MASTER WORK

Our technical editor takes the lid off the simplest of Acorn's new series of micros, the Master 128, and looks at one of its upgrade boards, the Turbo co-processor

Bruce Smith

Rumours have been circulating over the past six months or so about the impending arrival of model C BBC micro from Acorn. As revealed exclusively in last month's issue of Acorn User, it is now with us, under the name of the Master. In fact the Master is not a single micro but a range of computers, with the Master 128 as its cornerstone. By plugging in a variety of boards containing different microprocessors it's possible to emulate just about all the computing operating environments you are likely to need.

Over the next five pages I'll be looking at the Master 128 in depth, and also touch on the first of these upgrade boards, the Turbo co-processor. The other co-processors will be the subject of a whole series of articles planned to make you familiar with what looks to be the start of a new and exciting era in Acorn using.

The first question on everyone's lips as soon as a new micro is announced is 'How much memory?'. I've always wondered why this is. Certainly you can write longer programs if that's what you want; you can store more text or data if you're using a wordprocessor, spreadsheet or whatever, but it doesn't tell you anything about the micro's capabilities – and at the end of the day that's what really counts.

However, for the record, the Master 128 has exactly 50 bytes more memory than the last Acorn micro, the BBC B + 128, but the introduction of those 50 bytes and the way in which 12k of the 128k of main memory has been re-arranged transform the machine. Add to this a new internal design which will allow even an absolute novice to add sophistication to his or her computer, and you have turned the Master into a home, school and business micro that its competitors will find hard to beat – as you'll realise as you read on.

In appearance the Master is quite different to previous Acorn computers. The colour of the case matches that of a normal Beeb, and mounted in it are the standard BBC keyboard, and to its right, a full function numeric keypad. In addition to the standard numeric keys this includes keys such as Return, Delete and

The Master 128: the cornerstone of Acorn's new range of micros which can be upgraded with co-processors

mathematical functions – a total of 19 in all.

Above the keypad are two cartridge slots with spring loaded shutters, to take standard Acorn cartridges and allow the user to simply plug in software. The format is similar to the Electron Plus 1, and it's perhaps not surprising to find that Electron cartridgeware will function correctly on the Master.

To accommodate these extra features, the width of the Master has increased about two and a half inches over that of the BBC micro. Its depth is the same and there is a slight increase in height over the Beeb.

The function keystrip is now limited to the left-hand two-thirds of the micro, and is inclined at a slightly greater angle to increase readability, though it must be said that there is a slight magnifying effect due to the bevelling of the plastic, which can be a little off-putting to the user.

At the back of the micro all the standard BBC interfaces are available. To the power

supply side of the case is a small perforated disc which can be pushed out to allow passage of telephone cable if an internal modem is installed at some later stage.

The base of the micro contains the usual BBC micro connectors, arranged in the same order as before.

To the side of the Break key is now a small locking device which can easily be turned with a screwdriver to inhibit its action. This innovation will undoubtedly please the hecklers who have bemoaned the lack of such a feature since day one – of course, if they knew anything about programming the BBC micro they would know that the software key to do this has always been there.

Any slight resemblance the Master may bear to a standard BBC micro is lost when the lid is removed – inside it's like another world. The first thing to notice is that there are fewer chips but those that do exist are much larger than previously. Acorn has now moved further into

the arena of gate array chips – customised chips that Acorn has designed to replace up to a dozen or more smaller ones. Devising these often involves designing the circuit on a smaller board which, for testing purposes, is plugged into the appropriate socket on the board. Once finalised, this circuit is redesigned into a single chip – the gate array. The upshot of all this is that the reliability of the micro increases many-fold – there's less to go wrong – and also the power consumption is reduced. There are six new CMOS gate arrays in all, including special chips to handle the keyboard,

the inclusion of a single 128k ROM containing the Master's supplied firmware. Acorn has termed this its Megabit ROM – remember, this is Megabit not megabyte, which could lead to confusion. I'll look at the 128k MegaROM in more detail below.

A gap about the size of a cassette tape appears between the edge of the main printed circuit board (PCB) and the newer uprated power supply, for the inclusion of a third party modem. Extra sockets are provided on the PCB for this, which means that with an internal modem fitted, the RS423 serial port is still free

been omitted on purpose to optimise the board design. No doubt they will follow later in the form of the plug-in speech cartridge.

As mentioned, the Master comes with an extra 50 bytes of memory. These 50 bytes do not appear within the memory map, though they may be accessed via MOS calls. This RAM is battery backed which means that its contents are always powered and therefore not lost when the machine switches on. Stored within the RAM are the configuration bytes which define exactly how the Master is configured when it is switched on. You may alter these configurations using the appropriate command and thus define exactly how you want your Master to act on switch on.

The memory map

Figure 1 shows the memory arrangement. The Master 128 is fitted with 128k of RAM, and to understand how this memory is arranged, study the diagram as you read this. The first and main bank is the normal 32k supplied with the standard BBC B. This runs from &0000 to &8000. The 32k of memory above &8000 is used by ROM, the first 16k of which is normally Basic and the upper 16k is the Machine Operating System. The 32k below &8000 is used as follows:

■ &0 to &DFF – Basic (or language) and MOS workspace
■ &E00 to &3000 – Programming area
■ &3000 to &7FFF – Memory for high resolution screen

Depending on screen mode, the &3000 boundary is moveable up to &7C00. Note that PAGE is always equal to &E00, and should

Inside the Master 128: this model has the Turbo co-processor and Econet interface fitted

Input and Output and the television display.

To increase reliability and decrease power consumption even more Acorn has also made use of CMOS micro processor chip technology. The processor that makes all this run is the eight bit 65C12 chip. In software terms this is identical to the chip supplied with the standard 6502 second processor – the 65C02. It is also fully compatible with the standard 6502 chip supplied on the BBC micro and Electron.

The difference between the new processor and the old one is that it has an increased range of machine code instructions. In simple terms this means that it is now possible to write much more efficient machine code programs. As programs can be written in fewer instructions they will also run that bit faster. Obviously programs written using the enhanced instructions of the 65C12 will not run on a standard BBC micro, but 6502-based programs will run on the 65C12.

The other notable feature of the hardware is

for other uses – such as driving a serial printer.

The sound chip still supplies three sound channels plus a single pseudo random noise channel. However, it's much louder than before and connections are provided for use with a modem for generating dialling tones. The chip also drives an external phone connector fitted at the rear of the case.

The familiar 6845 CRTC chip is still present as are the user and machine 6522 VIA chips, and the analogue to digital convertor chip.

The number of sideways ROM sockets has decreased from the BBC B + 's six. Now there are three arranged as 2 by 32k sockets and a single 16k socket. Note that the minimum ROM size is now 16k; however, 8k ROMs may be fitted into external EPROM cartridges and plugged into a cartridge socket. The cost of the EPROM socket will be about £15.

The only obvious omission from the Master board over the BBC B and B + boards are sockets for the speech interface. These have
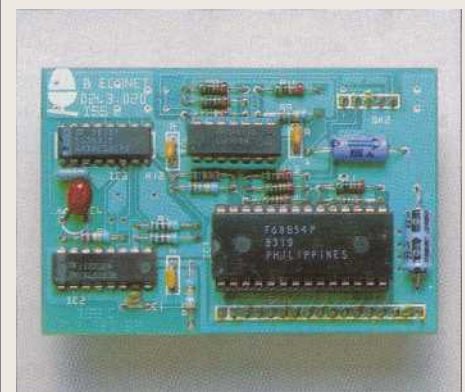
Econet upgrade board

not normally increase in value by adding more master ROMs.

The next 32k of memory is split into two sections. The first 20k bank is used as a shadow screen in identical fashion to the BBC B+ and Aries and Watford shadow RAM boards, so programs may now run and take full advantage of memory right up to HIMEM, ie, &7FFF, no matter what screen mode is selected.

The remaining 12k, which was unused on

the BBC B+ (for obvious reasons now!), comes into its own. It is to this region of memory that all of the previous memory grabbing operations have been allocated. This includes all ROM workspace, a fully exploded character font, and function key buffers. Figure 2 shows how this is ordered.

As you can see the 12k is itself split into two regions of memory. The first 1k holds the function key definitions. This space has increased four-fold over the BBC B and B + and means that function key definitions may be up to 1000 characters in length in total. The next

*APPEND — functions as BUILD but
    appends to end of file
*BUILD — as DFS but control codes input
    by mechanism
*CLOSE — closes open files on current
    filing system
*CONFIGURE — to set-up start-up options
*CREATE — creates empty file using
    *SAVE parameters
*DELETE — as DFS delete
*SHOW — displays soft-key contents
*DUMP — < start in file > < start address
    on output >
*EX — examine file (similar to *INFO)
*EXEC — as DFS
*GO — to enter address in language/IO
    processor *GOIO — to enter
    program at address in IO
    processor
*IGNORE — as *FX6
*INFO — as DFS
*INSERT — inserts ROM number n into
    ROM map from reset
*LIBS — define FS where LIB is from
    current FS *MOVE — copies
    files from one name to another
    including between filing
    systems
*PRINT — as TYPE but gets/processes
    VDU codes
*REMOVE — as DELETE but no error
    message if not found
*ROMS — lists ROM names, sockets,
    version and UNPLUG/PLUG
*SHADOW — with 0 or no parameters,
    gives shadow on next mode.
    with 1, drops shadow on next
    mode
*SHUT — close open files on all filing
    systems
*SPOOLON — functions as SPOOL but
    appends to end of file
*STATUS — lists status of start-up options
*TYPE — as DFS but control codes
    displayed as |D etc
*UNPLUG — removes control codes
   displayed as |D etc

Table 1. The new MOS commands

1k is used by the MOS as private workspace. In fact it performs calculations when carrying out fast flood-filling graphics.

The next 256 bytes in this area are used as VDU variable storage space.

The final 1.5k is used to hold the character definitions in a fully exploded state. Normally in a standard Beeb these are held within the MOS ROM and may be moved into RAM (or ` exploded') when *FX20,6 is executed. This previously meant raising PAGE by &600 bytes. Once exploded the character font can be redefined, eg, to produce italic or bold text on the screen – the December 1985 issue of AU showed how to do this.

The next section of the private 12k is 8k long and used by paged ROMs as workspace. This was the main reason why PAGE used to be bumped up when you added certain ROMs or a disc filing system (DFS). In a standard BBC B with a DFS PAGE is set to & 1900.

Even if many ROMs are fitted, the firmware supplied in the MegaROM is intelligent and will adjust its use so that ADFS and DFS will only ever use what is left over for them.
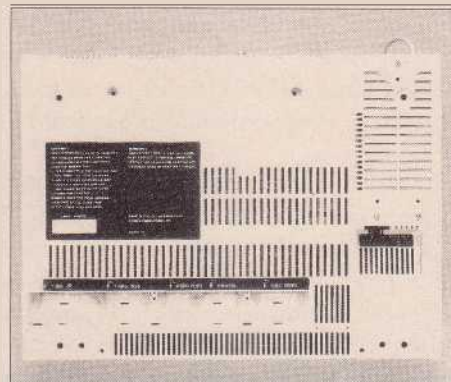
How the underside of the case looks

The final 256 bytes of the private RAM are again set aside for the MOS.

So what are the ramifications of all this? Well, the most obvious aspect is that when using shadow memory to display the screen there is always a full 29k of memory available to the user. Second, the problems associated with loading in programs from disc and moving them down in memory to &E00 to run are now removed.

On the negative side, I would imagine that quite a bit of software may not work because it, for example, pokes the function key buffer or character definition buffer directly. Of course, doing this is not 'legal', as Acorn has gone to pains to mention in the past.

Back to the memory map. The remaining 64k of RAM is mapped as four banks of sideways RAM, each 16k long. Using the special commands supplied in the MOS, this memory can be loaded with ROM images stored on disc. It's no coincidence that at the

time of launching the Master, Acorn has announced a ROM licencing scheme. I hope that other ROM-producing houses will follow their act (and also that of Glares) in allowing bona fide use of ROMs in RAM.

Of course, these sideways RAM banks were first installed on the BBC B+ 128k and, like that machine, the Master is also supplied with BAS128. This disc-based version of Basic reconfigures the four sideways RAM banks into a single 64k block of RAM for complete use by Basic programs. This effect is only possible in Basic and not from other languages.
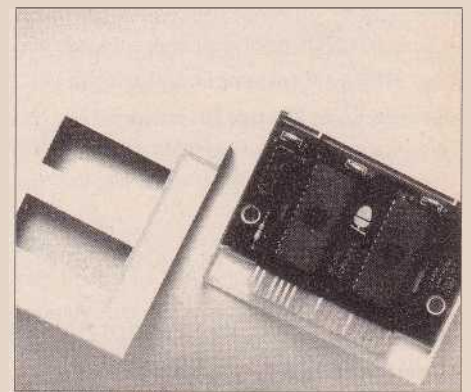
An EPROM cartridge

The MOS

Let's begin our look at the firmware with the Machine Operating System (MOS).

The MOS has doubled in size over the standard BBC micro – it's now 35k long and is called version OS3.2.

It incorporates advanced graphics features such as ellipse and circle drawing routines, fast flood fills, extended GCOL options giving up to six billion patterns and shades, etc. In fact the GXR ROM Acorn launched for the Beeb last summer has now been incorporated into the MOS as standard. Full details of this can be found in Malcolm Banthorpe's review (Acorn User December 1985).

There are 23 new commands in the MOS compared to the original OS1.2 and these are listed and described in table 1. As with the other MOS commands, these new ones and their associated actions are also available via corresponding OSBYTE and OSWORD calls. A whole host of new VDU commands have been added to ensure the user access to the enhanced graphics capabilities, plus more.

On the filing system front, filenames may include the filing system to which they refer. For example, the lines:

   100 *DISC
   110 LOAD "PROGRAM"
   120 *NET

can be replaced with the single line:

   100 LOAD "DISC.PROGRAM"

*NET need not be given as it remains the default filing system, but the MOS knows by

the filing system handle that PROGRAM is to be found on disc.

The cassette filing system has been extended to use OSGBPB calls 1 and 3 to get and write blocks of bytes to and from tape.

Twelve new sideways ROM service calls have been added to handle the extra facilities provided in the private RAM. Several improvements have been made with the handling of printed text, such as the addition of ASCII characters in the range 128 to 255 to the character font – these include Greek and mathematical symbols. Cursor options may

also be held across mode changes and there is an optional window scroll up, down, left or right.

It is also now possible to have a pending scroll to allow the bottom right hand character to be drawn.

Extras

Several specialised commands are provided to take advantage of the sideways RAM banks: *SRLOAD loads a ROM image file from the current filing system directly into sideways RAM.

would list the lines 100 to 200 inclusive, if A% went over 20.

To take advantage of the real time clock now installed there is a new Basic command, TIME$. This pseudo variable will return a 24 byte string from the MOS. For example, the command PRINT TIME$ might print:

Fri, 14 Feb 1986.23:59:59

Auto has been adapted so that it does not now print a space after it issues a line number. Leading spaces are stripped from commands entered when a non-zero Listo option is set.

The Basic Assembler has been extended to

Configure CMOS RAM commands – the state of the CMOS RAM can be set for both reserved and unreserved bits. Reserved bits include:

Start-up mode	MODE <0-7,128-135>
File-Server station number	FS <0-255[.0-255]>
Printer-Server station number	PS <0-255[.0-255]>
Econet station ID	Transient Command
Start-up language ROM number	LANG <ROM>
Start-up filing system ROM number	FILE <ROM>
TV position and interlace state	TV [<Dec>[,<Dec>]
Auto-repeat delay	DELAY <0-255>
Auto-repeat rate	REPEAT <0-255>
Default printer	PRINT <0-255>
Print ignore character (no param = no ignore)	IGNORE <0-255>
Tube selected (Internal/External)	EXTUBE/INTUBE
Tube ON/OFF	NOTUBE/TUBE
Serial baud rate (both ways)	BAUD <1-8>
Serial data format	DATA <0-7>
Boot status	BOOT/NOBOOT
Scroll state (on/off)	SCROLL/ NOSCROLL
Floppy-Drive params (speed, etc)	FDRIVE <0-7>
Floppy or Winchester start-up	FLOPPY/HARD
ADFS or FADFS as default	DIR/NODIR
Bell character volume	LOUD/QUIET
Caps lock on/off	CAPS/NOCAPS

FS and PS status bits only operational when ANFS fitted.
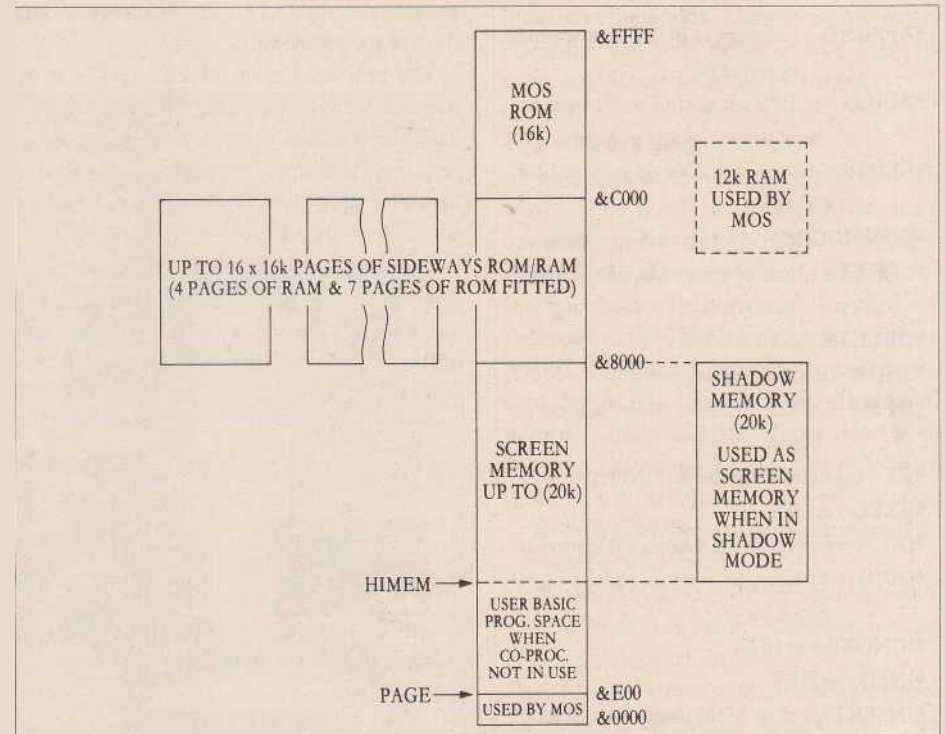
Table 2. The status bytes

Figure 1. **The Master's memory map showing how the 128k of RAM is arranged**

*SRWRITE will transfer a block of main memory into sideways RAM.
*SRSAVE saves the specified bank of sideways RAM to the named file.
*SRREAD performs the reverse of *SRWRITE and saves the specified block of memory to the current filing systems. *SRLOAD and *SRSAVE work intelligently in that they will not destroy the current contents of memory unless postfixed with a Q for a quick transfer.

Basic

The Master contains Basic 4 which offers several enhancements on Basic 2 and a few of the old bugs have been weeded out.

From a programming point of view, the most noticeable of these is that a cross reference-come-search output is now available from List – especially useful when debugging programs. In short, the specified lines will be LISTed IF a condition is met. For example:

LIST 100,200 IF A% > 20

incorporate the new enhanced instruction set of the 65C12 chip (see Martin Chaplin's article on page 91). Reference to the index registers X and Y plus A may now be in lower case, as can the EQU range of functions, bringing it in line with the rest of the mnemonic instruction set.

Editor

The Editor allows program and text to be edited very simply it includes a wide range of commands that can be used to format and operate directly on text or programs. The biggest use will be for the writing of programs. As such the Editor can be entered in two ways. To transfer a program from Basic to Edit the command EDIT is used which spools the program from Basic into the Editor. Use of the command *EDIT is limited to fresh starts as it clears the editing memory.

Once in Edit programs can be written in a friendly, easy style. The Editor is much simpler to use than the Basic Editor available for the standard Beeb. It contains several modes of

Help information so that it provides all the information on the screen as and when you need it. As with the program and text editors, it contains all the commands you would expect for search and replace, finding specific items and so forth.

View, ViewSheet, DFS and ADFS

The latest version of View 3.0 is installed. This has one advantage over the standard View 3.0 on sale, in that it has a new embedded command that allows time and date stamping. This will insert the date and/or time of your letter automatically as it is printed out using D or ;T. ViewSheet is the standard item.

The DFS is based on the 1770 disc controller chip. When employed with ADFS it can be used in double density mode to increase total disc storage capacity to over 1.2 megabytes. A review of the 1770 DFS and ADFS can be found in last month's issue.

Terminal

Another item of standard applications firmware is the Terminal Emulator. This provides facilities needed to use the Master as either a local or a remote terminal to other computer and Viewdata systems. Obviously a modem is required to use this firmware and this can be plugged into the RS423 port at the rear or, when available, fitted internally in the space provided. (A fuller review of Terminal will appear at a later date.)

Status bytes

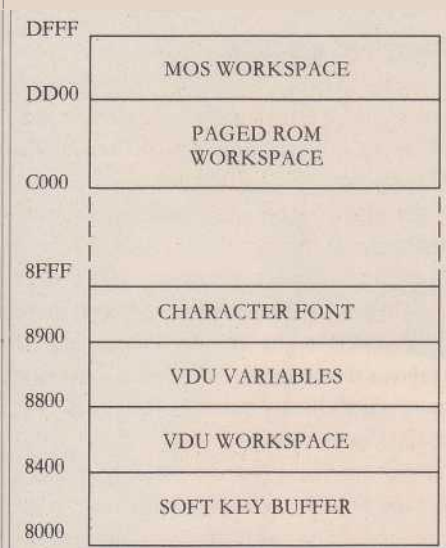There are 50 bytes of RAM held within the real time clock chip (called the configuration bytes)

Figure 2. How Private RAM is mapped

and they are organised as follows:
- (a) Bytes 0 to 19 – System configuration
- (b) Bytes 20 to 29 – Acorn future use
- (c) Use by third party ROMs
- (d) User memory

When the Master is first switched on, or when CTRL-Break is executed, the MOS checks the first 20 bytes and uses these to configure the start up of the hardware.

Obviously each byte has a predetermined function. To set or clear this function the *CONFIGURE command is used. For example, to change the volume of the internal speaker you use the command. *CONFIGURE LOUD or *CONFIGURE QUIET.

Table 2 lists the various configuration options that may be defined. A check on the status of these bytes may be made at any time
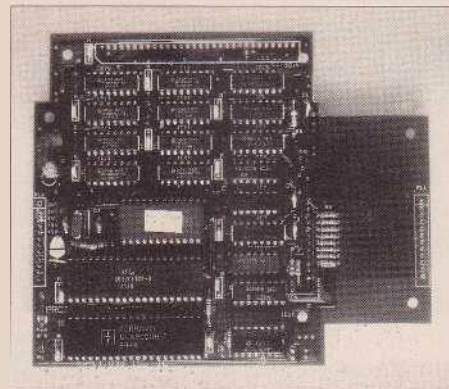
The Turbo co-processor board

using the command *STATUS which will list the state of play within these bytes.

Turbo co-processor

Upgrading the Master 128 is extremely straightforward. A popular first peripheral will undoubtedly be the Turbo board. This is, in effect, a second processor that fits inside the Master's case. To distinguish such upgrades from external second processors plugged into the Tube port, they are called co-processors.

The Turbo board is supplied with an extra 64k of RAM, and a Tube ROM all centred around an eight bit 65C102 CPU running at a lightning 4MHz. Table 3 shows how the Master 128 and Turbo upgrade demolished the PCW benchmarks.

Fitting the board is simple – as easy as installing a sideways ROM. The board is about the size of a paperback book and plugs into a position roughly central inside the case.

Once fitted, Turbo acts almost identically to a standard 6502 second processor. PAGE is set to & 800. A Hi version of Basic and Edit are supplied on disc and these load into the machine at &B800, giving roughly 47k of programming memory free. View and ViewSheet, if required, will automatically copy across the Tube and View relocates itself in the :o-processor.

Also supplied on the Turbo support disc is a printer buffer program. This enables you to use about 24k of memory available in the I/0 processor (the Master main board in other

words) as a long printer buffer – thereby allowing you to print out pages of text or programs. Once set going, you are still free to carry on programming or wordprocessing as normal with the Turbo board. The Turbo looks to be an excellent buy at £125 including VAT (not £99 as previously stated).

Econet

Schools and business users will be pleased to learn that upgrading the Master 128 with an Econet interface is just as simple. This is supplied on a small board, about the size of a cassette tape, and simply plugs into the rear right-hand corner of the machine. The only other requirement is to fit Acorn's new networking firmware, the Advanced Network Filing System (ANFS). Cost of the upgrade is just £49 including VAT.

The future

I started off by saying that I would be looking at the Master 128 in some depth and I think I have crammed in as many facts as possible.

Bench Mark	Master 128	Turbo
1	0.53	0.26
2	2.2	1.07
3	5.72	2.76
4	5.68	2.75
5	6.13	2.97
6	9.95	4.81
7	15.66	7.57
8	28.02	13.55

Table 3. How the Master 128 and Turbo performed the PCW benchmarks

have only begun to touch on what the Master 128 has to offer and what it is capable of – and of course there's still the Master 512 and Scientific to discuss!

Many of you will be wondering whether it is worthwhile putting your old Beebs and Electrons in their boxes and investing in a Master, and I'll look at this in our April issue.

Acorn seems to have hit the nail well and truly on the head with the Master. There will no doubt still be the sniggerers laughing at the use of eight bit technology – just as they address the memory question I kicked off with. However, my answer to them would always be It's not what you've got, but what you can do with it', and for my money you can do a good deal more with a Master than with any other micro around in its class at the moment.

With thanks to David and Marlyn of Acorn for their help and patience!