharp PC-1211 pocket computer.

As regards reviews, the Acorn Atom was featured in the July PCW which also contained items on both the Newbrain and the Sharp PC-1211.

How does Sinclair do it? To start with, 1 kbyte of memory will hold 1 kbyte of binary code, regardless of whose it is. It's what can be packed into that binary code that's significant. For example, on some machines (such as the TRS-80), data can be stored as integers, single-precision floating point, or double precision fp. One kbyte will hold 512 integer numbers, 256 single-precision, or 128 double-precision numbers. The ZX-80 saves space by storing Basic keywords (such as GOTO, PRINT, etc) as single bytes and so gets more program lines into a given amount of memory. Perhaps it's not too surprising that the ZX-80 is not unique in doing this, but there are certainly a lot of computers which don't.
P L McIlmoyle

HELPING THE HANDICAPPED

It's often said that microprocessors will play a major role in aiding the handicapped but few companies seem interested in actually doing much about it. One exception is Telesensory Systems Inc, which specialises in aids for the disabled. Julia Charles reports from California on TSI's activities.

Telesensory Systems Inc (TSI) is a small advanced electronics company based in Palo Alto, California. The company is located on a hillside surrounded by idyllic views of the San Fransisco Bay and hills in an area where electronic companies are both numerous and flourishing.

TSI differs from the other companies, however, because of the specialised nature of its expertise for it concentrates on the application of sophisticated equipment for the handicapped, a field now entitled 'rehabilitation technology' in which a device may augment, substitute or enhance the physical or sensory limitations of an individual.

The company was formed in 1970 to produce and market the OPTACON (OPtical to TActile CONverter), a reading device for blind people which resulted from a research project led by Professor J G Linvill at the Department of Electrical Engineering, Stanford University.

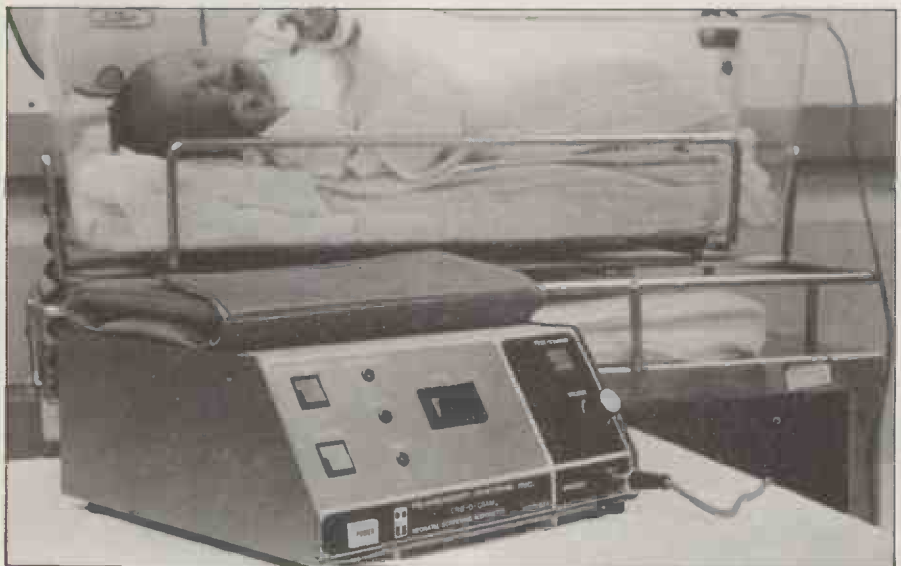
Professor Linvill developed the OPTACON after he realised the size of the barrier that the blindness of his daughter, Candy, imposed upon her ability to read. During that period Candy was at school and the time required for translating materials from print to braille, as well as the sheer bulk of braille material, were severe impediments to her studies.

The OPTACON is an optical to tactile converter that generates with an array of vibrating pins a tactile image which is a magnified facsimile of letters focused on its silicon retina. The OPTACON equipment comprises a hand-held camera and a box of electronics; as the user moves the camera across a line of print the optical impression from the camera is converted into electronic signals so that an enlarged, vibrating representation of the image the camera is receiving is displayed on a tactile array that the user feels beneath his index finger. The blind person is therefore able to read tactually in the same way that a sighted person reads visually — he feels the same shapes that the sighted see. The tactile array is a small rectangular pad about half an inch by one and a half inches, with 144 pins arranged in six columns.

The research project at Stanford began in 1963 and by 1970 such an improved and compact model of the OPTACON had been developed that it was decided to put it into quantity production. However, commercially, its potential was extremely dubious; it's an expensive and esoteric device whose usefulness is restricted to a small, select population. The gulf between the university-based research product and the manufacturing and marketing capabilities required to bring that product to its intended market was so great that it was necessary to form a new company in an attempt to bridge the chasm. TSI was established for the purpose in 1970 with Dr J Bliss as President, and production of the OPTACON began in 1971.

The OPTACON Research Group at Stanford still continued with its aims of developing useful devices for blind people but as with any research organisation their findings were immediately available to TSI, as they were to any other interested party. The openness of this relationship was valuable, for it provided a safeguard to the blind population in ensuring that the only insurance TSI had against competition was its own effectiveness. TSI still maintains a close relationship with Stanford University and two Stanford faculty members are on its Board of Directors.

As a sophisticated device of use to a limited market, the OPTACON displays many of the features that necessarily characterise rehabilitation technology devices and which help to explain why this is an area where successful manufacture and marketing is so difficult to achieve: the research and development



The neonatal screening audiometer is designed to detect hearing deficiencies in newly-born babies.

The TSI Optacon, with its miniature camera to the right. The tactile 'reading' pad is visible inside the slot.

cost of equipment of this nature is high; a handicapped population is generally small and the usefulness of any particular device is limited according to the type and degree of disability of the user (not all blind people can use an OPTACON, for example); handicapped people are generally hard to locate and they often do not have a lot of money.

Bearing in mind these factors it's interesting to look at TSI's development over the past decade, to consider some of the reasons for its success and to review some of its products.

Firstly TSI has always received considerable financial support from government and non-profit based organisations, which has subsidised research and development costs. For instance, much of the work on the OPTACON was done at Stanford with government support, keeping the price of the OPTACON lower as it was not necessary to recoup these research and development costs. The government investment, however, has been adequately retrieved in that a blind person, with the increased capabilities that the OPTACON gives him, is able to be more productive in the economic society in which he is expected to participate.

Secondly, TSI has been able to transfer the technology developed for the OPTACON to a number of other products so that today it has several commercial products on the market which derive from two basic technologies: synthetic speech and bimorph transducers. To illustrate these transfers it is best to look at TSI's current range of products.

The second product TSI brought out utilised the first of these technologies, synthetic speech. The Speech + talking calculator was introduced in 1975 and was the first consumer product to provide voice output through microprocessor-generated speech. The calculator has a 24-word mathematical vocabulary and is available in English, French, German and Arabic speaking models.

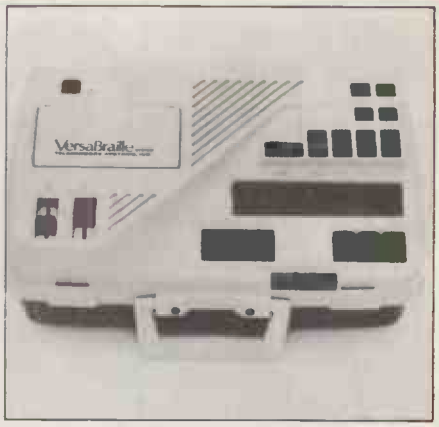
The synthetic voice of the 'Speech +' is also the voice of TSI's Game Centre, a microprocessor-controlled collection of eight electronic games, similar to video games but using only synthetic speech output and other audible cues to provide game information to the players so it can be utilised by blind persons.

The same synthetic speech technology is also available as pre-assembled speech boards and so can be used for experimental purposes as well as in such products as the talking Chess Challenger.

Having moved into speech technology, the next development was obviously to make a talking OPTACON, as this would increase its utility both in education and vocational settings. Voice output and automatic scanner units are expected to be commercially available in 1982. The units have been under development for four years, stemming from work on speech synthesis originally based at the Massachusetts Institute of Technology. This autumn prototype units are to be evaluated in the field over the next year before final decisions are made concerning design features.

The second area in which TSI has employed technology transfer has been in the area of bimorph transducers. These were originally utilised in the OPTACON and are now incorporated in both the Crib-O-Gram and the VersaBraille.

TSI's Speech+ talking calculator for the blind.



The VersaBraille is, in effect, almost a word processing system for the blind.

The Crib-O-Gram is a neonatal screening audiometer and was initially conceived and developed by Dr F Blair Simmons at Stanford University Medical Centre. The technology was transferred to TSI under licence from Stanford University. The Crib-O-Gram identifies serious hearing impairments in newborns, using a narrow band noise stimulus, a highly sensitive motion detector and a microprocessor-based decision analysis to assess neonatal motor activity in response to a series of 30 stimulus trials. Early identification of hearing impairment allows early treatment to facilitate the normal development of language and cognitive faculties that may otherwise be seriously impeded if the hearing deficit is not diagnosed until the child is two or three, which is an average age of detection by conventional means.

The VersaBraille is a portable microprocessor-based Braille information processing system which allows quiet and efficient writing, reading and note-taking as well as being a compact and economical way of storing Braille text. It's also an audio tape recorder which can record sound and Braille on the same tape and can provide an index and automatic retrieval system for both audio and Braille materials. Attachments for computers, typewriters and teletypewriters increase the system's usefulness in many vocational settings.

TSI has therefore utilised the spin-off of two particular technologies to produce seven successful products. The success of these products may be attributed to the clearly defined organisational objectives that provide TSI's goal when new products are being developed: that the product must fulfill a real customer need, that it provides lasting value and represents an unmatched contribution in the marketplace, and that it matches the marketing and manufacturing strengths possessed by TSI. Also, it should be a profitable concern.

An example of the application of these principles to a new product may be seen in the Autocom project, now nearing completion. The Autocom is a device which was originally developed at the TRACE Centre for the Severely Communicatively Handicapped at the University of Wisconsin. The rights to develop, manufacture and market the Autocom were awarded to TSI in 1978 and it is hoped that it will be in production later this year. The Autocom is a communication system for individuals who are both motorically and vocally impaired. It allows a user to select, store and display vocabulary items by moving a pointer to a chosen square on the board's grid surface. The board is housed in a wheelchair laptray, giving the user complete freedom of mobility. The vocabulary store is user-programmable and can be simple or complex in that vocabulary items can be symbols, pictures, letters, numbers, words or word parts, phrases or sentences. By using many 'levels' of electronic memory several thousand different items may be stored and the user programmability means that each individual may create and modify his own personal vocabulary. The variety of input and output modes available also helps to make the Autocom suitable for a wide range of users.

TSI came into being 10 years ago to research, develop and commercialise rehabilitation devices. It was entering a new and complex field in which the probability of success was low. However, during the 70s it not only established itself as a world leader in its specialised fields but is now in a position where it is able to broaden the range of these fields. The potential applications for products utilising high quality voice synthesisers are both numerous and obvious and will benefit areas both of disability and non-disability. The reputation TSI has gained for quality and reliability should ensure the continuing support of government and non-profit making organisations so allowing it to retain its heavy research bias, and although the company is expanding it is still sufficiently small to be involved in custom design development.

TSI came into existence because it wanted to introduce a new product in a new market, a risky venture for any commercial organisational framework is specifically designed for its particular needs and is fluid to allow for adaptations to changing environments. Its standards of research, development, production and maintenance and assessment and training of users are extremely high, as is the level of expertise demanded from its staff. TSI has been successful because it has been able to offset risk-taking against these high standards.

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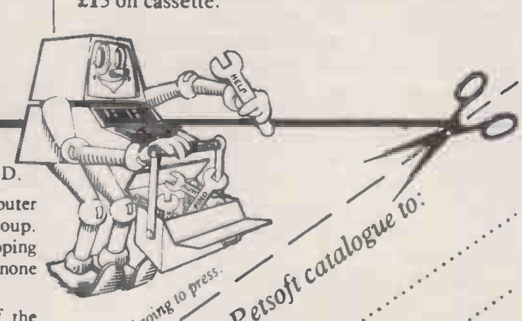

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This month our microchess expert Kevin O'Connell looks at two new chess-playing computers.

Once more - this time with feeling

Perhaps the title should say twice more since this month I am looking at the two new Chess Challengers, with sensory boards, which should take over from the Challenger 7 and the Voice Chess Challenger.

Sensory Voice Challenger

This is a new product and I had only a short time to test the one and only prototype in the UK at the time. That was sufficient to test all the features but not to form a reliable estimate of its playing strength, the program for which, in any case, was still being developed and improved. The ROM has been almost doubled and it should at least play rather better than the Voice Chess Challenger — that would be sufficient to put it in the top three commercially-available programs.

The unit's appearance is quite pleasant and the angled display overcomes the small but irritating problem associated with the earlier Challenger machines — it was necessary to crane over the machine if an E or F was displayed to see which of the two it was.

The sensory board is something that many major manufacturers have been working on but Fidelity is the first to make one available on a moderately-priced unit. The machine which I tested worked extremely well; the amount of pressure needing to be exerted on the sensory board was so slight that natural piece movement was usually adequate. However, that was a sample and first production units of the Sensory 8 are less satisfactory — I found it necessary to press down very firmly with the edge of a piece. It remains to be seen whether production units of the Sensory Voice, and later Sensory 8s, are more like the prototype I tested in their sensory action. If they are, then it is a great enhancement, for it makes playing against the computer both easier and more like playing a real game of chess.

When the computer chooses a move, it announces it both audibly through its voice chip, and by lighting up two of the 64 LEDs on the board. It lights up both the square on which the piece it wants to move currently stands and the square to which it wants to move that piece.

Something completely new is the Great Game feature: 64 complete games have been stored in ROM. The Game feature enables the user to try and predict the moves played by one of the chess masters represented. The idea of a test to establish 'How good is your chess' has long been a popular one in chess magazines and several books have been published using this theme. Those books and articles enjoy one great advantage — by assigning a certain number of points to each move, they enable you to rate your own play in certain types of game. The Sensory Voice's Game feature merely indicates whether you have selected the same move that was actually played and gives no indication of whether that was the best move or not. On the whole an interesting innovation, although, as a chess player, I take exception to Fidelity calling the games "The 64 Greatest Games by World Chess Champions" since six of the games do not involve anyone who ever held the title.

The Sensory Voice has quite a large openings book — the pre-programmed moves which are employed at the start of a game. There are 64 strings, ranging in depth from just one move to 18 (nine for each side). In all there are 377 moves stored in ROM. That doesn't compare with the thousands upon thousands of moves stored in a chess master's head but it is more than enough to ensure that the user meets a wide range of responses and should be in no danger of being bored by the opponent's repetitive play.

An important improvement over the Sensory Voice's unfeeling predecessor is that on the new model it is possible to turn down the volume of the synthetic voice. The user can also choose to restrict the machine's vocabulary, so that it will only warn of illegal moves and checks. The ordinary Voice Chess Challenger allows only the choice of full on or completely off; the problem with that is that the synthetic voice soon begins to grate on the ears, yet if you switch it off you have to keep looking at the machine to see if the computer has made a move, and you do not get any audible check of that move nor, indeed, your own moves. Giving the user more choice is very sensible.

Another innovation, made possible by the fact that the display is no longer required for displaying the computer's moves, is the inclusion of a chess clock. This enables the user to see how much time each player takes for each move, as well as the total elapsed time for each player since the start of the game. It can also be used in Count Down mode, so that one can pre-set the total amount of time allowed for each player for the whole game (if one player runs out of time he automatically loses), thus duplicating a popular form of inter-human chess in which everyone knows the latest possible completion time for a game. This is obviously very useful if you know that you have only 50 minutes to devote to playing chess and wish to avoid the frustration of an unfinished game or the risk of missing an appointment because you cannot drag yourself away from an intriguing position which has developed on the board.

The Sensory Voice Challenger.

Fidelity has taken a leaf out of SciSys-W's book by deciding to make available an accessory printer but this had not been developed at the time of writing. When it does become available (it is scheduled for November and will cost about £170) it will plug into the back of the main unit and will provide a permanent record of any game you play against the computer.

Sensory 8

The Sensory 8 is basically the old, but ever-popular, Challenger 7 with a sensory board attached. It has none of the special features of the Sensory Voice. Fidelity claims that the program is an improvement on that in the 7 — I have no reason to disbelieve this, but my tests so far have not revealed any noticeable differences, so the improvement can only be slight.

Summary

The Sensory 8 Challenger is widely available at about £129. The Sensory Voice Challenger should also now be in most shops, priced at about £279. The machines they augment, the Challenger 7 and the Voice Challenger have been reduced in price to, respectively, less than £90 and about £219.

My thanks to Paul Balcombe, Nick Beddoe and David Morein of Computer Games Ltd, Fidelity's UK distributors, for their help and loan of the machines. Thanks also to Peter Nasca and Oscar Segal of Fidelity Electronics. It required some courage on the part of CGL to persuade Fidelity to let a designer of rival systems be the first to review its new products!

Next month

Another new chess computer, one with several major innovations which make it the first chess machine which genuinely is useful for anyone interested in chess — from someone who does not even know how the pieces move up to and including the world champion himself.

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YOUNG COMPUTER WORLD

Compiled and written by Derrick Daines

There's this old boy (not me) driving down the M1 at a steady 45mph. His car's only a year old but suddenly — bang! — there he is, stranded for hours on the soft shoulder. When he finally gets home, sitting on the doormat is a computerised bill dunning him for £99999999.99!

He ought to have stayed in bed! In one day the poor old chap has been the victim of two breakdowns — his car and some computer or other. Stand by for a stupid question: which of those two breakdowns will receive the greater publicity?

We know, don't we, that the computer breakdown will be headline news the following morning? Maybe questions will be asked in Parliament, with demands that the computer be scrapped. The broken-down car will be ignored.

A full discussion on the reasons why there is this difference in attitude towards the car and the computer would take up far more room than I have available here. It would certainly include the glee that we all feel — somewhat uncharitably — at the downfall of the mighty. In some ways the computer is the victim of its own success. That is to say, we have come to expect the computer to be so reliable that it is headline news when it fails.

A good example of this attitude at work was given by the recent missile scares in the US, caused by a faulty computer in the defence network, Critics immediately called for the scrapping of the system, although they did not suggest what should replace it. An Observer Corps with binoculars, perhaps?

I mention all this because I was recently in a computer store and saw the embarrasement on a boy's face as he struggled to convince his dad that computers don't break down. Dad wasn't convinced and wouldn't buy. I was intrigued; why did dad insist upon total infallibility? Why should the boy have felt the need to prove something that in his heart he knew to be false?

Wouldn't it be better for all of us to admit that yes, computers do sometimes break down? Anything that exists will fail sooner or later! And wouldn't it be better for manufactuers and others to admit it openly too and spend as much on a repair service as ehy do on the original product?

Perhaps all that the dad really wanted was a frank and open admission of the possibility of breakdown and the assurance of swift and reasonably cheap repair. There are as yet no corner garage that can get a faulty computer up and running. No doubt they will come in time — but that's another story.

A large postbag this month. A while ago we published a listing of Don Walton's game Cat and Mouse, designed to give youngsters familiarity with they keyboard. Don is deputy head of Houghton County Primary School, Houghton, Huntingdon, and he sent along a tape of eight games for the PET with an educational flavour. He is selling the tapes at £12 each, which is good value by anybody's standards. I tested all the games and found them entertaining as well as educational and most had novel features. I was particularly impressed by a word matching game and a spelling game for two players; both must make a great contribution to reading skills. On the debit side, I personally found the car rally game a little irritating in that it asked me for a current position that it knew but there's no doubt that it would teach geography in an interesting way. It was also possible for either playin in Noughts and Crosses to overlay his opponent's position, but these are small niggles.

Verdict — a must for any primary school with a PET. Enquiries to Don at the above address; proceeds go to the school fund for another PET.

Anybody out there with a ZX-80 (which must be more than a few) should drop a line to Mark Wylie (16) of 24 Oakgrove, Hertford or ring him on Hertford 59081, because he has designed a buffered interface to allow the addition of more RAM, which can't be bad. Mark will let you have a photocopy of the circuit for only 20p and an SAE! I'm sure a lot of people will be interested.

A thick duplicated booklet called the CESI Newsletter (some letter — it ran to 56 pages!) arrived from the Computer Education Society of Ireland. I found it a good read, even the Gaelic bits. It's the journal of Eire teachers interested in computers and, as well as some domestic stuff, included a reprint of selected articles from around the world. My congratulations go to whoever made the selection, for they were without exception thought-provoking and forward-looking.

CESI was set up in 1973 and interested parties can write to Diarmuid McCarthy, 7 St. Kevin's Park, Kilmacud, Blackrock, Co. Dublin, Eire.

Diwyang Mistry (I hope I've got that right) who is 16 and lives in Middlesex, weighed in about the *Sunday Times* Young Computer Brain of the Year competition. (Regular readers will remember that the competition was criticised on this page because the ability to write an essay is not necessarily an indication of the best computer brain.) He makes two points: Good programs require good writing skills and accompanying documentation; and insisting on a program or piece of hardware would preclude those without access to a computer.

I can see the force of the first argument but have my doubts about the second. If you have no access to a computer, what do you know about their limitations and possibilities? If you have *some* access, then it has been my experience that keen youngsters are pretty quick at turning out interesting programs. Anybody else with views on the matter?

Robert Schifreen (16) of 4 Edgewarebury Gardens, Edgeware, wrote in with a plea for books or manuals about the Superboard 2 because he finds the manuals supplied are unhelpful. Anybody with ideas or suggestions drop a line to Robert. He also suggested that we publish a conversion table for screen locations between the UK101 and Superboard. We'd be glad to, if somebody would care to send one in!

Finally for this month, John Cowie of Fife wrote in extolling the virtues of the Aim conputer. This was in response to the article we published by S. J Hemming on the mother/daughter computer arrangement they've got at Sandbach High School. He urges anyone contemplating a similar arrangement to consider the Aim as the daughter micro. I would like to quote more of John's letter, but do not have space. If you're interested, drop him a line at 2 St Colme Road, Dalgety Bay, Fife. It will be worth your while.

Programs received

Breakout with Sound — Mark Knowles (14) of Bolton.

Noughts and Crosses for ZX80 — J Grove (14) of Tokyo.

Car Race — Kim Mulji (13) of Calne, Wilts.

Mk14 Routines — Richard Osborne (16) of Gateshead.

Lunar Lander Improvements — Graham Kirby (14) of Pitlochry.

Laser Duel — by P A Jefferson (160 of Bradford.

— AND (tarahhhh!) another girl — German Noun Declension, by Rachael McGhee (16) of Welwyn Garden City.

I must add, by the way, that Rachael's printout and letter are far and away the most beautifully printed that I have ever seen. I don't know what printer she uses — perhaps she'll tell us — but it is of professional quality.

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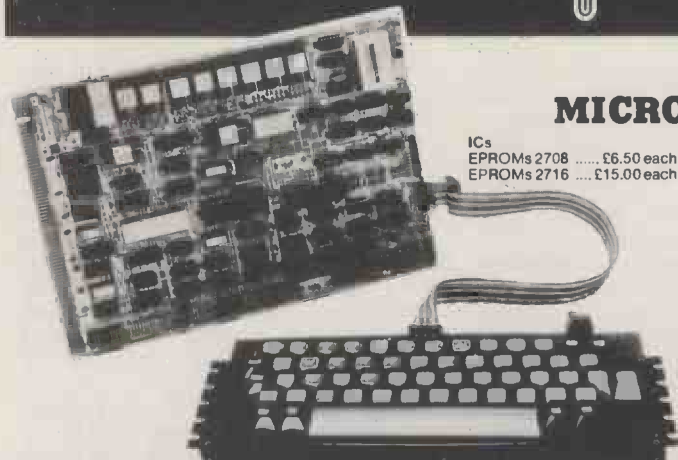

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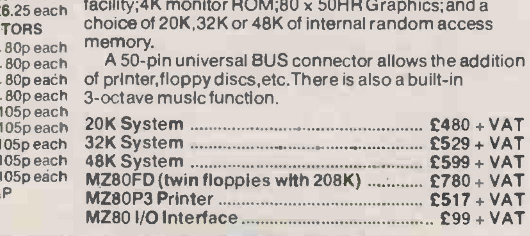

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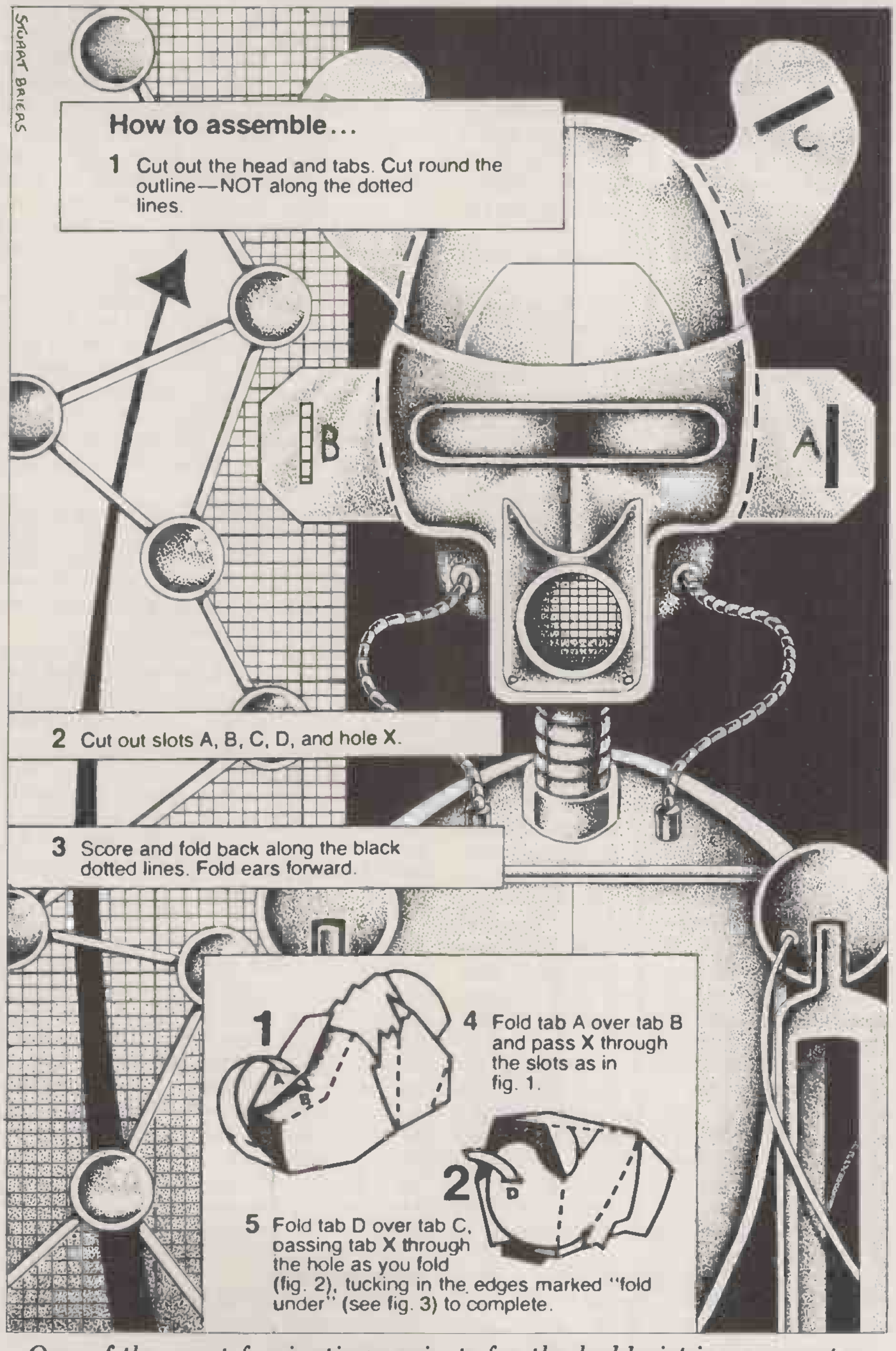

Illustration by Stuart Briers

One of the most fascinating projects for the hobbyist is a computer-controlled robot. Leslie Solomon, technical director of the US magazine Popular Electronics, *passes on some tips and ideas.*

I'll begin by telling you the story of the guy who went into the pizza parlour and ordered a large pizza. The man behind the counter asked him whether he should cut the pizza into six or eight slices. The customer said, "Cut it into six slices because I can't eat eight!"

The same is true of creating a robot — we have two large pieces, large enough so that we couldn't 'eat' them both. One half is the mechanics of robotics while the other half is computer. It's difficult enough to build complex mechanics, rather than simultaneously having to sweat out a computer and its software.

There are two steps in creating a computerized robot: first it should be mechanically constructed and tested before installing the computer, then it should be mated with the computer, after the computer and its software have been tested.

Building the physical elements of a machine is just as difficult as constructing the computer interfaces and writing the software. The question is like asking which came first — the chicken or the egg? Do we build the robot then the computer, or vice versa? Or do we build both together, and what do we do if the damn thing doesn't work? How do we decide where the problem is? I determined that we needed a separate electronic and mechanical approach and this is what we did.

Since we should be able to test the various physical elements of the robot as construction goes along, what's needed is a simple, low-cost, yet effective means to perform the tests, that also will emulate the future computer. In a real sense, we should first create our mechanical man analogue and have full control over it before we install the 'intelligence' Let's first take a look at a simple remote control.

The most common and usually the first thing that comes to mind is radio control, using the same systems as model planes — provided you have enough channels. However, this involves RF transmissions, the need for a licence, and a possible visit from government-type people who usually have no sense of humour. There are a couple of other ways that don't involve RF and the need for a licence, and they remove the probability of external noise or signals causing unwanted problems.

The first approach is called Induction Transmission and can be built by anyone. Unless two experimenters work in the same building, there will be no cross interference, and you can have quite a number of signalling channels going at the same time.

The technique is simple. All you have to do is wind a turn or two of conventional insulated wire around the area where the robot experiments are to take place. In my case, I wound my turns along the junction of the walls and ceiling of my workshop. It makes no difference how small or large the area is as long as the total resistance of the wire is not excessive; you can wind the turn around an acre if you so desire. This turn forms the primary of what will wind up as a strange-looking transformer.

This turn of wire is connected to the output of a conventional audio amplifier — the power requirement depends on how large the loop is, but a 5 or 10 watt amplifier will usually suffice. The turn then simulates the speaker load. The secondary of the transformer is formed by using a lot of turns a few inches in diameter, with this coil connected to a small transistorized battery powered audio amplifier.

To test the basic system, feed a conventional music source to the loop amplifier and connect an earphone or even a speaker to the portable amplifier of the secondary. As long as you keep the portable secondary within the large primary turn and orient the secondary so that it is parallel with the primary, you should hear the music. The magnetic field is strongest within the turn, but it also extends outwards a little; if the turn is on an upper floor the music will be heard one or more floors above and below the loop.

Some of you will probably realise

that this magnetic induction technique can be used to listen to a silent radio (a boon for those of you that have teenage children who play their music at deafening volumes), or can even be used as a hearing aid for those who need it, without the constraints of having any interconnecting wires.

Now, suppose you build an array of audio tone generators, each operating at a different audio frequency and whose outputs can be connected to the input of the loop power amplifier. Each generator has a pushbutton switch that turns its associated tone on and off.

At the receiver there's a companion array of tone decoders following the audio amplifier — the 567 PLL is a good choice. The output of each tone decoder operates a simple transistor switch that opens or closes a relay. A look at the 567 specs will show several circuits that can be used.

Each relay controls the supply power to a particular motor; as each originating pushbutton switch is operated, the associated remote relay operates. Latching flip-flops can be arranged to maintain a tone for some period if desired.

That then is a simple yet powerful remote control system which can be used anywhere without causing any electronic problems. In fact, using this technique, it's possible to build and operate a complex robot without having a computer.

Now to the robot. Since it's always best to start at the beginning, the first consideration should be total robot movement. This usually requires consideration of how to obtain forward, backward, right/left rotation, sideways motion (if desired), and any other direction you see fit. Then you have to consider the degrees of freedom for each limb — these are the joints. You can have hinge, rotation and telescope and combustions of the above.

Two very important items we discovered at great cost — be sure to install limit stops on all mechanical motion and don't make the arms too long! It's amazing how much damage can come when cables and PC boards get ripped out by excessive rotational zeal, and how easily things get bent out of shape by heavy robots falling on them.

You, the builder, have to consider whether to use driven wheels, tracks or make articulated legs. Keep in mind that wheels and slender narrow tracks are are good only in a billiard table type of environment — rough or soft surfaces may cause the machine to hang up, water can cause shorts, and mud is death.

After deciding on the means of motive power, it's best to start with the baseplate that mounts the drive motors, their battery, and the remote control receiver with one (or more) channel relays controlling motor power. Add sufficient weight to the baseplate to simulate the estimated final weight of the robot.

Using the master pushbutton switches on the tone system, you can now test the mechanism. Drive the baseplate around the area and thoroughly check its operation as to turns, forward and backward operation, and stopping. The latter is very important!

By using the loop technique, you can now construct any types of limbs or other mechanical items and test them merely by connecting them to the receiver tone decoders. The testing does not have to take place on the robot itself. The cost of the small receivers is so low (just a loop, an OP amp and a tone decoder) that you can build a few of them, each with only one or two tone decoders, just for the element you are testing. At one time we were playing with three different items at the same time while our robot baseplate was 'taking a walk' around our workshop using a computer program which in turn operated our computer to turn on the various tones.

It'll be useful at this point to make another small diversion.

If you consider a robot having a planned weight of 100 lbs and designed to travel at about 20 mph, or to carry a 300 lb load at 5 mph, you'll need about 5½ HP, or some 5kW of power, or over 300 amps from a conventional 12 volt battery. If you use four 17 lb car batteries, and add the weight of the motors, mechanics, etc, you will have reached 100 lbs. If you cut the top speed to 10 mph, and the top weight to 200 lbs (100 machine + 100 load), you can cut down to two batteries. So you had better sharpen up your pencil, break out the old physics book, and do a lot of paper work before construction.

Give some thoughts to the installation of a small solid-state TV camera so you can 'see' what the robot is up to.

Now for the computer. Essentially, all the computer has to do is turn on (and Off) a simple transistor relay driver that now substitutes for the loop-driven relays. Since most computers have 8 data bits, you now have the means to turn on 256 different relays. It's not difficult to create a logic tree, so arranged as to turn on any selected relay with one particular set of bits; 256 discrete functions are probably enough to run even a complex robot.

Software can either be written for the computer, or you can start with something like Dr Li Chen Wang's 'Robot' language as published in volume 2, issue 8 (number 18) of *Dr Dobbs Journal*, or John Webster's *Robot Simulation On Microcomputers* that appeared in the April 1978 issue of *Byte* magazine.

We used Li Chen's program with a little modification because like the computer-emulating tone loop just described, you don't need a robot to use this software. The cursor on the video display substitutes for the actual robot and you can use the software to guide the cursor through its paces. The software enables the cursor to walk around obstacles. In real life, the signals driving the video cursor can be used to drive the robot.

So, now you are in an interesting position since it's possible to build and operate a robot without a computer, and you can design and test software without a robot. After all is cleaned up, you can combine the two.

Then there is the question of what the computer should do in the robot. Unfortunately, it's been found that when you consider all the things that you would like the robot to do, you run out of computer — unless you install a disk system. With one thing leading to another, you suddenly realize that your computer will start to look like a tank and require submarine batteries.

There's *no* right answer as to what the robot computer should do; different people have different ideas. My answer was simple: why not have the robot computer do only internal 'housekeeping' — watching over battery level, robot mechanical component positioning, contact sensing, and other internal tasks. But what about the rest?

I thought that since my main computer had 56k of RAM, a dual 8 inch disk system, a light pen, an excellent video display and loads of software (in which I had Li Chen's language running), why not use it to control the robot by treating it (the robot) as a high-speed (19 kbaud) serial port? Using the light pen, we could sketch the area in which we wanted the robot to do things, include obstacles such as chairs, tables, walls, etc, and have the cursor wander along its course, avoiding the obstacles and behaving as if it had sense.

We even considered installing a small CB transceiver in the robot, so it could communicate with anyone it met during its travels. Of course, the computer operator, having the other transceiver, would perform this miracle.

We found that although the tone link worked fine, what we needed was a really high-speed link that wasn't bandwidth limited like the audio system. It was about this time that I saw a German audio system —built by Senheiser — that uses a bank of infra-red LEDs to talk to an infra-red detector mounted in a set of headphones. The audio reception was great and I decided to try this technique.

To experiment with this optical data link we built a pair of high-speed ultraviolet transmitters using a few UV LEDs in parallel, arranged so that their optical polar diagrams overlapped to produce a broad fan-like beam that would cover a wide area. One was used as the computer receiver and the other as the robot receiver and a conventional serial interface was installed on the robot computer. Thus, our robot now be passed back and forth between the host computer and the computer resident in the robot. At 19 kbaud we found that lots of data could be passed back and forth.

Of course, using this technique somewhat limited the range the robot could traverse even though we found out that the UV link could go around reasonable corners. The built-in TV camera, having its own RF link back to our TV receiver, enabled us to see what the robot was up to in its wanderings.

This approach may violate your concepts of what a robot is and how it should be controlled. But the robot, the induction loop and the optical system worked fine and we had a lot of fun. We've learned a lot — both from a mechanical and electronic viewpoint — and I guess that's what this computer stuff is all about.

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- Up to 26 single dimension arrays.
- FOR/NEXT loops nested up to 26.
- Variable names of any length.
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The display shows 32 characters by 24 lines.

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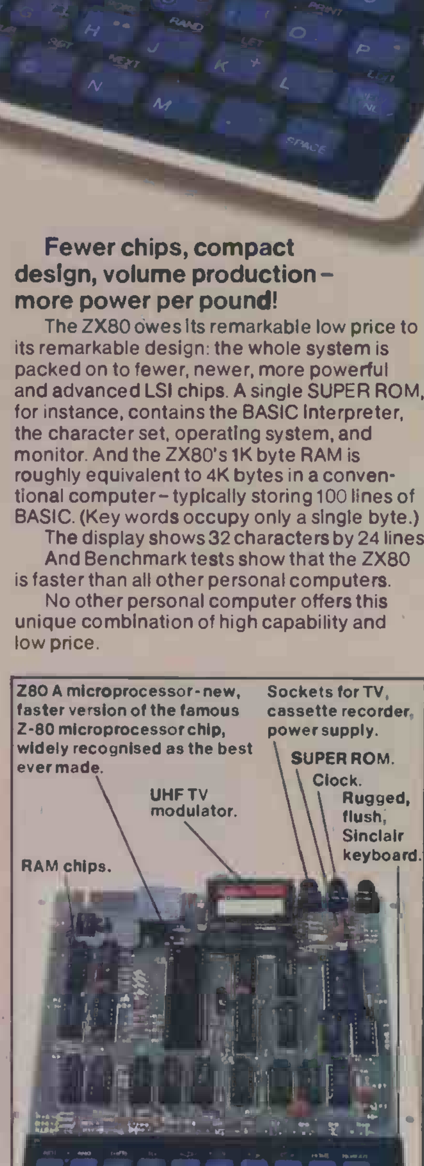


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CALCULATOR CORNER

This month Dick Pountain takes a breather from key-pressing to look at a fascinating and thought-provoking book

Gödel, Escher, Bach

Having regaled you for a couple of months with readers' programs, I now propose to shoot off at a tangent by reviewing a remarkable book which has nothing to do with programmable calculators. Nevertheless the contents of the book, *Godel, Escher Bach* by Douglas Hofstadter will certainly mesmerize many readers of this column, as they did me, especially if, as I suspect, you are more mathematically biased than the average computeer. Hofstadter is, incidentally, the assistant professor of Computer Science at Indiana University.

The book is so original in style and content that it is infuriatingly difficult to convey in a few words what it is *about*. It *isn't* about mathematics, music, painting, philosophy, molecular biology, computers, neuroscience or artificial intelligence. In fact it is about all these subjects but intertwined in such a unique way that no-one should be scared off by ignorance of any of them.

The principal theme running through the book is the notion of recursion, of recursive processes, recursive thought, recursive computer programs etc. This theme is extracted from the work of Hofstadter's three inspirers; the Incompleteness theorem of Kurt Godel, the music of Johann Sebastian Bach, and the paradoxical paintings of M C Escher. If you think that sounds pretentious all I can do is assure you that it isn't; Hofstadter's light touch nimbly sidesteps the precious and the pseudo-intellectual and you will very quickly accept his demonstrations that the structures of a Bach Canon, of Godel's *Proof* and Escher's *Waterfall* have in common a particular form of recursion (or self-reference) which he terms the "strange loop". And from there you will be effortlessly led through the theory of formal systems, logic, number theory, computer languages and up to some remarkable hypotheses about the mode of functioning of the human brain and the possibility (to Hofstadter a *certainty)* of artificial intelligence. You may surmise from this that it is not light reading and indeed it is a very demanding book which can on occasion make one's brain hurt. But it is rendered utterly absorbing and readable by the astonishing tour-de-force of style which Hofstadter has accomplished. Not so much the prose style, which though readable tends to the slightly whimsical American East Coast Academic, but the form.

The book is written in alternating chapters and dialogues. The dialogues, which are humorous but which illustrate points to be made in the following serious chapter, are between Achilles and the Tortoise, characters borrowed from Zeno's Paradox.

Many of the dialogues are written with a structure which reflects their content, such as the one about the Crab Canon, a musical form where a theme is played forwards and backwards simultaneously in different voices. This dialogue imperceptibly stops in the middle and then repeats its words in reverse order while making perfect sense, in the manner of a verbal palindrome. It is impossible to list all the tricks and devices, puns on many levels, acrostics and such which are woven into this book; in fact the text itself is structured as an Endlessly Rising Canon, since the final words take you back to page one but on a higher level of abstraction!

The book abounds with problems for the reader, many of which will delight the calculator buff and which may be solved by a calculator program. One such example which had me grabbing for my Casio occurs in the section on number theory. A number is chosen; if it is odd, triple it and add 1; if it is even, halve it. Then repeat the process. If by enough repetitions you arrive at 1 the number is a Wondrous number; if not it is Unwondrous. With some starting numbers the journey down to one is very long indeed. I played for several hours with a Casio program for testing numbers for the property of "wondrousness". The fact is that no-one has ever discovered an unwondrous number, but it cannot be proved that they don't exist! This example was introduced to illustrate the idea of terminating and non-terminating searches, which then leads Hofstadter on the theory of Turing machines, those primitive imaginary computers which can nevertheless in time perform any task which is possible on the largest mainframe. There follows a chapter in which Hofstadter invents three simple computer languages to illustrate Turing's theory. This chapter has some comfort for calculator fans, since he demonstrates that any language which allows loops and conditional tests to control looping is capable of solving any problem which is computable. This means that in a curious (and not very useful!) sense, a TI-59 or Casio 502 or HP-67 is as powerful as any computer which has ever been built or ever could be built. The fact that it may take several million years to compute some problems should not be allowed to spoil our new found pride!

Hofstadter goes on to discuss recursive functions and recursive programming in such a lucid way that I grasped the concept properly for the first time, along with pushing, popping and the operation of stacks, which had previously filled me with a certain unease. In fact I was immediately moved to write some recursive programs for the Casio, which is quite easy due to the automatic subroutine return feature. A program can call itself as a sub-routine without becoming ensnared by left-over Return commands. Unfortunately recursive programming on the Casio is not very rewarding since the stack only has ten registers and so recursions can only nest to a depth of ten, which is quite useless for evaluating a series from a recursive function such as the Fibonacci series, $F(x) = F(x-1) + F(x-2)$, beyond ten terms.

If I tell you that not far from here Hofstadter has moved on to the genetic code considered as a formal system, and then onto the brain considered as a hierarchy of computer languages, you will begin to get an idea of the scope and density of this work.

Unlike many such works written in the last decade, *Godel, Escher, Bach* has no trace of crankiness, nor any megalomaniac tendencies. Hofstadter is not preaching any soul-saving new revelation; indeed he is quite scornful of the guru culture and all its ramifications, as well as the craze for the 'paranormal'. His book is concerned with science, with certain threads in modern science which are of profound significance and which have never been pulled together in this way before. Rather than write another weighty textbook he has chosen to humanise his theme by his witty use of analogies drawn from art. As a result, any intelligent reader of PCW should have no trouble in following his path through these difficult regions. Anyone with any interest in computers must read it, if only for his wise and spirited defence of artificial intelligence. And anyone with a love of mathematics will, like myself, be very sad when the last/first page rolls around.

As a final tantaliser for programmers, I can reveal that in chapter 14, Hofstadter invents a simple alphabetic formal system which he calls "Typogenetics". By manipulating the symbols C,G,A and T according to a few simple rules, this sytem mimics very convincingly the way in which DNA replicates itself and codes for the synthesis of enzymes. The system looks to me a very suitable candidate for programming on a micro or even maybe an HP-41C. The result would be like a biochemical version of the 'Life' game. Anyone out there interested?

Godel, Escher, Bach by Douglas R Hofstadter, Harvester Press 1979 £10.50.

FACE TO FACE

This month David Hebditch considers ways of hotting up input procedures.

Last month's discussion of 'free-format' dialogues covered a style which seems to be most appropriate to applications where the display terminal has limited functionality and/or power. However, it is possible to achieve a much higher level of 'user friendliness' in situations where more control can be exercised over the use of the keyboard and display.

'Formatted' dialogues are structured to limit the degree of freedom available to the user and, thereby, reduce the possibility of things going wrong. In this article we shall consider three main types of structured dialogue:

— menu selection
— instruction-and-response and
— 'forms mode'.

Menu-based dialogues can make a major contribution to ease-of-use. The fundamental concept is that at each key stage in the dialogue, the user is presented with a range of possible options on the screen. Each of these is numbered so that the choice may be made merely by typing the number of the choice required, just like ordering food in a Chinese restaurant! Menus may be implemented at a control level or as a means of selecting data. For example, at the beginning of a sales accounting program, the user might see the following:

```
SALES ACCOUNTING
FACILITIES AVAILABLE ARE:
0. FINISHED WITH SALES
   ACCOUNTING.
1. EXAMINE/MODIFY
   CUSTOMER RECORD.
2. ADD NEW CUSTOMER
   RECORD.
3. ENTER ORDER.
4. POST CASH RECEIVED.
TYPE NUMBER OF FACILITY
REQUIRED:__
```

This type of menu has almost become a classic. Assuming that the supporting program is written in Basic, the programmer can employ the useful ON. . .GOSUB command as below:

```
        .
        .
1000  GOSUB 12000: REM DISPLAY MAIN MENU
1010  GET K$        : REM READ KEY PRESSED
1020  IF ASC (K$)< 0 OR ASC (K$)> 4 THEN GO TO 1010:    REM CHECK 0—4
1030  K = VAL(K$): REM CONVERT TO NUMERIC
1040  IF K = 0 THEN GOTO 19999: REM END
1050  ON K GOSUB 2000,3000,4000,5000: REM CALL PROCESSING SUBROUTINES
1060  GOTO 1000: REM BACK TO MENU.
        .
        .
2000  REM SUBROUTINE TO EXAMINE OR MODIFY A CUSTOMER RECORD
        .
        .
        .
```

If the user types '1' then this will cause the program to call the subroutine at statement 2000 which may then display a further menu for the particular functions it provides; examine customer record, delete customer record, modify customer record and so on.

There are at least two advantages to this approach:

— it is clear to the user at each stage in the dialogue exactly what can be done next (thus minimising the need to refer to manuals) and
— it is easy for the programmer to extend the program merely by adding a further option to the menu list, extending the range-check at statement 1020, adding a further subroutine address to the ON. . .GOSUB statement at 1050 and by writing the new subroutine itself.

The user does not need to learn command words and can select the option merely by typing a single key.

The technique can also be applied at 'data' level. For example, if the user wishes to enter some product descriptive information, the system could help by describing the options:

```
A4 2-RING BINDER WITH 2 INCH
SPINE.
THE COLOUR OPTIONS ARE:
1. BLACK        5. BRIGHT RED
2. BROWN        6. MAGENTA
3. WHITE        7. PURPLE
4. GREEN        8. BLUE
SELECT COLOUR REQUIRED: __
```

Here the user merely needs to press a single key in order to enter the colour code. To work effectively, only the colours actually available for the product concerned (A4 2—RING BINDER, etc) should be displayed. This makes it (theoretically) impossible to get an error message. Where the range of options is small, it might be effective to display more than one selection (colour, size, number of rings, etc) on the same screen.

A word of warning: the response time of 'data entry' applications of menus must be very fast if the user is not going to become frustrated with the speed of the system overall. After all, what the user does is fast so why can't the computer keep up?

Instruction-and-response (or 'question-and-answer') dialogues apply predominantly to data input. The technique has been around for a long time but really gained prominence through the use of Basic on multi-access minis and on single-station micros. The classic exchange is:

```
100 PRINT "ENTER NAME";
110 INPUT NM$
```

or, in its more streamlined version,

```
100 INPUT "ENTER NAME"; NM$
```

Consequently the dialogue is built up as a whole series of questions and answers, some of which may be multi-part, as shown below:

```
100 INPUT "PRODUCT CODE"; PC$
      (Checking routines)
.
.
200 INPUT "PRODUCT DESC"; PN$
.
.
.
300 INPUT "QUANTITY UNIT";QU$
.
.
.
400 INPUT "PURCHASE PRICE"; PP
.
.
.
500 INPUT "VAT CLASS"; VC$
.
.
.
```

and so on. This may appear on the display as:

```
PRODUCT CODE? GA439
PRODUCT DESC? PENCILS(HB)
QUANTITY UNIT? DOZ
PURCHASE PRICE? 1.45
VAT CLASS? 1
```

This is a simple and straightforward dialogue from the user point of view and can be applied to a wide variety of systems. However, the technique does not make full use of the formatting capabilities of the screen. Further, the use of simple INPUT statements in Basic can produce problems all of their own. For example, if you press RETURN on the PET without entering any data the system exits the program. Embarrassing.

On many commercial display terminals today, it is possible to make use of a facility for 'formatting' a screen so that its use resembles the filling-in of a form. This is achieved by being able to specify (through the use of control

FACE TO FACE

characters) that some areas of the screen, once set up by the program, are 'protected', ie cannot be modified from the keyboard. Other areas are 'unprotected' and can be used for data entry from the keyboard. The actual control characters used to implement this technique vary enormously from display to display, there being no provision in ASCII for this capability.

In the following example, I am using '[' (left square bracket) to indicate *start input field* and ']' right square bracket) to indicate *end input field*. The screen is initially displayed with the input fields blank and the cursor positioned at the beginning of the first item.

```
DATE: [ _      ]
A/C NUMBER: [          ]
AMOUNT: [         ]
TRANS. TYPE: [  ]
```

The underline indicates the position of the cursor. Seven characters are allowed for the date which is entered in the DDMMMYY format. When the last character is typed the cursor will automatically skip to the beginning of the next field (A/C NUMBER). This continues until the last item has been entered:

```
DATE: [24APR80]
A/C NUMBER: [4978465]
AMOUNT: [124.50]
TRANS. TYPE: [C]
```

In the case of items which do not fill the available space, the user will have to press a special key (usually TAB) to indicate that he has finished and to force the cursor to the next item. When the transaction has been completed, a single command can be used from the program to clear the input items *only* and to return the cursor to the start. In the above example, even better use can be made of the screen by changing the format as follows:

```
              TRANSACTION INPUT
DATE   ACCOUNT       AMOUNT    TRANS
       NUMBER                  TYPE
[     ][          ][        ][     ]
[     ][          ][        ][     ]
[     ][          ][        ][     ]
[     ][          ][        ][     ]
[     ][          ][        ][     ]
  .        .           .        .
  .        .           .        .
  .        .           .        .
```

. . . and so on for as many lines as you can fit on the screen. This technique is also possible on memory-mapped video systems such as the Apple and PET. In these cases the effect is achieved not by the use of control characters but through the judicious use of cursor control and the Basic GET command. More ideas on the 'forms mode' style of dialogue will be discussed next month.

BENCHMARKS

We have received a large number of requests for details of the Benchmark programs used in our Benchtests so we're reprinting them here. You'll also find the timings for machines Benchtested since May this year, including those in this issue.

The Benchmark programs, originally published in *Kilobaud*, are fairly self-explanatory and provide a rough rule-of-thumb guide to the efficiency of the machines' Basic interpreters and, to a lesser extent, to the efficiency of certain aspects of hardware design. They should be interpreted as such, and not used as absolute guides to which machine is 'better' than another; this is a decision which involves a great many factors and which can only be arrived at by studying the full Benchtests and by forming a clear idea of which machine is best suited to the purpose to which you intend to put it.

The disk Benchmark timings which were introduced earlier this year have not been listed, and neither have the disk timings been reproduced here as they do not apply to all machines. As different dialects of Basic have such widely different disk I/O formats, we cannot provide listings of a specific suite of programs which can run unaltered on any machine. Here, however, is a summary of what the disk tests do:

Test 1 OPEN a new file, then immediately CLOSE it.
Test 2 Using a FOR . . . NEXT loop, fill two strings, A$ and B$ with 128 As each; OPEN an existing file; using a FOR . . . NEXT loop, fill each of the 100 records, each of which contains two fields of 128 characters, with A$ and B$ in ascending order; CLOSE the file.
Test 3 Identical to Test 2 except that the records are written in reverse order.
Test 4 OPEN the file; read records 1 to 100 into A$ and B$; CLOSE the file.
Test 5 Identical to Test 4 except that the records are read in reverse order.

	BM1	BM2	BM3	BM4	BM5	BM6	BM7	BM8
Altos ACS 800-2	1.4	4.3	11.3	11.3	12.0	21.2	34.9	2.7
TRS-80 Model II (Int)	1.0	4.0	13.0	13.0	14.0	20.0	30.0	6.0
(S/prec)	1.0	5.0	13.0	13.0	14.0	23.0	35.0	6.0
(D/prec)	—	6.0	41.0	43.0	44.0	52.0	65.0	7.0
Periflex 630/48	4.5	10.5	27.5	28.5	31.5	59.0	79.5	60.0
Acorn Atom (Int)	0.8	5.5	10.0	11.5	14.5	20.0	31.5	—
(F/P)	—	—	30.5	27.0	30.0	—	—	26.0
DDE SPC/1	4.8	6.2	14.7	13.9	14.7	41.1	58.1	2.6
SuperBrain	1.6	5.2	14.0	13.9	14.8	26.3	43.2	5.6
BASF 7120	2.4	7.0	35.0	36.5	39.0	50.0	63.0	114.0
Atari 400/800	2.3	7.4	19.9	23.2	26.8	40.7	61.5	43.1
DAI	0.9	4.8	10.1	9.8	11.2	18.1	30.1	2.1
CBM 8032	1.7	10.0	18.4	20.3	21.9	32.4	51.0	11.9

Int = Integer Basic
F/P = Floating point Basic
S/prec = Single precision
D/prec = Double precision

All timings in seconds.

```
BM1  300 PRINT "S"
     400 FOR K=1 TO 1000
     500 NEXT K
     700 PRINT "E"
     800 END

BM2  300 PRINT "S"
     400 K=0
     500 K=K+1
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END

BM3  300 PRINT "S"
     400 K=0
     500 K=K+1
     510 A=K/K*K+K-K
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END

BM4  300 PRINT "S"
     400 K=0
     500 K=K+1
     510 A=K/2*3+4-5
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END

BM5  300 PRINT "S"
     400 K=0
     500 K=K+1
     510 A=K/2*3+4-5
     520 GOSUB 820
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END
     820 RETURN

BM6  300 PRINT "S"
     400 K=0
     430 DIM M(5)
     500 K=K+1
     510 A=K/2*3+4-5
     520 GOSUB 820
     530 FOR L=1 TO 5
     540 NEXT L
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END
     820 RETURN

BM7  300 PRINT "S"
     400 K=0
     430 DIM M(5)
     500 K=K+1
     510 A=K/2*3+4-5
     520 GOSUB 820
     530 FOR L=1 TO 5
     535 M(L)=A
     540 NEXT L
     600 IF K<1000 THEN 500
     700 PRINT "E"
     800 END
     820 RETURN

BM8  300 PRINT "S"
     400 K=0
     500 K=K+1
     530 A=K↑2
     540 B=LOG(K)
     550 C=SIN(K)
     600 IF K<100 THEN 500
     700 PRINT "E"
     800 END
```

PCW SUB SET

Continuing PCW's unique series aimed at the serious programmer working in assembler language, Alan Toothill brings more examples of work sent in by readers.

Relative calls

We said last month that we might use relative calls to produce position independent code. The Z80 does not have a relative call instruction, so we need some code to do it and this is the subject of our first Datasheet this month.

Location

A routine with such wide general use will need a location that does not change. What better place than one of the eight Z80 restart locations 00H, 08H, 10H, 18H, 20H, 28H, 30H, 38H, if you have one free? The routine can then be entered with a one-byte RST instead of a three-byte CALL, with the displacement now following the RST. Nascom does this in its NAS-SYS1 monitor.

The problem

The problem with this routine is in incrementing the return address to skip the displacement byte, after saving any registers used in doing this. Not having to save the DE register at this stage, NAS-SYS1 neatly uses the six bytes of:—

```
POP  HL   ;  to add 2 to SP.
POP  HL   ;  get return address
INC  HL   ;  increment it and
PUSH HL   ;  save it.
DEC SP    ;  subtract 2
DEC SP    ;  from SP.
```

compared with the 12 bytes of our 3rd to 12th instructions.

But this will not make a PCW Class 1 routine because it is not interruptable. An interrupt when the address in SP is above the address of any values on the stack we want to save can corrupt those values. So our 12 bytes is the best we can do. Or is it?

1 Byte into 2

See how the single byte displacement in A, which might be positive or negative, is loaded into the double byte DE register:

```
LD   E,A
RLCA
SBC  A,A
LD   D,A
```

Have you a better way?

RLTV in action

A reader has sent a routine which calls another routine it contains both from behind and ahead. Ideal for testing RLTV! You will also need a routine, called INPUT here, to wait for a character from the keyboard and return with it in A. The subroutine called by RLTV is labelled LSCN3. The routine enters characters from the keyboard, calculator fashion, into the least significant end of a RAM field. If you have a video RAM system, set the DE register to point to the end of a field in the video

Datasheet

```
;= RLTV — Relative call
;/ "RLTV" — level 0; class 1
;/ TIME CRITICAL? No
;/ Causes a call to the address formed by adding the displacement,
;/ given in the byte following the CALL RLTV instruction, to the
;/ address of the next instruction following the displacement byte
;/ ACTION:  ( SP + 0/1 )  ←   ( SP + 0/1 ) + 1
;          ( SP − 1/2 )  ←   ( SP + 0/1 ) + displacement
;          PC low        ←   ( SP − 2 )
;          PC high       ←   ( SP − 1 )
;/ INPUT: The byte following the CALL RLTV instruction holds the
;         positive or negative displacement
;/ OUTPUT:  The program counter is set to the address of the
;          displaced routine to be executed
;/ REGs USED: None
;/ STACK USE: 6
;/ LENGTH: 27
;/ SUBr DEPENDENCIES: None
;/ INTERFACES: None
;/ 8080 COMPATIBLE? Yes

RLTV:  PUSH  HL        ; save                           E5
       PUSH  DE        ; registers.                     D5
       LD    HL, +4    ; get in HL                      21 04 00
       ADD   HL, SP    ; SP value on entry.             39
       LD    E, (HL)   ; get displacement               5E
       INC   HL        ; address                        23
       LD    D, (HL)   ; in DE                          56
       INC   DE        ; increment it                   13
       LD    (HL), D   ; and                            72
       DEC   HL        ; return it                      2B
       LD    (HL), E   ; to the stack                   73
       EX    DE, HL    ; and HL register.               EB
       DEC   HL        ; point back to displacement     2B
       PUSH  AF        ; save AF.                       F5
       LD    A, (HL)   ; get displacement and           7E
       LD    E, A      ; store it in E.                 5F
       RLCA            ; put sign bit in carry          07
       SBC   A, A      ; propagate it through A         9F
       LD    D, A      ; and store in D.                57
       INC   HL        ; get next instruction addr.     23
       ADD   HL, DE    ; add displacement.              19
       POP   AF        ; restore                        F1
       POP   DE        ; AF and DE                      D1
       EX    (SP), HL; restore HL and put displaced     E3
;                      address 2nd on stack.
       RET             ; return to displaced routine.   C9
```

Datasheet

```
;= LSCN — Enter characters calculator fashion
;/ "LSCN" — level 1; class 1
;/ TIME CRITICAL?: No
;/ Loads RAM from the keyboard to the highest addressed byte
;  of a field, shifting previous entries to adjacent lower locations.
;/ ACTION:  A            ← keyboard
;          ( DE − 1 )    ← ( DE )
;          ( DE − 2 )    ← ( DE − 1 ) etc
;          ( DE )        ← A
;          B        ← B − 1
;          repeated until B = 0 or
;          return code entered
;/ INPUT: B contains maximum number of characters to be entered.
;        C contains a code to return before the maximum number
;          of characters has been entered.
```

(Continued on next page)

```
;            DE contains the address of the end of the RAM field
;                in which data is to be entered.
;            The RAM field in which data is to be entered is
;                space filled.
;/  OUTPUT:  The RAM field, at and below the location pointed to
;            on entry by the DE register, will contain input from
;            the keyboard.
;/  REGs USED:  BC      DE
;/  STACK USE:  6 + 4 x (contents of B on entry)
;/  LENGTH: 31
;/  SUBr DEPENDENCIES: INPUT — to get a character from the keyboard in A.
;                      RLTV  — Relative call.
;/  INTERFACES: Keyboard
;/  8080 COMPATIBLE?: No
LSCN:   PUSH AF         ; save AF.                      F5
        INC  DE         ; position RAM field pointer.   13
LSCN1:  CALL INPUT      ; get chr from keyboard         CD XX XX
        CP   C          ; and if "return"               B9
        JR   Z, LSCN2;  ; leave routine.                28 06
        CALL RLTV       ; relative call to LSCN3        CD XX XX
        DEFB +4         ; to put input in RAM           04
        DJNZ LSCN1      ; get next input                10 F4
LSCN2:  POP  AF         ; else restore AF               F1
        RET             ; and return from LSCN.         C9
LSCN3:  PUSH AF         ; save previous entry           F5
        DEC  DE         ; point one chr down.           1B
        LD   A, (DE)    ; get current chr               1A
        CP   20H        ; and if space jump to shift    FE 20
        JR   Z, LSCN4;  ; previous entries and load     28 04
;                         input into RAM
        CALL RLTV       ; else relative call to LSCN3   CD XX XX
        DEFB -11        ; to stack previous entries.    F5
LSCN4:  POP  AF         ; restore previous entry.       F1
        LD   (DE), A    ; put it in RAM.                12
        INC  DE         ; increment RAM pointer         13
        RET             ; return either for next        C9
;                         previous entry or for next
;                         input.
```

RAM, so that you will see on the screen the data as it is entered. The routine is in our second Datasheet.

Recursion

The second relative call comes within LSCN3 calling itself. If you have other examples of recursion like this, send them in and we will do a separate feature on them.

With its relative calls and recursion, LSCN is an interesting little routine. But is it the best way to enter characters calculators fashion? You tell us!

Join in

This piece on datasheets, and probably next month's, has to go to press before there has been time for any response to the September issue, in which the project was launched.

The idea is to build up a collection of machine-code routines, improved to a high standard by exposure and criticism. We will be trying to see that you who submit routines gain more from the exercise than readers who do not, perhaps by way of access to material there might not be space to print. You will in any case gain from putting your work into a shape fit for other people to see.

If you have any contributions for PCW Sub Set, send them to: PCW Sub Set, PCW, 14 Rathbone Place, London W1P 1DE.

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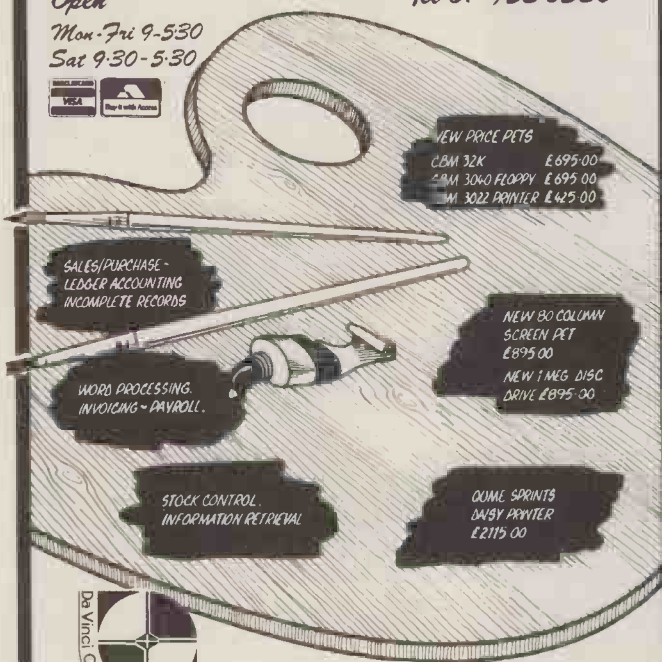

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SECRETS OF SYSTEMS ANALYSIS

Lyn Antill continues this country's first serious attempt to enable prospective computer users and micro specialists to bridge the gulf of misunderstanding that undoubtedly exists between them. The aim of the series is to enable users to analyse their own problems so that both sides are able to work constructively together towards successful system implementations.

Most of the first article in this series was devoted to justifying the existence of systems analysis as a discipline distinct from computer programming. I finished with a few examples to illustrate the importance of defining in advance exactly what it is you want your micro to do for you and what can go wrong if you don't. I shall be refering again to the saga of Mr Bloggs' garage.

Definitions

I must stress the word *defining;* which is more than just *deciding*. Requirements have to be spelt out in detail for two reasons: the first is to encourage the user to follow through the implications of what he thinks he wants to do to see whether or not it is feasible and that nothing has been left out; the second is that the person writing the programs will know nothing about those requirements except what has been written down. He (or she) will not have years of accumulated knowledge of the business and the way it works, nor of any specialised vocabulary involved.

Even if you are going to write your own programs, don't kid yourself that you'll be able to get away without this definition of requirements. Programming is a complicated activity, concentrating the mind on the technicalities of the machine, and unless you have already defined what you need, you will be tempted to settle for the solution that is easiest to program, or one that although elegant, isn't relevant.

A definition does not have to be fixed and inflexible. You can modify it as you go along. (At least you can if it's only micro-sized.) But this does presuppose that there is something written down to modify. The main reason for this is that you might not otherwise see the implications of the change that you want to make. A common mistake is to change A, forgetting that it needed to be like that to fit in with B, and realising too late that the system doesn't work because you should have changed B as well. Don't forget, though, that if you change the requirements after the programs have been written, or even partly written, then you have paid for quite a few man-hours' work that will have been wasted writing programs to do things that aren't required.

Having now (hopefully) convinced anyone who might have doubted the importance of defining requirements, I can go on to discuss how this might be done. Not, unfortunately, with '*the* way to do it', because systems analysis is a field of human endeavour rather than an academic discipline and so there are never right or wrong methods or solutions, just ones which seem more or less appropriate.

Getting started on the problem

So you've got a problem and you think a microcomputer might provide the solution. *Wrong!* You might be able to use a microcomputer as a tool to implement a solution. It is the use you are able to make of it rather than the machine itself which will determine whether your life is any easier or your business any more efficient. Lesson number two — a microcomputer cannot solve your problems but a *system* based on a micro might.

So you've got a problem and you think a micro-based system might provide the solution. The first stage in finding out whether or not you need a micro is to define the problem; this is the analysis stage. But how do you set about doing that? Well, it's just like any other problem — you find an impartial and sympathetic listener and talk it through. If you go to someone with with the same problem, you'll both finish up crying in your beer. If you go to someone like a micro shop, then they have a vested interest in providing you with a certain sort of 'solution' which might not actually make things any better. The salesman should be able to discuss impartially the strengths and weaknesses of the systems he stocks, and what each can do, but he cannot be impartial about your problem.

If you cannot find a listener then you are probably just as well off imagining one. Personally I find this very helpful, especially if I don't know where to start. I form a clear mental picture of someone who is intelligent, sympathetic, not conversant with the work, but totally interested and who will listen without interrupting, then ask perceptive questions about what I am explaining. You've probably written me off now as some sort of nut but thinking is a difficult process and one needs tools and techniques for doing it well. Almost invariably a genius is able to explain the techniques he uses for performing hefty intellectual tasks and most academic teaching is intended to train the student to think. Well, this is my thinking tool for analysing a problem — explain it to your 'analyst'.

This explaining isn't a simple one-off business. The more time and trouble you put into it, the more insight you will gain. Perhaps the best thing about this reflection is that it doesn't cost anything. It is the sort of thing you do automatically when you stand back from the problem and 'get things into perspective'. It is when you can't take time off that you have to discipline yourself to look objectively at what you are trying to do. This brings us to lesson number three: you can't solve the problem until you know what it is.

Knowing the problem

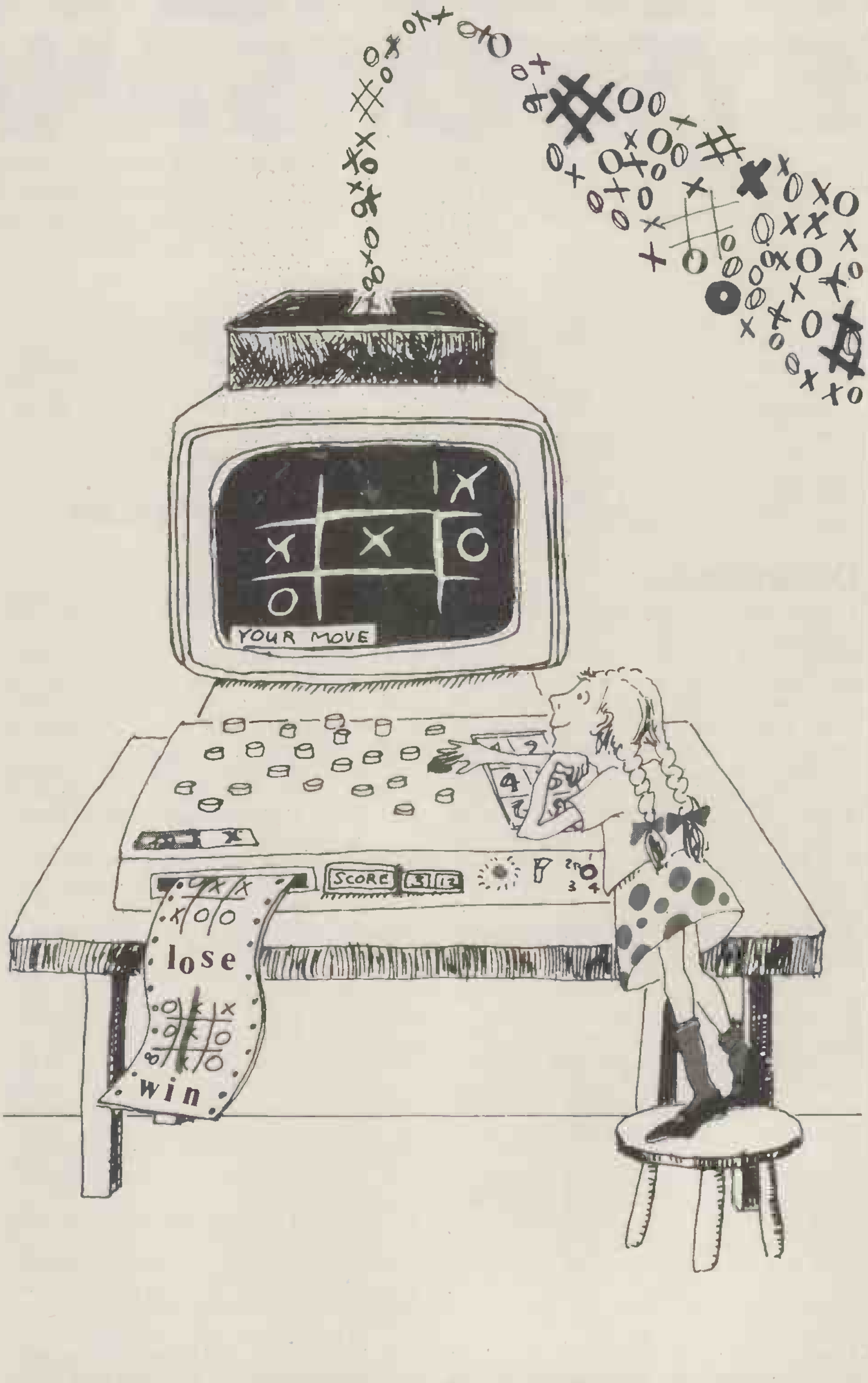
It is very important to remember that you are not sketching out a solution at this stage, merely trying to explain the problem. In part one, Mr Bloggs hadn't spelt out the problem, although I think I can guess what it was. As each item was sold, that sale should have been recorded so that the item could be re-ordered. Analysing the records to see what needed to be re-ordered obviously took time and was perhaps prone to careless mistakes, but the real problem arose when sales were not recorded; only laborious stock-checking could correct that. Every sale should have been recorded on the till roll, although the product code might not have been entered correctly and there would be no way of checking that. Also, there would be no way, other than checking through the whole roll again, of making sure that the tedious and lengthy job of keying all the data from the till roll had been performed without any mistakes. From my experience of boring key-punching jobs done at close of day, there would be lots of mistakes made and even more in trying to make corrections. So the suggested solution appears to be making even heavier going of the recording, which was causing the problem in the first place. Of course this is only a very superficial reading of the situation, based only on the published letter and I have used it solely to illustrate the general point that the first step in designing a new system is to put your finger on what is causing problems in the old one.

What features do you want to keep?

The next stage, having found out what we want to change, is to decide what we want to keep. We've defined the problems, now let's define the good features; don't replace Victorian terraces with tower blocks.

Before micros came along I used to work with visible record computers, particularly the Burroughs L range. The first complete system I was responsible for installing was remarkably successful. It handled twice as much work with half the number of staff and kept records which were significantly more accurate and up-to-date. When I studied the system a few years later I was disturbed to find that it only worked because the Burroughs ledger cards looked sufficiently like the old NCR ones that the accounts clerks could check the work in the same way they had before. If I had stored on a floppy disk the information that was on the magnetic stripe at the back of a ledger card, then I might have known that it held the same information but there was no way the accounts clerks could have proved it. I would have had to invent new clerical procedures for checking the accuracy of the accounts. In this case the good feature that I had under-valued was the ease with which the visual data on the ledgers could be checked and cross-checked.

It is a standard human failing to be more aware of what is wrong than of what is right. You take it for granted that if your new system puts right what is wrong with the old, you will be better off. If you don't spell out what is worth keeping, you might find you've lost it. When you're telling the programmer what needs to be done, try to remember all the things you take for granted — he might not be aware of them. It is an often repeated cry of programmers that, "the user never knows what he wants until he hasn't got it". Of course the user *knew* he wanted it, he just hadn't thought it needed spelling out to the programmer.



Errors

In any system some errors are picked up by deliberate checks, others are spotted by chance and some are written off as inevitable. If you are computerising an existing system, it is important to look at the sorts of checks that are being made and the errors that are being found as well as the ones that are getting through. You make different sorts of mistakes when you process things in different ways. In a manual system, mistakes are often made in the following ways:

— miscasting columns of figures
— posting items to the wrong account
— missing items or putting them through twice
— mis-keying or transposing characters.

We are accustomed to these sorts of errors and deliberately check for them. On the other hand, people are very good at picking up nonsense, such as a customer who appears to have ordered 1000 Rolls-Royces, or a string of numbers where a name should be. Unless you consciously realised that your computer couldn't spot these errors, you wouldn't think of checking for them yourself.

If you have a powerful mainframe you can write sophisticated error checking routines. You can even get the computer to build up profiles of the sort of entries you are accustomed to receiving and query anything that doesn't seem to fit into the pattern. After all, you or your assistants have been storing that sort of information in your heads for years about the information you have been processing. You know when something 'just looks wrong'. Don't forget that the micro doesn't. In a later issue I will look at some of the checking that a good micro program should be able to do for you. At this stage, though, just note down the things that need to be checked. You'll be surprised how much data vetting you're doing. For my fourth lesson, I shall adapt Murphy's Law — if it can go wrong it will, so build a check for it.

Input, Processing, Storage, Output

These are the four main headings under which requirements would normally be listed and of these I always tackle the output first. After all, there is no point in creating a micro system unless you are going to be able to get something out of it. (Incidentally, this is where the serious user differs from the hobbyist. What the latter gets out of his computer is therapy.) In Mr Bloggs' case, one of the main outputs would have been a list of all the parts that had been sold and needed to be re-ordered.

Outputs may simply be the answer to an occasional query, the solution of an equation, letters to your customers or visual displays. In order to produce this output you have to put data in, store it and process it; this gives us the other three. When you design a system these are sketched out first in rather broad terms; later sufficient detail is filled in for the programmer to work from without having to know any more. Let me give a simple example:

My daughter wants to play noughts and crosses against the computer.

OUTPUT:
— visual representation of the square and the moves made
— computer moves
— instructions to the operator

STORAGE:
— moves made so far
— whether computer is noughts or crosses
— rules of the game
— instruction messages

PROCESSING:
— calling for and accepting moves
— finding out whether user wants to be noughts or crosses
— deciding whether a move is valid and making or rejecting it
— deciding where the computer should move
— looking for three in a row

INPUT:
— choice of noughts or crosses
— position of next move

OPTIONAL EXTRAS:
— visually pleasing display
— amusing messages
— random element so that the computer sometimes lets you win
— there should be a working version of the program as soon as possible because daughter is clamouring to use it
— it should fit into 8k because I can't afford any more memory yet.

These last two aren't part of the functional specification but they are important and must be included somewhere. The others have not been put in any order, just jotted down as I thought of them. Nor have any of the details been spelt out, eg how are the squares to be numbered? How are the moves to be selected? And it is certainly not for the analyst to suggest how the data should be stored or the programming be done. Only with file design (of which more later) is the analyst concerned with the 'how' of what goes on inside the computer.

What we have here is a sound base on which to build a full functional specification, along with a clear statement of two attributes of the system (ie the constraints on time and available memory). I leave it to you to decide, as an exercise, whether what I have put down so far hangs together and what further details would need to be filled in.

Human considerations

It's all very well doing all this thinking about the machine but what about the people who are going to use it? They may also have requirements and they will certainly have things to say about the functional requirements as well. Who is actually going to be pressing the keys, looking at the screen, reading the printout? It may well turn out that one of your requirements is that input should be done by a mechanic with greasy fingers or protective gloves on, or that the screen should be legible by someone at a distance, or to you without your reading glasses on (you can't look at a screen through the bottom half of your bifocals).

Some of these limitations are obvious or even predominant. Micros can be of great value to the handicapped. The touch-sensitive keyboard and the ability to correct mistakes on the screen can make typing much easier for those with limited hand movement. If such a person has a separate keyboard, this can be even better as it can be positioned where it is most accessible. Such a requirement must be specified or it may be overlooked.

If a machine is going to be used by children it must be robust. A good set of graphics is immensely important, especially for juniors. They are captivated by cartoons and will cheerfully spend hours learning to use the machine as well as learning what the program was intended to teach. (And if there are sounds too, so much the better.) Also, any micro for infants or juniors must have lower case characters (many don't) because children learn to read in lower case and many don't take readily to capitals.

If you have specialised requirements like these, you probably don't need to be reminded to specify them. It is the person in a normal situation who is more likely to be scuppered because of some apparently trivial thing like one of his best employees who just can't type, or one who gets headaches looking at a flickering TV screen when you could have bought a high-quality monitor.

Another question you have to ask yourself is, 'how ready are you and your staff to change the details of your working life?'. Some people don't care how they go about doing a job just so long as they get it done as quickly and efficiently as they can. This is particularly true of the boss, whose only real concern is to keep the business viable. Others, particularly those who have been doing the same job in the same way for years, will be both mentally and emotionally slow to adapt. Their concern has always been with getting the details right and much of their self-image and way of life has been built around doing things a certain way; they would prefer not to change. You may decide, nevertheless, to start on a steady campaign to talk them round and you should certainly bring them in on the analysis stage. If you bear their detailed requirements in mind, you are more likely to come up with a system that they are able and willing to operate successfully.

Lesson number five: one of your requirements is that the user should be able and willing to use the machine.

Summary

You probably think I've been going on a bit about the preliminary stages and you're right. But I've only done so because the majority of computer systems that come to grief do so because this preliminary work has been neglected. This lesson was learnt the hard way by mainframe users a decade or so ago and now many micro users seem to be making the same mistakes all over again. So stand back from the problem and take a long cool look at it; talk it through with the people who will be involved and listen to what they say; split the functional requirements into Input, Processing, Storage and Output; think of all the things that can go wrong; list all the practical constraints (like cost); distinguish between essential and desirable features; and keep an open mind — don't try to impose a solution.

Now that you are clear in your own mind you are ready to start talking to salesmen and programmers. Next month — how to put your rquirements in a form that the programmer can use.

NEWCOMERS-START HERE

This is PCW's unique quick-reference guide for the microcomputing novice. While it's in no way totally comprehensive, it should help you pick your way through the most important pieces of (necessary) jargon which you'll find in PCW. We trust you'll find it useful. Happy microcomputing.

Welcome to the confusing world of the microcomputer. First of all, don't be fooled; there's nothing complicated about this business, it's just that we're surrounded by an immense amount of necessary jargon. Imagine if we had to continually say "numbering system with a radix of sixteen in which the letters A to F represent the values 10 to 15" when instead we can simply say "hex". No doubt soon many of the words and phrases we are about to explain will eventually fall into common English usage. Until that time, PCW will be publishing this guide — every month.

We'll start by considering a microcomputer's functions and then examine the physical components necessary to implement these functions.

The microcomputer is capable of receiving information, processing it, storing the results or sending them somewhere else. All this information is called data and it comprises numbers, letters and special symbols which can be read by humans. Although the data are (yes, it's plural) accepted and output by the computer in 'human' form, inside it's a different story — they must be held in the form of an electronic code. This code is called binary — a system of numbering which uses only 0s and 1s. Thus in most micros each character, number or symbol is represented by eight binary digits or bits as they are called, ranging from 00000000 to 11111111.

To simplify communication between computers, several standard coding systems exist, the most common being ASCII (American Standard Code for Information Interchange). As an example of this standard, the number five is represented as 00110101 — complicated for humans, but easy for the computer! This collection of eight bits is called a byte and computer freaks who spend a lot of time messing around with bits and bytes use a half-way human representation called hex. The hex equivalent of a byte is obtained by giving each half a single character code (0—9,A—F): 0=0000, 1=0001, 2=0010, 3=0011, 4=0100, 5=0101 ...... E=1110 and F=1111. Our example of 5 is therefore 35 in hex. This makes it easier for humans to handle complicated collections of 0s and 1s. The machine detects these 0s and 1s by recognising different voltage levels.

The computer processes data by reshuffling, performing arithmetic on, or by comparing them with other data. It's the latter function that gives a computer its apparent 'intelligence' — the ability to make decisions and to act upon them. It has to be given a set of rules in order to do this and, once again, these rules are stored in memory as bytes. The rules are called programs and while they can be input in binary or hex (machine code programming), the usual method is to have a special program which translates English or near-English into machine code. This speeds programming considerably; the nearer the programming language is to English, the faster the programming time. On the other hand, program execution speed tends to be slower.

The most common microcomputer language is Basic. Program instructions are typed in at the keyboard, to be coded and stored in the computer's memory. To run such a program the computer uses an interpreter which picks up each English-type instruction, translates it into machine code and then feeds it into the processor for execution. It has to do this each time the same instruction has to be executed.

Two strange words you will hear in connection with Basic are PEEK and POKE. They give the programmer access to the memory of the machine. It's possible to read (PEEK) the contents of a byte in the computer and to modify a byte (POKE).

Moving on to hardware, this means the physical components of a computer system as opposed to software — the programs needed to make the system work.

At the heart of a microcomputer system is the central processing unit (CPU), a single microprocessor chip with supporting devices such as buffers, which 'amplify' the CPU's signals for use by other components in the system. The packaged chips are either soldered directly to a printed circuit board (PCB) or are mounted in sockets.

In some microcomputers, the entire system is mounted on a single, large, PCB; in others a bus system is used, comprising a long PCB holding a number of interconnected sockets. Plugged into these are several smaller PCBs, each with a specific function — for instance, one card would hold the CPU and its support chips. The most widely-used bus system is called the S100.

The CPU needs memory in which to keep programs and data. Microcomputers generally have two types of memory, RAM (Random Access Memory) and ROM (Read Only Memory). The CPU can read information stored in RAM — and also put information into RAM. Two types of RAM exist — static and dynamic; all you really need know is that dynamic RAM uses less power and is less expensive than static, but it requires additional, complex, circuity to make it work. Both types of RAM lose their contents when power is switched off, whereas ROM retains its contents permanently. Not surprisingly, manufacturers often store interpreters and the like in ROM. The CPU can only read the ROM's contents and cannot alter them in any way. You can buy special ROMs called PROMs (Programmable ROMs) and EPROMs (Erasable PROMs) which can be programmed using a special device; EPROMs can be erased using ultra-violet light.

Because RAM loses its contents when power is switched off, cassettes and floppy disks are used to save programs and data for later use. Audio-type tape recorders are often used by converting data to a series of audio tones and recording them; later the computer can listen to these same tones and re-convert them into data. Various methods are used for this, so a cassette recorded by one make of computer won't necessarily work on another make. It takes a long time to record and play back information and it's difficult to locate one specific item among a whole mass of information on a cassette; therefore, to overcome these problems, floppy disks are used on more sophisticated systems.

A floppy disk is made of thin plastic, coated with a magnetic recording surface rather like that used on tape. The disk, in its protective envelope, is placed in a disk drive which rotates it and moves a read/write head across the disk's surface. The disk is divided into concentric rings called tracks, each of which is in turn subdivided into sectors. Using a program called a disk operating system, the computer keeps track of exactly where information is on the disk and it can get to any item of data by moving the head to the appropriate track and then waiting for the right sector to come round. Two methods are used to tell the computer where on a track each sector starts: soft sectoring where special signals are recorded on the surface and hard sectoring where holes are punched through the disk around the central hole, one per sector.

Half-way between cassettes and disks is the stringy floppy — a miniature continuous loop tape cartridge, faster than a cassette but cheaper than a disk system. Hard disk systems are also available for microcomputers; they store more information than floppy disks, are more reliable and information can be transferred to and from them much more quickly.

You, the user, must be able to communicate with the computer and the generally accepted minimum for this is the visual display unit (VDU), which looks like a TV screen with a typewriter-style keyboard; sometimes these are built into the system, sometimes they're separate. If you want a written record (hard copy) of the computer's output, you'll need a printer.

The computer can send out and receive information in two forms — parallel and serial. Parallel input/output (I/O) requires a series of wires to connect the computer to another device, such as a printer, and it sends out data a byte at a time, with a separate wire carrying each bit. Serial I/O involves sending data one bit at a time along a single piece of wire, with extra bits added to tell the receiving device when a byte is about to start and when it has finished. The speed that data is transmitted is referred to as the baud rate and, very roughly, the baud rate divided by 10 equals the number of bytes being sent per second.

To ensure that both receiver and transmitter link up without any electrical horrors, standards exist for serial interfaces; the most common is RS232 (or V24) while, for parallel interfaces to printers, the Centronics standard is popular.

Finally, a modem connects a computer, via a serial interface, to the telephone system allowing two computers with modems to exchange information. A modem must be wired into the telephone system and you need British Telecom's permission; instead you could use an acoustic coupler, which has two obscene-looking rubber cups into which the handset fits, and which has no electrical connection with the phone system — British Telecom isn't so uppity about the use of these.

IN STORE

DIRECT ACCESS

Dick Olney of Heuristics Consultants presents a revised 'In Store'; from now on this will appear bi-monthly, alternating with our 'Packages' software guide. Updates and revisions for In Store should be sent to Dick, c/o PCW, 14 Rathbone Place, London W1P 1DE.

Machine (Price from)	Main Distributor/s (No. of Dealers)	Hardware	Software	Miscellaneous (Documentation)
ABC 80 (£738)	Datormark Ltd: 09322 44896	16-40k RAM; Z80A; C; 12", 16x40 b&w VDU; 4680 bus; IEEE 488; RS232 port.	DOS; Basic (16k ROM); *Fortran; Pascal; A; Multi user Basic.*	Colour video graphics with UHF output. Viewdata compatible. Loudspeaker. Numeric keypad. Options: dual 5¼" F/D (160k) £895; dual 8" F/D (2 Mb).
ACT System 800 (£3950)	ACT: 021-455 9898 (50)	48k RAM; 6502; dual 5¼" F/D (800k); 12", 30x64 VDU; 1 S/P; 1 P/P; Multi-screen int.	MDOS; Basic; A; *CBasic; PL/M; Forth; Fifth; Cesil; Pilot; Fortran.*	IBM compatible K/B. High resolution graphics. Available with dual 8" F/D (2.4 Mb) £4950 — 4.8 Mb maximum. (E).
Alpha Micro (£5650)	Alpha Micro (UK) Ltd: 01-250 1616 (TBA)	64k — 1 Mb RAM; 16 bit; dual 8" F/D (2.4 Mb); 6 S/P.	Multi-user OS; Basic; M/A; Pascal; U.	Modular. Expands to 1200 Mb, 24 terminals or multiprocessor system. (E)
Altos ACS 8000 (£3398)	Logitek: 02572 66803 (33)	64k RAM; Z80; 1k EPROM; dual 8" F/D (1Mb); 2xRS232 ports; 1 P/P.	CP/M; *Basic; CBasic; Cobol; Pascal; Fortran.*	Expandable to 4-user system with 58Mb H/D. Maintenance contracts avail; (S&H).
Apple II (£695)	Microsense: 0442 41191 (190)	16-48k RAM; 6502; 8 I/O slots.	O/S; Basic; *Pascal; Fortran.*	280x192 high resultion graphics; Integer Basic in 6k ROM; Option: single 5¼" F/D (116k) £349.
Athena 8285 (£5694)	Butel-Comco Ltd: 0703 39890 (TBA)	64k RAM; 8085A; dual 5¼" F/D (644k); 12", 25x80 VDU; 150 cps printer; RS232 port.	AMOS; T/E; Basic; *Cobol; Fortran; Pascal; APL; M/A.*	Extended ASCII K/B with numeric pad; graphics. Options: dual 8" F/D (2Mb); up to 1200 Mb H/D
Atom (£120)	Acorn: 0223 312772 (N/A)	2-11k RAM; 6502; Full K/B; C int; TV int; 20 I/O lines; 1 P/P.	Basic in 8k ROM; A; Cass O/S.	High resolution graphics on bigger model; colour monitor O/P. Loudspeaker. Note also, systems based on Acorn SBC. (B).
Attache System II (£8000)	Friargrove Systems Ltd: 01-572 3784	64k RAM; 8080; dual 8" F/D (1.2Mb); 12", 24x80 VDU; 180 cps printer.	Basic; *Fortran; Cobol.*	Upgradable to multiuser system with 20Mb H/D. (S).
Billings BC-12 FD: (£3995)	Mitech: 04862 23131 (TBA)	64k RAM; Z80A; dual 5¼" F/D (640k); 12", 24x80 b&w (or b&g) VDU.	DOS; Basic; *Fortran; Cobol; A.*	With dual 8" F/D (2Mb) £5995. Additional dual 8" F/D £3000. (S).
C/09 (£3975)	SWTP Ltd: 01-491 7507 (16)	56k RAM; 6809; dual 8" F/D (2Mb); 8", 16x80 VDU; 1 S/P.	TSC FLEX; *Basic; Pascal; A; Dis A; T/E; U.*	VDU is intelligent. Option: 15Mb H/D £3575; with dual 5¼" F/D (350k) instead of 8", £3000.
Challenger 1P & C4P (£220 & £395)	CTS: 0706 79332. Millbank Computing: 01-549 7262. Mutek: 0225 743289. U-Microcomputers: 0925 54117	4-32k RAM; 6502; C int; RS232 port.	O/S; Basic (8k ROM) *Ex Basic; A.*	D/A conv; colour capability. Options: dual 5¼" F/D (160k) £550; for C4P dual 8" F/D (1.15Mb) and 20Mb H/D. Runs OSI business software on 8" F/D (S).
Challenger 2 (£1500)	As above	48k RAM; 6502; dual 8" F/D (0.5Mb); RS232 port.	OS65U; Ex Basic; A.	Designed as low cost business system (S).
Challenger C3 (£2334)	As above	32-56k RAM; 6502; 6800; Z80; dual 8" F/D (1.15Mb); 2-16 S/P.	OS65U; Basic; *CP/M; Fortran; Cobol.*	Expandable to multi-user (8) system. Options: C3B & C3C H/D units, 74Mb for about £8500. (S&H).
Clenlo Conqueror System B (£1950	Clenlo Computing Systems Ltd: 01-670 4202	64k RAM; Z80; dual 8" F/D (1Mb); 3 S/P; 2 P/P.	CP/M; CBasic-2; Pearl 1; *U.*	With four 8" F/D £2850.
Clenlo Conqueror System D (£5150)	As above	64k RAM; single 8" F/D (500k); 10Mb H/D; 3 S/P; 2 P/P.	CP/M; CBasic-2; Pearl 11; *U.*	With 26Mb H/D and no F/D £5950.
Compucolor II (£995)	Dyad Developments: 08446 729	8-32k RAM; 8080; 13" 32x64 8-colour VDU; single 5¼" F/D (51k); RS232 port.	DOS (ROM); Ex-Basic (ROM); A.	16k version £1078, 32k £1198. High resolution graphics. 6-month subscription to user magazine inclusive (S).
Compucorp 625 (£6000)	Compucorp: 01-952 7860 (17)	60k RAM; dual 5¼" F/D (630k); 9", 16x80 VDU; 40 col printer; RS232 port.	Basic; A; *Fortran; Pascal;* U.	Various systems available with 320k — 2.4Mb F/D and 9", 12" or 20" VDU.
Computermart 2000 DS (£1500)	Computermart: 0603 615089	32-256k RAM; 8085; dual 8" F/D (1-2Mb); S/P; P/P.	CP/M; *Cis Cobol; Basic; Fortran.*	Expandable to multi-user, multi-tasking, multi-processor 96Mb H/D system (around £15000).
Cromemco System 2, System 3, System Z2H. (£2100/ £3730/£5340)	Datron: 0742 585490. Comart: 0480 215005. MicroCentre: 031 556 7354	64k RAM; Z80; dual 5¼" F/D (346k) on System 2 & Z2H; dual 8" F/D (1.2Mb) on Sys 3; 10Mb H/D on Z2H; S/P; P/P.	CDOS; *Basic; Cobol; Fortran; RPG II; Lisp; A; W/P; Multi-user Basic.*	All systems expandable to multi-user (max 7) £6408 Sys 2, £8304 Sys 3. Options: dual 8" F/D (996k); 11-22Mb H/D. (E).
DAI (£998-48k)	Data Applications (UK): 0285 2588 (TBA)	12-48k RAM; 8080; C int; 24x 60 VDU int; RS232 port; over 20 industrial ints.	Basic (ROM); U.	Colour graphics up to 255x 335; 3 notes & noise generator; PAL O/P to TV; Paddle int; H maths option.
Diablo 3000 (£8950)	Business Computers Ltd: 01-207 3344 (TBA)	32k RAM; 8085; dual 8" F/D (1.2Mb); 12", 24x80 b&w VDU; 45cps printer.	DOS; Basic; DACL; A; U.	Selection of business packages included (S).
Digital Micro-systems DSC-2 (£3525)	Modata: 0892 41555 (10)	64k RAM; Z80; dual 8" F/D (1.14Mb); 4xRS232 ports; EIA port.	CP/M; Basic-E; CBasic; *Cobol; Fortran; Pascal.*	14 or 28Mb H/D available or additional F/D units (H).
Digital Micro-systems DSC-4 (£6045)	As above	128k RAM; Z80A; single 8" F/D (500k); 11Mb H/D; 4x RS232 ports; 2 P/P.	CP/M; Basic-E; CBasic; *Cobol; Fortran; Pascal.*	Also DSC-3 with 64k RAM. Options: 128k RAM £1295; up to 4Mb F/D and 29Mb H/D. (H).

List of Abbreviations

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B	Basic	G/C	Graphics card	N/A	Not available	T/E	Text editor
C	Cassette	H	Hardware	N/P	Numeric pad	TBA	To be announced
E	Extensive	H/D	Hard disk	O/S	Operating system	U	Utility
		I	Introductory	P/P	Parallel port		
		Int	Interface	S	Software		

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Durango F-85 (£7500)	Comp Ancillaries: 0784 36455 (12)	64k RAM; 8085; dual 5¼" F/D (1Mb); 9", 16x64 green VDU; 132 col 165 cps printer; N/P.	O/S; DBasic; *CP/M; CBasic; Micro Cobol.*	Up to 5 work stations; fully integrated system. Options: additional dual 5¼" F/D (1Mb); 12-24Mb H/D. (S).
Dynabyte DB8/1 (£1500)	Dynabyte UK/ Europe Ltd: 0723 65559 (6)	32-64k RAM; Z80; S100 bus; 2xRS232 ports; 1 P/P.	CP/M; Basic; Cobol; *Pascal.*	Expands to multi-user system. Options: dual 8" F/D (1Mb) £2000; Also DB8/2 with dual 5¼" F/D (400k) £3000. (E).
Equinox 200 (£7500)	Equinox: 01-739 2387 (N/A)	64-256k RAM; Z80; 10Mb H/D; 1 S/P; 1 P/P.	CP/M; CBasic; *Cobol; Fortran.*	Multi-user MVT/FAMOS available in place of CP/M. (S&H).
Euroc (£7995)	Euroc: 01-729 4555 (TBA)	64k RAM; 8080A; dual 8" F/D (1Mb); 15", 25x80 b&w VDU; 132 col 140 cps printer.	CP/M; CBasic; A; U.	Financial software available. Supply of stationary included.
Executive Mini-computer (£378)	Binatone Int: 01-903 5211	16k RAM: Z80; 500 bps C; 32x64 TV int; extra C int; 1 P/P.	Basic (12k ROM); M/A; *Fortran.*	Graphics avail. F/D under development. Also 4k version called 'Oxford minicomputer'.
Exidy Sorcerer (£749)	Liveport Data Products: 0736 798157 (27)	16-48k RAM; Z80; RS232 port; 1 P/P; S100 connector; 30x64 VDU int.	O/S: Basic (ROM); *T/E; A; CP/M; Algol; Fortran; Basic; 80.*	High resolution graphics capability; user programmable character set. 32k version £799; 48k £849. Option: single 5¼" F/D (315k) £600.
HP 85 (£2240)	Hewlett Packard Ltd: 0734 784774 (16)	16-48k RAM; Z80; RS232; 1 P/P; S100 int; 30x64 VDU; Option: 2x5¼" F/D (630k), £1200.	O/S; ExBasic (ROM); *Editor; A; CP/M; Algol; Fortran.*	Hi-res graphics capability; 32k version, £799, 48k, £849; user programmable char set. (I).
IMS 5000 (£1935)	Equinox: 01-739 2387 (20)	32-64k RAM; Z80; dual 5¼" F/D (320k)	CP/M; CBasic; *Cobol, Fortran.*	3 drives option: (S&H).
IMS 8000 (£3515)	As above	64-256k RAM; Z80; dual 8" F/D (1MB).	CP/M; CBasic; *Cobol; Fortran; MicroCobol.*	Multi-user MVT/FAMOS available in place of CP/M. (S&H).
ITT 2020 (£867)	ITT: 0268 3040 (15)	16-48k RAM; 6502	Monitor; A; ExBasic; Dis A.	360x192 high res graphics. ExBasic in 6k ROM: Options — single 5¼" F/D (116k), £425; 16k RAM, £110; RS232 port, £96: 32k system, £931: 48k system. £995. (B).
LX-500 (£3500)	Logabax Ltd: 01-965 0061 (13)	32k RAM; Z80; dual 5¼" F/D (180k); 12" 25x80 b&w VDU; 100cps printer.	DOS; Basic; A.	Other printers available. (S).
LSI M-One (£5995)	LSI Computers 04862 23411	8k RAM; 8080; dual 8" F/D (1.2Mb); 12", 24x80 b&w VDU.	FMOS; A.	Choice of standard business packages included in price. (S).
LSI M-One Model 5. (£9900)	As above	16k RAM; 8080; dual 8" F/D (2.4Mb); 2x12", 24x80 VDUs; 120 cps bidirectional printer.	FMOS; A.	One VDU is for inquiry only. (S).
Megamicro (£6080)	Bytronix: 0252 726814 (5)	56k RAM; Z80; dual 8" F/D (500k); 12", 20x80 green VDU; 180 cps printer; 2 S/P; 2 P/P.	CP/M; U; *Basic; A; M/A.*	(H&B).
Mikro 1000 (£3950)	Airamco: 0294 57755	64k RAM; Z80; dual 8" F/D (1Mb); 12", 24x80 VDU; S100; RS232; 1 P/P.	CP/M; Basic; Cobol; Fortran.	Also word processor with 44 special function keys & NEC Spinwriter printer £4450.
Microstar 45 Plus (£4800)	Data Efficiency Ltd: 0442 63561 (30)	64k RAM; 8085; dual 8" F/D (1.2Mb); 3 S/P; RS232 port.	Stardos; CP/M; Basic; Cobol; Fortran.	(E).
Microtan 65 (£69)	Tangerine: 0353 3633	1k RAM; 6502; TV int; Exp up to 277k RAM.	1k TANBUG monitor; 2k A, disassembler, cassette firmware; *10k Microsoft ExBasic.*	Options: bulk I/O modules, hi-def colour graphics, DOS, system racking, ASCII keyboard.
MS5001 (£8250)	BMG Ltd: 0793 37813 (N/A)	64k RAM; 8085; dual 8" F/D (1Mb); 12", 80x24 VDU; 160 cps printer; RS232.	CP/M; *Basic; Cobol; Fortran; MP/M.*	Price includes desk mounting and one computer. Hardware & software support. Leasing arrangements available.
MSI 6816 (£1200)	Strumech: 05433 4321 (5)	16-56k RAM; 6800; 9" 16x64 b&w VDU; C int; 1 S/P; 1 P/P.	Basic; A.	Graphics & PROM programmer available. (S&H).
MSI System 7 (£3500)	As above	56k RAM; 6800; dual 5¼" F/D (160k); 9", 16x64 VDU; 1 S/P; 1 P/P.	FDOS; Basic; A; U.	As above. Multi-user O/S avail. Options: 10Mb H/D.
MSI System 12 (£8000)	As above	56-184k RAM; 6800; 10Mb H/D; 9", 16x24 VDU; 1 S/P; 1 P/P.	SDOS; Basic; CBasic; U.	As above. Business packages avail. (H & S).
Nanocomputer NBZ80S (£420)	Midwich: 97 29310	4k RAM; 2k ROM; Z80; C int; 8 digit LED; Calc K/B; RS232 port; 2 P/P.	Machine language; *Basic; A; T/E.*	Designed for hardware education. Full training manuals included. Fully expandable. (E).
North Star Horizon (£2230)	Comart: 0480 215005. Comma: 0277 811131. Equinox: 01-739 2387 (20)	48-56k RAM; Z80A; dual 5¼" F/D (360k); 15", 24x80 VDU; 150cps printer; 2 S/P; 1 P/P.	DOS; Basic; CP/M; *Cobol; Fortran; Pascal.*	With 32k and single F/D £1495. Options: 18Mb H/D.
Panasonic JD 800U, JD 840U (£4275, £4950)	Panasonic Business Equipment: 01-262 3121	56k RAM; 8085A; 2-4k PROM; dual 8" F/D, JD800 U (500k), JD840U (2Mb); 12", 24x80 green VDU; 3xRS232 ports.	CP/M; Basic; *Micro-Cobol.*	Also available with 5¼" F/D; JD700U (140k) £3758; JD740U (570k) £4095. (S).
Pascal Microengine (£2295)	Pronto Electronic Systems Ltd: 01-554 6222	64k RAM; MCP 1600; 2x RS232 ports; 2 P/P.	Pascal.	CPU instruction set is P-code; no interpreter needed. Available with dual 8" F/D (2Mb) £3900.
Periflex 630/48 (£2500)	Sintrom: 0734 85464 (5)	48k RAM; Z80; dual 5¼" F/D (630k); 2xRS232 ports; 1 P/P.	CP/M; *Basic; Fortran; Cobol; A.*	One-day installation training on site included in price. Option: dual 5¼" F/D (630k) £859; dual 8¼" F/D (1Mb) £1025. (S&H).

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E Extensive	H/D Hard disk	O/S Operating system	U Utility
	I Introductory	P/P Parallel port	
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Periflex 1024/64 (£3300)	As above	64k RAM; Z80; dual 8" F/D (1Mb); 2xRS232 ports; 1 P/P.	As above.	As above.
PET 8k, 16k, & 32k (£450, £550, £695)	Commodore: 01-388 5702 (150)	8-32k RAM; 6502; C; 9", 25x40 VDU; IEEE-488 port; Options: dual 5¼" F/D (353k) £695; same but (950k) £895.	O/S; Basic (in 8k ROM); *Forth; Pilot; Pascal.*	Disk controller for 8k version £30. New 8032 with 80-col screen (32k) £895.(I).
Powerhouse 2 (£1125)	Powerhouse Micros: 0422 48422 (TBA)	32-64k RAM; Z80A; 5", 29x96 VDU; RS232 port; external bus.	4k Monitor; *FDOS; Basic; ExBasic (14k EPROM)*	VDU has flexible screen logic. Options: FDOS & Basic £210; graphics card £200.
Powerhouse 3 (£2600)	As above	32-64k RAM; Z80A; dual 5¼" F/D (350k); 5", 29x96 VDU; RS232 port; external bus.	As above.	VDU as above. With 1.2Mb F/D £3500. ExBasic & FDOS in 14k EPOMs £300.
Rair Black Box (£2250)	Rair: 01-836 4663 (N/A)	32-64k RAM; 8085; dual 5¼" F/D (260k); 2x RS232 ports.	CP/M; Basic; Cobol; Fortran; M/A.	16k RAM expansion £250 10Mb H/D £2500.
Research Machines 380Z (£1123)	Research Machines 0865 49791 (N/A)	16-56k RAM; Z80A; 2xC; RS232 port.	ExBasic; A; T/E; U; *CP/M; Fortran; Cobol; Algol; Cesil.*	Limited graphics. Many possible systems. With 48k RAM & dual 8" FD (1Mb) £3394.
S/09 (£5350)	SWTP Ltd: 01-491 7507 (16)	128k RAM; 6809; dual 8" F/D (2Mb); 8", 21x92 VDU; 2xS/P; 1 P/P.	TSC FLEX; *Basic; Pascal; A; Dis A; T/E; U.*	VDU is intelligent. Expands to 60Mb H/D multi-user system. Option: 15Mb H/D £3575. Maintenance contracts.
SBS 8000 (£1449)	Manhattan Skyline Ltd: 08012 3442 (TBA)	64k RAM; Z80A; 12", 16x64 VDU; 1 P/P; RS232 port (extra £133).	ExBasic (24k ROM); *DOS.*	Options: disk control card £237; dual 5¼" F/D (368k) £795; dual 8" F/D (2Mb) £1400.
SEED System 1 (£2000)	Strumech: 05433 4321 (4)	32-64k RAM; 6800; dual 5¼" F/D (160k); 9", 16x24 VDU; RS232 port.	DOS; Basic; U; *Fortran; A; Pilot; Strubal; T/E.*	Several F/D options. With 64k RAM & dual 8" F/D (1.2Mb) about £3000. (E).
Sharp MZ-80k (£480)	Sharp electronics (UK) Ltd: 061-205 2333	6-34k RAM; Z80; C; 10", 24x 40 VDU; Option: dual 5¼" F/D (280k) £780.	Basic (14k ROM); A.	Graphics; loudspeaker. 18k RAM version £529; 22k £549; 34k £599. (B).
Sinclair ZX80 (£100)	Science of Cambridge: 0223 311488 (N/A)	1-16k RAM; Z80A; C int; TV int; full K/B; 44-pin expansion port.	Basic (4k ROM).	Kit £80. Mains adaptor £9. (S).
Smoke Signal Chieftan (£1807)	Systems Implementation Ltd: 06924 5666 (TBA)	32-64k RAM; 6800; dual 5¼" F/D (160k); 12", 24x80 VDU; RS232 port.	DOS; *68/FLEX; Basic; Fortran; Cobol; U.*	With dual 8" F/D (2Mb) £2712. Designed as development system for industrial control.
Solitaire WP & BS200 (£6750 & £8200)	Solitaire KPG: 01-995 3573 (TBA)	64k RAM; 8085; 14" VDU (with own CPU); 45 cps printer; CPU port; dual 5¼" F/D (700k) 8" F/D (1.02Mb) with BS200.	DOS; Basic., dual	All solitaire systems are compatible; graphics on 11x13 dot matrix.(S).
Sord M100 (£795)	Midas Computer Services Ltd: 0903 814523	48k RAM; Z80; 8k ROM; 12", 24x64 green VDU; RS232 port; S100 bus; N/P.	O/S; Basic; *A; Fortran; Pascal.*	M100 ACE with single 5¼" F/D (143k) £1850. Up to 3 drives possible. Colour graphics avail. (I).
Sord M223 Mk II-VI (£3950)	As above	64k RAM; Z80; 8k ROM; single 5¼" F/D (350k); 12", 24x64 green VDU; RS232 ports; S100 bus; N/P.	O/S; ExBasic; *CBasic; Multi-User Basic; Fortran; Pascal; Cobol.*	Expandable to 4Mb F/D, 32Mb, H/D, 5 screens, 2 printers. (I).
SPC/1 (£3770)	Digital Data: 01-573 8854	64-1024k RAM; 8085A-2; dual 5¼" F/D (90k); 12", 24x80 VDU; 2xRS232 ports; Option: single 8" F/D (1Mb) £1090: 20Mb H/D £7000.	Mikados; Comal; Pascal; A.	With 32k RAM and single F/D (Comal only) £1995. Expandable to multi-user system (8 users). (S).
Superbrain (£1995)	Icarus: 0632 29593 (TBA)	64k RAM; 2xZ80; dual 5¼" F/D (320k); 12", 25x80 VDU; S100 bus; RS232 port.	CP/M; A; *Basic; Cobol; Fortran; APL; Pascal.*	Limited graphics. Mainframe int avail. Options: dual 5¼" F/D (320k); dual 8" F/D (2.4 Mb); 8-120Mb H/D. (S&H).
System 80 (£1355-48k)	Nascom: 02405 75155 (32)	16-48k RAM: Z80A; dual 5¼" F/D (560k); TV int; RS232 port.	CP/M; Basic (8k ROM).	EPROM firmware avail. Colour graphics card £165. Many configurations possible. (S&H).
Tandberg EC10 (£4000)	Tandberg: 0532 35111 (N/A)	64k RAM; 8080A; single 8" F/D (250k); 12", 25x80 VDU; 7x RS232 ports; printer int.	CP/M; ExBasic (24k) *Multi-user Basic; Pascal; Cobol;* A; U;	Up to 7 terminals. Includes V28 comms port. (S & H).
Tandy TRS80 Level 1 (£335)	Tandy: 021 556 6101 (200)	4-16k RAM; Z80; C; 12", 16x64 VDU.	Basic (4k ROM); A.	Expandable to Level II. Many extras available. (I).
Tandy TRS80 Level II (£408)	As above	4-48k RAM; Z80; C; 12", 16x 64 VDU; RS232 port; 1 P/P.	Basic (4k ROM); *M/A; Fortran.*	16k machine includes N/P. 4-16k upgrade £87, 48k system £620; Option: single 5¼" F/D (78k) £295, (subsequent £277, up to 4. (I).
Tandy TRS80 Model 2 (£1999)	As above	32-64k RAM; Z80A; single 8" F/D (500k); 12", 24x80 VDU; 2 S/P; 1 P/P; N/P.	DOS; Basic.	64k version £2249. Expandable to four F/D drives, single drive expansion £799: three drive £1589.
TECS (£1200)	Technalogics Computing Ltd: 061-793 5293 (TBA)	4-56k RAM; 8k PROM; 6800/ 6809; 2xC; TV int; 2xRS232 ports; internal viewdata modem & printer port.	FLEX; Basic; *Pascal; TDOS; A; T/E; Pilot; Fortran; Cobol.*	Fully viewdata compatible. Options — dual 5¼" F/D (320k) £850; dual 8" F/D £120 £1200. (S&H).
Terodec DPS 64/1 (£3099)	Terodec (Micosystems) Ltd: 0252 874790	64k RAM; Z80; dual 8" F/D (1Mb); 12", 24x80 VDU; 2 S/P: 3 P/P. Options: dual 8" F/D (1Mb) £1150; with 2Mb £1455.	CP/M; *Basic; Cobol; CBasic; Fortran; Algol; Pascal.*	TMZ 80 enhanced model in integral workstation £5595 (with 4Mb F/D). DPS 64/2 with 2Mb F/D £3404. (S&H).
TI 99/4 (£750)	TI: 0234 67466 (TBA)	16k RAM; 26k ROM; 9900; 24x32 VDU; 2x C int; TV int; RS232 port.	OS; Basic.	Can run 16-colour TV screen. (S).
Triton L8.2 (£611)	Transam: 01-405 5240 (N/A)	32k RAM; 8080; C int; 16x64 VDU int; 1 S/P; 1 P/P.	4k monitor; Pascal (20k ROM); *CP/M; Pascal.*	Graphics; 5¼" or 8" F/D are available; L7.2 with 2k monitor and Basic (no Pascal) £409. (S&H).

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DIRECT ACCESS

IN STORE

Machine (Price from)	Main Distributor/s (No. of Dealers)	Hardware	Software/ Firmware	Miscellaneous (Documentation)
Zilog MCZ 1/05 (portable): MCZ 1/20A (£3250)	Micropower: 0256 54121. Memec: 084421 5471 (N/A)	64k RAM; Z80; dual 8" F/D (600k); RS232 port; MCZ 1/20A only 1 P/P; Option: 10Mb H/D £7100	RIO; O/S; *Cobol; Basic; Fortran; Pascal; M/A; U.*	Available desk top or rack mounted. Debug in 3k PROM. 1/20A runs multi user Cobol, up to 5 terminals with 40Mb H/D.(S&H).
Z-Plus (£3950)	Rostronics Ltd: 01-874 1171 (16).	64k RAM; Z80; dual 8" F/D (1Mb); 4 S/P; 2 P/P.	CP/M; A; U; *Basic; Cobol; Fortran; Pascal; APL; PL/1; Algol.*	Available with 2Mb F/D. Option: 20Mb H/D £4000. (S&H).
Vector MZ (£2595)	Almarc: 0602 62503 (3)	56k RAM; Z80A; dual 5¼" F/D (630k); 3 S/P; 2 P/P.	CP/M; Basic; *Algol; Cobol; Pascal; Fortran; Coral; CBasic;* A.	High resolution graphics. Also system B with video board & terminal £3195. (E).
Vector System 2800 (£4195)	As above	56k RAM; Z80A; dual 8" F/D (2.4Mb); 3 S/P; 2. P/P.	As above.	High-res graphics. Also System 3030 with 32Mb H/D and single 5¼" F/D £7500.
Video Genie EG3003 (£330)	Lowe Electronics: 0629 2817	16k RAM; Z80; 500bps C; 32x64 TV int; extra C int; 1 P/P.	Basic (12k ROM); *M/A; Fortran.*	Graphics available.
Zentec (£4838)	Zygal Dynamics: 02405 75681 (TBA)	32-64k RAM; 2x8080; dual 5¼" F/D (256k); 15", 25x80 VDU; RS232 port.	O/S; A; U; *Basic;* Cis Cobol.	User programmable character se set. Option: dual 8" F/D (1Mb). (S).
Zenith WH-11A (£4359)	Heath Ltd: 0452 29451 & 01-636 7349 (N/A)	LSI 11; 16-32k RAM; 25x80 VDU; S/P; P/P.	*O/S; Basic; Fortran;* A; U.	PDP 11-compat. Option: 2x8" F/D (512k). (S&H).
Zenith Z89 (£1490)	As above	16-48k RAM; Z80; single 5¼" F/D (102k); 12" 25x80 b&g VDU; RS232.	*Basic; A; HDOS; CP/M; MBasic; CBasic: Fortran.*	3 drives option. (I).

SINGLE BOARDS

Machine (Price from)	Main Distributor/s (No. of Dealers)	Hardware	Software/ Firmware	Miscellaneous (Documentation)
Acorn System 1 (£65)	Acorn: 0223 312772	11/8k RAM; 6502; EPROM socket; Hex K/B; C int; 8-digit LED display; up to 16 ports. Options: Eurocard 64-way connector; VDU card; full K/B card.	½k monitor; *Basic.*	Kit. Programmable address linking. On-board 5 V regulator. Available assembled £79. Can be expanded to disk-based system. (S&H).
Aim 65C (£285)	Pelco: 0273 722155 (7)	1-4k RAM; 6502; 4-20k ROM; Full K/B; 2xC; 20 char LED; 20 char thermal printer; RS232 port.	A. Dis A; T/E; 8k monitor; *Basic (8k ROM); PL65.*	Power supplies and two types of case avail. Can be expanded to disk system. (E).
Cromemco SC (£260)	Comart: 0480 215005 (17)	1k RAM; Z80A; 8k EPROM sockets; RS232 port; 3 P/P. Option: S100 bus.	Monitor; *Basic.*	5 program interval timers. Can put own Basic programs in EPROM.(E).
Elf II (£60)	Newtronics: 01-348 3325	¼-64k RAM; RCA 1802; Hex K/B; 2-digit LED; TV int; C int; RS232. Options: Full K/B; VDU card.	1k monitor; A; Dis A; T/E; Elf-bug; *Tiny Basic; Basic.*	TTY, N-line decoders. Low resolution graphics (high res avail). Kits or built. (H).
Explorer (£82)	As above	4-64k RAM; 8085; Hex K/B; RS232 port; S100 bus; C int; 1k video RAM.	2k monitor; *Basic; CP/M.*	Supplied in kit or built. Full range of peripherals including F/D. (H).
Hewart 6800S (£299)	Hewart: 0625 22030 (N/A)	16k RAM; 6800; full K/B; VDU int; 2xC int; 1 S/P; 2 P/P; Option: 16k RAM £90.	1k monitor; A; T/E.	Can be upgraded with 6809. (H).
Hewart 6800 Mk III (£152)	As above	1k RAM; 6800; VDU board.	1k monitor.	Options: single 5¼" F/D (75k) £350; PROM programmer £32. (H).
Microtan 65 (£69)	Tangerine: 0353 3633	1k RAM; 6502; 16x32 TV int; Options: 64x64 Pixel graphics £6.50; 16k RAM £56.	1k monitor; *Basic.*	TANEX expansion kit with 7k RAM; 4k EPROM sockets; 10k Basic; 4 S/P; 32 P/P £145. (E).
Nascom 1 (£125)	Nascom: 02405 75155 (20)	4k RAM; Z80; Full K/B; TV int; 2 P/P; 1 S/P. Options: 16k RAM £140; single 5¼" F/D (250k) £240 (4 disk controller £127).	2k monitor; *BBasic; Tiny Basic; A; T/E; U.*	Kit. Built verstion £140. Also Nascom 2 with 8k Microsoft Basic in ROM £225 (no RAM). (S&H).
77/68 (£90)	Newbear: 0635 30505	4k RAM; 6800; LED; C int; VDU int.	1k monitor; *Basic.*	Expandable to 64k RAM with F/D. (B).
SBC 100 (£135)	Airamco: 0294 57755	1k RAM; Z80; 8k ROM; S100; 1 S/P; 1 P/P.	*1k monitor; DOS in ROM.*	Kit. Available assembled £196. (E).
Superboard (£188)	(as Challenger)	4-8k RAM; 6502; 10k ROM; full K/B; VDU int; C int.	Basic (8k ROM).	Options: RS232 port; single 5¼" F/D (100k) £316; 8k RAM £188. (S&H).
Smoke Signal SCB 68 (£174)	Systems Implementation Ltd: 06924 5666	1k RAM; 6800/6809; 10-20k EPROM; 1 S/P.	2k monitor.	Many expansion boards available including F/D.
SYM-1 (£160)	Newbear: 0635 30505	1-4k RAM; 6502; C int; VDU int; 2x6522 ports. Option: TV int.	4k monitor; *Basic; A.*	Expandable to 64k RAM with F/D. (B).
Triton L5.2 (£294)	Transam: 01-405 5240 (N/A).	1-3k RAM; 8080; 1k VDU RAM full K/B; 16x64 VDU or TV int; C int; 1 S/P.	1½k monitor; 2½k Basic.	64-char graphics. Disk int running CP/M about £200. (S&H).
Tuscan (£195)	As above	8k RAM; 8k ROM; Z80A; 5xS100 slots; RS232 port; TV int; C int; 1 P/P.	*2k monitor; 8k Basic; CP/M; Pascal.*	High res graphics available. Can be expanded to F/D system. (S&H).

List of Abbreviations

A Assembler
B Basic
B/P Business package
C Cassette
C/P Commercial package
E Extensive
F/D Floppy disk
G/C Graphics card
H Hardware
H/D Hard disk
I Introductory
int Interface
I/S Indexed sequential
M/A Macro assembler
N/P Numeric pad
O/S Operating system
P/P Parallel port
S Software
S/P Serial port
TBA To be announced
T/E Text editor
T/P Text processor
U Utility
W/L Word length
W/P Word processor

Please note: Software items listed in *italic* are not included in the basic price of the equipment. All prices are *exclusive* of VAT

SINGLE BOARDS

DIRECT ACCESS

UK101 (£179)	Comp Shop: 01-440 7033	4k RAM; 6502; full K/B; 16x48 VDU or TV int; C int; RS232 port, Options: 4k RAM £29.	1k monitor; 8k Basic; *Dis A; U.*	Graphics. Will run Superboard software. New monitor EPROM with enhanced U £22. (S&H).
ZCB (£260)	Almarc: 0602 625035	1k RAM; Z80A; 3 PROM sockets; RS232 port; 3. P/P.	*Will take any 2708/ 16/32 software.*	S100 bus compatible. Expandable to full system. (E).

DIARY DATA

Paris, France	SICOB. Contact French Trade Exhibitions, 01-439 3964	Sept 17 — Sept 26
Bristol, England	(Eurocrest Hotel) BIZTRONIC. Mini/Micro Computers, Word Processors and Business Machines Exhibition. Contact Groundrule Exhibition Co., 061-928 0406	Sept 23 — Sept 24
Plymouth, England	BEX. Business Equipment Exhibition. Contact Douglas Temple Studios Ltd, Tel: 0202 20533	Oct 1 — Oct 2
Melbourne, Australia	World Computer Exhibition. Contact Riddell Exhibition Promotions Pty. Ltd., 166 Albert Road, South Melbourne, Vic 3205.	Oct 14 — Oct 19
Edinburgh, Scotland	(Ingliston Showground) BEXIBITION. Business Equipment Exhibition. Contact Douglas Temple Studios, 0202 20533	Oct 15 — Oct 16
Doncaster, England	(Exhibition Centre) Business Efficiency and Office Equipment Exhibition. Contact Gwen Shillaber Designs, 0272 312850	Oct 15 — Oct 17
Bradford, England	(Norfolk Gardens Hotel) Business Efficiency Exhibition. Contact Gwen Shillaber Design, 0272 312850	Oct 21 — Oct 23
Manchester, England	(Forum) BIZTRONIC. Mini/Micro Computers, Word Processors and Business Machines Exhibition. Contact Groundrule Exhibition Co., 061-928 0406	Oct 21 — Oct 26
London, England	(Olympia) COMPEC. Computer Peripheral & Small Computer Systems Exhibition and Conference. Contact IPC Exhibitions Ltd., 01-837 3636.	Oct 28 — Oct 30
London, England	(West Centre Hotel) Professional Viewdata Exhibition. Contact IPC Exhibitions Ltd., 01-837 3636	Oct 28 — Oct 30
Cardiff, England	(Sophia Gardens) BEX. Business Equipment Exhibition. Contact Douglas Temple Studios Ltd., 0202 20533	Nov 5 — Nov 6
Birmingham, England	(NEC) Which Computer? Show. Contact Clapp & Poliak Europe Ltd., 01-995 4806	Nov 25 — Nov 28

USER GROUPS INDEX

Here are the details of additions and changes recently notified. If we have failed to include YOUR group (or have published incorrect information) either here or in the complete listing, then please address changes/additions to: PCW (User Groups Index), 14 Rathbone Place, London W1P 1DE. Finally, the next complete listing will appear in our November issue.

International
Microcomputer Users Club: recently established for program writing and exchange, emphasis on 6502/Z80 users. Contact c/o Synthetronics Microcomputers, P.O. Box 151, 1322 Hoevik, Norway.

National
Sharp User Group: Sub £3 p.a., inc newsletter and free Space Invaders cassette for MZ-80K. Contact: Knights TV & Computers, 108 Rosemount Place, Aberdeen. Tel 0224 630526.

Sorcerer Program Exchange Club: Contact Colin Morle, 32 Watchyard Lane, Formby, Nr. Liverpool L37 3JU, Tel 070 48 72137.

National TI58/59 Club: bi-monthly newsletter, program exchange etc. Annual sub £5.50 or, if you include a program with your cheque then it's £3.50. Contact: R M Murphy, Dept of Electronic Engineering, University College Swansea, S. Wales.

South
IPUG has changed its name to SUPA (Southern Users of PETs Association). Contact: 42 Compton Road, Brighton BN1 5AN.

Cornwall
Anyone interested in forming a computer club in Cornwall, catering mainly for PET, ZX80 and UK101 computers should contact: M F Grove, 35 Causeway Head, Penzance, Cornwall.

Isle of Wight
IoW TRS-80 Users Club: Meets each Friday at 8 pm at 72 Union Street, Ryde. Contact: Mr M R Collins, 3 Altofts Gardens, Ventnor, IoW.

Kent
MACRO (Medway Amateur Computer & Robotics Organisation). Meets monthly, sub £3. Contact Mrs Christine Webster, 13 Ladywood Road, Cuxton, Rochester, Kent. Tel: 0634 78517.

Lancs
Merseyside Microcomputer Group: Alan Pope of the 380Z Users Group has changed his tel. no to 051-924 2470.

Northants
Inaugural meeting of the Northampton Personal Computer Users Club takes place on 1 October at Mereway Upper School, Mereway, Northampton. Contact: J R Jackson at the school, Tel Mereway 63616.

Tyne and Wear
Newcastle-upon-Tyne Personal Computer Society: meets first Tues each month in Room D103, Newcastle Polytechnic. Over 60 members, sub £5.00. Several sub-groups inc. PET, TRS-80 and S100 (last one meets weekly). Contact Pete 0632 573905 or John on 0632 579887.

London
South-East London Microcomputer Club: Chairman is now Roger Kreitman; club meets fortnightly at the Thames Polytechnic, Woolwich.

TRANSACTION FILE

The classified service that's free to non-commercial readers. Advertisements (50 words max) to: PCW Transaction File, 14 Rathbone Place, London W1P 1DE.

For sale

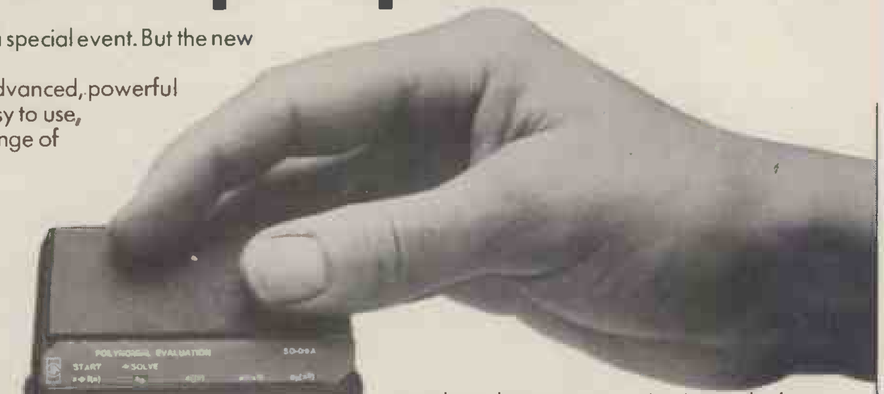
Casio FX502P... plus FA-1 cassette int & music adaptor, with manuals, leads, cases, program library, demo cassette & some orig progs, owner moving to bigger fish, £90 ono. Tel 0702 713626

ITT 2020... 48k, new & never used in anger, Palsoft in ROM, colour, UHF/video output, full doc, first over over £730. Also disk drive & controller with progs inc Space Invaders, £275. Tel 06284 73776

ZX80... 4k RAM, assembled with PSU, leads etc, list price £186, accept £120. Tel Chris Lawless, 01-903 1333 ext 393 office hours or 0442 40953 after 7

Introducing HP-41C

A powerful new calculator-with its own peripherals!



A new Hewlett-Packard calculator is always a special event. But the new HP-41C is especially special!

It's a fully programmable calculator - advanced, powerful and very versatile. Yet it's also remarkably easy to use, with a helpful alphanumeric display and a range of application modules.

Most important, it has its own dedicated peripherals - including printer, card reader and memory modules.

A unique machine

Program power. 400 lines of program memory (or 63 data storage registers) as standard, expandable up to 2000 lines (319 data storage registers). With RPN logic, for faster problem-solving.

Alphanumeric display. You can name and label programs, functions, variables and constants. The calculator uses words and sentences to prompt for data. The display shows calculator modes and status.

'Customise' feature. Assign any of 68 keyboard functions (or 130 library functions) - or any program you've written yourself - to any key on the HP-41C. To help you, the HP-41C comes with keyboard overlays. (Each assigned function or program name is displayed prior to execution.)

Continuous Memory. Maintains program and data when your HP-41C is switched off. Simply switch on, and continue with your calculation.

A unique system

Look at this impressive list of add-on peripherals!

HP-41C printer. Quietly gives numeric, upper and lower case alpha characters, in single and double width, as well as special characters. And performs high resolution plotting routines.

Application modules. For engineers, students, businessmen, scientists and others. Instantly converts your calculator to a specialised discipline.

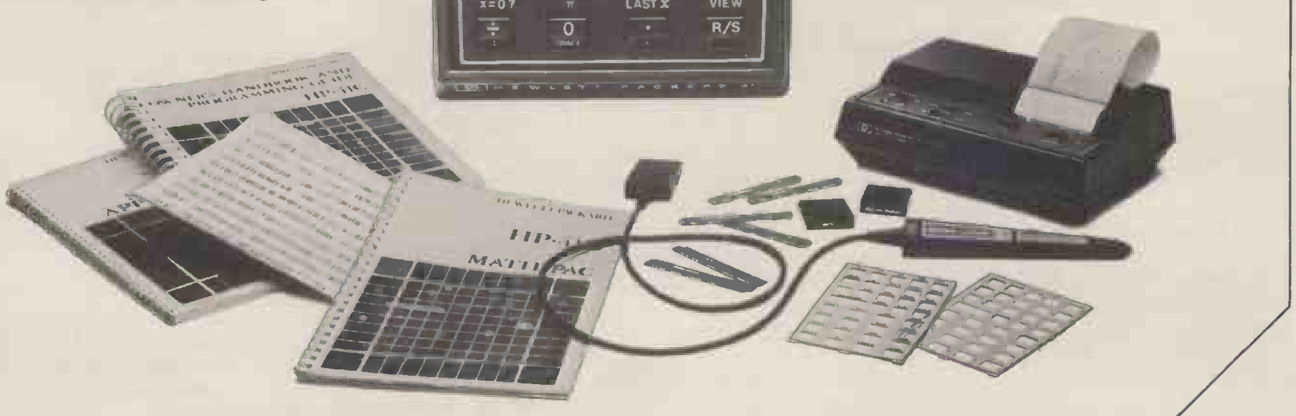
HP-41C card reader. Saves program and data on magnetic cards. Keeps track of cards as they're read, and prompts you for the next card.

Memory modules. Each contains 64 data storage registers (400 program lines, or any combination).

Incredible value at £192.55 (including VAT)!

This price includes the calculator, 63 registers for data or programs, owner's handbooks, overlay kit, zip-up pouch and batteries! Compare the HP-41C with other calculators in its price range. You'll find it has more functions and more options. See your dealer for a demonstration - you'll find his name below.

HEWLETT PACKARD



Aberdeen Tyseal Typewriter Services. **Belfast** Cardiac Services Company. **Birmingham** Anglo American Computing; John Mabon Associates; Taylor Wilson. **Bolton** T & R Office Equipment. **Bournemouth** South Coast Business Machines. **Brighton** Office Machinery Engineering Co. **Bristol** Decimal Business Machines; Wilding Office Equipment. **Bromley** Wilding Office Equipment. **Cambridge** W. Heffer & Sons. **Canterbury** R. E. Typewriters. **Cardiff** Sigma Systems (Calculators). **Carlisle** Thos. Hill Group. **Chelmsford** Automatic & Electronic Calculators. **Colchester** Wilding Office Equipment. **Croydon** Landau Calculators; Wilding Office Equipment. **Derby** Office Machines. **Dundee** Tayside Office Equipment. **Edinburgh** Business & Electronic Machines; Holdene. **Folkestone** R. E. Harding. **Glasgow** Robox. **Gloucester** Wilding Office Equipment. **Grimsby** Teesdale Office Equipment. **High Wycombe** A. C. Barratt & Co. **Ilford** Wilding Office Equipment. **Ipswich** Anglia Business Machines; Wilding Office Equipment. **Kingston-upon-Thames** Wilding Office Equipment. **Leeds** Holdene; T & R Equipment. **Leicester** A. C. Barratt & Co.; Sumlock Services. **Liverpool** Rockliff Brothers. **London** Automated & Electronic Calculators; City Business Machines, 57 Houndsditch, Bethnal Green Road; Concept Business Machines; Dixons Photographic, 64 New Bond Street; Euro-Calc Limited, 128-132 Curtain Road, 224 Tottenham Court Road, 55 High Holborn; Landau Calculators, Bourne's, Oxford Street, 227 Tottenham Court Road; Logic Box; McDonald Stores; Metyclean, 137 The Strand, 92 Victoria Street; Mountaindene; Reid's Office Equipment; Sumlock-Bondain, 15 Clerkenwell Close, Cannon Street Station; Wallace Heaton; Wilding Office Equipment, 7 The Arcade Hoe Street, 21 Thomas Street, 120 The Broadway, Wimbledon. **Luton** Wilding Office Equipment. **Maidstone** Wilding Office Equipment. **Manchester** Automated Business Equipment; Holdene; T & R Office Equipment. **Matlock** Derby Office Machines. **Middlesbrough** Thos. Hill Group. **Newcastle** Thos. Hill Group. **Northampton** A. C. Barratt & Co. **Norwich** Leamons Office Machines; Sumlock-Bondain. **Nottingham** Bennett's (Typewriter & Office Supplies); Trent Office Equipment. **Oxford** Reid's Office Equipment; Science Studio. **Plymouth** JAD Integrated Services. **Reading** Central Southern Calculators; Reid's Office Equipment, Caversham, 38 Market Place, Reading. **Romford** Wilding Office Equipment. **Royston, Herts.** Electroplan. **Sheffield** Butlers Office Equipment. **Slough** Wilding Office Equipment. **Southampton** South Coast Business Machines. **Southend** Wilding Office Equipment. **Sunderland** Thos. Hill Group. **Sutton** Landau Calculators. **Swindon** Wilding Office Equipment. **Waltham Cross** Wilding Office Equipment. **Watford** Automatic & Electronic Calculators; Wilding Office Equipment. **Worthing** Office Machinery Engineering Co. **All UK branches of Comet. CHANNEL ISLANDS: Guernsey** P.B.S. **Jersey** Professional Business Systems. **EIRE: Dublin** Abacus Systems.

TRANSACTION FILE

DIRECT ACCESS

Nascom 2 . . . 16k RAM board, extra graphics ROM, PSU & manuals £410 ono; TI PC 100 C print cradle for TI59/TI58, £140 ono; TI58, £45 ono. Tel Rochdale 524932

Computhink. . . 800k dual disk unit complete with DOS logic board for PET. Inc full operating and fitting instructions, technical help if required, only 6 months old, perfect order, bargain at £800 ono. CMC-ADA 1200 PET to RS232 interface for Teletype 43 and others, £50 ono. Tel Flitwick (05257) 2221.

PET. . . 16k, large keyboard, green anti-glare filter on screen, £450. Tel: Mr Trevena, 01-648 7090.

Cheap memory. . . 18-pin National full spec MM5270 4k x 1 dynamic RAM chips, 200 ns access, 400 ns cycle, TTL comp. (except CE), sold in lots of 8 plus 18-pin sockets for £1.50 each. Peter Bennell, 69 Rhyd-y-Defaid Drive, Sketty, Swansea SA2 8AN.

MK 14. . . revised ROM, improved keyboard, standard doc., £40 ono; Elf II static RAM and PSU, giant board, klug board, Elf Tiny Basic, Elfbug, users manual & other doc., £190 ono. Both delivered daytime N. London. Tel: 0438 54241 (Herts)

Acorn. . . 6502 CPU, hex keyboard, LED display, tape interface, built and working with doc. and PSU, £80. Tel: North Weald (037 882) 2924

77-68. . . VDU board complete, £30; 77-68 4k RAM board, wired, TTL & sockets less memories, £12.50; all LS & buffers for MON 2, £5; alloy rack for 5 boards, £7.50. Tel: Aldridge 52639 after 6pm.

PET 2001. . . 8k, small keyboard, with 2nd cassette, £395 ono. Tel Cardiff 77195.

Nascom 1. . . cased, PSU, T2+2k Tiny Basic A; offers or px for TRS-80 16k, C2.4P, PET or sim. If no takers then wanted, Nascom upgrade bits: m/board, buffer, memory boards, 8k Basic, Vero case, fast cassette int, etc. Tel: 0253 725979

UK101. . . prof. built & cased, 8k RAM, 8k Microsoft Basic, extra 2 x 8-bit PIO using 6522 VIA, ideal for beginner, with several working progs and m/c code textbook, etc, full working order, £270. Tel: Colchester 61193.

Texas TI58. . . prog calc, as new, £45; MK 14, additional keyboard, PSU, sockets & software, £40; disco system inc MMAP360, Altec speakers, Citronic console, Solar 250 etc, will exch for Nascom 2, Tandy, Apple, PET with cas either way. Tel: Alan, 01-675 1483.

PET 2001-8k. . . green screen, sound box, books, 15 tapes, Microchess etc, 9 months old, £450; must sell, unemployed. Tel: Mick Jarvis, (0322) 60150.

PET 2001-8. . . 8k RAM, integral cassette, inc £100 of software, £30 of books plus lots of PET literature, as new, all for £450 (worth £680). Tel (0344) 27660.

4k SS50. . . memory boards, built, tested, burnt in, £50 each or £160 for all 4 inc. postage. Tel: Nigel (07048) 76566 after 7.

UK101. . . 4k RAM, 8k Microsoft Basic, cased with sep. PSU & expansion sockets, fully working, £250. Tel: (06924) 2130.

PET 2001. . . 8k, hardly used, still under guarantee, £420 for quick sale. Tel: Doncaster 851269 evenings.

Nascom 1. . . fully built & tested inc NASBUS ext board, 8k RAM, 8k Basic, NAS-SYS, mounted in Vero rack case, 5 months old, £320 ono. Mr Sturgess, 108 Cleveland Rd., Midanbury, Southampton, Tel: 0703 583514.

Acorn. . . system 1, assembled & complete with PSU & manual, full working order, save over £30 on list, £65. Tel: 0905 353768 business hours, ask for Steve.

Acorn. . . system 1, built & working with all doc plus several 6502 books, total value £100+, no reasonable offer refused or px against HP67/TI59/WHY. Only selling because of lack of time for hobby. Tel: 03632 3157/ write Platter, 13 Beech Park, Crediton, Devon.

PET 16k. . . large keyboard, new ROMs, TIS workbooks, lots of programs, books & mags, £600 ono. Also spare set of new PET ROMs, £70 ono. Write J Bell, Flat 124, Summertown House, 369 Banbury Road, Oxford

TRS-80 L2. . . 16k, approx 4 months old, used for learning only, with manuals, Stock Control, Purchase Ledger, Mailing List plus a few games. Brand new CTR 41 inc. but no VDU, £360 ono. Tel: Graham, 04218 3347 or write 11 Glenlea Drive, West End, Southampton S03 3GU

KIM 1. . . 6502, 2k ROM, 1k RAM, hex keyboard, 6-digit display, Teletype & cassette ints, plus KIM4 motherboard, 2 x KM-8B 8k RAM, Basic cassette tape, manuals & PSU, all £275. Tel: 072 275 640

Sharp MZ-80K. . . 20k RAM with integral VDU, cassette & LS, excellent graphics, only 4 months old, hardly used (in home), with manual, demagnetiser games, etc. Best offer over £440 secures. Tel: (77) 44935 evenings.

PET 32k. . . with Toolkit, ROM, Spacemaker, hardware repeat key, sound box, cassette, 3022 printer, 3040 disk, dust covers, disks, tapes, library disk capes, mains interf. unit, doc., software inc Wordcraft, absolutely perfect, £2350 ono for complete system (won't split). Tel: 061-969 7508.

UK101/Superboard. . . sound module, generates tunes etc under software control, ready built with software on cassette, £5.50 inc p&p. Mr A Lall, 22 Netley Dell, Letchworth, Herts, Tel: 74089.

ASR33. . . printer, inc PET int/ software, manual, stand, good working order throughout, £150 ono; ASR33 spares: motor, 20 mA int, perf etc available separately or with above, £15 ono. Tel: 0403 69835.

HP41C. . . plus 2 memory modules & full doc, only 3 months old, £230. Tel: 0329 280642 after 6.

UK101. . . 8k RAM, manual, games/demo tape, cased with all cables, powerful Basic, ideal for teaching, £275. Buyer collects. Mr Blatch, 2 Newbury St., Kintbury, Berks. Tel: Kintbury 353.

S100. . . 8k static RAM board, fully working, £80 ono. G R Cass, 4 Kingsley Place, Heaton, Newcastle-upon-Tyne NE6 5AN.

Superboard II. . . with PSU, modulator, cassette int, all cables to link to TV and cassette, fully built in Microcase with 4k extra RAM fitted for 8k total, hardly used, complete with all manuals & selection of games, some homegrown, £200. Tel: Pudsey 551015.

Cheap printer. . . Creed 7B teleprinter £15, Motorola card reader with V25 (?) and teleprinter int, £6, IBM-style qwerty keyboard £3, buyer collects or postage extra. Richard Barns, 97 Ringmer Road, Worthing, Sussex BN13 1DU.

Triton. . . Transam built, L5.1 Tiny Basic and good 8080 monitor in ROM. Full on-board memory, internally expandable, software on cassette, doc, newsletters plus file of personal notes on software and use of comp. Also Merantz C190 recorder & blank cassettes. All reasonable offers considered. Tel: Earldoms 319.

PET 2001-8. . . complete with system desk, software, manuals, cassettes, green screen, ideal for beginner. Tel: Chris Slade, 048 68 4152 (day), 0420 82838 (eve).

MK 14. . . revised monitor, cassett cassette int, extra RAM, single step facility, £40. ASCII keyboard KB756, never used, £30. Tel: A Robson, Hull 443316.

NM1. . . plus 3 amp PSU, £110. CC Soft level A Basic for NM on two EPROMs, £10. W M Stuart colour graphics, built by Stuart, £30. Write D Climie, 397 Clarkston Rd., Glasgow G44 3JN or Tel: 637 6704.

TI58. . . prog calc, manuals & software book, excellent cond, £45. Tel: 01-807 3249.

Due to upgrading. . . must sell TRS-80 16k L2, numeric keypad, manuals, books, tapes, plus software. Keyboard fully debounced. Offers around £500. Tel: Cradley Heath 634798 after 6.

ZX80. . . works perfectly, complete with manual, TV and tape leads, little used, £70 inc p&p UK. Tel: Maidstone (Kent) 678782.

SYM1. . . sbc with extra 1k RAM, PIA, connectors, PSU, £130 ono. Boxed, unused components for S100 PSU, £20. Tel: Alan Calderwood, Duntocher 74451 evenings.

MK 14. . . SCIOS monitor, ¼k RAM, audio int, cased with PSU, SC/MP tech manual & data sheets, £40 ono. Casio FX201P prog. calc, batt/mains, £20. N Rushton, 123 Roughwood Drive, Northwood, Kirkby, Merseyside.

HP41C. . . with 4 additional memory modules, as new £220 ono. Tel: Colchester 72772 evenings.

UK101. . . 8k, built & tested, £270. Various books inc in price. Tom Allaway, 15 Stewards Close, Sutton, Cambs, Tel: 0353 778122.

TRS-80. . . 16k L2 with library 100 & chess progs, £500 ono. Tel: Lincoln 53254 after 6.

HP-41C. . . brand new as bought, unwanted gift, still in same packaging, 3 manuals, overlays, wallet, case, extra progs, £180 ono. Tel: 01-959 7818.

Sorcerer. . . 32k plus development pac, £600 ono. Tel: Poulton-le-Fylde (0253) 885067.

Sixteen. . . 4027 (4k x 1) memory chips, suitable for Nascom 1, £1 each, all 16 for £15. Tel: Dave on 0702 218662.

Sorcerer. . . 32k with word proc and development pac, all as new, full doc & tech manual, £800 (cost £1100+). Sorcerer S100 exp box, working but with suspected fault, manual, £100 ono. Tel: Nigel Clark, Harlow 24416 (work), 414234 (home).

Nascom 2. . . 32k, Basic, graphics, prof metal VDU case, keyswitch on/off, fan, I/O on D type sockets at rear, toroidal trfmr, full doc & tapes, £750. 2 high speed optical tape readers, need attention, with manual & spare boards, £50 the pair. Tel: 0234 43843 eve/weekend.

TRS-80. . . 48k, NEWDOS, printer int, 2 disk drives, dairy farming & accounts progs, as new, £950 complete. T R Worth, Truro, Tel: Mitchell 377.

ITT 2020. . . 48k, new cond, little used, with floppy disk drive & controller card, colour modulator, Centronics int, disks, brand new manuals, owner likely to work abroad so rig must go! First £1100 secures. Tel: 0385 61767.

Nascom. . . 16k DRAM board, built, tested, working on Nascom 1, full doc, memory tests & Basic on 300 baud cassette, £110 ono or £155 with 32k Robin Arak, LSVR, Southampton University, Tel: 0703 559122 ext 2196.

TRS-80. . . L2 16k, cassette deck, leads etc, 2 programming manuals, software, inc Mailfile, personal accounts, stat probability etc, all vgc, £350. Tel: Medway 271595 after 5.30.

UK101. . . 5k RAM, case, built by comp engineer, many games & routines on tapes, offers around £230. Tel: Mr Church 0245 869370 after 6.

Nascom 1. . . 8k static RAM (S100), 8k Basic ROM, NAS-SYS & B-BUG, Nascom graphics, 12" portable TV, joystick, sound unit, cassette rec, manuals, loads of software — m/c & Basic, Space Invaders, £270. Stuart colour graphics, £20. Tel: Rickmansworth 78335.

Superboard II. . . cased, good cond, little used, 2 months old (self-constructed PSU & monitor), expanded to 8k, fully working, £220 ono. Mr S Macnaughton, 66 Dannette Hey, Cantril Farm, Liverpool L28 6YF.

Philips MDCR. . . mini cassette drive with int to CBM & supporting software in EPROM, 6000 baud, 64 kbytes per side, 6 months, including assembler/ debug software, all for £190. Milt Bathurst, 73 rue du Village, 4545 Feneur, Belgium, tel 041/ 87 40 16.

MK 14. . . I/O port, extra memor memory, cassette int, new keyboard, revised monitor, £45. Tel: 01-464 2147, ask for Steve.

TRS-80. . . L2 16k with printer driver, sound box, light pen, wall cabinet, lots of software inc. Electric Pencil, cost £1100+, accept £500 cash. May also sell printer. Tel: 099 387 241

UK101. . . 4k, fully working with all leads, cased, various cassettes inc extended monitor, disassembler, some games, £200, buyer collects. Whitchurch (Hants) 2602 after 6.

TRS-80. . . L2 16k, VDU, cassette rec, manuals & some software, £400. 32k expansion int, Teac 40 track dual disks, manuals & some software, £700. Both for £1050. Tel: 0732 356728 eves/weekends.

Elf II . . . with giant board, monitor, 8-bit I/O, RS232/20 mA & cassette ints, 2 x 86-pin edge connectors, RF modulator, cased, PSU & RCS manuals + short programming course, £100. A T Holt, 65 John Street, Nelson, Lancs.

ZX80. . . Sinclair-built, inc all leads, PSU, manual & tape with my own progs (Moon lander, master mind etc), excellent cond, £65 — I'm buying larger computer. Tel 0865 511956

UK101 . . . 8k, cased, room for additional boards, RS232 printer int with cable, new editing monitor supplied, loads of prof. software inc chess & real time Startrek. Have upgraded to an Apple, therefore £275. Tel Nottingham 255935, eves.

TRS-80 . . . 16k L2, 7 months old, new style keyboard & green screen VDU, plus £200 worth of software inc Pascal, offers invited. Tel 01-979 5717 (eves)

TRS-80 . . . L2 16k, complete manual & various progs, 8 months old but hardly used, £425, no offers. Tel 0233 713198 after 6

TI57 . . . 50 fully-merged steps, subroutines, labels, trig, 8 fully arith mems, case, adaptor/ charger, manual, £17. Upminster 23222, ask for Richard.

Triton . . . built & cased, self-contained monitor, tape rec, keyboard & numeric pad, motherboard with ¾k RAM card, 7k scientific Basic on ROM card & PSU for expansion, £440 ono; Teletype ASR 33, good cond, working, with TRS-80 int, £200. Tel Byfleet 42348

Cheap . . . hard copy, Teletype ASR28, 240 V, 50 Hz, working but no data so only £50. Tel 0494 711014.

S100 boards . . . 2 off Econoram II 8k, both working, £70 each; Tarbell flobby disk PCB, FD1771 IC, bootstrap ROM & Tarbell manual, £55. Tel Camberley 0252 61543 after 6.

DIRECT ACCESS

TRANSACTION FILE

32k Apple . . . new, unused, must sell, double disks & controller, b/w monitor, price new £1780, will accept £1500 ono. Tel Burgess Hill 44268, eves.

Nascom 1/Creed . . . buffer board, 2k exp RAM, PSU, 20-slot case, keyboard. Creed 75 printer & int, Nascom/Creed software, 2 D/A converters with M5 software for CRT plotting, £225. Tektronix scope, 40 MHz single & 20 MHz double beam plug-ins, £170. Tel 01-387 5539 day or 0295 77 269 after 8

Telequipment . . . D31R dual trace scope plus 400 assorted comics, books, electronics & computer journals, £100. Tel Mr A Nicholls, Ingrebourne 75432

ZX89 . . . with reverse video switch, leads, PSU, manual, £80. Tel Hockley 9541

NS Horizon . . . dual disks, 40k RAM, 2 serial, + parallel ports, Volker Craig VDU, built into workdesk with computer, Creed Envoy printer, 8-pin punch & reader, with stand, several text books & progs, little used (in home), sensible offers invited. Tel 042 784 372

MK14 . . . fully working, cased, PSU, all doc, good cond, £40 ono. S Kheterpal; 8 Dunoon Close, Rise Park, Nottingham, Tel 0602 273688

TRS-80 . . . L2 16k, complete, boxed with progs, tapes, large selection of books & magazines, all mint, £525. Tel Jim Mitchell, Duntocher 72773 after 6.30

PET 2001 . . . 32k, unused for 9 months, with cover, electronic demagnetiser, cassettes, progs, etc, for quick sale at £420; bi-directional RS232 to parallel int complete for any RS232 printer, £50. Tel 01-267 9444 days or 01-387 6829 eves.

Triton . . . 8k, prof built, leather case, full doc, full on-board RAM, V5.1 monitor, L5.1 Basic, Hitachi tape, leads & tapes, £260. Tel 0299 403418

ZX80 . . . 3 months old, built & working, all leads & manual supplied, can be seen working, £80. Tel 0634 240053

MZ-80K . . . 24k RAM, brand new in makers box, inc Basic tape & manual, 55 progs (ham radio, maths, music, games, Space Invaders etc, Sharp User Club membership, full warranty, £500. S Fisher, 21 Balmoral, Adlington, Nr Chorley, Lancs PR7 4EL

Superboard II . . . 8k RAM, UHF modulator, PSU, cased, working, with progs, offers around £240. L J Stubbs, Tel Crewe 581657

TRS-80 . . . 16k L2, complete system inc Microchess, Backgammon, Blackjack tapes, £450 ono. Tel Horley 73209 after 7

Sorcerer . . . 16k, Basic & Assembler, terminal software (source), some tapes & games, £500. Modified TV to give monitor quality, £50; two good quality cassette units, £20 each. Tel 0628 20888

Acorn . . . system 1, assembled, tested, PSU, Zaks' *Programming the 6502*, all for £85. Write 1 Amberwood Drive, Camberley, Surrey.

Memory board . . . 32k for Nascom 1/2 with ZEAP 2 in EPROM, £190 or £75 less RAM; 4 x 4118 (4k), £35. Tel 01-458 8301

TRS-80 . . . 16k L2, practically unused, good cond, with selection of games & progs, demo given, offers around £400. Tel Ian, Plumtree 4181

ZX80 . . . 2 months old, built, leads, PSU, 4 C12 cassettes with 8 progs, £87 ono. Tel Coventry 415509 after 6

TRS-80 . . . L1 4k, new, game pack, manual & cassette, ideal beginner, complete, £250 ono. Tel 01-802 0777

TM990/189 . . . university module tutorial system, new, with PSU & doc, £250 ono. Tel 0703 557067 after 6

Printerm . . . high speed needle printer, full ASCII, 8½" paper, serial & parallel ints, list price £725, as new at £400 ono. Tel 023 062 200, eves or w/ends

Wordstar . . . w/processing software, unused disk cost £250 two months ago, offered at £165 inc manual. D Mortimer, 4 Royle Cres, London W13, Tel 01-840 1410 day, 01-997 1072 eves.

Apple II . . . 48k Europlus, disk drive, many disks & progs inc library index, w/proc, Space Invaders, chess, utilities, less than a year old, still guaranteed, £900. Tel Max, 01-743 1271 ext 6960 day, 01-354 1767 eves.

Apple . . . Europlus, 16k, Applesoft in ROM, 7 months old, as new, with Hitachi 9" monitor & tapes, £585. Tel 043 879 203

UV EPROM . . . cleaning tube unused, £12.50; ICL 7075 impact termiprinter with keyboard, upper & lower case, single & double spacing, 10, 20 or 30 cps, answerback, RS232, £320 ono. Tel 051-722 6692 eves & w/ends

Two oscilloscopes . . . Tektronix 545, £100; Solartron, £45. Tel Geoff Haydock, 04626 76422.

Modems . . . 4400 Racal/Milgo, 4800 baud, V24/RS232 2 & 4 wire, half/full duplex, sell as pair or single units, £25 each; Centronics 101 matrix printer, 132 col, record recently, working, used on PET, best offer over £75. Tel Horsham 69835

Practical . . . Computing magazine, all to date except Nov 78, Offers? *(I don't blame him for wanting to get rid of them — Ed)* Also wanted to buy/hire, Z80/8080 monitor in EPROM. Tel Basingstoke 22955, eves or w/ends.

PET 3016 . . . 16k, 2040 dual disk drive, ext cassette deck, box of disks, tapes, software inc Bridge challenger & all usual leads & things, hardly used, 3 months old, any sensible offers considered, Tel 0202 23350

Colour graphics. . . (Stuart) board for Nascom 1 with doc, £25; 5" TV, makes excellent monitor, as new, £30. Tel 0702 218662

T159/PC 100C . . . with stats module, RPN sim, maths/utilities module, dust cover, doc, inc TI source book, mag cards, excellent cond, £300 ono. Tel Chris, 01-449 9864

Apple . . . 48k, 1 disk, 4 months old, as new £1250. Tel 082 581 3168

TRS-80 . . . L2 16k, keyboard, mod, with manuals inc Learning Level II, progs, £350. Tel Berkhamstead 71827

Acorn . . . Sys 1 with opt RAM/IO chip, built Dec 79, good cond, all doc, £80; Tel 0302 62743

UK101 . . . 4k RAM, built & tested but uncased, cassette rec, games tape, £170 ono. Tel 0670 514536 after 5

UK101 . . . in Microcase, 8k RAM, new monitor ROM, working with manual, cassette software, all leads, recorder, £280 inc postage Tel 0969 23462 after 6.30

ZX80 . . . with manual & PSU, £90 ono. Tel Matthew, 01-340 6545

Full ASR terminal. . . made by ATS; ASCII, RS232 int, Logabax 132pp matrix printer, tractor feed feed, 60 ch/sec, 1 line buffer, full keyboard, excellent cond, complete, working, on stand with full maintenance doc & spares, originally £2500, asking £800, buyer collects. Tel: Leighton Buzzard 372286.

Dataplex word processor. . . typewriter printer, 2 mag card readers, utilities/word proc software, full set working drawings & doc, bought for hard copy but has developed small fault so £60 ono. Also approx 1 Mbyte spare mag cards, £15. Tel: 0924 271089 evenings.

ZX80. . . fully assembled with Sinclair PSU, brand new inc cassette/TV connecting leads & comprehensive instruction & programming manual, £80. Tel: 0908 78884.

T159. . . calc plus print cradle, stats module, rechargeable batt pack, mag prog cards & all manuals, cost £345, accept £195. Tel: Redcar 474707.

Wanted

Nascom 2. . . for part/total exch with Fischer 553-D metal detector (cost £274) with ground neutraliwing effect control, max depth penetration, exc. discrimination, 4-year guarantee, has paid for itself in 12 months. John Lewis, 16 Whittington Ave., Hayes, Middx.

80-col VDU. . . with lower case ASCII to swop for a printing terminal with integral cassette, 80-col, which can receive on cassette while transmitting from keyboard and printing, RS232 int for 10/15/20/30 cps. Tel: 01-658 3271.

Vol 1. . . issues 4,5,6,7,9 in good cond. will pay 70p per issue. A Postlewhite, 75 Glanrafon, Rhosllanerchrugog, Wrexham LL14 2DP, Tel: Legacy 227.

MK 14 VDU. . . circuit diagram & components list for one week. I Alder, 20 Camperdown, West Denton, Newcastle, Tyne/Wear.

ITT 2020. . . 16k with Palsoft in ROM, must be in good cond, willing to pay about £570. Tel: Nottingham 843970 after 6.

Creative Computing. . . vol 4 no 3 May/June 1978 or a listing of Oregon from that issue. Steward, 19 Carham Close, Corbridge, Northumberland, tel: 043-471 2913.

BACK NUMBERS

Volume 1 No. 1 May 1978
Nascom 1/77-68: The Mighty Micromite/A charity system

Volume 1 No. 2 June 1978
Research Machines 380Z/Computer in the classroom/The Europa Bus.

Volume 1 No. 3 July 1978
Buzzwords — A to Z of computer terms/Pattern recognition/Micro music

Volume 1 No. 8 December 1978 Computers and Art/3-D Noughts and Crosses/Mickie — the interviewing micro.

Volume 2 No. 1 May 1979
Small computers for small organisations/Sorcerer graphics/Chess Programming Hints/Parkinsons Revas.

Volume 2 No. 2 June 1979
MSI 6800/Witbit — disassemble your programs/The Multilingual Machine/Polytechnical Processing.

Volume 2 No. 3 July 1979
Vision link: Interfacing and Software for the Superscamp VDU/Pet Preening/Extended cursor graphics for the TRS-80.

Volume 2 No. 4 August 1979
The North Star Horizon/High Speed Cassette Interface for the SWTP 6800/Garage Accounting program/Apple Medical Application.

Volume 2 No. 7 November 1979 PCW Show issue/6800 Bug/Hard disc security/Detecting literary forgeries/Benchtest — the Challenger C3

For this years back issues, see Feature Index on page 47.

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PARKINSON'S PEP-UP

Continued from page 83

move and searches the table again.)

Optimisation

The loop takes 37 clock cycles to execute so, for every once round the loop, the program spends 22 cycles in the rest of itself (37/(22+37)=63%). If the Z80 instruction CPDR is used to search the table (21 cycles/loop) the ratio now becomes 21:22, approximately 49% of the total time now being spent in the loop. Changing the routine slightly to use CPDR gave the dotted activity profile in Figure 2, and Microchess's 'thinking time' was reduced by 27%.

8080-compatible optimisation is more complicated and involves ensuring that the piece table starts on a page boundary. As the program was completely dominated by this one small section of code, no further optimisation was attempted.

Other applications

Although I have not tried this, it should be possible to extend the technique to Basic programs. However in this case the interrupt routine must ignore the return address, (unless you are interested in profiling the interpreter) and use the line number of the currently executing line, which all Basics hold somewhere. Remember to watch that stack pointer — SWTP Basic does weird things with it almost everywhere, Nas-Sys 1 briefly on the RCAL and SCAL entry points (fixed on NAS-Sys 3), but what does your system/program do? The example of Microchess demonstrates the usefulness of the technique. It does not take long to apply (less than half-an-hour if you already have the hardware) and can save many fruitless hours' work, as it did in this case.

Computer Games cont. from page 85

A mistaken attempt to open up the diagonal to the white king.

21 f3-g5 f5-e4
22 c3-e4 f8-f2

This move appears, at first glance, to be very strong. If now 23 e4-f2, Black's queen immediately gives mate on g2. But the program had seen further in the crucial variation than its opponent.

23 d1-d6!

When he saw this move Stean exclaimed, "Bloody iron monster". The point is that Black's queen is needed to prevent d6-d8 mate, and the queen is attacked. If the queen moves to a square that protects d8, White can then capture the rook on f2. So White must win material.

23 . . . c6-d6

The best try.

24 e4-d6 f2-g2

Threatening to move the rook to g5, c2 or e2, with check from the bishop on b7. Any of these moves would win for Black, but . . .

25 g5-e4

Blocking the crucial diagonal.

25 . . . g2-g4
26 c2-c4

Blocking off another line of attack.

26 . . . e7-f5
27 h2-h3

Stean had hoped for 27 d6-f5 e6-f5, when Black wins the other knight which is pinned against the white king. When the computer played h2-h3 Stean cried out, "This computer is a genius".

27 . . . f5-g3+
28 h1-h2 g4-e4
29 a2-f2!

Yet another tactical blow. Black had only expected 29 d6-e4 g3-e4, when he has sufficient material to make the program's task quite difficult. But this latest move, threatening mate by f2-f7+ and then f7-f8 mate, forces an even greater material advantage.

29 . . . h7-h6
30 d6-e4 g3-e4
31 f2-f3 b4-b8
32 e1-e4 b8-f8
33 f3-g4 a8-e4
34 g4-e6+ g8-h8
35 e6-e4 f8-f6
36 e4-e5 f6-b6
37 e5-c5 b6-b3
38 c5-c8+ h8-h7
39 c8-a6 Black Resigns

There was once a time when leading experts in computer science would say that "Computers can't play chess".

Bibliography

Frey, Peter W: *Chess Skill in Man and Machine*, Springer Verlag, 1977.

Gillogly, J J: *The Technology Chess Program*, Artificial Intelligence, vol 3 (1972), pp 145-163.

Greenblatt, Richard D, Eastlake, Donald E III, and Crocker, Stephen D: *The Greenblatt Chess Program*, Proc. Fall Joint Computer Conf. 1967, pp 801-810.

IMAGE Listing cont. from page 59

```
  ***** Read N Cartesian coordinates and construct matrix
        OC of homogeneous coordinates                  *****
200 READ N
210 DIM OC(N,4),TC(N,4),T(4,4),IC(N,2)
220 FOR R=1 TO N: FOR C=1 TO 3: READ OC(R,C)
230 NEXT C: OC(R,4)=1: NEXT R: RETURN

  ***** Calculate the elements of the transformation
        matrix RSTCP                                   *****
300 F=3.141592/180
310 SA=SIN(ALPHA*F): CA=COS(ALPHA*F): SB=SIN(BETA*F)
320 CB=COS(BETA*F):SG=SIN(GAMMA*F): CG=COS(GAMMA*F)
330 T(1,1)=A*CB*CG
340 T(1,2)=B*CB*SG
350 T(1,4)=C*SB*RZ
```

```
360 T(2,1)=A*(SA*SB*CG-CA*SG)
370 T(2,2)=B*(SA*SB*SG+CA*CG)
380 T(2,4)=-C*SA*CB*RZ
390 T(3,1)=A*(CA*SB*CG+SA*SG)
400 T(3,2)=B*(CA*SB*SG-SA*CG)
410 T(3,4)=-C*CA*CB*RZ
420 T(4,1)=U: T(4,2)=V: T(4,4)=1-W*RZ
430 FOR R=1 TO 4: T(R,3)=0: NEXT R
440 RETURN

 ***** Matrix multiplication [TC] = [OC] X [T]   *****
500 MAT TC=OC*T :RETURN
                    or
500 FOR R=1 TO N: FOR C=1 TO 4: S=0
510 FOR J=1 TO 4: S=S+OC(R,J)*T(J,C): NEXTJ
520 TC(R,C)=S: NEXT C: NEXT R: RETURN

 ***** Calculate and print image coordinates (x'',y'')
       corresponding to homogeneous coordinates in [TC]
600 FOR R=1 TO N
610 IC(R,1)=TC(R,1)/TC(R,4)
620 IC(R,2)=TC(R,2)/TC(R,4)
630 PRINT R;IC(R,1),IC(R,2):NEXT R:RETURN

 ***** e.g. The Cartesian coordinates for the points
       shown in Figure 1.                            *****
1000 DATA 8,-1,1,1,1,1,1,1,-1,1,-1,-1,1,-1,1,-1
1010 DATA 1,1,-1,1,-1,-1,-1,-1,-1

*************************************************************

          ADDITIONAL SUBROUTINES.

***** Calculate screen coordinates (p q)
      corresponding to homogeneous coordinates in [TC]
          See VIDEO GRAPHICS section.              *****
700 DIM SC(N,2)
710 P=   : Q=    : YD=
720 FOR R=1 TO N
730 SC(R,1)=INT(TC(R,1)*Q/YD/TC(R,4)+P/2)
740 SC(R,2)=INT(TC(R,2)*Q/YD/TC(R,4)+Q/2)
750 NEXT R:RETURN

  NB. Insert suitable values in line 710.

***** Join the appropiate screen coordinates with
      straight lines; the example being the cube in
      Figure 1. See JOINING INFORMATION section *****
800 DATA 12,1,2,2,3,3,4,4,1,1,5,5,6
810 DATA 6,7,7,8,8,5,2,6,3,7,4,8
820 READ NL: FOR L=1 TO NL
830 READ P1,P2
840 JOIN (SC(P1,1),SC(P1,2),SC(P2,1),SC(P2,2))
850 NEXT L: RETURN
```

PROGRAMS

PET Racer

by Kim Mulji

An excellent two-player car race program from a YCW reader.

```
0 REM ** RACER BY KIM MULJI 19/6/80 **
1 FORI=0TO10:GETA$:NEXT:GOSUB 5010:PRINT"J"
2 PRINT"    LAPS= 0    CAR RACE    LAPS= 0":D=0:C=0:MA=0:ME=0:SE=0:SC=0
3 PRINT"                                       "
4 PRINT"        ------------------------------
5 PRINT"        |                 *           |
6 PRINT"        |                 ■           |
7 PRINT"        |    ---------------------    |
8 PRINT"        |    |                   |    |
9 PRINT"        |    |    -------------  |    |
10 PRINT"        |    |               |   |    |
11 PRINT"        |     ----------------    |    |
12 PRINT"        |              |    |     |    |
13 PRINT"        |---------     |    |     |    |
```

PROGRAMS

```
14 PRINT"   │               │    │  ╰─────────┤
15 PRINT"   │  ╭────────────╯    │            │
16 PRINT"   │  ╰───────╮         │            │
17 PRINT"   │          │         ╰──────╮     │
18 PRINT"   ╰──────╮   │                │     │
19 PRINT"          │   ╰────────────────╯     │
20 PRINT"          │                 │        │
30 PRINT"          │           │     │        │
40 PRINT"          │           │              │
50 PRINT"          ╰───────────┴──────────────╯
86 P=32948:H=P
87 F=32908:J=F
88 A=500:Z=98:X=104
90 IF P=33509 THEN MA=1
91 IF F=33509 THEN ME=1
92 IF MA=1ANDME=1ANDP=HANDF=JTHEN700
93 IF MA=1ANDME=1ANDP=JANDF=HTHEN700
94 IF MA=1 AND P=J THEN 800
95 IF MA=1 AND P=H THEN 800
96 IF ME=1 AND F=J THEN 900
97 IF ME=1 AND F=H THEN 900
98 GETA$:IF A$=""THEN200
99 REM *GETS CHARACTERS FROM KEYBOARD*
100 IF A$="8"THENC=-40:N=0:GOTO200
101 IF A$="W"THEND=-40:GOTO200
102 IF A$="5"THENC=0:GOTO200
103 IF A$="S"THEND=0:GOTO200
110 IF A$="6"THENC=1:N=0:GOTO200
111 IF A$="D"THEND=1:GOTO200
120 IF A$="4"THENC=-1:N=0:GOTO200
121 IF A$="A"THEND=-1:GOTO200
132 IF A$="2"THENC=40:N=0:GOTO200
133 IF A$="X"THEND=40:GOTO200
200 FORY=0TO500-A:NEXT:A=A+20
201 IF PEEK(P+C)=104ORPEEK(P+C)=92 THEN 300
202 IF PEEK(F+D)=98ORPEEK(F+D)=97 THEN 300
205 IF PEEK(P+C)<>32 THEN C=0
206 IF PEEK(F+D)<>32 THEN D=0
207 IF C=40 OR C=-40 THEN Z=97
208 IF D=40 OR D=-40 THEN X=92
209 IF C=1 OR C=-1 THEN Z=98
210 IF D=1 OR D=-1 THEN X=104
211 P=P+C:POKEP-C,32:POKEP,Z
212 F=F+D:POKEF-D,32:POKEF,X
214 GOTO90
300 POKEP,214:POKEF,214
310 FORI=0TO300:NEXT
311 A=0
320 GOTO205
700 SC=SC+1:SE=SE+1
710 PRINT"▒";TAB(9);SE;TAB(32);SC
720 IF SC=NN AND SE=NN THEN 780
730 IF SC=NN THEN 850
740 IF SE=NN THEN 950
750 GOTO 93
780 PRINT"▒                  A DRAW
781 PRINT"               PRESS ANY KEY
782 GET A$:IF A$=""THEN782
783 GOTO 2
800 SC=SC+1
801 MA=0
810 PRINT"▒";TAB(32);SC
820 IF SC=NN THEN 850
830 GOTO 93
850 ME=0:MA=0:SC=0:SE=0:PRINT"▒      THE WINNER IS THE '■' CAR
851 PRINT"               PRESS ANY KEY            "
852 FORY=0TO1000:NEXT
853 FORN=0TO9:GETA$:NEXT
854 GET A$:IF A$=""THEN854
855 GOTO 2
882 FORY=0TO1000:NEXT
883 GOTO 853
900 SE=SE+1
901 ME=0
910 PRINT"▒";TAB(9);SE
920 IF SE=NN THEN 950
930 GOTO 93
950 ME=0:MA=0:SC=0:SE=0:PRINT"▒      THE WINNER IS THE '*' CAR
951 PRINT"               PRESS ANY KEY            "
952 FORY=0TO1000:NEXT
953 GOTO 853
5010 REM *** INSTRUCTIONS ***
5015 PRINT"▒";
5100 PRINTTAB(14)"CAR RACE"
5150 PRINTTAB(14)"────────"
5200 PRINT"  THIS IS RACING GAME WHERE YOU HAVE TO"
5300 PRINT"DRIVE YOUR CAR AROUND THE TRACK FIVE"
5400 PRINT"TIMES."
5500 PRINT"  THERE ARE TWO CARS '*' AND '■' THESE"
5600 PRINT"ARE CONTROLLED BY FOUR KEYS EACH"
5700 PRINT:PRINT"         W             8  "
5800 PRINT" LEFT  A S D     RIGHT  4 5 6"
5900 PRINT"         X             2  "
6000 PRINT:PRINT"TO MAKE THE '*' CAR GO RIGHT YOU "
6100 PRINT"WOULD PRESS 'D' AND TO MAKE THE '■' CAR"
6200 PRINT"GO UP YOU PRESS '8'"
6210 PRINT"TO STOP PRESS THE CENTRE KEY 'S' OR '5'"
6300 PRINT"  YOU START OFF GOING LEFT AND CARRY ON"
6310 PRINT"GOING ROUND THE TRACK"
6400 PRINT"  SOMETIMES IF YOU HIT THE OTHER CAR "
6500 PRINT"YOU CRASH,WHEN YOU START AGAIN YOU MOVE"
6700 PRINT"SLOWLY AT FIRST AND GET FASTER AND "
6800 PRINT"FASTER UNTIL YOU RETURN TO NORMAL SPEED"
6850 PRINT
6900 PRINT"                ▒PRESS ANY KEY▒"
6910 GET A$:IF A$=""THEN6910
6920 PRINT"▒▒▒▒▒▒▒▒HOW MANY LAPS DO YOU WANT TO GO ROUND"
6930 PRINT"▒▒▒▒TO WIN";:INPUT NN
7100 RETURN
READY.
```

PROGRAMS

ZX80 Breakout

by K I Allsop

The aim is to remove a complete column of five bricks in as few attempts as possible. Brick removal is based on time because the screen is invisible while the ZX80 is thinking. Hit 'return' when you think it's time to fire the missile at the wall.

```
10 LET F=0
20 LET G=0
30 DIM B(160)
40 FOR A=1 TO 160
50 LET B(A)=1
60 NEXT A
70 PRINT, "BREAKOUT"
80 PRINT
90 PRINT
100 FOR A=1 TO 160
110 IF A=F THEN PRINT "*";
120 IF A=F THEN GOTO 150
130 IF B(A)=1 THEN PRINT "     ";
140 IF B(A)=0 THEN PRINT "     ";
150 NEXT A
160 FOR A=1 TO 32
170 FOR D=0 TO 4
180 LET E=A+D*32
190 IF B(E)=1 THEN GOTO 220
200 NEXT D
210 GOTO 320
220 NEXT A
230 LET G=G+1
240 POKE 16415,0
250 POKE 16414,0
260 INPUT A$
270 LET F=PEEK(16414)+ PEEK (16415)*256—4
280 CLS
290 IF F>160 THEN GOTO 350
300 LET B(F)=0
310 GOTO 70
320 PRINT "     "
330 PRINT, "BREAKOUT",G;"GOES"
340 INPUT W
350 PRINT "TIMEOUT"
```

Algebraic Expression Evaluation for the PET

by D Milnes

A super program which allows you to enter an expression followed by variable values which are then promptly evaluated.

```
100 GOSUB2000:PRINT"";:POKE59468,14:POKE59458,60:GOSUB7000
110 PRINT"ТYPE ANY ALGEBRAIC EXPRESSION":PRINT"X = ";:GOSUB3000
120 X$=ZA$:LZ=LEN(X$)
130 IFB%<A%THENPRINTS$:PRINT:PRINT"\ISSING RIGHT PARENTHESES":GOTO500
140 IFB%>A%THENPRINTS$:PRINT:PRINT"\ISSING LEFT PARENTHESES":GOTO500
150 DIMB$(LZ+2),A$(LZ+2)
160 FORIZ=1TOLZ+2:B$(IZ)="0":NEXT:FORIZ=1TOLZ:B$(IZ)=MID$(X$,IZ,1):NEXT
170 TZ=0:IZ=1:ZC=ASC(B$(IZ)):IF(ZC<65ORZC>90)AND(ZC<48ORZC>57)THEN1000
180 FORIZ=1TOLZ:ZC=ASC(B$(IZ)):IFZC<>65ANDZC<>67ANDZC<>83ANDZC<>76ANDZC<>73THEN
270
190 IFZC<65ORZC>90THEN340
200 IFASC(B$(IZ+1))<65ORASC(B$(IZ+1))>90THEN300
210 IF(ASC(B$(IZ+2))<65ORASC(B$(IZ+2))>90)ANDIZ<LZTHENLZ=LEN(X$):IZ=IZ+TZ+1:GOT
O1000
220 B$(IZ)=B$(IZ)+B$(IZ+1)+B$(IZ+2):FORI=1TO9:IFB$(IZ)=C$(I)THEN240
230 NEXT:Z$="—UNCTION INVALID":GOTO1000
240 IFB$(IZ+3)<>"("THENIZ=IZ+1:GOTO1000
250 FORJZ=IZ+1TOLZ:B$(JZ)=B$(JZ+2):NEXT:IZ=IZ+1:LZ=LZ-1:TZ=TZ+1
260 GOTO340
270 IFZC<65ORZC>90THEN340
280 IFASC(B$(IZ+1))<65ORASC(B$(IZ+1))>90THEN300
290 IFB$(IZ)<>")"THENLZ=LEN(X$):IZ=IZ+1:GOTO1000
300 FORJZ=IZ-1TO1STEP-1:IFB$(IZ)=B$(JZ)THEN340
310 NEXTJZ:IF(LEN(B$(IZ))=3ORASC(B$(IZ))<65ORASC(B$(IZ))>90)THEN340
320 KZ=KZ+1:PRINT"":POKE216,10:PRINT"ALUE FOR ";B$(IZ);" = ";:GOSUB3000:GOSU
B4000
330 A$(KZ)=ZA$:ZA$=""
340 NEXTIZ
350 PRINT"X=";X$:GOSUB5000
360 PRINT"ІHE ANSWER TO THE EQUATION AND VALUES   ENTERED IS AS FOLLOWS - -
370 PRINT"";TAB(5);"OHEN  X = ";X$:KZ=0
380 FORIZ=1TOLZ:IFASC(B$(IZ))<65ORASC(B$(IZ))>90ORLEN(B$(IZ))=3THEN420
390 FORJZ=IZ-1TO1STEP-1:IFB$(IZ)=B$(JZ)THEN420
400 NEXTJZ
410 KZ=KZ+1:PRINT:PRINTTAB(6);"♠ND  ";B$(IZ);" = ";A$(KZ)
420 NEXTIZ
430 PRINT"";TAB(8);"ХALUE OF X = ";X
440 PRINT:PRINT"\ORE  ";:GOSUB3000:R$=ZA$:IFLEFT$(R$,1)="N"THEN500
450 IFLEFT$(R$,1)="Y"THENKZ=0:GOTO470
460 PRINT"";TAB(7+LEN(R$));:FORIZ=1TOLEN(R$):PRINTCHR$(20);:NEXT:PRINT"":GO
TO440
470 PRINT:PRINT"♦AME EQUATION AS ABOVE ?";:GOSUB3000:R$=ZA$:IFLEFT$(R$,1)="Y"TH
EN180
```

```
480 IFLEFT$(R$,1)="N"THENCLR:GOSUB2000:GOTO110
490 PRINT"TT";TAB(24+LEN(R$));:FORI=1TOLEN(R$):PRINTCHR$(20);:NEXT:PRINT"TT":GO
TO470
500 POKE59458,30:END
1000 IFIZ=1THENZ$="ILLEGAL FIRST CHARACTER"
1010 PRINTS$;" MARKED ■"
1020 PRINT"";LEFT$(X$,IZ-1);"■";MID$(X$,IZ,1);"■";RIGHT$(X$,LZ-IZ):PRINTZ$
1030 GOTO500
2000 DIMC$(9):A%=0:B%=0:IZ=0:TZ=0:JZ=0:LZ=0:A=0:B=0:C=0:Y=0:X=0:LX=0:FL=0:KZ=0
2010 FORI=1TO9:READC$(I):NEXT
2020 IZ=PEEK(65000):IFIZ=254THEN2080
2030 IFIZ=192THEN2060 .
2040 PRINT"SORRY - YOUR PET IS NOT COMPTIBLE WITH  THIS PROGRAMME.
2050 PRINT:PRINT"-// ABORTED":GOTO500
2060 AA=527:AB=528:AC=529:AD=530:AE=531:AF=532:AG=533:AH=534:AI=535:AJ=536:AK=5
25
2070 GOTO2090
2080 AA=623:AB=624:AC=625:AD=626:AE=627:AF=628:AG=629:AH=630:AI=631:AJ=632:AK=1
58
2090 Z$="MORE THAN SINGLE CHAR: VAR:":S$="?  "
2100 RETURN
3000 A$="":ZA$=""
3010 GETA$:IFA$<>""THEN3030
3020 PRINTZZ$;:FORZT=1TO200:NEXT:ZZ$=" ■":PRINTZZ$;:FORZT=1TO200:NEXT:ZZ$="■ ■"
"
3030 IFA$="X"THENA$="":GOTO3010
3040 IFA$="("THENA%=A%+1
3050 IFA$=")"THENB%=B%+1
3060 IFZA$=""ANDA$=CHR$(13)THEN3010
3070 IFA$=CHR$(13)THENPRINTA$:RETURN
3080 IFA$=CHR$(20)ANDZA$=""THEN3010
3090 IFA$=CHR$(20)ANDZA$<>""THENPRINTA$;:ZA$=LEFT$(ZA$,LEN(ZA$)-1):GOTO3010
3100 ZA$=ZA$+A$
3110 PRINTA$;:A$="":GOTO3010
4000 PRINT"■";B$(IZ);" = ";ZA$:GOSUB5000:RETURN
5000 POKEAA,19:POKEAB,13:POKEAC,145:POKEAD,145:POKEAE,147:POKEAF,67
5010 POKEAG,79:POKEAH,78:POKEAI,84:POKEAJ,13:POKEAK,10:STOP:POKEAK,0
5020 PRINT"J";:RETURN
7000 PRINTTAB(8)"PROGRAMME FOR EVALUATING":TZ=800
7010 PRINT"■"TAB(9)"ALGEBRAIC EXPRESSIONS":PRINTTAB(3)"-E.MILNES-"TAB(25)"-6
JUNE 1980-
7020 PRINTTAB(13)"____________
7030 GOSUB8000
7040 PRINT"INSTRUCTIONS ? ";:GOSUB3000:R$=LEFT$(ZA$,1)
7050 IFR$="N"THENRETURN
7060 IFR$="Y"THEN7080
7070 PRINT"TT";TAB(15+LEN(ZA$));:FORI=1TOLEN(ZA$):PRINTCHR$(20);:NEXT:PRINT"TT
":GOTO7040
7080 PRINT"■     THE PROGRAMME IN MEMORY WILL■":PRINT"   EVALUATE ";
7090 PRINT"ANY ALGEBRAIC EXPRESSION":PRINT"■   ENTERED INTO THE PET.
7100 PRINT"■     THE ONLY RESTRICTION IS SINGLE":PRINT"■   CHARACTER VARIABLES
7110 PRINT"■"TAB(10)"'A' IS ACCEPTABLE":PRINT"■"TAB(10)"'A1' IS NOT ACCEPTABLE
7120 PRINT"■"TAB(10)"'BX' IS NOT ACCEPTABLE
7130 PRINT"■     OTHERWISE THE NORMAL PET ■":PRINT"   SYNTAX APPLIES.
7140 TZ=7500:GOSUB8000:PRINT"J"
7150 PRINT"     THE PET WILL PROMPT FOR AN":PRINT"■   ALGEBRAIC EXPRESSION AS
7160 PRINT"■          X = <BLINKING CURSOR>":TZ=3900:GOSUB8000
7170 PRINT"■     YOU TYPE IN ON ONE LINE (NO SPACES)
7180 PRINT"■ THE EXPRESSION YOU WANT TO EVALUATE,
7190 PRINT"■ TERMINATING WITH 'RETURN' - EG ■":PRINTTAB(10)"X = A↑2*SIN(B)/C+D
7200 TZ=5000:GOSUB8000:PRINT"■ THE PET WILL THEN PROMPT FOR THE VALUES
7210 PRINT"OF THE VARIABLES IN THE EXPRESSION":PRINT"■IN THIS CASE 'A','B','C'
& 'D'.
7220 TZ=6000:GOSUB8000:PRINT"J"
7230 PRINT"■ FINALLY THE PET WILL PRINT TO":PRINT"■ SCREEN THE EXPRESSION, VAL
UE OF
7240 PRINT" THE VARIABLES AND THE NUMERIC VALUE■":PRINT" OF THE EXPRESSION ";
7250 PRINT"USING THESE VALUES.
7260 PRINT"■      TO CONTINUE WITH PROGRAMME":PRINT:PRINTTAB(15)"PRESS -T /
-/
7270 GETA$:IFA$=""THEN7270
7280 RETURN
8000 FORIZ=1TOTZ:NEXT:IFFL=3THENPRINT"J"
8010 RETURN
9000 DATA SIN,COS,ATN,INT,SQR,ABS,EXP,LOG,TAN
```

UK101 Gunfight

by John Popplewell

A two-player game with good graphics which will run in under 4k provided the REM statements are left out.

```
1 DIMML(23),MR(24)
3 FORZ=546TO565:READX:POKEZ,X:NEXT:POKE11,34:POKE12,2
4 DATA169,32,160,255,153,0,208,153,0,209,153
5 DATA0,210,153,0,211,136,208,241,76
6 REM ABOVE DATA IS FOR M.C. CLEAR SCREEN
7 X=USR(X):GOSUB6070
8 SR=0:SL=0:A$="ARRGH !":HL=0:HR=0
10 X=USR(X):SF=0
11 POKE53265,SL+48:POKE53302,SR+48
15 FL=0:FR=0:PL=53838:PR=53878
20 POKE530,1:KE=57088:POKE54271,32
22 FORZ=0TO960STEP64:REM DRAW BOARDERS
23 POKE53257+Z,140:POKE53309+Z,140:NEXT
24 REM DRAW CACTI
25 POKE53399,203:POKE53400,218:POKE53464,216:POKE53465,206
26 POKE53860,203:POKE53861,218:POKE53925,216
27 POKE53926,206
28 REM LEFT AND RIGHT GUN CHARACTERS
29 L(0)=195:L(1)=132:L(2)=198:L(3)=132
30 R(0)=197:R(1)=132:R(2)=196:R(3)=132
31 REM PLAYER MOVEMENT DISPLACEMENTS
32 ML(12)=-64:ML(19)=64:ML(22)=-1:ML(23)=1
34 MR(19)=-64:MR(22)=64:MR(23)=-1:MR(24)=1
44 REM CONSTANTS,ASSIGNED VARIABLES FOR SPEED
45 B1=64:B2=1:B3=63:B4=65:B5=128:A7=32
49 REM REWRITE (PL)
50 POKEPL,161:POKEPL-B1,226:POKEPL-B2,195:POKEPL+B2,197:POKEPL+B3,143
55 POKEPL+B4,136:POKEPL+B1,A7:POKEPL-B5,158:POKEPL-B3,145
56 POKEPL-B4,145
60 REM REWRITE (PR)
61 IFSF=1THEN88
62 POKEPR,161:POKEPR-B2,195:POKEPR+B2,197:POKEPR-B1,226:POKEPR+B3,143
63 POKEPR+B4,136:POKEPR+B1,A7:POKEPR-B5,158:POKEPR-B3,145
```

PROGRAMS

```
64 POKEPR-B1,145
66 REM KEYBOARD SCAN ROUTINE
67 POKEKE,239:OS=PEEK(KE):POKEKE,223:OT=PEEK(KE)
68 POKEKE,253:OU=PEEK(KE):POKEKE,191:OQ=PEEK(KE)
72 POKEKE,127:OP=PEEK(KE):IFOP)239THEN74
73 OP=INT(OP/10):M=ML(OP)
74 IFOS=127THENGL=GL+1:IFGL=4THENGL=0
75 IFOQ)247THEN80
76 OQ=INT(OQ/10):M1=MR(OQ)
80 IFOT=223THENGR=GR+1:IFGR=4THENGR=0
81 IFOS=191ANDFL=0THEN250
82 IFFL=1THEN280
83 IFOU=253ANDFR=0THEN400
84 IFFR=1THEN420
85 SF=1
86 POKEPL+B2+B2,L(GL):POKEPR-B2-B2,R(GR)
87 IFM()0THEN135
88 IFM1=0THEN67
89 REM CHECK RIGHT PLAYER (PR) CAN MOVE
90 IFPEEK(PR+M1+M1+M1)()A7THEN67
99 REM BLANK (PR),CHANGE POS.,GOTO REWRITE
100 POKEPR-B2,A7:POKEPR+B2,A7:POKEPR-B5,A7
105 POKEPR-B4,A7:POKEPR-B3,A7:POKEPR+B4,A7:POKEPR+B3,A7
110 POKEPR-B2-B2,A7:PR=PR+M1:M1=0:GOTO62
134 REM CHECK LEFT PLAYER (PL) CAN MOVE
135 IFPEEK(PL+M+M+M)()A7THEN50
149 REM BLANK (PL),CHANGE POS.,GOTO REWRITE
150 POKEPL-B2,A7:POKEPL+B2,A7:POKEPL-B5,A7:POKEPL-B4,A7:POKEPL-B3,A7
160 POKEPL+B4,A7:POKEPL+B3,A7:POKEPL+B2+B2,A7
170 PL=PL+M:M=0:GOTO50
249 REM INITIALISE POS.(BL) AND DIRECTION (DL)
250 BL=PL+2:FL=1:IFGL=0THENDL=-62
260 IFGL=1ORGL=3THENDL=2
270 IFGL=2THENDL=66
279 REM MOVE (BL),CHECK NEW POS.
280 POKEBL,A7:BL=BL+DL:IFPEEK(BL)()A7THENFL=0:GOTO600
285 IFPEEK(BL+B2)()A7THENBL=BL+B2:FL=0:GOTO600
290 BL=BL+DL:IFPEEK(BL)()A7THENFL=0:GOTO600
295 IFPEEK(BL+B2)()A7THENBL=BL+B2:FL=0:GOTO600
300 POKEBL,213:GOTO83
399 REM INITIALISE POS.(BR) AND DIRECTION (DR)
400 BR=PR-2:FR=1:IFGR=0THENDR=-66
410 IFGR=1ORGR=3THENDR=-2
415 IFGR=2THENDR=62
419 REM MOVE (BR),CHECK NEW POS.
420 POKEBR,A7:BR=BR+DR:IFPEEK(BR)()A7THENFR=0:GOTO500
425 IFPEEK(BR-B2)()A7THENBR=BR-B2:FR=0:GOTO500
430 BR=BR+DR:IFPEEK(BR)()A7THENFR=0:GOTO500
435 IFPEEK(BR-B2)()A7THENBR=BR-B2:FR=0:GOTO500
440 POKEBR,213:GOTO86
499 REM SEE WHAT RIGHT BULLET HAS HIT (BR)
500 B=PEEK(BR)
501 IFB=140ORB=207ORB=212ORB=213THEN86
502 IFB)47ANDB(58THEN86
503 IFB=203THENPOKEBR,204:GOTO86
504 IFB=204ORB=205ORB=216ORB=218THENPOKEBR,A7:GOTO86
505 IFB=206THENPOKEBR,205:GOTO86
506 IFB=158THENB=BR:GOSUB5000:GOTO86
510 XO=PL-4:GOSUB2000
520 SR=SR+B2:IFSR=10THEN1000
530 GOTO10
599 REM SEE WHAT LEFT BULLET HAS HIT (BL)
600 B=PEEK(BL)
601 IFB=140ORB=207ORB=212ORB=213THEN83
602 IFB)47ANDB(58THEN83
603 IFB=203THENPOKEBL,204:GOTO83
604 IFB=204ORB=205ORB=216ORB=218THENPOKEBL,A7:GOTO83
605 IFB=206THENPOKEBL,205:GOTO83
606 IFB=158THENB=BL:GOSUB5000:GOTO83
610 XO=PR-4:GOSUB2000
620 SL=SL+B2:IFSL=10THEN1000
630 GOTO10
999 REM END OF GAME
1000 X=USR(X):POKE518,255
1005 PRINT"THE LEFT PLAYER SCORED"SL:PRINT
1015 PRINT"THE RIGHT PLAYER SCORED"SR:PRINT
1040 INPUT"ANOTHER GO ";A$
1050 IFLEFT$(A$,1)="N"THENPOKE518,0:END
1060 GOTO7
1999 REM WRITE "ARRGH !"
2000 FORZ=1TO7:POKEXO+Z,ASC(MID$(A$,Z,1)):NEXT
2015 FORZ=0TO1000:NEXT:RETURN
4999 REM HAT BOUNCE
5000 POKEB,A7:POKEB+B4,A7:POKEB+B3,A7
5002 POKEB-B1,158:POKEB-B2,145:POKEB+B2,145
5003 FORZ=0TO50:NEXT
5005 POKEB-B1,A7:POKEB-B2,A7:POKEB+B2,A7
5008 POKEB,158:POKEB+B4,145:POKEB+B3,145
5010 RETURN
6090 INPUT"DO YOU REQUIRE INSTRUCTIONS";A$
6095 X=USR(X):IFLEFT$(A$,1)="N"THENRETURN
7000 PRINTTAB(14)"** GUN FIGHT **":PRINT:PRINT:POKE518,255
7010 PRINT"THIS GAME SIMULATES A SHOOTOUT BETWEEN TWO"
7020 PRINT"COWBOYS CONTROLLED BY THE PLAYERS. THE COWBOYS"
7030 PRINT"CAN MOVE UP,DOWN,LEFT,AND RIGHT THE ANGLE OF"
7040 PRINT"THEIR GUNS CAN ALSO BE CHANGED. THEY ARE KILLED"
7050 PRINT"BY A HIT ANYWHERE OTHER THAN THEIR HATS, WHICH"
7060 PRINT"FLY INTO THE AIR WHEN HIT. TWO CACTI ARE"
7070 PRINT"DISPLAYED FOR DEFENSIVE PURPOSES, BUT ARE"
7080 PRINT"DAMAGED BY SUCCESSIVE HITS. THE FIRST PLAYER"
7090 PRINT"TO SCORE 10 POINTS WINS. ONLY ONE SHOT AT A"
8000 PRINT"TIME CAN BE FIRED.":PRINT
8010 PRINTTAB(13)"PLAYER MOVEMENT":PRINT
8020 PRINTTAB(4)"LEFT PLAYER"TAB(25)"RIGHT PLAYER"
8030 PRINT"UP"TAB(9)"'1'"TAB(30)"'9'"
8040 PRINT"DOWN"TAB(9)"'2'"TAB(30)"'0'"
8050 PRINT"LEFT"TAB(9)"'3'"TAB(30)"'*'"
8060 PRINT"RIGHT"TAB(9)"'4'"TAB(30)"'='"
8070 PRINT:PRINTTAB(14)"GUN CONTROLS":PRINT
8080 PRINTTAB(4)"LEFT PLAYER"TAB(25)"RIGHT PLAYER"
8090 PRINT"ANGLE"TAB(9)"'W'"TAB(30)"'O'"
```

```
9000 PRINT"FIRE"TAB(9)"'E'"TAB(30)"'P'"
9010 PRINT:INPUT"ARE YOU READY";A$
9020 IFLEFT$(A$,1)()"N"THENRETURN
9030 GOTO8010
```

UK 101 Graphics Development

by Mark A Fernandes

This program enables you to build, modify and interpret a screen layout. Very useful at the design stage of a program.

```
5 POKE11,0:POKE12,253
7 PRINT"DO YOU KNOW HOW TO USE THIS PROGRAM":X=USR(X)
8 IFPEEK(531)=78THEN280
10 INPUT"GRID DIMENSIONS(ROWS X COLUMNS)";R,C
20 IFR)90 OR C)90THEN10
30 DIMA(R,C)
35 FORX=1TOR:FORY=1TOC:A(X,Y)=32:NEXTY,X
36 PRINT
37 PRINT"1=WHOLE GRID INPUT MODE"
40 PRINT"2=SELECTIVE CO-ORD MODE"
45 PRINT"3=DISPLAY GRID"
47 PRINT"4=DISPLAY CODES IN GRID"
50 PRINT"5=CLEAR GRID"
53 PRINT"6=END PROGRAM"
55 PRINT"7=DISPLAY CHARACTER OF CODE INPUTED"
60 X=USR(X):U=PEEK(531)-48:IFU(1THEN60
70 ONU GOTO90,140,180,230,35,270
80 INPUT"GRAPHIC CODE";X:PRINTCHR$(X):GOTO37
90 FORX=1TOR
100 FORY=1TOC
110 PRINT"SQUARE ";X;Y;" OLD CONTENTS = ";A(X,Y)
120 INPUT"NEW CODE";A(X,Y)
130 NEXTY,X:GOTO37
140 INPUT"SQUARE CO-ORDS";X,Y
150 IFX(0ORX)RORY(0ORY)CTHENPRINT"INCORRECT,RE-ENTER!":GOTO140
160 PRINT"SQUARE ";X;Y;" OLD CONTENTS = ";A(X,Y)
170 INPUT"NEW CODE";A(X,Y):GOTO37
180 FORX=1TOR
190 FORY=1TOC
200 PRINTCHR$(A(X,Y));
210 NEXTY:PRINT:NEXTX
220 X=USR(X):GOTO37
230 FORX=1TOR
240 FORY=1TOC
250 PRINTX,Y;" =";A(X,Y)
260 FORZ=1TO10000:NEXTZ,Y,X:GOTO37
270 END
280 PRINT"THE GRID DIMENSIONS CAN BE AS LARGE AS YOUR"
285 PRINT"VDU.IF YOU USE LESS YOU MAY NUMBER THE SQUARES"
290 PRINT"BY INSERTING THE CODES FOR NUMBERS (OR LETTERS)"
295 PRINT"INTO THE n+1 SQUARES WHERE n IS ONE GRID"
300 PRINT"DIMENSION."
305 PRINT"'1' ENABLES YOU TO FILL UP THE GRID IN"
310 PRINT"NUMERICAL ORDER. '2' LETS YOU INPUT OR"
315 PRINT"CORRECT A PARTICULAR SQUARE. '3' DISPLAYS"
320 PRINT"THE PRESENT GRAPHICAL GRID CONTENTS. '4'"
325 PRINT"ENABLES YOU TO NOTE DOWN THE CODES FOR THE"
330 PRINT"PRESENT PICTURE. '5' RESETS THE GRID FOR"
340 PRINT"FRESH INPUT. '6' HALTS THE PROGRAM. '7'"
345 PRINT"ENABLES YOU TO KNOW WHAT GRAPHIC CODE"
350 PRINT"[X] IS, WHERE X IS A ASCII NO."
355 PRINT"PRESS ANY KEY TO START PROGRAM.":X=USR(X):GOTO10
```

PET Fighter Pilot

by E G Kemplen

Full instructions are in the listing.

```
100 REM***FIGHTER PILOT****
110 GOSUB740
120 PRINT"♪"
130 T=TI:SC=0:S=0
140 FORI=1TO25:POKE32788+40*I,66:NEXT
150 FORI=1TO40:POKE33287+I,64:POKE32768+I,160:NEXT
160 C=33308
170 POKEC,87
180 A=32868
190 B1=PEEK(A-2):B2=PEEK(A-1):B3=PEEK(A):B4=PEEK(A+1):B5=PEEK(A+2):B6=PEEK(A-40
)
200 REM ****CHECKS SCREEN****
210 POKEA-2,70:POKEA-1,70:POKEA,90:POKEA+1,70:POKEA+2,70:POKEA-40,93
220 REM ****PUTS IN ENEMY PLANE****
230 FORN=1TO50:NEXT
240 PRINT"※FUEL";30-INT((TI-T)/60)/10;" ";TAB(17)"SCORE";SC;TAB(30)"SHOTS";S
250 PRINT"※";TAB(11);"GALS"
260 GETX$:IFVAL(X$)<>0THEN410
270 REM****CHECKS AIM****
280 IFPEEK(516)=1THENB7=PEEK(C):POKEC,42:FORI=1TO10:NEXT:POKEC,B7:S=S+1
290 IFPEEK(516)=1ANDPEEK(C)<>87THENGOSUB520
300 IFS>249THENPRINT"OUT OF AMMUNITION RUN LIKE HELL FOR HOME":GOTO680
310 IF(TI-T)/60>300THENPRINT"YOU'RE OUT OF FUEL, BREAK OFF":GOTO680
320 REM****CHECKS FOR FIRE******
330 N=-41+INT(RND(1)*3)+INT(RND(1)*3)*40
340 REM****ENEMY AVOIDING ACTION****
```

```
350 POKEA-2,B1:POKEA-1,B2:POKEA,B3:POKEA+1,B4:POKEA+2,B5:POKEA-40,B6
360 A=A+N+AIM
370 IFA<32811THENA=A+80
380 IFA>33724THENA=A-80
390 REM*CALCULATES NEW ENEMY POSITION*
400 GOTO190
410 IFVAL(X$)=1THENAIM=-39
420 IFVAL(X$)=2THENAIM=-40
430 IFVAL(X$)=3THENAIM=-41
440 IFVAL(X$)=4THENAIM=1
450 IFVAL(X$)=5THENAIM=0
460 IFVAL(X$)=6THENAIM=-1
470 IFVAL(X$)=7THENAIM=41
480 IFVAL(X$)=8THENAIM=40
490 IFVAL(X$)=9THENAIM=39
500 GOTO290
510 REM**AIM CORRECTION***
520 IFPEEK(C)=70ORPEEK(C)=93THENII=2
530 IFPEEK(C)=90THENII=5
540 SC=SC+II
550 FORI=1TOII
560 POKEC-39,42:POKEC-41,42:POKEC+41,42:POKEC+39,42
570 IFSC>49THEN640
580 FORJ=1TO25:NEXT
590 POKEC-39,32:POKEC-41,32:POKEC+41,32:POKEC+39,32
600 FORJ=1TO10:NEXT
610 NEXT
620 RETURN
630 REM***HIT SUBROUTINE***
640 T1=INT((TI-T)/60)
650 PRINT"";TAB(17)"SCORE";SC
660 PRINT"ENEMY PLANE DESTROYED IN";T1;"SECONDS"
670 PRINT"USING";S;"ROUNDS OF AMMUNITION"
680 PRINT"TO PLAY AGAIN PRESS  SPACE 
690 PRINT"TO STOP PRESS  0 "
700 GETY$:IFY$="0"THENSTOP
710 IFY$=" "THEN120
720 GOTO700
730 REM***FINAL DISPLAY***
740 PRINT"";TAB(7)"
750 PRINTTAB(7)"
760 PRINTTAB(7)"
770 PRINT:PRINT
780 PRINTTAB(11)"
790 PRINTTAB(11)"
800 PRINTTAB(11)"
810 PRINT:PRINT
820 XX$="YOU ARE THE PILOT OF A SPITFIRE":GOSUB1110
830 XX$="AHEAD OF YOU IS AN M.E.109":GOSUB1110
840 XX$="HE IS TAKING AVOIDING ACTION, AND YOU":GOSUB1110
850 XX$="MUST TRY TO SHOOT HIM DOWN":GOSUB1110
860 XX$="YOUR GUNS ARE FIRED BY PRESSING THE":GOSUB1110
870 XX$="  SHIFT  KEY":GOSUB1110
880 PRINT:XX$="YOU CAN CHANGE YOUR AIM USING THE":GOSUB1110
890 XX$="NUMERIC KEYPAD AS FOLLOWS":GOSUB1110
900 PRINT:PRINT:XX$="  PRESS  SPACE  TO CONTINUE":GOSUB1110
910 GETY$:IFY$=" "THEN930
920 GOTO910
930 PRINT"":XX$="THE TOP ROW OF NUMBERS MAKE YOUR PLANE":GOSUB1110
940 XX$="CLIMB":GOSUB1110
950 XX$="THE BOTTOM ROW MAKE YOUR PLANE DIVE":GOSUB1110
960 XX$="THE LEFT ROW TURN YOU TO THE LEFT":GOSUB1110
970 XX$="THE RIGHT ROW TO THE RIGHT":GOSUB1110
980 XX$=" THE  5  KEY CENTRALISES YOUR CONTROLS":GOSUB1110
990 PRINT:XX$="7 8 9":GOSUB1110
1000 PRINT:XX$="4 5 6":GOSUB1110
1010 PRINT:XX$="1 2 3":GOSUB1110
1020 PRINT:XX$="YOU CANNOT ALTER COURSE WHILST FIRING":GOSUB1110
1030 XX$="YOUR GUNS":GOSUB1110
1040 PRINT:XX$="THE OBJECT OF THE GAME IS TO SCORE":GOSUB1110
1050 XX$="50 POINTS":GOSUB1110
1060 PRINT:XX$="A HIT ON THE WING OR TAIL SCORES 2":GOSUB1110
1070 XX$="A FUSELAGE HIT SCORES 5":GOSUB1110
1080 PRINT:XX$=" PRESS  SPACE  TO START THE GAME":GOSUB1110
1090 GETY$:IFY$=" "THENRETURN
1100 GOTO1090
1110 PRINTTAB((40-LEN(XX$))/2);XX$:RETURN
```

Apple plotting

by J J Clessa

Here's a relatively simple routine which enables you to plot a variety of mathematical functions using the Apple II.

The function should be input in polar form but don't worry if you don't know what that means — you'll soon get the hang of it by trial and error. Enter the function in line 200 and set the size control parameter A in line 10. Increase A to make the graph bigger or decrease A to make it smaller.

By experimenting with different functions and different values of A, you'll be able to create a variety of interesting curves. You might like to try these for starters:

R = A*(1—COS(T)) (A=50)
R = SQR(A*A*COS(2*T)) (A=100)
R = A (A=50)
R = A/T (A=150)
R = A*(1+2*COS(T)) (A=25)
R = A*SQR(TAN(2*T)) (A=50)
R = A*LOG(T) (A=20)

and for the romantic,

R = A*(COS(T—1.57) ∧ 9—2) (A=25)

while for something different try,

R = A*LOG(T/A)

(I've forgotten the A value for this last one so you'll have to experiment with it.)

The program calculates and plots the function of a range of T from 1^0 to 360^0. A FOR. . .NEXT loop isn't used because of the Apple's ONERR feature, which is necessary here for functions which produce negative square roots and the like.

I'd be pleased to hear of any interesting shapes you discover.

PROGRAMS

```
1  ONERR  GOTO 300
10 A = 25
100 X9 = 135:X1 =  - X9:Y9 = 75:Y1 =  - Y9
110 T1 = 1 / 3.1415926:T9 = 360 * T1:T0 = T1
120  HGR : HOME : HCOLOR= 3: VTAB (24): LIST 200
130  HPLOT X9,1 TO X9,2 * Y9: HPLOT 1,Y9 TO 2 * X9,Y9
190 T = T1
200 R = A *  LOG (T / A)
210 X =  INT (R *  COS (T)):Y =  INT (R *  SIN (T))
220  IF X < X1 THEN 270
230  IF X > X9 THEN 270
240  IF Y < Y1 THEN 270
250  IF Y > Y9 THEN 270
260  HPLOT X + X9,Y + Y9
270 T = T + T0
280  IF T <  = T9 THEN 200
290  STOP
300 E1 =  PEEK (222)
310 E2 =  PEEK (218) +  PEEK (219) * 256
320 T = T + T0
325  IF E1 <  > 53 THEN 340
330  RESUME
340  PRINT "ERROR CODE ";E1;" AT LINE ";E2
350  STOP
```

LEISURE LINES

by J J Clessa

Puzzle 11 must have been fairly easy — I received over 100 correct entries, although one or two people couldn't get it right. There was even a card from a regular Scottish reader, who normally sends abuse, saying that he needed eight months to solve the puzzle due to the slowness of both his computer and his algorithm. There was a particularly good entry from the MacSwapping family in Yorkshire — obviously the problem held some magnetic attraction for them. Anyway, the two required numbers are 4761 and 328509.

The winning entry, selected at random, was from C C Sharp of Leighton Buzzard. Congratulations, Mr (Mrs?) Sharp, 20 plugs are on their (eventual) way to you.

Quickie

As usual, no answers, no prizes for this: Jack's famous beanstalk doubled its height every day. After 21 days it was as high as the Town Hall; after how many days was it half the height of the Town Hall?

Prize puzzle

The other day, while trying to phone the PCW offices, I got a crossed line and found myself listening to the following conversation between two people whom I'll call A and B. But unfortunately the line was a bit crackly so I missed parts of what was said.

A: "I've just spent exactly £2 on a mixture of 12p, 14p and 17p stamps."
B: "How many of each did you buy?"
A: "I'll not tell you that but I will tell you that altogether there were (CRACKLE) stamps."
B: "In that case I'll work it out . . . wait a minute, I still can't tell how many of each you got. Did you buy only one of one kind?"
A: "(CRACKLE)"
B: "In that case you bought . . ."

At that point the line went dead. Unfortunately at the two key points, a crackle on the line prevented me from hearing the full conversation but I'm sure you'll all be able to tell me, without any more information, just how many stamps of each value were bought.

Answers on a postcard *please to Puzzle No 14, PCW, 14 Rathbone Place, London W1P 1DE, to arrive by 31 October.*

Prize of the month

Boring, I'm afraid, but from now on I'm giving away a book token each month.

BLUDNERS

Just as we were patting ourselves on the back for a comparatively Bludner-free August issue, the September PCW arrived. In case you hadn't noticed, the last pages of the two Benchtests were somehow transposed — page 53 belongs to the SuperPET review and page 87 is all about the BASF.

And we accidentally omitted a credit for the PET Demolition program — it was written by Peter Wright.

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Microcomputer
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Input/Output Ports: system is designed for 478 ports, with 30 ports implemented in standard unit. Including one RS-232C Serial Asynchronous Channel for a printer or modem.
50 pin bus: provides all addresses, data, clocks, etc., to allow the Compucolor II to be expanded with additional peripherals in the future.
CRT Terminal Commands: Page/Roll Mode, Erase Line, Erase Page, Tab; Two Character Sizes; Blink, Cursor Home, Left, Right, Up and Down; Cursor XY Addressing; Caps Lock; CPU Reset; Foreground/Background Color Selection; 15 Plot Modes; Blind Cursor Mode, Local, Full and Half Duplex Modes; Write Vertical Mode, and Transmit Cursor and Page Modes.
Language: DISK BASIC 8001 interpreter in ROM memory includes: 29 statement types: CLEAR, DATA, DEF, DIM, END, FILE, FOR, GET, GOSUB, GOTO, IF, INPUT, LOAD, NEXT, ON, OUT, PLOT, POKE, PRINT, PUT, READ, REM, RESTORE, RETURN, SAVE, STEP, THEN, TO and WAIT. 3 command types: CONT, LIST and RUN. 19 mathematical functions: ABS(x), ATN(x), CALL(x), COS(x), EXP(x), FN(x)(y), FRE(x), INT(x), INP(x), LOG(x), PEEK(x), POS(x), RND(x), SGN(x), SIN(x), SPC(x), SQR(x), TAB(x), and TAN(x). 9 string functions: ASC(x$), CHR$(x), FRE(x$), LEFT$(x$,I), LEN(x$), MID$(x$,I,J), RIGHT$(x$,I), STR$(x) and VAL(x$). 12 Disk File commands: COPY, DELETE, DEVICE, DIRECTORY, DUPLICATE, INITIALIZE, LOAD, READ, RENAME, RUN, SAVE, and WRITE.

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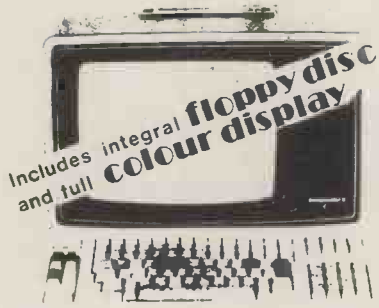
COMPUCOLOR II



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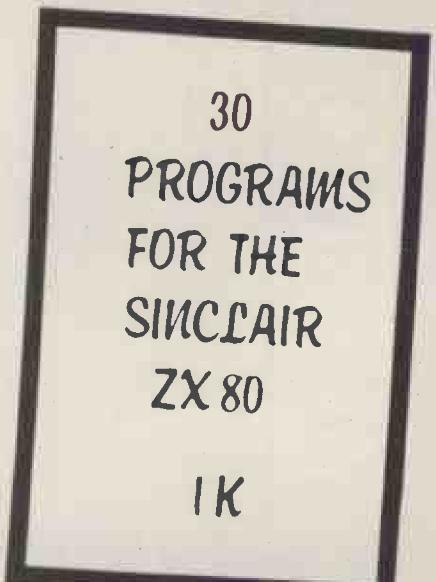

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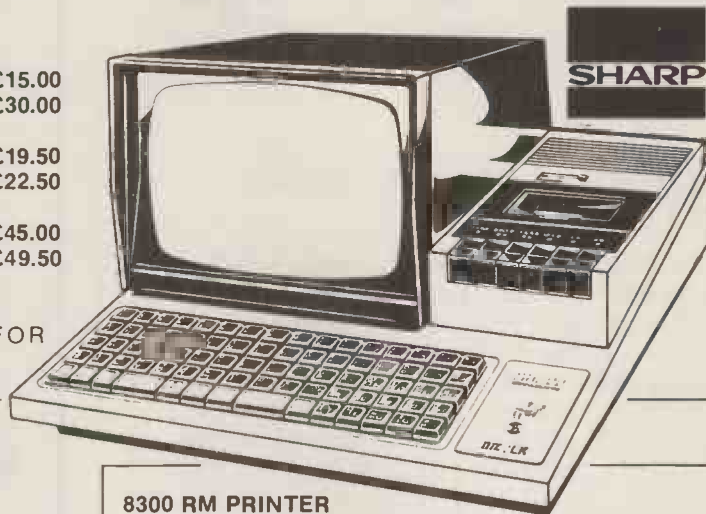

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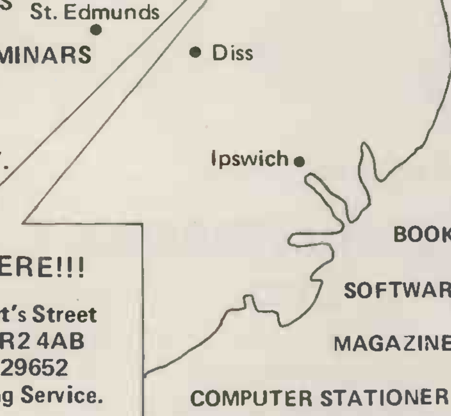

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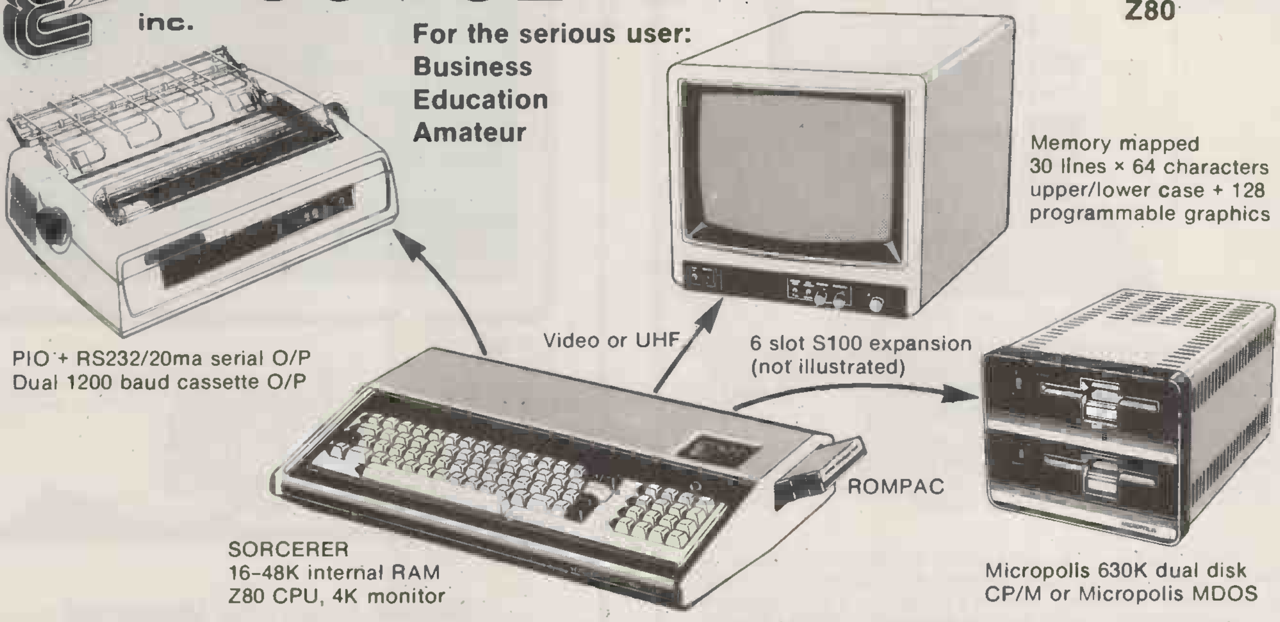

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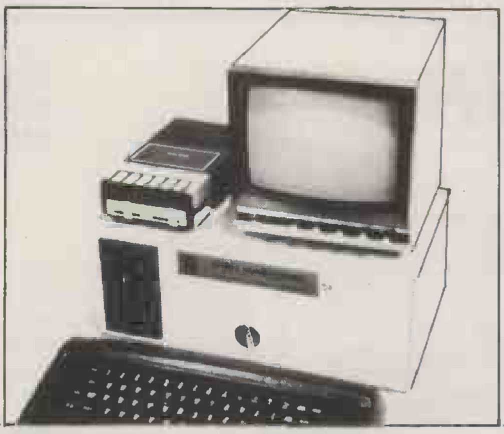

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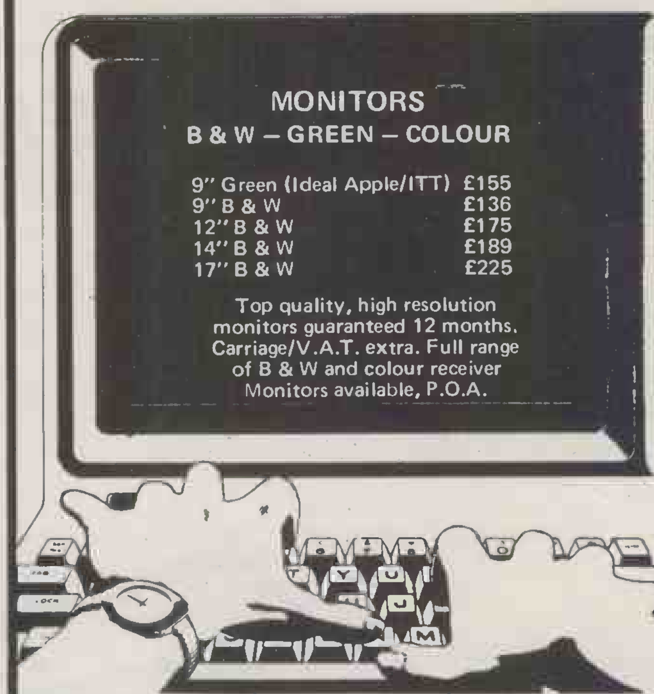

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SOFTWARE: Microsoft-90 in ROM or cassette. or CP/M disc operating system which will support four 8" drives.
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16K kit £149: W&T £169: 32K kit £218: W&T £238: 48K kit £287: W&T £307: 64K Kit £346 W&T £376: 16K expansion kits £69.
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74LS12	30p	74LS75	39p	74LS164	90p	74LS373	170p
74LS14	60p	74LS86	39p	74LS168	190p	74LS374	170p
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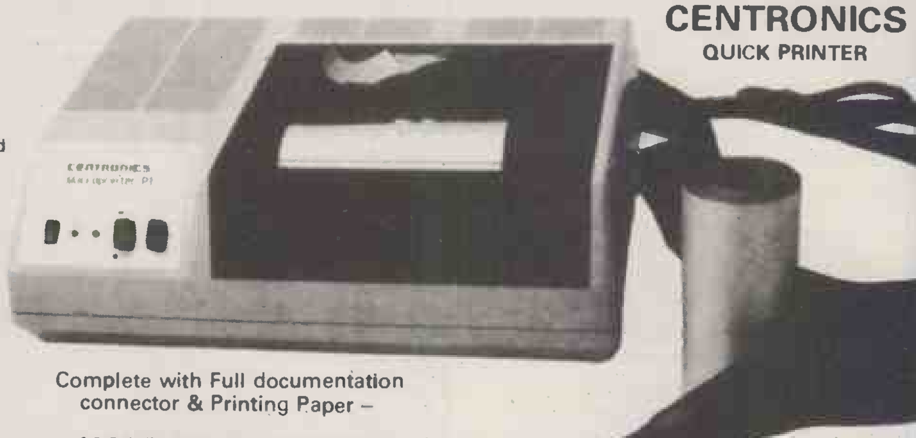

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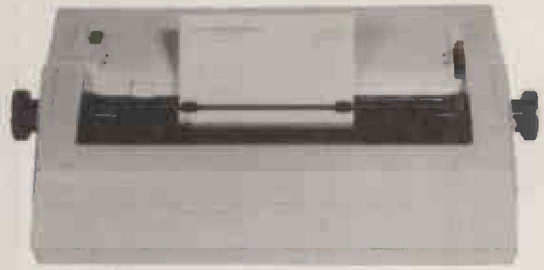

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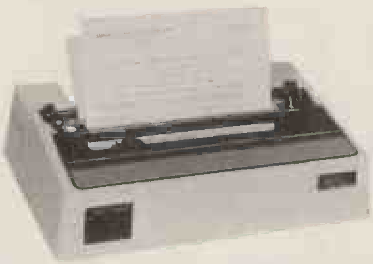

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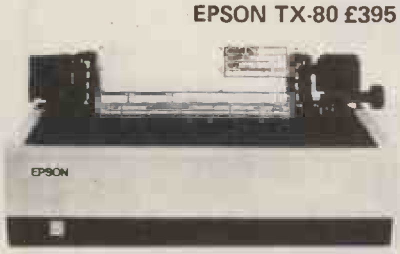

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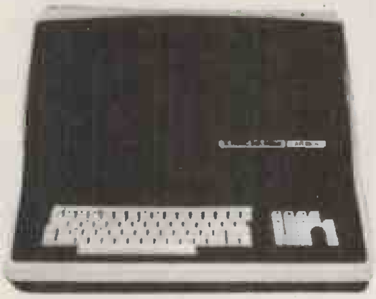

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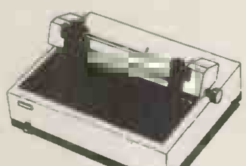

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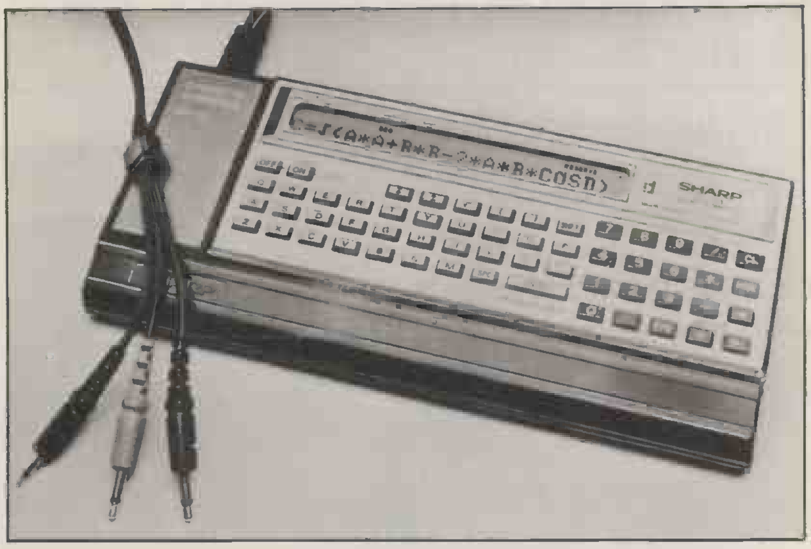

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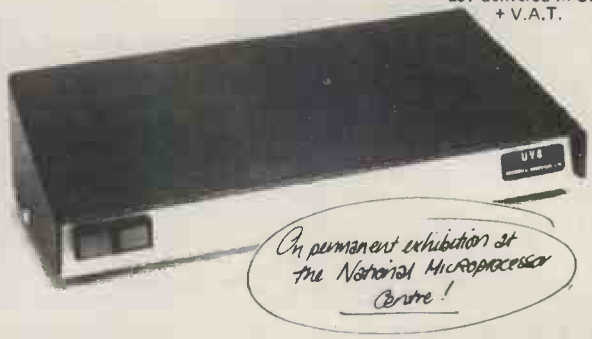

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Happy computing,
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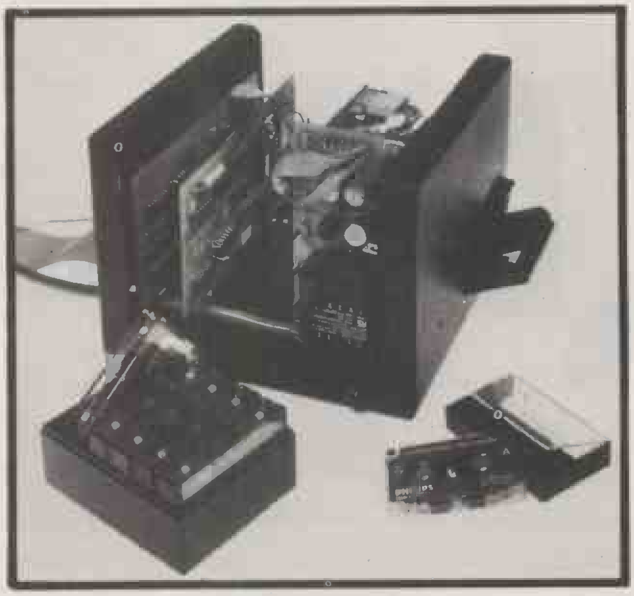

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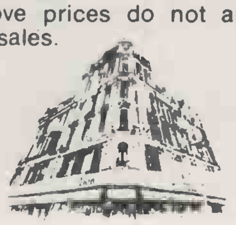

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CHIP CHAT

A rivalry is now developing in London between Tottenham Court Road — location of Byte Shop, Lion House and others — and the Edgware Road to see which will become Britain's Silicon Strip. The position of the latter has been 'improved' by a recent extension of Chris 'Spangles' Cary's empire — yes, Comp Shop of Barnet, Dublin and Santa Ana (California) has opened a new outlet at 311 Edgware Road . . . Now that we Brits are allowed to buy shares in foreign companies, who'll be the first to head the rush on this side of the Pond for Apple shares? Yes, Big A is going public and US investment analysts are waxing ultra-lyrical about the company's prospects on Wall Street. It seems that founders Steve Wozniak and Steve Jobs didn't originally plan a share-out but a federal securities regulation virtually compels any company with more than 500 shareholders and $1,000,000 in assets to go public. That Apple has those assets is no big surprise but all those shareholders? They're the result of an employee incentive scheme . . . Coming soon, another new British machine, whose backers say their avowed aim is to underprice the Transam Tuscan and promise a Z80-based, CP/M twin disk set-up with 64k RAM; as yet a name has not been devised but it won't, apparently, be called Nascom 3. . . And delayed, the eagerly-awaited British launch of the Maleca IV. It seems the Brazilian backers suddenly heard about 16-bit processors and insisted on a re-design, despite the IV's outstanding spec, so we'll have to wait until next spring for the new Maleca V. . . That's about the time the Apple III will now appear, according to informed rumour. As yet we've not found out why the delay but it surely couldn't be connected with Apple going public — could it?. . . Rumours abound of secret organisations, called Apple Rings, wherein certain dealers get together to import Apples directly from the States, circumventing the Eurapple/Microsense set-up. Microsense has recently taken to issuing press releases warning all of the danger of buying from these 'rogues' who undercut their prices. . . Adda has confused the world by snaking its way to new premises, from The Broadway, Ealing, to Broadway, West Ealing. . . Watch out for Personal Computers PPS software which adds software between the graphics tablet and the screen — makes plotting a joy and lets you key in text as well. . . 'Squire' Allason, ever keen to appear in these columns, just sent the Editor a green eyeshade. A pity the Editor hasn't got green eyes. . . Last month we promised news of a jolly to California and this month it's a reality — see page 55 if you haven't done so already for details of a trip to the 6th West Coast Computer Faire as part of a luxury holiday . . . As is normal in the run-up to our own show, we began to receive enquiries about the Show from members of the public. Among those interested in the PCW Show were others, also asking about the Show but sounding utterly confused when we told them it was at the Cunard Hotel, etc etc. Turned out that these were enquiring about the first London Computer Fair, organised by Robin 'Bogey' Bradbeer. These poor souls had telephoned the North London Polytechnic (where 'Bogey' works) for further information and had met with the telephonic equivalent of a very blank look. . . When the Fair did eventually take place, a highlight was the sound of Bogey himself advertising his new book (reviewed in this month's 'Bookfare') over the PA and announcing that he would be on his own stand in person to autograph copies. The announcement sent a tumult of apathy sweeping across the show. . .
As this column was written just before the PCW Show, gossip arising from that event will have to wait until next month. 'Bumper' Harris was, however, threatening to cause an uproar by streaking through the Chess Championship. . . Finally, congratulations to our lovely Art Editor, Julia, who finally got her man to the altar. Our sincere condolences to the bridgroom.

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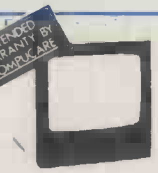

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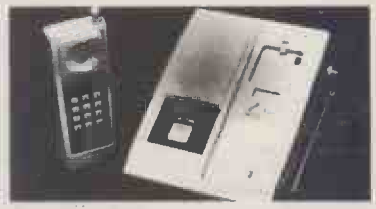

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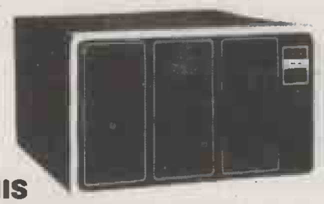

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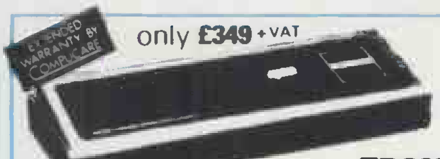

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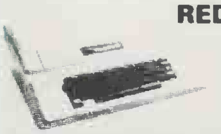

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