computing today

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DEC 1979
50p

HUBBLE BUBBLE TOIL AND... AIM 65?

PET Impressions

Life For Nascom

MMGU To Build

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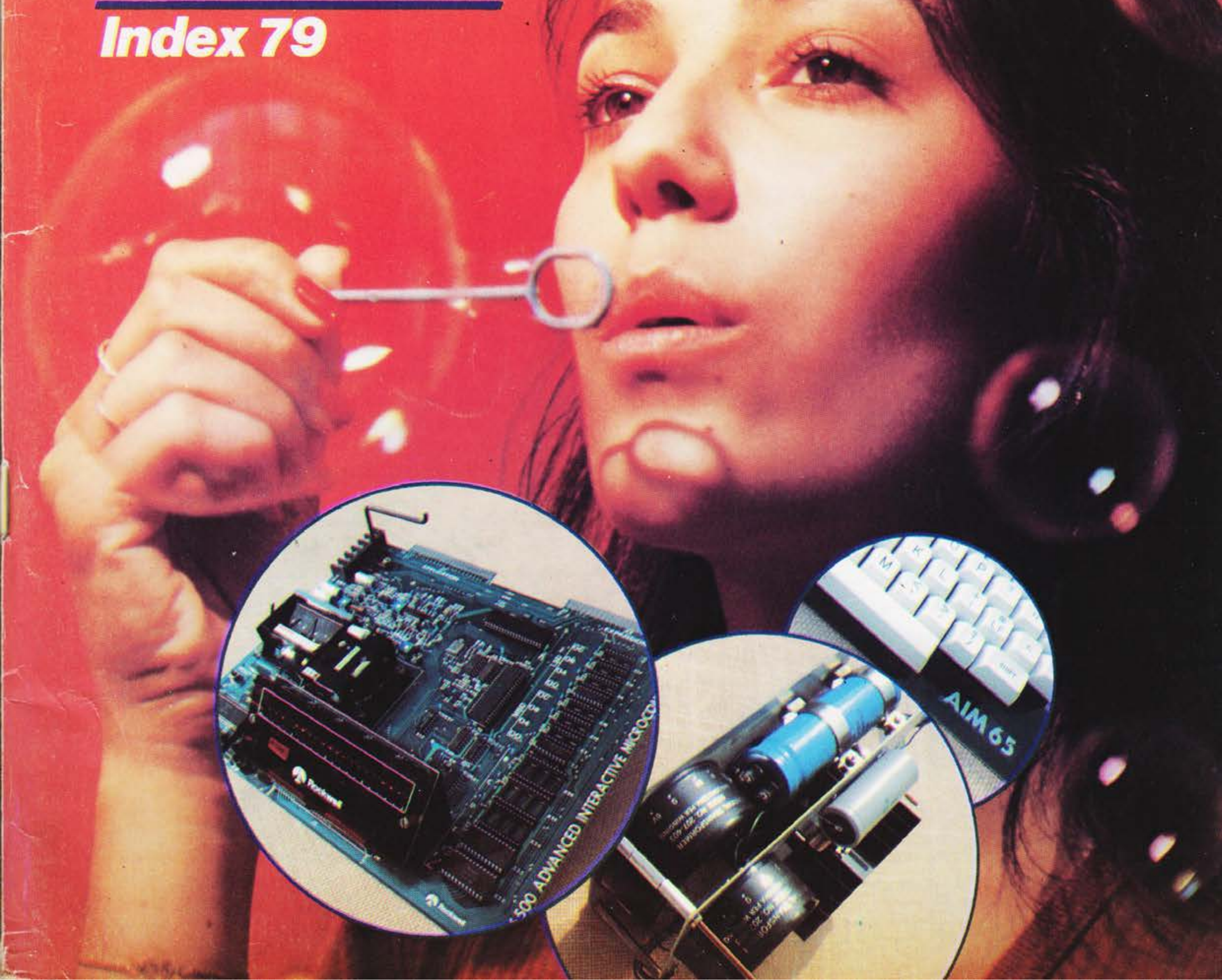

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PSI Comp 80.Z80 Based powerful scientific computer
Design as published in Wireless World April — September 1979

The kit for this outstandingly practical design by John Adams being published in a series of articles in Wireless World really is complete!

Included in the PSI COMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board, 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer, 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.

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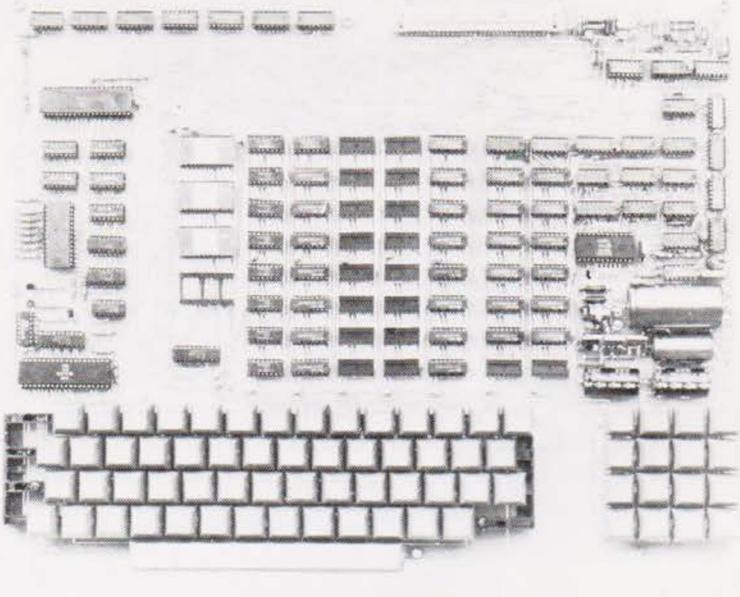
Floppy Disk, PROM programmer and printer interface coming shortly!



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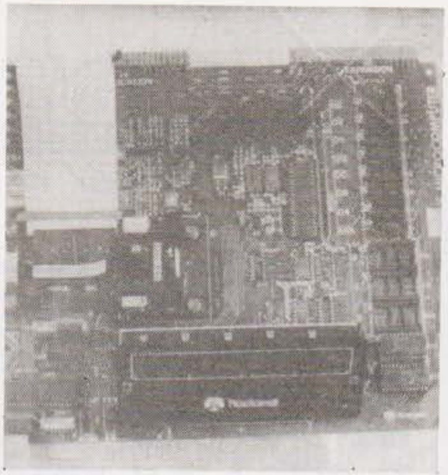
VOL 1 No. 10
DEC 1979



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interface

NASCOM's NEW BIG DISTRIBUTOR

NASCOM-2 + FREE 16K RAM

Here's an offer you can't refuse:
Because of the lack of availability of MK 4118 RAMs, Nascom Microcomputers is supplying its Nascom 2 without the 8 spare 4118s but with a FREE 16K dynamic RAM board.

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The Nascom 2 kit is supplied complete with construction article and extensive software manual for the monitor and BASIC.

No more slaving over a hot soldering iron – the Nascom 1 is now supplied BUILT!
Britain's biggest small system is available fully constructed for you to slot into your own housing for the ridiculously low price of £175 plus VAT (kit price still only £165 plus VAT).

nascom-1

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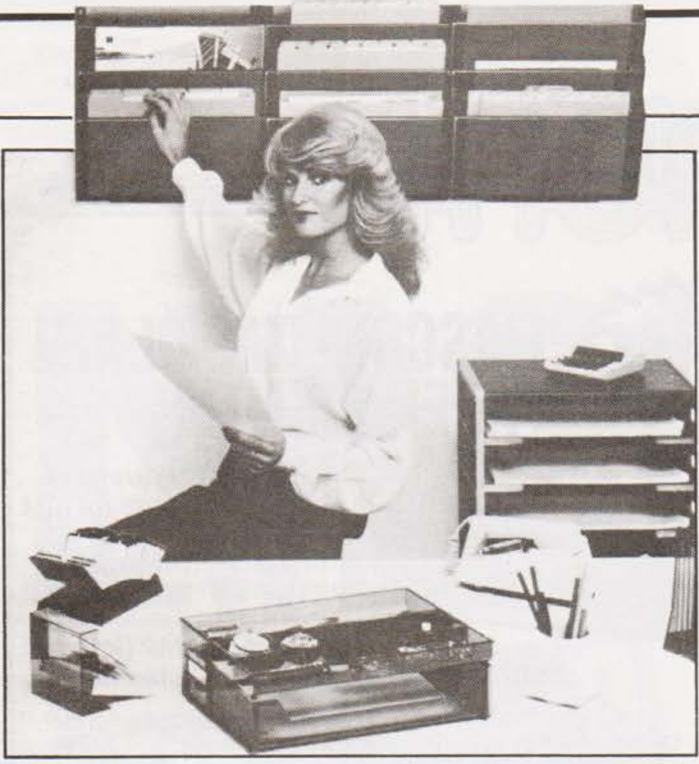
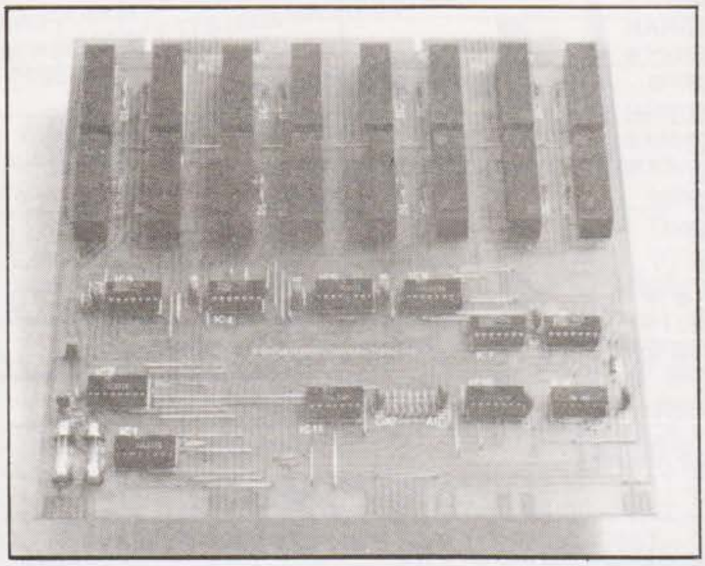


HANG IT ON THE WALL

Ideal for the home study, workshop or computer room is a new product from Eldon. Called the Super Hot File (?) it's a wall mounting filing system that will hold anything from computer printout to your latest copy of CT with consummate ease. You start with a basic filing pocket and three add-on pockets and expand to your hearts content, limited naturally by the size and strength of your wall. Each pocket measures a generous 400 by 229 by 38 mickey mice and is hung up with either sticky pads (dodgy) or screws and plugs (much better). A full colour leaflet extolling the virtues on Eldon's range of office requisites can be obtained by dropping a line to Eldon Office Products (Europe), Unit 3, Clifton Road, Shefford, Bedfordshire MK43 8AS. I wish I could remember her name . . . .

PAT ON THE BACK TIME

Back in August we announced that Microdigital were producing a series of utility boards for the Nascom. Well the first of that range has just been announced and will be available in mid-October. Priced at £49.95 the board holds 16 reed relays with 200 mA, 50 V (DC) capability, is ss glass fibre with gold plated edge connectors and can be hung on the Nasbus direct. Power required is a meagre 250 mA from both the +5 and +12 volt rails. All the IC's are socketed and the device is addressable to any two consecutive ports by links, hence you can use several on one system. Envisaged for use in control situations such as industrial processes, model railways, robots etc., the unit is supplied with sample software. Microdigital live at 25 Brunswick Street, Liverpool L2 0BJ.



FORTHING AT THE MOUTH
Julian Allason of Petsoft reports:

During a recent visit to California, I paid a visit to Programma Inc., one of the largest American micro software houses. I found them hard at work on a micro-version of the FORTH language. Programma Inc., are a new company who in just six months have elbowed their way to the front of the micro software scrum. What had brought me 6,000 miles from Berkshire was a rumour that someone had developed a version of the FORTH language for micros.

FORTH started as a relatively obscure language for minis, developed at the U.S. National Radio Astronomy Laboratory. Yet in the short while since Charles H. Moore had first described his new baby in the Journal of Astronomy and Astrophysics, it has achieved almost cult status. Its main features are speed and its characteristics as a user-defined language. And that was about the limit of my knowledge! After vigorous handshaking, I was led down several flights of stairs into a brightly lit office in the bowels of their building. There, surrounded by microcomputers of every description, I received an introduction to Micro-FORTH from the man who developed it.

"FORTH is a unique threaded language ideally suited to micro computers", explained Mel Norrell. Programs written in 6502 FORTH are very compact; in 10K bytes the user might have the interactive FORTH compiler/interpreter running stand-alone using the system's monitor for I/O, and other runtime routines, plus an incremental assembler, cassette memory software and a text editor. "All of this in 10K?", I asked. "Yes – and about 80% of it would be written in FORTH" replied Mel. It would also run in the same space with no additional symbol table area, overlays, swapping or use of any other software.

Typically, software development time is halved, in comparison with assembly language work. All programming is done in a structured manner – there is no GOTO for example – and the resulting code is re-entrant and can be designed for PROM.

',That is all very well", I said, struggling to keep myself afloat as the author, clearly a graduate of the IBM Academy of Systems Design, plunged deeper into conceptual territory. "But how do you actually use it?".

The basic element of the FORTH system is a "word" which would be roughly equivalent to a subroutine in BASIC. When referenced, the word causes a specified action or sequence of actions to be performed. Before a word can be executed and the particular subroutine called, the word itself must be defined and stored in the 'Dictionary'. The 6502 FORTH Dictionary initially contains some 200 words, which make up the standard vocabulary. The beauty of the system is that the user can effectively create his own language by using some of the standard words to define new ones. These can then be saved, so that the user has his own unique language on hand for instant use. Any sequence of characters can be used to define one of the new words with the exception of reserved words which have special meaning for the machine code environment being used. Each word must be separated from another by a space or blank. Control is passed to the system for execution when 'Carriage Return' is pressed. For example:

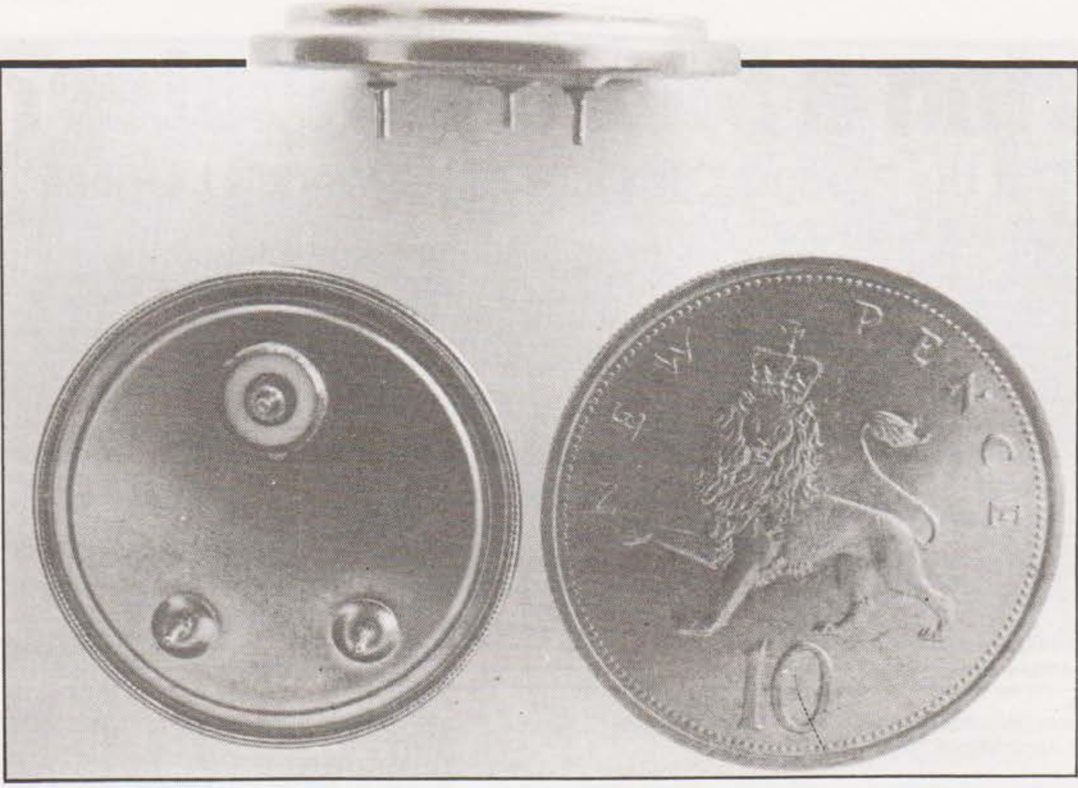
```
7 3 + . CR
```

will add the numbers 7 and 3 together, printing a 10 if the system has been set to decimal or A if it is in hexadecimal mode.

Reverse Polish Notation and Last-in First-out stacks are used. In the example above, the number 7 was pushed into the stack, followed by the number 3. Both numbers were added and "popped" off the stack by the previously defined word "+". The result, 10, is "pushed" onto the stack by the "+" operation also. The word "." then "pops" the stack to its initial condition and prints the number 10 on the screen or printer. To conserve memory, only the first four characters are stored. If a word typed into the input stream cannot be located in the dictionary, the system attempts to treat it as a number, and convert it to binary. If the word does not match the proper format and base, an error message is generated.

Some of this may sound a little strange, particularly to those whose experience is limited to high level languages such as BASIC. However, I did talk to a couple of people who had purchased 6502-FORTH, and both were delighted. So it seems that once you have got used to using the standard vocabulary, Micro-FORTH can be used for some very creative computing indeed. As for me, well, I am working on it.

NEWS



RAM SAVER

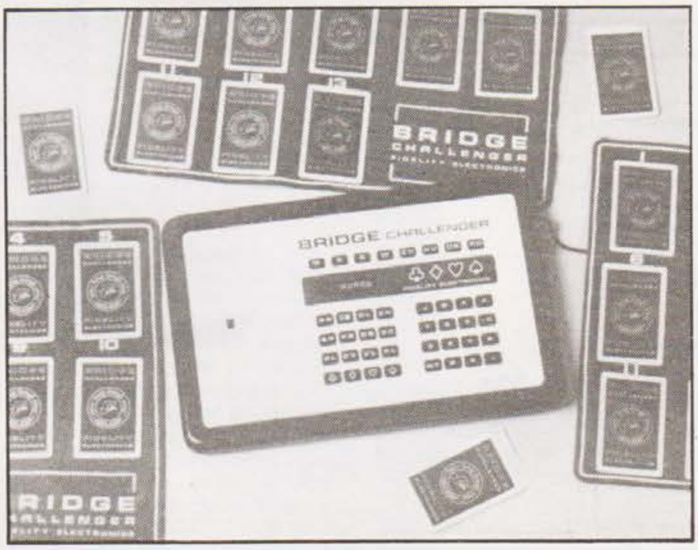
If you have that burning desire to protect your memories in the event of the Electricity people forgetting to put the kettle on you will be interested to learn of these new batteries. Made out of Lithium Iodine they are very tiny, as you can see, and offer a very high reliability as well as PC mounting. They will last for at least ten years and you can do all sorts of nasty things to them without upsetting their delicate little bodies. You have a choice of two sizes, both 2V8 460 mA hours and 870 mA hours to suit your application. For further details on these little wonders contact Mine Safety Appliances Co Ltd., Blairtummock Road, Queenslie Industrial Estate, Glasgow G33 4BT or ring them on 041-774 5111.

BRITISH IS BEST, PT 2

If you want to win a rather substantial sum of money, and who doesn't, you could have a bash at entering your micro-based doobry or whatsit in the British Microprocessor Competition. Sponsored by both the NCC and the NRDC it is open to UK residents or registered organisations and companies who wish to submit their microprocessor based invention, which must not be in full scale production. The prizes are in two categories, the working model section with a £10,000 first prize and the non-working model section with a first prize of £2000. As well as the actual loot the NRDC will consider investing up to £500,000 in any of the winning entries. Entries must be submitted by the 14th of December on the official entry form which is available from The British Microprocessor Competition, c/o The National Computing Center Limited, Oxford Road, Manchester M1 7ED.

BRIDGING THE GAP

Bored with beating your neighbours each week at the Bridge Night? Well you can now tackle a little box instead. It allows up to three players to play either with or against itself, or it will play all four hands in demonstration mode, cunning huh? It uses the International points system and caters for European, American and ACOL bidding systems with its two micro's. It arrives in a hardwood box with an alphanumeric keypad and large display, gracing any coffee table, and uses an optical scanning method to look at the special cards and keep the players up to date on the state of play. You can even set it problems to solve. The cost is rather high, £299.95 so you may have to win quite a few rubbers to afford one. The game can be seen at Harrods, where else, and more gen is obtainable from Computer Games Ltd at 48 Cambridge Road, Barking, Essex.



BEGGING YOUR PARDON

Some slight omissions from a November issue. We apologise profusely to both Malcolm Bell who wrote the Number Cruncher project and also to Iolo Davidson who contributed the Triton Typecast article. Owing to oversight, glasses have been issued, their names got left off. Credit should also have been given to the 20th Century Fox people for kindly letting us use photos from Alien for our review, and also to Heals for the loan of the bed for our October cover. All offenders are wearing sackcloth and ashes.

MORE HARD NEWS

Memorex have jumped into the hard disk market with an 8" unit for the small system. The new model 101 uses Winchester technology and holds 11.7 Mb on two platters. By using a direct drive technique such problems as belt and bearing wear have been eliminated, reducing part count and increasing reliability. Price for the unit in quantity is around $1,560 and shipments will start in early 80. For technical detail contact Memorex UK at Staines, Middlesex.

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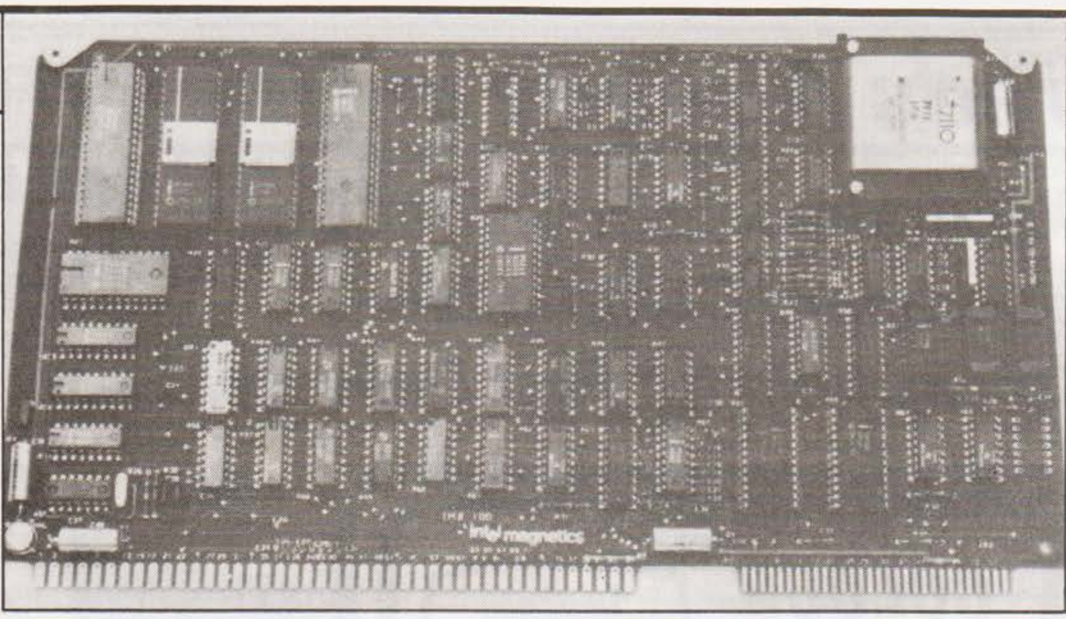


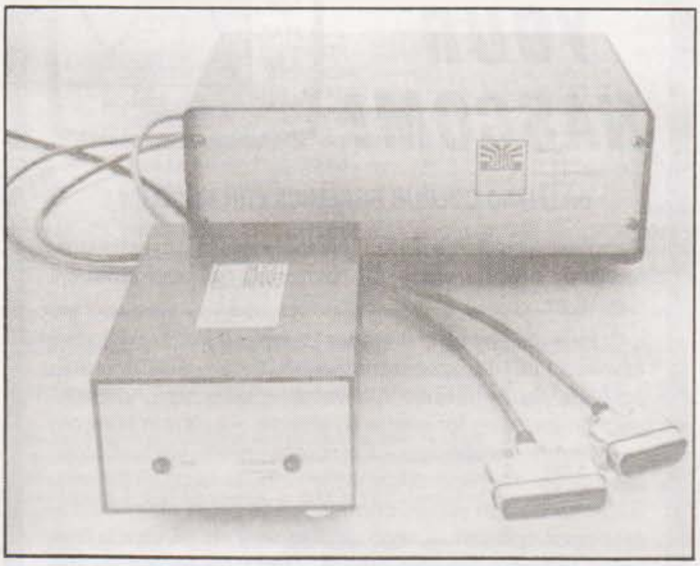
NEWS

BUBBLING FURIOUSLY

Following on from our cover this month comes more news on bubble memory systems. Intel have just produced a 1Mb board for use with their Intellec development systems or any other which uses the Multibus. The board is controlled by an 8085A which is built in and handles all the I/O routines. Along with the board you get a set of test routines on floppy to check out the system. Power requirements for the product are + and −12 and +5 volts. Further data is available from Intel at 4 Between Towns Road, Cowley, Oxford OX4 3NB.

INTERFACE PROGRAMMABLY

Small Systems Engineering, the electronic associate of Abacus Computers have just announced their latest offering for the micro world. Designed to link any IEEE-488 protocol device to the parallel or serial peripheral you wish to use it incorporates a Picoprocessor, programmed to handle the interface requirements. Costing around £120 it should offer an alternative method to those laborious hours with that soldering iron. Also on the way soon will be a version of their Stunt Box with an 8K BASIC included, making it into a programmable interface within a single board computer. Contact Small Systems at 62 New Cavendish Street, London W1M 7LD.



BRITISH IS BEST

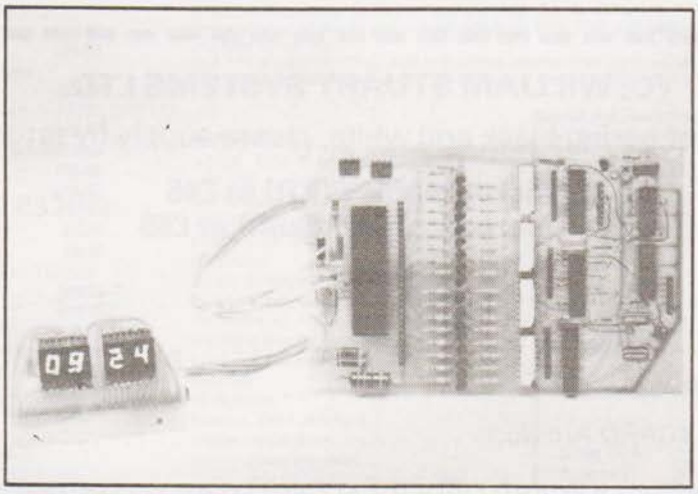
A copy of the E78 Microcomputer Bus Specification floated gently onto my desk this week. Gently is not quite the right word for this is a very 'heavy' document. Born out of a desire to produce a true standard Bus it has been considerably tidied-up from the first attempt a year ago and is now the definitive work as far as the homebrew enthusiast goes. Whether our computer industry will accept it is another matter, remember BS4421?. However there is an E78 to Nascom interface under development so perhaps someone will take it up and end the saga of the S100 et al. To obtain a copy of this reference work send £2.50 to The Microcomputer Bus Standards Committee, Avante House 9 Bridge Street, Pinner, Middlesex HA5 3HR if you are in the UK or £3.05, £3.15, £3.25 for airmail zones A, B and C respectively. Remember, if the hobbyist accepts it the manufacturers will hopefully follow suit.

CLOCK THIS ONE

How often have you forgotten the time whilst bashing away at your computer keyboard? Quite often I bet. Well your troubles with your loved one over all those missed dates, late nights/early mornings and being locked in at work could be over. Autosystems Development of Crosland Hall, Netherton, Huddersfield have released a clock-calendar module to slap onto your micro, saving you all the trouble and worry of writing a program to give you a nudge at bedtime. The module has LED displays for direct visual access as well as giving two digit serial BCD output via a tri-state buffer, selective output by code input and is available in either 12 or 24 hour versions. The calendar is programmed for four year cycles and the unit runs off the mains timebase although a crystal alternative will shortly be available. Imagine, at the top of every listing you have the time and date, never get mixed up again with yesterdays version of your Womp Rat Shoot ..... For more info write to the above address or give them a bell on 0484-665111.

SIXTEEN FOR S100

Now available from U Microcomputers of PO Box 24, Northwich, Cheshire is a sixteen bit processor card for the S100 bus. Based on the 8086 CPU it is fully compatible with the proposed IEEE standard, can address up to a Megabyte and is capable of running at up to 8MHz. It can be used with your existing eight bit memory and peripherals, saving a fortune in new hardware, and has a support card which includes a 2K monitor, disk bootstrap, selectable baud rate and other necessary bits and pieces. A Microsoft BASIC will soon be available as well as CP/M. For more detail contact U Microcomputers at the above address.



COLOUR COMES TO SUPERBOARD

The colour graphics system from William Stuart Systems is now available for your Superboard. Using Pixcel graphics, made up of individual addressable dots, it is capable of eight colours for foreground and background. Text can be interleaved with graphics to annotate graphs etc., in any of the available colours. Supplied as a kit complete with software routines it interfaces directly to a colour TV without affecting your normal video output. Access to the system is directly through BASIC using a CALLPOINT/LINE command and problems with the 50/60 Hz timebase are overcome with a simple mod. For more details contact William Stuart Microsystems at Dower House, Herongate, Brentwood, Essex.

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Why not call and see the fantastic Apple II the finest micro currently available. Demonstration without obligation.

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ARTIFICIAL INTELLIGENCE

A personal account of an endeavour to construct a machine with intelligent capabilities

The project which follows originated some years ago as the result of a determination to build a true 'electronic brain', as computers were referred to in the Press at that time, but it was held in abeyance until recently due to cost. The project was to have been a parallel processing special purpose machine with all hard wired logic. However, on recently reconsidering some of the criteria it was concluded that the use of microprocessors and their associated hardware would result in a machine that would require a smaller initial outlay and be far more open-ended.

The Theory Of Simulation

The central nervous system of any animal, from worm to man, consists of a network of special cells with some of the cells connecting to receptors (input) or effectors (output).

For the purposes of the exercise let us consider one of these cells as being a 'Black Box' of unknown function with a number of inputs and a single output. If we further assume that this cell functions in a binary manner, we can then apply Boolean algebra to its function. For a Black Box of N inputs the total number of functions possible is $2^*(2^n)$ which in the case of a single input cell are as shown in Table 1. (See Table 2 for those for a two-input cell.)

Table 1

I/P	f0	f1	f2	f3
0	0	1	0	1
1	0	0	1	1
A	0	$\overline{A}$	A	1

Similarly all the possible functions for three and four input cells could be defined. If the simulation is programmed on the basis of one routine per function the processing becomes inordinately slow and complex. Fortunately this can be simplified thus, for a two-input cell, any function can be generated from the terms AB, $A\overline{B}$, $\overline{A}B$ and $\overline{A}\overline{B}$ (maxterms)[1] by selectively ORing them together.

ie. $A = A B + A \overline{B}$

$A + B = A B + A \overline{B} + \overline{A} B$

So we now need to selectively generate these maxterms and the function of a cell can be written

$$F_1 = S_0 A + S_1 \overline{A}.$$

$$F_2 = S_0 A B + S_1 A \overline{B} + S_2 \overline{A} B + S_3 \overline{A} \overline{B}.$$

$$F_3 = S_0 A B C + S_1 A B \overline{C} + S_2 A \overline{B} C + S_3 A \overline{B} \overline{C} +$$

$$S_4 \overline{A} B C + S_5 \overline{A} B \overline{C} + S_6 \overline{A} \overline{B} C + S_7 \overline{A} \overline{B} \overline{C}.$$

Where S_n is the function selector.

Similarly for the sixteen terms required to define the function of a cour-input cell.

Cell Networks

We now have a network of cells all linked together somehow but we also require it to have some connection to its environment. If we consider Tables 1 and 2 we see that there are in each two apparently trivial conditions where the output is unrelated to input and is always zero or one respectively. These are extremely important for two reasons:

1, In an evenly distributed randomly connected cell population these would block the logic chains preventing them becoming too large.

2, As a result of their being at the end of the chains we shall use them as the output cells of the network. Needless to say we shall have to modify their function if there is to be a meaningful output.

As the outputs of these cells are now connected elsewhere we shall use any input, which would have connected to them as an external input.

We can now economically define the functions of the cells and how the network connects to its external environment.

Table 2

I/P 1 (A)	0	0	1	1	
I/P 2 (B)	0	1	0	1	
f0	0	0	0	0	0
f1	0	0	0	1	A.B
f2	0	0	1	0	$A.\overline{B}$
f3	0	0	1	1	A
f4	0	1	0	0	$\overline{A}.B$
f5	0	1	0	1	B
f6	0	1	1	0	$A \oplus B$
f7	0	1	1	1	A+B
f8	1	0	0	0	$\overline{A}.\overline{B}$
f9	1	0	0	1	$\overline{A \oplus B}$
f10	1	0	1	0	$\overline{B}$
f11	1	0	1	1	$\overline{A}.B$
f12	1	1	0	0	$\overline{A}$
f13	1	1	0	1	$\overline{\overline{A}.\overline{B}}$
f14	1	1	1	0	$\overline{A}+\overline{B}$
f15	1	1	1	1	1

Let us now consider the effect of using serial as against parallel processing:

Parallel Processing Is Faster!

So it may be, but consider. A well trained human reaction time is 1/10 second, – watch fencing to see how fast that is! An MPU with 2MHz clock runs through 100,000 cycles in that time. Let us assume that to process each cell, on average, requires 20 instructions taking 10 cycles each. That gives us 500 cells processed in 1/10 second, – a worm with fast reactions?

A micro does process in parallel; 8 bits at a time, although the same processing is applied to all of them. Our worm is therefore somewhat brighter and handling 2000 bits of (internal) information in a very reasonable time.

Using bytes also confers upon the "Intelligence" the ability to have a grey or shaded perception. It is suggested that, if bits are used as a switch type input, no byte contains data from unrelated sources.

Construction And Expansion

Personal computers are now easy to come by ready built or as kits, whereas a parallel machine would have to be hand built. A parallel machine would need to be rewired, whereas an MPU just requires more store with program changes to cater for it.

The hard storage of training data is far easier with a micro enabling the machine to be switched off without the need to retrain from scratch. This also enables the training to be passed more readily between machines.

The project is envisaged as developing through the following, possibly overlapping, phases.

Phase One

This is the minimum system requiring 2½K of store, plus whatever is required for the programs, and uses only two-input cells. The programs should preferably be written in Assembler as this would execute faster than Basic, etc.

The following programs are required and should need little amendment for larger systems.

1. A program to clear the storage mentioned above prior to the first run on any run where the size of this store is increased. If your monitor has a store checking routine which leaves the store as '0' this would be suitable.

2. PROCESSOR. This program reads in the tape containing the 'operand' and 'function' areas, defined below, from the previous run and then proceeds to simulate the function of the cells. There is some data needed by the 'Tutor' which is also required for each run, but as this is only four bytes it is easier entered manually. The program requires the following work areas in store.

a. Input and Output areas. Two areas in store for communication with the outside world, the size of which is determined by the number of cells whose output is always 0 or 1. In the case of two-input cells with a random distribution of function this is 1/8 of the total number of cells, here 32 bytes each.

The logic applied to determine what is moved between the I/O areas and the 'operand' areas is as follows:

I. The relative addresses of the I/O bytes within their respective areas is 1/8 of the output 'operand' relative address. This is a maximum, the program may or may not use all of it.

II. The 'input' byte is moved to the byte pointed to by the output 'operand' address.

III. The exclusive – OR of the input 'operands' is moved to the 'output' byte. The exclusive –OR is arbitrary; any other function would do as well.

b. Operand area. This area stores the output of the cells so that other cells may access them for use as input. In this case:–

$$32 \times 8 = 256 \text{ bytes} \equiv 256 \text{ cells}$$

are required.

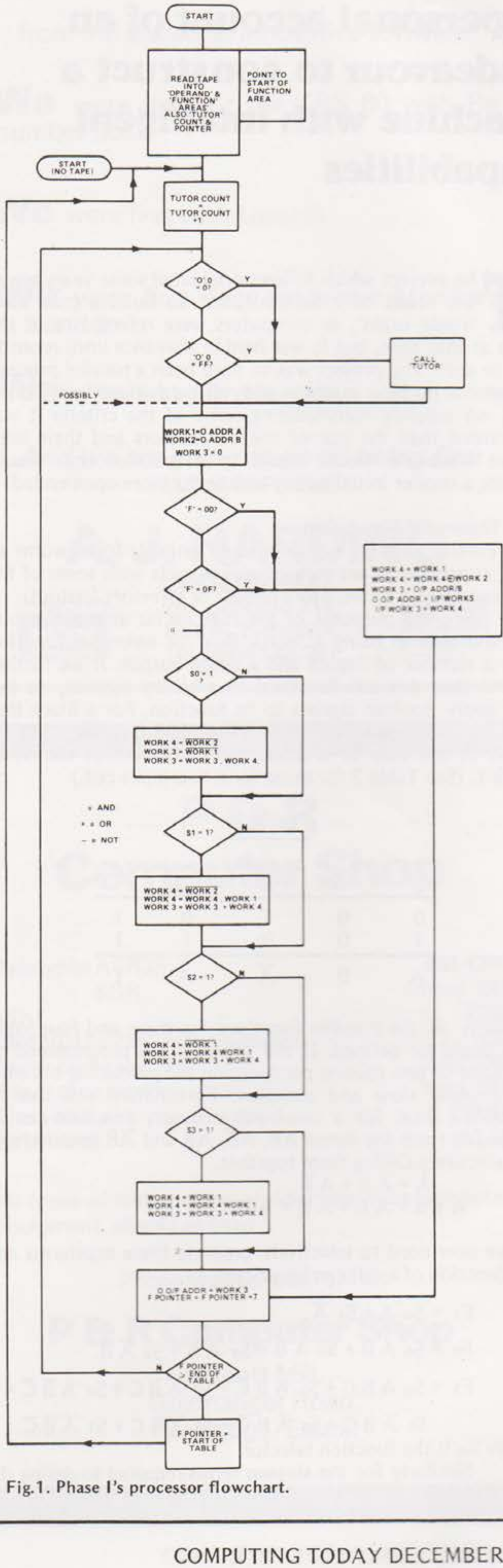

Fig.1. Phase I's processor flowchart.

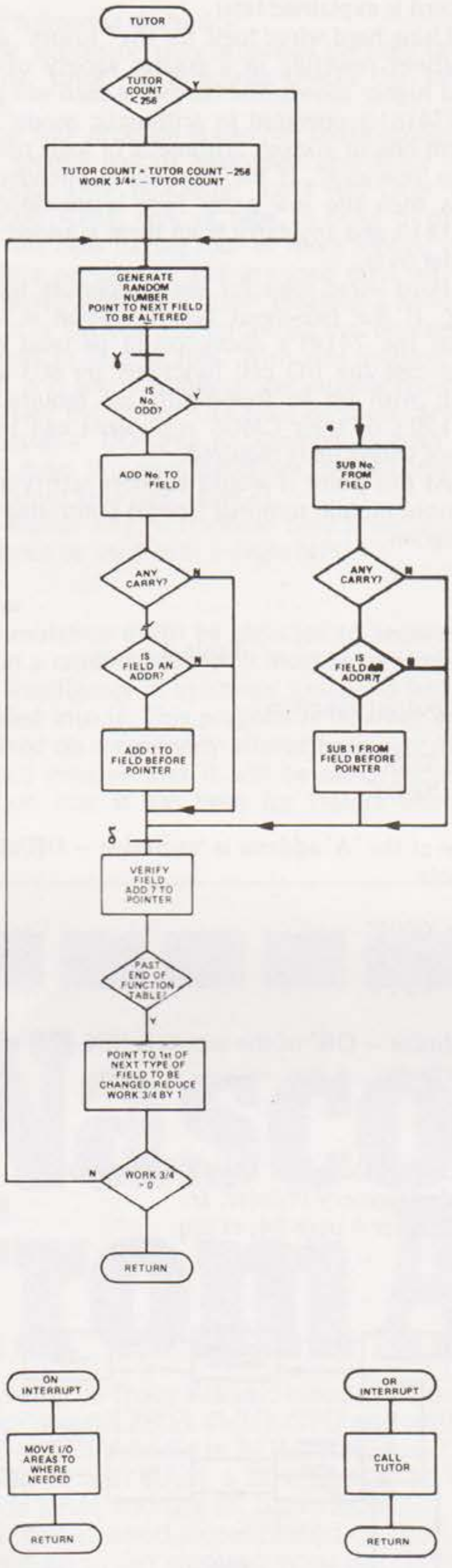

Fig. 2. Phase I's Tutor flowchart with its subroutines.

c. Function area. This is a structured area that defines which logical function is to be performed by each cell, where the input variables are and where the output is to be written to the 'operand' area.
The structure used is:–

1 byte	– logic function. The first four bits are zero, the remaining four are the function selector bits S_0 to S_3
2 bytes	– A input 'operand' 1 relative address.
2 bytes	– B input 'operand' relative address.
2 bytes	– output 'operand' relative address.
	(7 bytes total per cell)

The total work area required is 7 + 1 + 1/8 + 1/8 = 8¼ bytes per cell in multiples of 8 cells.

2. TUTOR. This program changes the contents of the 'function' area of store so as to produce the required output. There are two ways of achieving this:

a. by setting the 'output' to what is required and then working through the logic chain in reverse changing the functions to obtain the required result. This would work but would become an extremely long process for a reasonable number of cells for the following reasons:

I. After correcting any one byte in the 'output' area the whole function table would have to be reprocessed a number of times. This is because any of the changes made to correct this one byte could have effects elsewhere in the network.

II. The byte altered might be affected by a loop in the network and so not have a constant value.

III. By changing a number of functions in a random manner. The number changed should decrease with time so as not to affect the previous training in too large an extent.

In both cases it would be necessary to repeat previous after any new training, but I believe that the herutistic method will give acceptable results quicker and more easily.

Using the random method of training the following rules apply:

a. The program will be entered:

I. If arbitrarily chosen 'operand' bytes conform to an equally arbitrary pattern, specifically if the first byte of the 'operand' table is $00 or $FF. (It wants to learn).

II. From an external interrupt when the operator wants to change the output. (I'll larn ya!).

b. A two byte unsigned count of the number of times the function table has been processed is kept. This count, together with a pointer indicating where the 'tutor' has amended to, needs to be initialised on runs other than the first. The count is decremented by 256 (high order byte by one) whenever the 'tutor' is called. If the count ever becomes $FFFF then it becomes a constant.

c. The two's complement of the count, treated as an unsigned number is the number of functions to be altered when the 'tutor' is called.

d. The 'function' field altered on each pass through the complete table is alternately the logic field or an address field.

e. The field in question is altered by generating an eight bit random number and adding it to the field if it is even or subtracting if it is odd. The field is then checked for validity.

3. I/O. This program is the interface between the 'processor' I/O areas and the peripherals. For this minimum system the 'processor' I/O area could be situated in the store of a mapped VDU and the system trained to recognise patterns in this area. In this case all that would be needed is for the program to recognise keyboard input destined for this area.

Otherwise the program is driven by a timer interrupt to give a suitable sampling period for the external system and transfers data between the two systems.

4. An end-of-run program is required to dump the 'operand' and 'function' areas to tape to save them for the next run. This program could also be run periodically during the main run in case of power failures (rather frequent in my area).

Table 3

Multiple function structure:–

2 bytes – record length – only required for variable records.

2 bytes – cell logic selector bits – max Hex '0003' 1 I/P cell
" " '000F' 2 " "
" " '00FF' 3 " "
" " 'FFFF' 4 " "

2 bytes – O/P operand address

2 bytes – I/P 'A' address
For a variable length record the remaining fields may not be present.

2 bytes – I/P 'B' address
2 bytes – I/P 'C' address
2 bytes – I/P 'D' address

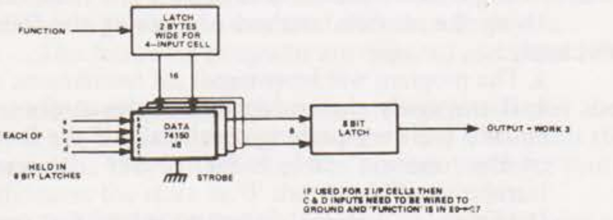

Fig.3. Phase II, delete from ∝ to β in in the Processor flowchart and insert: Move function to latch.

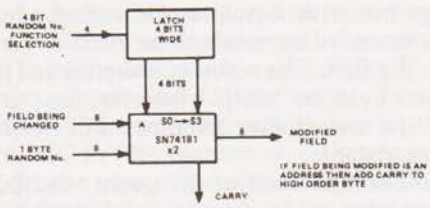

Fig.4. Phase II, delete from γ to δ in the Tutor flowchart.

Phase Two

This differs from phase 1 in the following respects:

a. Increased store for the 'operand' and 'function' tables. This would give the ability to recognise larger patterns. By using the one 'function' table to process two sets of 'operand' and 'I/O areas it is possible to increase the pattern size with little increase in store, but there would be interference between the training for the two areas.

b. The opportunity arises, with increasing store, to increase the complexity of the network by allowing functions with other than two inputs. See the structure/file layout in Table 3; the reason for variable record is explained later.

c. Using hard wired logic for the "tutors" amendment routines resulting in a greater variety of operations and higher speed. The hardware used will be a pair of SN74181's operated in arithmetic mode. These perform one of sixteen arithmetic or logic operations on two 'operands'. If the field being amended is an address then the low order byte is amended using the 74181's and any carry from them is added to the high order byte.

d. Hard wired logic for the 'processors' logic processing. If the two-input cell limitation is satisfactory then the 74181's above could be used for this. In this case the I/O cell functions are $03 and S0F. If cells with up to four-inputs are required then SN-74150's or their CMOS equivalent can be used, but more wiring up is required.

e. At this point it would be more satisfying to have a remote mobile terminal (robot) controlled by the I/O program.

Table 4

External output function:–

Cell type '0000'
'0003'

The value at the 'A' address is 'exclusive – OR'ed into the output area.

Cell type '000F'
'00FF'
'FFFF.

The 'exclusive – OR' of the inputs is 'EX–OR'ed into the output area.

Reference

Logical Design of Digital Computers.
Montgomery Philster, Jr.
Chapter 4 page 94, et seq.

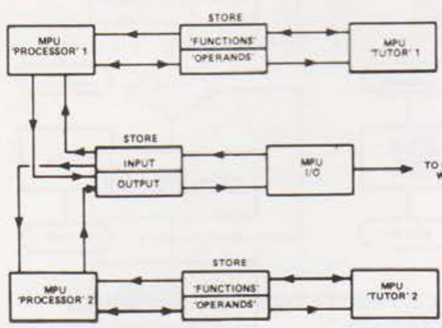

Fig.5. The outline of Phase III's CPU requirements.

Phase Three! (When I'm rich and retired).

In this phase the programs move into a multiple MPU environment with an MPU dedicated to each program. This results in the following changes:—

1. The 'processor' only processes the logic cells.
2. The 'tutor' continuously checks the 'self tuition' bytes.
3. The 'I/O' program is also run continuously.
4. A second pair of 'processor' and 'tutor' programs are used. This 'processor' has a very large 'function' store on RAM, disk or tape, in order of preference, with the cells having four or more inputs. If sequential files on tape or disk are used then two files will be needed with the 'tutor' creating a new file each time it is entered and informing the 'processor' when it needs to change files. With this multiple file approach it is also possible to use variable record lengths to offset the longer I/O time of these devices. The 'processor's' I/O area is common to both with the result from this new 'processor' being combined into the output area (see Table 4).

There is no reason why, if response time is not critical, this approach cannot be used with a single MPU.

In Conclusion

Whilst this simulation might be objected to because training takes place in a random manner it must be remembered that any organic intelligence in existence today has had an initial program loaded into it. This program is inherent in its genes and has evolved on a randomly altered basis over millions of years. I would imagine that it will be easier for us to train this simulation that it has been for Nature where both a general program and the necessary hardware have had to be created.

Training will in all probability be easier starting from a small system that grows than going in at the deep end with the biggest system that can be fitted in your machine.

Concerning the combining of training data, acquired either from another machine or by training for simple jobs, I would suggest the following procedure:—

a. Enlarge the function area so as to contain both sets of functions.
b. If one set is from another system amend the function addresses to suit the new area.
c. Treat both sets as if they are parts of a new contiguous tape file.

A Cautionary Note

The good Dr. Asimov not withstanding, there is no reason for an intelligent computer to be either tractable or benevolent. I have two organic computers of reasonably high intelligence, one of whom I have been trying to train for six years. This one, (the other is similar in outlook) can on occasion be completely intractable and decidedly malevolent. In fact there are times when I could quite cheerfully murder my son!

In all seriousness I will be pleased to hear from anyone who does try to train the above system. Also, as I have given very little thought as yet to the interface systems, I would welcome any suggestions for these.

INSTANT SOFTWARE

This month Computing Today launches a new unique service – Instant Software. This is exactly what the title implies – programs on a plate! Each comes recorded onto a high quality cassette with full documentation and neat packaging.

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TRS 80

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Profit and Loss – With this program you can quickly get trial balance and profit and loss statements.

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With this package, you can make your TRS-80 a working partner. Order No. 0013R 21.66.

PERSONAL FINANCE I Let your TRS-80 handle all the tedious details the next time you figure your finances:

Personal Finance I – With this program you can control your incoming and outgoing expenses.

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This handy financial control package for the home requires only a TRS-80 Level I 4K. Order No. 0027R 5.75.

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ELECTRONICS I This package will not only calculate the component values for you, but will also draw a schematic diagram, too. You'll need a TRS-80 Level I 4K, Level II 16K to use:

Tuned Circuits and Coil Winding – Design tuned circuits without resorting to cumbersome tables and calculations.

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LM 381 Preamp Design – Design IC preamps with this low-noise integrated circuit.

This package will reduce your designing time and let you build those circuits fast. Order No. 0008R 5.75.

HAM PACKAGE I This versatile package lets you solve many of the commonly encountered problems in electtronics design. With your Level I 4K or Level II 16K TRS-80, you have a choice of:

Basic Electronics with Voltage Divider – Solve problems involving Ohm's Law, voltage dividers, and RC time constants.

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Level 2

TRS-80 UTILITY I Ever wonder how some programmers give their programs that professional look? Instant Software has the answer with the TRS-80 Utility I package. Included are:

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TRS-80 UTILITY 2 Let Instant Software change the drudgery of editing your programs into a quick, easy job. Included in this package are:

CFETCH – Search through any Level II program tape and get the file names for all the programs. You can also merge BASIC programs, with consecutive line numbers, into one program.

CWRITE – Combine subroutines, that work in different memory locations into one program. This works with BASIC or machine-language programs and gives you a general checksum.

This package is just the thing for your TRS-80 Level II 16K. Order No. 0076R 5.75.

SPACE TREK IV Trade or wage war on a planetary scale. This package includes:

Stellar Wars – Engage and destroy Tie fighters in your attack on the Death Star. For one player.

Population Simulation – A two-player game where you control the economy of two neighbouring planets.

You decide, guns or butter, with your TRS-80 Level II 16K. Order No. 0034R 5.75.

RAMROM PATROL/TIE FIGHTER/KLINGON CAPTURE Buck Rogers never had it so good. Engage in extraterrestrial warfare with:

Ramrom Patrol – Destroy the Ramron ships before they capture you.

Tie Fighter – Destroy the enemey Tie fighters and become a hero of the rebellion.

Klingon Capture – You must capture the Klingon ship intact. It's you and your TRS-80 Level II 16K battling across the galaxy. Order No. 0028R 5.75.

CARDS This one-player package will let you play cards with your TRS-80 – talk about a poker face!

Draw and Stud Poker – These two programs will keep your game sharp.

No-Trump Bridge – Play this popular game with your computer and develop your strategy.

This package's name says it all. Requires a TRS-80 Level II 16K. Order No. 0063R 5.75.

HOUSEHOLD ACCOUNTANT Let your TRS-80 help you out with many of your daily household calculations. Save time and money with these fine programs:

Budget and Expense Analysis – You can change budgeting into a more pleasant job with this program. With nine sections for income and expenses and the option for one- and three-month review or year totals, you can see where your money is going.

Life Insurance Cost Comparison – Compare the cost of various life insurance policies. Find out the difference in price between term and whole life. This program can store and display up to six different results.

Datebook – Record all those important dates in your life for fast, easy access. The program has all major holidays already included.

All you need is TRS-80 Level II 16K. Order No. 0069R 5.75.

FINANCIAL ASSISTANT Compute the figures for a wide variety of business needs. Included are:

Depreciation – This program lets you figure depreciation on equipment in five different ways.

Loan Amortization Schedule – Merely enter a few essential factors, and your TRS-80 will display a complete breakdown of all costs and schedules of payment for any loan.

Financier – This program performs thirteen common financial calculations. Easily handles calculations on investments, depreciation, and loans.

1% Forecasting – Use this simple program to forecast sales, expenses, or any other historical data series.

All you need is a TRS-80 Level II 16K. Order No. 0072R 5.75.

PET

CASINO I These two programs are so good, you can use them to check out and debug your own gambling system!

Roulette – Pick your number and place your bet with the computer version of this casino game. For one player.

Blackjack – Try out this version of the popular card game before you go out and risk your money on your own "surefire" system. For one player.

This package requires a PET with 8K. Order No. 0014P 5.75.

CASINO II This craps program is so good, it's the next best thing to being in Las Vegas or Atlantic City. It will not only play the game with you, but also will teach you how to play the odds and make the best bets. A one player game, it requires a PET 8K. Order No. 0015P 5.75.

CHECKERS/BACCARAT Play two old favourites with your PET.

Checkers – Let your PET be your ever-ready opponent in this computer-based checkers program.

Baccarat – You have both Casino- and Blackjack-style games in this realistic program.

Your PET with 8K will offer challenging play anytime you want. Order No. 0022P 5.75.

MIMIC Test your memory and reflexes with the five different versions of this game. You must match the sequence and location of signals displayed by your PET. This one-player program includes optional sound effects with the PET 8K. Order No. 0039P 5.75.

TREK-X Command the Enterprise as you scour the quadrant for enemy warships. This package not only has superb graphics, but also includes programming for optional sound effects. A one-player game for the PET 8K. Order No. 0032P 5.75.

TURF AND TARGET Whether on the field or in the air, you'll have fun with Turf and Target package. Included are:

Quarterback – You're the quarterback as you try to get the pigskin over the goal line. You can pass, punt, hand off, and see the results of your play using the PET's superb graphics.

Soccer II – Play the fast-action game of soccer with four playing options. The computer can play itself, play a single player, two players with computer assistance, and two players without help.

Shoot – You're the hunter as you try to shoot the bird out of the air. The PET will keep score.

Target – Use the numeric keypad to shoot your puck into the hom position as fast as you can.

To run and score all you'll need is a PET with 8K. Order No. 0097P 5.75.

ARCADE I This package combines an exciting outdoors sport with one of America's most popular indoor sports:

Kite Fight – It's a national sport in India. After you and a friend have spent several hours manoeuvering your kites across the screen of your PET, you'll know why!

Pinball – By far the finest use of the PET's exceptional graphics capabilities we've ever seen, and a heck of a lot of fun to play to boot.

Requires an 8K PET. Order No. 0074P 5.75.

ARCADE II One challenging memory game and two fast-paced action games make this one package the whole family will enjoy for some time to come. Package includes:

UFO – Catch the elusive UFO before it hits the ground!

Hit – Better than a skeet shoot. The target remains stationary, but you're moving all over the place.

Blockade – A two-player game that combines strategy and fast reflexes.

Requires 8K PET. Order No. 0045P 5.75.

DUNGEON OF DEATH Battle evil demons, cast magic spells, and accumulate great wealth as you search for the Holy Grail. You'll have to descend into the Dungeon of Death and grope through the suffocating darkness. If you survive, glory and treasure are yours. For the PET 8K. Order No. 0064P 5.75.

Apple

MATH TUTOR I Parents, teachers, students, now you can turn your Apple computer into a mathematics tutor. Your children or students can begin to enjoy their math lessons with these programs:

Hanging – Perfect your skill with decimal numbers while you try to cheat the hangman.

Spellbinder – Cast spells against a competing magician as you practice working with fractions.

Whole Space – While you exercise your skill at using whole numbers your ship attacks the enemy planet and destroys alien spacecraft.

All programs have varying levels of difficulty. All you need is Applesoft II with your Apple II 24K. Order No. 0073A 5.75.

MATH TUTOR II Your Apple computer can go beyond game playing and become a mathematics tutor for your children. Using the technique of immediate positive reinforcement, you can make math fun with:

Car Jump – Reinforce the concept of calculating area while having fun making your car jump over the ramps.

Robot Duel – Practice figuring volumes of various containers while your robot fights against the computer's mechanical man.

Sub Attack – Take the mystery out of working with percentages as your submarine sneaks into the harbor and destroys the enemy fleet.

All you need is Applesoft II with your Apple II and 20K. Order No. 0098A 5.75.

GOLF Without leaving the comfort of your chair, you can enjoy a computerized 18 holes of golf with a complete choice of clubs and shooting angles. You need never cancel this game because of rain. One or two players can enjoy this game on the Apple with Applesoft II and 20K. Order No. 0018A 5.75.

BOWLING/TRILOGY Enjoy two of America's favorite games transformed into programs for your Apple:

Bowling – Up to four players can bowl while the Apple sets up the pins and keeps score. Requires Applesoft II.

Trilogy – This program can be anything from a simple game of tic-tac-toe to an exercise in deductive logic. For one player.

This fun-filled package requires an Apple with 20K. Order No. 0040A 5.75.

David Sinfield

We take a close look at this development system and its capability for expansion into bubble memories

Rockwells Advanced Interactive Microcomputer has been around for quite some time but seems to have received little attention perhaps because it won't interface to a VDU and therefore can't be used for playing real time, interactive games. It seems there are other uses for micro's!!! With no video interface the AIM relies on the onboard 20 column thermal printer and 20 character, 16 segment LED display.

Description

The standard machine consists of two boards, one holding the keyboard the other the processor, LED display, and printer. The boards are coupled by ribbon cable terminated by DIL plugs. The CPU is the 6502 as found in KIM, SYM, PET and Superboard to name but a few. 1K User RAM is provided in two 2114's, six extra sockets provide for onboard expansion. A very comprehensive monitor in ROM is standard with a further three sockets for the assembler (1 ROM) and BASIC (2 ROM's). If desired any pin compatible ROMs, EPROMs or PROMs may be used and their contents called using the appropriate Monitor function.

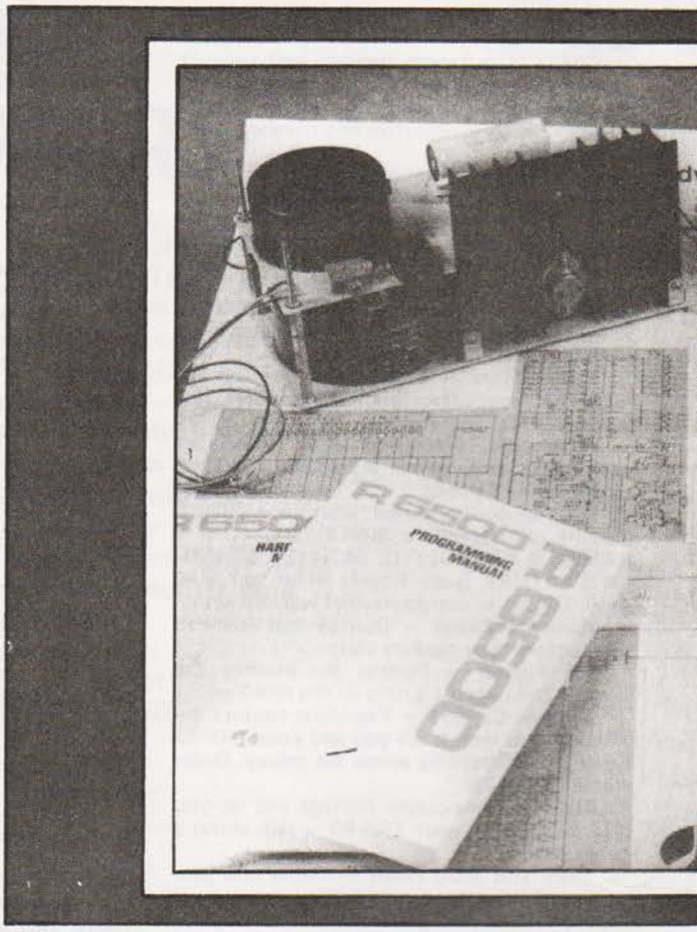
I/O is available via two edge connections labelled "Application" and "Expansion". The Application port provides two 8 bit I/O ports from the Versaile Interface Adapter – a chip allowing a fantastic range of possibilities. Cassette and TTY interfacing are also via the application port. The addressing capability of the 6502 is limited to 64K and this limits the amount that can be hung on to the expansion port. For the real trailblazers Rockwell have Bubble Memories (and Space Shuttles) to append to the 6502. More on Bubble memories later. A power supply is required giving 5 V @ 2 amps for the CMOS. The current drawn depends on the amount of memory and which chips are used. The printer requires 24V. A simple PSU will be described next issue.

Documentation

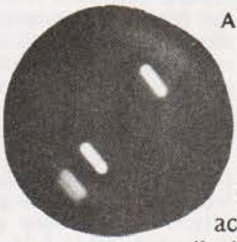
Four books are supplied with the AIM, the users guide which gives an introduction to programming and interfacing the machine, hardware and programming manuals which go into much more detail, and a complete disassembled listing for the monitor. All are in A5 paperback format and are very complete technical manuals as you would expect from a machine designed as a complete development system. All assume a fair knowledge of microprogramming except the users guide which gives programming examples, and demonstrates each of the monitor functions in use. It also includes a detailed memory map and the locations and functions of the monitor subroutines.

The Monitor

The AIM comes complete with a ROM based monitor/disassembler/text editor which allows machine code or mnemonic programming from the 54 key keyboard. Fig.3 gives the monitor functions and some idea of what they do. Part of the monitor is given over to a text editor, more about this later. Illegal commands are followed by question marks on the display whether it is the monitor or text editor that is in control.



Above: the AIM package plus CT PSU (right). Full details of this next month.



The processor used is the ubiquitous 6502 and in this machine it is extremely accessible. All the registers can be accessed, displayed and amended at any stage of programming. Using the single step program execution facility the registers can be inspected at each step. Four breakpoints can be set using command "B", toggled using command "A" and their position displayed by "?".

Incorporated in the Monitor are several subroutines available to the user through the JSR instruction. At the end of the subroutine control is returned to the instruction after the JSR.

Practical Programming

On powering up the AIM performs its own cold start, puts a header "ROCKWELL AIM 65" on the printer and the monitor prompt (<) on LED display. If for any reason the printer is out of commission the message "PRINTER DOWN" appears.

Assuming that there is a monitor prompt on the display the machine is awaiting a command. Any letter or symbol input from the keyboard is enclosed between < > signs. If the command is illegal the display is terminated with a question mark and the machine awaits a further instruction.

To enter a program the stack pointer has to be reset to the starting address required using "*". To enter a program in Hex "/" is used. The start location appears on the

AIM 65

display and four bytes of program may be entered. If the printer is on, the start location and the four bytes are printed. The LED display shows the monitor prompt again and by using "/" again the next four bytes can be entered in the same way.

When the program is entered it can be inspected using the "M" command after resetting the stack pointer to the start address using "*". When the "M" command has been initiated pressing the space bar increments the stack pointer by four causing the next four locations to be displayed/printed.

Programming mnemonics is a little different. The Mnemonic mode is called using "I". This results in the current value of the stack pointer being displayed with a cursor. The machine is now awaiting a three letter mnemonic instruction. If it doesn't get one the word "error" is flashed on the display/printed. The Program counter is not incremented in this case and you get another try at it.

Programs can be disassembled to mnemonics using the "K" command. The output format is :— four characters of location, two characters of opcode, three letters of mnemonics, and an operand if applicable. This procedure applies to programs entered in both mnemonics and Hex.

To run a program the stack pointer has to be set to the start address using "*" and the "G" command starts the program execution. A miniature slider switch to the left of the display can be used to select either single step or continuous execution. If switched to single step the contents of the registers can be examined after each step for debugging purposes.

Text Editor

I was surprised to find a Text Editor as part of the standard system software. I was even more surprised to find it was so comprehensive. The user manual implies that the Editor's main function is to manipulate programs written under the optional assembler but I can visualise various 'filing cabinet' applications.

The system is basically line orientated i.e. operations are carried out on one line at a time and a pointer (which is not displayed) can be manipulated to indicate any particular line. In this context the word line is misleading as it can be up to 60 characters long and therefore represents three lines on the AIM's printer and display.

The Editor is initialised from the monitor by typing "E". The machine responds by asking which block of memory is to be used for the text buffer. Any contiguous block from Hex location 0200 upwards can be used and if space or return is entered the maximum space is allocated. On the standard machine, which has 1K RAM, the Text buffer can extend to 0400 Hex giving memory space for 512 characters including carriage returns (which must terminate each line) and an end of text character.

Text can be input from and output to the buffer from the keyboard, audio tape, paper tape or TTY. It is stored as ASCII code. Unfortunately lower case cannot be input from the keyboard or displayed by the LED's or printer although the ASCII codes can be stored (I tried it using the "M" command and entering Hex ASCII code) so the lucky user who owns a full ASCII keyboard and a fair printer has the beginnings of a usable RAM based word processor system. Naturally 1K RAM is insufficient for any serious purposes but consider what I have to say about bubble memories later.

The commands available under the Text Editor are listed in Fig.2, the string orientated functions "C" and "F" being particularly useful but when using them it must be borne in mind that the search is only carried out from the current line downwards so for a full search the "T" command must be used to set the text pointer at the top.

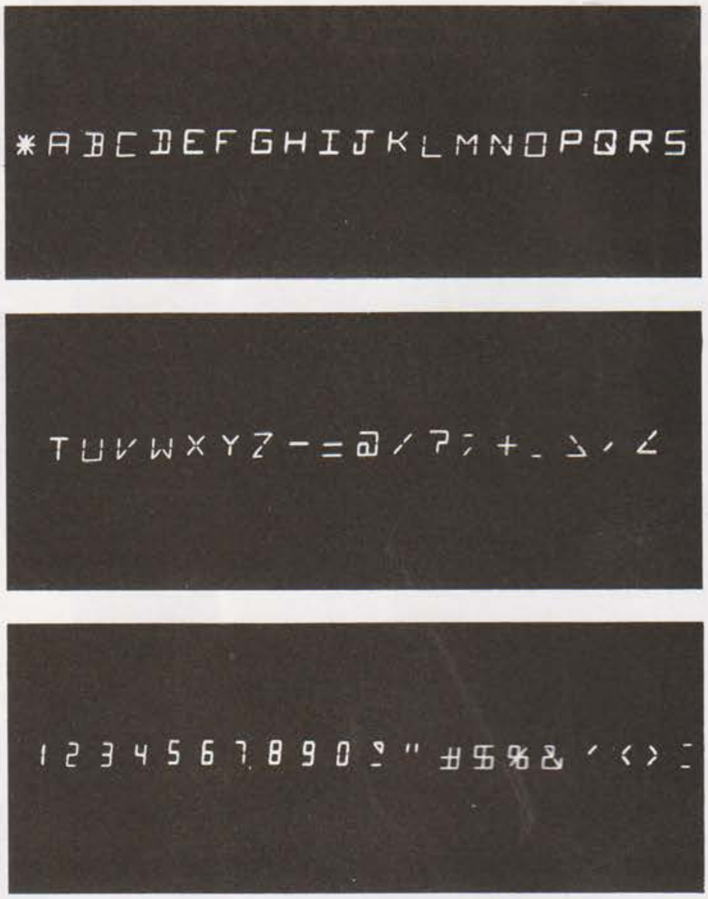


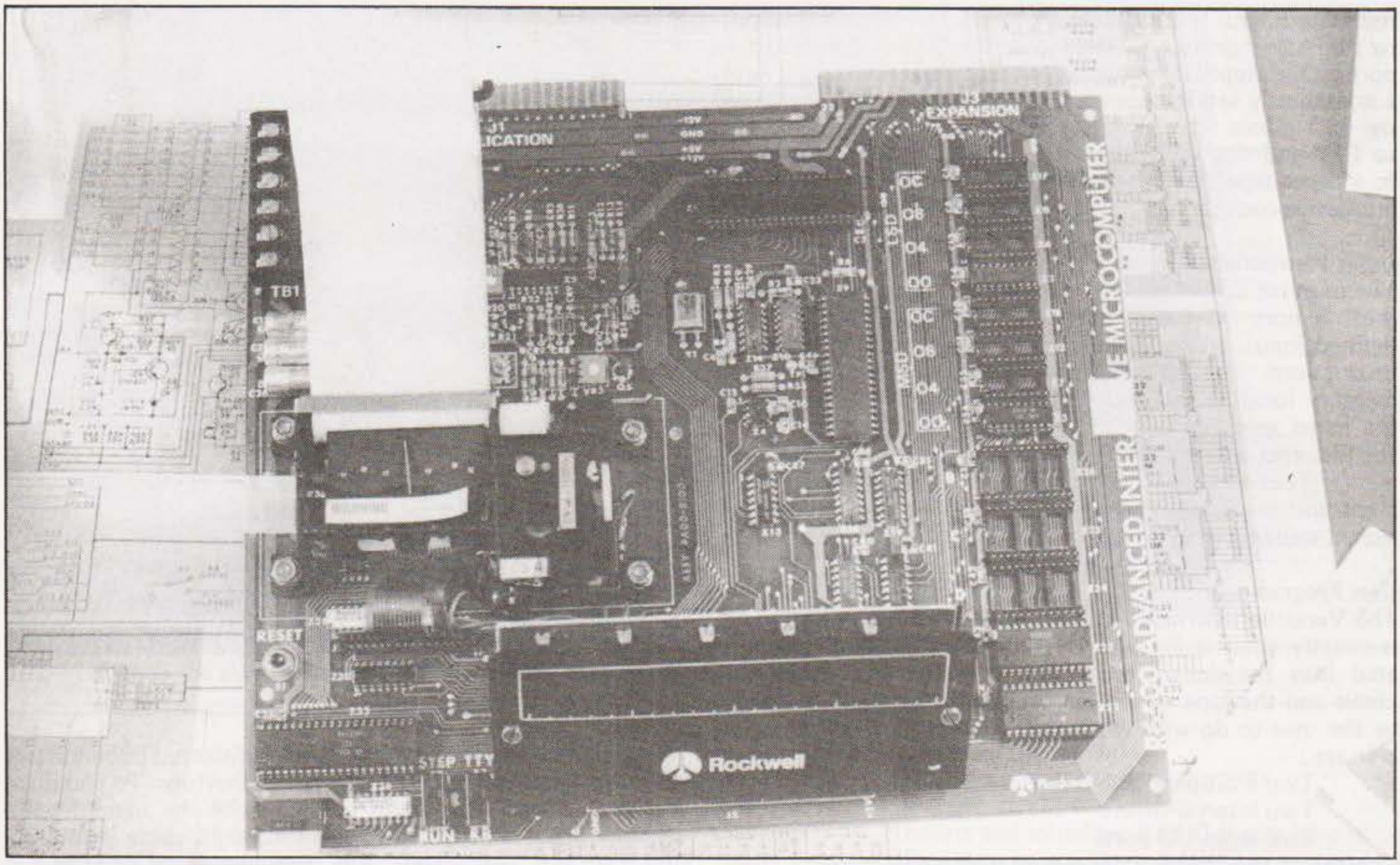
Fig.1. The AIM 65 character set as displayed by the 16 segment displays.

Output Instructions

The application connector on the AIM allows two tape recorders to be used. Provision for remote control of tape motors is included but is only absolutely necessary for use with the optional assembler. Any recorder can be used as long as it has earphone and microphone sockets. The user guide goes into a great deal of detail and includes a program that produces a test tape of characters which can be played back to the machine where another program will check them for legibility and display a "Y" if the tape is being successfully read. If it isn't "N" is displayed. As with most other aspects the manuals are excellent. A complete troubleshooting guide is given with details of how to make adjustments in case the setting made at the factory is upset at all.

Because of the excellent monitor dumping data to tape is simple. In the monitor the command is "D" and when entered a start and finish address are requested. If you reply with something blatantly daft the prompt remains until a sensible reply is given. The output device is now requested if the reply is not P, X,T,K,L, or U, the output defaults to the AIM's own printer. Fig.3 sheds light on the output device codes. This can be a little unfortunate if you're dumping 64K as this represents a lot of paper through the printer. During a dump the only escape is the reset button!

A five character file header can be used for both the hex dump and the ASCII listing. Spaces are not permitted in the filename and hitting the space bar terminates the heading and causes the next prompt, which asks to which tape (one



Above: the main PCB in somewhat more detail. The display sits neatly on the front of board.

or two) the data is to be written.

Two tape formats are available, either AIM's own or KIM–1 compatible. The AIM format records the data in blocks of 80 bytes, the first block includes the file name. All blocks are preceded by 32 SYN characters, and a block number. Whilst a Hex dump is taking place the block number is shown on the two rightmost digits of the display. Although this is of little practical use it gives you something to look at other than the tape going from one spool to the other! Each block is followed by two bytes of checksum. If the data does not fill the last block zeroes are used to make it up to the 80 characters.

Outputting data in the KIM–1 format requires the same procedure by the operator and the only immediately apparent difference is that no block counter is displayed (KIM format consists of a continuous string of data).

When the finish address is reached (whichever output format is used) the display shows "More?". Anything other than Monitor "Y" in response is treated as no and the machine awaits a further command.

The contents of the Text buffer can be listed to tape using the "L" command. As with the rest of the Editor commands the required action is only taken from the current line so the "T" command has to be used if the listing is required from the first line of text. When the "L" command is entered a "/" appears on the display requesting a decimal number indicating the amount of text (in lines) to be output. Replying with a space causes the whole of the text in the buffer to be transmitted. The choice of output device, and, if tape, filename and choice of machine are as for the dump command in the monitor.

The TTY output can be selected using a switch on

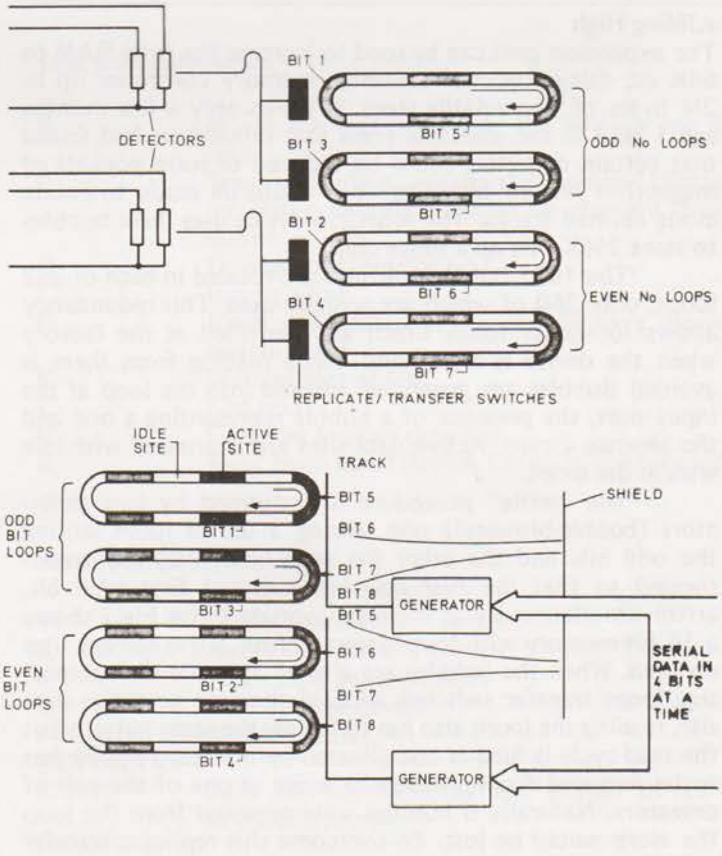


Fig.2. A 16 bit bubble memory using four 'loops' of generation.

the main board. With this switch in the TTY position output to the AIM's printer is diverted to the 20 mA current loop port on the Application connector. The baud rate of the AIM automatically sets in response to typing the RUBOUT key on the TTY. Once set control can be transferred from keyboard to TTY and vice versa by using the KB/TTY switch. Output to a paper tape punch on the TTY is achieved using the output device code L.

Input Instructions

The monitor command "L" allows object code to be loaded into memory from audio tape, TTY punched tape or a user defined input device, the device codes are as for the output instructions. The object code is loaded starting from the memory location indicated by the program counter. (If the file name specified isn't the first on a cassette the titles of the files encountered are displayed).

Text can be loaded into the Editor, using the "R" command in a similar fashion from any of the above mentioned sources.

User Programmable I/O

The Versatile Interface Adapter on the AIM is an R6522 and is exactly what it says – versatile. There are two incorporated into the design; one looks after the I/O mentioned above and the tape remote control and the other is available to the user to do with what he/she will. The facilities available are :–

Two 8 bit parallel I/O ports
Two interval timers
Two serial I/O ports

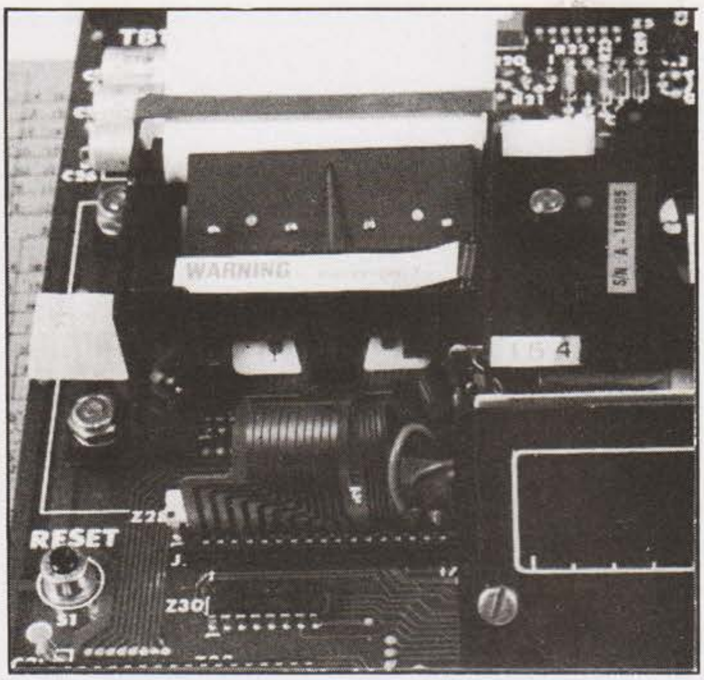
Control of the chip is achieved by addressing memory from A000 to A00F. Rockwell's suggestions for applications range from monitoring equipment to testing integrated circuits.

AIMing High

The expansion port can be used to increase the total RAM to 64K or, using Rockwell's Bubble memory controller up to 2M bytes of non-volatile store. It seems only a few months ago I read in the scientific press that researchers had found that certain materials could be induced to form pockets of magnetism which, by using coils could be made to rotate along defined tracks. The RBM256 device uses these bubbles to store 256K bits on a single chip!

The 1025 bubble positions are rotated in each of 282 loops, only 260 of which are actually used. This redundancy allows for faulty loops which are identified at the factory when the device is tested and hence reading from them is avoided Bubbles are generated and fed into the loop at the input port, the presence of a bubble representing a one and the absence a zero. Active data sites are alternated with idle sites in the loops.

The "write" procedure is performed by two generators (bubble-blowers?) one serving a set of loops storing the odd bits and the other the even bits. They are synchronised so that the first odd bit and that first even bit, arrive simultaneously at their appropriate loops Fig.2 shows a 16 bit memory with four loops and four active storage sites on each. When the bubbles are aligned apposite their respective loops transfer switches allocate them to an active data site, reading the loops also has to follow the same pattern but the read cycle is further complicated by the fact a bubble has to be removed from its loop to arrive at one of the pair of detectors. Naturally if bubbles were removed from the loop the store would be lost. To overcome this replicate/transfer switches are used. These either copy or transfer bubbles depending on whether a destructive read is required or not.



Above: AIM is printer with appropriate warning on use of 'pirate' paper!

The detectors work because a distorted bubble alters the resistance of a stack of permalloy chevrons. To eliminate the problem of stray fields causing noise the signal from a dummy stack that has not encountered a bubble is subtracted from the "real" stack.. Any remaining signal must be due to the presence of a bubble.

A 15kHz or 100kHz signal can be used to drive the field which rotates the loops one bit being output for each cycle. The bubbles are unable to exist outside a magnetic field so to ensure non-volatility permanent magnets are used to maintain the condition of the loops after power down.

Of course all this shifting around of bubbles requires control and co-ordination and this is the function of the RCM650 Bubble memory control module. Centred around another 6502 with its own RAM, PROM's and interface chips it is designed to be compatible with the System 65 bus. One RCM650 will run up to sixteen 1/8M byte RLM658 modules, each of which has 4 256 Kbit memory cells.

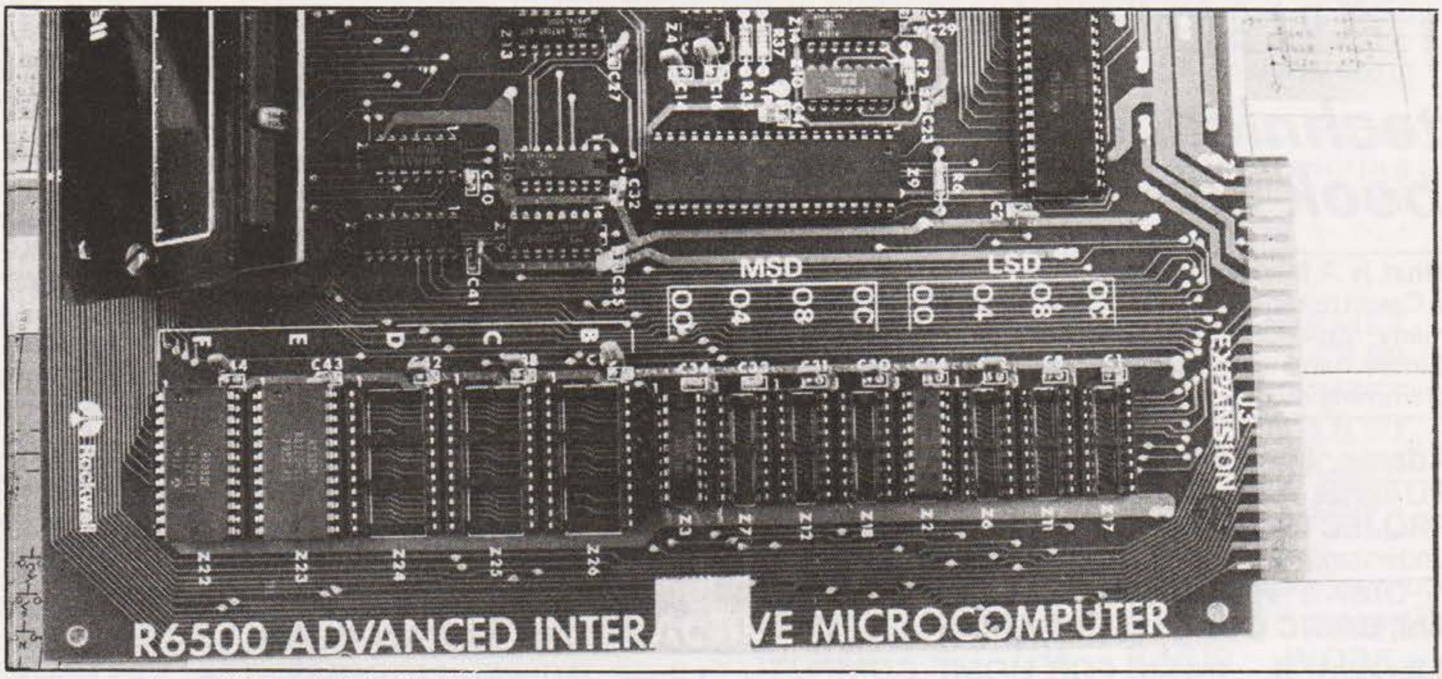
Now I've stimulated your interest I'm going to spoil it by mentioning the drawback-expense. The controller Module will set you back £700 and each 1/8M byte bubble memory module is £1750. I didn't dare ask how much the space shuttle was . . . .

Seriously though, although £4200 for 1/4M byte at first sight seems a lot we are dealing with the 'frontiers of the technology' and congratulations to Rockwell for making it available at *any* price.

Down To Earth Again

The basic AIM65 only sets you back around £250 and is as good a starting point as any as I've come across. The documentation is excellent. A lot of manuals I've seen hint at the incredible power under your finger tips but getting at it is left to trial and error – great if you like guessing games. Personally I prefer details and their was no lack of these. Well done Rockwell!!!

The AIM is distributed in the UK by Pelco (Electronics) Ltd, Enterprise House, 83-85 Western Road, Hove, Sussex and we would like to thank them for the loan of the machine.



Above: expand your AIM to take in bubble blowers and other BASIC necessities.

Command	function/comments
A	Alter accumulator
B	Set or clear a breakpoint. Breakpoints are numbered 0–3 and are handled individually under this command.
D	Dumps a specified section of memory. Prompts for starting and ending addresses and output device. Defaults to on board printer.
E	Enters and initiates Text Editor. This allocates memory for text clearing it. Only to be used for cold starting editor.
G	Executes program from instruction currently indicated by Program counter. Single step execution can be selected or a given no. of instructions may be specified.
H	Traces program counter history.
I	Calls up mnemonic instruction mode.
K	Disassembles memory. Starting address and number of instructions to bespecified.
L	Load from input device.
M	Displays memory from a specified byte. Four bytes are on LED display at once. Pressing space bar steps to next four bytes.
N	Enters Assembler if you have it. If you don't and have nothing in the ROM space starting D000 the machine hangs up until reset is pressed.
P	Alter processor status.
R	Displays register values. Can be selected during single step execution so that registers are displayed after each step.
S	Alter stack pointer.
T	RE-enters text editor at top of text. Can only be used after Text editor has been set up using E.
V	Toggles register trace mode.
X	Alters X register.
Y	Alters Y register.
Z	Toggles Instruction trace mode.
#	Clears all breakpoints.
?	Displays addresses of breakpoints.
4	Toggles breakpoint enable.
5	Enters and initialises BASIC if you have it.
6	Re-enters (warm starts BASIC).
/	Program in Hex.

Fig.3. How to tell it what to go and do once you've got it. Commands list.

Text Edit commands

B	Moves the text pointer to the bottom line of text.
C	Searches for line containing a specified character string and allows it to be changed if required.
D	Displays next line of text.
I	Inserts a line.
F	Finds a specified string and displays the lie containing it.
K	Deletes lines of text.
L	List text.
Q	Gets you back to monitor.
R	Read from input device. Defaults to keyboard

Input/output device codes

T	Audio tape AIM65 format.
K	Audio tape KIM–1 format.
L	Paper tape punch/reader.
U	User defined device.
P	AIM65 printer.
RETURN Or SPACE	AIM Keyboard/Display and printer or TTY keyboard/printer.

Fig.4. Text editor commands and below that the codes which will tell you which device is doing what and when.

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Robert Butler

Acorn File Namer

The following program for the Acorn allows you to load and store programs on cassette tape with an eight digit(Hex) file-code. The program uses 128 bytes of RAM and is located to start at 0E80.

The following Monitor subroutines are used:-

FE0C DISPLAY
FE88 QDATFET
FEB1 PUTBYTE
FF6A STORE
FFDD GETBYTE
FF80 LOAD

Instructions For Program Use

Using the Acorn Monitor, GO at 0E80, (Display is - - - - - - - -) Press S for Store or L for Load. When storing the display will now show Fxxxx - - - . Set FAP by entering the start address of the program to be stored, terminating with any command key. The display now shows t xxxx - - -. Set the TAP by entering the terminating address of the program, terminated with any command key,the display will now show 00000000 (all zeroes). Now enter any number of hex digits (the file code) up to a maximum of eight and terminate with any command key. If more than eight digits are entered the program will store (or load) on entry of the ninth digit.

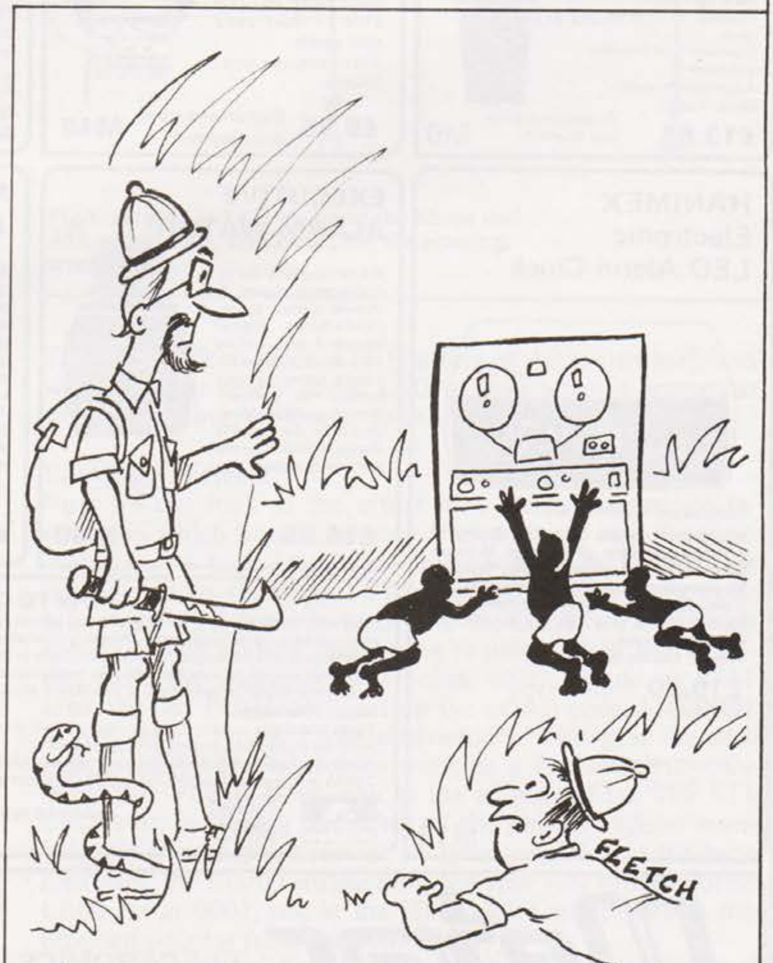
On termination the display will blank and after the program has stored your file code will re-appear. You can now press any command key to re-enter the Monitor.

Note:- Set your cassette machine to RECORD before you terminate the file code. The data is recorded in the following format, eight AA's, file code in seven segment code, Start address, End address, Program.

To load a program press L, display shows all zeroes, and then enter the file code of the required program terminated with any command key. The display will now blank.

On recognition of your file code following the eight AA's of the filemarker the data will be loaded. Loading is performed under the Acorn's Monitor and on termination your file code will re-appear. Press any command key to enter the Monitor. As the program looks for a filemark and a file code before attempting to load any data glitches between blocks of data are ignored.

```
0E80   A9 40       LDA 1                Set up display
0E82   20 F8 0E    JSR Write Display
0E85   20 0C FE    JSR Display
0E88   A5 0D       LDA Z                Get Key
0E8A   C9 14       CMP 1
0E8C   F0 35       BEQ LOAD
0E8E   C9 13       CMP 1
0E90   D0 F3       BNE JSR Display
0E92   A9 71       LDA 1                Store! Set Disp 0=F
0E94   85 10       STA Z
0E96   A2 06       LDX 1                Set X=FAP
0E98   20 88 FE    JSR QDATFET          Load FAP
0E9B   A9 78       LDA 1                Set Disp 0=t
0E9D   85 10       STA Z
0E9F   A2 08       LDX 1                Set X=TAP
0EA1   20 88 FE    JSR QDATFET          Load TAP
0EA4   A9 3F       LDA 1                Set up display all 0's
0EA6   20 F8 0E    JSR Write Display
0EA9   20 E6 0E    JSR Write Filecode
0EAC   A2 07       LDX 1                Out Filemark
0EAE   A9 AA       LDA 1                'Load Filemark'
0EB0   20 B1 FE    JSR PUTBYTE
0EB3   CA          DEX
0EB4   10 F8       BPL Load Filemark
0EB6   A2 07       LDX 1                Out Filecode
0EB8   B5 10       LDA Z                'Load Filecode'
0EBA   20 B1 FE    JSR PUTBYTE
0EBD   CA          DEX
0EBE   10 F8       BPL Load Filecode
0EC0   4C 6A FF    JMP Store            'Store Program'
0EC3   A9 3F       LDA 1                'Load'
0EC5   20 F8 0E    JSR Write Display    Set up display all 0's
0EC8   20 E6 0E    JSR Write Filename
0ECB   A2 07       LDX 1                Set up X1 'Check Filemark'
0ECD   20 DD FE    JSR GETBYTE          'Data From Tape'
0ED0   C9 AA       CMP 1
0ED2   D0 F7       BNE Set Up X
0ED4   CA          DEX
0ED5   10 F6       BPL Data From Tape
0ED7   A2 07       LDX 1                Set up X2 'Check Filecode'
0ED9   20 DD FE    JSR GETBYTE
0EDC   D5 10       CMP Z
0EDE   D0 EB       BNE Set Up X1
0EE0   CA          DEX
0EE1   10 F6       BPL GETBYTE
0EE3   4C 80 FF    JMP Load             'Load Program'
0EE6   A2 F7       LDX 1                'Write Filecode'
0EE8   20 0C FE    JSR Display          'Set up display'
0EEB   B0 0A       BCS RET              Command Key = RET
0EED   A4 0D       LDY Z                Hex-7Seg using FONT
0EEF   B9 EA FF    LDA Abs Y
0EF2   95 19       STA Z
0EF4   E8          INX
0EF5   30 F1       BMI JSR Set up display
0EF7   60          RET                  Return
0EF8   A2 07       LDX 1                'Write Display'
0EFA   95 10       STA Z                Store Acc in display
0EFC   CA          DEX'
0EFD   10 FB       BPL Store Acc
0EFF   60          RET                  Return
```



"I DOUBT IF THEY'LL WANT YOUR BEADS"

Ian Sinclair

MPU's BY EXPERIMENT

Our popular series takes a last look at the breadboard system before the MK14 arrives

In part 5 we looked at the memory transfer system which uses program-counter displacement, and noted that it's limited to steps of +127 or −128 from the program count at the stage when the transfer is programmed. This is the sort of transfer instruction which every microprocessor chip has in its instruction set, but there are always others. In this Part, we'll look at the other choices which the INS8060 can offer. These involve the use of a set of sixteen-bit registers which are called pointer registers. These registers can be loaded from the accumulator (in two steps, because the accumulator holds one byte only), or their contents exchanged might not look too promising at first sight, but the SC/MP can work quite a few neat tricks with these few instructions.

A Quick Mod

Before we start to look at these methods, a small alteration to the Eurobreadboard layout helps to make what is happening much clearer. The modification consists of soldering a 2k7 resistor to one lead of a spare LED, and then connecting this lot between address line A11 (location B5 on the Eurobreadboard) and earth (on Y1). The LED and resistor need not be positioned precisely, just strung between these points, just make sure that the LED is the right way round, and that the bare wires are not shorting against anything else. The idea of this is to find out when the program counter changes to a much higher address number, higher than can be achieved by a program-relative displacement from the first four address lines.

Let's start by looking at how a pointer register can be loaded. The 8060 contains four sixteen-bit registers, coded 00 (which is the program counter), 01 (Pointer 1, P1), 10 (P2) and 11 (P3). We shall work with P1 only, because the methods which we use can be applied to the others simply by changing the last two bits in the code instruction. Each instruction which makes use of pointer registers consists of a 'root' of 5 or 6 bits, and an ending of the two bits, noted above, which specify which pointer register (or program counter). There can be another code bit as well — you'll have to wait a mo'.

Loading Your Pointer

To load a number into the pointer P1, we start by loading the accumulator. After the usual RESET and CANCEL steps, set up 11000100 (LDI), PUSH, 00001000 PUSH. This sets up the number 00001000 in the accumulator. The next step is to exchange the number in the accumulator with the high order byte of P1, using instruction XPAH. This is done by setting the toggles to 00110101. Note the last two bits, 01. If we had wanted to exchange with P2 we would have used 10, and if we had wanted to exchange with P3 we would have used 11. The first six bits of this instruction are common to all the XPAH shifts. When PUSH is operated, the exchange takes place, and the higher order byte of P1 is now equal to the number, 00001000 which was set up in the accumulator. Any number which was in the higher order byte of P1 is now in the accumulator — in our example, this will be zero because we reset all the registers before starting.

We can now load a lower order byte by a similar set of steps, but using the instruction XPAL — exchange the lower order byte of the selected pointer with the number in the accumulator. In this example, we don't really need to load up because we are using a set of zero bits and the reset procedure will have provided these anyway, but we need the experience at this stage. The steps are: 11000100 (LDI) PUSH 00000000 (data) PUSH 00110001 (XPAL) PUSH. Once again, the 01 ending of the XPAL instruction indicates that we're using Pointer 1. The result of all these steps is to load the P1 register with the number 0000100000000000.

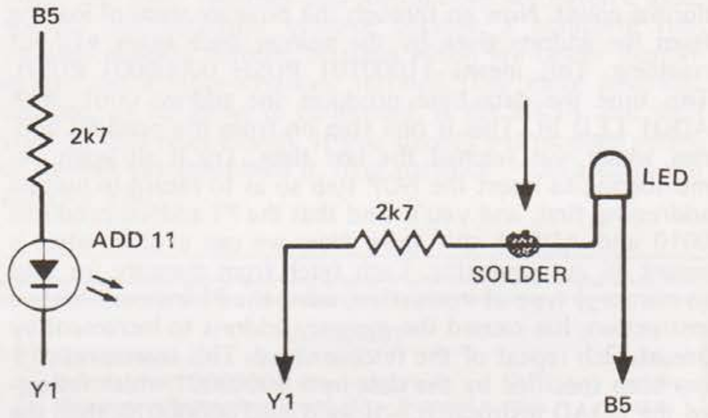


Fig.1. Adding an LED to detect the bit on the A11 address line. (a) Circuit, (b) the practical arrangement.

The "1" bit is at place A11 (starting at A0 remember), and will cause our newly added LED to glow when it appears at this address line. We'll refer to this LED as the A11 LED.

Looking At Effects

Now we can look at the effect of a memory reference instruction which loads a number from memory into the accumulator. The basic load instruction has five bits, 11000. This is made up to the required total of eight by an index code bit, which we'll come to later, and the usual two bits which specify which pointer register we're using, 01 in this example. Note the address at this point, which should be 0111 after the last PUSH. Now set up the LOAD code, 11000001 PUSH, which means Load-relative-to-P1. This gets the address to 1000. The next byte must be a displacement — try 00000001 PUSH. Now look at the address LEDs. The A11 LED is lit, indicating the effect of the pointer register number, and since a displacement of 1 was specified in the byte following the LOAD instruction, the four low order address LEDs are at 0001, not at the 0000 which was placed in the program counter from the pointer.

This style of memory addressing is called indexed addressing, with the number stored in the pointer referred to as the index number – all displacements are then relative to the index number rather than to the program counter number. As before, both positive and negative displacements in the usual range of +127 to –128 are possible.

A very useful variation on this scheme is called auto-indexing. Let's look at some examples. The basic sequence is to load the upper P1 as before; and if the RESET – CANCEL sequence has just been used, then we don't need to load the lower byte of P1, it will automatically be set at zero. Now use the LOAD instruction coded as 11000101 PUSH 00000001 PUSH, and then follow with 00001000 (NOP) PUSH. We're not interested in the data steps here, but in the address LEDs. On the first LOAD step, the address is 0101, but when the data byte is loaded in, the address changes to 0000, with ADD11 LED glowing to show the bit which was loaded in from pointer P1. Note the difference from the previous load – the instruction has a 1 in the 6th bit, and there has not been any addition of 1 to the basic address which was loaded into the P1 register – which means that the data byte didn't act as a displacement. We're not finished, though. At the end of the NOP step, which has been put in to allow the address to return to normal, the address is 0110, and the ADD11 LED is not lit – we're back on the normal count. Now go through the program steps of loading from the address given by the pointer once again, without resetting. This means 11000101 PUSH 00000001 PUSH. This time the data byte produces the address 0001, with ADD1 LED lit. This is one step on from the previous address which was fetched the last time. Try it all again, remembering to insert the NOP step so as to return to normal addressing first, and you'll find that the P1 address produces 0010 and ADD11 this time. Now we can explain what is meant by auto-indexing. Each fetch from memory (or load to memory) type of instruction, using the P1 indexed relative instruction, has caused the memory address to increment by one at each repeat of the fetch or load. This increment of 1 has been specified by the data byte 00000001 which followed the LOAD instruction – if we'd used 00000010, then the memory would have incremented by two each time. This byte which follows the instruction is not, therefore, a displacement number but an increment number, and the automatic incrementing is ordered by the 1 in the 6th place of the instruction byte (reading from the left this time).

Down Instead Of Up?

Next question obviously, is can we decrement the pointer memory as it happens. We can because the increment byte is interpreted by the microprocessor as a signed binary number, so that if we use 11111111 as the increment number, the address will be decremented by 1 on each instruction.

To work, then RESET, CANCEL, and then load up the P1 register, using the usual routine: 11000100 PUSH 00001000 PUSH 00110101 PUSH, so that the pointer 1 register has a 1 in place ADD11. Follow this now with 11000100 PUSH 00001111 PUSH 00110001 PUSH, which loads the byte 00001111 into the lower byte of P1. The result of this is to load P1 with 0000100000001111, which should cause all of the address LEDs including LED11 to light when this address appears on the address lines.

Now do a NOP to clear the decks (00001000 PUSH), and the displayed address should be 1000. Just for a change, we'll use a STORE instruction rather than a load instruction, the one which is referred to in mnemonic forms as ST@P1, meaning STORE WITH AUTO–INDEX RELATIVE TO P1 (the @ sign is used to indicate auto-indexing). The ST @ P1 is coded as 11001101, with the usual meanings for the last three bits. This causes the address after PUSH to display

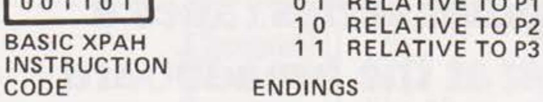


Fig.2. A basic 6-bit instruction code, and the variable 2-bit endings.

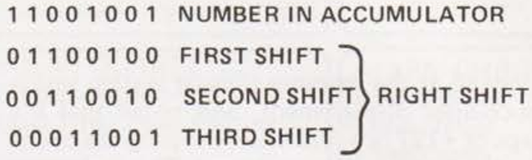


Fig.3. The SHIFT operation.

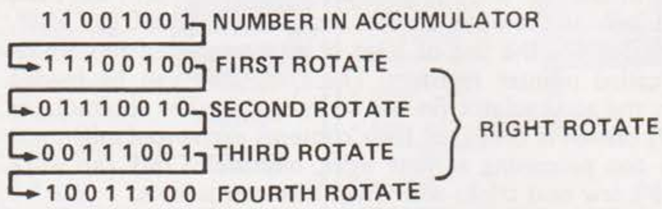


Fig.4. The ROTATE operation.

1001. The next byte is 11111111 (equal to –1 in 2's complement form), and the PUSH after this one causes the transfer, showing memory address 1110 (one less than 1111) and ADD 11 lit. Note that the decrement has taken place on the first transfer, causing the address which was loaded, 1111, to be decremented to 1110. Now do the NOP to return to normal addressing, to step 1010, and go through the whole set of ST @ P1, –1, NOP again. This time the address which is fetched is 1101, ADD 11, which is one less than before. Keep taking the medicine, and watch the address lines!

Why should we want this auto-indexing? In many microprocessor applications we need to keep a large chunk of memory filled with data bytes which also need to be taken out, byte by byte, in order. An obvious application is when we use each byte to represent a letter of a word, so that the bytes must be in the correct order to assemble the word. Another example is when we need to keep a table of number values stored for the purposes of using in order, perhaps for drawing a graph. The use of both increment and decrement on auto-indexing makes it possible both to load such a table and to read out the bytes either in the order in which they were stored or in the opposite order, as we choose.

Pointing To An Address

Back to the board. If you haven't yet reset, you can now check the contents of the lower byte of pointer P1 by using the exchange-with-program counter instruction, XPPC, which is coded 00111101. Check what the last address was in P1 – you will find that the exchange takes place, and then the program counter, which now contains the address which was in P1, increments at the end of the instruction, so that the address which you will see displayed will be one bit more than the number which was stored. That's why (as you'll see later) we often store in P2, P3 or P3, an address number which is one less than the number we want to jump to by using the XPPC instruction.

These pointer-register instructions of the 8060 are therefore a very useful method of going to a completely new address to load or store or to jump to a sub-routine. A pointer register can, for example, carry the starting address (less 1) of a piece of program which can be brought into action at any time by having the instruction XPPC for the correct pointer in the main program. Because this is an exchange instruction, the correct address ofthe main program ends up in the pointer register, so that we can return to the normal program again by repeating the XPPC instruction — it's usually done by jumping back to the previous XPPC. It's a particularly simple and effective method, though if you try to write really complex programs you'll wish you had more registers.

The Single Byters

Back to the old chip pan. We've nearly finished tasting the choice of instructions which this set-up can teach us, but we haven't yet looked at the single byte instructions, SHIFT and ROTATE. RESET and CANCEL, then load a data byte by using 11000100 PUSH 11110000 PUSH. The data byte 11110000 has been chosen as one which will be easily recognised again. Now for the next trick, set up 00011100 (SR) and PUSH three times. This instruction is the SHIFT RIGHT instruction — we can view the effect by using 11001000 PUSH 00000001 PUSH. As you'll see, the block of 1's has been right-shifted three places in its byte. This is an instruction which makes binary multiplication possible — but we're not going to try it on this machine! Another shift instruction, shift-with-carry/link (SRL) will put the bit in position 7 of the status register. Load up again with the same byte, 11110000, and shift right by using 00011100 and two PUSH operations. Now set the CY/L bit to 1 by using 00000011 PUSH, and put this bit into the accumulator by using SRL, 00011101 PUSH. View in the usual way.

The result shows that the block of 4 1's has been right-shifted by three places (two SR, one SRL) and the 1 from the carry/link has been moved into the highest order of the byte.

The ROTATE–RIGHT (RR) instruction also shifts bits around, bit by bit, but with a difference. Load up the data byte 00110011 by using the sequence 11000100 PUSH 00110011 PUSH. Now set up the RR code, 00011110 and use PUSH twice. Display the result in the usual way, and you'll find that the bits which were shifted out of the lowest places in the byte have now been moved into the highest places. A modified instruction, code 00011111, takes the carry/link bit into this chain, so that bit D0 is moved to CY/L, the bit in CY/L is moved to D7, and all the other bits on the accumulator are moved one place right on each RRL instruction. These shift and rotate instructions are particularly useful when four bits of a byte are to be selected for a hexadecimal display, since we can choose either the higher four or the lower four by suitable shift or rotate instructions.

An Advanced Machine

There are some facilities and instructions we haven't used, notably the interrupt system, because a complete run-through needs a number of steps which are better demonstrated on a more-advanced test-bed. The more advanced test-bed, as far as we're concerned, is the MK14, and we'll start on that next month. If you haven't yet received yours, or haven't yet assembled it, have patience — the articles will keep for a bit!

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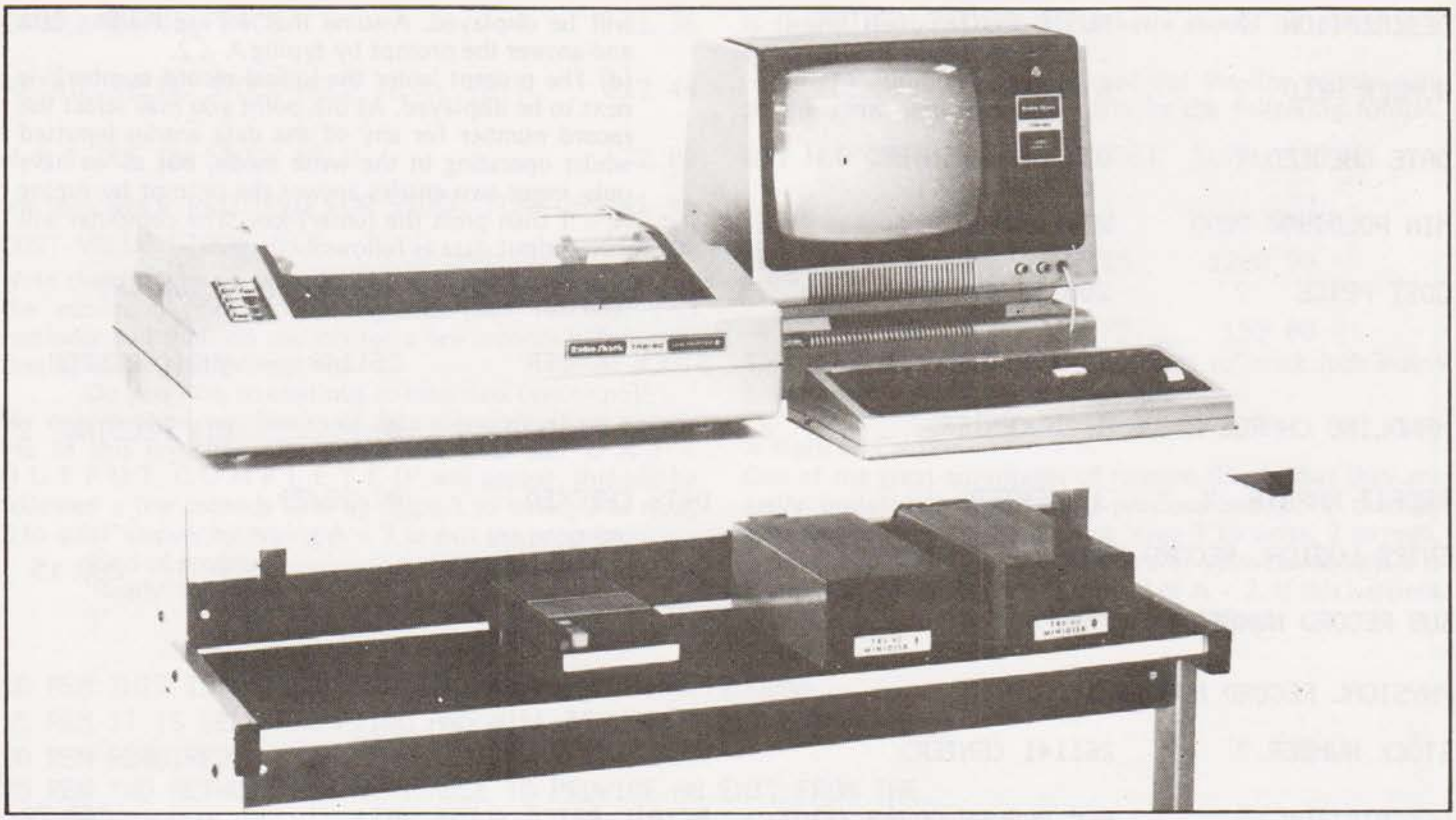
STOCK CONTROL



A small business application for 16K TRS-80

This program which is written in TRS-80 level II disk BASIC, is another example of the use of the random file utility. It is simple to use and data is passed very quickly to and from the buffers. Full use is made of the provision for converting numeric values with the MKI$, MKS$, CVI and CVS functions so as to make maximum use of the 256 bytes available in each buffer. Integers are converted to occupy 2 bytes and single precision numbers to 4 bytes prior to fielding.

The program is self prompting, easy to use and gives a page format display on the VDU of the data relevant to each stock item. When in the 'read' mode a print-out is also given on the line printer which identifies logical record numbers to stock items, it also prints the quantities held of each item, the minimum holding, the item cost (each), the total stock cost value, and the total nett retail value. A reminder is given when the minimum holding quantity has been reached.

The minimum equipment requirements required to operate this program are as follows:—

```
(A) TRS-80 16K LEVEL II WITH VISUAL
    DISPLAY UNIT

(B) FLOPPY DISK DRIVE UNIT

(C) EXPANSION INTERFACE

(D) LINE PRINTER
```

Note: Two floppy disk drives are preferred, one to accommodate the system diskette (especially if you are fortunate enough to have NEWDOS) the other can then be used solely for the program and data storage.

Operation

After entering the listed program via the keyboard, check for accuracy then save on disk using the file name 'STOCK/EVL'

1. Writing data.

(a) Switch on the line printer and set (print switch) to 'PRINT'.

(b) Load the program from disk then 'LIST' to see if it has loaded correctly. If all is in order type 'RUN' then press the (enter) key.

(c) The prompt 'type 1 to write, 2 to read, 3 to quit' will be displayed. As this is the initial run of the program the 'WRITE' mode should be selected by typing A − 1 in answer to the prompt then press the (enter) key.

(d) The prompt 'enter logical record number' is next to be displayed, answer this by typing A − 1 (as this will be the first data entry), then press the (enter) key.

(e) The computer should now (run) as per the sample listing given below, prompting for entries whenever necessary.

```
SAMPLE LISTING OF DATA ENTRY FOR
LOGICAL RECORD NO. 1.

TYPE 1 TO WRITE, 2 TO READ , 3 TO QUIT ?
1 <ENTER>

SUB RECORD NUMBER 0

PHYSICAL RECORD NUMBER 1

STOCK NUMBER ?        261140 <ENTER>
```

```
DESCRIPTION  ?          MUSIC CENTRE <ENTER>

NUMBER HELD  ?          6 <ENTER>

DATE CHECKED ?          07/28/79 <ENTER>

MIN HOLDING  ?          2 <ENTER>

COST PRICE   ?          200.15 <ENTER>

V.A.T %      ?          15 <ENTER>

HANDLING CHARGE % ?     1.25 <ENTER>

PROFIT MARGIN  %  ?     33 <ENTER>

ENTER LOGICAL RECORD NUMBER ? 2 <ENTER>

SUB RECORD NUMBER 1

PHYSICAL RECORD NUMBER 1

STOCK NUMBER ?          261141 <ENTER>

DESCRIPTION  ?          REC. PLAYER GC240 <ENTER>

NUMBER HELD  ?          4 <ENTER>

DATE CHECKED ?          07/28/79 <ENTER>

MIN HOLDING  ?          4 <ENTER>

COST PRICE   ?          39.75 <ENTER>

V.A.T %      ?          15 <ENTER>

HANDLING CHARGE % ?     1.25 <ENTER>

PROFIT MARGIN  % ?      33 <ENTER>

ENTER LOGICAL RECORD NUMBER ? 0 <ENTER>
```

Note 1. We have assumed here that all our data has been entered and have answered the above prompt by typing in A – 0 (zero). The prompt 'type 1 to write, 2 to read, 3 to quit' will be displayed, answer by typing A – 3 to exit press the (enter) key, and when the 'end of program' (ready) is displayed withdraw the diskette and store in a safe place.
However, should you wish to enter the 'READ' mode, answer the prompt by typing A – 2 then press the (enter) key. Follow the procedure given at paragraph 2.

2. Reading data from disk.
(a) Switch on the line printer and set 'print switch' to 'PRINT'. (This assumes printer not already on).
(b) Load the program 'STOCK/EVL' from disk, then list. If it has loaded correctly type 'RUN' then press the (enter) key.
(c) The prompt type 1 to write, 2 to read, 3 to quit will be displayed. Assume that we are reading data and answer the prompt by typing A – 2.
(d) The prompt 'enter the logical record number?' is next to be displayed. At this point you may select the record number for any of the data entries inputted whilst operating in the write mode, but as we have only input two entries answer the prompt by typing A – 1 then press the (enter) key. The computer will then output data as follows:

```
ENTER LOGICAL RECORD NUMBER ?  1 <ENTER>

STOCK NUMBER          261140      MUSIC CENTRE

NUMBER HELD           6           MIN HOLDING  2

DATE CHECKED          07/28/79

COST PRICE (EACH)                         200.15

VAT (PERCENT)         15

HANDLING CHARGE  %    1.25

PROFIT MARGIN    %    33

RETAIL PRICE (LESS VAT)                   268.70

V.A.T. DUE AT 15 %                         40.31

GROSS RETAIL PRICE                        309.01

RETAIL VALUE STOCK HELD (EXCL VAT)       1612.20

V.A.T. DUE ON STOCK HELD                  241.83

COST VALUE OF STOCK HELD                 1200.90

DO YOU WISH TO CONTINUE TO READ DATA
(YES OR NO) ?

YES <ENTER>

STOCK NUMBER          261141    REC. PLAYER GC240

NUMBER HELD           4           MIN HOLDING  4

DATE CHECKED          07/28/79

COST PRICE (EACH)                          39.75

V.A.T  %              15

HANDLING CHARGE %     1.25

PROFIT MARGIN %       33

RETAIL PRICE (LESS VAT)                    53.36

V.A.T DUE AT 15%                            8.00
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```
GROSS RETAIL PRICE                               61.36

RETAIL VALUE STOCK HELD (EXCL VAT)              213.44

V.A.T DUE ON STOCK HELD                          32.02

** RE-ORDER REQUIRED FOR STOCK ITEM 261141 **
COST VALUE STOCK HELD                           159.00
```

Note that in this case a reminder is displayed to indicate that the minimum holding quantity has been reached. This reminder will flash on and off for a few seconds before continuing to the next prompt viz.

Do you wish to continue to read data (yes or no)?

We only entered two blocks of data therefore, if we answer yes to this prompt, the screen will clear and 'D A T A O U T P U T C O M P L E T E D' will appear, this will be followed a few seconds later by 'type 1 to write, 2 to read, 3 to quit?' answer by typing A – 3 to exit the program.

'End of program'
'Ready'
')'

is finally displayed and the diskette should be stored in a safe place for future use.

In addition to visual read out the line printer will, at the same time print-out data in the following format.

```
QTY HLD  MIN HDG  ITEM COST  TOTAL STOCK

                    EACH     COST VALUE
6          2       200.15     1200.90


4          4        39.75      159.00
```

This identifies logical record numbers to stock item numbers, and gives other useful information.

A Word Of Caution

One of the great advantages of random files is that they are easily updated by overwriting previous entries, so then an incorrect answer to the prompt 'type 1 to write, 2 to read, 3 to quit?' will result in the erasure of your stored data if it is answered by typing A – 1 instead of A – 2. If this happens type A – 0 to the next prompt and start afresh.

```
10 REM THIS IS A STOCK CONTROL AND EVALUATION PROGRAM
15 REM IT IS SELF PROMPTING AND WILL REQUEST INPUT DATA WHEN
20 REM REQUIRED.
25 REM TWO METHODS ARE AVAILABLE TO PROVIDE AN EXIT FROM THE
30 REM PROGRAM :-
35 REM   1. TO THE PROMPT 'ENTER LOGICAL RECORD NUMBER' ANSWER
40 REM      BY TYPING A - 0 (ZERO) IF NO MORE DATA IS TO BE
45 REM      ENTERED.
50 REM   2. TO THE PROMPT 'TYPE 1 TO WRITE,2 TO READ,3 TO QUIT'
60 REM      ANSWER BY TYPING A - 3.
65 REM RIGID ADHERENCE TO THIS PROCEDURE WILL ENSURE PROTECTION
70 REM OF DATA PREVIOUSLY ENTERED.
75 REM ENTER ITEM STOCK NUMBER USING A 6 FIGURE FORMAT, (NO
80 REM SPACES).
85 REM ENTER ITEM DESCRIPTION USING A MAXIMUM OF 18 CHARACTERS
90 REM (OR LESS).
95 REM DELETE ALL REM STATEMENTS WHEN PROGRAM FAMILIARISATION
100 REM IS COMPLETE. THIS ACTION WILL CONSERVE MEMORY.
105 PRINT:CLS:PRINT
110 PRINT"  ** STOCK CONTROL AND EVALUATION PROGRAM **  "
125 FOR I = 1 TO 500:NEXT I:CLS
130 LPRINT"LR #";TAB(8)"STOCK #";TAB(17)"QTY HLD";TAB(27)"MIN HDG";
135 LPRINT TAB(37)"ITEM COST";TAB(49)"TOT. STOCK";TAB(62)"TOT. NETT"
140 LPRINT TAB(39)"EACH";TAB(49)"COST VALUE";TAB(62)"RETAIL VAL"
150 LPRINT" "
160 PRINT:CLEAR3000:CLS:CLOSE
170 PRINT:INPUT"TYPE 1 TO WRITE, 2 TO READ, 3 TO QUIT";N
180 OPEN "R",1,"EVAL"
190 ON N GOTO 200,400,990
200 PRINT:INPUT"ENTER LOGICAL RECORD NUMBER ";LR:PRINT
210 IF LR = 0 THEN 160
220 GOSUB 800:PR=INT((LR-1)/5)+1
230 GET 1,PR:PRINT"PHYSICAL RECORD NUMBER ";PR:PRINT
240 PRINT"STOCK NUMBER";TAB(20);:INPUT N$:LSET NS$ = N$
250 PRINT"DESCRIPTION";TAB(20);:INPUT E$:LSET ES$ = E$
260 PRINT"NUMBER HELD";TAB(20);:INPUT H%:LSET HD$ =MKI$(H%)
```

The TRS-80 tractor fed printer, suitable for business stationery.

```
270 PRINT"DATE CHECKED";TAB(20);:INPUT T$:LSET TK$ = T$
280 PRINT"MIN HOLDING";TAB(20);:INPUT M%:LSET MN$ = MKI$(M%)
290 PRINT"COST PRICE";TAB(20);:INPUT C!:LSET CP$ = MKS$(C!)
300 PRINT"V.A.T (PERCENT)";TAB(20);:INPUT V%:LSET VT$=MKI$(V%)
310 PRINT"HANDLING CHARGE %";TAB(20);:INPUT H!:LSET HC$=MKS$(H!)
320 PRINT"PROFIT MARGIN %";TAB(20);:INPUT P%:LSET PT$ = MKI$(P%)
330 PUT 1,PR:GOTO 200
400 PRINT:INPUT"ENTER LOGICAL RECORD NUMBER ";LR
410 IF LR = 0 THEN 160 ELSE 450
420 PRINT:CLS:PRINT CHR$(23)"DATA OUTPUT COMPLETED"
430 FOR I = 1 TO 500 : NEXT I
440 CLS:GOTO160
450 GOSUB 800:PR=INT((LR-1)/5)+1
460 GET 1,PR
470 V$ = "#####.##"
480 IF VAL(NS$) = 0 THEN 420 ELSE 490
490 H=CVS(HC$):P=CVI(PT$):X=CVI(HD$):Y=CVI(MN$):Z=CVS(CP$)
500 V=CVI(VT$): H=H/100:P=P/100:V=V/100
510 U=INT((Z+Z*H+Z*P)*100+.5)/100
520 S=INT(U*V*100+.5)/100:R=INT(U*X*100+.5)/100
530 Q=INT(X*Z*100+.5)/100
540 PRINT"STOCK NO. ";TAB(20);NS$;TAB(32);ES$
560 PRINT"NUMBER HELD";TAB(20);X;TAB(32)"MIN HOLDING    ";Y
570 PRINT"DATE CHECKED";TAB(20);TK$
590 PRINT"COST PRICE (EACH)";TAB(40)USING V$;Z
600 PRINT"V.A.T %";TAB(20);V*100
610 PRINT"HANDLING CHARGE %";TAB(20);H*100
620 PRINT"PROFIT MARGIN %";TAB(20);P*100
630 PRINT"RETAIL PRICE (LESS V.A.T)";TAB(40)USING V$;U
640 PRINT"VAT DUE AT ";V*100;"%";TAB(40)USING V$;S
650 PRINT"GROSS RETAIL PRICE";TAB(40)USING V$;U+S
660 PRINT"RETAIL VALUE STOCK HELD(EXCL VAT)";TAB(40)USING V$;R
670 PRINT"V.A.T DUE ON STOCK HELD";TAB(40)USING V$;INT(U*X*V*100+.5)/100
680 PRINT"COST VALUE STOCK HELD";TAB(40)USING V$;Q
```

```
690 GOSUB 1000
700 IF X=Y OR X<Y THEN GOSUB 900
710 LR = LR+1
720 PRINT:INPUT"DO YOU WISH TO CONTINUE TO READ DATA (YES OR NO)";F$
725 IF F$ = "YES" THEN 410
726 IF F$ = "NO" THEN 160
727 PRINT" **** PLEASE ANSWER EITHER YES OR NO ****":GOTO720
740 END
800 SR=LR-5*INT((LR-1)/5)-1
810 FIELD 1,SR*50 AS D$,6 AS NS$,18 AS ES$,2 AS HD$,10 AS TK$,2 AS MN$,4 AS CP$,2 AS VT$,
    4 AS HC$,2 AS PT$
820 RETURN
900 FOR J=1TO15:PRINT@896,"**** RE-ORDER STOCK ITEM ";NS$;" ****";:FOR K=1 TO 50:NEXT
902 PRINT@896,"                                                              ":FOR K=1TO50:NEXTK,J

904 PRINT@832,"COST VALUE STOCK HELD";TAB(40)USING V$;Q
910 LPRINT"      ***** RE-ORDER REQUIRED FOR STOCK ITEM ";NS$;" *****"
920 RETURN
990 PRINT:CLS:PRINT"      ****  END OF PROGRAM  ****      "
995 CLOSE
999 END
1000 LPRINT TAB(0);LR;TAB(8);NS$;TAB(17);X;TAB(27);Y;
1005 LPRINT TAB(37) USING V$;Z;:LPRINT TAB(49) USING V$;Q;
1010 LPRINT TAB(62) USING V$;R
1015 RETURN
```

computing today

WHAT TO LOOK FOR IN THE JANUARY ISSUE. ON SALE DECEMBER 14TH.

LOSING YOURSELF IS FUN

Next month we present what we hope is the ultimate maze game. The programs designs a maze in plan and then projects it in 3D so you actually walk through it, hopefully finding the way out! Written in BASIC for the Triton it is fully documented for conversion to other systems. Once you get into your micro you may never get out so beware.

GAMING GAMES IN MICRO FORM

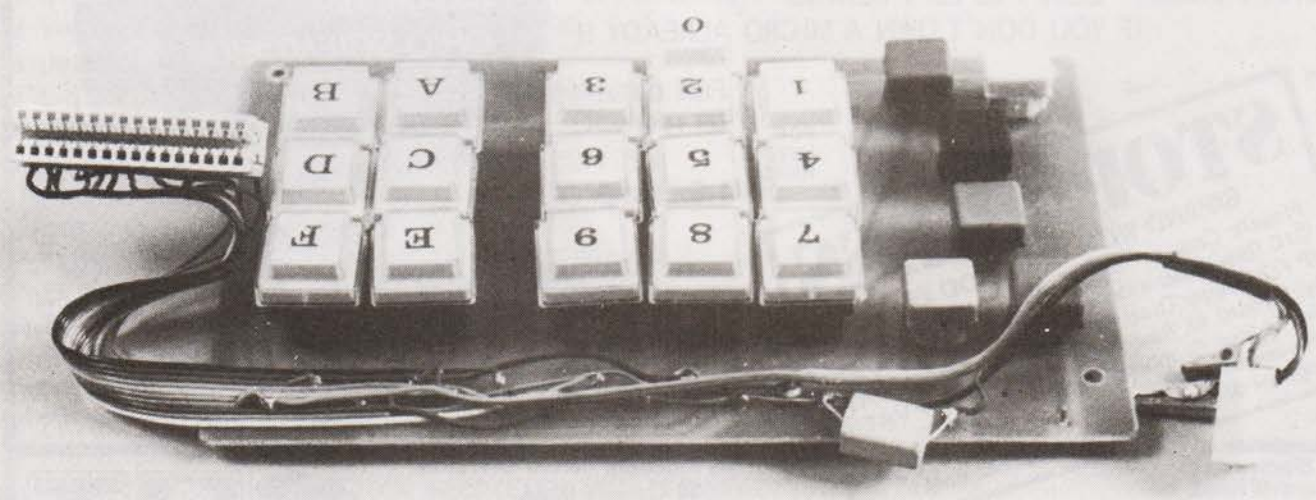
The famous game of Pontoon has been written in BASIC and we present it in next month's issue. A better way to spend Christmas afternoon than watching repeats, on telly that is. Gamble your 50p on next months's issue for hours of fun.

SAILING A CALCULATOR

A brand new game of naval strategy combining air to sea operations with conventional submarine attacks. You will have to guide your submarine through the Pacific avoiding submarine hunters and sinking ships. A must for the sea-dogs amongst you.

KEY TO SUCCESS

If you are following our MPU's by Experiment series this project is for you. A simple add-on keyboard to replace the one on the Mk 14 is a must for easy programming, and this simple project will save those stubbed fingers.



What we printed, where and when since our birth in ETI

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Robert Harvey

A reader's experience in the microcomputer jungle

Three months ago I knew nothing about computers. Now, after just nine weeks of proud ownership, I am writing programs, not to professional standards of course, but they do work. My biggest problem was choosing the right system in the first place.

The Beginning Of The Search

It all started when I read a magazine article about silicon chips. For around £500 one could buy a computer which would play chess, process statistical information and even help with income tax computations. I was hooked!

Finding out about the computers available was difficult for a person with a non-technical background, such as myself. The brochures I acquired were almost incomprehensible to the layman — full of bits and bytes, ROMs and RAMs. This may seem a trivial complaint, but I suspect that quite a few readers of this magazine are not too comfortable with all the jargon. I've still not figured out what a monitor does.

Nevertheless, after ploughing through them and two issues of ETI and Computing Today, I discovered enough to make a short list of the features I was interested in. These included a powerful but easy to use BASIC and good overall design. The availability of a wide range of cheap software was important to me as a beginner. Price, graphics capability and general ease of use were my other main criteria. I also wanted the ability to expand the system as my knowledge grew.

Specify The Requirement

This may seem a fairly obvious specification, yet I found it a useful yardstick for comparison. It enabled me to dismiss three well-known systems right away. An experienced programmer would doubtless have had a completely different set of priorities and might well have reached a different decision. The important thing is to formulate what you want in advance.

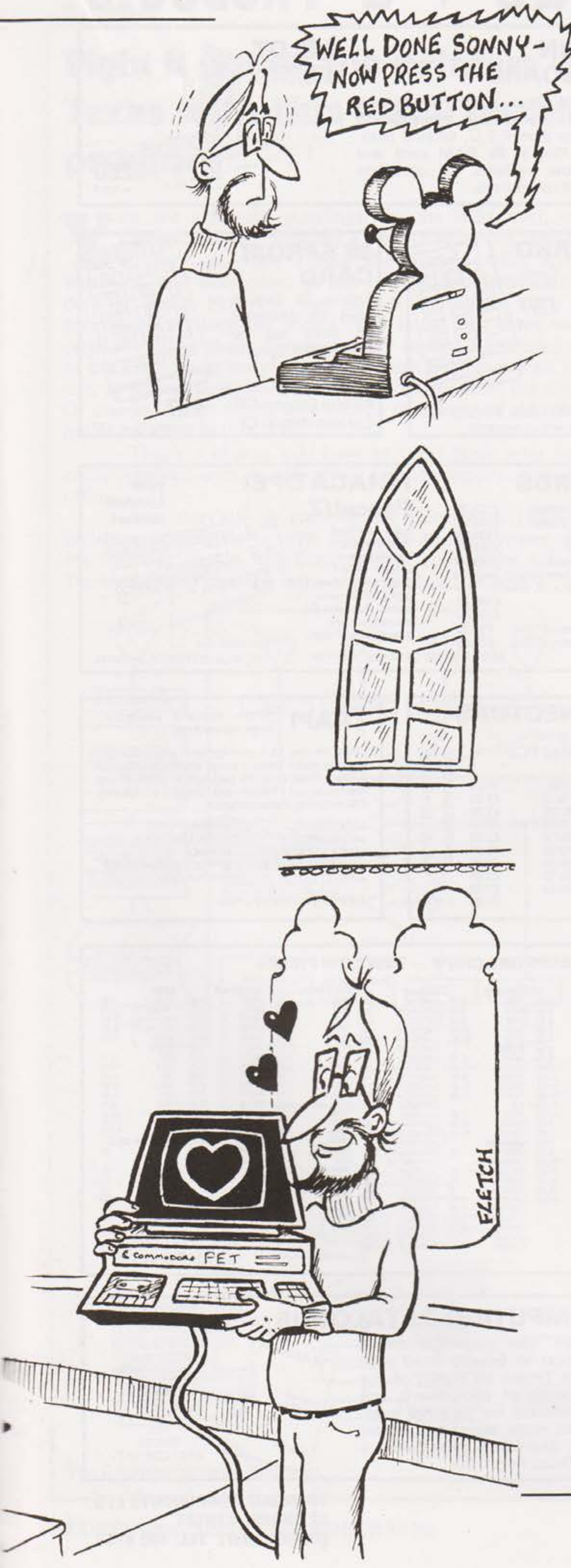
Next I visited four computer shops in London's Tottenham Court Road, where I saw demonstrations of six systems costing £1200 or less for the basic package.

The demonstrations, with the honourable exception of Eurocalc, consisted in each case of a quick recital of jargon followed by a run through a program which I did not always fully understand. Fortunately, I was left alone with the three computers which came closest to my ideal specification.

The Available Choice

The first was an Apple II costing £985 for a smart attache case type keyboard unit which actually contained the whole computer. It had marvellous colour graphics, which I found a little difficult to use. These, the salesman assured me, could easily be mastered with practice. However, when the cost of the cassette recorder and various bits and pieces to attach it to a colour television had been added, the total cost came to £1,500 — more than I could really afford to spend. A speech synthesiser was about to be released also — too bad!

I played a good game of Microchess on a Tandy TRS-80. My immediate impression was that the computer system was less well designed than the others, although I liked the feel of the keyboard. The keyboard unit itself, cassette deck and TV monitor, were all strung together with



a mass of wires. Expansion involved yet another box. I noticed that the salesman also had to fiddle with the volume and tone controls in order to get the tapes to load satisfactoryily. Even with my limited book-acquired knowledge of programming, it was clear that the TRS-80's level one BASIC was vastly inferior even to that of the Exidy Sorcerer. For an additional charge, level two BASIC could be installed on the TRS-80, but even so the Apple and PET basics seemed easier to use. For example, editing a mistake in a PET program, it was necessary only type the correct character over the erroneous one and then press the return key. With most of the other systems one had to re-type the whole line.

The last machine I tried was the Commodore PET. Every store I visitied had racks displaying a wide variety of PET programs by Commodore and PETSOFT. I was told that there was relatively little software available for the other systems.

Love At First Byte?

I fell in love with the PET instantly. It looks so futuristic for one thing, self contained in its own steel case. I started to tell the salesman that the TRS-80 had a much better keyboard than the PET's fiddly little calculator type keys. "A traditional complaint, sir" he said "come this way". And there, at the back of the shop, was a smart looking PET with a proper, typewriter style, keyboard. It was the new 16K model retailing at £680 inc. VAT, plus £54 for the cassette recorder.

Looking down my list it was clear that the PET came closest to meeting my needs. This has been borne out by subsequent experience, although I still also like the Apple. In retrospect, I would probably add another item to my list: documentation. Commodore's is poor, although I subsequently bought PETSOFT's work books at £15 per set of 5. These filled the need.

Instead of a discount the shop gave me some free software. Neither of the Commodore games programs worked properly. I eventually discovered this was due to a change in the type of ROM memory chips used. The PETSOFT Addressbook and Restaurant Finder programs ran perfectly, and I subsequently ordered some more programs from them by telephone, using my Barclaycard. These arrived by first class post the following day.

Learning The Language

I have read several books on BASIC, of which Illustrating BASIC by Donald Alcock was the most helpful. On the whole though I find the magazines more helpful. In addition to 'Computing Today', I like the Commodore magazine, which seems expensive at £10 for 5 issues a year. There is also an independent PET User Group who publish a bimonthly newsletter; membership is just £3 p.a. I have also seen newsletters produced by the TRS-80 and Apple Groups which seem equally good.

Undoubtedly the most productive learning method has been sheer trial and error. I have had quite a lot of help from other PET users and owners of different systems. For this reason I would recommend membership of the Amateur Computer Club, who have local groups operating in most parts of the country.

Conclusion

Looking back, I regret the absence of an independent information source giving unbiassed advice on the different systems available. Right now I am attempting to write a program that will attempt to match people and applications to the right micro system. It looks like being a long job!

M. Lindsell

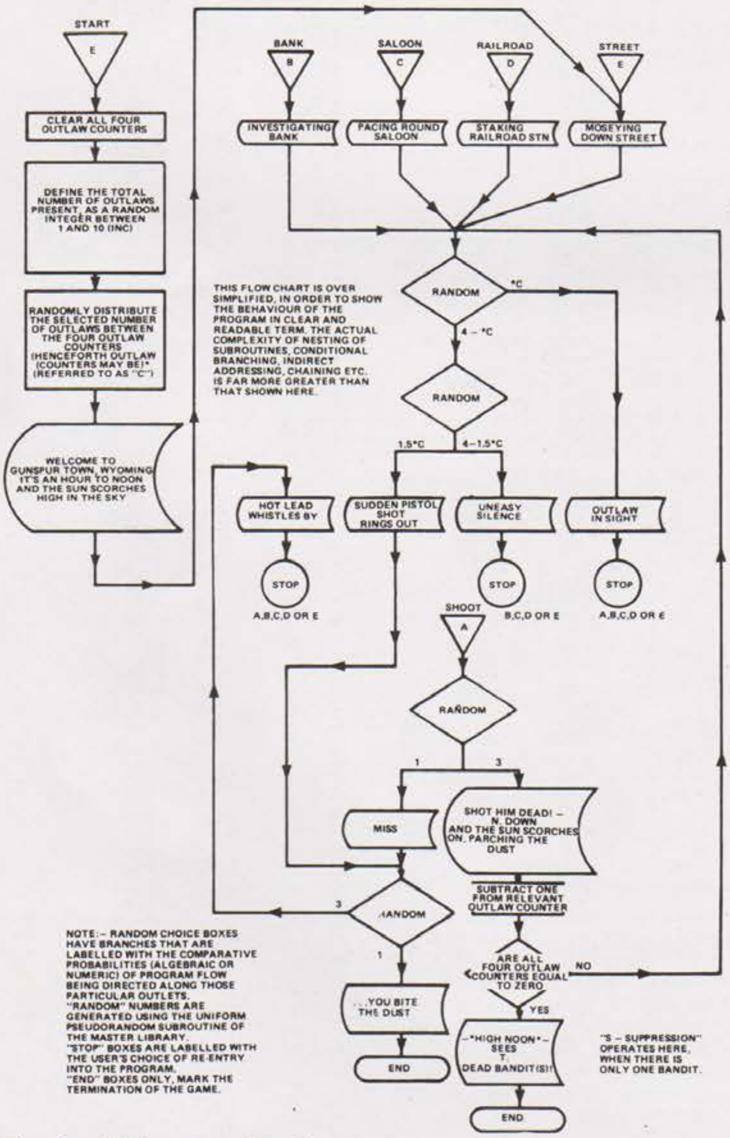
HIGH NOON

Fight it out on the printers of Texas with this pistol packin' program

You are a famous gunslinger, in the Wild West, and you're currently pursuing a band of infamous outlaws. So far, you have chased them many miles across Wyoming, and have come at last to a final showdown in a deserted town. However, you do not know how many of them have survived the ordeal. You know that there were originally 10 of them. But how many remain alive holed up in the town is anybody's guess, although there is at least one left, as several shots have been heard coming from the town. Of course, all ten might very well be still alive and able waiting to pack you full of lead.

That's a chance you have to take! Both sides have come prepared with an effectively limitless supply of ammunition.

You start off by entering the main street. The only buildings in fit state to offer any cover to the outlaws, are, the Railroad station, the Bank, and of course, the Saloon. The street itself provides some cover in places, as well.



The simplified program flowchart.

So, there's nothing for it, but to search each of these three buildings, and the street, in the hope of spotting the outlaws before they see you. Of course if you do spot an outlaw first, then you can get a shot in before he knows you're there. However, the other side might become aware of your presence first, in which case you will hear a pistol shot resound before you have the chance to do anything about it. Obviously, the greater the number of outlaws in a particular location, the greater your chances are of spotting one of them first, although, by the same token, the greater their chances of getting in the beginning shot. Gunfights proceed with shots coming alternatively from you and the enemy; each time you hear a bullet whistle safely by, you have the opportunity to return fire, or duck aside unseen into another building, to have a look around there. A similar choice is open to you when you first spy out a hidden gunman. On average, being a crack marksman, your slugs find their targets, three out of every four shots, compared with one out of four, for the bandits.

Sometimes, though, a disquieting silence may hang over the place you are searching, and you can see no sign of any bandits. This may well mean that the place is deserted, or that you have finished off the last outlaw hiding out there. It may, however, mean that the bandits are just lying low, and haven't noticed you yet. Remaining in that location, or subsequently returning to it, may have a quite different result.

Meanwhile, the sun climbs higher in the sky, moving towards its zenith. Will high noon see the whole gang dead, or will they get you first? ....

Machine

Texas instruments TI-59 Calculator, attached to PC/100A, B or C print cradle, with Master Library Module installed (supplied with calculator).

The program is best recorded on two magnetic cards, (both program memory, and some data registers, have to be entered at the start of play).

The complete program listing.

```
000  76 LBL
001  16 A'
002  42 STO
003  07  07
004  69 OP
005  37  37
006  73 RC*
```

```
007  07  07
008  69  OP
009  04  04
010  69  OP
011  37  37
012  43  RCL
013  07  07
014  76  LBL
015  17  B'
016  42  STO
017  07  07
018  73  RC*
019  07  07
020  69  OP
021  03  03
022  69  OP
023  37  37
024  76  LBL
025  18  C'
026  73  RC*
027  07  07
028  69  OP
029  02  02
030  69  OP
031  37  37
032  73  RC*
033  07  07
034  69  OP
035  01  01
036  69  OP
037  05  05
038  92  RTN
039  76  LBL
040  19  D'
041  36  PGM
042  15  15
043  71  SBR
044  88  DMS
045  92  RTN
046  76  LBL
047  86  STF
048  05  5
049  06  6
050  69  OP
051  00  00
052  98  ADV
053  17  B'
054  98  ADV
055  25  CLR
056  91  R/S
057  76  LBL
058  22  INV
059  43  RCL
060  10  10
061  69  OP
062  04  04
063  05  5
064  03  3
065  98  ADV
066  17  B'
067  69  OP
068  00  00
069  06  6
070  09  9
071  42  STO
072  07  07
073  18  C'
074  98  ADV
075  19  D'
076  65  ×
077  04  4
078  95  =
079  32  X:T
080  01  1
081  77  GE
082  68  NOP
083  61  GTO
084  37  P/R
085  76  LBL
086  11  A
087  19  D'
088  65  ×
089  04  4
090  95  =
091  32  X:T
092  03  3
093  77  GE
094  69  OP
095  69  OP
096  00  00
097  03  3
098  00  0
099  02  2
100  04  4
101  03  3
102  06  6
103  03  3
104  06  6
105  69  OP
106  02  02
107  69  OP
108  05  05
109  98  ADV
110  19  D'
111  65  ×
112  04  4
113  95  =
114  32  X:T
115  01  1
116  77  GE
117  68  NOP
118  76  LBL
119  37  P/R
120  02  2
121  04  4
122  16  A'
123  98  ADV
124  25  CLR
125  91  R/S
126  76  LBL
127  69  OP
128  69  OP
129  00  00
130  69  OP
131  20  20
132  01  1
133  02  2
134  17  B'
135  01  1
136  06  6
137  03  3
138  02  2
139  04  4
140  03  3
141  03  3
142  01  1
143  69  OP
144  04  04
145  43  RCL
146  00  00
147  69  OP
148  06  06
149  98  ADV
150  06  6
151  08  8
152  16  A'
153  05  5
154  00  0
155  42  STO
156  07  07
157  02  2
158  02  2
159  00  0
160  00  0
161  03  3
162  07  7
163  02  2
164  03  3
165  01  1
166  07  7
167  69  OP
168  03  03
169  43  RCL
170  27  27
171  69  OP
172  04  04
173  18  C'
174  98  ADV
175  01  1
176  22  INV
177  74  SM*
178  48  48
179  43  RCL
180  32  32
181  50  I×I
182  85  +
183  43  RCL
184  37  37
185  50  I×I
186  85  +
187  43  RCL
188  42  42
189  50  I×I
190  85  +
191  43  RCL
192  47  47
193  50  I×I
194  95  =
195  32  X:T
196  01  1
197  77  GE
198  88  DMS
199  61  GTO
200  24  CE
201  76  LBL
202  68  NOP
203  02  2
204  08  8
205  16  A'
206  76  LBL
207  98  ADV
208  25  CLR
209  98  ADV
210  98  ADV
211  98  ADV
212  98  ADV
213  91  R/S
214  76  LBL
215  88  DMS
216  02  2
217  52  EE
218  09  9
219  22  INV
```

```
220  52 EE
221  69 OP
222  04  04
223  01  1
224  05  5
225  98 ADV
226  17 B'
227  98 ADV
228  69 OP
229  00  00
230  03  3
231  06  6
232  01  1
233  07  7
234  01  1
235  07  7
236  03  3
237  06  6
238  69 OP
239  02  02
240  69 OP
241  05  05
242  01  1
243  08  8
244  42 STO
245  07  07
246  43 RCL
247  00  00
248  99 PRT
249  32 X:T
250  01  1
251  67  EQ
252  95  =
253  06  6
254  00  0
255  33 X²
256  85  +
257  76 LBL
258  95  =
259  43 RCL
260  19  19
261  95  =
262  69 OP
263  03  03
264  18 C'
265  61 GTO
266  98 ADV
267  76 LBL
268  10 E'
269  25 CLR
270  42 STO
271  32  32
272  42 STO
273  37  37
274  42 STO
275  42  42
276  42 STO
277  47  47
278  19 D'
279  65  ×
280  01  1
281  00  0
282  85  +
283  01  1
284  95  =
285  59 INT
286  42 STO
287  00  00
288  76 LBL
289  81 RST
290  19 D'
291  65  ×
292  04  4
293  95  =
294  59 INT
295  65  ×
296  05  5
297  85  +
298  03  3
299  02  2
300  95  =
301  42 STO
302  07  07
303  01  1
304  74 SM*
305  07  07
306  97 DSZ
307  00  00
308  81 RST
309  69 OP
310  00  00
311  02  2
312  98 ADV
313  17 B'
314  07  7
315  16 A'
316  98 ADV
317  06  6
318  04  4
319  16 A'
320  06  6
321  08  8
322  16 A'
323  69 OP
324  00  00
325  43 RCL
326  14  14
327  69 OP
328  01  01
329  43 RCL
330  16  16
331  69 OP
332  02  02
333  43 RCL
334  08  08
335  69 OP
336  03  03
337  69 OP
338  05  05
339  98 ADV
340  76 LBL
341  15  E
342  05  5
343  85  +
344  76 LBL
345  14  D
346  05  5
347  85  +
348  76 LBL
349  13  C
350  05  5
351  85  +
352  76 LBL
353  12  B
354  03  3
355  02  2
356  95  =
357  42 STO
358  48  48
359  98 ADV
360  16 A'
361  98 ADV
362  76 LBL
363  24 CE
364  69 OP
365  00  00
366  19 D'
367  65  ×
368  04  4
369  95  =
370  32 X:T
371  73 RC*
372  48  48
373  77  GE
374  86 STF
375  19 D'
376  65  ×
377  04  4
378  95  =
```

```
379  32 X:T        3230243122.   06   3637132624.   38
380  73 RC*                 0.   07   3122003513.   39
381  48  48        1700362645.   08   2427353213.   40
382  65  X                  0.   09   1600363731.   41
383  01  1         3623323700.   10            0.   42
384  93  .         2324300016.   11   3032361745.   43
385  05  5         1713167320.   12   2431220016.   44
386  95  =               2051.   13   3243310036.   45
387  77  GE        2324222300.   14   3735171737.   46
388  22 INV        3132323151.   15            0.   47
389  76 LBL        2431003723.   16            0.   48
390  89  π             161713.   17   3231573313.   49
391  69 OP         1600141331.   18   3515232431.   50
392  00  00        1624370073.   19     36411616.   51
393  05  5         2332370027.   20   1731003324.   52
394  09  9         1713160043.   21   3637322700.   53
395  98 ADV        2324363727.   22   3241372713.   54
396  17 B'         1736001445.   23   4300243100.   55
397  98 ADV        4040404532.   24   3624222337.   56
398  25 CLR        4100142437.   25     41311713.   57
399  92 RTN        1700372317.   26   3645003624.   58
                     16413637.   27   2717311517.   59
DATA MEMORIES,       24314217.   28   2437653600.   60
ALSO TO BE ENTERED 3637242213.   29   1331002332.   61
AT THE START OF THE 3724312200.  30   4135003732.   62
GAME.              1413312600.   31     31323231.   63
          0.    00          0.   32   1331160037.   64
4317271532.     01 3313152431.   33   2317003641.   65
3017003732.     02 2200353241.   34   3100361532.   66
2241313633.     03 3116003613.   35   3515231736.   67
4135003732.     04 2732323100.   36     35243122.   68
4331574345.     05          0.   37   3600324137.   69
```

User Instructions

1. To start the game, press 2nd E', and go to 2
2. (a) If "UNEASY SILENCE" is printed (after introductory messages) then, if it is desired to try bank, press B. Saloon, press C and go to 2. Railroad Station, press D, or remain in street, press E.
   (b) If an outlaw is in sight, the above options are open, in addition to that of shooting at him – press A and go to 3.
3. If a sudden pistol shot rings out, or if you miss on shooting, then if you bite the dust, the game has obviously ended, but if hot lead whistles by, then you have another chance, and so, go to 2(b).
4. If "–*HIGH NOON*–" etc, is printed, the game is terminated, all the bandits are dead, and you have won!

```
    WELCOME TO
GUNSPUR TOWN, WYOMING

IT'S AN HOUR TO NOON
AND THE SUN SCORCHES
HIGH IN THE SKY

MOSEYING DOWN STREET

OUTLAW IN SIGHT
```

A

```
SHOT HIM DEAD!-
        1.     DOWN
```

```
AND THE SUN SCORCHES
ON, PARCHING THE DUST

 UNEASY SILENCE
```

C

```
PACING ROUND SALOON

 SUDDEN PISTOL SHOT
 RINGS OUT
...YOU BITE THE DUST
```

```
      WELCOME TO
GUNSPUR TOWN,WYOMING


IT'S AN HOUR TO NOON
AND THE SUN SCORCHES
HIGH IN THE SKY


MOSEYING DOWN STREET


 UNEASY SILENCE
```

C

```
PACING ROUND SALOON


OUTLAW IN SIGHT
```

A

```
      MISS

HOT LEAD WHISTLES BY
```

A

```
SHOT HIM DEAD!-
          1.      DOWN

AND THE SUN SCORCHES
ON,PARCHING THE DUST


OUTLAW IN SIGHT
```

A

```
SHOT HIM DEAD!-
          2.      DOWN

AND THE SUN SCORCHES
ON,PARCHING THE DUST


 UNEASY SILENCE
```

B

```
 INVESTIGATING BANK
```

```
OUTLAW IN SIGHT
```

A

```
SHOT HIM DEAD!-
          3.      DOWN.

AND.THE SUN SCORCHES
ON,PARCHING THE DUST


 UNEASY SILENCE
```

D

```
STAKING RAILROAD STN


 UNEASY SILENCE
```

C

```
PACING ROUND SALOON


 UNEASY SILENCE
```

D

```
STAKING RAILROAD STN


OUTLAW IN SIGHT
```

A

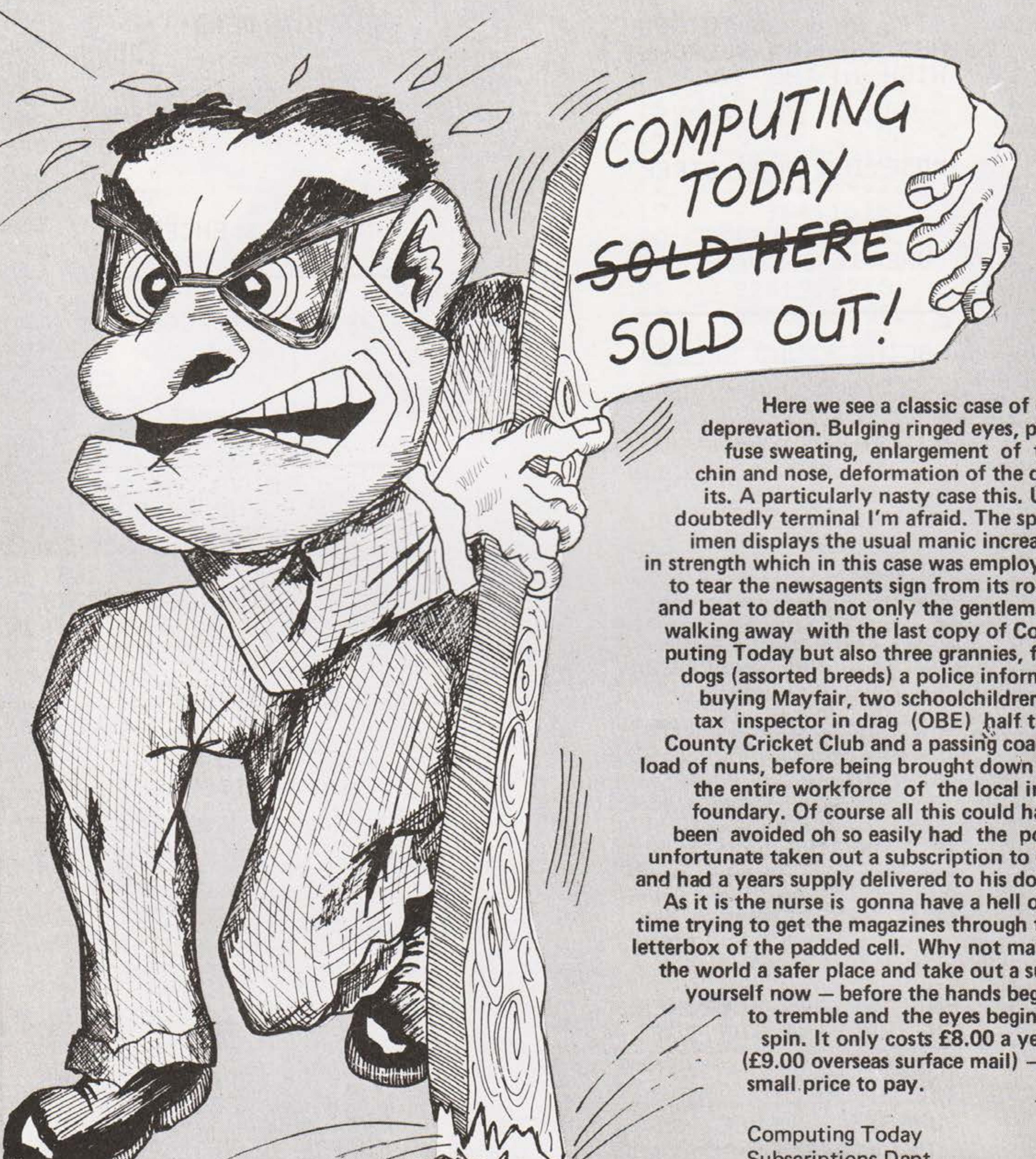
```
SHOT HIM DEAD!-
          4.      DOWN

AND THE SUN SCORCHES
ON,PARCHING THE DUST


   -*HIGH NOON*-

       SEES
         4.
   DEAD BANDITS!
```

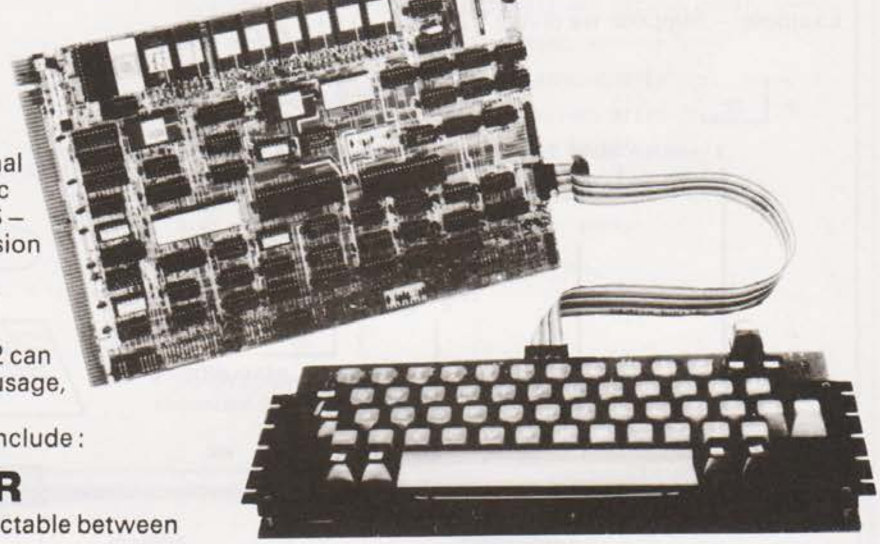
ARRRGGGHHH.....



Here we see a classic case of CT deprevation. Bulging ringed eyes, profuse sweating, enlargement of the chin and nose, deformation of the digits. A particularly nasty case this. Undoubtedly terminal I'm afraid. The specimen displays the usual manic increase in strength which in this case was employed to tear the newsagents sign from its roots and beat to death not only the gentleman walking away with the last copy of Computing Today but also three grannies, five dogs (assorted breeds) a police informer buying Mayfair, two schoolchildren, a tax inspector in drag (OBE) half the County Cricket Club and a passing coach load of nuns, before being brought down by the entire workforce of the local iron foundary. Of course all this could have been avoided oh so easily had the poor unfortunate taken out a subscription to CT and had a years supply delivered to his door. As it is the nurse is gonna have a hell of a time trying to get the magazines through the letterbox of the padded cell. Why not make the world a safer place and take out a sub yourself now — before the hands begin to tremble and the eyes begin to spin. It only costs £8.00 a year (£9.00 overseas surface mail) — a small price to pay.

Computing Today
Subscriptions Dept.,

M.A.P. PO Box 35,
Bridge Street,
Hemel Hempstead,
Hertfordshire.

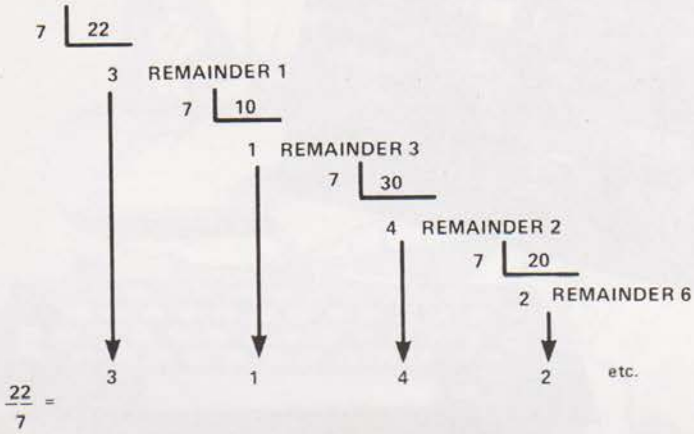


Trevor Lusty

We solve one and give you another! Square trianges, would you believe

The method used is that of normal long division. An integer multiple of the denominator is found which is usually a little smaller than the exact quotient. A zero is added to the remainder (multiplication by ten) and the process is repeated to find the next decimal place.

Example:– Suppose we divide 22 by 7,



As the printout (Figure 1) shows, 22/7 is a fair approximation to π. Can you find a better one?

Our Solution

The program listing (Figure 2) and flowchart (Figure 3) give full details of the method. When implemented in Tiny or Integer BASIC the INT function is not required, but obviously the numerator and denominator are then limited to integer values.

All real values will ultimately produce a recurring sequence and this normally occurs quickly, as for 22/7, but this is not always the case as 1001/997 shows. Of particular interest is the quotient of 99991 divided by 99989 ––– if you find the point at which this begins to repeat itself, please let me know.

Square Triangles?

The triangle for a full-sized snooker table holds 15 red balls. If the triangle were a little smaller only 10 red balls would fit, if it were a little larger 21 red balls would go in it. However, for none of these numbers would the balls exactly fill a square frame ––– 36 balls will do both.

```
       0
      0 0                 000000
     0 0 0                000000
    0 0 0 0               000000
   0 0 0 0 0              000000
  0 0 0 0 0 0             000000
 0 0 0 0 0 0 0            000000
0 0 0 0 0 0 0 0
```

What is the next number of balls which will have the property of fitting both a triangular and a square frame?

Write a program to find all such numbers less than 1,000,000

N.B. Before trying to solve problem 3, run this program on your computer.

```
10 PRINT SQR( 400) – 20
20 PRINT SQR( 900) – 30
30 PRINT SQR(2500) – 50
40 END
```

The program should print 3 zeros, if it does not, be careful!

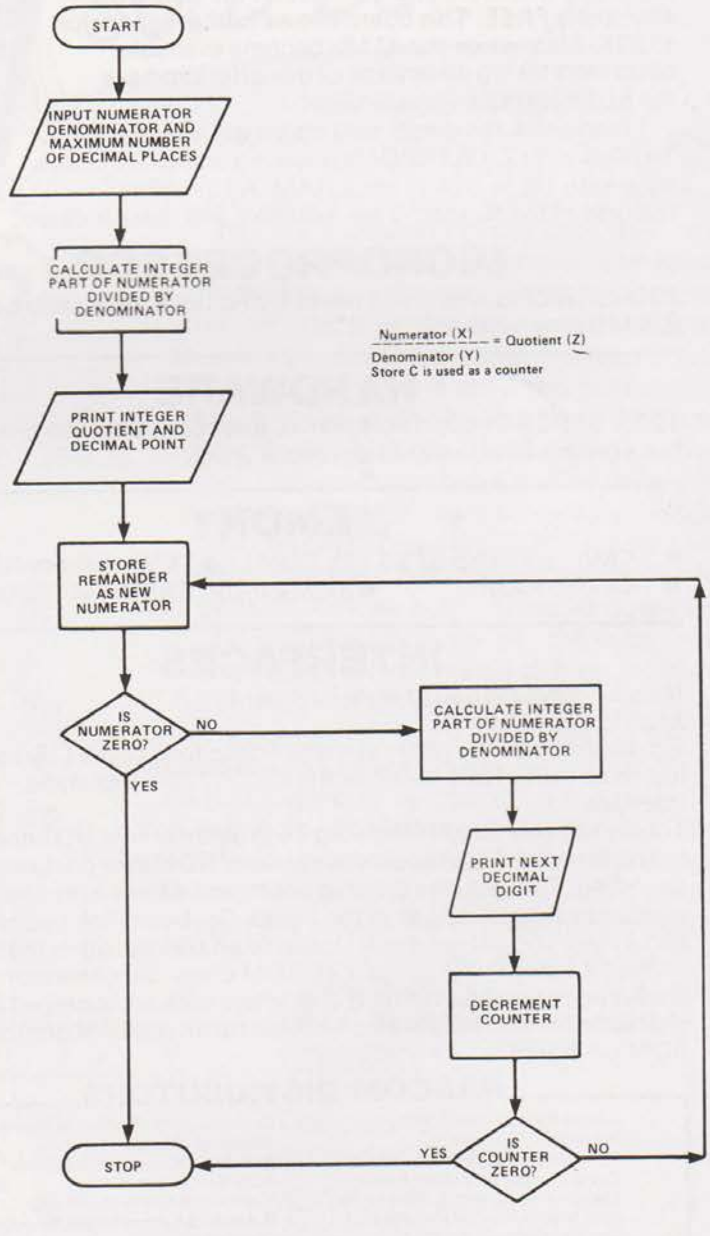


Fig.3. Flowchart for the program.

```
DIVISION-UNLTD.



FIRST NUMBER  1001

SECOND NUMBER  997

HOW MANY DECIMAL PLACES  100

 1 . 0  0  4  0  1  2  0  3  6  1  0  8  3  2  4  9  7  4  9  2
 4  7  7  4  3  2  2  9  6  8  9  0  6  7  2  0  1  6  0  4
 8  1  4  4  4  3  3  2  9  9  8  9  9  6  9  9  0  9  7  2
 9  1  8  7  5  6  2  6  8  8  0  6  4  1  9  2  5  7  7  7
 3  3  1  9  9  5  9  8  7  9  6  3  8  9  1  6  7  5  0  2


DIVISION-UNLTD.



FIRST NUMBER  22

SECOND NUMBER  7

HOW MANY DECIMAL PLACES  20

 3 . 1  4  2  8  5  7  1  4  2  8  5  7  1  4  2  8  5  7  1  4
```

Fig.1. Sample printout from the program.

```
10 REM ******************************
20 REM *                            *
30 REM * PROGRAM --- DIVISION-UNLTD. *
40 REM ,*                           *
50 REM * PROGRAMMED IN 'PET' BASIC  *
60 REM *                            *
70 REM * TREVOR L LUSTY     11/8/79. *
80 REM *                            *
90 REM ******************************
1000 PRINT
1010 PRINT "FIRST NUMBER ";
1020 INPUT X
1030 PRINT "SECOND NUMBER ";
1040 INPUT Y
1050 PRINT "HOW MANY DECIMAL PLACES ";
1060 INPUT C
1070 PRINT
2000 REM  *****  CALCULATE INTEGER PART OF DIVISION  *****
2010 LET Z=INT(X/Y)
2020 REM  *****  PRINT INTEGER PART AND DECIMAL POINT  *****
2030 PRINT Z;".";
2040 REM  *****  CALCULATE REMAINDER  *****
2050 LET X=10*(X-Z*Y)
2060 REM  *****  STOP --- IF THE REMAINDER IS ZERO  *****
2070 IF X=0 THEN 2170
2080 REM  *****  CALCULATE NEXT DECIMAL DIGIT  *****
2090 LET Z=INT(X/Y)
2100 REM  *****  PRINT NEXT DECIMAL DIGIT  *****
2110 PRINT Z;
2120 REM  *****  SUBTRACT ONE FROM THE COUNTER  *****
2130 LET C=C-1
2140 REM  *****  HAVE WE FINISHED ?  *****
2150 IF C>0 THEN 2050
2160 REM  *****  LINE-FEED  *****
2170 PRINT
2180 REM  *****  STOP  *****
2190 END
```

Fig.2. Program listing for the Division Unlimited program.

Mr A.P. Stephenson

PET IMPRESSIONS

One of our regular contributors presents a close look at the PET from the owner's point of view

I have recently bought a PET. This is of course a classical understatement because people just don't go out and buy a PET; they read about it, compare it with other makes, rearrange finances and above all, think of a good excuse for justifying its purchase. Reading the glossy sales literature on PETS, APPLES, TRS 80's, etc. etc., the impression is gained that a home without a computer is no home at all, branding the occupant as an unfortunate member of the underpriviliged classes deserving of state aid.

Justification, The Name Of The Game

It is unfortunate that the writers of these brochures place so much emphasis on the delights of game playing at the keyboard. There is nothing wrong in using a highly sophisticated system to play noughts and cross, neither is it wrong to use a Rolls Royce for delivering bags of coal. It does seem to the writer (who it must be admitted is old and inclined to be a trifle crusty) that there is something grotesque in such practices, amounting to almost a deliberate act of discourtesy to the design team responsible for the birth of the computer. There is also a practical economic reason why such emphasis could become a double edged weapon by reducing the sales potential. The manufacturers should realise that the purchase of a home computer could mean the postponement of a new lounge suite or abandoning the prospect of a couple of weeks in Majorca. Although I am fortunate in having an understanding wife it is highly probable that the domestic harmony in many households could be endangered if it was a case of new furniture or the PET, particularly if the reasons given centred around the ability of the contraption to play Star Trek or Moon Landings.

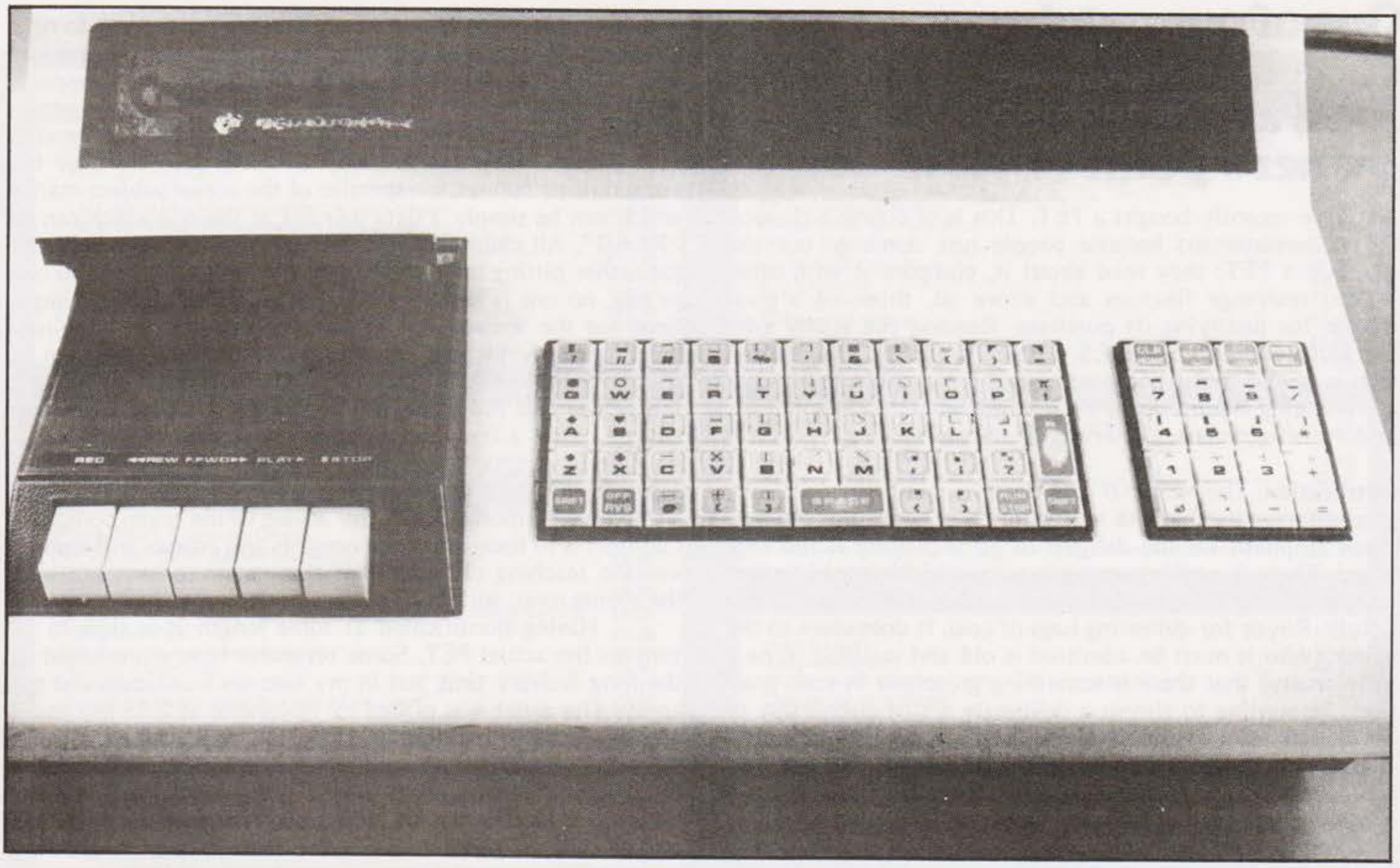
A computer can do many things, in fact anything you know how to tell it to do! As far as family life is concerned however, its role as a teaching machine offers the greatest return for the capital invested. Teachers (the normal human variety) must surely realise there are areas in any syllabus where their services are not strictly necessary. They are needed to guide, to place concepts in correct perspective and to explain difficult points which may arise but when it comes to teaching mere *facts* they are more expensive and less efficient than a computer. Assuming literacy, no student needs the presence of a teacher in the classroom to learn the names of the rivers in a given country or to learn the atomic numbers of the chemical elements or the dates of the English and French kings or the SI system of physical units. Not only is the teacher superfluous but the students are often bored with the monotony and inwardly praying for the bell to ring. On the other hand, a computer which presents questions and asks for the answers from the keyboard is in many respects superior to a teacher, particularly if it finally gives the score, the time taken and a few words of encouragement at the end.

Such programs are easy to write and will have the same outline format, irrespective of the actual subject matter which can be simply a data pair list at the end which can be "READ". All children under the age of sixty enjoy learning (or rather pitting their wits) at the keyboard. There is no one to nag, no one is looking over your shoulder, no one is impatient for the answer . . . in fact the psychological environment is nearly ideal. I recently wrote a simple program to test knowledge of foreign currency. Apart from the Franc, the Dollar and the Mark, my previous knowledge was virtually nil. After a few fascinating hours at the keyboard, I can now smugly remark that the Albanians use the Lek which can be quite an impressive conversation piece if fired during an opportune moment. So, my advice to the home computer salesmen is to tone down the noughts and crosses and emphasise the teaching capabilities if they want to compete with the dining room suite.

Having pontificated at some length it is time to return to the actual PET. Some reviewers have complained of the long delivery time but in my case such criticism did not apply. The order was placed by telephone at 2.15 pm and it was delivered to the door and installed by 6.30 the same evening. It is fair to point out that the firm MICRODIGITAL of Brunswick St, Liverpool is only a few miles across the water but this in itself is not an explanation because previous telephone calls to other firms in the same area were received with indifference and vague remarks like "difficult to get hold of you know". Good service deserves praise and MICRODIGITAL as far as I am concerned certainly deserve some.

Impressions

The first impression on switching on the PET is the truly remarkable clarity and sharpness of the displayed characters, almost as if they are painted by a laser beam and without a trace of jitter. The second impression is a feeling of irritation with Commodore for giving a misleading impression that the user has an "8K memory" to play with. The first message from the PET which is displayed a few seconds after switch-on is "7167 BYTES FREE" which by elementary arithmetic is only slightly less than 7K. The explanation of course is that the operating system in ROM needs some breathing space to work in; this it conveniently swipes from the 8K RAM which ethically should belong exclusively to the user. The irritation is only temporary however because a second glance at the crisp display soothes it away: a kind of video balm. Due to a lifelong interest in electronics hardware my first job was to investigate the innards by removing four large



screws on the base and folding back the hinged cover to expose the logic. It was reassuring to discover that everything that should be unplugable is. The keyboard, the cassette recorder, the video umbilical cord, the power supply and most important of all, the major multipin IC's are all movable without the intervention of the cursed soldering iron. The mains transformer appears to be quite respectable in terms of sheer bulk and a glance at the specification markings plus a quick, and hopefully correct, calculation indicates that one could safely pinch about an amp from it without initiating a thermal chain reaction. The voltage regulators on the other hand do run a little warm so any thought of utilising the spare amp direct from them should be rejected. There are only two PC boards. One, in the lower compartment handles the entire computer logic and the RAM/ROM support with edge connecters for the external ports projecting through to the outside world. The other board caters for the various analogue demands of the CRT display. The general impression is one of sound engineering which has been influenced by the desire for high reliability and ease of access. In fact the latter quality is strikingly evident because of the large lumps of empty space which could quite easily house another large PCB without severe cramming. It must be a disturbing, almost frightening, experience for a traditional computer engineer used to minis or mainframes to believe that so much computing power lies inside such a demure little box.

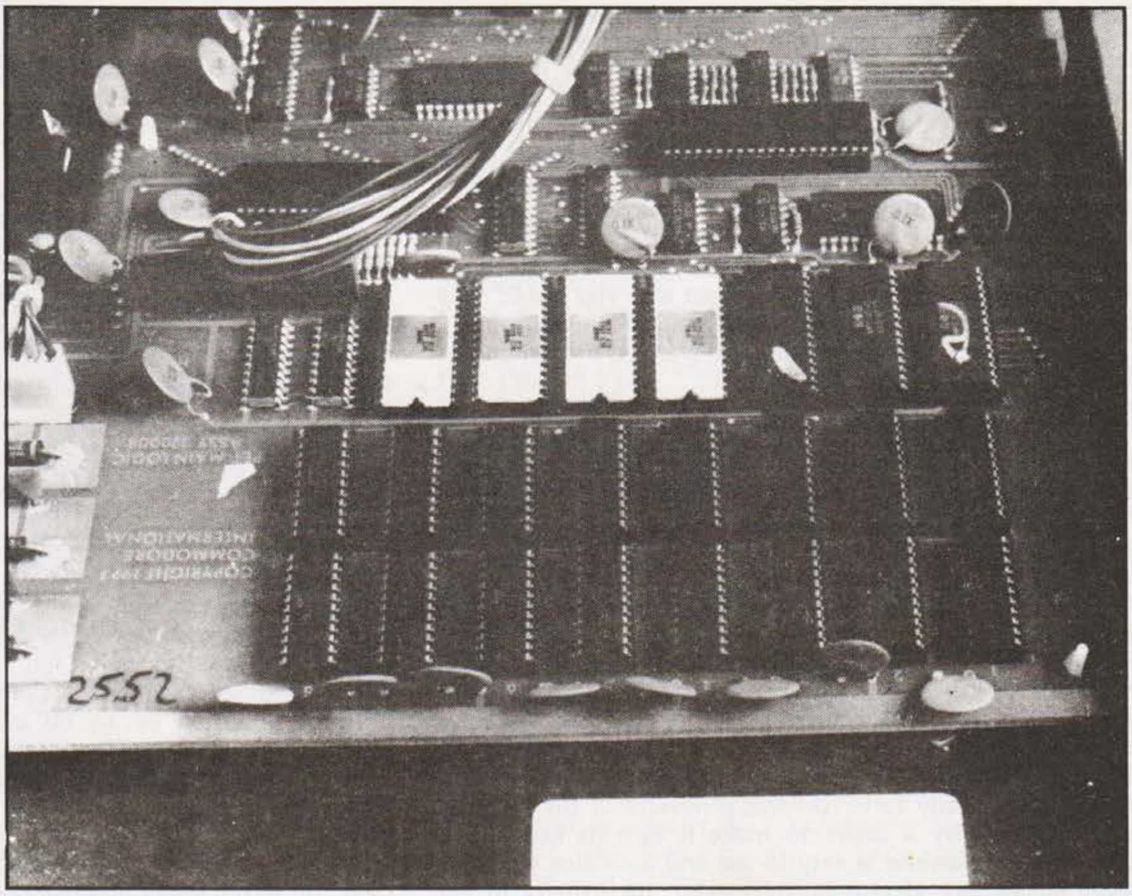
This brings us to the well-discussed question of the PET keyboard . . . the "computer style" (not the "Typewriter Style" used on the 16K varieties). As far as the touch typist is concerned there is no doubt that the keyboard is a shocker. The keys are spaced only two thirds the normal "standard" and although the QWERTY layout is preserved the conventional staggering isn't. So much for the touch typist's view. But how many of us are touch typists? And how many would ever really take the trouble to learn it . . . in spite of the oft-quoted advice that it is easy. My own prowess on a normal typewriter is somewhere in between the "one-fingered-prodder" and the skilled touch typist, in fact a typical amateur keyboard basher who has to *look* at the keyboard before striking. Now it may be that my metacarpals are abnormal but the strange fact is that I can use the PET keyboard *faster* than my typewriter! Dare I suggest that the particular spacing of the conventional keyboard came about by accident without the assistance of ergonomic principles? It may be that the professional touch typist only thinks the typewriter layout is perfect because she or he has never been trained on anything else. For example, there is no doubt that the piano keyboard spacing was indeed a mistake in the beginning. The most beautiful interval on the musical scale is the tenth and yet very few performers can stretch it because the keys are just a shade too far apart for comfort. But this subject is of course sheer heresy and could lead to an avalanche of abuse from the "establishment". In any case it appears to me that the actual entering of a program (or data) occupies a relatively minor proportion of the time spent on computing exercises; it probably takes twenty times longer to write the program than to enter it afterwards. In view of this, I believe that the criticism of the PET computer-style keyboard is a little harsh and unjustified, as far as the computer hobbyist is concerned.

Taping The Problem?

Another much discussed question is the PET cassette recorder which apparently caused a good deal of frustration at one time. There are two kinds of PETs, the so called "early PETs" and the others. I don't know at the moment whether my species is early or not-early since the chronological details

PET IMPRESSIONS

Two of the much maligned areas of the PET. The original keytops wear out, Commodore have sent us a replacement set, and the keyboard spacing and layout would make a touch typist shriek. The cassette unit has been much improved but still needs regular cleaning and de-magnetizing.

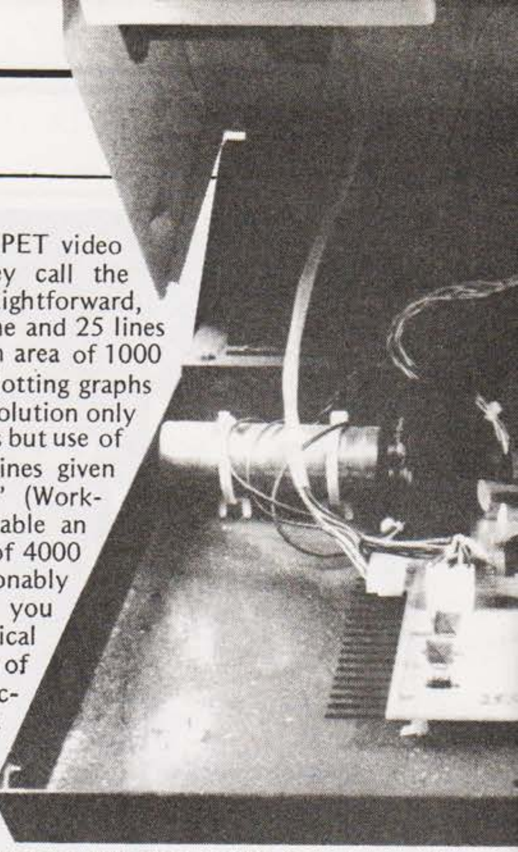


The memory areas of PET are well laid out. The first two rows are the RAM chips, with the lower end on the right. Behind are the BASIC and monitor ROMs. All are socketed for easy replacement should anything die on you.

of the transition point remain misty. Perhaps I am lucky because LOAD and SAVE have never yet resulted in the dreaded message "LOAD ERROR" on my machine. When it came to inputting long streams of DATA (rather than programs) I was not so lucky because there is no doubt that the blocks are either written too close or conversely, the tape motor speed is wrong because the programs frequently crash causing funny little groups of colons to be painted at random screen positions. However, study of one of the Workbooks ("PET CASSETTE No 4") published by TIS points out that thsi tendency is due to some sort of software "mistake" in the part of the operating system ROM which handles the INPUT and PRINT#1 commands. Apparently the reliability is improved if the cassette motor is switched on for 0.2 seconds in between blocks and they publish a simple subroutine which handles the problem. Perhaps Commodore may feel they are ethically (if not legally) obliged to replace the ROM. After all, if the statement advertised as PRINT#1 frequently prints colons instead of the required data and crashes, then PRINT#1 should be "repaired". After all, they have already swiped about 1K of our memory, so they have no right to expect us to waste another block of precious RAM to rectify an inherent fault in the operating system. Perhaps Commodore may like to comment on these points?

Manual Discourse

The next grumble is directed at the so-called "PET USERS MANUAL" supplied with the machine. Considering the intention is to instruct the first-time user of a "home" computer in the mysteries of a new art, it fails miserably. Frankly, it is an atrocious document, unworthy of the brilliant piece of engineering it purports to explain. It gives the impression that it was written by an expert who was slightly bored and annoyed he was given the job of explaining it to the common proletariat. It alternates between unnecessary detail and condescending trviality. It was obviously never proof read because there are numerous errors. I wonder if Commodore (or indeed many other manufacturers in the home computing field) realise how damaging are the effects of a slovenly written manual. The advertising campaign indicates that sales are expected from the ranks of the "small businessman". It must be an entertaining sight to watch the face of one of them as he plugs in his PET, and opens the manual expecting to "dash" off a program which will handle all his VAT and other accounting chores. An article appeared recently in a well known trade journal which illustrates the kind of cloud cuckoo land that some people inhabit. Apparently ". . .most businessmen have the initiative and common sense to master a small computer in an hour or so. . .". Assuming such naive faith to be justified one would certainly need a little more than initiative and common sense to battle through the Manual. The alternative is of course to forget programming and buy the software on tape. But here lies another false idea because there is no such thing as *general purpose* software and however much a businessman spends on tapes there will almost inevitably be an awkward twist which is peculiar to his own system. This will require some "slight modification" to the software, which is normally where the real trouble starts. It would be a good idea if the present manual was withdrawn and replaced by a simple account of the principles of computing, a short glossary of terms, and clear, repeat clear, instructions on how to operate the machine. There should also be a straightforward list of the BASIC statements and commands printed on a pull-out card. The teaching of the BASIC language should be left to either a list of recommended books or perhaps the profits could stretch to the inclusion of one free with the machine.



The Language It Talks

The version of BASIC used on the PET is excellent. Pity they couldn't have included the MAT functions but perhaps a plug-in ROM with these and a few more functions may turn up one day. One useful feature is the abolition of the word LET before every assignment statement. It is pleasant to be able to use it or ignore it at will. Another useful time-saving aid is the ability to use "?" instead of laboriously typing out the word PRINT every time. One rather peculiar function included is "POS" which simply tells you where the cursor is! Can't for the life of me fathom out why you would need to know where the cursor is because you can see the thing . . . . but perhaps this is just a failure to grasp its hidden power. No hint of course from the manual . . . but I mustn't start again on that.

An illustration of the foresight of Commodore is the provision of, what is almost certain to become an industry standard, the IEEE-488 general purpose BUS. There have been some discussions on the relative merits of this bus and a "rival" system called the S100 BUS. This argument seems pointless because the two systems are not intended to be in competition. The IEEE-488 BUS is intended to handle peripherals, in fact a maximum of fifteen at one time can be handled. The S100 on the other hand is a MEMORY bus and belongs properly to the mini, rather than the microcomputer environment. It may be some time before PET users will have the courage and acquire the necessary knowhow to exploit the full potential of the IEEE-488 BUS but it will certainly repay future study (after the initial novelty of the PET has been replaced by a desire to make it earn its keep). The USER PORT however is easy to use and providing you have some elementary electronic knowledge, particularly in the field of TTL logic, it should enable the machine to control some very interesting external systems . . . model railways etc. It would be a pity to underuse the full potential of the PET by restricting its working life to number crunching and table printing. One little word of warning may be issued at this point. Always use some form of buffer gate between any of the port pins and the external system, preferably opto-isolators. The conversion of analogue to digital (or vice versa) is accomplished quite cheaply by a couple of Ferranti ZN425E chips and the supporting software should not prove difficult.

Machine Code Lack Disappoints

One disappointment to me was the absence of a machine code monitor; perhaps a full blooded assembler would be asking too much. No doubt these are available on tape but it would have been nice to have found it was already in ROM. There will be several times during program development when the inherent slowness of a BASIC interpreter will cause frustration. It is during such times when the user would be willing to sacrifice the simplicity of a high-level language for the lightning speed of a machine orientated conversation, perhaps a thousand times faster in some cases. Facilities exist already for leaving the shelter of BASIC and nipping into the hard logic world of the machine via the help of the User Subroutine function (USR) but without the help of a monitor it appears to be a tricky kind of operation, this may be due to lack of experience.

The microprocessor used in the PET is a 6502 which is a kind of 'tarted-up' version of the 6800. The single index register has been split into two called the "X" and the "Y" registers and two new addressing modes have been included, pre-indexed and post-indexed. Unfortunately, the second accumulator has been sacrificed in the process which may be considered by some a rather severe restriction.

Display Yourself

The layout of the PET video display (which they call the "TV" display) is straightforward, 40 characters per line and 25 lines giving a total screen area of 1000 printing positions. Plotting graphs on such a limited resolution only yields crude displays but use of some ingenious routines given in the "GRAPHICS" (Workbook 3) by TIS enable an effective resolution of 4000 points which is reasonably tolerable providing you are not a mathematical pundit. The position of the next print character is signalled by a winking cursor, to my mind it winks a little too brightly and is rather distracting; a winking asterisk or full stop would have been adequate. Another example of Commodore's foresight is the inherent provision of an 80 column line which is more standard for commercial printers. Thus, although the video line is only 40 characters, the program memory will allow 80 characters. The ability to display in reverse lighting is very useful for italic text although it is possible to get into some weird fixes until the procedure becomes second nature. To clear the screen under program control we are told to use the "reverse heart" but it is so easy to forget to cancel the "reverse" afterwards that I have decided to use ?CHR$(147) which is a bit longer but less error prone. The special graphics characters are all that Commodore says they are and have been very carefully chosen to enable the most impressive artwork to appear on the display. It does take a lot of practice however before the keys can be controlled to act as a doodling pencil. It is a pity there is no provision for locking the SHIFT key because it would avoid the feeling of strained tendons which could result from an attempt to keep it depressed simultaneously with a character.

Lower case characters can be obtained by POKE 59468,14 but they function as if they were upper case because you have to push the shift key to obtain them. I often wonder why, bearing in mind so many people will use the PET for maths and physics, that Commodore did not include the Greek alphabet set as a pokeable function; but then, as far as I know, no other home computer has this facility.

Expansion For Me

Having spent several hundred pounds on a PET the thought of spending any more fills the mind with horror but nevertheless there will be a nagging desire to own one or two of the fascinating "extras" . . . similar to the hi-fi addict's complex. The greatest dream is probably the floppy disk because the ability to have about half a megabyte of backing store capable of delivering the wanted file in about a thousandth of the time it takes the lowly cassette to oblige is almost as fascinating as the tales from the Arabian Nights. Unfortunately they are expensive gadgets even if a single disk drive is considered satisfactory. But there are many reasons why a double disk is virtually an essential. The floppies themselves are prone to wear because they rotate inside their cover and important data should be periodically copied onto

PET IMPRESSIONS

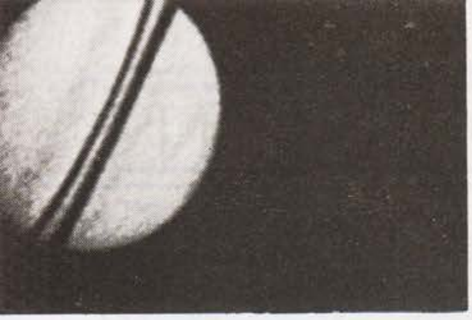
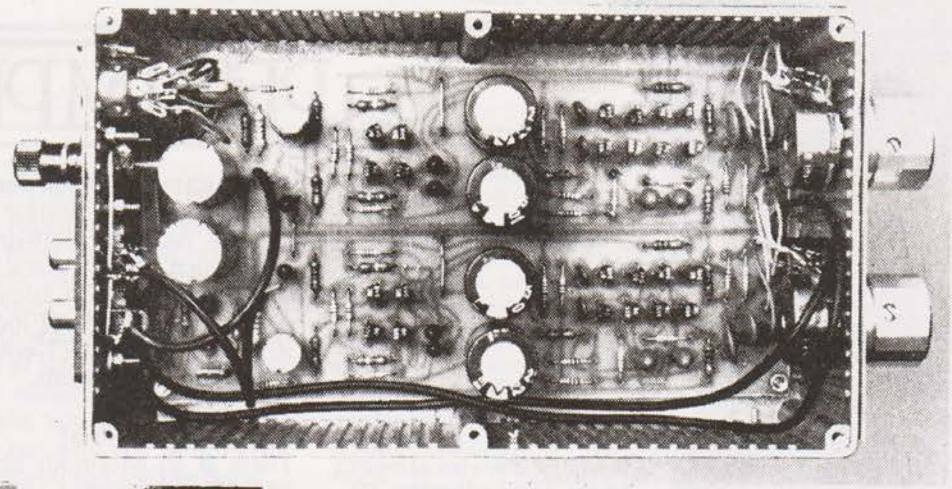
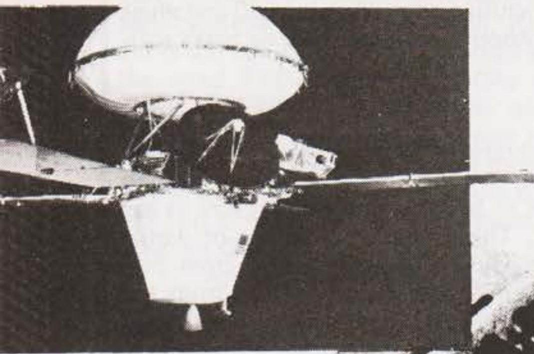
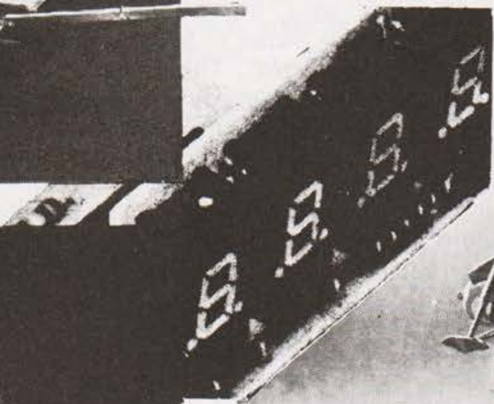
A general internal view of the PET. All the umbilicial cables are terminated in plug/sockets so removal of any section is easily accomplished. The various ports are PCB edge connectors which feed out through slots in the case. The case has a strut built in, which holds the machine open as shown, fitted on the left hand side, a very useful addition.

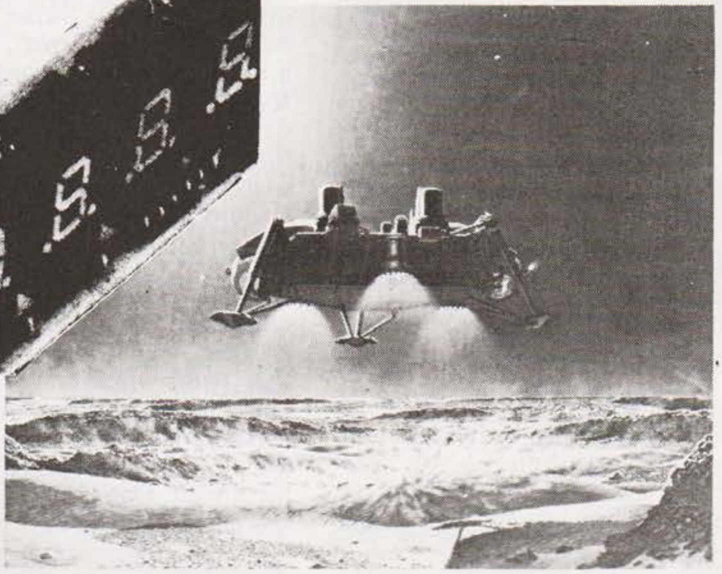
a fresh disk. A single disk drive is at a disadvantage here and a full copy protect via the RAM in small instalments is a lengthy project.

The official PET printer is about £800 which, although probably worth it in terms of spec, is certainly out of reach of many people's pockets. Perhaps it is a trifle over-spec. for the mass market and Commodore might like to consider the production of a cheaper model, with a less sophisticated function repertoire? The first thing I will buy (if of course the Editor accepts this article!) is a second cassette recorder, perhaps the most valuable addition to a PET which doesn't place unnecessary strain on the finances, and makes data file copying a simple exercise. The C2N is obtainable at the VAT inclusive price of about £60 and plugs straight into the PET without any interfacing or extra software support problems.

Software = Laziness?

There is an enormous library of software available for the PET. In some ways, this is a pity because it will tend to influence the new owner to become lazy, turning him or her into a "cassette parrot". There should be an act of parliament forbidding anyone who has bought a PET from purchase of program tapes for a period of one year from the date of owning it! In this way, the owner will have had some time to learn BASIC thoroughly and to have built up a degree of independance and develop a critical attitude to commercial software. At the risk of offending some of the software houses, the price charged for some of their work is downright robbery. To be tied to other peoples programs all the time is waste of the creative potential of the PET. It is far better and yields far more satisfaction to write your own program, even if it does take a few more bytes and uses a few ugly twists which draw tut tuts from the professionals.
Some of my colleagues can't understand why someone like myself, who teaches programming and computers for a living, should want to actually BUY a computer. Sometimes I wonder myself. One thing I can say . . . I don't regret it and very few people who do buy them will.





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7490	—	.28
7492	—	.33
7493	—	.28
7495	72	.40
7496	—	.48
74107	—	.22
74121	—	.23
74122	—	.33
74126	35	—
74141	—	.46
74145	—	.46
74150	—	.58
74151	51	—
74153	—	.43
74154	—	.68
74155	75	.46
74156	—	.43
74157	—	.40
74160	98	.57
74161	—	.56
74162	—	.57
73163	69	.49
74164	—	.60
74165	—	.56
74166	1.69	—
74170	1.31	—
74174	—	.58
74175	—	.58
74180	—	.43
74181	—	1.44
74184	—	1.14
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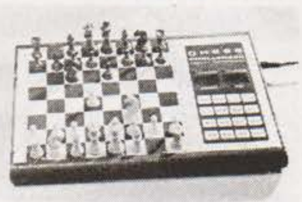

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Tim Orr

SPEECH SYNTHESIS

A talking, talking point or two?

Speech and language have been the natural way of communicating information for thousands of years and writing, particularly in its new form of computer data, is a comparitive newcomer. This results in an interface problem between men and machines. A computer finds it easy to output written data on a VDU screen and to accept data from an ASCII keyboard, but to 'speak' the results and to 'listen' for instructions is enormously more complex. This would, however, be an ideal situation because the computer would literally talk your language. It would also be far more efficient because you can listen at a faster rate than you can read and you can talk at a faster rate than you can type. Also, this natural interface releases the operator from the VDU screen or keyboard, enabling them to perform other tasks. There are several machines presently available that can talk and listen, but before discussing them it would be useful to describe how natural speech is produced.

The Vocal Tract

The vocal tract (Fig.1) is an air-powered sound generating system. When we expel air from the lungs it has to pass around the vocal cords. These are a pair of muscular tissues which may be voluntarily tensioned. When they are so, the airflow causes them to buzz, (just like a reed in a reed instrument), the pitch of the buzz is then acoustically filtered by the rest of the vocal tract, which has some very complex patterns, (Fig.2). In fact the vocal tract looks like a multi-peaked acoustic resonator. The peaks are known as formants and they change position as the tongue hump and lips move to form different sounds. This process is known as mouthing or articulation. This dynamic filtering that changes the vocal cord buzz into speech. Some typical formant frequencies for steady state vowels are given in Fig.3.

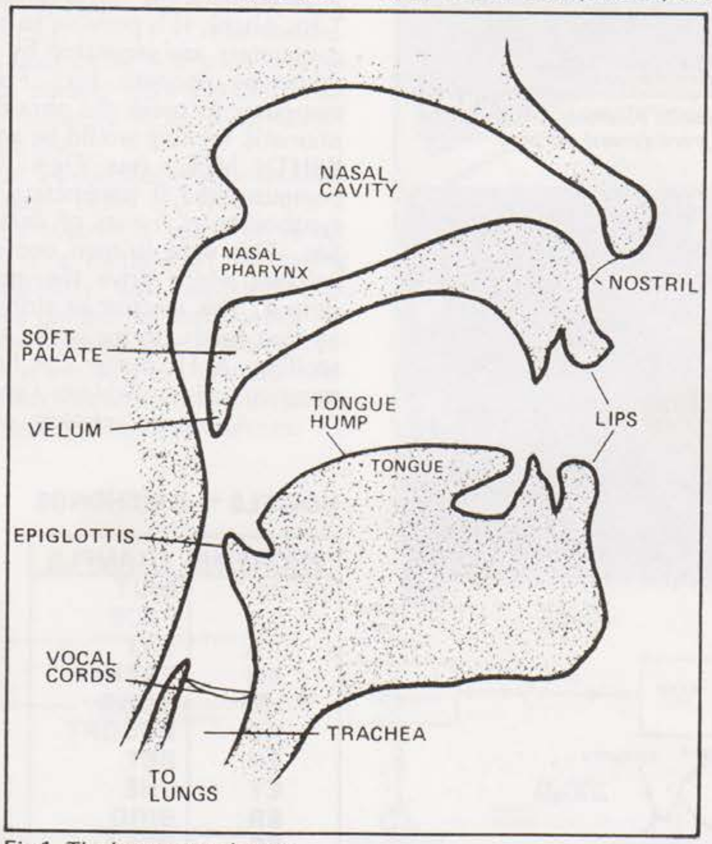


Fig.1. The human vocal tract.

If speech were merely composed of a few steady state vowels it would be quite simple to synthesise. It isn't, there are many other phonetic elements. Take for example the word HOW. This has two sections, an aspired H and then the OW sound which is a vowel glide from the AW vowel (as in down), to the OO vowel (as in too). The vowel glide is known as a dipthong and is generated by rapidly altering the shape of the vocal tract. Some other dipthongs are :— BAY, BUY, BOY and HOE. The aspired H sound is produced by blowing air through the vocal tract whilst mouthing the ER vowel as in BIRD. Note that the vocal cords are not producing a buzz, the sound is made by filtering noise. This type of sound is known as unvoiced; voiced sounds being produced by the vocal cords. Another type of unvoiced sound is the fricative, the 'S' sounds. These are produced by blowing air inbetween the teeth and lips. For example the following word has several fricatives, 'TWELFTHS'.

Nasals are yet another type of phoneme generated by closing the mouth and allowing the sound to exit via the nasal cavity. The last type of sound to be considered is the stop consonant, (a plosive), which is characterised by a sudden opening of the mouth. This produces a period of silence, (a stop), and then as the mouth opens the formants rapidly move towards their target positions. For example, the stop consonant GA starts with a rapid opening of the mouth, the formants moving quickly to take up the position of the AH vowel. If a short noise burst is introduced at the start the phoneme becomes KA instead of GA. A table of phonemes is given in Fig.4. Using this list it is possible to phonetically spell words and phrases, the spelling actually describing the sound structure of the words.

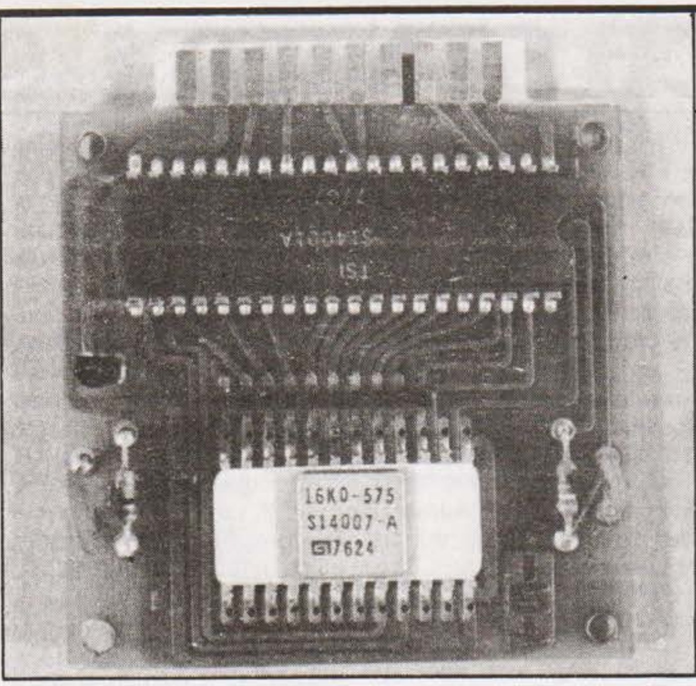
Pitch is often used in speech to impart some information. If a particular word in a sentence needs to be emphasised then the pitch might rise until it reaches that point and then fall, thus stressing that word. Other stress mechanisms are volume and timing.

This brief description of speech generation shows how complex the system is. Machines that talk will also have to perform the same complex tasks.

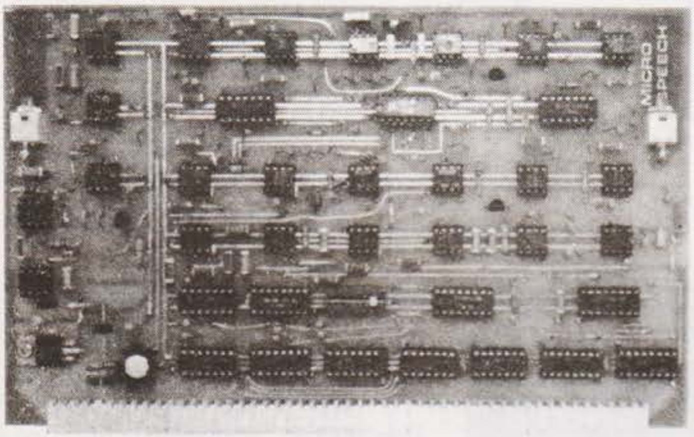
Electronic Speech Production

There are many ways to generate speech electronically. It could simply be converted into a digital code (Fig.5), which could be recalled from a memory when required. This method produces high quality speech, but uses up very large amounts of memory. The speech produced has the same accept and inflection of the original speaker and new speech can simply be entered by a repeat recording. It is possible to store the speech as a series of disconnected words and phrases which can be recalled and reassembled into a variety of phrases. There is a commercial data entry system that operates on this principle, (Fig.6). This is a stock ordering/availability system for garages. Each user has a data entry keyboard/loudspeaker terminal that connectes into the telephone system. When a user wants to order a seat belt say, they phone up the distributor and then type in the part number of the component that they require. A series of 2 tone signals are sent down the telephone line, which are decoded at the other end and the data is sent to the computer stock control. This looks at its memory to see the price and delivery for the part and then selects stored words from a drum storage unit. These words are then strung together to form a sentence which is then spoken to the user at the other end of the system.

Note that the user has to use a keyboard to input information and the speech storage unit has to be a drum because of the vast amounts of data required. Most of the



Telesensory systems speech generation unit. Available as either a 24 word calculator vocabulary or two 64 word general purpose vocabularies. The speech is in ROM.



The Microspeech synthesiser.

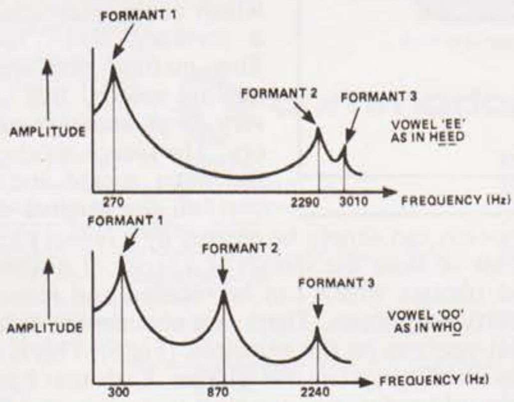


Fig.2. The output spectrum for two vowels. Spectrum is equal to the frequency response of the vocal tract times the excitation waveform.

EXAMPLE	VOWEL	FORMANT FREQUENCY F1	F2	F3
HEED	EE	270	2290	3010
HID	I	390	1990	2550
HAD	AE	660	1720	2410
PAW	AW	570	840	2410
WHO	OO	300	870	2240

Fig.3. The vocal tract resonances for steady state vowels.

information in speech is redundant, there are many repeated waveforms that are not unique. It is possible to produce speech from very little data but this requires the use of a speech model. The rest of this article is a resume of speech based products on the market.

Microspeech – Synthesis By Rule

Microspeech is a speech synthesiser that generates speech from phonetic text. It is a peripheral device that plugs into the SWTP and MSI microcomputer bus. It uses a synthesis model to produce the speech, (Fig.7). An oscillator is used to simulate the vocal cords and a noise generator for the unvoiced sounds. Three voltage controlled filters are used to simulate the action of the formants and a fourth is used for the fricative sounds. By supplying the model with the correct 9 parameters, (4 for amplitude, 4 for resonant frequency, 1 for pitch), it is possible to produce synthetic speech. These parameters are generated by the software which in turn is driven by phonetic text. For example, if you wanted the computer to speak the phrase 'Well, it can do with me', the phonetic spelling would be entered 'WEHL IHT KAAN DOO WIHTH MEE', (see Fig.4 for list). The programme then computes the 9 parameters which it then delivers to the synthesiser as frames of data, (8 bit resolution), every 50m Sec. This data is then converted into 9 analogue control voltages which drive the model and so generate a speech output. The amount of storage required is very low indeed, all that needs storing is the ASCII characters of the phonetic spelling. A 1K buffer can hold 90 seconds of speech. The programme is available as a speaking BASIC option.

A second version of the synthesiser will shortly

VOWELS *–DIPTHONGS

PHONEME	EXAMPLE
* AI	BAIT
* AY	PACE
AA	BAT
AH	FATHER
* HW	DOWN
AO	BOUGHT
EH	BET
ET	THE
ER	BIRD
EE	BEAT
IH	HARMONY
IX	BIT
* IY	BUY
* OY	BOY
OO	BOOT
O	HOT
* OW	BOAT
U	BUT
UH	BOOK

SEMI VOWELS

Y	YOU
W	WHEN

LIQUIDS

R	RENT
L	LET

NASALS

PHONEME	EXAMPLE
M	MET
N	NET
NG	SING

PLOSIVES

P	PET
T	TEN
K	KIT
B	BET
D	DOG
G	GET

ASPIRATIVE

H	HAT

FRICATIVES

F	FAT
TH	THING
S	SAT
SH	SHUT
DH	THAT
V	VAT
Z	ZOO
ZH	AZURE
CH	CHURCH
J	JAM

Fig.4. The table of phonemes.

become available, MICROSPEECH II, (Fig.8). This has its own dedicated microprocessor, a 6802 with the program stored in EPROM (two 2716). The machine is a stand alone device which receives its instructions as phonetic text via a standard teletype interface. The speech model uses a more complex filter structure with a male/female option. Other manual controls are pitch and speech rate. An internal amplifier/loudspeaker provides the speech output.

Speak And Spell

The Speak and Spell unit is a teaching aid to assist children with spelling. The machine asks the child to spell a series of words which have to be entered via an alphabetic keyboard. An alphabetical display provides a visual indication of the entered data in addition to the machine speaking the letters. When the word has been correctly spelt, the machine says, 'THAT IS CORRECT, NOW SPELL ....'. The vocabulary is about 200 words and is expandable with plug-in modules. It is possible to construct phrases from the individual letters of the alphabet, for example 'L,O,I,C,U,R,O,K! (translation; "Hello, I see you are OK").

The hardware consists of a dedicated microprocessor (a modified TMS1000), two large 128K bit ROMs and a speech synthesiser, (Fig.9). The system is based on linear predictive co-efficients which is a method of producing speech with very high intelligibility but requiring only medium data storage, about one percent of that needed for a direct conversion method. To produce speech the microprocessor addresses the ROM and extracts the linear predictive co-efficients, which are then decoded into 12 speech synthesis parameters. Two of these parameters determine the

Speech Lab recognition hardware.

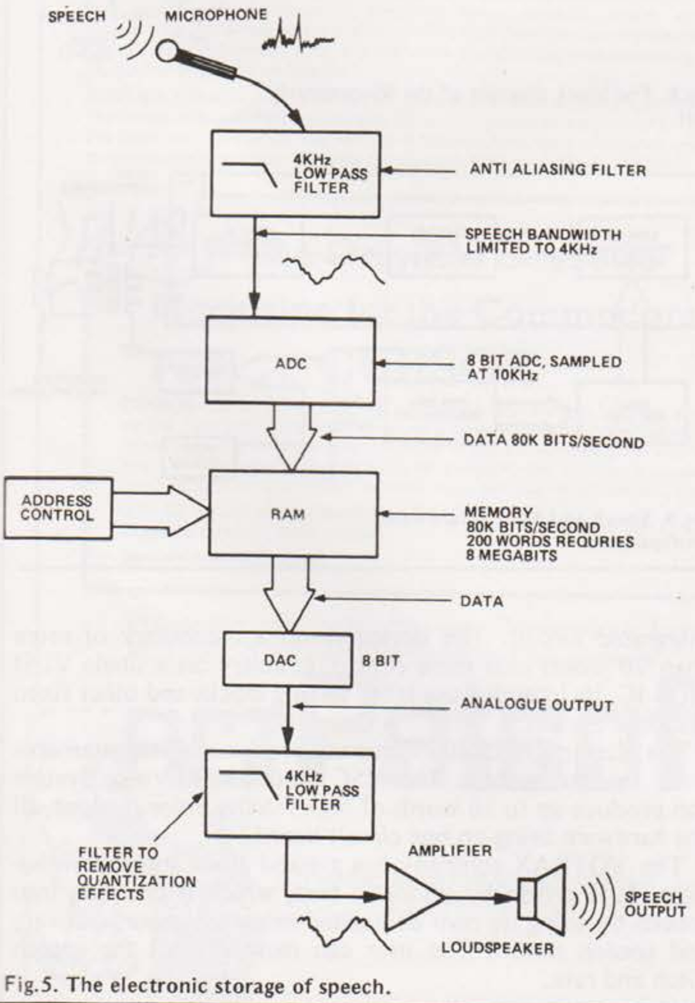


Fig.5. The electronic storage of speech.

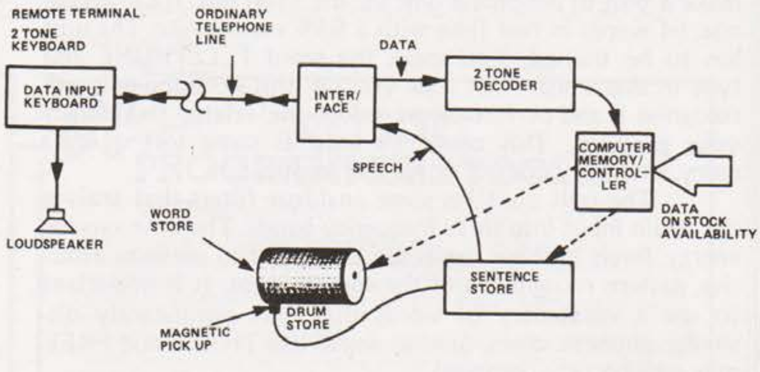


Fig.6. A typical data entry system.

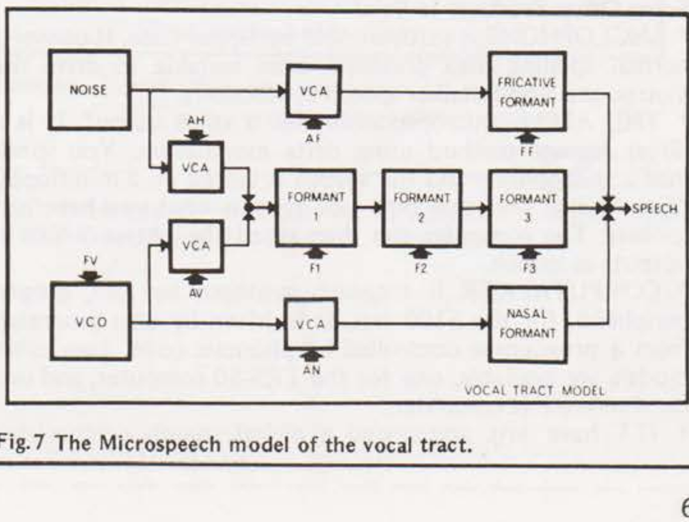


Fig.7 The Microspeech model of the vocal tract.

voiced/unvoiced decisions, pitch and amplitude and the other ten parameters the formant positions in the digital speech model. Data generated by this model is fed into a DAC which then drives a small loudspeaker.

The Speak and Spell chip set is not at present available, but someday perhaps it will be. This will enable the constructor to produce fixed vocabulary voice output units, probably with a considerable choice of words, (a few thousand). The new TI home computer is available with a speech output option, based on this system.

Talking Calculators

Telesensory systems make a range of products for the blind, one of which is a talking pocket calculator which speaks the results of the computation. The unit has a fixed vocabulary of words which are stored in a ROM. They also sell separately a printed circuit board containing the speech electronics, with three vocabulary options, one with 24 words, the other two with 64 words. For a small consideration they will, I believe, produce a custom vocabulary ROM.

Another blind aid from Telesensory Systems is an electronic reading device. The operator uses a handheld miniature camera to scan the printed page. The typeface is analysed, using pattern recognition techniques. The spelling of the text is then determined and is then converted into phonetic text to drive a speech synthesiser which actually 'reads' the printed text. The problems involved in performing all these processes are enormous but the company claims good results with a wide range of typeface.

Speechlab

In the film '2001 A Space Odyssey' the two astronauts had to find a soundproof enclosure so that the computer could not hear what they were saying about it, although they didn't know it could lip read. Lip-reading computers are still science-fiction, but speech analysing ones are here. Heuristics make a plug-in peripheral unit for the S100 bus. It can recognise 64 words in real time with a 95% success rate. The unit has to be trained. You speak the word TELEPHONE and type in this word. Next time you say this word the unit will recognise it and perform some 'telephone' related task, as per your program. This could be used as some sort of data entry, inventory control or speaker verification.

The unit contains some analogue filters that analyse the audio input into three frequency bands. The time varying energy levels in these bands are then used to perform effective pattern recognition of the speech input. It is important to use a vocabulary of words that have significantly dissimilar phonetic clues. Similar words like THREE and FREE may well become confused.

Some Other Products In Brief

* ANGLOPHONE is software sold by Upper Case. It converts normal spelling into phonetic code suitable to drive the Votrax and Computalker speech synthesisers.
* THE APPLE microprocessor has a voice output. It is a direct storage method using delta modulation. You speak into a microphone and the speech is stored on a minifloppy disc. Also at the same time you type in what you have just spoken. The computer can then recall the phrase which it outputs as speech.
* COMPUTALKER is a speech synthesis by rule, plug-in peripheral, for the S100 bus. It is driven by data generated from a programme controlled by phonetic code. Two other models are available, one for the TRS-80 computer, and one for the Apple II computer.
* ITT have just announced a digital speech synthesizing

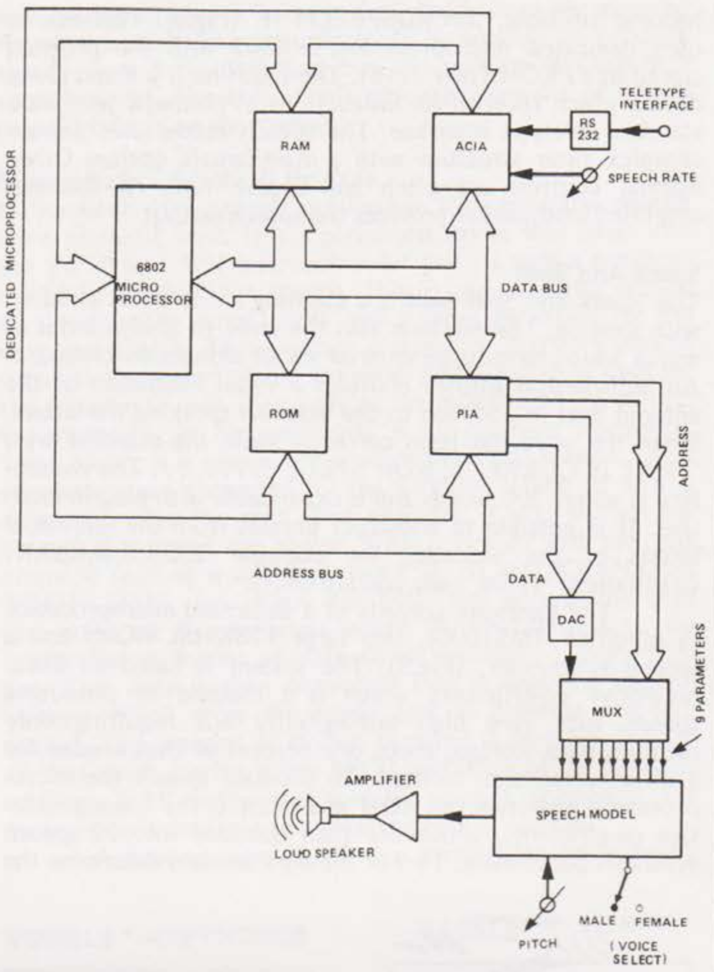


Fig.8. The block diagram of the Microspeech unit.

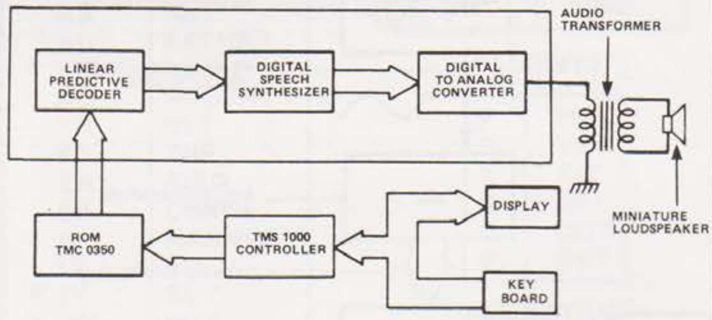


Fig.9. Speak and Spell's hardware configuration.

integrated circuit. The device stores a vocabulary of more than 20 words plus some control circuitry on a single VLSI MOS IC. Its intended use is for talking clocks and other fixed response devices.
* The Master Specialities Company produces a programmable voice readout system. The MSC Model 1700 Voice System can produce up to 16 words of high fidelity voice readout, all the hardware being on one circuit board.
* The VOTRAX company has a stand alone speech synthesizer. It is driven by phonetic text, which it converts into speech by using its own deducated microprocessor, software and speech model. The user can manually set the speech pitch and rate.

CT MARKETPLACE

LCD CHRONO

We feel we've got to tell you carefully about this offer which we're introducing for the first time. Why? Because our price is so enormously lower than anywhere else you may suspect the quality.

The display is LCD and shows the seconds as well as the hours — and minutes — press a button and you'll get the date and the day of the week.

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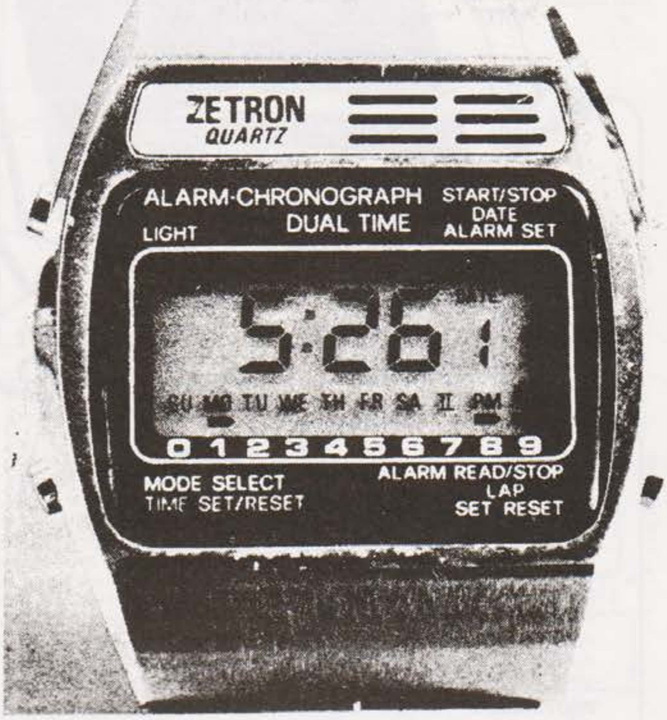

This new addition to our unbeatable selection of bargains is no ordinary LCD watch. It's a slim, multi-function, dual time chronograph alarm watch, no less.

This model will show hours, minutes, seconds, date, day of the week, stop watch, split time, alarm and alternate dual time zone — not all at once, of course. There is also a night light.

Hours, minutes, seconds and day of the week are displayed continuously, while the date will appear at the touch of a button. The day of the week is indicated by a flag. When used as a stopwatch, the maximum count is 0.1secs. short of thirteen hours.

£19.95

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Name . . . .

Address . . . .

. . . .

. . . .

Please allow up to 28 days for delivery.

John Wike

GRAPHICS UNIT

A simple to build add-on for your Nascom, it's memory mapped don't forget!

This circuit came into being because of a desire to simulate on a Nascom some of the video games that can be found in pubs and clubs. It soon became clear that the character set (font) of the existing alphanumeric generator, whilst being useful, was not extensive enough to provide really interesting displays. In fact, graphics generation was required.

At present there seem to be two common types of graphics generator systems in use. The first type, as used in Teletext, splits each character cell into six blocks and assigns one bit of the character code to each block to determine whether it shall be white or black. This gives a low definition structure which is alright for large diagrams, but not for the sort of display required. The other type, as used in Triton etc, features a second character generator (in PROM) to give characters of equal definition to the alphanumerics. This would have been exactly what was needed, except that the character shapes would need to be defined at the time the PROM was programmed. The inflexibility this gave was unacceptable.

What was obviously required was a RAM that could be addressed by the microprocessor and filled with the appropriate font from a table at the start of each program.

Addressing

To understand how the RAM can be addressed, consider the alphanumerics generator. It can produce 128 characters so a seven bit code ($128 = 2^7$) will select a particular character block within the generator. Each character consists of 16 lines on the screen so a further four bits will inform the generator which line the VDU is currently displaying.

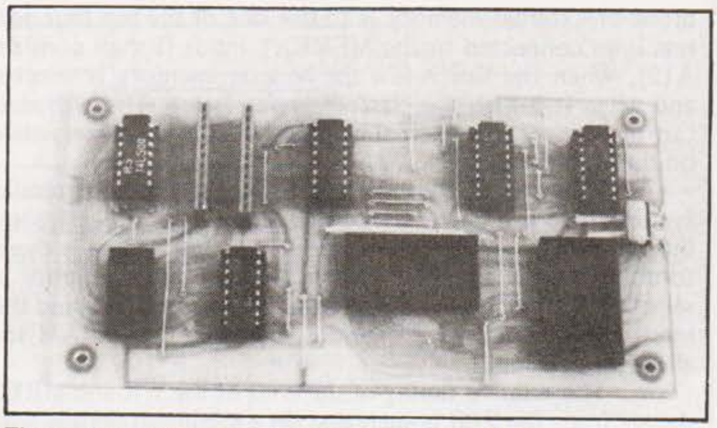
Thus, if the VDU is showing the top line of a letter 'A', the generator input will be 410 (41 = ASCII 'A', 0 = line zero of character). Similarly, the input for the bottom line of a letter 'T' would be 54F.

The output of the generator is a seven bit parallel word representing the white (1) and black (0) portions of the character line addressed. The RAM graphics generator will therefore need to be programmed with each line of each character required.

Choice Of RAM

Believe it or not, the main requirement of this circuit was that it should be useable on a minimum Nascom! Any program would therefore use less than 1K bytes. As this would have to contain the graphics font there was obviously a practical limit to the size of font that could be handled and therefore the size of RAM needed. 256 bytes was thought to be the most reasonable figure, and this would give either 16 characters of 16 lines each or 32 characters of 8 lines each. A limitation of 16 characters seemed rather restrictive so the 32 character scheme was chosen. This had the added advantage that in order to maintain the same character aspect ratio as the alphanumerics, ie. one dot horizontally to two lines vertically, the output of the RAM only required four bits. The complete generator could therefore consist of one 256 x 4 RAM.

Did I just say advantage? Because the video circuits can sample the RAM at any time, its outputs must be constantly enabled. However, its inputs are connected to the CPU data bus — it has to be programmed, remember. The use of tri-state buffers would have meant a larger circuit board, so 256 x 4 RAM with separate input and output pins was needed. A search of data sheets yielded one device that satisfied these criteria: the 2101. With a Z80 working at 2MHz the standard 1uS version is not really fast enough, and to be on the safe side the 650nS version, 2101–2 is used. It must be said that this family of RAMs have not previously been common on the amateur market, but hopefully some kind suppliers will start stocking them.



The prototype PCB. The strip socket is for the RAM.

Wherefore Art Thou RAM

Because the alphanumeric generator only requires seven character select bits, it is possible to use the most significant bit in the VDU to select either a graphics or an alphanumerics output. This means that the graphics character codes will be in the range 80 to 9F.

The position of the RAM on the microprocessor memory map is very much up to the individual. For a minimum system the best position is 1000 to 10FF, as discussed later, but it must be remembered that it is Write Only Memory. Thus although the least significant four data bus bits can be written into the RAM, its contents cannot be inspected by the CPU.

The Nascom Connection

The design of the circuit is based on a philosophy of using a minimum of existing connectors on the Nascom for all the interconnections. Indeed, the character generator socket and the edge connector between them carry all the necessary lines except two. These are the most significant VDU data bit and one of the inputs to the video shift register (earthed on the Nascom). Luckily there are two unused pins on the character generator socket (IC16) so these can be used. (The alphanumeric generator, IC16, is of course going to be transferred to the new board). As the VDU bit must be latched there are three links to make on the Nascom board:

1) IC28 pin 18 to IC17 pin 18 (VDU bit 7 to latch input)
2) IC17 pin 19 to IC16 pin 14 (latch output to character generator)
3) Disconnect IC15 pin 6 from earth and connect to IC16 pin 10 (one bit of character output to video shift register)

The connections to the character generator board are made via two DIL connectors — a 24 way for the VDU and power supplies, and a 16 way for the CPU busses.

Decoding

In a minimum Nascom system the easiest way of selecting a block of external memory is to use one of the top four address lines connected to the MEMEXT input (I shall consider A12). When the line is low the Nascom memory is selected and when it is high the Nascom is deselected. The high state can then select the external memory. This is the arrangement on the graphics board.

However, if the board is to be used in an extended system there is a good chance that a decoder with active low outputs will be in use (cf. IC36 on Nascom). There is therefore an inverter and link option to allow either polarity of select input. Once the correct polarity has been selected this input can be used to change the addresses of the RAM and allow the WR input.

The relative timing of the ends of the WR and MREQ signals from the Z80 is such that, in a minimum system with no gate delays, the MREQ signal cannot be included in the address switching. This means that the presence of a high on A12 is the only reliable way of changing the RAM addresses.

However, during input/output operations the CPU transfers information on the high order address lines so any graphics characters on the screen will assume random shapes. To overcome this a second link option allows the generator output to be blanked under these conditions by strobing the output selectors. Corruption of data is prevented by disabling the RAM when both A12 and MREQ are high.

The Board

The graphics board measures 3" x 5½" and contains both character generators, four 74LS157 data selectors, one 74LS00 address decoder and the two DIL connectors.

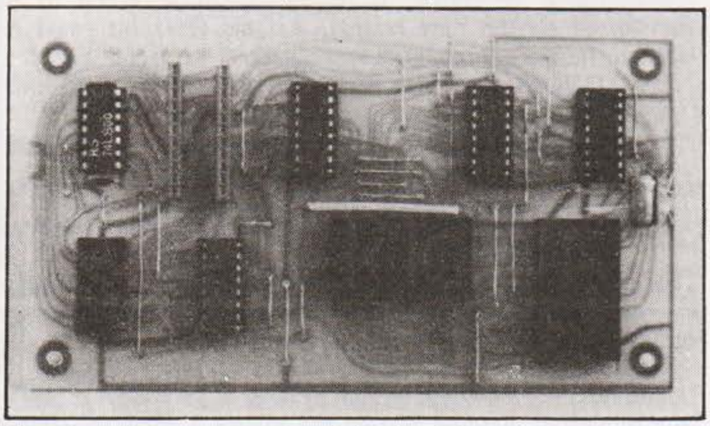
You will see that the circuit diagram is straightforward, the only problem being the link options. Read the previous section again before wiring them. The input shown as A12 should be connected to the select signal you have decided to use.

If you are connecting to a minimum Nascom remember to change the memory select link LK5 to EXT and to connect the A12 pin on the edge connector to pin 40 (MEMEXT).

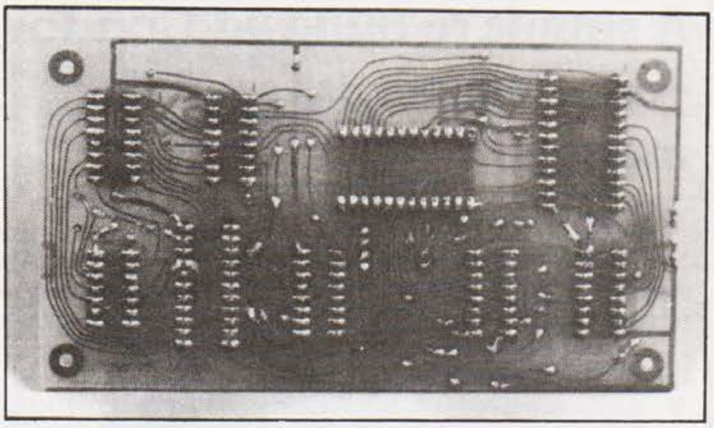
Troubleshooting

When the unit is completed check *very* carefully for shorts between the four supply lines (0, +5, −3, +12) and any other lines by examining the tracks on the board, then connect to the Nascom and switch on.

Type in some characters and observe the display. Any vertical jitter is caused by coupling in the cable to the character generator socket. Shorten this cable and if necessary use a separate cable for the row select signals to pins 21, 22, 23 and 24. Incorrect characters are probably caused by shorts on the board between inputs and outputs.



Top view of the prototype board showing links.



The copper side of the board.

The Nascom video circuit is very sensitive to the width of the shift register load pulse. This board increases that sensitivity, so if you have not already made the following modification you will have to do so now: cut the track leading to IC18 pin 5, and connect it instead to IC18 pin 12.

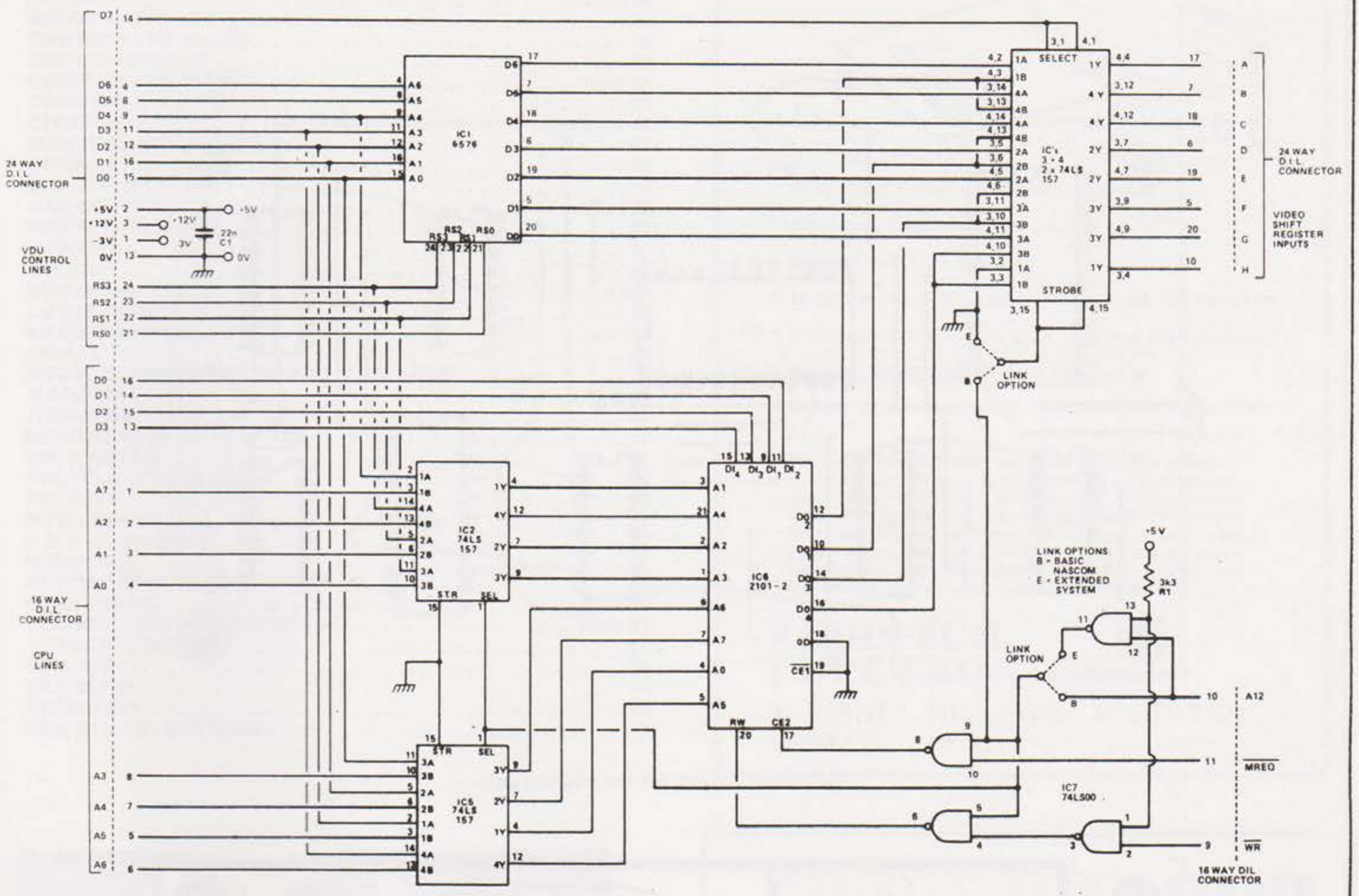
Put a group of characters on the top (unscrolled) line by using the Memory Modify command (M) starting at address BD0. If you enter the codes 31, 32, 33, 80, 81, 34 you should see the characters 1, 2, 3, random, random, 4. If the right hand edges of the numbers are too narrow, then the output pulse from IC18 is still too wide and this device should be replaced, preferably with a non-LS version, 74123. To alter the random graphics characters use Memory Modify at address 1000 (or whatever start address you have chosen), but remember that you cannot inspect the existing contents of this address. Enter the code F (it is only a 4 bit RAM) into 16 locations finishing at 100F. The two graphics characters should now be a complete white block. If they have not changed at all check for faulty connections to the address decoder IC7 on the graphics board. If they are not complete blocks check for shorts or bad connections around the graphics RAM.

Assuming everything is satisfactory at this stage, return to address 1000 and enter 1, 2, 3, 4, etc., watching the displayed characters change as you do it. Once you are happy that you understand the operation of the circuit you can start programming your own displays on the screen.

Programming Hint

Although it is possible to allocate a byte of your program to each graphic character line and use the Block Transfer instruction 'LDIR' to load the generator this is not very efficient. Because each line only requires four bits you can combine two lines into each byte and use a small transfer routine similar to mine:

11 00 10	LD DE 1000	Graphics RAM pointer
21 ** **	LD HL (start of font)	Font pointer
06 **	LD B (length of font)	
7E	LD A, (HL)	Get one byte from font
12	LD (DE), A	Transfer 4 LSB's to RAM
1F 1F 1F 1F	RRA	4 MSB's to 4 LSB's
13	INC DE	Next graphics RAM address
12	LD (DE), A	Transfer 4 LSB's to RAM
13	INC DE	Next graphics RAM address



The circuit diagram of the graphics unit. Table 1 gives the necessary connection details.

23	INC HL	Next font address
10 F4	DJNZ	Do until complete

This is normally the first routine in the program and is followed by the setting of the Stack Pointer and other program parameters.

Table 1

16 way DIL socket	Nascom edge connector	Designation
1	16	Address bit 7
2	24	" " 2
3	23	" " 1
4	21	" " 0
5	18	" " 5
6	17	" " 6
7	19	" " 4
8	22	" " 3
9	26	$\overline{WR}$
10	9 + 40 (minimum system)	Address bit 12+ $\overline{MEMEXT}$
11	27	$\overline{MREQ}$
13	6	Data bit 3
14	2	" " 1
15	4	" " 2
16	1	" " 0

PARTS LIST

Semiconductors

IC1	6576
IC2,3,4,5	74LS157
IC6	2101-2
IC7	74LS00

Resistors

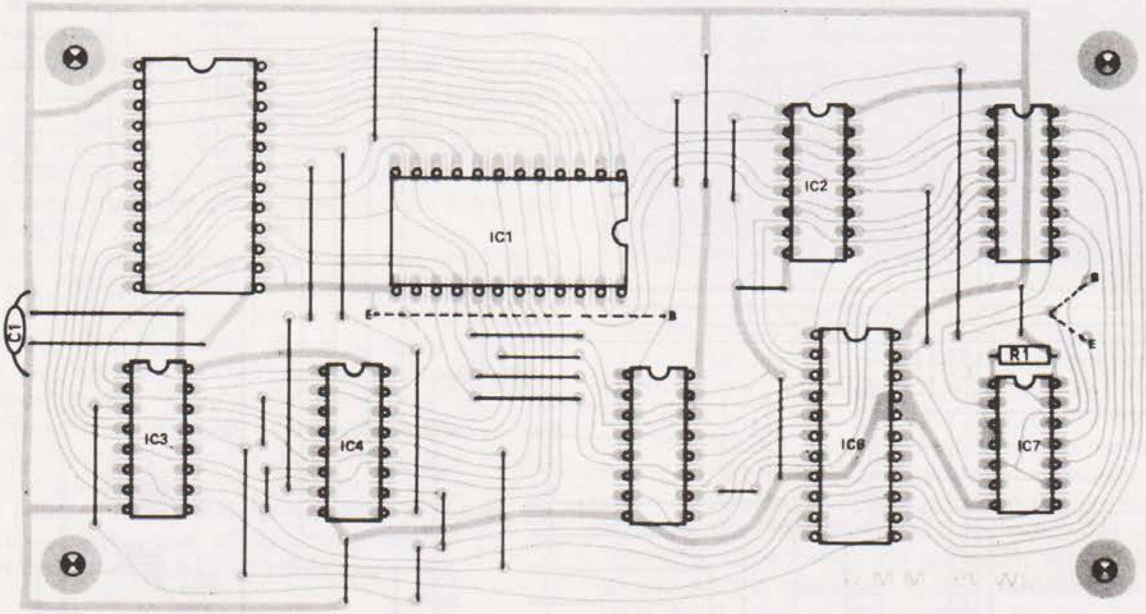
R1	3k3

Capacitors

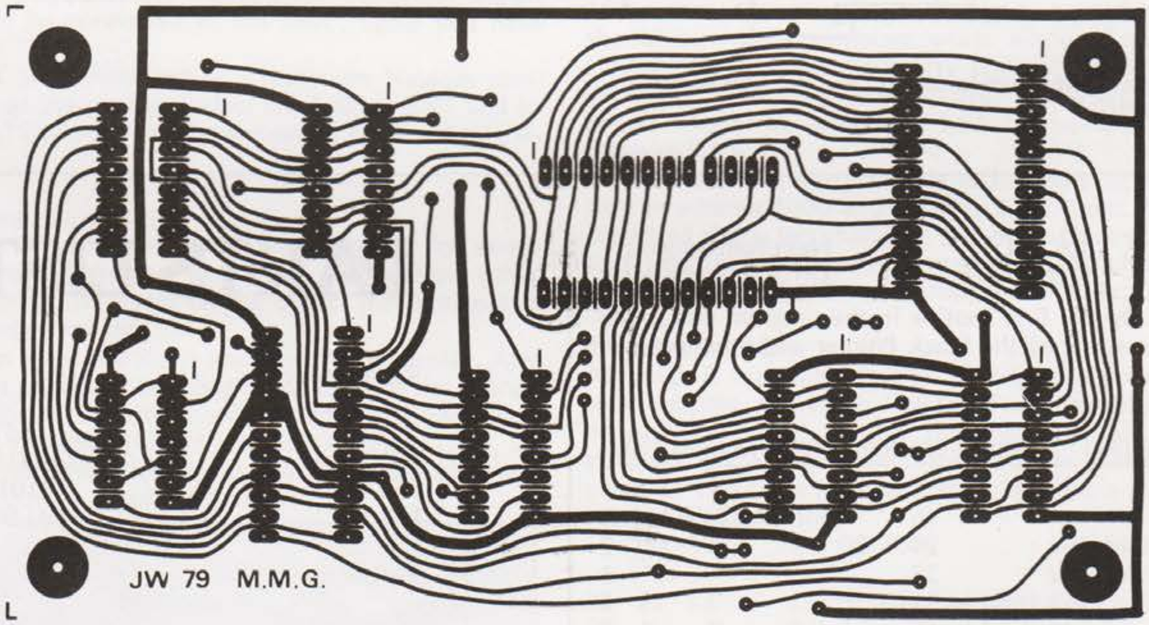
C1	22n

Miscellaneous

IC sockets to suit
24 way DIL connector
16 way DIL connector
PCB



The overlay pattern for the graphics unit.



The foil pattern for the graphics unit.

A kit for this project will be available from Crystal Electronics of 40 Magdalene Road, Torquay, Devon. The price will be £30 + VAT.

AD INDEX

Marek Kuczynski

A famous game implemented on popular system, what more could you ask?

Many of you owning a NASCOM 1 will, no doubt, be tired of playing Mastermind or Hangman, and would welcome a more interesting game to play. This article is about the game of LIFE, and includes a fully assembled program listing to run on a minimum NASCOM 1.

Life was developed by John Horton Conway, a mathematician from Cambridge University. Its name comes from its resemblance to changing societies of living organisms which alter in position and number from generation to generation.

What Is Life?

LIFE can be described as a mathematical game, played on a two-dimensional board, similar to a chess board with all white squares. An initial pattern is entered on the board, and then the computer applies the basic laws of life to the pattern; Birth, Survival or Death.

Rules Of The Game

Imagine a large board containing a gridwork of squares. Each square is called a cell, and all cells are identical. Ideally, the board is infinite, but for practical purposes, it is bounded on all four sides by a border, which confines the pattern to a particular area.

Each cell can be either dead or alive, and can sense the state of its eight neighbouring cells.

After each generation, the board changes. Some cells die, some are born and some remain the same, according to these simple laws of life:

(1) Any cell (dead or alive) which has exactly three live neighbouring cells, will be alive in the next generation.

(2) Any cell with exactly two live neighbouring cells will remain in the same state in the next generation.

(3) If a cell has less than two neighbours, it will die in the next generation from loneliness; if it has more than three neighbours, it will die from overcrowding.

The above rules are applied simultaneously to each cell on the board. Every cell is checked, along with its neighbours, and the fate of that cell in the next generation, is decided. This involves many thousands of checks per generation – a task ideally suited to a computer, which can compute a new generation in a fraction of a second, whereas it would take an average person with a pen and paper, at least an hour to check through the entire board once.

The Program

The program was written to run on a minimum NASCOM 1, utilising almost all of the available user RAM from 0C50 to 0FFF. The program can be split into various parts:

Routines INIT to BOTTOM generate a playing board or buffer starting at location 0E3D. A grid of cells, 24 x 15 is produced, surrounded by a border, which limits the growth of any pattern to a fixed area.

Routines SCAN to QUIT enable a pattern to be written onto the screen via the keyboard.

Routines CPYVDU to BLANK transfer the screen contents to the buffer in RAM. For each live cell on the screen, a "1" is written into the corresponding cell in the buffer. A "0" is written for each dead cell.

The heart of the program begins at LOOP. Each cell is selected in turn and routine CHECK is called for each of its eight neighbours. CHECK tests bit 0 of each cell in the buffer. Bit 0 is the "current generation" bit in each cell. Border cells and dead cells are ignored, and the "neighbour counter" in register B is incremented for each live neighbouring cell found.

After testing the cell, the number of neighbours is determined. If three neighbours are found, bit 1 is set in the buffer cell, this being the "next generation" bit. If two neighbours are found, bit 0 is tested and copied into bit 1; if neither three nor two live neighbouring cells are found, bit 1 is reset. These operations satisfy the laws of life.

After the complete buffer has been tested, its entire contents are shifted, cell by cell, one bit to the right, by routine REGEN. The "next generation" now becomes the "current generation".

After regenerating each cell, bit 0 is tested, and if it is a "1", a □ is written into the corresponding screen position, by routines DEAD to LDSCRN. A blank is written if bit 0 is zero.

GEN and COUNTR deal with the generation counter. The method employed here may seem rather odd, i.e. incrementing the ASCII code for the appropriate numbers, but it works, and also takes less bytes than the conventional means of using the DECIMAL ADJUST ACCUMULATOR (DAA) instruction.

Routines MANUAL and AUTO deal with the two selectable run modes of the program, while CHOICE decides on action to be taken when the run has been terminated. Routine KEY is used extensively throughout the program, scanning the keyboard until a key is pressed.

At the end of the program are strings of ASCII text which are written into the top line of the screen. This line is non-scrolling, so it is ideal for headings and comments.

The memory from 0E3D to 0FE6 is reserved for the buffer, while the remaining RAM is used by the program stack. Extensive use has been made of labels in the program; this not only makes the listing more understandable, but allows straightforward re-assembly for those fortunate enough to have an assembler to run on their Nascom, and who would like to relocate the program. All labels external to the program i.e. monitor routines for the loader, are listed at the end of the program.

The program has been written using standard Z80 mnemonics on a Z80 assembler. All hexadecimal constants are prefixed by a "0", if the first digit is A to F, and suffixed by an "H". All other constants are decimal, and are converted to the appropriate hexadecimal object code by the assembler.

DEFB 18H assigns the value 18 (hex) to that particular byte.

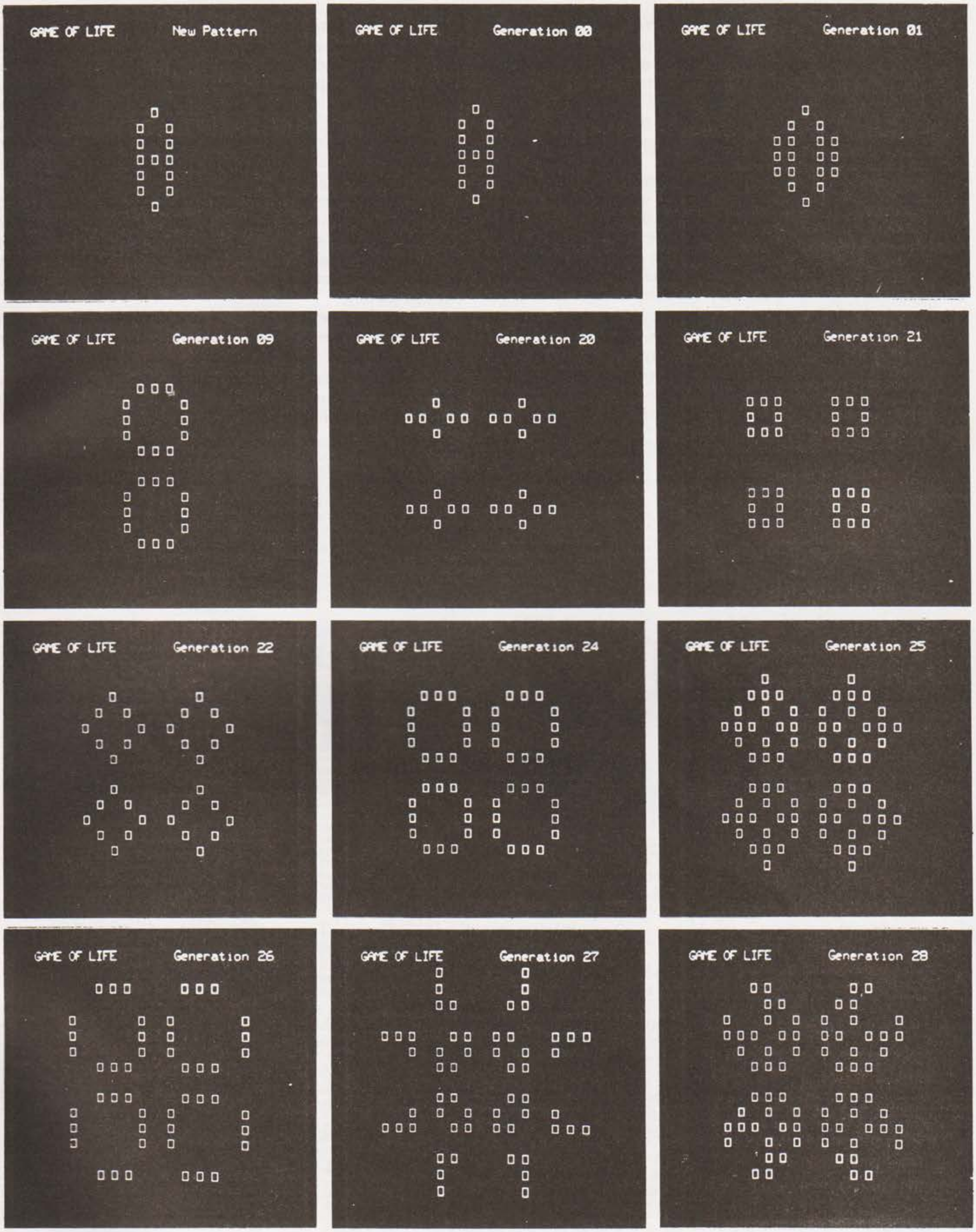
DEFS 1 reserves one byte in RAM for a variable.

DEFM 'GAME' stores the ASCII equivalent of a string of text in quotes, in RAM.

EQU assigns a numeric value to a label.

Playing Life

Once the program has been loaded into RAM (and saved on cassette), enter EC50 "NEWLINE" to start the program. The screen should clear, and the text "GAME OF LIFE New Pattern" should appear on the top line; the cursor will be positioned at the bottom left of the screen. A pattern can now be entered via the keyboard, using any key, with the



The game of LIFE showing the stages taken from the insertion of a new pattern.

exception of "SPACE" "B/S" and "NEWLINE", which provide the normal functions, "R" which restarts the loader if a mess has been made of the pattern, or "Q" which quits input mode and awaits further instructions.

Having entered the pattern, (and making sure that it is as near to the centre of the screen as possible), press "Q", and the text on the top line should change to "Manual/Auto, to which the reply can either be "A" which immediately enters auto mode, or "M" for manual mode. In auto mode, the generations are computed one after another. Due to the large amount of cell testing involved in the program, it takes approximately 0.2 seconds to compute and display a new generation so in auto mode, the pattern changes five times a second, which fortunately happens to be fast enough to give a continuously changing display, yet slow enough to be able to observe the individual steps without having to introduce any extra delay loops into the program. This mode is ideal for tried and tested patterns, however for new patterns, it is always best to use manual mode. In this mode, pressing any key (except "A" or "Q") will single-step the program a generation at a time, enabling easy analysis of users' patterns.

During auto mode, if "M" is pressed, manual mode is selected; likewise during manual mode, control can be transferred to auto mode by pressing "A". During both modes, the generation number is updated at the top of the screen, which is a very useful feature for keeping track of new patterns. Pressing "Q" quits run mode, and the text "New/Continue?" is written on the top line. The user then has the choice of "C" to continue the run, or "N" to clear the screen, and enter a new pattern.

When entering large patterns, make sure that they are as centrally positioned on the screen as possible, otherwise one edge of the growing pattern may hit the border before the other edge, and either symmetry will be lost, or the pattern will take a totally different course, and maybe even die out completely.

I would be interested to hear from readers who have tried this program and have discovered some new and interesting patterns, or ideas on improving the program.

Life is a very addictive game. Once hooked, it is all too easy to stay up to the early hours of the morning trying to invent the "ultimate pattern".

```
GAME OF LIFE                     LIFE   LISTING 17/8/79          PAGE   1
 LOC   OBJ CODE    STMT SOURCE STATEMENT                          ASM 1.1

                      1 *H GAME OF LIFE ; Written by M.Kuczynski 1979
0C50                  2          ORG 0C50H
0C50   213030         3 START:   LD HL,3030H      ;3030 = ASCII '00'
0C53   22140E         4          LD (NUMBER),HL   ;RESET COUNTER
0C56   EF             5          RST 40           ;CLEAR THE SCREEN
0C57   1E             6          DEFB 1EH         ;1E = 'CLEAR' CODE
0C58   00             7          DEFB 0           ;00 = END OF ROUTINE
0C59   11D00B         8          LD DE,0BD0H      ;TOP LINE OF SCREEN
0C5C   21FD0D         9          LD HL,TITLE      ;'GAME OF LIFE'
0C5F   010C00        10          LD BC,12         ;NUMBER OF LETTERS
0C62   EDB0          11          LDIR             ;WRITE TITLE
0C64   213D0E        12 INIT:    LD HL,BORDER     ;START OF BORDER
0C67   0619          13          LD B,25          ;CELLS IN TOP BORDER
0C69   0E0F          14          LD C,15          ;NUMBER OF ROWS
0C6B   36FF          15 TOP:     LD (HL),0FFH     ;WRITE TOP BORDER
0C6D   23            16          INC HL           ;NEXT CELL
0C6E   10FB          17          DJNZ TOP         ;REPEAT UNTIL END
0C70   36FF          18 LEFT:    LD (HL),0FFH     ;WRITE LEFT BORDER
0C72   23            19          INC HL           ;NEXT CELL
0C73   0618          20          LD B,24          ;CELLS PER ROW
0C75   3600          21 ROW:     LD (HL),0        ;WRITE BLANK CELL
0C77   23            22          INC HL           ;NEXT CELL
0C78   10FB          23          DJNZ ROW         ;REPEAT UNTIL END
0C7A   0D            24          DEC C            ;LAST ROW ?
0C7B   20F3          25          JR NZ,LEFT       ;NEXT ROW
0C7D   061A          26          LD B,26          ;CELLS IN BOTTOM BORDER
0C7F   36FF          27 BOTTOM:  LD (HL),0FFH     ;WRITE BOTTOM BORDER
0C81   23            28          INC HL           ;NEXT CELL
0C82   10FB          29          DJNZ BOTTOM      ;REPEAT UNTIL END
0C84   11E40B        30 LOADER:  LD DE,0BE4H      ;MIDDLE OF TOP LINE
0C87   21160E        31          LD HL,NEWPTN     ;'NEW PATTERN'
0C8A   010D00        32          LD BC,13         ;NUMBER OF LETTERS
0C8D   EDB0          33          LDIR             ;WRITE COMMENT
0C8F   CDF70D        34 SCAN:    CALL KEY         ;KEY PRESSED ?
0C92   FE1F          35          CP 1FH           ;NEW LINE ?
0C94   2005          36          JR NZ,BS         ;TEST FOR 'B/S'
0C96   CD4002        37          CALL CRLF        ;SCROLL PAGE
0C99   18F4          38          JR SCAN          ;NEXT CHARACTER
0C9B   FE1D          39 BS:      CP 1DH           ;BACKSPACE ?
0C9D   2008          40          JR NZ,SPCE       ;TEST FOR 'SPACE'
0C9F   CD3B01        41          CALL BACKSP      ;BACKSPACE CURSOR
0CA2   CD3B01        42          CALL BACKSP      ;BACKSPACE CURSOR
0CA5   18E8          43          JR SCAN          ;NEXT CHARACTER
0CA7   FE20          44 SPCE:    CP 20H           ;SPACE ?
0CA9   2008          45          JR NZ,QUIT       ;TEST FOR 'QUIT'
0CAB   CD3C02        46          CALL SPACE       ;ADVANCE CURSOR
0CAE   CD3C02        47 SPCE1:   CALL SPACE       ;ADVANCE CURSOR
0CB1   18DC          48          JR SCAN          ;NEXT CHARACTER
0CB3   FE51          49 QUIT:    CP 51H           ;QUIT ?
0CB5   280F          50          JR Z,RUN         ;GO TO RUN MODE
0CB7   FE52          51          CP 52H           ;RESTART ?
0CB9   2895          52          JR Z,START       ;RETURN TO START
0CBB   2A180C        53          LD HL,(CURSOR)   ;CURSOR POSITION
0CBE   3680          54          LD (HL),80H      ;FILL IN CELL
0CC0   23            55          INC HL           ;NEXT CELL
0CC1   22180C        56          LD (CURSOR),HL   ;SAVE CURSOR POSITION
0CC4   18E8          57          JR SPCE1         ;NEXT CHARACTER
0CC6   11E40B        58 RUN:     LD DE,0BE4H      ;MIDDLE OF TOP LINE

GAME OF LIFE                     LIFE   LISTING 17/8/79          PAGE   2
 LOC   OBJ CODE    STMT SOURCE STATEMENT                          ASM 1.1

0CC9   21230E        59          LD HL,CHOOSE     ;'MANUAL/AUTO?'
0CCC   010D00        60          LD BC,13         ;NUMBER OF LETTERS
0CCF   EDB0          61          LDIR             ;WRITE COMMENT
0CD1   CDF70D        62 AGAIN:   CALL KEY         ;KEY PRESSED ?
0CD4   FE4D          63          CP 4DH           ;MANUAL ?
0CD6   2004          64          JR NZ,AUT        ;IF NOT,THEN AUTO
0CD8   3E00          65 MANREF:  LD A,MANUAL-JUMP-1
0CDA   1806          66          JR LDJUMP        ;CALCULATE DISPLACEMENT
0CDC   FE41          67 AUT:     CP 41H           ;AUTO ?
0CDE   20F1          68          JR NZ,AGAIN      ;IF NOT,RECHECK
0CE0   3E0A          69 AUTREF:  LD A,AUTO-JUMP-1
0CE2   32BD0D        70 LDJUMP:  LD (JUMP),A      ;WRITE DISPLACEMENT
0CE5   11E40B        71 GEN1:    LD DE,0BE4H      ;MIDDLE OF TOP LINE
0CE8   21090E        72          LD HL,RUNSTR     ;'GENERATION XX'
0CEB   010D00        73          LD BC,13         ;NUMBER OF LETTERS
0CEE   EDB0          74          LDIR             ;WRITE COMMENT
0CF0   2A180C        75 CPYVDU:  LD HL,(CURSOR)   ;CURSOR ADDRESS
0CF3   3620          76          LD (HL),20H      ;REMOVE CURSOR
0CF5   210A08        77          LD HL,080AH      ;TOP OF SCREEN
0CF8   11570E        78          LD DE,BOARD      ;START OF BOARD
0CFB   7E            79 BACK:    LD A,(HL)        ;TEST CELL
0CFC   3C            80          INC A            ;END OF SCREEN ?
0CFD   CABC0D        81          JP Z,REFL        ;GO TO RUN MODE
0D00   3D            82          DEC A            ;TEST CELL
0D01   2009          83          JR NZ,WRITE      ;REPEAT IF NOT END
0D03   D5            84          PUSH DE          ;SAVE REGISTERS
0D04   111000        85          LD DE,16         ;LINE OFFSET
0D07   19            86          ADD HL,DE        ;ADD OFFSET TO LINE
0D08   D1            87          POP DE           ;RESTORE REGISTERS
0D09   13            88          INC DE           ;NEXT CELL
0D0A   18EF          89          JR BACK          ;REPEAT TO END OF LINE
0D0C   CB6E          90 WRITE:   BIT 5,(HL)       ;LIVE CELL ?
0D0E   2008          91          JR NZ,BLANK      ;RETEST IF DEAD
0D10   3E01          92          LD A,1           ;'1' = LIVE CELL
0D12   12            93 CELL1:   LD (DE),A        ;WRITE CELL ON BOARD
0D13   23            94          INC HL
0D14   23            95          INC HL           ;NEXT SCREEN POSITION
0D15   13            96          INC DE           ;NEXT BOARD POSITION
0D16   18E3          97          JR BACK          ;NEXT CELL
0D18   AF            98 BLANK:   XOR A            ;'0' = DEAD CELL
0D19   18F7          99          JR CELL1         ;WRITE CELL ON BOARD
0D1B   DD21570E     100 INIT2:   LD IX,BOARD      ;START OF BOARD
0D1F   217601       101          LD HL,374        ;NUMBER OF CELLS
0D22   0600         102 LOOP:    LD B,0           ;CLEAR NEIGHBOUR COUNTER
0D24   DDCB007E     103          BIT 7,(IX+0)     ;BORDER CELL ?
0D28   2045         104          JR NZ,NEXT       ;IGNORE IT
0D2A   DD7EE6       105          LD A,(IX-26)     ;TEST CELL TO NORTH-WEST
0D2D   CDEF0D       106          CALL CHECK       ;CHECK IF ALIVE
0D30   DD7EE7       107          LD A,(IX-25)     ;TEST CELL TO NORTH
0D33   CDEF0D       108          CALL CHECK       ;CHECK IF ALIVE
0D36   DD7EE8       109          LD A,(IX-24)     ;TEST CELL TO NORTH-EAST
0D39   CDEF0D       110          CALL CHECK       ;CHECK IF ALIVE
0D3C   DD7EFF       111          LD A,(IX-1)      ;TEST CELL TO WEST
0D3F   CDEF0D       112          CALL CHECK       ;CHECK IF ALIVE
0D42   DD7E01       113          LD A,(IX+1)      ;TEST CELL TO EAST
0D45   CDEF0D       114          CALL CHECK       ;CHECK IF ALIVE
0D48   DD7E18       115          LD A,(IX+24)     ;TEST CELL TO SOUTH-WEST
0D4B   CDEF0D       116          CALL CHECK       ;CHECK IF ALIVE

GAME OF LIFE                     LIFE   LISTING 17/8/79          PAGE   3
 LOC   OBJ CODE    STMT SOURCE STATEMENT                          ASM 1.1

0D4E   DD7E19       117          LD A,(IX+25)     ;TEST CELL TO SOUTH
0D51   CDEF0D       118          CALL CHECK       ;CHECK IF ALIVE
0D54   DD7E1A       119          LD A,(IX+26)     ;TEST CELL TO SOUTH-EAST
0D57   CDEF0D       120          CALL CHECK       ;CHECK IF ALIVE
0D5A   78           121 NEIBRS:  LD A,B           ;LOAD NEIGHBOUR COUNTER
0D5B   FE03         122          CP 3             ;THREE NEIGHBOURS ?
0D5D   2006         123          JR NZ,SAME       ;IF NOT,TEST FOR TWO
0D5F   DDCB00CE     124 ALIVE:   SET 1,(IX+0)     ;CELL WILL BE ALIVE
0D63   180A         125          JR NEXT          ;NEXT CELL
0D65   FE02         126 SAME:    CP 2             ;TWO NEIGHBOURS ?
0D67   2006         127          JR NZ,NEXT       ;IF NOT,TEST NEXT CELL
0D69   DDCB0046     128          BIT 0,(IX+0)     ;IS CELL ALIVE ?
0D6D   20F0         129          JR NZ,ALIVE      ;CELL WILL STAY ALIVE
0D6F   DD23         130 NEXT:    INC IX           ;NEXT CELL
0D71   2B           131          DEC HL           ;DECREMENT CELL COUNTER
0D72   7C           132          LD A,H           ;ARE ALL CELLS TESTED ?
0D73   B5           133          OR L
0D74   20AC         134          JR NZ,LOOP       ;IF NOT,TEST NEXT CELL
0D76   016801       135 GEN2:    LD BC,360        ;NUMBER OF CELLS
0D79   110A08       136          LD DE,080AH      ;TOP OF SCREEN
0D7C   21570E       137          LD HL,BOARD      ;START OF BOARD
0D7F   CB7E         138 TEST:    BIT 7,(HL)       ;BORDER CELL ?
0D81   2808         139          JR Z,REGEN       ;IF NOT,REGENERATE
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NASCOM LIFE

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0D83  23        140 NEWLIN: INC HL           ;NEXT CELL
0D84  E5        141         PUSH HL          ;SAVE REGISTERS
0D85  211000    142         LD HL,16         ;LINE OFFSET
0D88  19        143         ADD HL,DE        ;ADD OFFSET TO LINE
0D89  EB        144         EX DE,HL         ;EXCHANGE REGISTERS
0D8A  E1        145         POP HL           ;RESTORE REGISTERS
0D8B  CB3E      146 REGEN:  SRL (HL)         ;REGENERATE
0D8D  CB46      147         BIT 0,(HL)       ;TEST CELL
0D8F  2004      148         JR NZ,LIVE       ;IS CELL LIVE ?
0D91  3E20      149 DEAD:   LD A,20H         ;DEAD CELL   BLANK
0D93  1802      150         JR LDSCRN        ;FILL IN SPACE ON SCREEN
0D95  3E80      151 LIVE:   LD A,80H         ;LIVE CELL   SQUARE
0D97  12        152 LDSCRN: LD (DE),A        ;FILL IN SPACE ON SCREEN
0D98  13        153         INC DE
0D99  13        154         INC DE           ;NEXT SCREEN SPACE
0D9A  23        155 NXCELL: INC HL           ;NEXT CELL
0D9B  0B        156         DEC BC           ;DECREMENT CELL COUNTER
0D9C  78        157         LD A,B           ;ALL CELLS COPIED ?
0D9D  B1        158         OR C
0D9E  20DF      159         JR NZ,TEST       ;IF NOT,COPY NEXT CELL
0DA0  E5        160 GEN:    PUSH HL          ;SAVE REGISTERS
0DA1  21F00B    161         LD HL,0BF0H      ;'UNITS' COUNTER
0DA4  34        162         INC (HL)         ;INCREMENT UNITS
0DA5  7E        163         LD A,(HL)        ;TEST UNITS
0DA6  FE3A      164         CP 3AH           ;GREATER THAN 9 ?
0DA8  200B      165         JR NZ,COUNTR     ;IF NOT,STORE IN RAM
0DAA  3630      166         LD (HL),30H      ;CLEAR UNITS
0DAC  2B        167         DEC HL           ;'TENS' COUNTER
0DAD  34        168         INC (HL)         ;INCREMENT TENS
0DAE  7E        169         LD A,(HL)        ;TEST TENS
0DAF  FE3A      170         CP 3AH           ;GREATER THAN 9 ?
0DB1  2002      171         JR NZ,COUNTR     ;IF NOT,STORE IN RAM
0DB3  3630      172         LD (HL),30H      ;CLEAR TENS
0DB5  2AEF0B    173 COUNTR: LD HL,(0BEFH)    ;LOAD SCREEN COUNTER
0DB8  22140E    174         LD (NUMBER),HL   ;STORE IN RAM

GAME OF LIFE                LIFE   LISTING 12/8/79          PAGE   4
 LOC   OBJ CODE   STMT SOURCE STATEMENT                       ASM 1.1

0DBB  E1        175         POP HL           ;RESTORE REGISTERS
0DBC  18        176 REFL    DEFB 18H         ;18 = 'JUMP RELATIVE'
0DBD            177 JUMP    DEFS 1           ;DISPLACEMENT GOES HERE
0DBE  CDF70D    178 MANUAL: CALL KEY         ;KEY PRESSED ?
0DC1  FE41      179         CP 41H           ;AUTO ?
0DC3  CAE00C    180         JP Z,AUTREF      ;GO TO AUTO MODE
0DC6  1808      181         JR ENDRUN        ;TEST FOR 'Q'
0DC8  CD4D0C    182 AUTO:   CALL KBD         ;KEY PRESSED ?
0DCB  FE4D      183         CP 4DH           ;MANUAL ?
0DCD  CAD80C    184         JP Z,MANREF      ;GO TO MANUAL MODE
0DD0  FE51      185 ENDRUN: CP 51H           ;QUIT ?
0DD2  C21B0D    186         JP NZ,INIT2      ;CONTINUE IF NEITHER
0DD5  11E40B    187 CHOICE: LD DE,0BE4H      ;MIDDLE OF TOP LINE
0DD8  21300E    188         LD HL,NEWCON     ;'NEW/CONTINUE?'
0DDB  010D00    189         LD BC,13         ;NUMBER OF LETTERS
0DDE  EDB0      190         LDIR             ;WRITE COMMENT
0DE0  CDF70D    191 CALLKB: CALL KEY         ;KEY PRESSED ?
0DE3  FE43      192         CP 43H           ;CONTINUE ?
0DE5  CAE50C    193         JP Z,GEN1        ;IF 'C',CARRY ON
0DE8  FE4E      194         CP 4EH           ;NEW ?
0DEA  CA500C    195         JP Z,START       ;IF 'N',RESTART
0DED  18F1      196         JR CALLKB        ;RECHECK IF NEITHER
0DEF  CB7F      197 CHECK:  BIT 7,A          ;BORDER CELL ?
0DF1  C0        198         RET NZ           ;TEST NEXT CELL
0DF2  CB47      199         BIT 0,A          ;DEAD CELL ?
0DF4  C8        200         RET Z            ;TEST NEXT CELL
0DF5  04        201         INC B            ;ADD ANOTHER NEIGHBOUR
0DF6  C9        202         RET              ;AND RETURN
0DF7  CD4D0C    203 KEY:    CALL KBD         ;KEY PRESSED ?
0DFA  30FB      204         JR NC,KEY        ;IF NOT,TEST AGAIN
0DFC  C9        205         RET              ;AND RETURN
0DFD  47414D45  206 TITLE   DEFM 'GAME'      ;'GAME OF LIFE'
0E01  204F4620  207         DEFM ' OF '
0E05  4C494645  208         DEFM 'LIFE'
0E09  47656E65  209 RUNSTR  DEFM 'Gene'      ;'GENERATION XX'
0E0D  72617469  210         DEFM 'rati'
0E11  6F6E20    211         DEFM 'on '
0E14            212 NUMBER  DEFS 2           ;COUNTER GOES HERE
0E16  4E657720  213 NEWPTN  DEFM 'New '      ;'NEW PATTERN  '
0E1A  50617474  214         DEFM 'Patt'
0E1E  65726E20  215         DEFM 'ern '
0E22  20        216         DEFM ' '
0E23  4D616E75  217 CHOOSE  DEFM 'Manu'      ;'MANUAL/AUTO? '
0E27  616C2F41  218         DEFM 'al/A'
0E2B  75746F3F  219         DEFM 'uto?'
0E2F  20        220         DEFM ' '
0E30  4E65772F  221 NEWCON  DEFM 'New/'      ;'NEW/CONTINUE?'
0E34  436F6E74  222         DEFM 'Cont'
0E38  696E7565  223         DEFM 'inue'
0E3C  3F        224         DEFM '?'
0E3D            225 BORDER  DEFS 25+1        ;26 BYTES FOR TOP BORDER
0E57            226 BOARD   DEFS 400         ;400 BYTES FOR BOARD
                227 BACKSP  EQU 013DH
                228 CRLF    EQU 0240H
                229 CURSOR  EQU 0C18H
                230 KBD     EQU 0C4DH
                231 SPACE   EQU 023CH

   0 ASSEMBLY ERRORS
```

The complete program listing with both source and object codes. As can be seen the program is bug free!

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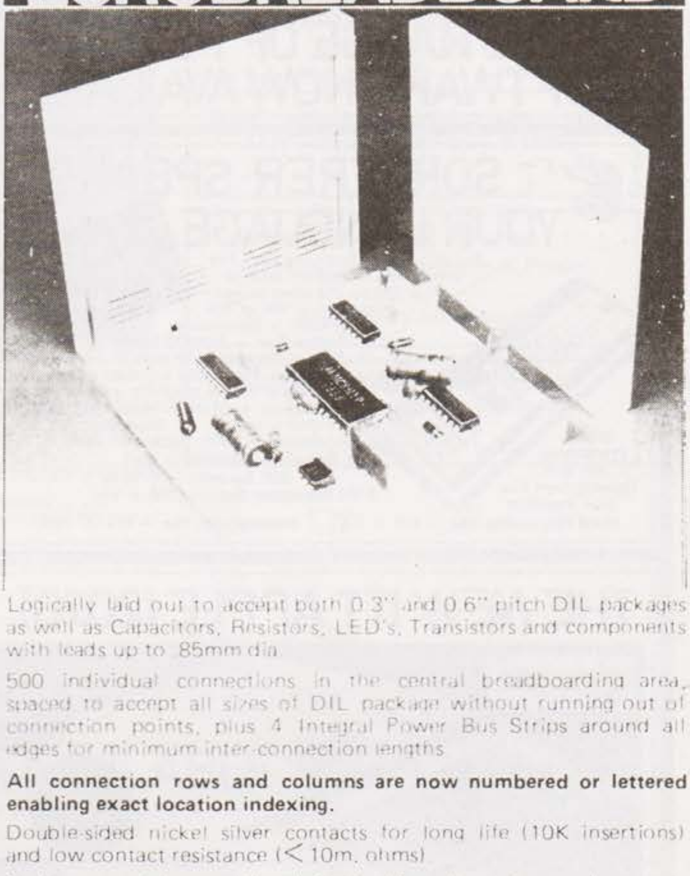

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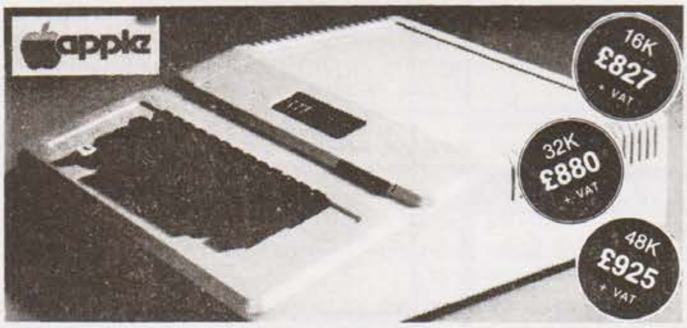

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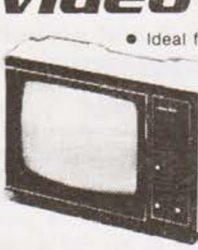

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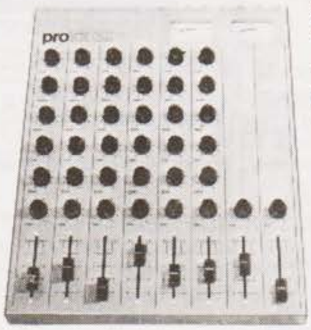

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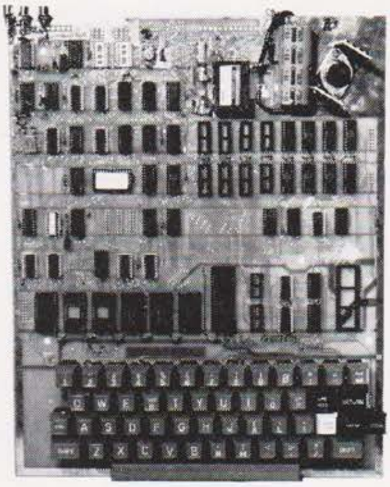

COMMANDS
CONT LIST NEW NULL RUN

STATEMENTS
CLEAR DATA DEF DIM END FOR
GOTO GOSUB IF GOTO IF THEN INPUT LET
NEXT ON GOTO ON GOSUB POKE PRINT READ
REM RESTORE RETURN STOP

EXPRESSIONS

OPERATORS
+ - * / ↑ NOT AND OR > < <> > = < = RANGE 10^{-32} to 10^{+32}

VARIABLES
A.B.C. ... Z and two letter variables
The above can all be subscripted when used in an array. String variables use above names plus $.e.g A$

*8K Microsoft Basic means conversion to and from Pet, Apple and Sorcerer easy.
Many compatible programs already in print.

SPECIAL CHARACTERS
@ Erases line being typed, then provides carriage return, line feed.
← Erases last character typed.
CR Carriage Return — must be at the end of each line.
: Separates statements on a line.
CONTROL/C Execution or printing of a list is interrupted at the end of a line.
"BREAK IN LINE XXXX" is printed, indicating line number of next statement to be executed or printed.
CONTROL/O No outputs occur until return made to command mode. If an Input statement is encountered, either another CONTROL/O is typed, or an error occurs.
? Equivalent to PRINT

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FUNCTIONS
ABS(X) ATN(X) COS(X) EXP(X)
LOG(X) PEEK(I) POS(I) RND(X)
SPC(I) SQR(X) TAB(I) TAN(X)
FRE(X) INT(X)
SGN(X) SIN(X)
USR(I)

STRING FUNCTIONS
ASC(X$) CHR$(I) FRE(X$) LEFT$(X$,I)
RIGHT$(X$,I) STR$(X)
LEN(X$) MID$(X$,I,J)
VAL(X$)

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