

Acorn Archimedes

Fuelled by Acorn's innovative ARM RISC processor, the Archimedes or 'A' series offer workstation power and spectacular graphics abilities at PC prices. With their place in education already assured, Dick Pountain believes their speed may also guarantee them entry into the business world.



Ever since Acorn first announced the details of its ARM RISC processor chip it has been quite obvious, despite rather feeble denials from the company, that ARM was intended to power the successor to the venerable BBC Computer. ARM's designers quite openly stated their goal, which was to produce a 32bit replacement for the 6502, all the major competitors having been rejected as inadequate.

When last year Acorn launched the Master, a slightly repackaged Beeb, it was received in the press with something approaching scorn, and many people expressed scepticism about whether Acorn had the wherewithall to do anything useful with ARM.

With the launch of the Archimedes or 'A' series of computers, we can see that the Master was merely a stopgap measure, and that behind the scenes Acorn was giving everything it had to ARM technology. It has been well worth the wait. The A series machines offer workstation power at personal computer prices, and they deliver this power to the programmer in an easy-to-use way, resulting in truly spectacular graphics abilities.

It would be as well to clarify the status of this Benchtest. At the time of writing, the production models A305, A310, A440 and the A410 were not quite finished. Instead what Acorn loaned to me was an A500 Development System. This machine, which is not on sale to the public, is what Acorn uses for internal development of A series software, and has been distributed to selected external software producers for some months. It has a very similar hardware specification to that of the high-end A410 model (20Mbyte hard disk, one floppy, 2Mbytes memory), though it uses the older (3micron process) versions of the ARM chips which are very slightly slower than the 2micron production versions. The system software I saw was at various stages of development; none was final and some sections were incomplete.

You should, therefore, read this more as a preview than a review, and I shall point out various places where the production machines will differ from the A500. You may also be confident that any bias will be in the right direction; the production machines will be better than that which I tested.

Hardware

Enough has been written about the Acorn ARM chip (in this magazine, by myself, for one) that I shall only briefly describe this new processor. It is a full 32bit processor of classic RISC (Reduced Instruction Set) design. It uses 27 32bit registers and a small instruction set of 44 simple instructions, almost all of which ex-



One concession to 'industry standards' is the Archimedes keyboard, which offers both IBM PC and BBC Model B compatibility. Like the Model 300 it has red function keys, presumably to persuade BBC Model B owners to 'upgrade' to an Archimedes. A three-button mouse is fitted as standard

ecute in a single clock cycle. Like the old 6502 which partly inspired it, it gets its speed from short instructions rather than fast clocks (the 4MHz clock yields roughly four MIPS). Indeed, it was designed specifically to be usable with cheap dynamic memory parts, unlike many new ultrafast processors which require astronomically expensive static RAM and 25MHz clock rates to get their performance. This has been a major factor in allowing ARM to be the first 'super' processor to find its way into a mass-market micro.

We've heard much less about the three peripheral chips which Acorn designed to go with the ARM CPU, and which were launched in late 1986. These are the VIDC Video Controller, the MEMC Memory Controller and the IOC Input/Output Controller. All four chips are used in the A series machine architecture, forming a complete 'designer' chip set.

The VIDC controls a colour display with one, two, four, or eight bits per pixel: that is, from monochrome up to 256 colours. It includes a 16word colour lookup palette which allows a choice from a total of 4096 colours, and has onchip digital-to-analogue converters to directly provide RGB signals. It also supports a hardware cursor in up to three colours, and directly controls VDU timing parameters in a programmable way. Its pixel rate is programmable between 824MHz (the rate at which the machine supplies information to the screen). It's hard to translate that directly into maximum screen resolution because there are some tricks which allow it to look like 96MHz in certain circumstances; briefly, it can support a 1024x1024 high-resolution mono display, 640x256 in 256 colours or 640x512 in 16 colours.

Rather surprisingly the VIDC also provides the Sound Controller. It can

handle up to eight sound channels in stereo. The sound generation facility provided is rather simple compared with dedicated synthesiser chips like the Ensoniq, but fancy stuff can be done in software, exploiting the tremendous speed of the ARM.

The MEMC chip can address and refresh up to 4Mbytes of actual RAM, but also has the capability of translating logical to physical addresses so that a 32Mbyte logical address space can be supported. This can be used to provide a disk-based virtual memory system, or to provide hardware memory protection for multitasking systems; that is, stopping one task interfering with another's memory. As an aside: it's been the lack of such hardware protection for the 68000 (Motorola's Memory Manager having been hugely delayed) that has hindered the development of serious multitasking software on the Mac, ST and Amiga.

The MEMC doubles as a DMA controller which manages the buffers for video, sound and cursor data. It is also the glue which sticks all the four chips together, providing as it does the processor clock signal and all other system timing signals.

The IOC controls system interrupts and the system bus. It contains a number of timers, a serial keyboard interface and logic for talking to other peripherals.

The importance of this all-Acorn chip set is twofold. The careful packing of functions into the four chips removes the need for a lot of so-called 'glue logic' and so keeps the overall chip count low. But also the chips are optimised to work together, using pipelining and other tricks to maximise the performance of the whole combination. There is no compromise due to mismatch with other people's chips, and this shows in the performance. Practically all that is

needed to make a computer out of the four chips is to add some disk controllers and some RAM and put it all in a box.

The actual specifications of the Archimedes machines are as follows. There are two series of machines, both of which live under the generic name Archimedes. The A300 series are the direct replacements for the BBC Micro and Master and will bear the BBC logo. The A400 series is more upmarket, featuring internal hard disks, more memory and more expansion capabilities, and will be sold under the Acorn logo (and maybe later Olivetti?).

The lowest cost machine, the £799 A305, comes with 512k of RAM, while the A310 has 1Mbyte; the A305 is upgradable to 1Mbyte by simply populating vacant RAM sockets. Both models have one 3½" floppy drive, whose disks can be formatted to 800k or to 640k for Master compatibility.

All models come in the same system unit case, which has a metal top and sides and a plastic front panel with an ergonomically inclined (that is, at 'hand angle' rather than flat) floppy socket. The system unit contains a fairly quiet cooling fan, and the power supply. It has a smallish footprint about the same as an Amiga, but large enough to stand the monitor on, and the metal box supports this very robust optional backplane to hold 'podules'. Serial (RS423) and parallel ports are standard but Econet requires a podule. The A400 models come with 14Mbytes of RAM and four expansion slots for podules are fitted as standard, as also is the Econet socket.

All the models include a massive 512k of ROM containing the operating system and Basic. They also share a batterybacked clock/calendar and 256 bytes of nonvolatile CMOS RAM for system configuration. Video output is analogue RGB or composite monochrome. Acorn supplies a colour monitor capable of 640x256 resolution, but for the very maximum resolution you will need a NEC Multisync or equivalent.

All models share a keyboard design, which is virtually a clone of the 101key IBM Enhanced Keyboard, with just one special BBC key named 'COPY'. This is a very smart move; if you're going to copy IBM, copy its keyboards not its graphics. A touching concession to Beeb fans is that on the A300 models the 12 function keys are red! A three button mechanical mouse is fitted as standard, which plugs into an socket on the keyboard.

The A500 which I used for this preview is closest to the A400; it has a 20Mbytes internal hard disk but

2Mbytes rather than 4Mbytes of RAM. The keyboard, however, was quite different from the production model, cased in metal with only 10 function keys, and covered in keys with names like HELP, MENU, LOOKS and AGAIN which certainly don't do what they say (some don't do anything at all).

The hard disk in the A500 is most noticeable for its ferociously rapid access speed. It loads huge programs with a faint burping noise, in the time it takes to blink an eye. The reason for this speed is that the disk is run with no interleaving of sectors. On an IBM XT, for example, the disk rotates about six times between each read to give the puny CPU time to digest; Archimedes eliminates this dead time as the ARM processor can suck stuff off the disk as fast as it can rotate.

The A300 models can be expanded with a second floppy disk drive, or with a 20Mbyte Winchester if the backplane is purchased. The podules which fit into the slots are double Eurocards. So far Acorn has announced its intention to produce the following podules: 'Floating Point', a hardware floating point coprocessor; 'ROM', a card to hold ROMbased applications, similar to the BBC sideways ROMs; 'BBC I/O', which reproduces the ports of the BBC B and Master, including DtoA and 1MHz bus; 'MIDI', the music synthesiser control; and '80186', which runs an MSDOS environment for IBM software.

Software

Operating System

The operating system for the Archimedes series is new, and is called Arthur (after the King rather than Daley, one hopes). Like the BBC operating system before, it is modular, the disk filing system being kept separate from the machine operating system or MOS. This means that alternative disk filing systems can be loaded, and indeed two alternatives are supplied. The ADFS (Advanced Disk Filing System) is a descendant of the ADFS on the Master. It supports a hierarchical directory structure and all the usual utilities for creating, deleting and housekeeping disk files. The other filing system supplied is ANFS (Advanced Network Filing System) which is for use with Econet, and allows access to files kept on a remote file server. Changing filing systems is just a matter of typing ADFS or ANFS at the prompt.

The command line interface of Arthur is very much like that of the BBC operating system, so that Beeb users will be immediately at home. It uses the same asterisk prompt, and also has the *FX commands though

there are rather more of them. I have never been a regular Beeb user so I was lost in Arthur at first; the fact that it shares some command names with PCDOS (for example, DIR) which do different things didn't help.

However, I soon learned to get around Arthur and found that it has some attractive aspects. For example, it has the Unixlike facility to define aliases for commands whose names you don't like. In fact, it is very strong on configuration altogether; stored in the CMOS RAM there is a list of 30 system parameters, such as the amount of Font space and number of open files, whose values can be inspected using STATUS and altered using CONFIGURE from the keyboard. It is also possible to assign strings to the function keys interactively from the keyboard using KEY, and control characters may be embedded in such strings. Any text file of commands can be run as a batch file using EXEC, and such files can be created without using an editor by the BUILD command which directs keystrokes into a file.

I found Arthur's way with files rather disconcerting at first. Filenames have no extensions to indicate their type, and file types are treated in a very uniform manner. In fact, only datestamped text files, plain text files and binary files are distinguished. All files contain a load address, and if you type the name of any kind of file Arthur will do its damndest to load it. Arthur knows about Basic source programs and executes them correctly without you having to load Basic explicitly. Acorn tells me that in the finished product Arthur will know more about more file types in this way, and be able to pick the correct application to open a given file, as the Mac does.

The other intriguing aspect of Arthur is that it can load files to any address in memory; its memory allocation strategy is utterly different from CP/M or MSDOS 'style' systems. This makes it very easy to have several coresident programs, and for data files to load themselves without the use of an application program. For example, a picture can be displayed simply by typing the name of the picture data file, which loads itself into video RAM.

At the command level Arthur could not be described as a friendly operating system, though it has the all the features that programmers need. I found it rather spartan, even compared to PCDOS.

On the proper Archimedes machines, however, Arthur will be hidden from the user by a window/ icon/mouse Desktop interface; this, was only in a prototype form on my

machine but, nevertheless, looked very good indeed. The overlapping, resizable windows are in colour, and resemble a hybrid of GEM, Windows and the Macintosh. Each window has horizontal and vertical scroll bars, a zoom box to expand it to full screen, and a close box marked with an 'X'.

Acorn uses the mouse in the same way that the original Xerox research team did; the left button is for 'Select', the middle button is for 'Menu', and the right button is for 'Alter'. When you press the middle button a popup menu appears at the cursor position (that is, where your eyes are focused), not at the top of the screen. You then select from it with the left button.

The idea of pulldown menus along the top of the screen is not employed, possibly to avoid trouble from Apple's legal bully boys. Instead there is a thick bar at the foot of the screen which contains large icons, similar to those in MSWindows. Five desk accessories, a clock, calculator, diary/calendar, notepad and colour palette are permanently installed, and directory listings are obtained by opening the disk icons.

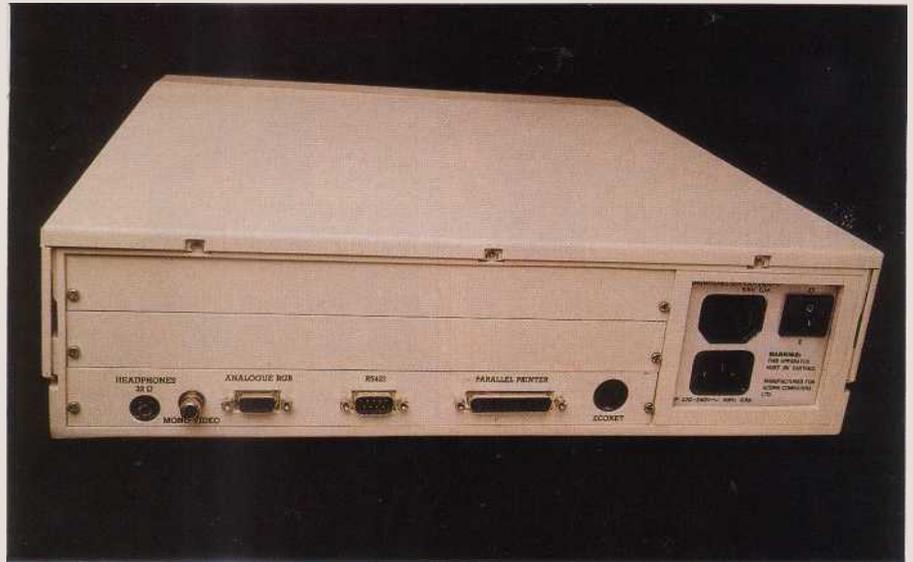
Windows are resized by grabbing the lower righthand corner using the Select button, while the Alter button allows the window to be dragged across the screen. The power of the ARM is such that the windows respond more quickly than on any other machine I've tried, with no hint of lag — even more impressive when you realise that this WIMP desktop is written in BBC Basic.

The desktop will be automatically entered when the production machine is booted, whereas my A500 booted into the Arthur command line.

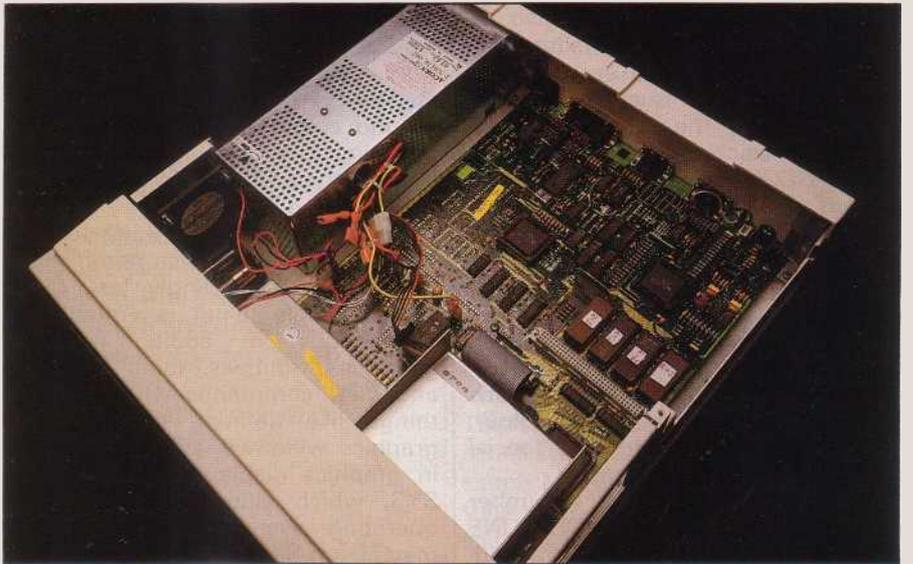
Arthur also supports the graphics and sound of the A series. This is in contrast to machines like the IBM PC where graphics are performed outside the operating system, by direct hardware access. Screen modes and colours can be changed direct from the "*" prompt by sending Ctrl characters; it's even possible to plot points in this way.

There are no less than 20 graphics modes in all, using from a minimum of 20k to a maximum of 160k of memory. The colours available are 2, 4, 16 or 256. The highest mode usable on the standard colour monitor is mode 15 — that is, 640x256 in 256 colours. However, in this case the colours are not all independently selectable; the palette permits 64 base colours to be selected, and each one can be displayed in four tints (with varying amounts of white added).

The 64 base colours can be chosen from the total of 4096 only in groups of 16 at a time. Nevertheless, the colour range available in mode 15 is



The back of the Archimedes is relatively sparse by today's standards, consisting of: headphone sockets, mono video out, analogue RGB, serial, parallel and Econet. The two removable plates above the ports will accommodate 'podules' —that is, peripheral modules



Critics of the Model B's PCB will be pleasantly surprised by the minimal chip count of the Archimedes. The absence of 'glue' chips means that it has fewer chips than all the popular 16bit and 32bit micros

good enough to create almost photographic realism. Modes 18 to 20 gives 512 lines of vertical resolution and need a Multisync monitor to display them. The teletext mode 7 of the BBC Micro is retained for compatibility. There are also text modes ranging from 40 characters x 25 lines to 132x32 in up to 16 colours.

BBC Basic V

The Basic built into Archimedes is version 5 of BBC Basic, which incorporates many extensions. Some of these are improvements to the control structures of the language, while others implement sound and graphics support for Archimedes.

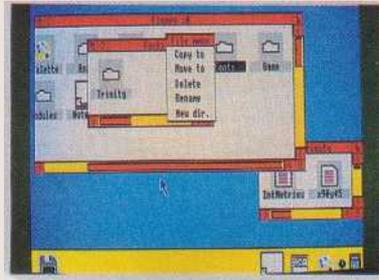
While BBC Basic was a big improvement over unstructured Basics such as Microsoft's, it still had plenty of warts. Almost all have now been removed. In particular, IF ... THEN ... ELSE ... ENDIF can now span many lines to allow proper block

structure; WHILE ... ENDWHILE loops are added; a CASE statement has been added; and functions and procedures can now be built into libraries which are held in RAM and invoked by name in programs. Line numbers are optional, so Pascal type programs can be written using the powerful windowing fullscreen editor which is built in. The obnoxious BBC line editor is still there for those who are hooked on it. As on the Beeb, any operating system command can be issued from inside Basic by prefacing it with a "*".

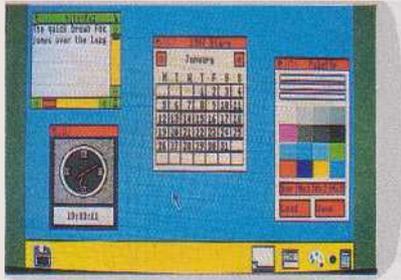
Basic V is not limited to 64k but can address the whole 4Mbytes memory space, allowing substantial programs to be written. Operations on whole arrays have been added to the language, so that, for instance, all the elements can be assigned to, added to, multiplied or divided by a constant in a single statement:

```
DIM A(1000) A() = A() * 8
```

BENCHTEST



The Acorn WIMP interface is fast, colourful and easy to use. The Archimedes makes this all possible from a BBC Basic program



The usual collection of desk accessories is included on the Welcome disk, and includes a clock, notepad and calendar



The Archimedes bundled 'lander' game, written in BBC Basic, is destined to become as famous as the Amiga's 'bouncing ball' demo

Arithmetic operations can be performed between two arrays of the same dimensions, and matrix multiplication is supported between vectors and 2D matrices.

The graphics and sound extensions would take a lot more space to describe in full than is available here, but I'll sketch the most important bits. The basic colour control primitive is GCOL which sets both background and foreground colours. It can also take an optional second parameter which sets the logical plotting mode. There are eight such modes, namely Overwrite, OR, AND, XOR (or FOR as Acorn insists on calling it) with the current screen colour, and various logical combinations with the inverse of the screen colour. These can be used to get special effects such as transparency.

Drawing is controlled by a number of powerful primitives. MOVE, LINE and POINT cater for basic drawing, but the more interesting routines are PLOT, RECTANGLE, CIRCLE and ELLIPSE. PLOT m,X,Y is an extraordinary command, where the first parameter m sets one of 255 different modes; these cover drawing just about anything you can name, including lines, triangles, rectangles, circles, ellipses, arcs, segments, filled or empty, solid or dotted. In fact, RECTANGLE, CIRCLE and ELLIPSE are just special cases of PLOT which are easier to use and to read. ELLIPSE draws ellipses of any orientation, not just those parallel to the axes. RECTANGLE has a special extension TO, in which a specified

rectangle of screen is moved or copied to another location, in effect a high level bitblit. For example:

```
RECTANGLE FILL 10,10,40,40 TO
100,200
```

would move a 40x40 square of pixels from coordinates 10,10 to 100,200 and fill the original space with background colour. The most noticeable omission is a general filled polygon routine, though you can flood fill any outline using PLOT.

The most important thing to note about all these graphics primitives is that they are blindingly fast. Circle and rectangle filling is virtually instantaneous. In addition to the graphics primitives, there are *FX and VDU commands which can do things like defining scrolling and graphics windows, and printing text in graphics displays. Then there is SYS, which allows direct calls to operating system routines to be made from Basic. It's also possible to write to and read from memory directly using the indirection operators, ?,!,,\$ far more elegantly than with the cursed PEEK and POKE. And if none of this is fast enough, in the last resort you can CALL machine code routines. By combining all these features it is possible to write professional standard graphics programs in interpreted Basic. To my astonishment I discovered that the Desktop demonstrations and the font and sprite editors on my A500 were all written in Basic.

Basic supports the mouse in a very straightforward way through the command MOUSE X,Y,BUTTON. This

returns the current mouse position in X and Y and the button status, and you call it as often as needed. The command MOUSE RECTANGLE defines the screen area in which the mouse pointer can be moved. I was able to write a quite nifty mouse driven painting program in a couple of hours and 77 lines of Basic.

The Arthur operating system can reserve memory space for storing 'sprites'; graphic images which can be manipulated as single objects. These are purely software sprites, not hardware generated like those on the Amiga or Commodore 64. Such is the raw power of the ARM, though, that you would never notice. The supplied sprite editor permits mouse assisted drawing of sprites in any of the screen modes (that is, in up to 256 colours) and of any size not exceeding the memory allocated, so full screen sprites are possible.

Once drawn a sprite is saved in RAM under a name, and it can be put on the screen using PLOT and its name, an operation which is fast enough to perform effective animation. The stored sprites can be saved to disk and loaded using the operating system commands SSAVE and SLOAD; many application programs will be started by a batch file which begins with a list of SLOADs.

The Basic is extraordinarily fast for an interpreter, and in applications whose execution time is dominated by arithmetic or graphics operations there is little point in using anything else. The Basic does show its weakness on programs which are dominated by loop timing, however; its performance on Eratosthenes' Sieve, at 8.7 seconds per iteration, is pretty average. For this kind of program a compiled language would better exploit the ARM power. Only the most demanding of applications (for example, realtime simulations) would tempt one to use machine code. Acorn has a reasonable amount of developer's software for the ARM. There are compilers for C and For

Technical specifications: Archimedes 305

Processor:	Acorn ARM
RAM:	512k
ROM:	512k
Mass storage:	One 3½in 800k floppy
Display:	Choice of high-resolution mono and medium-resolution colour
Expansion:	Two expansion slots via optional back-plane
Operating system:	Arthur
Bundled software:	BBC Basic V, Archimedes Desktop, 6502 emulator, tutorial and GAME1

BENCHTEST

tran, Lisp and Prolog systems, and of course an assembler and debugger.

There is a very powerful programmer's editor called Twin (because it can use twin windows) which was on the hard disk of my A500; it is extremely fast and includes Econet electronic mail so that programmers on a net can exchange source code and jokes. For mathematicians there is an implementation of the Reduce 4 symbolic maths system, and on a 4Mbyte A440 this becomes a very serious proposition, in terms of both speed and workspace.

Welcome disk

The Welcome disk supplied free with the A models will contain the Desktop program, some tutorials and a number of demonstration programs which illustrate the power of the ARM. It will also contain 65EMU, a software 6502 emulator that allows many old BBC programs to run on the A series. I was not able to try this emulator, but am led to understand that it will run well behaved software that does not directly control the BBC chips, which will exclude a number of popular games.

Of the demos, the one which is destined for instant fame is the game by D Braben, which on my disk was cryptically called just GAME1. It's not much to describe. A flying saucer shaped like a wedge of cheddar is controlled by the mouse and flies over a landscape shooting things up. It's the way it does it that is astonishing. The game is a full 3D flight simulation, with a stunning perspective landscape. You can fly in any compass direction, and the rolling landscape covered with trees and houses unfolds below (it's actually a cubic surface coloured in a chequerboard of different shades of green). The saucer obeys the laws of gravity exactly, as does each spark from its jet exhaust, each bullet from the gun and each drop of spray when it flies low over water. Nothing could better illustrate the way a quantitative jump in processing power can lead to a qualitative step in applications. You just can't do this stuff on an 8088, and it's doubtful on a 68000; the hefty calculations of landscape perspective and particle motion for each scene need to be performed in less than the screen refresh period or the illusion collapses.

Another impressive demo is the Font Designer, which appears to be inspired by Donald Knuth's 'Metafont'. Instead of defining characters as simple bitmaps on a grid as is usual, it allows you to draw character skeletons using lines and curves, and then to 'flesh out' these skeletons with user defined pens; cursive effects (like copperplate) are obtained

Benchmarks

Intmath	0.37secs
Realmath	0.41secs
Trig log	2.31 secs
Textscrn	6.67secs
Grafscrn	(MODE 1) 6.78secs

For a full explanation of the PCW Benchmarks, see the December 1986 issue, page 164. All programs are in BBC Basic V

Prices

A305	
512k RAM, 1x640k 31/2in floppy drive, keyboard, mouse, operating system	£799
A310	
As above but with 1Mbyte RAM	£875
A410	
1Mbyte RAM, four sockets for podules, coprocessor bus, one 31 in 640k floppy drive, hard disk controller	£1399
A440	
4Mbyte RAM, one 31/2in 640k floppy drive, one 20Mbyte hard disk	£2299
Mono monitor	£50
Colour monitor	£200
(All prices exclude VAT)	

by defining oblique pen 'nibs'. In a similar way, a menu of serifs can be defined to be stuck onto characters. Any font can be italicised by adjusting a sloping line in a window to the desired angle in degrees. The skeleton drawing part of the editor uses techniques cribbed from CAD/ CAM to draw curves and lines in 'rubber band' fashion with the mouse. With some practice it is possible to achieve professional standard typeface designs. Fonts are presumably stored as geometric descriptions, rather than bitmaps, and so could be reproduced at any size.

Currently, the program is only a demonstration, as the fonts it creates cannot be used on Archimedes. The resolution of a standard VDU is hopelessly inadequate to depict fonts of this quality, except when blown up to headline size, and a laser printer or typesetter would be needed to reproduce them. Arthur does have the facility to replace the system font with a soft font, but at present this is limited to an 8x8 grid.

Another one of the demo programs offers a hint of things to come though; it displays automatically scaled text (the font size enlarges and shrinks as the window is resized) in a variety of fonts, with antialiasing in three shades of grey to soften the jagged edges. It seems clear that in some future version of

Arthur this autoscaling will be provided as an operating system service, and the fancy fonts will become usable.

Benchmarks

Times for 'Store' and 'Retrieve' are not given in the timings because a bug in the version of ADFS supplied stopped them running correctly. Results obtained by Acorn suggest that Store takes between 23 seconds on the hard disk, and around 20 on the floppy, but we will have to wait for a production machine to confirm this.

I also feel obliged to point out that ADFscrn, based on point plotting, is an inadequate indicator of Archimedes' graphic performance; a test based on line drawing and area filling would show off its exceptional speed better.

Documentation

I was supplied with photocopies of the 66page Welcome Guide and the 456page Users' Guide, the latter being a Basic manual with enough discussion of the operating system for an enduser. Both were well written and the Basic manual is quite complete enough to start serious programming.

However, professional programmers will need more reference than these books provide (for example, ARM machine code is not covered, nor are the Window Manager calls) and I understand that a Reference Manual will be available as an extra.

Conclusion

The A500 felt like the fastest computer I have ever used, by a considerable margin. Benchmarks are inadequate to convey the feeling of power that exudes in use; just about everything you do happens instantly, and it takes a hefty sized Mandelbrot computation before you believe that anything can tax it. Power is nothing if it cannot be harnessed, and the A series allow you to translate this power easily into results on the screen; they can be programmed immediately by anyone competent in Basic, without requiring a sixmonth course of study.

The A series deserve to succeed in the education market in the way the BBC B did before. It will be no surprise if, unlike the BBC, they make it into the business field, too, as they have the sort of power that is becoming essential for Desktop Publishing and CAD/CAM applications, at a fraction of the cost of a Mac II or IBM PS/2 80. This combination of speed and graphic resolution could open up a whole new level of capability in popular software.

Acorn Computers is on (02231 245200:

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