ELECTRON
SON OF BBC MICRO

Paul Beverley finds out what Acorn's new machine can do, and how similar it is to the BBC

WHAT follows is not really a review of the Electron, but rather the results of playing with a field trial machine provided by Acorn. Also, there are one or two details not yet finalised, and no doubt modifications will be made to the operating system before the launch.

Obviously we will make comparisons with the BBC micro, but not with other micros. No doubt there will be plenty of other people to do that! The aim here is to give a few facts.

To say the Electron measures 340 by 160 cm probably does not give you much real idea of its size, but figure 1 might. As you can see, it appears the Electron is all keyboard, and not much else. The size has been kept to a minimum by having an external mains transformer, integral with the mains plug. Unfortunately, this is so large that on some double mains sockets there is not enough room to use the adjacent socket.

Inside the case there are two circuit boards - one for the switched-mode power supply and the other for the computer itself, the two being separated by a partition which gives the case extra rigidity. Power from the transformer enters on the right side, and along the left side are cassette socket and connectors for outputs to an RGB monitor, a black and white monitor, and a colour or black and white television. (The sockets are clearly labelled - on the underside of the case!) The only other output is an edge connector in a recess along the bottom edge of the back of the case.

The main board contains a 6502A microprocessor running at 2MHz, two 16k memory chips (Basic in ROM and operating system in EPROM), four RAM chips (32k total), nine simple TTL chips, a quad operational amplifier chip, a handful of discrete components and last, but not least, a *huge* ULA!

The keyboard is a full QWERTY version, with full depression keys, but they don't seem such good quality as on the BBC micro. There are 55 keys (compared with 73 on the BBC), but they are well used, and the only functions not included are tab and shift lock. What is more, there is an extra facility. Of the 55 keys, 29 can be used for entering whole Basic keywords, such as REPEAT, INPUT, PLOT etc. This is done by the FUNC key, which is used rather like CTRL or SHIFT. For example, <func> A, produces AUTO, <func> C, produces COLOUR, and <func> R, produces RUN with a carriage return.

However, if you have got into the habit of using abbreviations don't worry - they are all exactly the same as in BBC Basic. And the Basic chip bears a remarkable similarity to that in the Beeb. As with the Beeb's function keys, you have the alternative of using them for the entry of single characters, including user-programmed characters.

Although the Electron does not have the ten red function keys, the same facility is provided by using the FUNC key in combination with the number keys 0 to 9. This reduces the key count by 10 and

produces exactly the same effect as the BBC's function keys.

Screen editing is identical to the BBC, using cursor keys along with the copy key, and here again there is a saving on the number of keys. In this case it has been done by combining the cursor and copy keys with the five keys adjacent to them on the BBC. To get the two characters on each of these keys instead of the normal editing functions, they are used in combination with either the SHIFT or CTRL. One minor gripe here is that COPY is above RETURN key, and then, where a BBC user would expect to find COPY is the DELETE key! This can be frustrating, and a menace in an environment where Electrons are used alongside BBC micros.

*KEY10 will program the BREAK key and *KEY11 to 15 the cursor and COPY keys. This means any software written for the BBC which relies on function keys, can run on the Electron. Another single key saving has been made by combining the 0 and @ characters.

One of my main concerns is interfacing, and in this respect I am a little disappointed in the Electron. Apart from the cassette socket and the various output display devices, the only other form of interface is an edge connector which provides address and data lines for hardware, such as a printer

interface, user port, Econet interface or perhaps a modem. Unfortunately, no information was given about this in the provisional manual. The only clue is that the operating system can access pages &FC00, &FD00 and &FE00. &FE00 to &FE07 are used for addressing registers in the ULA, but as well as FX calls 150 and 151, they seem to have implemented (but not yet documented) FX calls 146 - 149, associated, in the BBC, with Fred and Jim - the 1 MHz bus.

Whilst mentioning the edge connector, it is worth making two comments about its design. First the good news . . . at each end of the recess in the back of the computer is a huge bolthole so add-on units can be securely fixed. Now, the bad news ... if you leave a metal object lying on the table behind the computer (in my case a jack plug provided with the cassette lead), it can go underneath the edge connector and short out

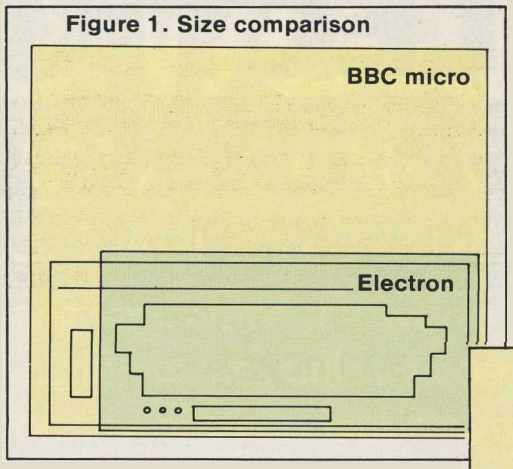


Figure 1. Size comparison

the power supply! It wasn't until the second time this happened that I realised what was causing the machine's demise.

The power supply is designed so that although it does not seem to suffer any long term damage by being shorted out, it stays dead until left switched off for several minutes.

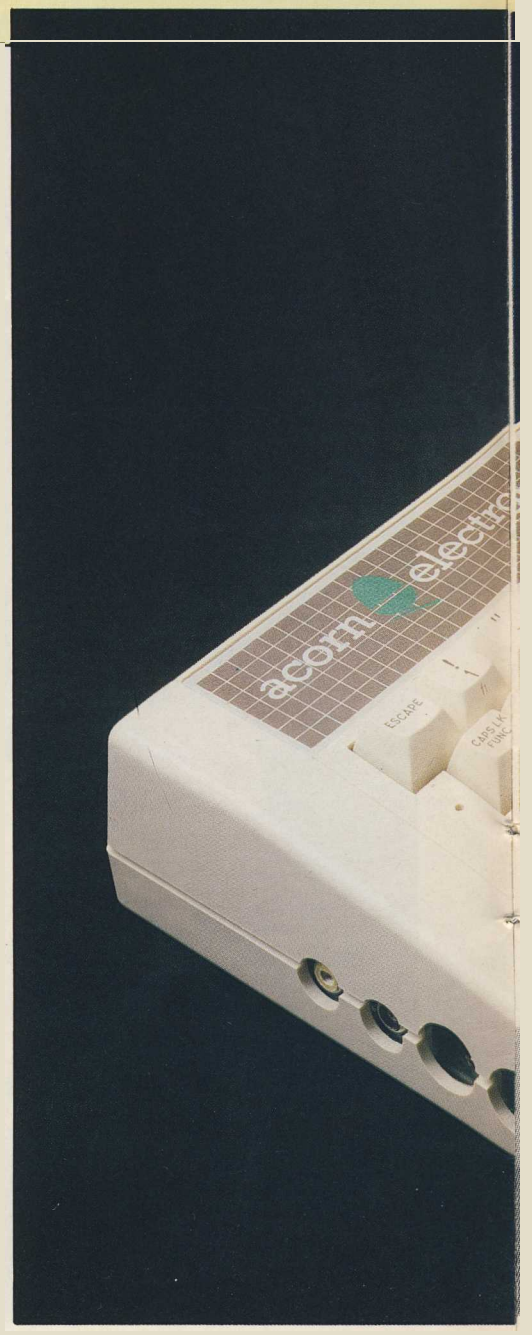
Not surprisingly, the Acorn designers have gone out of their way to make the Electron compatible with the BBC micro. This can be seen by comparing the two memory maps - and they look identical. First, there is 32k of RAM and 32k of ROM. The ROM consists of 16k of Basic and 16k of operating system. Of the RAM, 31/4k is used by the operating system, and 1/4k is kept for the user's machine code routines, so Basic programs normally start at &E00 as they do on the BBC. The remaining RAM is used to provide program and data storage and graphics.

The Electron has seven of the eight modes provided by the BBC microcomputer - the only one missing being mode 7 - the teletext mode. The graphics are identical with the BBC (OS 1.2) so that you have at the one extreme mode 0 which provides a resolution of 640 by 256 in two colours, and then trading off the resolution against the number of colours, you can go to mode 2 with a resolution of 160 by 256 in 16 colours. Two of the modes, 3 and 6, are text only, being 80 characters and 40 characters respectively by 25 lines. If you need graphics but only want to use 10k of RAM for the screen then modes 4 and 5 provide either 2 or 4 colours, with a resolution of 320 by 256 or 160 by 256 respectively.

On the BBC micro, graphics are provided by a standard CRT controller chip - the 6845 - plus a ULA to extend the controller's memory range and provide a colour palette. It was this ULA which gave problems in the early stages of development of the BBC micro.

Figure 2. Comparison of speeds of BASIC
(Timings are given using the onboard tim

	BM1	BM2	BM3
BBC micro	0.64	2.8	8.0
Electron	0.86	3.7	10.7
Drop in speed (%)	34	32	34

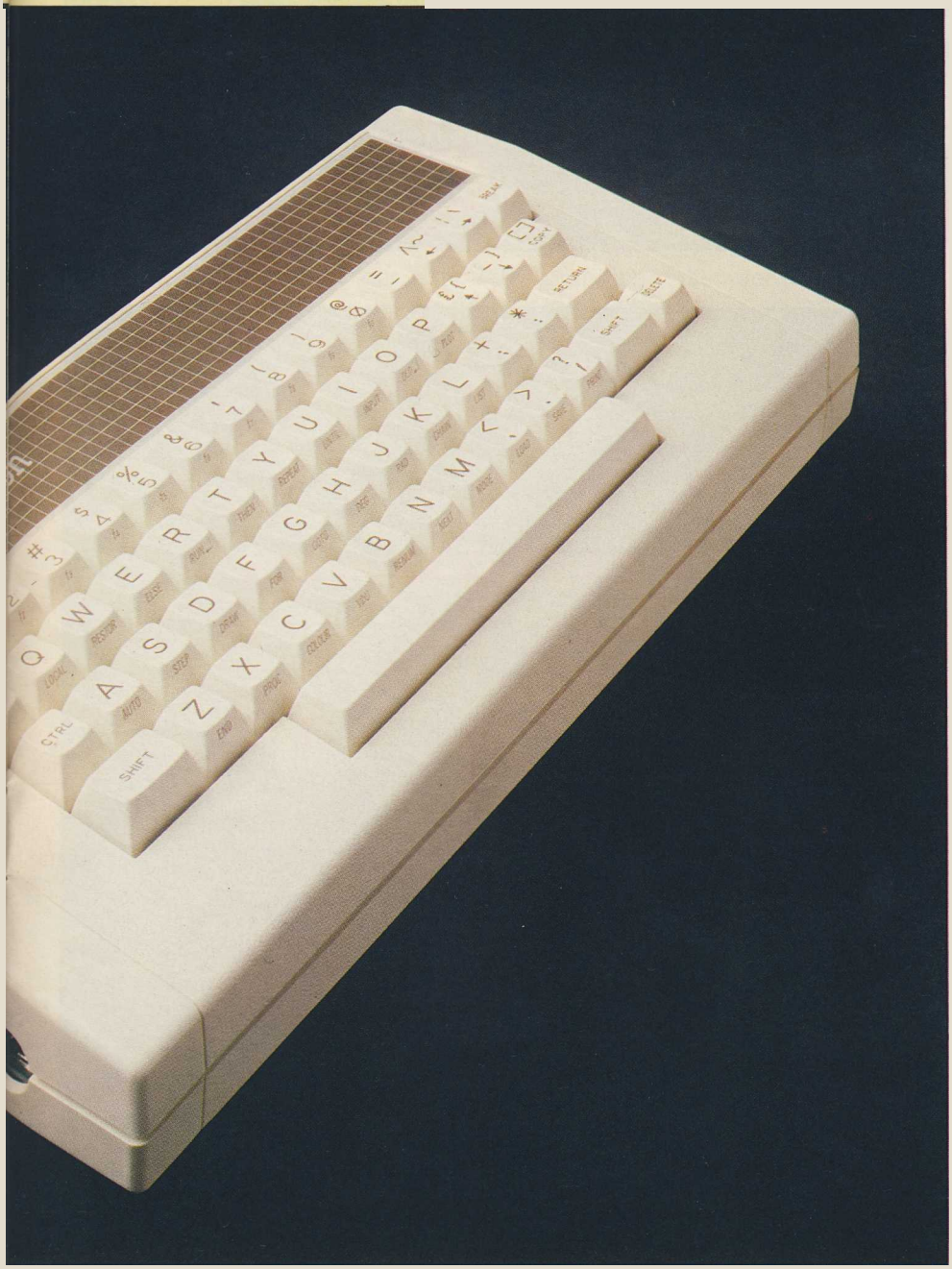


Acorn's designers were trying to include more and more functions within one ULA, and in the case of the video ULA were pushing it to the limits of its specification by running at 16 MHz to get the necessary resolution in mode 0.

The Electron ULA not only contains the colour palette circuitry but also the CRT controller action of the 6845, although without the 6845's full programmability. For example, there is no facility for sideways scrolling by reprogramming the 6845. This means programs such as *Rocket Raid* and *Planetoid* which rely heavily on sideways scrolling, although they run on the Electron, produce a garbled screen. Also some games such as *Snapper* make use of hardware timers in the second 6522 VIA on the BBC micro and will not run properly on the Electron without external hardware, again since there is no 6522 VIA, and for the same reason, there is no user port. The lack of 6522s also means internal timing has had to be taken over by the ULA. The ULA also contains control circuitry for the cassette interface which makes it a busy little chip! Actually it's not so little — it's a 30mm square 68-lead ceramic package.

using the P.C.W. bench marks.
clocks.)

BM4	BM5	BM6	BM7	BM8
8.5	8.9	13.7	21.2	5.0
11.4	11.9	18.2	28.1	7.1
34	34	33	33	42



The two machines are compatible as far as the cassette interface is concerned, so programs from the BBC can be loaded into the Electron and vice versa. The Electron will not load at 300 baud; it accepts *TAPE3, but continues to load and save at 1200 baud. Once programs have been loaded, many will work directly on the Electron provided they use the operating system commands. (Beverley's on his hobby-horse again!) Hobbyhorse or no, if you have written your programs using the operating system commands, they will transfer straight to the Electron without modification! If programs use mode 7, they are run using mode 6 and will usually run out of space because of the 7k difference.

One sad omission is the absence of sideways ROMs, though the operating system software can cope with serial cartridge ROMs. These would presumably be mounted in one of the extension modules. However, it is worth noting that if you take out the Basic chip and put in a different language, the Electron seems quite happy. For example, View and Computer Concepts Beebcalc both run on the Electron, although Wordwise does not since it relies on mode 7.

Where the Electron's hardware does not match up to the BBC, as much as possible has been done to avoid it causing errors. For example, a program which calls for mode 7 doesn't produce 'Bad mode', but sets up mode 6 and does the best it can to obey PRINT instructions. (For example teletext double height characters are printed twice!)

There was little in the field trails manual about FX calls, but a few hours digging un-earthed the calls in figure 2. Naturally those calls concerned with the A to D converters or the RS423 serial interface have not been implemented, but most of the others have. Again, compatibility allows

calls such as *FX2 and *TV to be accepted, but nothing is done with them. (*FX — selecting the output channel works to some extent. That is to say that if you select *FX3,2 it disables the screen, and 3,0 re-enables it.)

Some OSWORD calls are also implemented. Certainly those which access the system time clock, the interval timer and the sound channels all appear to work normally. Also there are all the normal operating system routines such as OSFIND, OSBGET, OSCLI etc. I have not bothered to check these individually since they are called by Basic and therefore must be present for Basic to work properly.

All the VDU driver routines are implemented although VDUs 1, 2 and 3 need additional hardware and software. There are however none of the advanced graphics routines (VDU23,0, etc) used for altering the various registers on the 6845 CRT controller chip. since all these functions have now been incorporated into the ULA. This unfortunately means that although the Electron supports all seven of the modes which used the 6845 it does not allow some of the clever tricks possible on the BBC micro.

However, one of the VDU 23,0 routines has been maintained, and that is for switching the cursor on and off. It has been arranged so existing software runs normally. but when the cursor is switched off and you attempt to do screen editing, you do not get the inverted cursor which moves around the screen for copying various bits, so you have to switch the cursor back on with VDU23;1 ,1 , 0;0;0;.

Four sound channels have been incorporated into the ULA, but it will only produce one channel at a time, and the envelope command is more limited. This means programs which call the sound and envelope commands run, but do not sound the same.

As far as speed is concerned, a quick look at the results of running benchmarks (figure 2) will show the Electron aparently to be between 32% and 44% slower than the BBC. This is because of the way memory is arranged. It is too technical to go into, but Acorn has used four64k x1 bit chips to make up the 32k RAM to keep down the cost. This means each byte that has to be read from or written to memory has to be dealt with in two, four-bit nibbles. During such RAM access, the processor clock is effectively stretched to 1 MHz — the same technique as used on the BBC for the 1 MHz bus. Thus if you look at benchmark 8 which deals with arithmetic functions, you will see it is noticeably slower than other benchmarks since it makes so much use of RAM while doing its calculations.

So what about graphics? Yes. you've guessed it — this is where you see why the Electron is less than half the cost of the BBC model B. The speed of the graphics routines is reduced not only because of the slow access to RAM but also because they have done away with the 6845 CRT controller chip (a good example of the so-called ' software/hardware trade-off'). How slow? Well on average, programs with a lot of graphics take between two and three times as long as the same program run on the BBC micro computer. Persian *(User Guide,* p46) for example, takes 108 seconds on the Electron as opposed to 44 seconds on the BBC — a factor of 2. 45.

It seems therefore that the Electron is basically a cut-down version fo the BBC model B. That is to say it has 32k of RAM, but does not have any of the following facilities;

RS423 interface,
analogue to digital converters,
1 MHz interface bus,
Tube interface,
printer port,
user port,
sideways ROMs
300 baud option on cassette interface,
mode 7

However, it does have the added facility for single key entry of 29 different basic keywords, in addition to the 10 function keys, and the programmable cursor, copy and break keys. Also, all of the above items, except the last two. can be added externally says Acorn.

*FX	Function
0	Report OS version
3	Select output stream
4	Change effect of copy and cursor keys
9	Set flash rate (mark)
10	Set flash rate (space)
11	Auto repeat delay time
12	Auto repeat interval time
13	Enable various events (all work except ADC and RS423 events)
14	Disable various events
15	Flushes a given class of buffer
18	Empties user key buffer
19	Waits for vertical sync pulse
117	Reads the VDU status byte in the X register
118	Uses the sign bit of X to indicate if CTRL is pressed
129	Read à key with a time interval
130	Read machine high order address
131	Read top of RAM address
132	Read bottom of display RAM address
133	Read lowest address for a particular mode
134	Read text cursor position
135	Read character at text position
136	Motor control
137	Insert character into a buffer
138	File options
145	Get character from a buffer
146	Read from page &FC
147	Write to page &FC
148	Read from page &FD
149	Write to page &FD
150	Read from page &FE
151	Write to page &FE
181	Read flash (space) time (set by FX10)
182	Read flash (mark) time (set by FX9)
211–214	Set effects of CTRL-6
225	Set base for f0 – f9
226*	Set base number for <func> A – P
227*	Set base number for <func> Q – /
242	Reads cassette motor status

Figure 3. List of FX calls which work on Electron OS 0.31 (* – calls which are extra to the BBC OS).