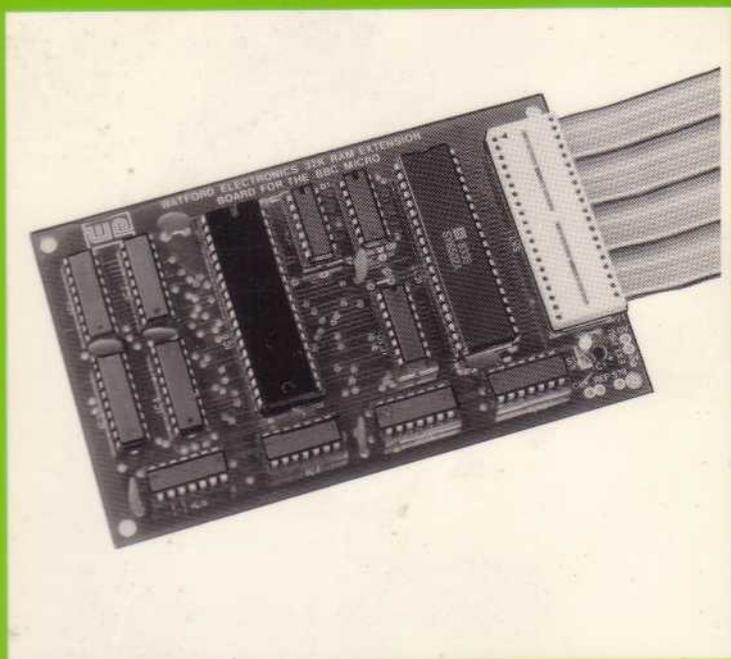


# 32k RAM CARD

## for BBC Micro



 **Watford Electronics**





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Watford Electronics has now been established for over 14 years. We are one of the major electronics distributors and retailers in the country, supplying thousands of different components and micro peripherals by mail order and through our retail outlet in Watford. In the last few years Watford Electronics have expanded to one of the most prolific software houses for the BBC Microcomputer. We market a wide range of software, hardware and peripherals for the BBC range of computers.





# ROM FITTING INSTRUCTIONS

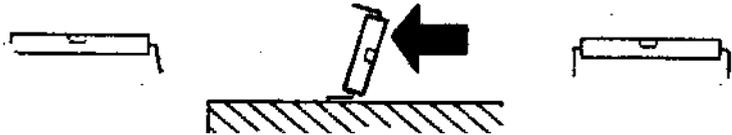


## BEFORE INSTALLING ROMS SWITCH OFF THE COMPUTER

The following instructions refer to the unexpanded computers as supplied by Acorn. Some computers may contain 3rd party hardware that affects installation of ROMs, where the layout of your computer differs from the following instructions, you should consult documentation supplied with said hardware to fit ROMs.

### Hints on Handling ROMs

Often the supplied ROM has the legs slightly splayed apart which means that they do not fit easily into the ROM sockets. Rather than herding each leg individually it is easier to take hold of the ROM at each end between thumbs and forefingers, rest the ROM on a non conductive surface (eg wooden), then gently lever the ROM forward until the legs are at right angles.



### Inserting a ROM

When inserting the ROM into a socket be sure to check it is facing the correct way and all the legs line up in the socket before applying firm, even pressure to the ROM to press it home.

### Removing a ROM

In our experience we have found the ideal tool for removing an ROM is a small, flat blade screwdriver. The technique we employ is to *first* lever one end of the ROM up to an angle of about 15-20 degrees, then press that end back in slightly, then insert the screw driver under the opposite end of the ROM and gently lever it to a similar angle as before. Repeat levering the ROM from alternate ends until it becomes free.

After following the relevant installation instructions, try switching the computer on. If the computer fails to power up or the ROM does not respond to its call, then turn off the computer and carefully remove the ROM, if any legs are bent then carefully straighten them out. Refit the ROM as before and try turning the computer on. *Do not* under *any* circumstances try fitting the ROM in with the notch facing the opposite way to that stated in the instructions.

### **Fitting a ROM to a BBC Model B Computer**

First remove 4 case screws (usually marked FIX) from computer, there are 2 at the back and 2 underneath the computer. Next remove the keyboard retention bolts.

In the bottom right hand corner of the computer you should see something resembling Figure 1.

The left most socket of the five (IC 51) contains the operating system marked PB04, this must not be moved. In one of the other 4 remaining sockets will be the BASIC ROM, for convenience this should be relocated to the right most socket (IC 101). The ROM can then be inserted into one of the 3 remaining sockets, making sure that you have the polarity notch facing towards the rear of the computer, ie the same *way* as the OS and BASIC.

Some BBC computers cannot switch between ROMs unless circuit changes are made. A TTL 74LS163 chip must be fitted into IC 76 and the PCB links S12 and S13 (located near the keyboard connector) Must be broken. A true BBC Model B should already have these circuit changes carried out.

### **Fittings ROM to BBC Model B Plus Computer**

First remove 4 case screws (usually marked FIX) from computer, there are 2 at the back and 2 underneath the computer.

On the top left corner of the computer you should see a circuit layout resembling Figure 2.

The top right most socket (IC 71) of the 6 available contains the combined OS and BASIC ROM, this must not be moved. The sideways ROM may be inserted in to any of the 5 remaining sockets making sure the polarity notch on the ROM faces towards the rear of the computer, ie the same way as the combined OS/BASIC ROM. Under *no* circumstances plug a sideways ROM into IC sockets 29 and 37, as you will destroy them, these are for the Acorn speech upgrade only.

Links 9, 11, 12, 15 and 18 on the left hand side of computer correspond to sockets IC 35, 44, 57, 62 and 68 respectively. With the link made *west* the computer expects a 8/16K ROM to be present, with the link made *east* the computer expects a 32K ROM to be present.

Users may like to know that making link S13 from *north* to *south*, alters the logical ROM socket numbers of the BASIC and OS from 14 and 15 to 0 and 1. If 64K of sideways RAM is fitted then the 32K of sideways RAM normally mapped into sockets 0 and 1 will now be mapped into sockets 14 and 15.

### **Fitting a ROM to a BBC Master 128 Computer**

First remove the 4 case screws labelled fix from the underside of the computer.

On the right hand side of the computer you should see a circuit lay out similar to Figure 3.

The uppermost socket houses the **mega ROM**, containing all the Master's standard software, this must not **be moved**. Normally the only socket that you can plug a 16K ROM into is IC 27 (the central one of the 3 available). When inserting the ROM make sure that the polarity notch on the **ROM faces** towards the left hand side of the computer ie. the **same** way as the mega ROM.

However it is possible to alter sockets IC 37 and IC **41** to accept ROMs by making links 19 and 18 respectively, *east*. This will however disable the 64K of sideways RAM.

The other alternative provided for is to use the ROM cartridge option. By inserting the sideways ROM into a **ROM** cartridge, making sure the polarity notch points towards the area marked pin 1, you then simply insert the cartridge into one of the slots on the top of the Master. It is only possible to insert the cartridge one way round.

### **Fitting a ROM to a BBC Master Compact Computer**

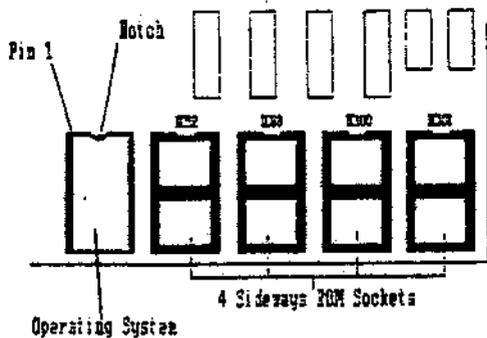
Following the printed instructions on the underside of the Master Compact keyboard remove the 4 case screws. Carefully lift the top of the keyboard out of the way.

On the right hand side of the keyboard you should see a circuit layout similar to Figure 4.

The forward most ROM socket contains the Compact's mega ROM, this must not be moved. In a factory configured Compact only sockets IC 17, IC 23 and IC 29 can be used for normal 16K sideways ROMs, socket IC 38 is reserved for a 32K ROM device. Users wishing to use IC 38 for 16K sideways ROMs can change link PL11 from its *north* position to *south*.

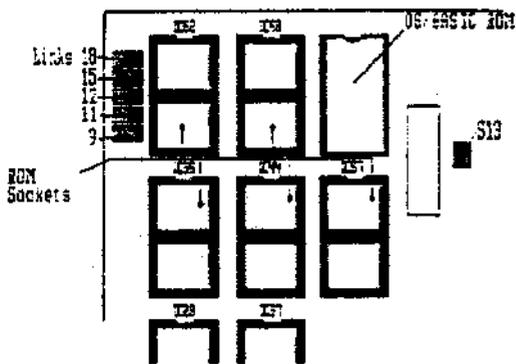
When inserting the sideways ROM check the polarity notch is facing towards the left hand side of the keyboard ie the same way as the mega ROM.

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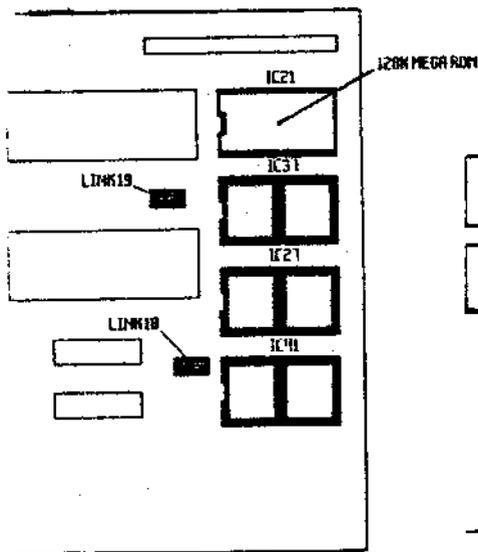


**Figure 1**  
**BBC Model B**

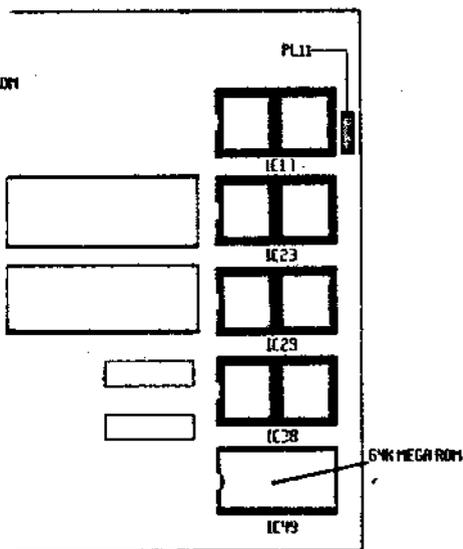
**Figure 2**  
**BBC Model B Plus**



**Figure 3**  
**BBC Master 128K**



**Figure 4**  
**BBC Master Compact**



# WATFORD ELECTRONICS 32K RAM EXTENSION BOARD FOR THE BBC MICRO

## INTRODUCTION

The Watford Electronics 32K RAM Extension Board doubles the RAM capacity of the standard BBC Micro, and has been designed to fit in with existing products such as the Watford Electronics Double Density Disc System and ROM Expansion System.

It allows programs of up to 28K to run in any screen mode, thus avoiding the "No room" error message. This operation is completely transparent to the user and can be used in BASIC, VIEW, VIEWSHEET, WORDWISE 1.20 etc. Thus, long adventures can be written with full graphics.

Simultaneously, the board provides a 12K buffer, allowing two jobs to be done at the same time. This is ideal for word-processing as one text may be printed out while the next one is typed. The buffer can also use the full 32K of the RAM board, and can replace any of the buffers in the BBC Micro such as printer, RS423 or speech.

If you prefer to write your own software, full support has been provided for the user to use this memory for data storage.

The operating software in ROM and this manual are copyright (C) 1984 Ian Smith / Watford Electronics.

# CONTENTS

1. INSTALLATION	3
2. OPERATION	6
3. TECHNICAL SOFTWARE INFORMATION	16
4. TECHNICAL HARDWARE INFORMATION	22
5. ERROR MESSAGES	23
INDEX	24

## 1. INSTALLATION

First open the case of the BBC Micro by removing the four case screws. Two are at the back, and two under the keyboard. They may be marked FIX. Put the lid to one side and remove the bolts holding the keyboard. Remove the keyboard connector and loudspeaker connector and put the keyboard to one side.

With a screwdriver, remove IC1. This is labelled 6502 and is in the centre of the computer board. Plug it into the RAM board in the second socket from the right with the same orientation (notch north). If you do not have a RAM board with wires labelled "CLK", "REF" or "S19" (a MKI RAM board), then skip the next two paragraphs.

Remove IC86 which is just south of the keyboard connector, and plug in the IC attached to the RAM board. If you have IC86 soldered in, you will need to desolder the wires from the supplied chip and solder the wire coming from "REF" to pin 10 and the wire from "CLK" to pin 1. These are identical positions to those on the supplied IC.

Now pull out the connector on link S19 of the BBC Micro, which is located to the left of the 6502. In its place plug the wire coming from "S19" on the RAM board. The plug should push onto the centre terminal. If the link is soldered (on ISSUE 7 BBCs) then desolder it, solder a piece of wire into the centre terminal of about a quarter of an inch (7 mm) and plug the wire onto it.

Alternatively you could solder the wire directly onto the centre terminal.

Now take the supplied ribbon cable and plug one end into the 6502 socket making sure the red stripe is north. DO NOT BEND ANY PINS. Insert the other end into the rightmost socket on the RAM board with the red stripe north again. If you have another board which plugs in to the 6502 socket, then plug the ribbon into the board where the 6502 IC was originally positioned.

Now put the RAM board ROM into a sideways ROM socket, with the same orientation (notch north). These are located at the bottom right of the computer. If you have several ROMs in your machine, the RAM Board ROM should be put in the lowest priority socket. This is the fourth from the right of the case. However if you have a DFS ROM, put this in the lowest priority socket and put the RAM Board ROM next to it. The BASIC ROM should be in the highest priority socket (nearest the case). It is also necessary to make sure you have an OS 1.20 in your machine (found by typing \*FXO).

The RAM board can easily lie in the computer or preferably it should be stuck to the lid by its self adhesive feet.

Now replace the keyboard, not forgetting the loudspeaker connector. Fit the lid and switch on the computer. The message "Watford Electronics 32K RAM" should appear.

If the computer does not come on properly, then switch off and check all connections - especially the keyboard connection! If the keyboard is not properly fitted then the screen will be blank apart from the flashing cursor, and a continuous buzz will be heard.

As you switch the machine on, it fully tests the RAM board and indicates if there is a fault. Should this be the case, check that all the ICs are plugged into the RAM board correctly.

## 2. OPERATION

To obtain a summary of the commands type \*HELP RAM. All commands can be prefixed with a "W" to avoid clashes with other ROMs.

### \*BUFFERON (S/L) (0-8)

This command turns the buffer on and can have two optional suffixes.

"S" stands for a small 12K buffer and "L" stands for a large 32K buffer. If you require a large buffer you will need to turn off the RAM board with \*RAMOFF.

The second suffix is the buffer number. This is the same number as for \*FX21. The buffers are :

- 0 Keyboard
- 1 RS423 input
- 2 RS423 output
- 3 Printer
- 4 Sound channel 0
- 5 Sound channel 1
- 6 Sound channel 2
- 7 Sound channel 3
- 8 Speech

If you wish to change the buffer size or number during operation, you must type \*BUFFEROFF first.

To obtain a summary of the \*BUFFERON command, type \*HELP BUFFERON.

\*BUFFERON alone is equivalent to \*BUFFERON S 3 which is a 12K printer buffer.

If the disc drive is accessed during buffer use, the buffer will deactivate itself in order to protect its contents, for purely technical reasons. To reactivate after disc use, type a dummy command appropriate for that buffer. In BASIC if the buffer was for the printer you would type CTRL-B' SPACE CTRL-C. If the buffer was for sound channel 1 you would type SOUND 1,0,0,0. In a wordprocessor you would print a space or some more text. Having done this, operation will continue as normal.

Some disc systems will need a disc access made since the last BREAK so that the buffer can function correctly. The easiest thing to do is \*CAT.

The buffer is flexible enough to allow you to queue thousands of words, and it can save you having to slow down your typing if you type 100 characters a second! It is also useful for storing incoming data from the Watford Electronics Modem when used as buffer number 1.

The buffer replaces one of the BBC Micro's own internal buffers. Therefore all the buffer operations are available on it. These operations include \*FX 13,14,15,21,128,138,145,152. This means you can use ADVAL(-n) to find the amount of space/number of characters in the buffer.

\*BUFFEROFF

This command simply turns off the buffer.

### \*CLAIMON

This command allows the RAM board to take 256 bytes workspace (in a similar manner to a DFS) when you press BREAK. This raises PAGE by 256 bytes.

### \*CLAIMOFF

This command releases for the user the 256 bytes workspace used by the RAM board when you press BREAK. The command will automatically turn off the board, including the buffer, and PAGE will be reduced by 256 bytes. The other way of doing this is to press CTRL-BREAK.

### **\*PURGEOFF**

As the buffer is just an extension of the computer's buffer, all the operations on the buffer will work. These include the amount of space left and the ability to purge (clear) the buffer contents on ESCAPE, \*FX15 etc. In certain cases this is undesirable for a large buffer, and so the use of this command will prevent the buffer from being purged.

### **\*PURGEON**

This enables purging of the buffer (default).

### **\*PURGE**

This purges the buffer even if \*PURGEOFF has been typed. This is useful in a wordprocessor if something went wrong during printing as this would easily clear the buffer if you had purging disabled.

## \*RAMEDIT

This is a utility which is quite unique. It allows the user to look through memory in HEX and ASCII formats, while the screen is CONTINUOUSLY UPDATED, thus allowing the user to see the operating system in operation. The memory can be any sideways ROM or either RAM bank.

On typing \*RAMEDIT a MODE 7 display appears. The flashing cursor is at the address entry point (default OSHWM). The address can be entered with the use of the arrow keys and the DELETE key. If you press TAB the cursor moves to the RAM bank selection. RAM bank 0 is the BBC memory and bank 1 is the RAM board memory. If you press TAB again the cursor moves to the ROM selection and a list of the active sideways ROMs in the machine is printed. If at any time you press RETURN the editor goes into the memory display mode.

On the right the ASCII characters are printed (or a full-stop if the character is outside the range 32-126). The cursor now flashes under the byte being edited. In the middle of the screen is the HEX tabulation of memory and there are two arrows either side of the byte being edited. If a key is pressed its ASCII value is entered into memory at the cursor position and the cursor will move to the right. In HEX entry mode, obtained by pressing TAB, the cursor does not move.

The keys are :

TAB	ASCII/HEX entry toggle
ESCAPE	return to entry mode
CTRL-ESCAPE	exit editor
left arrow	move left one byte
right arrow	move right one byte
up arrow	move up one line
down arrow	move down one line
SHIFT left arrow	move to start of line
SHIFT right arrow	move to end of line
SHIFT up arrow	move up &80 bytes
SHIFT down arrow	move down &80 bytes

## \*RAMON

This command turns on the RAM board to free the memory normally used by the screen. BASIC gains this memory and consequently HIMEM is set to &8000 in any screen MODE. You will need to change screen MODE to inform BASIC of the change, or if there is no workspace already set aside, then you will need to press BREAK at the given message. In either case it is usually easier to press BREAK after typing \*RAMON.

## \*RAMOFF

This command turns the RAM board off instantly, without affecting the buffer. BASIC can be informed of the change by changing MODE or by pressing BREAK.

## \*SLOAD

This directly replaces \*LOAD for loading the screen. You must still specify the addresses, but the screen is automatically switched in and out. This is equally useful for loading data into data area 0.

## \*SSAVE

This directly replaces \*SAVE for saving the screen in the same manner as \*SLOAD.

An example of saving a MODE 2 screen is : \*SSAVE  
screen 3000+5000

## \*XHELP

This lists all the sideways ROMs in the machine which are enabled and the sockets that they are in. This is usually quicker and simpler than \*HELP because it is concise.

## \*XWORD

This combines \*RAMON, \*BUFFERON, \*PURGEOFF and \*WORD together for VIEW. If you press BREAK while in VIEW you must re-type \*XWORD. If the RAM is not active you will get error number 0 : "Please press BREAK". You must press BREAK and re-type the command.

## \*XWORDWISE

This combines \*RAMON, \*BUFFERON, \*PURGEOFF and \*WORDWISE together. It is not necessary to re-type this if you press BREAK when in WORDWISE. If the RAM is not active you will get error number 0 : "Please press BREAK". You must press BREAK and re-type the command. This command will also work for WORDWISE-PLUS.

## STATUS OF THE BOARD DURING OPERATION

To get a summary of the RAM board's status, type \*HELP RAMSTATUS. This message applies to the BBC micro's end if you have a second processor.

On power up, the buffer is inactive and the RAM board is active.

On CTRL-BREAK the whole system is disabled and no workspace is claimed, which is usually necessary for games.

On BREAK the buffer and RAM board remain in the state they were in before BREAK, but the buffer is purged.

### 3. TECHNICAL SOFTWARE INFORMATION

The RAM board exists in parallel with the BBC's internal RAM and is switched with it in the same manner as the sideways ROM system, from address &0000 or &3000 to &7FFF. To obtain a summary of the OSBYTE and OSWORD calls type \*HELP RAMFX.

#### \*FX 32

This command is identical to \*FX 132 but is used when the RAM board is active and the user wishes to find the highest available space in the current screen MODE. It is ideal for data storage programs. The address is returned in X and Y.

#### \*FX 33,X

This command is identical to \*FX 133 but is used when the RAM board is active and the user wishes to find the highest available space in the screen MODE in the X register. The address is returned in X and Y.

## \*FX 34,X

This command is provided to switch between the RAM banks, but does not affect OS calls for screen operations etc. Data area 0 is the BBC's RAM which is used for some of the BASIC program and the screen memory. Data area 1 is the RAM board area and is used for the program. To switch to data area 1 use \*FX 34,1 and to switch to data area 0 use \*FX 34,0. This is ideal for loading data into either bank of RAM, but only applies to the top 20K. As the top half of your program disappears during this procedure (just like the sideways ROM system), the section of program doing this operation must be below &3000 in memory. This means your procedure must be fairly near the beginning of the program, or alternatively use \*SLOAD and \*SSAVE.

The full summary of OSBYTE 34 is : On

entry :

A=34

X :

Bit 0=0 select BBC RAM .

1 select Watford RAM

Bit 6=0 write current state

1 read current state

Bit 7=0 no stack operation

1 read operations : take state off stack

write operations : put state onto stack

On exit :

A,X,Y are preserved, except on read operations where the value is returned in X.

The stack for past states is 8-deep and can be used thus :

\*FX 34,128 : Select BBC RAM, saving old state.

\*FX 34,192 : Select previous state.

This is useful for screen dumps and other utilities which directly access the screen memory for speed.

## \*FX 35

This returns the location of the page workspace in X and Y.

## \*FX 36,X,Y

This reads/writes the RAM buffer number.

New value=(old value AND Y) EOR X. So for a read X=0 and Y=&FF, for a write X=buffer number and Y=0. The former value is returned in X, and Y is preserved.

## \*FX 250,X,Y

This call is a read/write call for the RAM Board's status.

New value=(old value AND Y) EOR X.

On entry :

To read, X=0 and Y=&FF To  
write, X=value and Y=0

On exit :

X=old value as follows :

Bit 0=1 RAM board active

Bit 1=1 Buffer active

Bit 2=1 Buffer small

Bit 3=1 Buffer large

Bit 4=1 Purging disabled

Bit 5=1 NMI in use

Bit 6=1 Workspace at fixed location

Bit 7=1 ROM claims workspace on BREAK

## OSWORD &6E

This call reads a byte from the RAM Board. On entry :

A=&6E

Y,X=high, low byte of address of parameter block.

YYXX+0 : low byte of address of byte to be read from RAM Board.

YYXX+1 : high byte of address.

YYXX+2 : Bit 0 = 0/1. If address in range 0-&2FFF, read data from data area 0/1. Bit 1 = 0/1. If address in range &3000-&7FFF, read data from data area 0/1.

On exit :

A,X,Y preserved.

YYXX+3 : byte read from RAM Board

## OSWORD &6F

This call is identical to OSBYTE &6E, except that on entry YYXX+3=byte to be written, and on exit YYXX+3=former contents of the memory location.

The OSWORD calls are essential if you want a large amount of apparently contiguous memory for data storage : YYXX+2 would be set to &01 so that memory locations 0-&2FFF in data area 1 and &3000-screen bottom in data area 0 would appear to be contiguous.

\*MWS aaaa

This call moves the RAM Board workspace to the specified address page in HEX (eg \*MWS 0A00). The call is necessary if you wish to set PAGE to &1100 with a DFS and still have the RAM Board active. The workspace should be in the range 0400-2F00. The workspace is not reset on BREAK, and can be moved when the RAM board and buffer are active. Thus after a BREAK, PAGE will go down by 256 bytes. To return the board to reclaiming memory in the usual way type \*CLAIMON.

## DIRECT CONTROL

For those programmers who want top speed, even though a speed decrease of less than 1% occurs, then there is another technique available. A write to &FFFF will select the Watford RAM and a write to &FFFE will select the BBC RAM. This applies for memory locations &3000 to &7FFF. To swap the whole memory write to &FFFC. This is a crude method and not normally advised as there are problems doing this - you must disable interrupts, and you can only do this from a sideways ROM.

Please note zero page locations &00-&0F on the RAM board are reserved for the RAM Board ROM. All the zero page locations in the BBC RAM, which the ROM uses, are preserved.

#### 4. TECHNICAL HARDWARE INFORMATION

The board adds very little extra load onto the power supply :

MKI typ. 85 mA, max. 125 mA

MKII typ. 155 mA, max. 175 mA

It will work happily with a fully populated ROM board, double disc drives, double density board etc. However, if the user still feels dubious then there is provision for an external 5v power supply. This can be wired into the two labelled holes and link S1 on the RAM board must be cut.

## 5. ERROR MESSAGES

0 : "Please press BREAK"

This message occurs when you have typed in a command where the RAM board needs to gain some workspace or relinquish it. The only way to overcome the problem is to press BREAK so that PAGE (OSHWMM) can be set up to the new value.

160 : "Buffer too big"

This message occurs if you try \*RAMON when you already have a large buffer, or if you try \*BUFFER L when you have the RAM board on. You must decide what you want to do with the memory without flowing over the 32K

220 : "Syntax: BUFFERON (S/L) (0-8)"

This message is self-explanatory - you have not typed in the command correctly. "S" selects a small (12k) buffer and "L" a large (32k) buffer. 0-8 is the buffer number (see \*FX21).

You need not type the two options, in which case the default settings of S and 3 are assumed.

# INDEX

## A

ADVAL 7

## B

BREAK 7, 8, 12, 14, 15, 21, 23  
Buffer 6, 7, 9, 14, 15, 19, 21, 23  
BUFFEROFF 7  
BUFFERON 6, 7, 14, 19, 23  
Buffer too big 23

## C

CAT 7  
CLAIMOFF 8  
CLAIMON 8, 21  
CLK 3  
CTRL-BREAK 8, 15

## D

Direct control 21  
Disc 7

## E

Error messages 23  
Escape 9

## F

Fitting instructions 3  
FX 0 4  
FX 21 6, 7  
FX 32 16  
FX 33 16

FX 34	13,17,18
FX 35	19
FX 36	19
FX 250	19

## G

Games	15
-------	----

## H

### HELP

BUFFERON	6
RAM	6
RAMFX	16
RAMSTATUS	15
HIMEM	12

## I

Installation	3
--------------	---

## K

Keyboard	6
----------	---

## M

MK1	3,22
MKII	3,22
MODE	12,13,16
MANS	21

## 0

OS 1.20	4
OSBYTE	16,17,18,19
OSHWM	8
OSWORD	16,20

## P

PAGE	8,21
Please press BREAK	12,14
Power consumption	22
Powering up	4,5,15
Prefix	6
Printer	6,7
PURGE	9
PURGEOFF	9,14
PURGEON	9

## R

RAMEDIT	10,11
RAMOFF	12,14
RAMON	12
Reactivation of buffer	7
REF	3
ROM position/priority	4
RS423	6

## S

S19	3
Screen dumps	18
SLOAD	13

SOUND	6,7
Speed of operation	21
SSAVE	I3
Stack	17, I8
Status	15
Syntax	23

## T

Test of operation	5
-------------------	---

## W

Workspace	8, I2, 14, 15, 19, 21
WORDWISE-PLUS	15

## X

XHELP	I4
XWORD	I4
XWORDWISE	I4

zero page	21
-----------	----

