Workstation. Tube interfacing is handled in customary Acorn fashion by a Ferranti ULA chip, but the operating system is much more complex than the eight-bit little brothers', occupying two 27128 EPROMs. At the other end of the Tube, a sideways DNFS ROM provides the communications routines. A 32081 floating-point unit handles all floating-point calculations, except for those running in BBC Basic. There is a large gap adjacent to the processor to house a 32082 memory management unit, should the Co-Processor be upgraded to provide virtual-memory facilities or to run a multi-user operating system such as Unix.

WHAT'S IN A NAME?

National Semiconductor's chip which powers the Co-Processor started life as the 16032. but became the 32016 when the marketing folk decided there was some mileage in emphasising the fact that it had 32-bit registers and many other attributes of a 32-bit microprocessor. Nevertheless, the external data bus, which is the main criterion for classifying a processor, is 16-bit.

The chip is housed in a 48-pin dual in-line package with a multiplexed 24-bit address bus and 16-bit data bus, permitting a direct address space of 16Mbyte. Internally, there are eight 32-bit general registers, and six 24-bit and two 16-bit dedicated registers.

The 32016 has over 100 basic instructions and nine address modes. It can add, subtract. multiply, divide, set bits, reset, test. transfer data, string, processor control,

CAMBRIDGE 32016 CO-PROCESSOR
BBC MAINFRAME ADD-ON

By Roger Cullis

The BBC host micro is dwarfed by the power —and price — of Acorn's latest second processor, which nevertheless provides a cheap way into mainframe-style computing.

After a gestation period longer than that of an elephant, Acorn has finally given birth to its heavy-weight, 16-bit second processor for the BBC Micro. Planned originally as part of the BBC Computer Literacy Project, the product which has emerged far outstrips the original concept. It is now considered to be too powerful for the needs of the education market, and has been transferred to Acorn's Scientific Division, which services the universities and other advanced academic and

industrial users. During the metamorphosis, it has been renamed the Cambridge Co-Processor to emphasise its relationship to the Cambridge Workstation, which was launched at the same time.

Physically, the Cambridge 32016 Co-Processor resembles the other Acorn second processors and 1MHz bus accessories, with a half-width case and an umbilical ribbon cable to connect it to the host computer. Internally, the arrangement is the same as that of the 6502 and Z-80 second processors, with a separate power supply and a single PCB occupying the whole of the available space in the case. This PCB carries the parasite processor and has two rows of RAM chip holders down one complete side. Either 64K or 256K chips can be fitted, but all production models use the larger chips. The current version of the software requires a minimum of 512K of RAM, so only 512K and 1Mbyte versions are to be sold.

The 32016 processor is clocked at 6MHz, compared with 8MHz on the Cambridge

perform Boolean logic, array and block move and compare. Most operations can be performed on bytes, words and double words, while some can only be performed on bits and others on quadruple words. The instruction set is symmetrical, which means that all of the two-operand instructions can be used in all addressing modes. It

BASIC BENCHMARKS

The standard Benchmark routines - see *Practical Computing,* January 1984, page 104 - were run on the following units:

	BM1	BM2	BM3	BM4	BM5	BM6	BM7	BM8	Av.
Cambridge 32016 Co-Processor	0.43	2.32	4.14	4.82	5.96	9.80	15.07	12.51	6.88
Acorn Z-80 Second Processor	0.49	2.27	7.49	8.10	9.62	13.38	19.20	22.81	10.42
Acorn 6502 Second Processor	0.42	2.10	5.49	5.98	6.96	10.30	15.54	35.57	10.27
BBC Micro model B	0.65	3.17	8.20	8.93	10.42	15.41	23.27	52.56	15.53

can also perform memory-to-memory operations. One useful feature is top-of-stack addressing, which provides an extremely economical and speedy mode of operation.

Acorn has not adopted a standard operating system for the 32016 Co-Processor but has commissioned its own, called Panos, which was written in Modula-2. Panos offers the ability to amend, reconfigure or supplement parts of the operating system without a total rewrite, and is economical of systems resources. This last factor is particularly important when running mainframe software. Panos will support cross-language calls for Fortran, C and Pascal, which means that program suites written in any of these languages are available to applications writers working in different high-level languages.
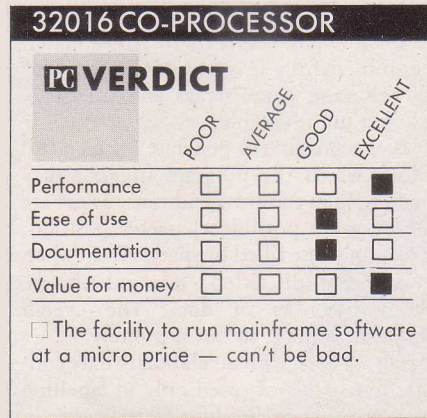
Those familiar with the BBC Micro operating system will recognise many features of Panos, which supports program loading and execution, a procedural model of program execution, command-line interpretation, command files with parameter substitution, event handling, cross-language calls, a stream-based I/O model, support for Acorn ADFS, NFS and DFS filing systems, time stamping on files and file name extensions.

Cambridge Lisp has been developed to provide support for an ongoing research project in computer algebra. The impetus to write it came from a growing dissatisfaction with the Stanford system available on the 370 / 165. The 32016 implementation, intended for running experimental programs, makes a policy of checking for exceptional cases and provides clear and concise diagnostics.

ALGEBRA SYSTEMS

The expectation that the system would be used for writing parts of algebra systems has led to the inclusion of an arithmetic package that puts consistency above efficiency. Integers can grow to be any size, the normal arithmetic primitives know about rational numbers, and there is a well-defined interface between exact and floating-point number representations. The system provides a number of character-handling facilities, can select and use several input/ output streams and has a built-in Lisp prettyprinter.

The Cambridge Lisp is largely compatible with the Lisp standard proposed by Professor A C Hearn of the University of Utah. The main limitations are a less efficient use of memory resulting from large parts of the

32016 CO-PROCESSOR

PC VERDICT

	POOR	AVERAGE	GOOD	EXCELLENT
Performance	☐	☐	☐	■
Ease of use	☐	☐	■	☐
Documentation	☐	☐	■	☐
Value for money	☐	☐	☐	■

☐ The facility to run mainframe software at a micro price — can't be bad.

system being coded in BCPL rather than machine code, and lack of support for functional closures or environments.

Acorn ISO Pascal is a compiled language comprising a two-pass compiler to translate Pascal source programs into 32016 machine code, and a library of pre-compiled modules to provide facilities such as string to numeric conversion. The Pascal compiler has been formally validated and conforms to BS6192 Level 1 Category A.

C IMPLEMENTATION

The Acorn implementation of C is a compiled language which conforms closely to the 1978 definition of Kernighan and Ritchie. It includes a C compiler, several standard C Include source files and a C runtime library. Source programs are prepared using the standard Acorn text editor, and machine-code modules are combined into a runnable program using the Acorn linker.

The BBC Basic provided for the 32016 closely follows the versions supplied with the other Acorn second processors, even to the extent that floating-point routines do not use the 32081 floating-point unit, but follows algorithms built into the interpreter. Basic IV, as the 32016 version is known, provides a classic illustration of the propensity for operating systems to fill available memory. The succint error messages of Basics I and II and HiBasic have been translated into extensive literary works. For example, " Division by zero" has been replaced by " Righthand operand of / , DIV or MOD should not be zero" whilst " - ye root" is now " Operand of SQR must be non-negative".

There are a number of extensions and additions to immediate commands, but, in general, BBC Basic programs will not need to be changed. The major differences are the

lack of a built-in assembler and the handling of arrays in functions and procedures. The Basic Benchmark tests clearly indicate where the power of the 32016 processor comes into its own.

The 32000 Assembler runs in the Panos environment and supports the complete 32016 instruction set, including the 32081 floating-point and 32082 memory-management units. It handles all nine general addressing modes and can generate two types of object file: a simple binary image for immediate execution and an image in Acorn Object Module format. A source line may contain mnemonics, ASM assembly-language directives, comments or may be left blank for visual formatting. ASM accepts the full range of National Semiconductor assembly-language mnemonics and has the ability to define macros. Object code may be absolute or relocatable.

DOCUMENTATION

Documentation for the system is made up of eight separate volumes. Six reference manuals cover the 32000 Acorn Assembler and the high-level languages BBC Basic, C, Fortran 77, Cambridge Lisp and ISO Pascal. The Cambridge 32016 Co-Processor User Guide introduces the Panos operating system, while the Panos Programmer's Reference Manual is designed for the more experienced programmer. We saw only provisional versions of the documentation; it is being substantially revised for shipment with production machines.

A wide range of software has already been ported from mainframe and supermini implementations. Priority has been given to generic packages like spreadsheets, word processors and database managers, and software tools like mathematics and graphics libraries. There is a full NAG Fortran library with a number of statistical packages. The algebra system Reduce, written in Lisp, is an example of a product relying on artificial intelligence techniques. For the integrated-circuit designer there is Spice, a circuit-simulation program, while in the field of software engineering there are additional languages such as BCPL and Alogol 68C and graphics libraries including Gino-F, Grape-2D and Grape-3D.

Econet and RS-423 facilities are built-in, and there is an emulator to permit the microcomptuer to act as terminal for mini-computers or mainframes.

CONCLUSIONS

■ The 32016 Co-Processor provides a tool which will give specialist micro users access to mainframe software.

■ Acorn appears to have abandoned its original concept of providing a 16-bit upgrade path for the BBC Micro. There is little in the 32016 Co-Processor for the average micro punter at this stage.

■ This solution represents a very cheap route to mainframe computing. Particularly cost-conscious users may well be buying the 512K version and plugging in the extra chips themselves to expand the memory capacity to 1Mbyte.