

To the BBC by bus and Tube

Roger Cullis explores some second-processor options for the BBC Micro.

ALTHOUGH the BBC Micro is a very fast machine with comprehensive facilities for driving peripheral devices, it was planned that it would ultimately be the basis of a much more powerful system.

The 6502 which lies at the heart of the BBC Micro is an eight-bit microprocessor, capable of addressing only 64K of memory. Of this, the powerful machine operating system and memory-mapped I/O takes 16K of ROM and a further 2.5K for zero page storage, processor stack and I/O buffers. The Basic interpreter requires 16K and the screen buffer needs up to 20K. As a consequence, there may be less than 10K available for user programs. Acorn's answer to this limitation has been to dedicate the basic computer exclusively to input/output and other housekeeping functions and to provide a second processor for data manipulation.

Ignoring the RS-432 port, which is too slow for this purpose, there are two practical ways of connecting a parasite processor: via the 1MHz bus or via the Tube interface. The latter provides faster communications, since it runs at 2MHz, but at the same time is less tolerant of timing inaccuracies. Most second processors are Tube based, a notable exception being the Torch Graduate.

Torch Z-80

The first commercially available second processor for the BBC Micro was the Torch Z-80, which was launched as a component of the Torch Z-80 disc pack in September 1982. Apart from a change to half-height drives, the current pack is mechanically similar to the original product and comprises a metal housing containing 28-track disc drives and a heavy-duty power supply. A ribbon cable couples the floppies to the disc interface connector on the underside of the BBC Micro.

The second processor electronics are on a double-sided printed circuit board which is mounted inside the main computer. The board contains a Z-80A running at 4MHz, 64K of dynamic RAM, a 2732 bootstrap EPROM and a 6522 versatile interface adaptor which handles communications with the base processor in the BBC Micro.

A short 40-way ribbon cable from the Z-80 printed circuit board passes through a slot in the BBC Micro's case and plugs into the Tube connector on the underside. A sideways ROM which contains the BBC Micro housekeeping routines completes the setup.

Torch has done a neat job with the sideways ROM, which has evolved from 8K to 16K to provide system enhancements. The current version, MCP 0.41, contains the routines necessary to interface all the Torch second processors, other than the Graduate, as well as the firmware to control the Torchnet local area network. The operating system for the Z-80 is CPN 0.71, which is configured in the same way as CP/M 2.2 and permits the user to run CP/M software.

The advantages of having the operating system in ROM are that the cold boot is instantaneous, 63K of RAM is available for user programs and system tracks are not required on the disc. CP/M utilities such as Format, Copy, Input, etc. are normally loaded in from disc. With CPN

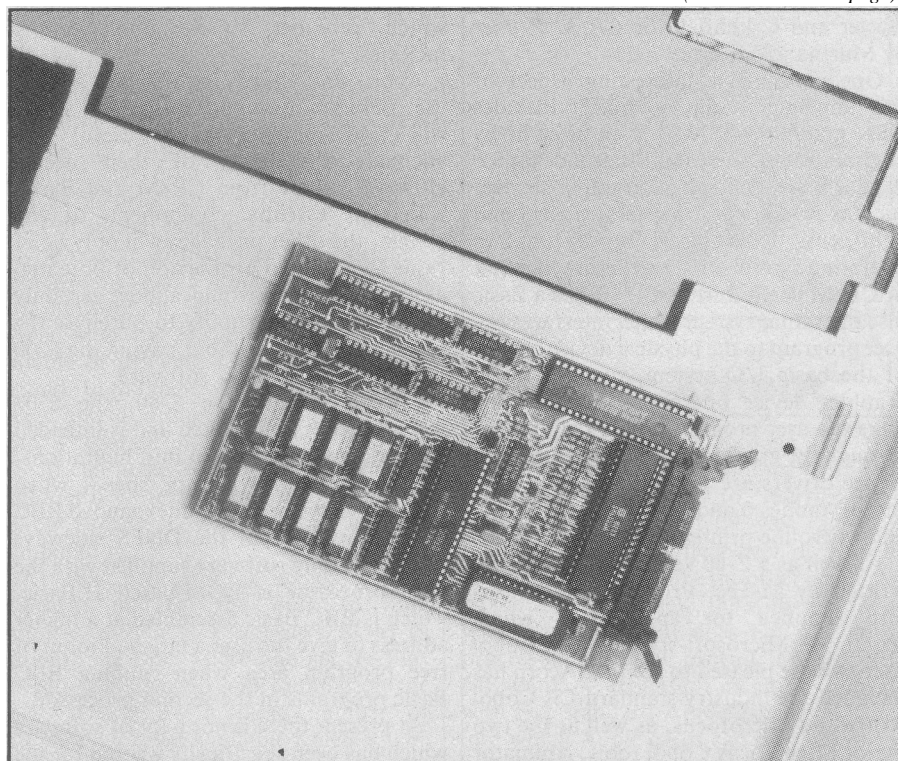
they are in ROM and instantly ready. BBC * commands are also available from ROM.

Torchnet, which will operate only if the BBC Econet hardware is present, is an enhanced version of Econet which does not require dedicated stations for file and printer servers. Bundled with the Torch disc pack is the Z-80 version of BBC Basic as well as Perfect Writer, Perfect Speller, Perfect Filer and Perfect Calc.

Acorn Z-80 and 6502

In fact, Z-80 and 6502 are misnomers, since the processors are actually a Z-80B and a 65C02. The Z-80B is simply a faster version of the Z-80, but the 65C02 also enhances the instruction set of its predecessor. There are also some timing changes and the famous 6502 page-spanning bug has been removed, together

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The Torch Z-80 pcb fits under the lid of the host micro.

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with the illegal instructions which some people have used as a means of program protection.

Conceptually, the two second processors are very similar. Both are mounted in a narrow case styled to match that of the BBC Micro, both have a power supply with toroidal transformer and transistor regulator on the main circuit board, both address 64K of RAM with a 2732 bootstrap EPROM and both communicate with the Tube through a Ferranti ULA chip.

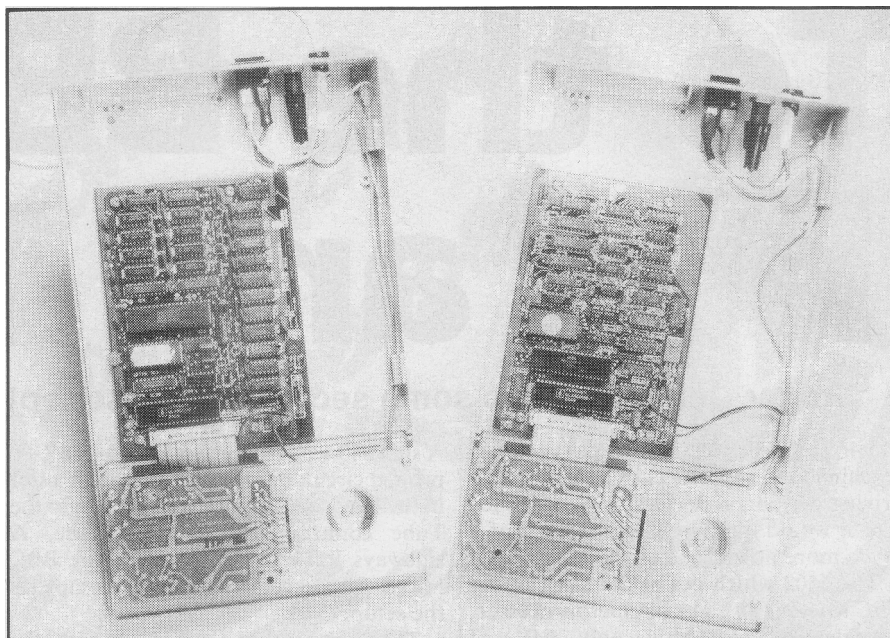
Apart from the differences which are the result of the different processors, the main distinguishing feature is the software which is supplied with the Z-80. To say that there is an abundance is an understatement; a separate box is necessary to hold the 11 manuals and seven discs. Clearly Acorn was not certain of its target market, so it took a shotgun and aimed at everything in sight.

Surprisingly, Acorn chose to make CP/M 2.2 the operating system for the second processor even though the much more user-friendly CP/M Plus has been available for over a year. A possible explanation is that CP/M Plus requires an extra 64K bank of memory to exploit it fully. With the current price of chips it would not have added greatly to the cost, and it would have been a real advantage.

A much more serious drawback is that the accompanying manual is no more than the infamous Digital Research CP/M 2.2 manual in a BBC Micro cover. My advice to new users is to throw it away — having preserved Appendix J, which contains the BBC-specific details — and buy one of the really good books on CP/M, such as CP/M and the Personal Computer by Dwyer and Critchfield or CP/M Primer by Murtha and Waite.

One particularly interesting aspect of this implementation, is that it includes GSX graphics. GSX-80 is an attempt by Digital Research to establish standards for the software control of graphics devices such as printers and plotters, tracers and light-pens. It is based on a graphics operating system with a structure like that of CP/M itself. Just as CP/M has a Basic disc operating system which interfaces the user program to the physical device drivers of the basic I/O system, so GSX has a graphics device operating system which links the user program to the real devices through the graphics I/O system. Physical device drivers are provided for the VDU screen, modes 0 and 1, and for the Epson and Microline printers.

As well as a Z-80 version of BBC Basic written by M-Tec, Professional Basic is also supplied for applications which require a Microsoft-style Basic. Cobol users will be pleased to see that Acorn has included the industry-standard Cis Cobol written by Microfocus, as well as the two major Microfocus Cobol tools, Animator and Forms-2.



Acorn's Z-80 (left) and 6502 are housed in separate matching boxes.

Moving up through the packages, the next level is a program generator, Nucleus, which can be used by those with no previous programming experience since it is menu-driven. It can create databases, such as records of club members, prepare planning schedules, print reports from accounting programs or design reports to be prepared from programs written by Nucleus itself.

There are three office software packages: Fileplan, described as a database management program or an automated card index; Graphplan, a financial modelling spreadsheet; and Memoplan, a simple word processor. Complementing these is Accountant, which provides simple book-keeping facilities.

Acorn has already established a large user base among small businesses, which will find these packages useful and adequate for many of their needs. However, apart from CP/M and Basic, which are essential components of any system, the other packages will only be of value to a limited proportion of potential users. The others would almost certainly welcome the opportunity to purchase the second processor without paying the £200 premium for the extra software.

Compared with the Z-80, the 6502 second processor is naked and is intended for people who have run into limitations, either of memory size or speed, when running software on the unexpanded BBC Micro. Apart from the DNFS sideways ROM, the only software supplied with the 6502 processor is ROM-based HiBasic, which is BBC Basic assembled at a higher address to give the user a larger amount of free program area when running BBC Basic programs in the second processor.

At present there is not a lot of software which has been specifically written for the 6502 second processor. Bitstick needs it, as

does the Level-2 file server software for Econet. Acornsoft has prepared a special version of the View word processor, and a comprehensive macro assembler package, the 6502 Development System, is in the pipeline. This will produce code for the 6502 or the 65C02.

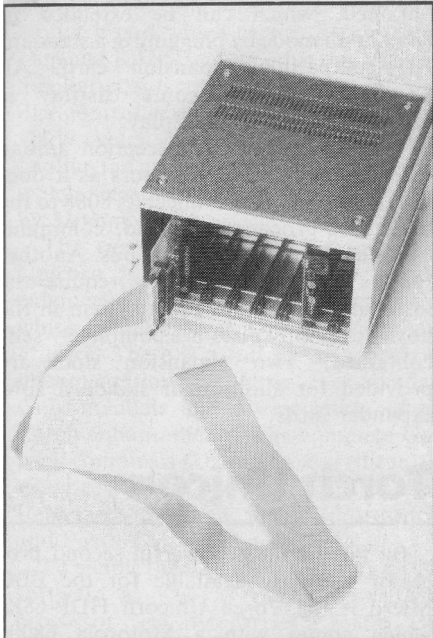
When the BBC Micro was introduced, Acorn issued dire warnings about not accessing the operating system and peripherals directly. All use of the MOS routines should be via specified calls such as Osbyte or Osword. Those who wrote directly to the I/O devices or made Pokes to the screen are now finding that their software is having to be rewritten to run on the 6502 second processor. This is true of a number of sideways ROMs as well as most arcade games which include animation techniques.

Both Acorn second processors expect OS 1.0 or higher and are provided with a voucher for free exchange of earlier versions. They also come with a 16K DNFS filing system ROM which replaces the 8K disc filing system and 8K Econet filing system ROMs, and also contains the interface routines to initialise the Tube for second processor communication.

CMS 6809

The most exciting of the eight-bit add-ons is the 6809 system from Cambridge Microcomputer Systems. It is an engineers' system based on the microprocessor that arrived too late. Compared with the 6502 and Z-80, the Motorola 6809 has a whole orchestra of bells and whistles. Had it been developed sooner it would have been adopted for a wide range of computers rather than just the Dragon and the Tandy Color Computer.

The Motorola 6809 has two eight-bit accumulators, A and B, which can be

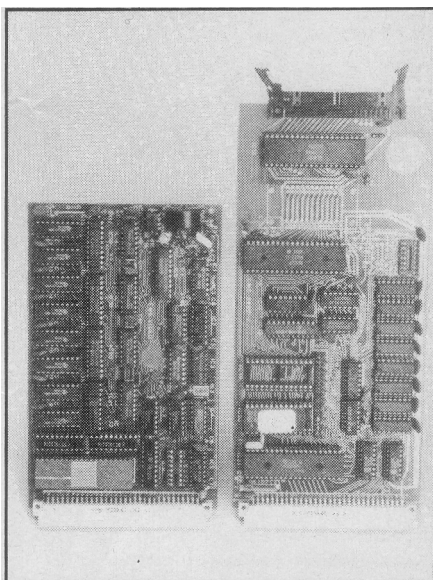


CMS mini-rack development system.

combined as a single 16-bit accumulator, D. It has two 16-bit index registers, X and Y; a 16-bit user stack register, U, which is a cross between a typical microcomputer index register and a typical microcomputer stack pointer; a 16-bit hardware stack pointer, S; a 16-bit program counter, PC; an eight-bit direct page register, DP; and an eight-bit condition code register, CC.

The direct page register holds the eight most significant bits of an address and extends the concept of zero-page addressing to any page in memory. It thus allows the programmer to take advantage of short-paged addressing without being limited to the first 256 bytes of memory. Different programs can have different base pages, eliminating the need for multiple use of page zero locations and reducing the possibility of conflict.

CMS sells a 6809 Eurocard which you



CMS colour-graphics card (left) and 6809 card.

can mount inside the case of the BBC Micro in the same way as the Torch Z-80 card, but its full potential is only realised as the engine which drives the CMS version of microprocessor Meccano, a rack-based development system connected to the BBC Micro by a trailing umbilical ribbon cable.

Unlike the other second processors in this review, whose main purpose is data processing, the CMS 6809 is mainly used to develop systems which will be used in control applications. The heart of the system is a neat 8in. rack containing a switched-mode power supply and a seven-way buffered backplane which can be used to connect a variety of Eurocard-based subsystems. As well as the 6809, the processor card itself carries 64K of dynamic RAM, a 4K bootstrap EPROM and a pair of back-to-back 6522 VIAs which communicate with the Tube by way of a 40-way IDC connector. Situated at the other end of the card is a 64-way DIN 41612 connector which plugs into the backplane.

Among the other CMS cards which also plug into the backplane are a high-performance colour graphics card, an IEEE talker/listener controller, a universal controller with either a 6809 or 6502 processor, a memory carrier and a variety of analogue and digital interfaces.

The system is robust. Mechanically it is soundly made and the Tube connector is three or four times as long as those which operate the other second processors without problems of noise or crosstalk. It is even possible to insert and unplug the cards with the system powered up and only experience the occasional crash which requires no more than a reboot to correct.

The colour graphics card is based on the Thompson EF-9366 graphics processor chip and has a 64K graphics memory compared with 20K in the highest-resolution mode on the BBC Micro. It is capable of displaying mixed text of differing sizes, orientations and colours as well as pictorial data. It requires only 32 bytes of system memory.

The colour display has three primary colour planes and a luminance plane with a flashing option. Each colour plane is 512 pixels wide by 256 pixels high and is capable of drawing 1.5 million dots per second. In monochrome there are 16 grey levels, and in colour eight colours per pixel with a separate intensity plane. The full ASCII character set is held in ROM and a high-density text mode supports 32 85-character rows in any colour combination.

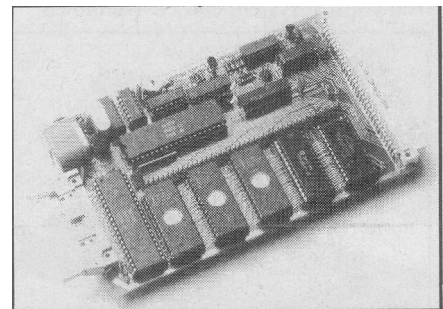
As this processor is aimed at the industrial market, the only software supplied with it is a sideways ROM to initialise the BBC Micro and get the Flex operating system up and running on the 6809. There are a large number of software packages available which will be of immense value to the software development engineer both for the

development of 6809 software and for work with other processors. Reflecting the nature of the CMS system as a development tool for control applications, many of the software utilities produce code which can easily be put into ROM. One of these is the editor/compiler/tracer, PL/9. It is a structured language, having procedures and statements such as IfThen-Else, which the user of BBC Basic will find familiar. Lucidata Pascal is another high-level language whose programs can be saved to ROM. Among the low-level utilities is a range of cross-assemblers, disassemblers and simulators for the 6809, Z-80, 6502, 6800, 8080/8085 and 68000.

CMS 6502

A very recent introduction is the CMS 6502 second processor. Based on the CMS universal controller card, it permits the user to select a variety of combinations of ROM and RAM up to a total of 160K. Address decoding is by means of a bipolar ROM, giving the opportunity to redefine the memory map. Provision is made on the printed circuit board for a real-time clock and battery backup, which are available as an optional extra.

As with the 6809 card, it may be mounted as a stand-alone board inside the case of the BBC Micro, or it may be plugged into the rack-based bus system for further expansion. The card has a 4K monitor ROM which contains the routines necessary for Tube communications and will run all base processor software which is compatible with a 6502 second processor.



CMS 6502 card.

Xcalibur Xmem

Another company looking to the industrial market is Xcalibur with its Xmem, which seeks to marry BBC technology to some of the vast range of peripheral cards that have been developed for the Apple II. Unlike the other products included in this review, the Xmem is not a second processor. It does not contain a processor chip at all; instead, it provides a 64K bank of expansion memory coupled with five standard Apple expansion slots into which Apple cards can be plugged.

The Xmem is connected to the 1MHz

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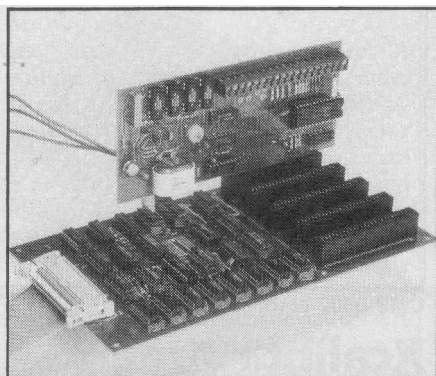
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bus and is accessed by calls to Jim, page FD extended memory, the pages being selected one at a time, using the Fred paging register. Power is obtained either from the auxiliary power-connector socket on the BBC Micro or from an independent power supply.

There are a number of limitations on the connection of peripherals, mainly stemming from the passive nature of the device and its alien environment. Since the Xmem has no 6502 processor and no Apple monitor, there is no means of controlling Apple cards with routines in ROM. But this does not present a limitation to Xcalibur, which produces a range of accessories for industrial applications.

Typical of these is the Xad-1 four-channel 12-bit analogue-to-digital converter with a battery-backed real-time calendar/clock. It also controls four channels of isolated relay outputs. The analogue input channels are set to a nominal 0V to 5V range and so can be used to monitor TTL digital lines or contact closures, as well as continuously variable analogue levels. The relay contacts are individually programmable and may be used to actuate external devices, so the card may be used as the basis of a process control system.

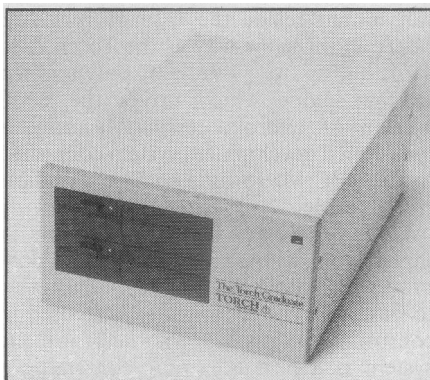
Among other cards available are larger and smaller analogue-to-digital converters, thermocouple amplifier modules, counters and digital-to-analogue converters. The Xmem card itself will fit into the standard Xcalibur portable computer case. This will also take a BBC motherboard and the Xcalibur 5in. monitor so that a transportable industrial control system can be assembled.



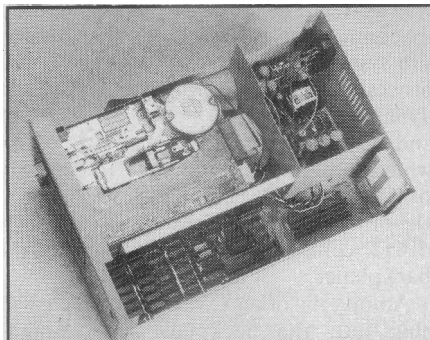
Xcalibur Xmem with I/O converter and clock card.

Torch Graduate

"Add the capability of running IBM software for less than £1,000" was the offer made by Torch when it launched the Graduate. There are four versions, ranging from a single-floppy 128K machine to a twin-floppy 256K RAM model which offers almost complete IBMulation. Using BBC graphics, a 40-column full-colour display can be



The Torch graduate outside ...



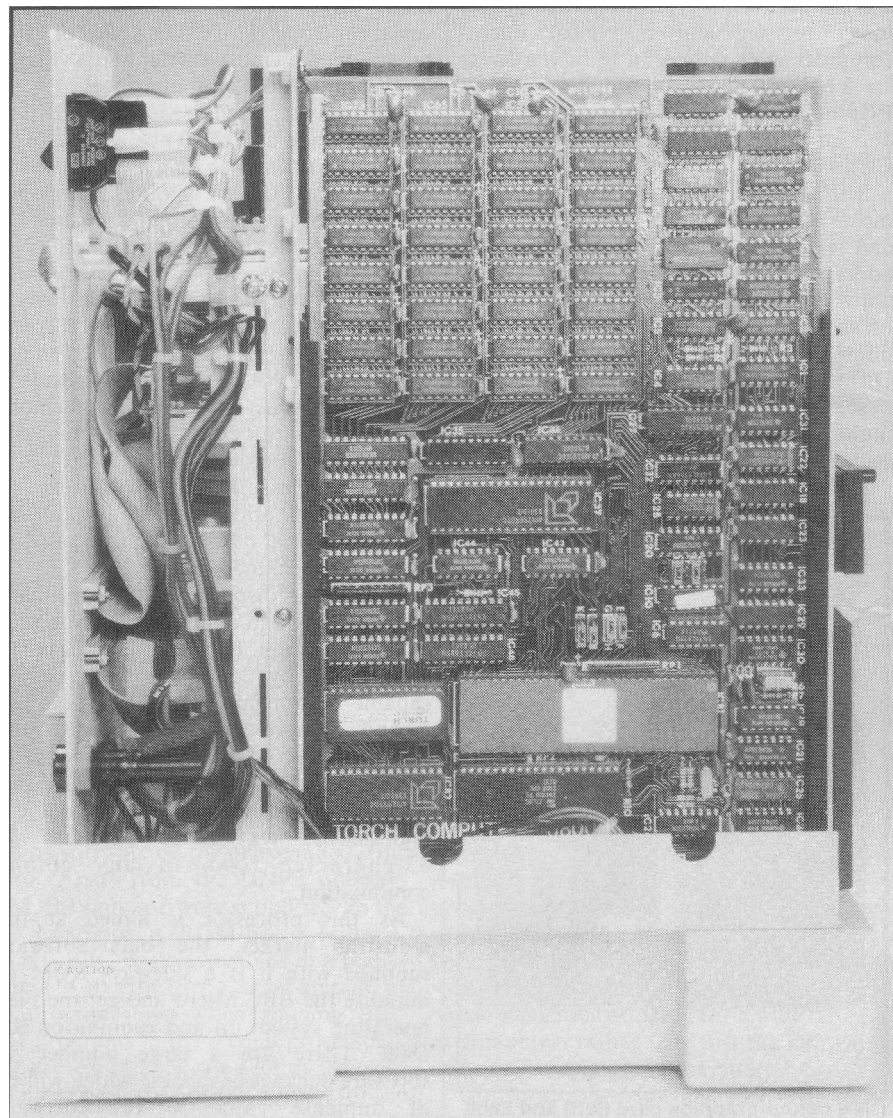
... and inside

obtained, which can be extended to 80-column mode by plugging in a standard IBM-compatible expansion card. An 80-column monochrome display is achieved via the BBC display.

The Graduate is an exception among BBC Micro second processors as it does not use the Tube to connect its 8088 to the 6502 base processor. Instead, communication is through the 1MHz bus. Another feature is that it does not require the installation of a disc filing system in the host. Its floppy discs are completely self-contained. Two expansion slots are provided for addition of standard IBM expander cards.

Torch Unicorn

By far the most powerful second processor currently available for the BBC Micro is the Torch Unicorn HDP-68K, which comes with a Motorola 68000 16/32-bit processor and a 20Mbyte hard disc and a 400K floppy as backing store. As supplied, there is 256K of dynamic RAM but by changing internal links and substituting 256K chips, this can be

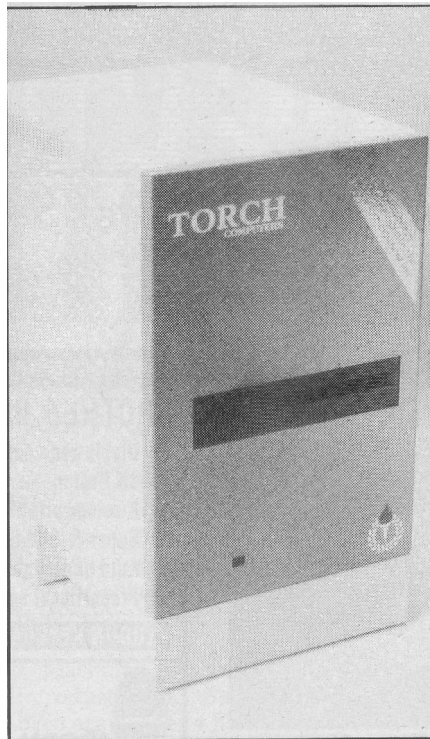


The Unicorn's motherboard is mounted vertically beside the drives.

increased to one megabyte. The main circuit board which carries the processor chip and RAM is mounted at one side; and auxiliary cards are provided for the hard-disc controller and SASI disc interface. A 100W switched-mode power supply and a cooling fan are also squeezed into the case, which measures only 190mm. by 270mm. by 330mm.

The operating system for the 68000 Unicorn is Unix III with the Berkley enhancements. It comes on 24 floppy discs which contain over 200 programs and utilities. There is a full set of supporting documentation including the standard Unix manuals and a description of the Torch enhancements. The complete Unix pack contains a C compiler and editor, the vi screen editor and the csh C shell. Languages available include Fortran 77 and Pascal.

To enable the user to run existing CP/M software as well as Unix, the parasite processor card also carries a Z-80B. Due to the faster memory chips required by the 68000, the Z-80B can be run at 6MHz, rather than the 4MHz of a normal Z-80 second processor. This means that CP/M programs will run 50 percent faster. A



The Torch Unicorn.

memory management unit allows multi-tasking without interference between tasks.

Conclusions

- With the second processors covered by this review, BBC Micro owners have the opportunity to enhance their systems to virtually any degree within the current state of the art.

- The availability of the CP/M, Flex, UCSD p-system, Xenix and Unix operating systems together with languages such as Basic in many forms, Pascal, Cobol, Forth, Lisp and Fortran mean that there is the capability of running practically all serious software available for microcomputers.

- It is time for manufacturers to review the practice of giving away software with new machines. Most buyers either have a specific application in mind or have already invested a large amount of time and effort in installing their programs on another machine. They would be far better served by a service which upgrades and configures existing software for the new machine.

	Acorn 6502	Acorn Z-80	CMS 6809	CMS 6502	Torch Z-80	Torch Graduate	Torch Unicorn	Xcalibur Xmem
CPU	65C02	Z-80B	6809	6502 or	Z-80A	8088	68000, Z-80B	None
Memory	64K	64K	64K	Up to 160K in 32K banks of ROM or RAM	64K	128K expandable to 256K	256K expandable to 1Mbyte	64K
Connection	Tube	Tube	Tube	Tube	Tube, disc interface	1MHZ bus	Tube, 1MHz bus, disc interface	1 MHz bus
Operating systems	Acorn DNFS	CP/M 2.2	Flex	DFS	CPN	MS-DOS	Unix 111, CPN, UCSD p-system	Memory-mapped read/write instructions
Expansion	None	None	DIN 41612 connector, optional seven-slot backplane	DIN 41612 connector, optional seven-slot backplane	None	Two IBM PC compatible slots	None	Five Apple II slots
Software	HiBasic	BBC Basic, Professional Basic, Cis Cobol, Animator and Forms 2, Graphplan, Fileplan, Memoplan, Accountant	BBC to Flex linker	Linker to base processor	BBC Basic, Perfect Writer, Perfect Speller, Perfect Filer, Perfect Calc	None	Full Unix suite with over 200 programs and utilities, including C compiler and editor	None
Price	£199	£399	£408	£199	£699	£945	£2,895	£299

Suppliers:

Acorn Customer Services, Cambridge Technopark, 645 Newmarket Road Cambridge CB5 8PD. Telephone: (0223) 210111
 Cambridge Microprocessor Systems Ltd, 44A Hobson Street, Cambridge CB1 1NL. Telephone: (0223) 324141
 Torch Computers Ltd, Sales Department, Abberley House, Great Shelford, Cambridge CB2 5LQ. Telephone: (0223) 841000
 Xcalibur Computers Ltd, Spencer House, 3 Spencer Parade, Northampton NN1 5AB. Telephone: (0604) 21051