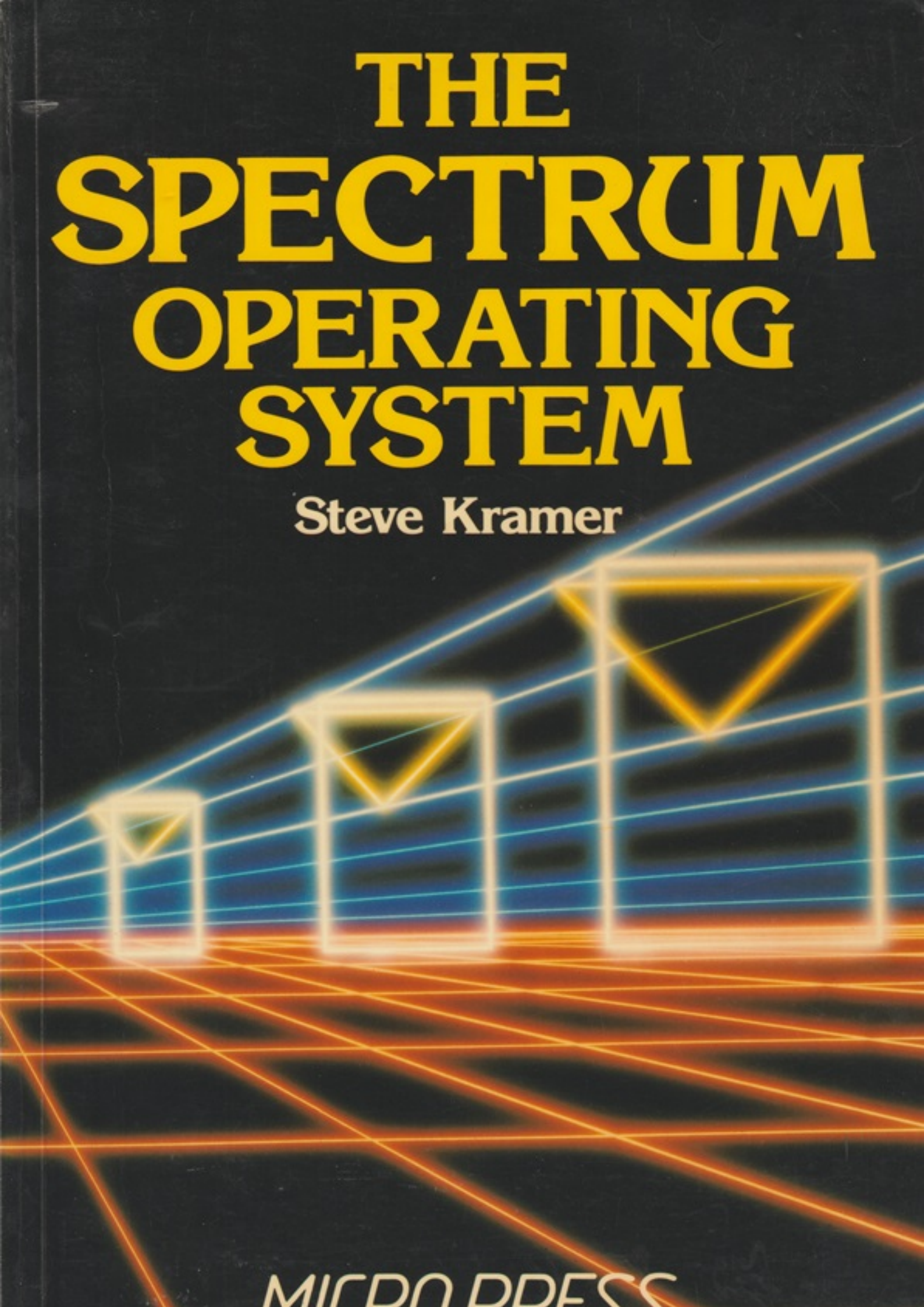
THE SPECTRUM OPERATING SYSTEM

Steve Kramer



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Chapter One

Getting Started

While this book is primarily aimed at those people who have a reasonable understanding of assembly language programming, there will be a considerable amount of information which will be of use to the uninitiated programmer who would like to be able to gain access to the versatility of machine code, without having to learn how to write it. If you belong to the latter group I hope that this book will whet your appetite, and prompt you to start learning a little about assembly language programming. With the minimum amount of knowledge and using the routines in the following chapters, short machine code routines can be written and used very easily.

For anybody not familiar with the operating system of the Spectrum or who is basically bone idle (like me) and who prefers to use ROM routines and existing facilities — rather than re-inventing the wheel every time they want to write a program— I will be discussing how to use ROM calls in both the 16K ROM, which is in the Spectrum, and in the 8K ROM in the Microdrive Interface. In some cases, I shall give examples as well as descriptions of how to use them, except where they are just a simple CALL.

I shall also look at the system variables and show how to use them to advantage, and explain the use of interrupt-driven routines, which can allow sprites to be used on the standard Spectrum.

Unless you wish to convert the assembly language routines by hand into numbers and then poke them into your computer's memory, a prerequisite to being able to use this book is an Assembler program. I can recommend the Picturesque Editor Assembler and also their Monitor/Disassembler programs, which are both very easy to use and fast. I can also recommend Highsoft's Devpack 3 which will be even better with a few improvements which will probably have been made by the time

you read this chapter. For the more experienced user, the Devpack (which contains both Monitor/Disassembler and Editor/Assembler) is, in my opinion, at present unsurpassed. The latest versions of both these programs are Microdrive-compatible.

It is not my intention to teach assembly language programming as there are a great many books already available which cover this in detail. Two that I can recommend are Rodnay Zaks' *Programming the Z80* and *Spectrum Machine Language for the Complete Beginner*. The first is not related to the Spectrum, but goes into far more detail than the second and also has concise descriptions of all the available op-codes.

To call a machine code program from BASIC you can either use a RANDOMIZE USR NN, a PRINT USR NN or a LET V = USR NN command, where NN is the entry point to the machine code program and V can be any numeric variable. On return from the machine code routine, the variable in the LET command will be equal to the BC register pair on exit, and with the PRINT command the value in the BC register pair will be printed to the current stream. In all cases the BC register pair will contain NN on entry to the machine code program.

Whenever a machine code program is called, it is advisable to save the contents of the H'L' register pair since the contents of this are necessary for a successful return to BASIC. The IY register pair should not normally be used as the ROM uses this to index the system variables, but it can be used so long as the interrupts are off and no ROM routines are used before it is restored to holding 23610 (5C3Ah).

This book is intended to be a reference work which you will turn to for information for as long as you have your Spectrum. I have made no attempt in the main text to be chatty or to hold your hand, but I hope the information required *is* there. Obviously it would be impossible to detail all the ROM routines and all the ways they could be used, so I have selected those that I am asked about most often and find most useful. Further reading for the serious programmer must be Dr Ian Logan's *Complete Spectrum ROM Disassembly*.

Chapter Two

Useful Call Addresses and How to Use Them: the 16K ROM

It is important before using ROM routines always to save the H' and L' registers, and restore them afterwards before a return to BASIC is made. Also the IY register must always contain the address of the system variable ERR NR 23610 (5C3Ah) whenever a ROM routine is used.

Printing: RST 16 (10h)

The character whose code is in the A register will be printed to whichever stream is currently open. This can also be used to 'print' control codes (i.e. TAB, INK, OVER, etc.; see the Spectrum manual for details).

Opening and Closing Streams (for RST 16 (10h)): CALL 5633 (1601h)

CALL 5633 (1601h) sets the output for RST 16 (10h) to the stream held in the A register when called. Normally A = 2 will print to the main screen, A = 3 will print to the printer and A = 1 or 0 will print to the lower screen. With the Interface 1 connected, other streams can be used for output to the Microdrives, network or other devices. Details are given on how to divert streams for your own purposes (e.g., for controlling an interface for other uses such as the Kempston or other Centronics printer interface)

in the section on **Expanding Tokens for Output** later in this chapter.

Detecting if Break is Being Pressed: CALL 8020 (1F54h)

This call will return with the carry flag set if it is not being pressed, and with the carry flag reset if it is being pressed. (*Note:* This call tests for both CAPS SHIFT and SPACE being pressed.) If you want to test for SPACE alone see the section later on **Getting a Character from the Keyboard** for full details but, for the time being, you could use:

```
LD  A,7FH
IN  A (0FEH)
RRA
JP  NC,PRESSED
```

Setting the Position for Printing Using RST 16 (10h): CALL 3545 (DD9h)

This routine requires the B register to hold the screen line number in the form:

B = 24 − line number

(i.e. if B = 24, this is the top line of the screen; if B = 1 this is the bottom line). Unfortunately due to an oversight in the writing of the ROM, you cannot use lines 23 and 24 for printing on the main screen. So you must use the lower section by setting up the output stream for RST 16 (10h) to be 1, and using the top two lines of the lower screen.

C = 33 − column number

(i.e. if C = 33 this is the left-most column; if C = 2 is the right-most).

This call automatically updates the system variables for the print positions on whichever stream you are using, as set up by

calling 5633 (1601h). Caution needs to be exercised on the last line of the main screen as a scroll message will be generated after printing on the last available position. This will cause a return to BASIC if answered with 'n' or SPACE. In addition to this, any attempt to print to stream 1 will cause scrolling up of the lower screen when the available space set up by the system variable DF SZ (23659) has been filled. This can produce some very unexpected results.

Obviously when printing to a printer you cannot set a line number so the B register is not used.

Clearing the Screen (Whole Screen): CALL 3435 (D6Bh)

This call will clear the whole screen and reset the attributes to those in system variable ATTR P for the main screen and BORDCR for the lower screen (23693 and 23624, respectively; see the Spectrum manual for how these are made up).

Clearing the Screen (Lower Screen): CALL 3438 (D6Eh)

This will clear the lower screen only and reset the attributes.

Note: Both 3435 (D6Bh) and 3438 (B6Eh) reset DF SZ to 2 and can corrupt the current channel used by RST 16 (10h) so this will need to be reset. The current print positions are set to the top left of the respective screens.

Scrolling the Screen: CALL 3582 (DFEh)

This scrolls the screen up by one line, but leaves the current print position unaffected. Therefore if you continually print to the same line, scrolling the screen at the end of each line, you will have an effect like typing using a typewriter (with the printing taking place at the bottom and the print being moved up after a carriage return).

Plotting to the Screen: CALL 8933 (22E5h)

The point addressed by the B register (Y 0–175) and the C register (X 0–255) will be plotted to the screen. The INK and PAPER colours can be set up previously by loading the system variables for the attributes with the colours you require or the current attributes will be used. OVER 1 can be set by SET 0,(IY + 87) or reset by RES 0,(IY + 87) and any point can be unplotted by SET 2,(IY + 87).

Note: It is perfectly possible to plot to the lower screen and this should be avoided, if not required, by setting the stream required with the 5633 (1601h) CALL.

Getting a Number to a Stream

This is the most complicated routine so far and does not have a simple call address as such. There is a routine in the ROM for taking a 16-bit number from two addresses and outputting it in decimal form, but this routine has the disadvantage that the bytes must be stored 'about face' from the way that the Z80 stores them. This means that you must load the number into a register pair and then store it back into a space in memory the opposite way round (i.e. high-order byte first). A short program such as this would serve:

```
LD    DE,(address where No. stored)
LD    HL,SPARE WORD
LD    (HL),D
INC   HL
LD    (HL),E
```

The ROM routine at 6696 (1A28h) can now be called with HL pointing to the address SPARE WORD which will then be output in ASCII to the current stream, but there are two drawbacks.

1) It will only be output correctly if it is less than 10 000 decimal and it must be an integer.
2) The number will be output with leading spaces so that chaining outputs to create a larger number will work only if each number output is between 1000 and 9999, otherwise spaces will be introduced.

Those of you who have the *Spectrum Pocket Book* and have read about this call address, but not used it, will now be calling me an idiot. In that book, the author points out that the E register controls the way the number is formatted, but if you have used the routine you will know that this is not quite the case, as the E register is ignored. There are two ways round this problem.

Firstly, you could write your own routine to bypass the first part of the ROM routine, such as:

```
PUSH    DE
LD      D,(HL)
INC     HL
LD      E,(HL)
PUSH    HL
EX      DE,HL
LD      E,20H
JP      1A30H
```

Note: The last instruction must be a jump (JP) and the routine you have written must be called, otherwise the stack will be mixed up as the return address is stored on the stack and the routine POPs from the stack the PUSHes you have made. You will see that the E register is loaded in your routine and as this is a duplicate of the start of the routine on ROM you can now see why the *Spectrum Pocket Book* is wrong. Now you can change the LD E, instruction in this routine to be either 48 decimal, in which case leading 0s are printed, or 255 when anything not significant is not printed.

"But wait a minute," you will be saying, "now I can see why the byte order has to be changed." Quite correct, if you reverse the order of loading the DE register pair or even load HL directly the number does not have to be reversed, so it is well worth while rewriting this short piece of code for incorporation into your own program as a subroutine for outputting numbers.

There is one other part to this routine in the ROM worth considering at this point and that is the part starting at 1A1Bh. This simply takes the number in the BC register pair and outputs that with no leading 0s or spaces; *much* more useful in many cases.

With a little thought, these routines now give you the possibility of outputting any size of number from your program. It is probably easier, however, to use the routines which take a value from the calculator stack (for details see Chapter 8).

Getting a Character from the Keyboard

The RST 56 (38h) instruction is used by the Spectrum to scan the keyboard and update the FRAMES system variables, and it is called by the maskable interrupt routine. If all that is required is to see if a key has been pressed, bit 5 of FLAGS 23611 (5C3Bh) can be tested; if the bit is set a key has been pressed since it was last reset. Note that bit 5 needs to be explicitly reset.

The code of the last key pressed can be found from 23560 (5C08h) LAST K, detailed in Chapter 4. This is often sufficient for getting input from the keyboard, but it has disadvantages.

Firstly, it is updated only 50 times a second (60 if the mains frequency is 60 Hz, as in the USA) so you cannot do a RES 5 instruction immediately followed by a look at the bit since almost certainly, even if a key is being pressed, the keyboard will not have been scanned by an interrupt. Otherwise, if the interrupts are off, the keyboard will never be scanned unless you do so. Therefore something along the lines of:

```
        LD   HL,23611  ;FLAGS system Variable
        RES  5,(HL)
        LD   A,FFH
        LD   (23552),A ;23552 is part of the
                        system variable KSTATE
        PUSH HL
        RST  56
        POP  HL
        XOR  A
        BIT  5,(HL)
        JP   Z,NO KEY
        LD   A,(23560) ;LAST K system variable
NO KEY  ( whatever )
```

will return in the A register the code of the key being pressed at the label NO KEY or 0 if no key is being pressed. In the above routine, the LD HL,23611 instruction could have been omitted

and (IY + 1) tested instead, as the IY register contains the address of the system variable ERR NR (23610) (5C3Ah) and is used for addressing the system variables by the ROM. This is why if you use the IY register in your programs you *must* make sure the interrupts are off or directed to your own routines, and you must also reset the IY register to the correct address before using the ROM or reverting to the normal interrupt mode.

The second problem is that you cannot test for more than one key being pressed at a time. This is because if a combination of keys which is not a valid character is being pressed the Spectrum will ignore them. To overcome this you will need to write your own keyboard-scanning routine. Firstly, if you only want to find out if a key is being pressed without worrying about which key or how many keys, you could do something like this:

```
XOR A          ;make sure that A contains 0
                to scan all keys
IN   A,(FEH) ;FEH is input port from keyboard etc.
LD   D,31
AND  D         ;Get rid of the etc.(the 3 high bits)
XOR  D         ;Flip the remaining bits
JR   Z,NO_KEY
```

The keyboard can be scanned properly to discover which keys are being pressed by loading the A register with the value of the lines to be scanned prior to the IN A,(FEH) instruction.

Chapter 23 of the Spectrum manual explains how the keyboard is laid out, and it is also shown in Appendix D in this book, but in brief this is the layout. The first character in each case is BIT 0 and the second BIT 4, the hex number is to be loaded into the A register to set the bit for the line being scanned low:

CAPS SHIFT — V	FEH
A — G	FDH
Q — T	FBH
1 — 5	F7H
0 — 6	EFH
P — Y	DFH
ENTER — H	BFH
SPACE — B	7FH

So, for example, to read the keyboard for ENTER being pressed the program would be:

```
LD   A,0BFH
IN   A,(0FEH)
AND  1
JR   Z,ENTER PRESSED
```

To see if more than one key is being pressed you could use the logical operators AND, OR, etc. if they are on the same line or bit test instructions. See the next CALL 5598 (15DEh) for getting normal characters easily.

Wait Input: CALL 5598 (15DEh)

This is a most useful routine which allows for input from any stream that has an input address. Before use the stream from which the input is required must be opened by the routine at 5633, described earlier. When the Wait Input routine is CALLed, it in turn calls the input routine of the current channel. On return from this the carry flag is checked, if set the main CALLing program is returned to. If the carry flag was not set the 0 flag is then checked, and if set the process is repeated.

The routine is used by the Spectrum as the control for the current input subroutine, normally the keyboard input, but if CURCHL is set to point to a channel with the input address pointing to your input subroutine this will be used. (How to do this is explained in Chapter 5.) When used with stream 1 (the keyboard and lower screen), the routine will wait for a key to be pressed and return its code in the A register. This use is demonstrated in the DeBASE program in the Appendix G.

There is, however, a problem when using this to read the keyboard if the mode is changed. Each time the routine is called, TV FLAG 23612 (5C3Ch) IY + 2 is checked and if bit 3 is set the input buffer is copied to the edit area of the screen. This can be overcome by using the Key Input routine at 4264 (10A8h) directly and not via the Wait Input routine, as shown in the DeBASE program in Appendix G at the label INPUT. The program duplicates the Wait Input routine but ensures the MODE CHANGE flag is always reset. The Wait Input routine is used at the label

INPUTF and if the program is entered (or just this section of it) the problem can be demonstrated by pressing CAPS SHIFT and SYMBOL SHIFT to go into EXTENDED MODE. The last line that was typed in from the keyboard will then appear at the bottom of the screen.

When using these routines to read from the keyboard the interrupts must be on and the normal interrupt routine at 56 (38h) called within the interrupt cycle, otherwise no input will ever be received.

Screen Copy to Printer: CALL 3756 (EACh)

This routine requires no presetting and a straightforward CALL will output a screen copy to the ZX printer.

Printing Graphics to Printer: CALL 3789 (ECDh)

This is similar to the screen copy routine in that it uses the printer buffer and outputs its contents to the printer. It is used by the RST 16 routine which normally treats the buffer as one screen line (eight pixels high). If you place your graphics into the buffer one line at a time and then make a CALL to this address, the printer will copy the buffer to the printer.

Note: The layout is 32 bytes per pixel line with the next pixel line following immediately and not as the screen. The buffer is also cleared to 0s after a CALL.

Clearing the Printer Buffer: CALL 3807 (EDFh)

This simply clears the buffer to 0s.

Using the Beep: CALL 949 (3B5h)

The DE register pair holds the length of the output and the HL register pair the frequency. 0 is high for frequency and FFFFh is low. The problem with this routine is that the duration is

frequency-dependent, hence if you halve the frequency you double the duration for a given value in DE. The actual figures are calculated as follows:

HL = (437 500/frequency) − 30.125
DE = duration* frequency
(duration should be in seconds)

The reason why the 30.125 is taken away from the HL calculation is that the routine itself takes 120.5 T states actually to generate the note and amend its own registers, etc.

Middle C is approximately 261 Hz so the value for HL would be about 1646 decimal and DE for one second would be about 261 decimal.

Remember that the interrupts from the ULA will occur 50 times a second (60 times in the USA) and they will corrupt the sound output if the routine is in the bottom 16K of RAM.

Printing Messages: CALL 3082 (COAh)

On entry the DE register pair must hold the address of the message table's start marker, which must have BIT 7 set, and the A register must hold the entry number in a table of messages, each with BIT 7 set on the last byte. The first message has entry number 0.

If you wanted to print the message " I am " you might have a line in your program such as: MESSAGE DEFM " I am ", but this would carry on printing after the last space until it came to a byte with bit 7 set. You should therefore change the program line to 'MESSAGE DEFB 80H : DEFM " I am" : DEFB " " + 80H'. The routine will subtract the 80H and print the last space correctly, but will know that it has reached the end and return to the calling routine. So, the whole program might look something like this:

```
        LD   A,0       ;(to print first message in table)
        CALL PR_MES
          ...
;   REST OF PROGRAM GOES HERE
          ...
```



```
PR_MES   LD   DE,MESSAGE
         CALL 3082
         RET
MESSAGE  DEFD 80
         DEFM "ENTRY"
         DEFB " "+80H
         DEFM "ENTRY 2"
         DEFB " "+80H
```

This would print to the current stream at the current position the message <ENTRY>. To print <ENTRY 2>, the A register would hold 1. The chevrons are only to show the limits of what will actually be printed, and will not appear when a message is printed. This is the routine used by the ROM to expand tokens and generate error messages when called from another routine at 2898 (B52h). The DeBASE program (see Appendix G) makes extensive use of this routine.

Expanding Tokens for Output: CALL 2898 (B52h)

Whenever the Spectrum comes across a token code (anything with bit 7 set) it has to decide what to do with it, as it could either be a User-Defined Graphic, a block graphic or a word from the BASIC vocabulary. Normally this is taken care of automatically when using RST 16 (10h) (which is directed through this routine). If you have changed the address for output on a stream (e.g. to output to your own printer interface), whenever your routine is being used the A register will hold the code for the token and if you wish to expand it you will have to do it yourself. If you leave it as it stands you may get some peculiar results from the printer. This routine can be used to expand the keywords, but you will have to deal with the graphics yourself and make sure that no graphic codes are sent to the routine, otherwise the machine may lock up.

Note: When expanding, the routine itself makes repeated calls to the address pointed to by the stream in use and returns only after all the letters have been output. This means you will most likely jump to the routine so as to ensure the code in the A register on the final return is not output. This is shown in the following typical program for output to a printer interface:

```
INIT    LD    HL,(23631) ; CHANS (address of channel
                           data)
        LD    BC,15      ; offset for stream 3
                           (printer)
        ADD   HL,BC      ; HL now points to the
                           location holding the
                           address to be called with
                           output on this stream
        LD    BC,START   ; START = address of the
                           start of your O/P routine
        LD    (HL),C
        INC   HL
        LD    (HL),B
        RET              ; stream three is now
                           initialised to send its
                           output to your routine

START   LD    B,A        ; save the ASCII code in B
        CP    165
        JP    NC,B52H    ; expansion routine in ROM
        CP    13
        JR    Z,CRLF     ; carriage return & line
                           feed
        CP    32
        RET   C          ; anything below 32 is an
                           unprintable control code
        CP    128
        JR    C,PRINT    ; must be normal character
                         ; anything left here is a
                           graphic, and you must
                           deal with it as you wish
PRINT                    ; your O/P routine comes
                           here
        RET              ; go back for next
                           character, if there
                           isn't one execution will
                           return to the original
                           calling program
```


This program is a very basic one; if you wish to send any printer control codes, it will not print them. To get round this you will have to carry out further checks and act accordingly. The first section only needs to be called once as it permanently alters where output to stream 3 is sent. The only times it needs re-initialising are either after a NEW command from the keyboard or if the output has been changed by another part of the program.

Expanding Block Graphics: CALL 2878 (B3Eh)

If you want to create from the code of a block graphic the block graphic itself, the routine at 2878 (B3Eh) will do it for you. On entry the base address of eight spare bytes where you want the graphic constructed should be in the HL register pair, and the B register should contain the code of the block graphic. Two CALLs need to be made, the second immediately after the first, as each CALL constructs four bytes of the character. The first byte of your eight-byte block will be the top of the block graphic and HL will point to the byte after the last byte of the graphic. The register pairs altered by this routine are AF, HL and BC; no others are used by it.

Drawing Circles: CALL 9005 (232Dh)

The routine to draw a circle requires the parameters of the circle to be on the calculator stack of the Spectrum. Thus the first thing to do is put the details onto the calculator stack. A routine located at 11560 (2D28h) will do this for us if we put the number we wish to stack into the A register (see Chapter 8 for fuller details on **Use of the Calculator**). All you need to know now is that it resets the IY register to point to ERR NR and corrupts most of the other registers so you should save them before calling this routine.

The parameters must be saved onto the calculator stack in the order X,Y,Z (Z = radius). The circle-drawing routine updates the system variables COORDS so if you do not want them changed

you should save them before drawing your circle and restore them afterwards. Thus, the routine to draw a circle would look something like this:

```
LD      HL,(23677)   ;COORDS
PUSH    HL           ;SAVE COORDS
LD      A,X          ;WHERE X = 0 - 255
CALL    2D28H        ;STACK A ROM ROUTINE
LD      A,Y          ;Y 0 — 175
CALL    2D28H
LD      A,Z          ;Z = RADIUS (MAKE SURE THAT
                      THERE IS ROOM ON THE SCREEN
                      OTHERWISE YOU WILL GET AN
                      ERROR REPORT)
CALL    2D28H
CALL    232DH        ;DRAW CIRCLE
POP     HL
LD      (23677),HL   ;RESTORE COORDS
```

If you wanted to draw your circle round the current COORDS position, you could have placed these onto the calculator stack, but you would still have to save them to the machine stack if you want to restore them unaffected.

Drawing a Line: CALL 9146 (23BAh)

The ROM line-drawing routine proper starts at 9399 (24B7h) and takes its parameters from the calculator stack in the same way as the circle routine. In this case, however, it is easier to bypass the part which uses the calculator stack. The routine takes its start from COORDS so if you want to start from somewhere else you will have to load COORDS with your start position after first saving them if required for later restoration. Otherwise they will point to the end of your line. On entry the DE registers hold the signs of the DRAW parameters which are held in the BC registers: −1 (FFh) for negative, +1 (01h) for positive. The registers C and E hold X, whereas B and D hold Y.

The machine code equivalent to the BASIC line DRAW 0,175 would look like this:

```
  LD      BC,AF00H  ; 175,0
  LD      DE,0101H;+
  CALL    24BAH
Or to DRAW −255,0
  LD      BC,00FFH  ; 0,255
  LD      DE,01FFH  ; +,−
```

Note that these will draw from the current COORDS, and no attempt has been made to save them or alter them. After running the routine they will point to the last point plotted while drawing the line and an error will occur if you try to draw off the screen.

Finding the Address of a Pixel: CALL 8874 (22AAh)

To find the address of the byte holding the pixel for a PLOT command this routine can be called with the BC register pair holding the X and Y coordinates (Y 0–175 in B and X 0–255 in C) will return with the HL register pair holding the address and the A register holding the bit position.

Clearing Part of the Screen: CALL 3652 (E44h)

This routine will clear the number of lines set by the B register from the bottom of the screen (e.g., if B contained 1 then just the bottom line would be cleared, or if B contained 10 then the bottom ten lines would be cleared). The bottom of the screen is always line 24, not the lowest line of the main screen.

Scrolling Part of the Screen: CALL 3584 (E00h)

To scroll part of the screen, first the B register has to be set to the number of lines to be scrolled − 1. Then the routine can be called. The bottom line after each call will be cleared and at least two lines

must be scrolled. Lines are again counted from the bottom of the full screen.

Input to Current Channel: CALL 5606 (15E6h)

This routine picks up the address of the current channel from the system variable CURCHL, finds the address of the input sub-routine from the channel information area and then calls the required routine.

Clearing the Calculator Stack and Workspace: CALL 5823 (16BFh)

This routine can be very useful to ensure that the calculator has the maximum workspace and that there is nothing inadvertently left on the calculator stack. It uses only the HL register pair and will return with the contents of the system variable STKEND in this.

SAVEing, LOADing and VERIFYing

The Spectrum SAVE and LOAD routines are fairly straightforward and very easy to use if both saving and loading are to be carried out from within the program, if the exact length of the data is known and if it does not matter if control is returned to BASIC in the event of an error or BREAK being pressed. If the length is not known, or something other than data is to be handled, things become more complicated.

Normally when loading the Spectrum expects a header to be received before the main block, and it is this header that tells the Spectrum how to deal with the main data block which follows. It is much easier to save and load without the header but, as mentioned previously, this can only be done if the exact parameters are known.

The header is 19 bytes long (not 17 as most books will tell you), but only the 17 middle bytes need to be set up as the routines for SAVEing and LOADing create the first and last bytes themselves.

Byte 1 is always 00 for a header and the last byte is a parity byte which is generated within the routine, so there is no need to worry about it. Byte 2 holds a type number:

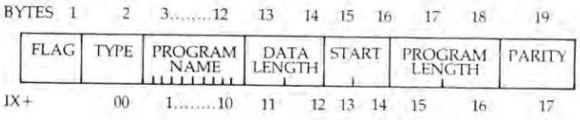
0 for a BASIC program	2 for a string array
1 for a numeric array	3 for a block of code

Bytes 3 to 12 hold the name. Bytes 13 and 14 hold the length of the main block. For a BASIC program this would be E LINE — PROG system variables. Bytes 15 and 16, for a code block, will hold the start address for loading the block. Bytes 15 and 16 for a BASIC program, will hold the auto-start line number if applicable or the start address if not. For an array, byte 16 holds the array name in the form of:

Bits 0–4 the name (A = 1 to Z = 26)
Bit 5 reset if the array is numeric
Bit 6 set if the array is a string
Bit 7 set

Bytes 17 and 18 hold the length of the program for a BASIC program (i.e. VARS − PROG system variables). The last byte is a parity byte, and this is created as the actual SAVEing or LOADing is being carried out.

The Header



To save onto tape either a header must be created as above and saved followed by the main data block, or if the parameters of the main data block are known, and will still be known when it comes to be loaded, the data block alone can be saved.

There are a number of entry points to the SAVE routine which can be used and each has its own merits and disadvantages. The first entry point to be considered is perhaps the easiest, but also the most fraught with problems. It is used by setting the IX register to point to the start of the header (byte 2 as described in the header information above) and the HL register pair must be set to point to the start of the main block to be saved. Once these registers have been set a CALL can be made to 2416 (0970h) and SAVEing of both the header and the main block will take place. The problems are as follows:

1) The message "Start tape then press any key" will appear. If any key except BREAK is pressed all will be well, otherwise control will be returned to BASIC via the error-handling routine.
2) The BREAK key is periodically tested during the SAVE routine. If pressed, a premature return is made to the BASIC error-handling routine, which can be embarrassing.
3) The header is saved in such a form so as to ensure that the SAVEd material can be loaded back by BASIC. Under some circumstances, this may be regarded as an advantage not a problem.

The next entry point can be regarded as the same as the last with the exception that it does not ask for or wait for a key to be pressed. This must be accessed via a *subroutine* in the calling program because correct operation depends upon correct loading of the machine stack. First set the IX and HL register pairs as above, then CALL the following routine from your program:

```
SAVE   PUSH   HL
       JP     2436 (0984H)
```

The return after SAVEing is complete will be made to the location following the CALL to SAVE. This is a neat way of SAVEing several successive blocks complete with headers, as repeated 'start tape' messages are avoided.

To SAVE without the possibility of BREAKing into the SAVE routine to return to BASIC, the normal start must be bypassed, and the header and data saved separately as blocks. The routine SA_BYTES located at 1218 (04C2h) is normally called to do any SAVEing, with the A register holding 00 for a header or FFh for a data block. The first thing that this routine does is preload the machine stack with the address of the SAVE/LOAD RETURN routine. The SAVE/LOAD RETURN routine enables the interrupts then looks to see if BREAK has been pressed. The error-handling routine is called in with an RST 8 if BREAK has been pressed, thereby making a return to BASIC. If BREAK has not been pressed return is to the original RETURN address, put onto the stack by the calling routine.

If the instructions to place the SAVE/LOAD RETURN routine are bypassed, the RETURN address on the machine stack will be that of your calling program, and control will be returned to that on exit from SAVEing, with the carry flag reset if there has been an attempt to BREAK into the SAVEing process, or set if not, and the interrupts will be *off*, so they must be re-enabled. You will also have to organise some form of message to make sure that the tape has been started, perhaps by using the message printing and Wait Key routines detailed elsewhere in this chapter.

To save a block of code by this method, the IX register must point to the start of the block, and the DE register must hold the length. The A register must hold either FFh for a data block or 00 for a header. A direct CALL can then be made to 1222 (04C6h). Remember that the DE register pair will have to hold 17 (11h) if a standard header is being saved. Blocks of data can be saved by this method without a header, but can only be loaded back if the length is known.

If a return to BASIC is not a worry, or is an advantage, then the same routine can be used, but from the start, which is at 1218 (04C2h). If BREAK is pressed control will then be returned to BASIC. Again you will have to make sure the tape is running.

LOADing and VERIFYing

Data on tape can be loaded into the Spectrum in two forms: either with a header or without. Where there is a header this can be used either to provide all the parameters for the loading of the main data block to follow or, as when loading from BASIC, only the details which are either unknown, known and definitely correct, or to ensure that the correct data is being loaded. Where there is no header, all the details that would have been in the header section *must* be known before the data can be loaded.

It is possible to create a different type of header from that used by the Spectrum, to define the parameters of the following data, by SAVEing a fixed length of data as a main data block and writing one's own decoding routine, which will furnish the details when the main block is loaded. This is often a good idea as it prevents the possibility of a block being lost, because you have forgotten the length or where it was on the tape, and hence cannot reload it. This will also prevent the code being loaded by an 'unauthorised' user, unless he takes the time to write his own code to examine what you have done and manages to interpret it. A routine which creates a special header is given in the DeBASE program in Appendix G.

To load a data block preceded by a normal header the first thing that must be done is allocate a space of 34 bytes in memory. In the first 17 bytes of this a 'dummy' header must be created. This defines details which are required to match, before the following block is loaded. Once a match of the required details is made any non-matching information will be checked against the real header and, assuming that the changes are acceptable, these details for the LOADing will be taken from the 'dummy' header. Should the changes be unacceptable, a BASIC error report will be generated by an RST 8 instruction. The second 17 bytes will be filled from the tape with headers for comparison. Only when a match is made will this area become free for use again.

The dummy header is made up in exactly the same manner as the header saved on the tape and again, the first and last bytes of the full 19 are generated internally, so are not included in the 17-byte specifier. The first byte *must* be the same identifier as the first byte in the header of the data to be loaded (i.e. the type must match). This is held in the A register on entry to the LOAD BYTES subroutine and need only be set if calling this directly. If the types do not match, a new leader is waited for and the process repeated until the types do match. The second byte (the first of the 17 that need to be set up in the dummy header) again *must* match: 0 for a BASIC program, 1 for a numeric array, etc. If there is no match the next block will be waited for. The next ten bytes are the name. If the name is to be disregarded then the first of these bytes must be FFh, the names will then be taken as matching. The next two bytes are the length, if this is set at 0 then the length will be taken from the tape header otherwise the two lengths *must* match. For a block of code, bytes 15 and 16 will be the start address to load to,

whereas for a BASIC array, byte 15 will be ignored and byte 16 will be the name of the array in the same form as when SAVEing. For a BASIC program, byte 15 will be 0 and byte 16 80h. The last bytes can be effectively ignored.

Before attempting to use the dummy header, the low byte of the system variable T ADDR must be set to contain 01 to LOAD or set to 2 in order to VERIFY.

The HL register pair must contain the address to which the main block is to be accepted, or 0 if the information in the tape header is to be used. For an existing BASIC array, this will be the start of the array data, following the array name and length bytes in the variables area of a BASIC program.

Finally the IX register must be set to point to the first byte of the dummy header. The ROM routine at 1889 (761h) can now be called to LOAD or VERIFY both the header and main data block from the tape.

LOADing or VERIFYing without a header can be achieved only if the full parameters of the block to be accepted are known, when it is a very simple process.

First the A register is loaded with FFh which signals that a main block is to be accepted. Next the DE register pair is loaded with the total length of the block to be accepted. Then the IX register is set to point to the address to start LOADing or VERIFYing the main data block. This followed by the carry flag being set, signalling a LOAD or reset to VERIFY. Finally, the ROM routine at 1366 (556h) is called to do the actual operation.

The start of this routine preloads the machine stack in the same way as the SAVEing routine detailed earlier, giving an error return in the event of BREAK being pressed. It can be bypassed by CALLing the following short subroutine in your own program:

```
LOAD INC  D          ;RESET 0 FLAG
     EX   AF,A'F'
     DEC  D          ;RESTORE D
     DI              ;THE INTERRUPTS MUST BE
                      OFF TO ENSURE THAT THE
                      TIMING IS CONSTANT. THEY
                      ARE NOT TURNED ON BY THE
                      ROM ROUTINE BEFORE RETURN
```

```
LD   A,0FH
OUT  (FEH),A  ;SET BORDER AND EAR PORTS
JP   562H     ;JUMP TO MAIN LOAD ROUTINE
```

The OUT instruction sets the BORDER colour to white with the three low bits; these can be changed as required to give a different colour. Bit 5 should be left set as this initialises the EAR port for indication of anything coming from the tape prior to the leader.

A tape-loading error can be detected by the carry flag being reset on return to the calling routine and, as an attempt to BREAK will result in an immediate return, if the test break routine is called after checking for errors this can be catered for.

Note: The interrupts will be *off* on return from loading.

The routine can also be used to read in a header, instead of a main data block, by loading the A register with 0 prior to calling it. This can be useful if you wish to create a different type of header and read it with your own routine. This is demonstrated in the DeBASE program in Appendix G.

Chapter Three

The 8K Interface ROM

With the addition of the 8K ROM in the Microdrive interface, Sinclair have opened up the possibility of expansion in the form of sideways ROM as used in the BBC microcomputer, as well as an easy route to expansion of the Sinclair BASIC. The first thing that needs to be understood is the mechanism by which the Z80 CPU can be used to address memory outside its normal direct addressing range of 64 kilobytes.

The CPU has two sets of information lines — A 1–16 (which it uses to tell the memory which byte it wishes to use) — called the address bus, and D 0–7, the data bus, which is used to read and write to the memory location pointed to on the address bus. Normally it would be impossible to access outside the 64K range, so some form of interception must be made which substitutes a different bank of memory in the same address range.

This is quite easy to do by choosing a byte of memory, looking for its address on the address bus, and when a match is made switching to the alternative memory. Execution will then continue at the next address as the program counter will move on to point to the next location as normal, but the data will be fetched from the new bank of memory.

In the Spectrum this is done by looking at the address bus for the program counter addressing location 8, which is the error-handling routine. Since this address is reached only by a restart (RST 8), the top of the stack will always hold the address of the instruction following the calling instruction (i.e. the return address). This is fetched by the shadow ROM routine, and the contents of that memory location examined. Values in the range 00 to 1Ah cause a return to the 16K ROM as these are normal error codes, but numbers between 1Bh and 32h are used as 'hook codes'. These call shadow ROM routines and will now be detailed. To use a hook code use RST 8 followed by DEFB hook code. All locations relate to the shadow ROM.

Inputs

Get Key: Hook Code 1Bh, Location 6617 (19D9h)

This is similar to the GET command in some BASICs (although the Sinclair BASIC does not have this command). It waits until a key is pressed and then returns with the code of the key pressed in the A register. The maskable interrupt should be on as the 16K ROM routine is used to scan the keyboard.

RS232 Input: Hook Code 1Dh, Location 2945 (B81h)

To use this routine, first the BAUD rate must be set using the system variable BAUD 23747/8 (5CC3/4h) calculated as 3 500 000/(26 × baud rate) − 2, 3 500 000 being the clock frequency of the Spectrum. Next SER_FL 23751 (5CC7h) should be set to 0, and then the input routine can be called. The A register will hold the code of the character received and the carry flag will be set. The routine will wait for only a certain period for a code to be received. If it has to wait too long, or if the space key is pressed, it will return, but without the carry flag set.

Network Input: Hook Code 2Fh, Location 6705 (1A31h)

Before use, a network channel must be opened and made current by the use of the Open Channel routine described later (see **Network Output** section). This routine will read a packet from the network, on entry the IX register should be set to the start of the network area and IX + 11, IX + 12, and IX + 13&14 must be set to the correct values for the block to be received (see the details on the network header in the section on **Network Output** using hook code 30H). The block number in IX + 13&14 will be incremented after each block is successfully received.

It would appear that it was intended that the carry flag should indicate if a packet has been read or, if there was an error, when the return to the calling routine is made. However, the carry flag can be corrupted by the resetting of the border colour on exit from the routine. A return will be made from this routine when a packet has successfully been received, with the carry flag reset. If the time allowed for a packet to be received has elapsed, there is a checksum error. Alternatively, if BREAK is pressed, the carry flag would be set.

Because of the problem inherent in this routine, it is easier to use the 16K ROM routine at 5606 (15E6h). Remember to preserve the IX register before calling this routine as it would be corrupted otherwise. The carry flag will be set if the A register does not hold a received code.

Outputs

Print to Screen: Hook Code 1Ch, Location 6636 (19ECh)

To use this the character code must be in the A register prior to calling the routine. This routine is a direct equivalent to the 16K ROM routines for setting output to stream 2 (main screen) and RST 16 printing to current stream, which actually uses these 16K ROM routines. Used in connection with the Get Key routine (see **Inputs** section above) you can create a sort of 'dumb terminal'. The program to do this would look something like this:

```
RST     8
DEFB    1BH
RST     8
DEFB    1CH
```

The first RST 8 will wait for a key to be pressed and return with the code in the A register, and the second RST 8 will echo the character to the main screen (or whatever output to stream 2 has been directed to).

Print to the Printer: Hook Code 1Fh, Location 6652 (19FCh)

This is identical to the print-to-screen routine above except that it uses stream 3 (normally the printer) instead of stream 2.

RS232 Output: Hook Code 1Eh, Location 3162 (C5Ah)

Again this is used by putting the code to be output in the A register, but using the RS232 output port on the interface. The

baud rate is picked up from the system variable BAUD and the border colour from the system variable IOBORD (see Chapter 4 for the settings of these). No information will be sent unless the DTR (Data Terminal Ready) line is high.

The main entry point called by the hook code allows any value of the A register to be output; care therefore needs to be taken to avoid sending control codes unintentionally. The other useful entry point is at 3132 (C3Ch) which looks for unprintable ASCII codes and intercepts them: any codes below 32 (20h) will cause an immediate return, except for code 13 (0Dh) (carriage return) which will be output and followed by a line feed code 10 (0Ah). Codes from 128 (80h) are treated according to their type. Graphics characters will be output as a '?' and tokens will be expanded by a call to the 16K ROM routine at 3088 (C10h), which requires 165 (A5h) to be subtracted from the code prior to its being called.

Network Output

Open Channel: Hook Code 2Dh, Location 3753 (EA9h)

Before any data can be sent or received on the network, a network channel must be opened. This is done by using this call after first setting D STR1 23766 (5CD6h) and NSTAT 23749 (5CC5h) system variables to be the destination and sending station numbers, respectively. A network channel will then be created at the end of the CHANS area, and everything from the address contained in the PROG 23635/6 (5C53/4h) system variable to that in the STKEND 23653/4 (5C65/6h) system variable will be moved up by 276 bytes and the relevant system variables will be reset, assuming there to be room below RAMTOP 23730/1 (5CB2/3h). If there is not enough room, an error will be caused.

On return the IX register will point to the start of the new channel. The newly created channel is temporary and signified as such by bit 7 of IX + 4 being set. To make it permanent this bit should be reset, and it can now be used to send by loading CURCHL 23633/4 (5C51/2h) with the address in the IX register and using the RST 16 (10h) routine in the 16K ROM to output data, a byte at a time.

After the final data has been passed to the RST 16 (10h) routine, the channel should be closed by the use of the hook code 2Eh

routine (see **Close Network Channel** below), which will send any remaining buffer contents and reclaim the buffer area. It will *not* close any streams attached to the network channel, and care must be exercised to ensure that other streams and channels are not corrupted.

Send Packet: Hook Code 30h, Location 3530 (DB2h)

This CALL allows a 'packet' to be sent over the network. Before use a network channel must be opened, the header and system variables must be set up, and the data to be sent placed in the buffer. To open a network channel use hook code 2Dh (see details above).

On calling this routine, first a 'scout' is sent which claims the network if it is free. Then the header is sent followed by the main data block. The header is held in the front of the network channel and is addressed by the IX register which points to the first location in the channel. Bytes IX + 00 to IX + 10 are set up by the channel-operating routine and bytes IX + 11 to IX + 18 are the header. The header is made up as follows:

IX + 11	The station receiving
IX + 12	The station sending
IX + 13 & 14	The block number
IX + 15	1 for the last block otherwise 0
IX + 16	The length of the buffer (0–255)
IX + 17	Checksum for the data block
IX + 18	Checksum for the header
IX + 19 & 20	USED FOR RECEIVING ONLY
IX + 19	The position of the last code taken from the buffer
IX + 20	The number of bytes available in the buffer

IX + 21 to IX + 275 are the data for sending, up to 255 bytes.

The checksums are created by the routine itself so do not have to be inserted and IX + 15 is loaded from the A register on entry to the routine, but all the other details must be set by the user. In addition to setting the header, the system variables D_STR1 23766 (5CD6h) must be the destination station number and NTSTAT 23749 (5CC5h) the sending station number. On each call to this routine the block number will be incremented. The base

address of the network channel is returned in the IX register by the channel open routine.

Close Network Channel: Hook Code 2Eh, Location 6692 (1A24h)

If this routine is called after a send operation, it will transmit any data remaining in the network buffer, marking it as an end-of-file block, but after a receive operation it will discard any remaining data in the buffer. The 270 bytes of the buffer area will then be reclaimed using the 16K ROM routine at 6632 (19E8h) but the channel information is left.

Microdrive Output

Open Channel/Open File: Hook Code 22h, Location 6953 (1B28h)

Before data can be sent to a Microdrive, a Microdrive channel and a map area for the drive selected must be created. Hook code 2Bh was intended to serve this purpose, but there was an error in the program, although this hook code can be used to perform the operation. First set D_STR1 23766/7 (5CD6/7h) to contain the drive number (1–8), N_STR1 23770/1 (5CD4/5h) the length of the file name and T_STR1 23772/3 (5CD6/7h) to the start address of the file name in memory. The H'L' register pair must then be saved and the hook code can then be called.

The channel will be opened as a read channel if the file name exists, otherwise it will be opened as a write channel. To make the channel a permanent one, the data must be incorporated into the STREAMs information. The following subroutine achieves this:

```
EXX             ;SAVE THE RETURN ADDRESS TO
                 BASIC
PUSH   HL
EXX
LD     A,S      ;S IS THE STREAM NUMBER FOR THE
                 CHANNEL
RLA             ;DOUBLE IT
```



```
LD     HL,5C16H ;BASE ADDRESS OF STREAMS
LD     D,0      ;OFFSET FOR S STREAM TO THE DE
LD     E,A      ;REGISTER PAIR
ADD    HL,DE    ;NOW HL = STREAM LOCATION
PUSH   HL       ;SAVE IT
RST    8        ;CALL HOOK CODE
DEFB   22H      ;22 (OPEN CHANNEL/FILE)
PUSH   HL       ;ON RETURN FROM THIS ROUTINE
                 HL = STREAM DISPLACEMENT
XOR    A        ;THE OPEN CHANNEL ROUTINE
                 LEAVES THE
RST    8        ;MICRODRIVE MOTOR RUNNING
DEFB   21H      ;SO IT MUST BE TURNED OFF
POP    DE       ;DE = STREAM DISPLACEMENT
POP    HL       ;HL = STREAM LOCATION
LD     (HL),E   ;SET S STREAM TO CORRECT
                 DISPLACEMENT
INC    HL
LD     (HL),D
RES    7,(IX+4) ;ON RETURN FROM THE HOOK
                 CODE 22 IX = START OF CHANNEL
                 AREA. RESETTING (IX + 4) MAKES
                 THE CHANNEL PERMANENT
EXX             ;RESTORE THE RETURN ADDRESS TO
                 BASIC
POP    HL
EXX
RET             ;FINISHED
```

To write to or read from a Microdrive, the channel created must be made current by loading the system variable CURCHL 23633/4 (5C51/2h) with the base address, returned in the IX register after opening the channel. The cartridge can then be written to with the 16K ROM RST 16 (10h) routine, or read from with the 16K routine at 5606 (15E6h), which returns with each character in the A register. If it is required to SAVE, VERIFY, MERGE, or LOAD with the Microdrive as opposed to using the cartridge as a file, this is explained later in this chapter.

Write Record: Hook Code 26h, Location 4607 (11FFh)

This hook code will write the contents of the Microdrive buffer to the next free sector on the Microdrive cartridge. Before calling the routine, the buffer must contain the information to be saved, the IX register must point to the start of the Microdrive channel. IX + 11 must contain the length of the data, IX + 13 the sector number (starting at 0 for the first sector of a record and automatically incremented each time a record is either sent or received), IX + 14 to IX + 23 the record name and IX + 25 the drive to be used. Locations IX + 82 to IX + 593 are available for the data to be placed for sending.

Write Sector: Hook Code 2Ah, Location 6801 (1A91h)

This performs the same action as above but looks for a sector of a record with the sector number in IX + 13 and, if it exists, overwrites it with the information currently in the buffer. If the sector does not exist, a 'FILE NOT FOUND' error will be generated. No check is made as to whether the sector is free or not, so care must be exercised to ensure that nothing that you want is already on the sector.

Close Microdrive Channel: Hook Code 23h, Location 4777 (12A9h)

This hook code performs the same action as the Close Network Channel (hook code 2Eh) but for the Microdrive and on entry the IX register must hold the base address of the file. If the channel was used for sending, any information left in the buffer will be sent as an 'end of file' message and the buffer will then be reclaimed, or if it was a read channel anything left in the buffer will be lost as the channel is reclaimed.

Erase File: Hook Code 24h, Location 7534 (1D6Eh)

This will erase a Microdrive file whose name is written in memory and pointed to by T_STR1 with name length N_STR1 on Microdrive D_STR1.

Microdrive Input

All the following 'read' routines return with the Microdrive motor still running and the maskable interrupt off.

Read Print Record: Hook Code 27h, Location 6679 (1A17h)

This will read a record from a print file, the record number of which is held in IX + 13. The IX register must point to the start of the Microdrive channel, IX + 25 must hold the drive number and IX + 14 to IX + 23 the record name. Assuming the record sector to be present, it will be read into the buffer otherwise an error will be caused.

Read Next Print Record: Hook Code 25h, Location 6665 (1A09h)

This is as above but, when used after the previous Hook Code, it will automatically read in the next record of a print file, if there is one. Otherwise an error will be caused.

Read Record Sector: Hook Code 28h, Location 6731 (1A4Bh)

This will read a record from a file. The IX register must point to the start of the Microdrive channel, IX + 13 should be set, the record number (within the file) IX + 25 must hold the drive number and IX + 14 to IX + 23 the file name. Assuming the record sector to be present, it will be read into the buffer. If it is a print file, a return will be made with the carry flag reset and the record in the Microdrive buffer area. Should the record be other than a print record the carry flag will be set and the record cleared from the buffer.

Read Next Record Sector: Hook Code 29h, Location 6790 (1A86h)

This is as above but for the next sector of a file. It is similar to Hook Code 25h.

Motor on/Motors off: Hook Code 21h, Location 6135 (17F7h)

The A register should be loaded either with 0, to turn off any motors that are running, or with the drive number whose motor is to be started. If the drive is not present, an error will be caused. If the drive is present, the motor will be started and a return made, with the interrupts *off*.

Reclaim Microdrive Channel: Hook Code 2Ch, Location 4292 (10C4h)

The Microdrive channel area currently pointed to by the IX register will be reclaimed. Any streams currently using the channel will be closed and the Microdrive map area is also reclaimed if not in use from another channel. All memory above the reclaimed channel up to RAMTOP is moved down by the 627 bytes freed by the reclamation.

Keyscan: Hook Code 20h, Location 6657 (1A01h)

This returns with the carry flag set if any key is being pressed.

Insert Variables: Hook Code 31h, Location 6568 (19A8h)

This inserts the extra system variables needed for the Interface 1. In fact, it is a single RET instruction as the variables are created automatically when the first 16K error occurs.

ROM 2: Hook Code 32h, Location 6564 (19A4h)

Perhaps this is the most useful of all the hook codes as it allows the 8K ROM to be paged in at will; therefore any routine can be called. To use it the location of the routine you want accessed must be placed in the system variable HD_11, the hook code can then be used. Unfortunately, the only register that can be passed directly by this hook code is the A register, but this is no real problem.

When the hook code is used, the address in HD_11 23789/90 (5CED/Eh) is put on the machine stack followed by the return address for the 8K ROM to 16K ROM switchover (1792 (700h)). If you make the address in HD_11 point back to your own program, you can then 'POP' the two return addresses off the stack and have the 8K ROM paged in, with your program in control. Any registers can now be used freely with 8K routines. To return to the 16K ROM all that you need to do is to CALL 1792 (700h), and the 8K ROM will be switched out.

Note: Many routines look at the syntax/run flag in FLAGS 23611 (5C3Bh) IY + 1, and cause a return to the BASIC interpreter in syntax time. Some of the Microdrive routines also return to BASIC via the address in ERR SP 23613/4 (5C3D/Eh) if they are completed successfully, or via an 8K ROM error if they have failed. The 16K error can be diverted to point back to the calling routine by altering the address in ERR SP so that it points to the return address of your routine on the machine stack. This is demonstrated in the DeBASE program in Appendix G, in the Microdrive SAVE/LOAD routines.

The following routines are called by the RST 8 DEFB 32h hook code after putting the location into HD_11.

Catalogue Cartridge: Hook Code 32h, Location 7256 (1C58h)

Before use, save H'L' registers. D_STR1 must contain the Microdrive number and S_STR1 the stream number for the catalogue to be printed to. The call can then be made and after the catalogue has been done H'L' registers are restored.

Format Cartridge: Hook Code 32h, Location 7022 (1B6EH)

Once again, before use the H'L' registers must be saved. N_STR1 must hold the length of the name to be given to the cartridge, and T_STR1 the address of the first character of the name when the routine is CALLed. The H'L' registers should be restored afterwards for a successful return to BASIC.

Run: Hook Code 32h, Location 2709 (A95H)

This is the simplest of the routines. It loads a program from Microdrive 1 called 'Run'. All that is necessary is a jump to the routine in ROM. This can be made after the 16K ROM has been paged out in the way described in the **Hook Code 32h** section above.

The following routines for SAVEing, LOADing, VERIFYing and MERGing all require a header to be set up before they can be used. The details of the make-up of a Microdrive channel are given in the Microdrive and Interface 1 manual (see pages 47 and 48) so I shall not repeat this detail here. I shall, however, explain how a header is made so that the Microdrive can be used from machine code.

Making a Microdrive Header

The Microdrive header is made up in much the same way as the tape header described in Chapter 2, but it is not necessary actually to set up the header in the Microdrive channel, as there is a routine in the ROM which will do this for you. All that has to be done is to set the system variables correctly. The subroutine to do this within your program would look something like this:

```
LD   HL,23782  ;HD_00
LD   (HL),T    ;T = 0 for a program: 1 for a
                numeric array: 2 for a string
                array: 3 for code
INC  HL
LD   DE,LEN    ;length of the main data block
LD   (HL),E
INC  HL
LD   (HL),D
INC  HL
LD   DE,START  ;start of data to be saved or dest
LD   (HL),E    ;when loading. 0 if information on
INC  HL        ;cartridge is to be used
LD   (HL),D
the rest of this need only be carried out for
BASIC programs and arrays. Otherwise jump to GO_ON
```



```
       INC  HL
       LD   DE,DATA   ;program length or variable name as
       LD   (HL),E    ;described in chapter 2 in  saveing
       INC  HL        ;and loading
       LD   (HL),D
       INC  HL
       LD   DE,AUTO   ;auto start line number, if any
       LD   (HL),E    ;otherwise a number over 10000
       INC  HL
       LD   (HL),D
GO_ON  LD   HL,23769  ;make it a microdrive operation
       LD   (HL),"M"  ;it must be a captial letter
       SET  BIT,(IY+124);bit 4 to load, bit 5 to save
                        bit 6 to merge, bit 7 to verify
       LD   HL,NLEN   ;length of file name (max 10
                       letters characters or tokens)
       LD   (23770),HL;this is NSTR1
       LD   HL,NAME   ;start address of file name
       LD   (23772),HL;T_STR1
       LD   HL,DRIVE  ;the drive number (1 - 8)
       LD   (23766),HL;D_STR1
       BIT  5,(IY+124);is it a save operation
       JP   NZ,1E7FH  ;if so go into save routine in ROM
       JP   08AF      ;else ROM load/verify/merge routine
NAME   DEFS 10        ;10 spare bytes for file name
```

The subroutine above *must* be CALLed from the main program. The RETurn after the operation has been performed is from the ROM routine to your calling routine, via the address on the machine stack pointed to by ERR SP (see the DeBASE program in Appendix G for details of how to ensure a return). The 16K ROM will be paged in by the SAVE or LOAD routine.

Any errors in the setting up of the header will cause either a BASIC error or a machine crash, so great care must be taken. As with most 8K ROM routines, it is important to save the H'L' registers before using the routines and restore them afterwards.

When a machine code program using ROM routines is being written, it is very important to remember which ROM will be switched in at any given time. Not only are all the routines in ROM changed, but all the ReSTarts in the 8K ROM are different from those in the 16K ROM.

It is possible to have a free exchange between the two ROMs by using Hook Code 32h from the 16K ROM and RST 10h from the 8K ROM. The use of Hook Code 32h has already been explained, but

details of how to use RST 10h and the other ReSTarts (RST) in the 8K ROM are given below:

```
RST 0   POP  HL          ;REMOVES THE RETURN
                          ADDRESS FROM THE
                          MACHINE STACK
        LD   (IY + 124),00 ;THIS IS FLAGS 3
        JP   700H         ;700H IS THE RETURN TO
                          THE 16K ROM
```

The address at the top of the stack at this stage should be the return to the routine that originally called the 8K ROM.

```
RST 8   LD   HL,(CH_ADD) ;THIS HAS NO EFFECT
                          WHEN CALLED FROM 16K
        POP  HL          ;THE ADDRESS OF THE
                          ERROR CODE
        PUSH HL          ;SAVE IT AGAIN
        JP   009AH       ;THIS WILL CHECK WHAT IS
                          BEING EXECUTED AND
                          EITHER RETURN TO A 16K
                          ERROR, EXECUTE A HOOK
                          CODE OR ACCESS A
                          CHANNEL.
```

This is of no practical use when the 8K ROM is switched in.

The RST 16 (10h) in the 8K ROM CALLs a 16K ROM routine, the address of which is held in a DEFined word (DEFW) after ReSTart. After the 16K routine has been executed control is returned to the address after the DEFW in the CALLing routine.

```
RST 16  LD   (5CBAH),HL  ;SAVE HL FOR
                          RESTORATION AFTER
                          RETURN
 (10H)  POP  HL          ;COLLECT IN HL THE
                          ADDRESS OF THE DEFW
        PUSH DE          ;SAVE DE ON MACHINE
                          STACK
        JR   0081H
```



```
0081H   LD   E,(HL)      ;PUT THE ADDRESS TO BE
                          CALLED IN THE
        INC  HL          ;16K ROM INTO DE
        LD   D,(HL)
        INC  HL          ;HL NOW HOLDS THE
                          RETURN ADDRESS AFTER
                          THE DEFW
        EX   (SP),HL     ;MAKE THIS THE NEW
                          RETURN ADDRESS
        EX   DE,HL
        LD   HL,0        ;THIS WILL LET THE RST 8
                          ROUTINE KNOW
        PUSH HL          ;IT IS A RETURN FROM A
                          8K TO A 16K CALL
        LD   HL,8        ;THE ERROR RESTART
        PUSH HL          ;ONTO THE STACK FOR A
                          LATER RETURN
        LD   HL,5CB9H    ;THE START OF THE
                          SUBROUTINE
        PUSH HL          ;ONTO THE STACK FOR A
                          RETURN
        JP   0700H       ;A RET INSTRUCTION
                          THAT SWITCHES IN THE
                          16K ROM
0700H   RET              ;PAGE IN THE 16K ROM
                          AND RETURN
```

I have given the full listing for this as it is an interesting method of transferring control.

When the RETurn at 0700h is made, switching in the 16K ROM, the address collected from the stack is 5CB9h. This address contains 21h, the instruction LD HL,NN. As can be seen above the NN was the value in HL when the ReSTart was made. The next location — 5CBCh — contains CDh, the instruction CALL NN. Again this address was loaded above, from the DEFW after the RST 16 (10h). The return from the 16K routine will be to 5CBFh which contains 22h, the instruction LD (NN),HL. The NN in this case is 5CBAh, so the new value in the HL register is saved where the original value was. Finally there is the instruction RET. This will be a return to the address on the top of the machine stack,

now 8 (i.e. the error ReSTart). This time when the address for the DEFBs is 'POPped' off the stack it will be 0. This will tell the ROM (8K now) that the HL register has to be loaded from (5CBAh), and after this there is yet another RETurn, this time to the address after the two DEFBs after the RST 16 (10h), seemingly so long ago.

The following ReSTart can be used to generate the shadow ROM error messages in the same way as the RST 8 in the main ROM:

```
RST 24    BIT   7,(IY + 1)    ;THIS IS FLAGS
  (18H)   RET                 ;THE ZERO FLAG WILL BE
                              SET IF A BASIC LINE IS
                              BEING CHECKED FOR
                              SYNTAX
RST 32    RST   24            ;CHECK IF SYNTAX OR
                              PROGRAM RUN
  (20H)   JR    Z,0068H       ;THIS WILL RESET THE
                              STACK POINTER TO THE
                              ADDRESS IN ERR_SP SET
                              X_PTR TO CH_ADD AND
                              RETURN TO THE MAIN
                              ROM LINE INPUT
                              ROUTINE VIA THE CLEAR
                              CALCULATOR ROUTINE,
                              AND INDICATE THE
                              POSITION OF THE
                              ERROR.
          JR    003AH         ;THIS WILL GENERATE AN
                              ERROR REPORT. THE
                              SHADOW ROM ERROR
                              CODE WILL BE
                              COLLECTED FROM THE
                              BYTE AFTER THE
                              RESTART.
```

This ReSTart can be used to generate a 16K error by loading ERR_NR with the error code before calling it.


```
                              ;THIS IS TV FLAG
  (28H)   JR    0040H         ;THIS WILL CHECK IF THE
                              ERROR OCCURRED IN
                              SYNTAX OR RUN TIME. IF
                              IN RUN TIME IT WILL
                              RETURN TO THE 16K
                              ERROR ROUTINE
                              OTHERWISE IT WILL
                              JUMP TO 0068H, AS
                              EXPLAINED ABOVE.
RST 48    JP    01F7H         ;CHECKS TO SEE IF THE
                              INTERFACE
  (30H)                       VARIABLES ARE PRESENT
                              AND IF NOT INSERTS
                              THEM.
RST 56    EI                  ;THIS IS THE NORMAL
                              MASKABLE INTERRUPT
  (38H)                       WHICH WOULD SCAN
                              THE KEYBOARD IF THE
                              16K ROM WAS PAGED IN.
          RET                 NOTE THAT THE
                              KEYBOARD WILL NOT BE
                              SCANNED WITH THIS.
```

The non-maskable interrupt routine at 102 (66h) consists of the single instruction RETN.

More 8K ROM routines are discussed in Chapter 7 but there are few routines that are of use for other purposes. Their use and locations have already been detailed in the hook codes section.

Chapter Four

The System Variables

The BASIC interpreter requires some means of keeping track of where information is stored, and what it is supposed to be doing, since it is located in ROM (Read-Only Memory) and has to use RAM (Random Access Memory) to store this information. Since the ROM is unalterable, the addresses of the system variables have to be predefined in such a way that they can be accessed on a regular basis. In the Spectrum, this is achieved both by having their locations fixed in particular area of memory and also by indexing them with the IY register, which always points to 5C3Ah (ERR NR).

16K System Variables

KSTATE: Locations 23552–23559 (5C00h–5C07h)

These locations are used in reading the keyboard. They can be divided into two sets of four, and each set is treated the same as the other. Which set is actually used depends upon the state of the other set.

The CAPS SHIFT value of a key being pressed is stored in the first location of each set or, if no key is pressed, 255 (FFh) which flags the set as free for use. The count down to a set being free is stored in the second byte, initially set to 5, free when 0. The repeat delay is in the third byte, initially loaded from REPPER. The ASCII code of the key pressed when a set was in use is in the last location of that set until the countdown to the set being free reaches 0. In order to try to make some sense of this I will explain the routine that uses these variables.

If a key is pressed, the scanning subroutine looks to see whether the first set is empty. If it is it will then use this set, otherwise it will look at the second set. When a set is free then the

CAPS SHIFT code of the key being pressed will be saved in the first location. The second location is set to 5 (the countdown to free, which also serves to debounce the keyboard), the third location is loaded with the repeat delay REPDEL. The ASCII code of the key pressed is decoded, saved in the last location and copied into LAST K, bit 5 of FLAGS is set to signal a new key press and a return to the calling routine made. When neither set is free then a counter in the second byte of each set is decremented and the calling routine is returned to.

Once one of the counters reaches 0, the code of the key being pressed (if any) is saved and a comparison is made between the code of the keys in the two sets. If they match a key is being held down and then the routine allows for repeating of the key. This is not the key-debouncing routine, but the repeating key routine. The repeat delay being held in the third byte and initially loaded from the system variable REPDEL.

Once the delay for the first repeat is over (the routine must be called the number of times set by the delay counter), if the match has been continuous then the third byte is loaded from the system variable REPPER, the code is again passed to the system variable LAST K, bit 5 of FLAGS set and a return to the calling routine made. On subsequent calls to the keyboard-scanning routine, the whole process is repeated but with the shorter delay from REPPER until the codes no longer match. If the keys do not match then the treatment is the same as for a free set.

The net result of all this is that there is a two-key rollover, which allows for a second key being pressed before the delay for a repeat on the first set has elapsed, avoiding the loss of the second key if it is not held down long enough for the original set to become free.

LAST K: Location 23560 IY − 50 (5C08h)

This contains the code of the last key pressed.

REPDEL: Location 23561 IY − 49 (5C09h)

The number of times the keyboard-scanning routine must be called before a key repeats is contained at this location.

REPPER: Location 23562 IY − 48 (5C0Ah)

This contains the number of times the keyboard scan must be called before a repeating key repeats.

DEFADD: Locations 23563/4 IY − 47 (5C0B/Ch)

These locations hold either the address of a user-defined function being evaluated or 0.

K DATA: Location 23565 IY − 45 (5C0Dh)

This is used as temporary storage of the colour information when colour controls are being entered (i.e. the second byte, the colour number, after the E shift).

TVDATA: Location 23566/7 IY − 44 (5C0E/Fh)

These are as above but for output and used with AT and TAB values as well, hence the two bytes.

STRMS: Locations 23568–23605 IY − 42 (5C10h–5C35h)

These contain the addresses of the channels attached to streams. Initially streams −3 to 3 are in the first 14 bytes, but the information for extra streams (up to a total of 19) is added when they are opened, in the relevant place.

CHARS: Locations 23606/7 IY − 4 (5C36/7h)

These contain the address of the theoretical start of the character set, each character comprising of eight bytes; in fact, 256 less than the actual start as all characters are addressed relative to this position by multiplying their ASCII code by eight and ASCII 0–31 are not printable and thus are handled differently, not from this table.

The last valid ASCII code is 127 (7Fh), but the Spectrum uses the remaining 128 values of the full eight-bit range for tokens. These are dealt with separately and do not comprise part of this character set.

RASP: Location 23608 IY − 2 (5C38h)

This contains the length of the buzz generated when a basic line exceeds 22 lines or memory has run out.

PIP: Location 23609 IY − 1 (5C39h)

This contains the duration of the beep whenever a key is pressed.

ERR NR: Location 23610 IY + 0 (5C3Ah)

This contains one less than the report code that will be generated on an error. It can be used to generate your own reports or use the resident reports for your own purposes (see Chapter 2 for details).

FLAGS: Location 23611 IY + 1 (5C3Bh)

Bit 0 is set to suppress a leading space when a token is being printed if a space immediately precedes it, but is reset if a space is to be printed.

Bit 1 is set when stream 3 (normally the printer) is to be used for output from the RST 16 routine, but is reset for stream 2 (normally the main screen).

Bit 2 is set when printing is to be using L mode and is reset for K mode.

Bit 3 is set to signal L mode, normally when getting an input, but is reset to signal K mode.

Bit 5 is set if a new key has been pressed since it was last reset (see

details on Scanning the Keyboard in Chapter 2 and for KSTATE system variable).

Bit 6 is used to indicate if an expression is numeric or a string, being set for numeric and reset for a string, and is used by the BASIC interpreter.

Bit 7 is reset when the BASIC interpreter is checking a line for syntax on entry and is set when the program is being run.

TV FLAG: Location 23612 IY + 2 (5C3Ch)

Bit 0 is set if handling the lower screen and is reset for the main screen.

Bit 3 signals that the current mode may have changed and needs to be rechecked.

Bit 4 is set when an automatic listing is being printed, otherwise it is reset.

Bit 5 signals that the lower screen needs to be cleared (e.g. when a report is about to be printed).

ERR SP: Locations 23613/4 IY + 3 (5C3D/Eh)

These locations hold the address on the machine stack of the RETurn to be used in the event of an error in a BASIC command being executed. It is picked up by an error ReSTart and frequently changed by BASIC. It can be changed from machine code to make an error go to your own routine, as demonstrated in the DeBASE program in Appendix G, in the Microdrive SAVE/LOAD section. If an error occurs this must be reset and the error cancelled by making ERR NR hold 255 (FFh). Note that 0 OK is counted as an error.

LIST SP: Locations 23615/6 IY + 5 (5C3F/40h)

LIST SP is used to save the address of the stack pointer so that it

can be restored after automatic listing is completed. This is necessary because the listing can be terminated at different places, with different amounts on the machine stack (e.g., by a 'n' in response to a 'Scroll?'.

MODE: Location 23617 IY + 7 (5C41h)

This determines the cursor used in an input, but it will only affect the first key press except when changed to force the graphics mode. However, it can be useful to get different cursors for input (e.g., if you POKE MODE with 32 you will get a flashing graphics input). Experimentation is the best way to make use of this facility as the system will not crash.

NEWPPC: Locations 23618/9 IY + 8 (5C42/3h)

This contains the line number of the next statement to be interpreted.

NSPPC: Location 23620 IY + 10 (5C44h)

This is the number of the statement in the line to be evaluated next. Poking first the line number then the statement number forces a jump in execution to that place.

PPC: Locations 23621/2 IY + 11 (5C45/6h)

This contains the line number of the statement currently being evaluated. Also it is used by an auto-run program loaded from the header.

SUBPPC: Location 23623 IY + 13 (5C47h)

This contains the statement number currently being evaluated.

BORDCR: Location 23624 IY + 14 (5C48h)

This contains the value for the border colour *8 plus the attributes for the lower screen. Bits 7 and 6 can be used to make the lower screen flash or bright.

E PPC: Locations 23625/6 IY + 15 (5C49/Ah)

E PPC contains the number of the current line (i.e. the line that will be displayed with the cursor and brought into the editing area addressed by E LINE by an EDIT command).

VARS: Locations 23627/8 IY + 17 (5C4B/Ch)

This contains the address of the start of the variables area. When it is used in conjunction with E LINE, the total length of a BASIC program's variables can be calculated.

DEST: Locations 23629/30 IY + 19 (5C4D/Eh)

This contains the address of the first letter of the name of the variable currently in use. If a new variable is to be used, it is the 80h end marker immediately before the address in E LINE where the start of a new variable is being placed.

CHANS: Locations 23631/2 IY + 21 (5C4F/50h)

This contains the address of the start of the channel information area in which the details for open channels are kept.

CURCHL: Locations 23633/4 IY + 23 (5C51/2h)

These locations hold the address of the start of information in the channel information area for the channel currently in use.

PROG: Locations 23635/6 IY + 25 (5C53/4h)

This is the address of the start of the BASIC program area, which will be the byte following the channel information area and any input/output buffers being used by Interface 1.

NXTLIN: Locations 23637/8 IY + 27 (5C55/6h)

This is the address of the start of the next BASIC line in a program.

DATADD: Locations 23639/40 IY + 29 (5C57/8h)

This is the address of the terminator of the last data item used, or the start of the line given by a RESTORE command, or the first after it if it does not exist. This keeps track of which data item is to be used next and if there are no more data after this pointer it will cause an 'out of data' error.

E LINE: Locations 23641/2 IY + 31 (5C59/Ah)

E LINE is the address of the start of the editing area, which will be the start of any line in the edit area.

K CUR: Locations 23643/4 IY + 33 (5C5B/Ch)

This is the address of the cursor in the current line. It is used to edit or to create a new line in the edit area.

CH ADD: Locations 23645/6 IY + 35 (5C5D/Eh)

This is the address of the next character to be interpreted by the BASIC interpreter (n.b., any numerics are marked by a CHR$ 14 and these are skipped).

X PTR: Locations 23647/8 IY + 37 (5C5F/60h)

These locations hold the address at which BASIC syntax has

failed when entering a new BASIC program line, marked by a '?'. It is also used to store information temporarily by the interpreter.

WORKSP: Locations 23649/50 IY + 39 (5C61/2h)

This is the address of temporary workspace, the first byte of free space created by a CALL 5717 (1655h) Make bc Space routine (see Chapter 5 for details, given in the section on **Standard Streams**).

STKBOT: Locations 23651/2 IY + 41 (5C63/4h)

These locations are the address of the bottom (start) of the calculator stack. This is explained fully in chapter 8.

STKEND: Locations 23653/4 IY + 43 (5C65/6h)

This is the address of the top (end) of the calculator stack. Again it is fully explained in Chapter 8.

BREG: Location 23655 IY + 45 (5C67h)

This is the B register for use by the calculator (see Chapter 8 for further details).

MEM: Locations 23656/7 IY + 46 (5C68/9h)

MEM provides the address of the calculator memory area (see Chapter 8 for further details).

FLAGS2: Location 23658 IY + 48 (5C6Ah)

Bit 0 is set if it is unnecessary for the main screen to be cleared when a line is being input into the editing area.

Bit 1 is set if the printer buffer has been used by a 16K ROM routine and is reset after it is cleared by the **Clearing Printer Buffer** routine described in Chapter 2.

Bit 2 set signals that the screen is clear.

Bit 3 set signals that CAPS LOCK is on.

Bit 4 set signals that K channel is in use.

DF SZ: Location 23659 IY + 49 (5C6Bh)

This is the number of lines allocated to the lower screen. It can cause the BASIC system to crash if set to less than three since one spare line is always left between the main screen and any reports. If there is nowhere for the reports to be printed, the interpreter hangs up.

S TOP: Locations 23660/1 IY + 50 (5C6C/Dh)

This address contains the line number of the first program line to be listed by a BASIC LIST command.

OLDPPC: Locations 23662/3 IY + 52 (5C63/Fh)

This address holds the line number containing the statement after that at which a BREAK or STOP was executed (i.e. the line that will be interpreted after a CONTINUE command).

OSPCC: Location 23664 IY + 54 (5C70h)

This is as above but provides the statement number within the line.

FLAGX: Location 23665 IY + 55 (5C71h)

The FLAGSX system variable is a rough equivalent of the FLAGS

system variable (location 23611 (5C3Bh)) and is used in its place in the interpreter when INPUT commands are being executed.

Bit 1 is set if the BASIC interpreter is handling a new variable.

Bit 5 is set when the 16K ROM is in input mode and is reset when in editing mode.

Bit 6 is set if a string is being handled.

Bit 7 is set if the BASIC interpreter is dealing with an INPUT LINE command.

STRLEN: Locations 23666/7 IY + 56 (5C72/3h)

These locations hold either the length of an existing string variable that is currently being used or, for a numeric or new string variable, the low byte will hold the letter of the variable (in the form described in the section on SAVEing and LOADing, see Chapter 2).

T ADDR: Locations 23668/9 IY + 58 (5C74/5h)

This normally holds the address of the next item in the syntax tables located from 6728 (1A48h) in the main ROM. However, it is also used for other purposes by some routines.

SEED: Locations 23670/1 IY + 60 (5C76/7h)

This is the seed for a random number. It is taken from the low two bytes of FRAMES if a RANDOMIZE command has no number, otherwise it is taken from the RANDOMIZE number.

FRAMES: Locations 23672–23674 IY + 62 (5C78h–5C7Ah)

At this address, a three-byte frames counter is held. It is set to 0 when the Spectrum is first switched on and is incremented each

time the normal interrupt routine is called. The least significant byte is in 23672 (5C78h).

UDG: Locations 23675/6 IY + 65 (5C7B/Ch)

This is the address of the first User-Defined Graphic.

COORDS: Locations 23677/8 IY + 67 (5C7D/Eh)

COORDS provides the X and Y coordinates of the last point plotted. This can be used to reset the start position for DRAWing or CIRCLE without having to PLOT the start; X (across) is in 23677 (5C7Dh).

P POSN: Location 23679 IY + 69 (5C7Fh)

This contains the column number of the next position to be used in the printer buffer (as **S POSN: Locations 23688/9 IY + 78 (5C88/9h)** below but for printer).

PR CC: Location 23680 IY + 70 (5C80h)

This is the low byte of the printer buffer current address. In effect, this is identical to **DF CC: Locations 23684/5 IY + 48 (5C84/5h)** and the printer buffer can be moved by changing the so-called unused byte below, which is in fact the high byte of the PR CC system variable. Unfortunately this is reset at the end of each print line to point to the original address; care therefore needs to be exercised if it has been moved.

NOT USED: Location 23681 IY + 71 (5C81h)

In effect, this is not used if the printer buffer is in the normal place (see **PR CC: Location 23680 IY + 70 (5C80h)**) but not free for use, except as above.

ECHO E: Locations 23682/3 IY + 72 (5C82/4h)

As **S POSN: Locations 23688/9 IY + 78 (5C88/9h)** this is the column and line number for the next print position, but for the input buffer. It is used when entering a BASIC line.

DF CC: Location 23684/5 IY + 74 (5C84/5h)

This contains the address of the top pixel line of the next print position. DF CC can be used to change the position of normal printed characters, by altering this to the next line down, but it can cause unexpected effects since the RST 16 (10h) routine simply adds 256 (100h) for each subsequent pixel line of a printed item. **The Spectrum screen map** in the appendix can be used to see the effect when moved down by more than one pixel line.

DFCCL: Locations 23686/7 IY + 76 (5C86/7h)

This is the lower screen version of **DFCC: Locations 23684/5 IY + 74 (5C84/5h).**

S POSN: Locations 23688/9 IY + 78 (5C88/9h)

These locations hold column and line number for the next PRINT position on the main screen and set up by the CALL 3545 (DD9h) routine detailed in Chapter 2 (where 33 is left column and 24 is top line).

SPOSNL: Locations 23690/1 IY + 80 (5C8A/Bh)

Like **S POSN: Locations 23688/9 IY + 78 (5C88/9H)**, these locations hold the column and line number for lower screen.

SCR CT: Location 23692 IY + 82 (5C8Ch)

This holds 1 more than the number of times the screen can be scrolled without a 'scroll?' question. It should always be kept to a high value since a machine code program could be broken into or crashed, if a negative response is given.

ATTR P: Location 23693 IY + 83 (5C8Dh)

This provides the global attributes for any screen printing, plotting, drawing, etc. It is set by a BASIC colour statement and can be loaded from within a machine code program, in which case all subsequent colours will be changed.

MASK P: Location 23694 IY + 84 (5C8Eh)

This is used as a mask to discriminate between transparent colour items and colour items to be taken from **ATTR P: Location 23693 IY + 83 (5C8Dh)**. For any bit set to 1, the attribute bit will be taken from the screen attribute for the current position, otherwise it will come from ATTR P.

ATTR T: Location 23695 IY + 85 (5C8Fh)

This provides the temporary attributes, set up by a colour item printed by a RST16 (10h) instruction.

MASK T: Location 23696 IY + 86 (5C90h)

This is used as a mask to discriminate between transparent colour items and colour items to be taken from **ATTR T: Location 23695 IY + 85 (5C8Fh)**. For any bit set to 1, the attribute bit will be taken from the screen attribute for the current position, otherwise it will come from ATTR T.

P FLAG: Location 23697 IY + 87 (5C91h)

This is the flag used to discriminate between the print parameters for any output to the screen by the ROM. The even bits are temporary bits, whereas the odd ones are permanent bits, each relating to the same items.

Bit 0/1 is set if OVER 1 is to be used.

Bit 2/3 is set if INVERSE is to be used.

Bit 4/5 is set if INK 9 is to be used.

Bit 6/7 is set if PAPER 9 is to be used.

MEMBOT: Locations 23698–23727 IY + 88 (5C92h–5CAFh)

This is the area used by the calculator to store values which cannot conveniently be kept on the calculator stack (see Chapter 8).

Not Used: Locations 23728/9 IY + 118 (5CB0/1h)

RAMTOP: Locations 23730/1 IY + 120 (5CB2/3h)

The main use of this address, which contains the address of the last byte of the BASIC area, will probably be to ensure that the calculator stack has sufficient space (see Chapter 8). It is set by a clear number command from BASIC which also initiates the machine stack to this address.

P–RAMT: Locations 23732/3 IY + 122 (5CB4/5h)

This contains the address of the last byte of physical RAM.

8K System Variables

There now follow the 8K ROM system variables which are only present when inserted by the Microdrive interface.

FLAGS3: Location 23734 IY + 124 (5CB6h)

Bit 0 is set if an extended command is being executed.

Bit 1 is set if a CLEAR# is being executed.

Bit 2 is set if the ERR SP system variable has been altered by the 8K ROM.

Bit 3 is set for NETWORK routines.

Bit 4 is set for LOAD routines by the 8K ROM.

Bit 5 is set for SAVE routines by the 8K ROM.

Bit 6 is set for MERGE routines by the 8K ROM.

Bit 7 is set for VERIFY routines by the 8K ROM.

VECTOR: Locations 23735/6 IY + 125 (5CB7/8h)

This contains the address to be jumped to if syntax has failed both the 16K and the 8K ROM interpreters. It is normally set to 496 (1F0h) which will cause a 16K ROM error. It can be changed to point to routines which check syntax further. This is covered in Chapter 7.

SBRT: Locations 23737–23746 (5CB9h–5C2h)

Strictly this is not a system variable but a short subroutine used by the 8K ROM to call 16K routines. The full details of this are given in Chapter 3 with the RST 16 routine in the 8K ROM.

BAUD: Locations 23747/8 (5CC3/4h)

This is the value used to set the BAUD rate for RS 232 input/output. It is calculated as follows:

$$\frac{3\ 500\ 000}{26 \times \text{baud rate}} - 2 = \text{BAUD}$$

3 500 000 being the clock rate of the Spectrum. This can be used to send or receive at non-standard baud rates. The default value is 12 (0Ch) which gives a baud rate of about 19 200.

NTSTAT: Location 23749 (5CC5h)

This is the network station number currently assigned to the Spectrum.

IOBORD: Location 23750 (5CC6h)

This holds the colour for the border during input/output operations, and is loaded with the colour number. It is normally 0 for black, but can be changed.

SER_FL: Locations 23751/2 (5CC7/8h)

This is used during RS232 input. The first byte is a flag, set to 0 on entry to the input routine and set to 1 when a byte has been received. The second byte is the received byte, on return from the input routine.

SECTOR: Locations 23753/4 (5CC9/Ah)

This is used by the 8K ROM to count Microdrive sectors.

CHADD_: Locations 23755/6 (5CCB/Ch)

This is the 8K ROM equivalent to CH_ADD (Locations 23645/6) for the 16K ROM. It is used to store the address of the CH_ADD address while the extended syntax is being checked and then replaced if necessary.

NTRESP: Location 23757 (5CCDh)

NTRESP is the response code given to the network.

The next eight bytes make up the network header which is explained in Chapter 3.

NTDEST: Location 23758 (5CCEh)

This contains the station to which network output is directed.

NTSRCE: Location 23759 (5CCFh)

This contains the station sending on the network.

NTNUMB: Locations 23760/1 (5CD0/1h)

This contains the number of the network block currently being passed.

NTTYPE: Location 23762 (5CD2h)

This holds the identifier for a network block, 0 for a normal block or 1 for the final block.

NTLEN: Location 23763 (5CD3h)

This holds the length of the network block being transmitted.

NTDCS: Location 23764 (5CD4h)

This contains the checksum for the data block to follow.

NTHCS: Location 23765 (5CD5h)

This holds the checksum for the seven bytes of the header.

The next eight bytes make up the first file specifier.

D_STR1: Locations 23766/7 (5CD6/7h)

For Microdrive transactions, this provides the drive number (as two bytes).

For network transactions, this provides the destination station number.

For RS232 transactions, this provides the baud rate.

(For a fuller description of the use of D_STR1 see Chapter 3, where each use is discussed when explaining the routines which use it.)

S_STR1: Location 23768 (5CD8h)

This contains the stream number (0–15).

L_STR1: Location 23769 (5CD9h)

This contains channel type in upper case.

N_STR1: Locations 23770/1 (5CDA/Bh)

N_STR1 holds the length of the file name.

T_STR1: Location 23772/3 (5CDC/Dh)

T_STR1 holds the address of the start of the file name.

The next eight bytes are used by LOAD and MOVE commands.

D_STR2: Locations 23774/5 (5CDE/Fh) to T_STR2: Location 23780/1 (5CE4/5h)

These eight bytes are the same as previous eight which make up the first file specifier.

The following bytes are direct equivalents to the header bytes for the 16K ROM routines, but they are used by the 8K ROM (for an explanation of their uses see Chapter 3).

HD_00: Location 23782 (5CE6h)

This holds the file type where: 0, program; 1, numeric array; 2, string array; 3, code.

HD_0B: Locations 23783/4 (5CE7/8h)

The length of data is held in these locations.

HD_0D: Locations 23785/6 (5CE9/Ah)

This holds the start of data.

HD_0F: Locations 23787/8 (5CEB/Ch)

This holds the array name or program length.

HD_11: Locations 23789/90 (5CED/Eh)

This holds the auto-start line number. It can also be used by hook code 32h (see Chapter 3).

COPIES: Location 23791 (5CEFh)

This dictates the number of copies made by a SAVE command.

Chapter Five

Input and Output Ports and Channels

The standard Spectrum has all the address and data bus lines available on the edge connector at the back, and the BASIC allows for communication with the outside world by means of the IN and OUT commands. These use the IN A,(C) and OUT A,(C) instructions on the Z80 CPU allowing the full address bus to be used for discriminating which peripheral device is to be controlled.

Port 254 (FEh) is used as an output for the BORDER colour, for the tape output and to drive the internal loud (soft?) speaker. It also handles the keyboard and the tape input. A brief résumé of this was given in the chapter on the 16K ROM, and I shall discuss it fully later in this chapter.

Port 251 (FBh) runs the ZX printer and is used for both input and output.

Port 247 (F7h) passes data for both the network and the RS232 communications input/output.

Port 239 (EFh) controls the Microdrive and the handshaking on the RS232 input/output of the Interface 1.

Port 231 (E7h) handles the Microdrive data for both read and write.

This last port is one reason for some peripherals being incompatible with the Microdrive interface. The Spectrum manual failed to mention that it would be used. I shall now consider the details of the more useful ports in turn.

Port 254 (FEh) 11111110 BIN

The keyboard is read through this port on bits 0–4. Each line of keys is split into two sections of five keys and for each section the key on the outside is read on bit 0 and the key nearest the middle bit 4. Each bit is returned high (1) unless a key is being pressed, in which case the respective bit is low (0).

The address lines are used to determine which half row is read by an IN instruction. The bit to be set low for each line is set out below:

A0	CAPS SHIFT	to V	254 (FEH)
A1	A	to G	253 (FDH)
A2	Q	to T	251 (FBH)
A3	1	to 5	247 (F7H)
A4	0	to 6	239 (EFH)
A5	P	to Y	223 (DFH)
A6	ENTER	to H	191 (BFH)
A7	BREAK/SPACE	to B	127 (7FH)

It is unfortunate that bits 5–7 of the data read in are set in an unpredictable manner and, in fact, the reading of the keyboard has been changed in issue 3 Spectrums, giving rise to some problems in programs which employ scruffy keyboard scanning which fails to exclude these. The Spectrum's own keyboard-scanning routine ignores them. This last fact opens up possibilities for their use for other purposes: for example as defined function keys as found on the BBC and other computers, scanned by an interrupt-driven routine.

It is possible to read more than one line of the keyboard at a time, by setting the relevant bits low before reading in the data lines, but this does not allow discrimination between the different lines of keys.

Note: Extreme care needs to be used when reading for more than one key pressed at a time. Sinclair have not put any protection against feedback between lines on the keyboard. This means that if, for example, the 'A', 'S' and 'W' keys are pressed at the same time, a scan of the line Q to T will show Q as being pressed, even though it is not. This is because while pressing two keys on

different address lines but with the same data bit the lines are effectively connected together. Therefore any other key pressed on either line, will set the respective bit low on both lines, so long as both the other keys are being pressed.

Bit 6 is the input from the tape socket and has a tendency to stay low, although it can be reset by an OUT instruction. Care needs to be exercised since any output to bits 0–2 will set the border colour. The safest way of setting all bits to 1 is to output 248 (F8h), but (1) it will only be temporary, and (2) it should never be necessary if proper decoding is practised.

For the output, bits 0,1 and 2 control the border colour, bit 0 controls the blue, bit 1 the red and bit 2 the green, all colours being made up from a mix of these.

Colour	*Number*	*Binary*
BLACK	0	00000000
BLUE	1	00000001
RED	2	00000010
MAGENTA	3	00000011
GREEN	4	00000100
CYAN	5	00000101
YELLOW	6	00000110
WHITE	7	00000111

Bit 3 controls the microphone socket. Remember that to get anything more than a click this needs to be turned on and off repeatedly to give a tone. The 'MIC' printed on the rear of the Spectrum is slightly misleading, since this gives output to the mic input of a tape recorder and plugging a microphone in would be a waste of time.

Bit 4 controls the loudspeaker inside the Spectrum and the same comments as above regarding use apply.

A program that demonstrates the use of the internal speaker and the 'EAR' input by reading speech or music in, storing it in memory and allowing its subsequent replay through the loudspeaker is given at the end of this chapter.

Port 251 (FBh) 11111011 BIN

Bit 0 INPUT is the busy line of the ZX printer, low (0) is busy.

Bit 1 OUTPUT high (1) slows the motor, low (0) speeds it up again.

Bit 2 OUTPUT low (0) starts the motor.

Bit 6 INPUT high (1) if the printer is not connected.

Bit 7 OUTPUT high (1) does the actual printing, one bit at a time.

Port 247 (F7h) 11110111 BIN

Bit 0 OUTPUT serial data for both network and RS232;
INPUT serial data from network.
Bit 7 INPUT serial data from RS232.

Port 239 (EFh) 11101111 BIN

The write protect tab on a Microdrive cartridge can be checked by IN A,(239) AND 1; the 0 flag will be set if the cartridge is protected.

The presence of a drive can be checked by reading bit 2 of port 239, after selecting the drive to be checked; it will be reset if the drive is present.

The RS232 DTR line is on bit 3 of port 239 and the CTS line is on bit 4 of port 239.

It is most unlikely that it will be necessary to use ports 247, 239 and 231, other than from within the 8K ROM with the exception of checking the presence of an ancillary device.

The remaining ports are available for use by other ancillary devices. Remember that if a printer or other interface is connected it will use a port or ports for information transfer. Two of the most common parallel printer interfaces are the MOREX (which also has a bidirectional RS232 interface built in, and which I can highly recommend) and the Kempston, which use the following ports:

Morex Ports 251 (FBh) 11111011 BIN & 127 (7Fh) 01111111 BIN

Port 251 (FBh) 11111011 BIN

Bits 0–7 OUTPUT Centronics Data.

Bit 0 INPUT Centronics Busy.

Bit 1 INPUT RS232 DTR.

Bit 7 INPUT RS232 RX data.

Port 127 (7Fh) 01111111 BIN

Bit 0 OUTPUT Centronics strobe.

Bit 1 OUTPUT RS232 TX data.

Bit 2 OUTPUT RS232 CTS.

Kempston Ports 58047 (E2BFh), 57535 (E0BFH) & 58303 (E3BF)

The Kempston interface can be used only with IN (C) and OUT (C) instructions since it looks at the full 16 bits of the address bus. Routines to send a single character to each of these interfaces Centronics output are given in the **Useful Subroutines** appendix.

Port 58047 (E2BFh)

Bit 0 INPUT is the busy line.

Port 57535 (E0BFh)

Bits 0–7 OUTPUTS Centronics data.

Port 58303 (E3BFh)

Bits 0–3 OUTPUTS Centronics strobe.

Standard Streams

Stream K −3/253 (FDh) is a duplicate of streams 0 and 1.

Stream S −2/254 (FEh) is a duplicate of stream 2.

Stream R −1/255 (FFh) is used to write to workspace, and will place the code currently in the A register into the address contained in the system variable K CUR 23643/4 (5C5B/Ch), and increment the address in K CUR. This is not as useful as it seems at first, since the make room routine is called first, and this moves up all memory above the address in K CUR as far as RAMTOP, making the stream useless for putting anything into anywhere above RAMTOP, or anywhere else that must not be moved. The routine starts at 3969 (F81h) and the stream can be used only for output; any attempt to use it for input will cause an error.

Stream 0 and Stream 1 K are normally attached to the lower screen, and the keyboard. They also allow input to be made to their channels.

Stream S 2 is for output only, normally to the screen.

Stream P 3 is for output only, normally the printer.

There are 19 streams available and each has to be attached to a channel; each stream has two bytes in the streams area of the system variables, starting at 23569 (5C10h) for stream −3, containing the displacement of the channel that it is attached to, from the base of the channels area. Remember that the first stream is −3 so that to find the address of the channel for stream 0 you will have to look at 23574/5 (5C16/7h).

A channel consists of a minimum of five bytes; the first two hold the address of the output routine, the second two the address of the input routine and the final byte the upper case letter of the channel code (S,K,P, etc.). The channels associated with the Microdrive Interface are substantially longer than the minimum and their format is shown in the handbook provided with the interface.

Record and Play Back Routine

```
Pass 1 errors: 00

                10 ; THIS SHORT PROGRAM ALLOWS SPEECH
                20 ; TO BE RECORDED FROM THE TAPE RECORDER INTO MEMORY
                30 ; THROUGH THE EAR INPUT
                40 ; THE RECORDED SPEECH CAN THEN BE PLAYED BACK THROUGH
                50 ; THE SPECTRUM'S SPEAKER FROM MEMORY
                60 ; THIS IS A VERY CRUDE PROGRAM BUT IS QUITE EFFECTIVE
                70 ;
                80 ;
C350            90 LIMIT  EQU  50000 ;       THE BOTTOM LIMIT OF AVAILABLE MEMORY
0005           100 TIME   EQU  5 ;           THE DELAY BETWEEN EACH BIT
FDE6           110 FIRST  EQU  64998 ;       THE FIRST BYTE OF MEMORY TO USE
FDE8           120        ORG  65000
FDE8 21E6FD    130 START  LD   HL,FIRST ;    CALCULATE THE AMOUNT OF MEMORY
FDEB 1150C3    140        LD   DE,LIMIT ;   AVAILABLE FOR USE
FDEE E5        150        PUSH HL
FDEF A7        160        AND  A
FDF0 ED52      170        SBC  HL,DE
FDF2 E5        180        PUSH HL
FDF3 C1        190        POP  BC
FDF4 E1        200        POP  HL
FDF5 F3        210        DI   ;             INTERRUPTS OFF TO ENSURE EVEN TIMING
FDF6 3E7F      220 LISTEN LD   A,#7F ;       WAIT FOR A SOUND
FDF8 DBFE      230        IN   A,(#FE)
FDFA CB77      240        BIT  6,A
FDFC 28F8      250        JR   Z,LISTEN
FDFE C5        260        PUSH BC
FDFF 0608      270 BYTEIN LD   B,8 ;         READ IN 8 BITS
FE01 2B        280        DEC  HL
FE02 DBFE      290 HEAR   IN   A,(#FE);      A BIT AT A TIME
FE04 17        300        RLA
FE05 17        310        RLA
FE06 CB16      320        RL   (HL) ;       AND TRANSFER IT TO MEMORY
FE08 100A      330        DJNZ PAUSE ;      PAUSE AND GET NEXT BIT
FE0A D1        340        POP  DE ;         BUT IF 8 BITS READ IN THEN CHECK
FE0B 1B        350        DEC  DE ;         ROOM AND DECREMENT COUNTER
FE0C 7A        360        LD   A,D
FE0D B3        370        OR   E
FE0E D5        380        PUSH DE
FE0F 20EE      390        JR   NZ,BYTEIN ;  IF STILL ROOM GO BACK FOR ANOTHER BYTE
FE11 C1        400        POP  BC ;         OTHERWISE FINISH
FE12 FB        410        EI
FE13 C9        420        RET
FE14 0E05      430 PAUSE  LD   C,TIME
FE16 0D        440 DELAY  DEC  C
FE17 20FD      450        JR   NZ,DELAY
FE19 18E7      460        JR   HEAR
FE1B 21E6FD    470 SPEAK  LD   HL,FIRST ;    THIS IS THE SAME AS FOR LISTEN
FE1E 1150C3    480        LD   DE,LIMIT
FE21 E5        490        PUSH HL
FE22 A7        500        AND  A
FE23 ED52      510        SBC  HL,DE
FE25 E5        520        PUSH HL
FE26 C1        530        POP  BC
FE27 E1        540        POP  HL
FE28 C5        550        PUSH BC
FE29 F3        560        DI
FE2A 0608      570 BYTEOT LD   B,8 ;         OUTPUT 8 BITS
FE2C 2B        580        DEC  HL
FE2D 7E        590        LD   A,(HL) ;     NOTE ALL BITS ARE PUT OUT AND THIS
FE2E 0F        600        RRCA ;            WILL CHANGE THE BORDER COLOUR
FE2F 0F        610        RRCA
FE30 0F        620        RRCA
FE31 D3FE      630 BITOUT OUT  (#FE),A ;    A BIT AT A TIME, AS READ IN
FE33 07        640        RLCA
```



```
FE34 0E05      650        LD   C,TIME
FE36 0D        660 HOLD   DEC  C
FE37 20FD      670        JR   NZ,HOLD
FE39 10F6      680        DJNZ BITOUT
FE3B C1        690        POP  BC
FE3C 0B        700        DEC  BC
FE3D 79        710        LD   A,C
FE3E B0        720        OR   B
FE3F C5        730        PUSH BC
FE40 20E8      740        JR   NZ,BYTEOT
FE42 C1        750        POP  BC
FE43 FB        760        EI
FE44 C9        770        RET

Pass 2 errors: 00

BITOUT FE31    BYTEIN FDFF
BYTEOT FE2A    DELAY  FE16
FIRST  FDE6    HEAR   FE02
HOLD   FE36    LIMIT  C350
LISTEN FDF6    PAUSE  FE14
SPEAK  FE1B    START  FDE8
TIME   0005

Table used:  170 from  725
```

Chapter Six

Using the Interrupts

The start-up sequence in the Spectrum, which clears the memory and sets the system variables, also initialises the interrupt register to hold 63 (3Fh) and sets the interrupt mode to 1 (IM1). The setting of the I register appears unnecessary since the IM1 mode has no use for it — because in this mode any interrupt does a RST 56 (38h) — but the novel manner in which the ULA in the Spectrum handles the display makes bits 6 and 7 of the I register important.

On every machine instruction cycle, the Z80 executes a memory refresh operation during which the contents of the I register are put out on high eight bits of the address bus and the memory request line is activated. The ULA generates an interrupt each time it wishes to update the screen. This makes the CPU execute the interrupt service routine, assuming the interrupts are enabled. This is normally the keyboard scan and frames counter update, but if the Interface ROM is switched in all that happens is the interrupts are enabled and an immediate RETurn made, without the keyboard being scanned or anything else done.

When the interrupt routine is completed the CPU returns to whatever it was doing previously. If this involves a read or write instruction to the memory between 16384 (4000h) and 32767 (7FFFh), which the ULA checks by looking at the top two lines of the address bus, and the $\overline{\text{MREQ}}$ line, the ULA stops the clock on the CPU while it completes the screen update.

If the I register has the top bit reset and bit 6 set the ULA gets confused, due to the refresh of dynamic memory during T3 and T4 of an M1 (instruction fetch) cycle. This activates the $\overline{\text{MREQ}}$ line and causes the I register to be put out on the top eight bits of the address bus. The ULA then thinks that the CPU is doing a read or write operation to this area of the RAM, even though it has tried to stop this, and the ULA omits its own read to update the display, causing break-up of the picture. The I register cannot

therefore hold a value which has the top two bits set in this manner, in other words any number from 64 to 127 (40h to 7 Fh) inclusive, if this break-up of the picture is to be avoided.

By setting IM2, it is possible to use the interrupts for your own purposes, so long as you do a RST 56 (38h) at the end of your own interrupt-servicing routine, which will enable the interrupts before returning to the CALLing program — if you want the keyboard scanned and frames counter updated — and end with a RETI instruction.

If you have not used the RST 56 (38h) within the interrupt routine, you must execute an EI instruction before the RETI if you want the interrupts enabled to CALL the interrupt service routine again. Remember that you will have to reset the IM1 mode and enable the interrupts before you return to BASIC unless you are using a RST 56 (38h) within the interrupt routine.

The IM2 mode is somewhat convoluted. On receipt of an interrupt, which occurs 50 (60 in the USA) times a second, the CPU saves the address of the next instruction in the program that it is executing on the machine stack, and disables any further interrupts. It then looks at the location pointed to by the data bus + (256 × the I register) and jumps to the address which is contained in this location + (256 times the contents of the following location). It is normally regarded as bad practice to have bit 0 on the data bus high for use as a pointer in IM2 since the vector should always start in an even numbered address, but unfortunately with the Spectrum there is no choice.

Example. The I register contains 10 (0Ah) and the data bus will hold 255 (FFh). $10 \times 256 = 2560$ and $2560 + 255 = 2815$, therefore the address to be jumped to will be taken from the contents of address 2815 + (256 × the contents of address 2816). Address 2815 contains 34 and address 2816 contains 128. You can see this for yourself by PEEKing on your Spectrum, as these are in the ROM. So the address jumped to will be 34 + (256 × 128), which is 32802.

Similarly, if the I register held 6:

$6 \times 256 = 1536$, and $1536 + 255 = 1791$.

1791 contains 221 and 1792 contains 113.

$\therefore 221 + (113 \times 256) = 29149$, so the jump will be to 29149.

Alternatively, if you have a 48K Spectrum and the I register held 200: 200 × 256 = 51200, and 51200 + 255 = 51455. So the jump will be to the address that you put into this and the following location, in normal Z80 fashion low byte first.

This can be represented by imagining the interrupt as an invisible instruction in the program being run. At the moment of the interrupt the invisible instruction is executed as if it were a DI followed by a CALL instruction in the address immediately prior to the address pointed to by the I register and the data bus, the address being CALLed is in the next two bytes in the standard Z80 low byte first order. The instruction, being invisible, cannot place its own return address on the machine stack, hence the address after the last instruction executed in your program goes onto the stack, and it is this address that will be returned to after the RETI instruction at the end of the interrupt service routine.

The RETI instruction must be preceded by an EI instruction. The reason for the DI being incorporated in the CALL performed by the interrupt is to ensure that, should the interrupt service routine be longer in execution time than the delay between two interrupts, the program does not become tied up in a loop.

It is quite easy to write a program which changes the address jumped to by an interrupt by loading the vector bytes (the two addresses looked at to determine where the jump is made to) with the desired address within the program.

Note: Whenever interrupt routines are used it is of vital importance that any registers which are used by the interrupt routine are preserved on entry, and restored before going back to the main program. No attempt should be made to pass data to and from the interrupt routine in registers.

Because of the limitation on the values that can be held in the I register, there are only a limited number of addresses that can be jumped to in the 16K Spectrum, and these are dictated by the contents of the ROM. An added problem when using ROM-vectored interrupts is caused by the Microdrive interface which changes the vector whenever it is paged in. A list of the vectors for the Issue 2 Spectrum and the Issue 1 Microdrive interface is given in Appendix F, but if you are unsure which issue you have, or you have a different issue, these *must* be checked. For commercial software, it is dangerous to use ROM vectors as any changes and future additions could make your software unusable.

Typical uses of interrupt routines are SPRITE control and CONTINUOUS SOUND within a program. Since it is known how often an interrupt will be generated, it is easy to calculate the speed of movement for a SPRITE and, since it will be independent of any other operation within the program, the speed will normally remain constant.

The use of ROM routines within an interrupt routine is complicated by the possibility of the interface ROM being switched in at the time of the interrupt, and this *must* be allowed for when the routine is written. For example, if a SPRITE routine relies on a 16K ROM call to plot the sprite to the screen by use of the PLOTting CALL at 8933 (22E5h) when the Interface ROM is paged in, the CALL will be to 8933 in the Interface ROM. This is an address that does not exist. This will inevitably cause the program to crash.

One way of solving the problem is to incorporate into the interrupt routine a check to see which ROM is present. The easiest way of checking is to look at a ROM address which contains a different value in each ROM. I tend to use address 20 (14h), which contains 213 (D5h) in the Interface ROM and 255 (FFh) in the 16K ROM. The appropriate action for each ROM can then be taken.

If the ROM call is to the 16K ROM, it can be called directly when the 16K ROM is present and via the RST 16 instruction when the 8K ROM is paged in. For the 8K ROM, this can be used with hook code 32h (details are given in Chapter 3).

I have given a simple SPRITE program in Appendix G. This program moves a group of four pixels, bouncing them off the four edges of the screen, emitting a sound and changing the border colour, demonstrating this way round the problem.

As a full understanding of how to use interrupts is so important, if any use at all is to be made of them, I suggest that you enter the program, using your assembler. The listing is taken direct from my assembler to ensure that there are no errors; it is slightly unusual in that *hex* numbers are prefixed by a # and *binary* numbers by a % in the source code. The routine can be relocated if a new vector is calculated and the I register is changed to suit. Once you have entered and assembled the program, *before* attempting to run it, turn back to this page and read on.

The first problem you may encounter is, if you have a 16K Spectrum, that the vector will have to be ROM-based. Unfortu-

nately at the time of writing this I have found no way that a 16K Spectrum with the Microdrive Interface can be used.

Before doing anything further save both the source and the object code to tape or Microdrive and, if you have a Microdrive, remove the cartridge. To initiate the SPRITE the routine labelled SETUP in the listing must be called. If the vector has not been changed, RANDOMIZE USR 51457. You should now be able to see a single black dot moving about the screen. Should it not be there check your code again. The presence of the SPRITE should have no effect on anything else the computer is doing, so a program can be entered and run as normal, as long as it does not encroach on the memory used by the interrupt routine.

Some of the BASIC instructions that act on the interrupts can now be demonstrated. Enter the BASIC line:

```
10 BEEP 5,60 : FOR N = 1 TO 100 : NEXT N: GOTO 10
```

When this is run you will see that the SPRITE stops while the BEEP is being executed. Other commands which disable the interrupts are those involved with SAVEing and LOADing.

The SPRITE will travel at the rate of 50 pixels per second in the UK (60 pixels per second in the USA), so in the UK it will take 3.5 seconds to travel from the bottom of the screen to the top.

Chapter Seven

Extending BASIC with Interface 1

With the addition of Interface 1, any BASIC instruction which fails the Sinclair syntax checking is normally vectored back to the error-handling routines, via the address held in the new system variable VECTOR. This can be changed to point to an address in RAM. This allows a program to be written which can check further, and act upon any instructions that it is programmed to deal with. Before any use can be made of this facility it is necessary to understand the method by which lines are checked, so that the extra routine can make the same checks.

As soon as ENTER is pressed after entering a BASIC line into the input buffer, the ROM interpreter is called into action. This RUNs the line, but stops short of actually doing the commands, because the syntax flag (bit 7 in FLAGS) is reset. If any error occurs, it is flagged with a '?', and the error must be corrected before the line can be inserted into a program.

The same process is carried out in run time but, since the syntax flag is set, the command is acted upon. Remember that whenever a routine in RAM is being used as part of the BASIC interpreter, the 8K ROM will be paged in.

There are routines in both the ROMs which check for the syntax flag and return to the calling routine only in run time. These are most useful when adding commands, as demonstrated by the routines at the end of this chapter. The basic (no pun intended) criteria for checking the syntax are given below, and ROM routines have been used as far as possible.

The address of the character at which the syntax failed, so far as the ROM is concerned, will be present in the system variable CH_ADD on arrival at the extended syntax checker in RAM. Because of this it is important to ensure that the first character of the added BASIC command fails normal syntax. If this was not

the case, the interpreter would start execution during run time, and it would be almost impossible to regain control. For this reason, it is simplest to use a non-alphabetic character to start the additional command, which gets the system out of the normal K or command mode, ensuring syntax failure. The '*' and '!' symbols are ideally suited to this.

The first thing that must be checked is the command characters. This is done by getting each character in turn and ensuring that it is the one expected. The 16K ROM routine at 24 (18h) will get the current character in the a register, and the routine at 32 (20h) will collect the next character and advance CH_ADD by one. Each character can then be checked and, if it is not correct, the error handler can be called in by jumping to the original VECTOR which was 496 (1F0h).

Then:

1) If there should be a numeric expression next, the 16K routine at 7298 (1C82h) can be used. This evaluates the next expression as numeric; if it is not an error will be caused. In run time it will also put the value onto the calculator stack.
2) If there should be two numeric expressions next separated by a comma, the 16K routine at 7290 (1C7Ah) can be used. This acts as above but stacks both numbers in run time.
3) If there should be a string expression next (either in quotes or a $) then the 16K routine at 7308 (1C8Ch) can be used. Again this acts as above, but generating an error if the expression is not a string, and in run time stacking the string parameters as described at the end of Chapter 8.

Note: In all three of the above routines, the first character of the expression to be evaluated must be in the A register, and CH_ADD must contain its address, before CALLing the routine. After the evaluation, the A register will contain the first character *after* the expression and CH_ADD its address. Mathematical operators *are* allowed as are the use of variables in the expressions evaluated, and this can be used to advantage to find details of variables. For example, the expression X$(1,4 TO 9) or A*(B + (C/(D + E))) *would* be allowed, the result being stacked in run time.

When evaluation is completed, a CALL 1463 (5B7h) will check that the current character is the end (a colon or carriage return code 13 (ODh)), and return to the interpreter in syntax time, or to your routine for execution in run time, if it is, and generate an error if not.

In run time, your routine will have to act upon the command, collecting information from the calculator stack as necessary, and then return to the interpreter via a JP 1473 (5C1h) instruction, with CH_ADD pointing to the next character for interpretation.

To demonstrate the addition of commands the following program adds !CALLnn and !FRE. !CALLnn will call a machine code routine at the address after the !CALL. !FRE will return the free memory.

```
!CALL   RST  16
        DEFW 24        ; get character
        CP   "!"       ; is it a !
        JR   NZ,ERROR  ; if not allow error
        CALL NEXT_CH   ; get next character
        CP   "C"       ; is it C
        JR   NZ,!FRE   ; if not, jump and see
                         if it's a !FRE
        CALL NEXT_CH
        CP   "A"       ; each character is
        JR   NZ,ERROR  ; checked, the error is
        CALL NEXT_CH   ; allowed to pass if
        CP   "L"       ; a match fails
        JR   NZ,ERROR
        CALL NEXT_CH
        CP   "L"
        JR   NZ,ERROR
        JR   ISCALL    ; to reach here the word
                         must match
!FRE    CP   "F"       ; same again for !FRE
        JR   NZ,ERROR ;
        CALL NEXT_CH
        CP   "R"
        JR   NZ,ERROR
        CALL NEXT_CH
        CP   "E"
        CALL NEXT_CH
        JR   Z,ISFRE   ; it is !FRE
ERROR   JP   496       ; the original 'VECTOR'
ISCALL  CALL NEXT_CH
        RST  16
```

```
        DEFW  7298     ; evaluates next basic
                         expression as numeric.
                         causes error if not.
                         In run time value is
                         put on calc. stack
        CALL  1463     ; checks for end of
                         basic statement.
                         and returns only in
        RST   16       ; run time
        DEFW  11682    ; stack to BC, see chap 8
        JR    C,ERROR  ; carry set if over 65535
        LD    (DEST),BC; the address to CALL
        RST   16
DEST    DEFS  2        ; and put it here
        JR    FINIS    ; 16K ROM will be present
                         when called routine is
                         executed
ISFRE   CALL  1463     ; exits in syntax time
        LD    HL,00    ; clear HL
        ADD   HL,SP    ; add the address in SP
        LD    DE,(23653);this is  STKEND
        SBC   HL,DE    ; sub from address in
        PUSH  HL         SP to give free space
                         for basic
        POP   BC       ; result now in BC
        RST   16
        DEFW  11563    ; stack BC, see chapt 8
        RST   16
        DEFW  11747    ; prints value on stack
FINIS   JP    1473     ; return to basic
NEXT_CH RST   16
        DEFW  32       ; ROM NEXT_CH routine
        AND   223      ; make it upper case
        RET
```


Normally extended BASIC commands or functions will be ended by a jump back to the main interpreter as above and it is most important that it is the 8K ROM which is switched when this jump is made, otherwise the program will crash.

Chapter Eight

The Calculator

The Spectrum contains a powerful calculator in the ROM which can be used to advantage by the machine code programmer. As it has 66 different routines, I shall be examining in detail only the more useful ones. To use the calculator it is important to understand the form in which the Spectrum handles numbers, how to place them so that the calculator can access them and how to retrieve the answer to the completed calculation.

All numbers being used by the calculator are stored as five bytes in either binary floating point representation or small integer representation.

Small Integer Representation

The first byte is always 0.
The second byte is the sign, 255 (FFh) for negative or 0 for positive.
The third and fourth bytes are the actual number in standard Z80 format, low byte first.
The final byte is always 0.
The number 0 is regarded as being positive.

Floating Point Representation

The first byte is the exponent: this is the number of times the binimal point has been moved to the left to make bit 7 set and to the right of the binimal point, and bit 7 of the exponent shows which way the binimal point has been moved. If it is set, the point has been moved to the left, as in the example below.

Take the number 126 decimal, 7Eh, which in binary is 01111110. The binimal point (were we to show it) would be on the right. It takes seven moves to the left to make the most significant set bit on the right of the binimal point. To follow the process:

0 moves 0 1 1 1 1 1 1 0
1 move 0 1 1 1 1 1 1.0
2 moves 0 1 1 1 1 1.1 0
3 moves 0 1 1 1 1.1 1 0
and so on until after
7 moves 0.1 1 1 1 1 1 0

Any bits left to the left of the binimal point will always be reset and so can be discarded, as can the binimal point since it is known where it is and it will always be there for any number. We normally do this ourselves with decimal numbers, albeit unknowingly, by not showing a decimal point to the right of an integer (a whole number) as everybody knows that that is where it would be.

This process gives us the part of the number known as the *mantissa* which, for the example given, is 11111100 in binary and the exponent (the number of times the binimal point has been moved to the left) is seven. The most significant bit of the mantissa will always be set so this bit can be used to show the sign of the number; it is set for a negative number and reset for a positive number.

The *exponent* is expressed in signed binary, bit 7 set if the binimal point has been moved to the left, and reset if it has been moved to the right. Thus, for the example above the mantissa was 7, binary 00000111, but the point was moved to the left so bit 7 must be set giving 10000111 or 135 decimal. Now the number can be shown in its full five-byte form:

	Exponent	Mantissa			
Binary	10000111	01111100	00000000	00000000	00000000
Decimal	135	124	0	0	0
Hex	87	7C	0	0	0

Normally the number given in the above example would have been stored in small integer representation, but it has been used for simplicity.

The calculator uses its own stack on which it keeps any numbers upon which it is working, and the first thing that must be done before any calculations can be performed, is to put the

numbers to be manipulated onto the calculator stack. This can be tackled in three basic ways:

1) A number can be placed on the stack from a register or register pair, using a ROM routine to convert it to the form that the calculator requires.
2) The number can be changed into the form that the calculator understands and then put onto the stack.
3) The number can be written to memory in ASCII representation and the BASIC syntax checker used to read it and place it onto the calculator stack in the correct form.

Each method has its own advantages and disadvantages and each lends itself to different types of numbers. I shall now consider their use in turn.

1) For small integers, there are two routines that can be used:

   CALL 11560 (2D28h)

   This is employed by putting the number to be transferred to the calculator stack into the A register. Obviously the range is limited to 0–255 (0–FFh) and the number must be positive.

   CALL 11563 (2D2Bh)

   This will accept numbers in the range 0–65535 (0–FFFFh) from the BC register pair. Again the number can only be positive, unless the start of the routine is bypassed. The CALL is then made to 11569 (2D31h) with the A register holding 0, and the E register set to 255 (FFh) and the number will be transferred to the calculator as negative.

2) For numbers in five-byte form ready for use by the calculator the following routine is used:

   CALL 10934 (2AB6h)

   The five-byte representation of the number as described above in **Floating Point Representation** must be in the registers A, E, D, C, B; the exponent in the A register and the mantissa in the other four registers in order.

3) ASCII representation

CALL 11419 (2C9Bh)

Whenever the BASIC interpreter comes across a number in a BASIC line being entered, it places the five-byte binary form of the number after the ASCII version, ready for use later when the program is being run. The routine used for this can be made to do the conversion for a machine code program written by the user. This saves all the problems of converting numbers manually or writing a routine to convert them in your program, and is well worthy of detailed consideration.

To use this routine to load the calculator stack the BASIC system variable CH_ADD 23645 (5C5Dh) must contain the address of the first character of the number to be stacked, and the A register must hold the code of the character pointed to by CH_ADD. The first character will normally be the most significant digit of a decimal number but, because the routine is that used for BASIC line scanning, it could be the BIN token 196 (C4h) if the following digits are a binary number. A binary number can only be evaluated to 16 digits, decimal 65535 (FFFFh). Any attempt to exceed this will result in a jump to the BASIC error-handling routine. E format can be used if it is so wished, and the number should be arranged exactly as it would be in a BASIC line.

After the characters comprising the number, and the exponent if used, a defined byte of value 13 (0Dh) should be added. This lets the routine know that it has reached the end of the number and that there is nothing else to look at.

There are two ROM routines the reverse of the two routines to Stack A and Stack BC. These take the last entry on the calculator stack and compress it into a rounded integer if possible. If the number was too large then the carry flag will be set on return, and if the number is negative the 0 flag is reset. For a positive number the 0 flag will be set. The number will be deleted from the stack by changing the pointer, but the DE register pair still points to it in memory allowing it to be reclaimed if recovery was not successful, although it is easier to duplicate the number before attempting recovery, and then delete the copy on a successful operation. The call addresses are:

STACK TO A: CALL 11733 (2DD5H)
STACK TO BC: CALL 11685 (2DA5H)

There is also a reverse to the routine in (2) above located at 11249 (2BF1h) which returns the last value on the stack to the same registers. This routine also deletes the number from the stack but since it cannot fail to recover a number, the flags are not set. A duplicate must be made on the stack if the number is still required to be on the stack after recovery.

STACK TO A, E, D, C, B: CALL 11249 (2BF1H)

When numbers are generated inside the program the routine to print a number from the stack can be used to 'print' the number to a space in memory — as opposed to printing it to the screen — in ASCII form. The maximum number of spare memory locations that will be needed for a single number is 14.

This is achieved by writing a subroutine which places the contents of the A register into the next memory location each time it is called, opening a channel which points to your own subroutine, and making this channel current by putting its base address in CUR_CHL 23633 (5C51h). The ROM routine at 11747 (2DE3h) can then be called to print the number. The subroutine will then be called with each character of the number in turn, which it places into successive memory locations, ready for use later. Remember that the indexing for the address in which the characters are being saved cannot be held in a register between calls to your subroutine, nor can it be saved on the machine stack, therefore two bytes of memory must be allowed for saving this address. A program to do this might look something like this:

```
SET_UP  LD   HL,SPACE
        LD   (SP_WD),HL
        LD   HL,(23633) ;CUR_CHL
        PUSH HL
        LD   DE,START ; make current channel to
        LD   C,(HL)   ; your subroutine and save
        LD   (HL),E   ; original address for
        INC  HL       ; later restoration
        LD   B,(HL)
        LD   (HL),D
        PUSH BC
```



```
        CALL 11747    ; the routine to print
                        numbers
        POP  BC       ; restore original address
        POP  HL       ; and current channel
        LD   (HL),C   ; restore channel
        INC  HL       ; destination
        LD   (HL),B
    ;REST OF PROGRAM GOES HERE
START   LD   HL,(SP_WD)
        LD   (HL),A
        INC  HL
        LD   (SP_WD),HL
        RET
SPACE   DEFS 16
SP_WD   DEFW SPACE
```

This is the routine used above and mentioned previously. When called it takes the top entry from the calculator stack and outputs it in ASCII, as a decimal number, to the current stream. The number is removed from the stack.

Whenever the calculator is used it is important to ensure that the calculator stack is kept balanced. The calculator itself always behaves in a predictable manner (when correctly used) and imbalances can lead to erroneous results. Room must also be left between RAMTOP and STKBOT for the calculator stack to expand upwards and the machine stack to grow downwards without their colliding.

Since some calculator routines use the calculator recursively, it will be necessary to leave more space than that which will apparently be used. It is best to err on the large side for the space allowed because of this fact. Should there be any doubt as to what is on the stack after completing a set of operations it can be cleared by a CALL 5823 (16BFh), but remember that this will delete *everything* that was on the stack.

Use of the Calculator

In order to understand how to operate the calculator, it may help to think of it as a separate processor, with its own instruction set, which is switched in by a RST 40 (28h) and switched out by an ENDCALC, op-code 56 (38h).

During the time that the calculator is switched on, its op-codes are taken from the memory following the RST 40. These are a series of DEFined Bytes in a normal Z80 program. When the calculator gets an ENDCALC instruction, control is returned to the Z80 and this continues execution of the program from the address following the ENDCALC. Some op-codes require operands, and some can be used only at the start of a series, since they require the Z80 registers to be set in a particular manner in order to operate.

Each time the stack is used its size changes by five bytes. Therefore, every time a number is placed on the stack a check is made to see that there is room. Should there be inadequate space a BASIC error will be caused.

The calculator is not limited to numeric operation, it is also used to perform the BASIC string and VAL functions. These will be discussed later.

The op-codes that the calculator understands are set out below with descriptions of their operation. In each case the change to the calculator stack is given in bytes — five bytes are used for each value — for the calculator's execution of a single op-code.

X is the value below Y on the calculator stack, Y being the last value put onto the calculator stack. The result of a calculation is always left on the top of the calculator stack, and this result is represented by Z. For example, for the subtract op-code (03) if X = 5 and Y = 9, X would be placed onto the calculator stack followed by Y, the RST 40 (28h) would be followed by a defined byte 03. After the operation, the calculator stack is −5, the answer is on the top as Z. Therefore both X and Y have been deleted.

Jumps are made from the location of the distance operand, the standard Z80 manner.

Op-code Function Operation

00 JUMP TRUE — Jumps the distance (2s complement notation) in the operand (the defined byte after the 00 op-code) if Y is non-zero. (STACK CH. −5)

01 EXCHANGE — Reverses the order of X and Y on the stack (STACK CH. 0)

02 DELETE — Removes Y from the stack. Z = X (STACK CH. −5)

03 SUBTRACT — X − Y = Z (STACK CH. −5)

04 MULTIPLY — X * Y = Z (STACK CH. −5)

05 DIVIDE — X / Y = Z (STACK CH. −5)

06 TO POWER — X ^ Y = Z (STACK CH. −5)

07 BINARY OR — X OR Y. If = 0 then Z = X, otherwise Z = 1 (STACK CH. −5)

08 BINARY AND — X AND Y. Both X and Y must be numbers. If Y = 0 then Z = 0, otherwise Z = X. There is a separate op-code to deal with strings 16 (10h) (STACK CH. −5)

The sequence of op-codes from 09 to 14 (0Eh) deals with numeric values. Each code can be used only as the first operation after the rst 40 (28h) as the b register must contain the op-code at the moment the actual operation is performed.

There is a second set of op-codes for string comparisons; all return Z = 1 if true or Z = 0 if false (STACK CH. −5).

09 Y <= X — 10 (0Ah) Y >= X — 11 (0Bh) Y <> X
12 (0Ch) Y > X — 13 (0Dh) Y < X — 14 (0Eh) Y = X

15 (0FH) ADDITION — X + Y = Z (STACK CH. −5)

In the following sequence of op-codes, one or both of the X and Y values must hold the parameters of a string. Details of how to get these parameters and put them on the calculator stack are given later. The part or parts that are string parameters are shown with a $ symbol.

Op-code Function Operation

16 (10h) $ AND No. — X$ and Y. If Y = then Z$ will be an empty string, otherwise Z$ = X$ (STACK CH. −5)

The op-codes 17–22 (11h–16h) are the string equivalents of op-codes 09–14 (0Eh), called with the B register holding the op-code. Again Z = 1 if true or Z = 0 if false. (STACK CH −5)

17 (11h) Y$ <= X$ 18 (12h) Y$ >= X$ 19 (13h) Y$ <> X$
20 (14h) Y$ > X$ 21 (15h) Y$ < X$ 22 (16h) Y$ = X$

23 (17h) ADDITION — X$ + Y$ = Z$. The two $trings are concatenated in workspace and the new parameters are returned in Z$. Remember that if there is inadequate room for the two strings to be copied into an expanded workspace a BASIC error will be caused (STACK CH. −5).

24 (18h) VAL$ — VAL$ Y$ = Z$. The new string is created in workspace in the same manner as above. The op-code must also be contained in the B register at the time of use. Any errors will cause a BASIC error. This is the routine used by the BASIC interpreter and is subject to all the syntax checking procedure (STACK CH. 0)

25 (19h) USR$ — Z = USR$. Again used by the BASIC interpreter and subject to syntax checking. Y$ must contain the parameters of a $tring containing a single letter from A to U. Z will be the address of that user-defined graphic on completion (STACK CH. 0)

26 (1Ah) READ IN — This routine allows a single byte to be put into WORKSPACE through any stream 0–15 (0Fh), taken from Y. The byte is regarded as a string and Z$ is the parameters of this string. If the carry flag is not set by the input routine, no action is taken and Z$ is returned as a null string

27 (1Bh) NEGATE — Z = Y but with the sign changed (STACK CH. 0)

28 (1Ch) CODE — Z = CODE Y$. As used by the BASIC interpreter (STACK CH. 0)

29 (1Dh) VAL — Z = VAL Y$. As used by the BASIC interpreter and in fact accesses the line scanner to get the result into Z. Subject to BASIC errors. (STACK CH. 0)

30 (1Eh) LEN — Z = LEN Y$. This is easier to do without using the calculator, all it does is stack the length bytes of the string parameters (STACK CH. 0)

The following algebraic functions all return the answer (Z) on the top of the calculator stack and the stack size is unchanged.

Op-code	*Operation*
31 (1Fh)	Z = SIN Y
32 (20h)	Z = COS Y
33 (21h)	Z = TAN Y
34 (22h)	Z = ASN Y
35 (23h)	Z = ACS Y
36 (24h)	Z = ATN Y
37 (25h)	Z = LN Y
38 (26h)	Z = EXP Y
39 (27h)	Z = INT Y
40 (28h)	Z = SQR Y
41 (29h)	Z = SGN Y
42 (2Ah)	Z = ABS Y

43 (2Bh) PEEK — Z = PEEK Y. As used by the BASIC interpreter (STACK CH. 0)

44 (2Ch) IN — Z = IN Y. This performs the Z80 IN A,(C) instruction after taking Y from the stack into the BC register pair as an integer (STACK CH. 0)

45 (2Dh) USR No. — *Caution* This will cause an execution jump to the address Y. Used by BASIC to jump to machine code. The return address will be 11563 (2D2Bh), the stack BC routines

which will put the value in the BC register on return on the calculator stack. This is an interesting op-code since it opens up the possibility of using routines in ROM and RAM recursively from within the calculator (STACK CH. 0)

46 (2Eh) STR$ Z$ = Y. The top value on the calculator stack is printed to WORKSPACE and evaluated as a string, the parameters of which are then put on the calculator stack (STACK CH. 0)

47 (2Fh) CHR$ Z$ = CHR$ Y. If 0 < Y < 255 then a single space is made in WORKSPACE and the value transferred there as one byte. This is then interpreted as a string and the parameters returned as Z$ (STACK CH. 0)

48 (30h) NOT Z = 1 if Y = 0, otherwise Z = 0 (STACK CH. 0)

49 (31h) DUPLICATE Z = Y. Y is duplicated (STACK CH. +5)

50 (32h) X MOD Y This returns Z = INT (X/Y) and underneath Z (where X was originally) X − INT (X/Y) (STACK CH. 0)

51 (33h) JUMP This simply does the equivalent of a Z80 JR (Jump Relative) instruction, but for the calculator. The jump length is taken from the location following the op-code. The calculator stack is untouched (STACK CH. 0)

52 (34h) STK DATA This allows a value to be read in from the locations following the op-code. Bits 6 and 7 of the first byte (the exponent) following the op-code determines the number of bytes which follow to make the mantissa, 00 BIN for 1 to 11 BIN for 4. The floating point number is then read to the calculator stack (STACK CH. +5)

53 (35h) DEC JR NZ This is a direct equivalent to the Z80 DJNZ op-code, but for the calculator. The B register is taken as being BREG system variable. *Not safe to use*, since this routine is extensively used within the calculator for its own purposes, and the value of BREG cannot be guaranteed (STACK CH. 0)

54 (36h) Y < 0 Z = 1 if Y < 0, otherwise Z = 0 (STACK CH. 0)

55 (37h) Y > 0 Z = 1 if Y > 0, otherwise Z = 0 (STACK CH. 0)

56 (38h) ENDCALC Returns control to the Z80 at the next address (STACK CH. 0)

57 (39h) GET ARGT Used internally to the calculator to establish the value Y (which for the purposes of Z being the result will be Z) of SIN Y or COS Y (STACK CH. 0)

58 (3Ah) TRUNCATE Z = INT Y, where Z is Y truncated towards 0 (STACK CH. 0)

59 (3Bh) FP CALC 2 Used by the interpreter to perform a single calculator operation. Of no practical use for the purposes of this book

60 (3CH) E TO F.P. Z = Y E (Exponent) A register (STACK CH. 0)

61 (3Dh) RE STACK Z = the floating point version of Y, where Y could have been a small integer (STACK CH. 0)

62 (3Eh) SERIES Used internally to the calculator to generate a Chebyshev polynomial. Of no practical use as it is called by the routines that need it

63	(3Fh)	STACK NO.	As above, but used to stack constants
64	(40h)	ST MEM.	Used to store in the memory area. On entry the A register must hold C0 to C5 according to which of the five memory locations is to be used (STACK CH. −5)
65	(41h)	REC MEM.	Recall from memory. The reverse of the above routine (STACK CH. +5)

For string operations the parameters can be passed to the calculator stack using the routine at 10934 (2AB6h) mentioned earlier. The BC register pair holds the length of the string, the DE register pair the start address and the A register the name (in the form mentioned in chapter 2 under SAVEing LOADing and VERIFYing.

To assist with the understanding of the calculator a routine that will allow experimentation with the calculator is given in the **Useful Subroutines** appendix.

Appendix A

Hex to Decimal Conversions

MSB

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0	256	512	768	1024	1280	1536	1792	2048	2304	2560	2816	3072	3328	3584	3840
1	4096	4352	4608	4864	5120	5376	5632	5888	6144	6400	6656	6912	7168	7424	7680	7936
2	8192	8448	8704	8960	9216	9472	9728	9984	10240	10496	10752	11008	11264	11520	11776	12032
3	12288	12544	12800	13056	13312	13568	13824	14080	14336	14592	14848	15104	15360	15616	15872	16128
4	16384	16640	16896	17152	17408	17664	17920	18176	18432	18688	18944	19200	19456	19712	19968	20224
5	20480	20736	20992	21248	21504	21760	22016	22272	22528	22784	23040	23296	23552	23808	24064	24320
6	24576	24832	25088	25344	25600	25856	26112	26368	26624	26880	27136	27392	27648	27904	28160	28416
7	28672	28928	29184	29440	29696	29952	30208	30464	30720	30976	31232	31488	31744	32000	32256	32512
8	32768	33024	33280	33536	33792	34048	34304	34560	34816	35072	35328	35584	35840	36096	36352	36608
9	36864	37120	37376	37632	37888	38144	38400	38656	38912	39168	39424	39680	39936	40192	40448	40704
A	40960	41216	41472	41728	41984	42240	42496	42752	43008	43264	43520	43776	44032	44288	44544	44800
B	45056	45312	45568	45824	46080	46336	46592	46848	47104	47360	47616	47872	48128	48384	48640	48896
C	49152	49408	49664	49920	50176	50432	50688	50944	51200	51456	51712	51968	52224	52480	52736	52992
D	53248	53504	53760	54016	54272	54528	54784	55040	55296	55552	55808	56064	56320	56576	56832	57088
E	57344	57600	57856	58112	58368	58624	58880	59136	59392	59648	59904	60160	60416	60672	60928	61184
F	61440	61696	61952	62208	62464	62720	62976	63232	63488	63744	64000	64256	64512	64768	65024	65280

LSB

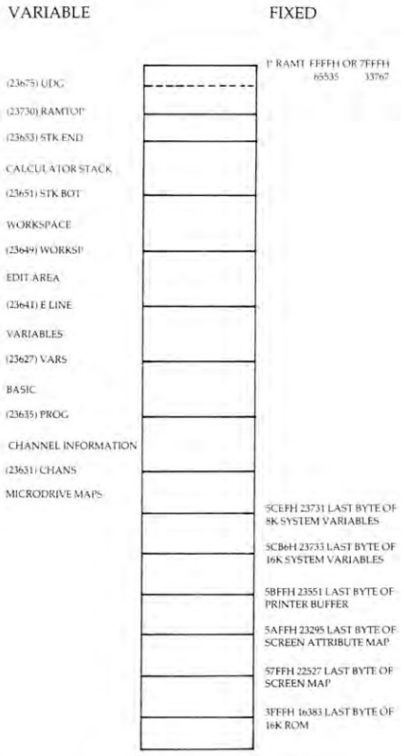
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
3	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
4	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
5	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
6	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
7	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
8	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
9	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
A	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
B	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
C	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
D	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
E	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
F	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

NIBBLES

HEX	DEC	BIN	HEX	DEC	BIN
0	0	0000	8	8	1000
1	1	0001	9	9	1001
2	2	0010	A	10	1010
3	3	0011	B	11	1011
4	4	0100	C	12	1100
5	5	0101	D	13	1101
6	6	0110	E	14	1110
7	7	0111	F	15	1111

Appendix B

The Spectrum Memory Map



Appendix C

The Spectrum Screen Map

The Spectrum screen is divided into 192 rows of 256 pixels. Each line comprises 32 bytes of memory in ascending order. Below are listed the addresses of the first byte of each screen line with the address of the attribute that controls the first byte. Line 1 represents the top line on the screen.

LINE	PIXEL	ATTRIBUTE
1	4000H	5800H
2	4100H	
3	4200H	
4	4300H	
5	4400H	
6	4500H	
7	4600H	
8	4700H	
9	4020H	5820H
10	4120H	
11	4220H	
12	4320H	
13	4420H	
14	4520H	
15	4620H	
16	4720H	
17	4040H	5840H
18	4140H	
19	4240H	
20	4340H	
21	4440H	
22	4540H	
23	4640H	
24	4740H	
25	4060H	5860H
26	4160H	
27	4260H	
28	4360H	
29	4460H	
30	4560H	
31	4660H	
32	4760H	
33	4080H	5880H
34	4180H	
35	4280H	
36	4380H	
37	4480H	
38	4580H	
39	4680H	
40	4780H	
41	40A0H	58A0H
42	41A0H	
43	42A0H	
44	43A0H	
45	44A0H	
46	45A0H	
47	46A0H	
48	47A0H	
49	40C0H	58C0H
50	41C0H	
51	42C0H	
52	43C0H	
53	44C0H	
54	45C0H	
55	46C0H	
56	47C0H	
57	40E0H	58E0H
58	41E0H	
59	42E0H	
60	43E0H	
61	44E0H	
62	45E0H	
63	46E0H	
64	47E0H	
65	4800H	5900H
66	4900H	
67	4A00H	
68	4B00H	
69	4C00H	
70	4D00H	
71	4E00H	
72	4F00H	
73	4820H	5920H
74	4920H	
75	4A20H	
76	4B20H	
77	4C20H	
78	4D20H	
79	4E20H	
80	4F20H	

81	4840H	5940H	137	5020H	5A20H
82	4940H		138	5120H	
83	4A40H		139	5220H	
84	4B40H		140	5320H	
85	4C40H		141	5420H	
86	4D40H		142	5520H	
87	4E40H		143	5620H	
88	4F40H		144	5720H	
89	4860H	5960H	145	5040H	5A40H
90	4960H		146	5140H	
91	4A60H		147	5240H	
92	4B60H		148	5340H	
93	4C60H		149	5440H	
94	4D60H		150	5540H	
95	4E60H		151	5640H	
96	4F60H		152	5740H	
97	4880H	5980H	153	5060H	5A60H
98	4980H		154	5160H	
99	4A80H		155	5260H	
100	4B80H		156	5360H	
101	4C80H		157	5460H	
102	4D80H		158	5560H	
103	4E80H		159	5660H	
104	4F80H		160	5760H	
105	48A0H	59A0H	161	5080H	5A80H
106	49A0H		162	5180H	
107	4AA0H		163	5280H	
108	4BA0H		164	5380H	
109	4CA0H		165	5480H	
110	4DA0H		166	5580H	
111	4EA0H		167	5680H	
112	4FA0H		168	5780H	
113	48C0H	59C0H	169	50A0H	5AA0H
114	49C0H		170	51A0H	
115	4AC0H		171	52A0H	
116	4BC0H		172	53A0H	
117	4CC0H		173	54A0H	
118	4DC0H		174	55A0H	
119	4EC0H		175	56A0H	
120	4FC0H		176	57A0H	
121	48E0H	59E0H	177	50C0H	5AC0H
122	49E0H		178	51C0H	
123	4AE0H		179	52C0H	
124	4BE0H		180	53C0H	
125	4CE0H		181	54C0H	
126	4DE0H		182	55C0H	
127	4EE0H		183	56C0H	
128	4FE0H		184	57C0H	
129	5000H	5A00H	185	50E0H	5AE0H
130	5100H		186	51E0H	
131	5200H		187	52E0H	
132	5300H		188	53E0H	
133	5400H		189	54E0H	
134	5500H		190	55E0H	
135	5600H		191	56E0H	
136	5700H		192	57E0H	

Appendix D

The Keyboard Map

	D4	D3	D2	D1	D0
254 (FEH)	V	C	X	Z	C/S
253 (FDH)	G	F	D	S	A
251 (FBH)	T	R	E	W	Q
247 (F7H)	5	4	3	2	1
239 (EFH)	6	7	8	9	0
223 (DFH)	Y	U	I	O	P
191 (BFH)	H	J	K	L	ENT
127 (7FH)	B	N	M	S/S	B/S

Appendix E

The Spectrum Character Set

Code	*Character*	*Special Notes*
0&1	None	Used only after INK, PAPER, OVER, INVERSE, FLASH, BRIGHT AT or TAB
2–5	None	Used only after INK, PAPER, AT or TAB
6		Does a TAB on the screen to the next half screen position.
7	EDIT	Code returned by the keyboard input routine is used if CAPS SHIFT and 1 are pressed. Not printable. Often the BELL code on printers and terminals
8	BACKSPACE	Code returned by the keyboard input routine if CAPS SHIFT and '5' are pressed. Can be printed to give a backspace on the screen. Also recognised by most printers, as it is the ASCII backspace code
9	RIGHTSPACE	Code returned by the keyboard input routine if CAPS SHIFT and '8' are pressed. Not usable to give a screen rightspace as the Spectrum does not update the print positions after its use. ASCII horizontal TAB code
10	DOWNSPACE	As above but for CAPS SHIFT and '6'. Is the ASCII code for line feed
11	UPSPACE	As above for CAPS SHIFT and '7'. ASCII vertical TAB code

12	DELETE	As above for CAPS SHIFT and '0'. ASCII Form Feed code
13	ENTER	Returned when the ENTER key is pressed, performs a carriage return and line feed when printed to the screen. Is also the ASCII code for carriage return
14		Precedes a number in a BASIC program line. Not of any practical use. ASCII Shift Out code
15		Not used in the Spectrum. ASCII Shift In code
16		Ink control code used to precede the number for the INK colour. For example to change the on-screen printing colour for all following characters to red, you would use the RST 16 routine with the A register holding 16 followed by 2. Note *NOT* ASCII 2 but value 2. This is demonstrated in the DeBASE program.
17		As above but for PAPER
18		As above for FLASH, the following code can be only 0 or 1
19		As above for BRIGHT
20		As above for INVERSE
21		As above for OVER
22		AT control code, must be followed by the line and column values
23		As above but TAB, needing only the column value

Codes 24 to 31 are not used by the Spectrum; code 27 however is the escape code which is used by most peripherals, followed by a letter to indicate the action required. While the CHR$ 27 *has* been standardised as the escape code, the codes that follow it have *not* been standardised.

The remaining codes are all character representations, with codes 32 to 126 conforming to standard ASCII and these are shown in the Spectrum manual.

Code 127 — the Spectrum copyright symbol — is the ASCII delete code, *be careful*!!

Appendix F

ROM Interrupt Vectors

	16K ROM Mk 2 Spectrum	8K ROM Mk 1 Interface
I = 0	20430	23755
I = 1	52818	8501
I = 2	22269	25888
I = 3	39026	4196
I = 4	10419	52486
I = 5	2294	6701
I = 6	29149	51711
I = 7	16039	32459
I = 8	2088	14353
I = 9	65129	58170
I = 10	32802	1200
I = 11	58888	2039
I = 12	53183	59861
I = 13	52503	8205
I = 14	14367	49921
I = 15	27928	58884
I = 16	51984	32742
I = 17	8729	32477
I = 18	52481	4831
I = 19	49749	21965
I = 20	25705	56790
I = 21	51673	45182
I = 22	51568	65535
I = 23	12493	57851
I = 24	15582	61947
I = 25	23842	60952
I = 26	13824	52189
I = 27	7306	16129
I = 28	49947	6400
I = 29	2344	4870
I = 30	26573	65535
I = 31	3360	57855
I = 32	52513	23755
I = 33	33485	8501
I = 34	544	25888
I = 35	49537	4196
I = 36	8527	52486
I = 37	23670	6701
I = 38	20444	51711
I = 39	288	32459
I = 40	32348	14353
I = 41	58154	58170
I = 42	19754	1200
I = 43	23653	2039
I = 44	7117	59861
I = 45	55781	8205
I = 46	23713	49921
I = 47	4569	58884
I = 48	60208	32742
I = 49	57640	32477
I = 50	13627	4831

	16K ROM Mk 2 Spectrum	8K ROM Mk 1 Interface
I = 51	13256	21965
I = 52	1560	56790
I = 53	57124	45182
I = 54	34307	65535
I = 55	41231	57851
I = 56	65535	61947
I = 57	65535	60952
I = 58	65535	52189
I = 59	65535	16129
I = 60	255	6400
I = 61	0	4870
I = 62	255	65535
I = 63	60	255

Appendix G

Useful Subroutines

Calculator Routines

To assist with the understanding and use of the calculator the following routines will allow experimentation with the calculator. The first routine is for demonstration purposes.

```
EXX                 ; YOU MUST ALWAYS SAVE
                      H'L'
PUSH HL             ; IF A SUCCESSFUL RETURN IS
                      TO
EXX                 ; BE MADE
CALL PRSTK          ; PRINT STACK START AND
                      END
LD   BC,X           ; FIRST NUMBER
PUSH BC             ; SAVE IT
CALL 2D2BH          ; STACK X
POP  BC             ; RESTORE X
CALL 2D2BH          ; STACK X AGAIN
CALL 2DE3H          ; PRINT X
LD   A,20H
RST  10H            ; PRINT A SPACE
LD   HL, NUMBER     ; BASE ADDRESS OF THE
                      NUMBER IN ASCII FORM
CALL STKNUM         ; STACK NUMBER (THIS WILL
                      BE Y)
RST  28H            ; CALL THE CALCULATOR
DEFB 31H            ; DUPLICATE Y
DEFB 38H            ; TURN OFF THE
                      CALCULATOR
CALL 2DE3H          ; PRINT Y
RST  28H            ; TURN ON CALCULATOR
```



```
YOU CAN PUT A SERIES OF DEFINED BYTES HERE TO
EXPERIMENT WITH THE CALCULATOR
DEFB 38H            ; END CALC
CALL 2DE3H          ; PRINT RESULT
CALL PRSTK          ; PRINT STKBOT AND STKEND
                      TO SEE IF THE STACK WAS
                      BALANCED
EXX                 ; RESTORE H'L'
POP  HL
EXX
RET
NUMBER
DEFM "1234.567"
DEFB 13             ; THERE MUST ALWAYS BE A
                      DEFB 13 TO LET THE
                      ROUTINE KNOW THAT IT
                      HAS FINISHED THE NUMBER
```

This subroutine will print the address of the start and end of the calculator stack:

```
PRSTK   LD   BC, (23651) ; THIS IS STKBOT
        CALL 2D2BH       ; STACK IT
        LD   A, "B"
        RST  10H
        LD   A, " "
        RST  10H
        CALL 2DE3H       ; PRINT STKBOT
        LD   A, " "  ;
        RST  10H
        LD   A, "T"
        RST  10H
        LD   A, " "
        RST  10H
        LD   BC, (23653) ; THIS IS STKEND
        CALL 2D2BH
        CALL 2DE3H       ; PRINT STKEND
        LD   A,0DH
        RST  10H
        RET
```

This routine will stack a number in ASCII form.

ON ENTRY THE HL REGISTER PAIR MUST CONTAIN THE ADDRESS OF THE START OF THE NUMBER TO BE STACKED

```
STKNUM  LD      DE, (23645)   ; THIS IS CH_ADD
        PUSH    DE            ; SAVE IT
        LD      (23645), HL   ; POINT CH_ADD TO THE
                              START OF THE NUMBER
        LD      A, (HL)       ; PUT THE FIRST
                              CHARACTER IN A
        CALL    2C9BH         ; STACK THE NUMBER
        POP     DE            ; RESTORE CH_ADD TO
                              ITS ORIGINAL
        LD      (23645),DE    ; VALUE
        RET
```

Morex and Kempston Interface Drivers

On entry to these subroutines the ASCII code to be output to the Centronics lines should be in the A register. No expansion will be made; see the section in Chapter 2 on EXPANDING TOKENS FOR OUTPUT if it is required.

This is the Morex Interface Centronics Output Routine:

```
        PUSH    AF            ; SAVE CHARACTER
                              CODE
BUSY    IN      A, (0FBH)     ; READ BUSY LINE FROM
                              PRINTER
        AND     1             ; TEST BIT 0
        JR      NZ, BUSY      ; IF NOT LOW PRINTER
                              BUSY
        POP     AF            ; RESTORE CHARACTER
        OUT     (0FBH), A     ; SEND IT
        LD      A, 1          ; STROBE PRINTER
        OUT     (7FH), A
        XOR     A
        OUT     (7FH), A
        RET                   ; FINISHED
```


This is the Kempston Interface Centronics Output Routine:

```
        PUSH    BC            ; SAVE BC REGISTER PAIR
                              AS THEY ARE USED FOR
                              I/O
        PUSH    AF            ; SAVE CHARACTER
                              CODE
        LD      BC, 0E2BFH    ; BUSY PORT
BUSY    IN      A, (C)        ; READ BUSY LINE
        RRA                   ; BIT 0 TO CARRY
        JR      C, BUSY       ; IF NOT LOW PRINTER
                              BUSY
        POP     AF            ; RESTORE CHARACTER
        DEC     B             ; CHANGE PORT TO 02BFH
        DEC     B
        OUT     (C), A        ; SEND CHARACTER
        LD      A, 00EH       ; STROBE DATA FOR
                              SENDING
        LD      B,0E3H        ; CHANGE PORT TO
                              E3BFH, STROBE PORT
        OUT     (C), A        ; STROBE PRINTER
        INC     A
        OUT     (C), A
        POP     BC            ; RESTORE BC REGISTER
                              PAIR
        RET                   ; FINISHED
```

Interrupt Driven Sprite Routine

```
Pass 1 errors: 00
              10 ;   DEMONSTRATION PROGRAM FOR SPRITES
              20 ;   SEE CHAPTER 6
              30
CBFF          40       ORG  51455
CBFF          50       ENT  51455
              60
```

```
                 70 ;  51455 CONTAINS THE INTERRUPT VECTOR
                 80 ;
CBFF 2CC9        90         DEFW 51500
                100 ;
C901 3EC8       110 SETUP  LD   A,200
C903 ED47       120        LD   I,A
C905 ED4BB3C9   130        LD   BC,(COORD)
C909 CD87C9     140        CALL PLOT
C90C ED5E       150        IM   2
C90E C9         160        RET
                170
                180 ;THIS IS THE ACTUAL PROGRAM, STARTING AT THE ADDRESS
                190 ; WHERE THE INTERRUPT HAS BEEN VECTORED
                200
C92C            210        ORG  51500
                220 ;
                230 ; FIRST SAVE ALL REGISTERS THAT WILL BE USED
                240 ;
C92C E5         250        PUSH HL
C92D C5         260        PUSH BC
C92E D5         270        PUSH DE
C92F F5         280        PUSH AF
                290
                300 ; SAVE TV FLAG AS IT MAY BE ALTERED LATER
                310 ;
C930 3A3C5C     320        LD   A,(23612)
C933 F5         330        PUSH AF
                340
                350 ; AND SAVE CO_ORDS AS THEY WILL BE CHANGED AND THEY MUST BE
                360 ; RESTORED BEFORE RETURNING
                370 ;
C934 2A7D5C     380        LD   HL,(23677)
C937 E5         390        PUSH HL
C938 ED4BB3C9   400        LD   BC,(COORD) :   (THE SPRITE CO-ORDINATES)
C93C C5         410        PUSH BC :           SAVE THEM
                420 ;    CALL THE ROUTINE TO PLOT THE SPRITE
                430 ;    AS EACH PLOT OF THE SPRITE IS OVER 1 THIS WILL ERASE
                440 ;    THE PREVIOUS POSITION
C93D CD87C9     450        CALL PLOT
C940 C1         460        POP  BC:            RESTORE THE SPRITE COORDS
                470 ;
                480 ;L   IS USED AS A FLAG REGISTER
                490 ;TO  TELL THE SPRITE WHICH WAY IT MUST MOVE
                500 ;BIT 0 IS SET FOR UP, RESET FOR DOWN
                510 ;BIT 1 IS SET FOR LEFT AND RESET FOR RIGHT
                520 ;
C941 2AB5C9     540        LD   HL,(FLAG)
C944 CB45       550        BIT  0,L
C946 2807       560        JR   Z,UP
C948 05         570 DOWN   DEC  B:             MOVE SPRITE DOWN 1 PIXEL
C949 200C       580        JR   NZ,LEFT:       IF ZERO FLAG SET IT HAS REACHED THE
C94B CB85       590        RES  0,L:           BOTTOM OF THE SCREEN AND ITS
C94D 1808       600        JR   LEFT :         DIRECTION IS CHANGED
C94F 04         610 UP     INC  B:             UP ONE PIXEL
C950 78         620        LD   A,B:           HAS SPRITE REACHED TOP ?
C951 FEAE       630        CP   174
C953 2002       640        JR   NZ,LEFT
C955 CBC5       650        SET  0,L:           IT HAS SO CHANGE DIRECTION
C957 CB4D       660 LEFT   BIT  1,L:           SAME CHECKS AGAIN FOR LEFT/RIGHT
C959 2807       670        JR   Z,RIGHT
C95B 0D         680        DEC  C
C95C 200C       690        JR   NZ,CPLOT
C95E CB8D       700        RES  1,L
C960 1808       710        JR   CPLOT
C962 0C         720 RIGHT  INC  C
C963 79         730        LD   A,C
C964 FEFE       740        CP   254
C966 2002       750        JR   NZ,CPLOT
C968 CBCD       760        SET  1,L
```



```
                770
                780 ; THE NEW CO-ORDINATES FOR THE SPRITE ARE SAVED
                790 ;
C96A ED4383C9   800 CPLOT  LD   (COORD),BC :  AND SO ARE THE FLAGS
C96E 22B5C9     810        LD   (FLAG),HL
                820
C971 CD87C9     830        CALL PLOT :         PLOT THE NEW SPRITE POSITION
                840 ;
                850 ;
                860 ;ALL THE PLOTTING IS DONE SO THE SYSTEMS VARIABLES
                870 ;ARE NOW RESTORED TO THEIR ORIGINAL STATE
                880 ;
                890 ;
C974 E1         900 NRET   POP  HL
C975 227D5C     910        LD   (23677),HL
C978 F1         920        POP  AF
C979 323C5C     930        LD   (23612),A
                940
                950 ;THE REGISTERS ARE NOW RESTORED
C97C F1         960        POP  AF
C97D D1         970        POP  DE
C97E C1         980        POP  BC
C97F E1         990        POP  HL
                1000
                1010 ;AND THE KEYBOARD SCANNED AS IT HAS NOT BEEN
                1020 ;BECAUSE THE INTERRUPT WAS RELOCATED
                1030 ;
C980 FF         1040       RST  #38
C981 ED4D       1050       RETI
C983 0000       1060 COORD DEFW 0
C985 0000       1070 FLAG  DEFW 0
                1080 ;
                1090 ; D IS GOING TO BE USED AS A COUNTER, AS B IS IN USE
                1100 ;
                1110 ;
C987 1604       1120 PLOT  LD   D,4
                1130 ;
                1140 ;
                1150 ; SAVE THE CO-ORDINATES AS THEY ARE CORRUPTED BY THE R.O.M.
                1160 ;ROUTINES
                1170 ;
                1180 ;
C989 C5         1190       PUSH BC
C98A 7A         1200 LOOP  LD   A,D
C98B D5         1210       PUSH DE :          SAVE THE COUNTER
                1220
                1230 ;THE ACTUAL PLOT IS MADE FOUR TIMES, MOVING EACH TIME
                1240 ;TO CREATE A LARGER SPRITE
C98C FE04       1250       CP   4
C98E 280F       1260       JR   Z,LOOP4
C990 FE02       1270       CP   2
C992 2001       1280       JR   NZ,LOOP1
C994 0C         1290       INC  C
C995 FE02       1300 LOOP1 CP   2
C997 2001       1310       JR   NZ,LOOP2
C999 04         1320       INC  B
C99A FE01       1330 LOOP2 CP   1
C99C 2001       1340       JR   NZ,LOOP4
C99E 0D         1350       DEC  C
                1360
                1370 ; A TEST MUST NOW BE MADE TO SEE WHICH R.O.M. IS PRESENT
                1380 ;
C99F 3A1400     1390 LOOP4 LD   A,(#14):       PICK A R.O.M. LOCATION THAT IS
                1400
                1410 ;                         DIFFERENT IN EACH R.O.M.
C9A2 FDCB0286   1420       RES  0,(IY+2) :     SIGNAL COLOURS TO BE FROM MAIN SCREEN
C9A6 C5         1430       PUSH BC
C9A7 FED5       1440       CP   #D5:
C9A9 280C       1450       JR   Z,ROM2:        R.O.M. 2 IS PAGED IN SO DONT CALL THE
                1460 ;                         MAIN R.O.M. ROUTINE DIRECT
```

```
                1470
                1480 ; TO GET HERE THE MAIN R.O.M. MUST BE PAGED IN
                1490 ;SO DIRECT CALL O.K.
                1500
C9AB CD4D0D     1510        CALL #D4D ;         COLLECT THE COLOURS FOR THE PLOT
C9AE FDCB57C6   1520        SET  0,(IY+87) ;    SET OVER 1 WITH P FLAG
C9B2 CDE522     1530        CALL 8933:          DO THE PLOT
C9B5 1808       1540        JR   CONT1:         JUMP THE INDIRECT BY TO 1st CALLS
                1550
                1560 ; THE INTERFACE R.O.M. IS PAGED IN IF THIS IS REACHED
C9B7 D7         1570 ROM2   RST  16:            THE 16 K ROUTINES MUST BE
C9B8 4D0D       1580        DEFW #D4D ;         CALLED INDIRECTLY
C9BA FDCB57C6   1590        SET  0,(IY+87)
C9BE D7         1600        RST  16
C9BF FDCB5786   1610 CONT1  RES  0,(IY+87);     RESET OVER 1
C9C2 C1         1620        POP  BC ;           RESTORE LATEST PLOT POSITION
C9C4 D1         1630        POP  DE ;           AND THE COUNTER
C9C5 15         1640        DEC  D
C9C6 20C2       1650        JR   NZ,LOOP
                1660
C9C8 C1         1670        POP  BC ;           RESTORE STARTING PLOT POSITION
C9C9 7B         1680        LD   A,B ;          AND SEE IF AN EDGE HAS BEEN
C9CA A7         1690        AND  A ;            REACHED
C9CB 280D       1700        JR   Z,PING ;       AND IF SO TAKE THE NECESSARY
C9CD FEAE       1710        CP   174 ;          ACTION
C9CF 2809       1720        JR   Z,PING
C9D1 79         1730        LD   A,C
C9D2 A7         1740        AND  A
C9D3 2805       1750        JR   Z,PING
C9D5 FEFE       1760        CP   254
C9D7 2801       1770        JR   Z,PING
C9D9 C9         1780        RET  ;              OTHERWISE RETURN
                1790
C9DA C5         1800 PING   PUSH BC ;           SAVE THE PLOT CO-ORDINATES
C9DB 0600       1810        LD   B,0 ;          SO THAT B CAN BE USED AS A COUNTER
C9DD 78         1820 PINGL  LD   A,B ;          SEND OUTPUT TO THE SPEAKER
                1830
                1840 ;SEND OUTPUT TO THE SPEAKER
C9DE D3FE       1850        OUT  (#FE),A ;      REPEATEDLY CHANGING THE STATE
C9E0 10FB       1860        DJNZ PINGL ;        TO MAKE A NOISE
C9E2 C1         1870        POP  BC
                1880
                1890 ;NOW SEE WHERE THE CALL CAME FROM
                1900 ;
C9E3 2174C9     1910        LD   HL,NRET
C9E6 7D         1920        LD   A,L
C9E7 E1         1930        POP  HL
C9E8 E5         1940        PUSH HL
C9E9 AD         1950        XOR  L
                1960
                1970 ; IF THE RETURN WAS NOT MADE HERE EVERY ALTERNATE TIME
                1980 ; THIS ROUTINE WAS CALLED ONLY THE EVEN NUMBER COLOURS
                1990 ;WOULD BE SET
                2000 ;
C9EA C9         2010        RET  Z
                2020
                2030 ; INCREASE THE BORDER COLOUR, BITS 0-2
                2040 ;
C9EB 3AF5C9     2050        LD   A,(COL)
C9EE 3C         2060        INC  A
C9EF 32F5C9     2070        LD   (COL),A
                2080 ;
                2090 ; AND SET THE BORDER
                2100 ;
C9F2 D3FE       2110        OUT  (#FE),A
C9F4 C9         2120        RET
C9F5 00         2130 COL    DEFB 0
```



```
Pass 2 errors: 00

COL     C9F5    CONT1   C9BF
COORD   C9BC    CPLOT   C96A
DOWN    C948    FLAG    C9B5
LEFT    C957    LOOP    C98A
LOOP1   C995    LOOP2   C99A
LOOP4   C99F    NRET    C974
PING    C9DA    PINGL   C9DD
PLOT    C987    RIGHT   C962
ROM2    C9B7    SETUP   C901
UP      C94F

Table used:   228  from   680
```

DeBASE

DeBASE is made up from a number of separate routines building up to a crude, but efficient, data base program, with routines for saving to and loading from both tape and Microdrive.

The program will allow entries to be input, printed out, found, erased and changed. There is no constraint on the number of separate records nor on the size of each record, except that it must fit on the screen without scrolling it. Any part of any record may be found, and the cursor will be placed at the start of the details that were looked for. A record may be changed, enlarged or shrunk after its original creation, without destroying or altering any other records. After a record deletion all space used by the record is reclaimed.

The program uses only 1 byte of memory per character plus 1 byte per record for the end marker of the record; 32 000 bytes are available for records as written, with plenty of room for added facilities.

```
Pass 1 errors: 00

                  10 ; THIS SUBROUTINE WILL PRINT ANYTHING WHICH STARTS WITH
                  20 ; A BYTE WITH BIT 7 SET UP TO THE NEXT BYTE WITH BIT 7 SET.
                  30 ; IT HAS THREE MAIN ENTRY POINTS AND TWO METHODS OF USE
                  40 ; IF THE A REGISTER HOLDS 255 (#FF) ON ENTRY, THE DE REGISTER
                  50 ; MUST HOLD THE ADDRESS OF THE FIRST CHARACTER OF A MESSAGE
                  60 ; WHICH MUST BE PRECEEDED BY A BYTE WITH BIT 7 SET.
                  70 ; FOR ALL OTHER VALUES OF A THE MESSAGE OF THAT NUMBER
                  80 ; FROM A TABLE OF MESSAGES STARTING WITH A MARKER BYTE
                  90 ; WILL BE PRINTED
                 100 ;
                 110 ;
F424             120 MC1     ORG  62500
F424 F5          150 PMESS   PUSH AF ;     THIS ENTRY POINT SETS THE PRINT POSITION
F425 D5          160         PUSH DE ;     TO THE TOP LEFT OF THE SCREEN
F426 3E02        170         LD   A,2
```

```
F428 CD0116     180         CALL #1601 : ENSURE MAIN SCREEN CURRENT, OTHERWISE
                190 :                    THE PRINT POSITION COULD BE SET
                200 :                    FOR THE WRONG SCREEN, LEAVING THE MAIN
                210 :                    SCREEN AT ITS PREVIOUS POSITION
F42B 01211B     220         LD   BC,#1B21
F42E CDD90D     230         CALL 3545 :  USE THE R.O.M. CALL DETAILED IN CHAPTER 2
F431 D1         240         POP  DE
F432 F1         250         POP  AF
                251 :
                252 :
F433 F5         260 PRINAT  PUSH AF :    THIS ENTRY LEAVES THE CURRENT PRINT
F434 D5         270         PUSH DE :    POSITION AND USES THE MAIN SCREEN
F435 3E02       280         LD   A,2
F437 CD0116     290         CALL #1601
F43A 3EFF       300         LD   A,255 : SET SCROLLS BEFORE scroll ? MESSAGE
F43C 328C5C     310         LD   (23692),A : THIS IS THE SYSTEM VARIABLE SCR CT.
F43F 3E0D       320         LD   A,13 :  ENTER (CARRIAGE RETURN AND LINE FEED)
F441 D7         330         RST  16 :    THE PRINT RESTART
F442 D1         340         POP  DE
F443 F1         350         POP  AF
F444 3C         360 PRINT   INC  A :     THIS ENTRY USES THE CURRENT STREAM
F445 1B         370         DEC  DE :    SET DE TO POINT TO THE START MARKER
F446 2804       380         JR   Z,PRINTP : IF A WAS #FF THEN USE THE ADDRESS IN DE
F448 3D         390         DEC  A
F449 110000     400         LD   DE,MESS-1 : POINT DE TO THE START OF THE MESSAGES
F44C CD0A0C     410 PRINTP  CALL 3082 :  PRINT MESSAGE R.O.M. ROUTINE
F44F C9         420         RET
0001            430 MESS    EQU  1

Pass 2 errors: 00

MC1    C256    MESS   0001
PMESS  F424    PRINAT F433
PRINT  F444    PRINTP F44C


Pass 1 errors: 00

                440 : THIS SUBROUTINE WILL SEARCH MEMORY FOR A STRING WHICH
                450 : MATCHES THE STRING STARTING AT SCHAR (SEARCH CHARACTER)
                460 : AND ENDING WITH A MARKER BYTE OF 255 (#FF)
                470 : IF A MATCH IS FOUND THE START OF THE RECORD CONTAINING
                480 : THE MATCH IS THEN FOUND, BY STEPPING BACK TO A BYTE
                490 : WITH BIT 7 SET. IT IS THEN PRINTED BY THE PREVIOUS
                500 : SUBROUTINE.
                510 :
                520 : IF THE END OF EACH RECORD IS MARKED WITH A #BD
                530 : THEN IF THE CONTENTS OF SCHAR IS #FF (IE FIND NOTHING)
                540 : EACH RECORDS END WILL BE FOUND INSTEAD
                550 :
                560 : ON EXIT THE BC REGISTER PAIR WILL EITHER HOLD THE ADDRESS
                570 : OF THE START OF THE RECORD CONTAINING THE STRING
                580 : OR 0 IF THE STRING WAS NOT FOUND
                590 :
                600 :
F450            610 MC2     ORG  #F450
F450 21CBF4     620 FINDIT  LD   HL,SCHAR :   THE MAIN ENTRY POINT
F453 7E         630         LD   A,(HL)
F454 FEFF       640         CP   #FF
F456 2006       650         JR   NZ,SEARCH
F458 23         660         INC  HL
F459 77         670         LD   (HL),A
F45A 2B         680         DEC  HL
F45B 36BD       690         LD   A,#BD
F45D 77         700         LD   (HL),A
F45E E5         710 SEARCH  PUSH HL
F45F 213275     720         LD   HL,30002
F462 01D084     730         LD   BC,34000
```



```
F465 D1         740         POP  DE
F466 D5         750 LOOKMO  PUSH DE
F467 EDB1       760 LOOKON  CPIR :           LOOK FOR THE FIRST CHARACTER
F469 2046       770         JR   NZ,NOTFND : IF THE STRING IS NOT FOUND
F46B 2B         780         DEC  HL
F46C 22EEF4     790         LD   (LOCFND),HL : SAVE THE LOCATION WHERE FOUND
F46F ED43ECF4   800         LD   (LOCCNT),BC : AND THE COUNT LEFT TO GO
F473 D1         810         POP  DE
F474 D5         820         PUSH DE
F475 23         830 MAYBE   INC  HL :        NOW EACH CHARACTER IS TESTED IN TURN
F476 EB         840         EX   DE,HL
F477 23         850         INC  HL
F478 7E         860         LD   A,(HL)
F479 FEFF       870         CP   255 :       AND WHEN THE END OF THE STRING
F47B 280D       880         JR   Z,FOUND :   IS FOUND THEN THE STRING HAS
                890 :                            BEEN FOUND
F47D EB         900         EX   DE,HL
F47E BE         910         CP   (HL)
F47F 28F4       920         JR   Z,MAYBE
F481 2AEEF4     930         LD   HL,(LOCFND) : IF THE MATCH FAILS THEN LOOK
                940 :                          FOR THE FIRST CHARACTER AGAIN
F484 23         950         INC  HL
F485 3ACBF4     960         LD   A,(SCHAR)
F488 18DD       970         JR   LOOKON
                980 :
F48A E1         990 FOUND   POP  HL
F48B 2AEEF4     1000        LD   HL,(LOCFND) : FIRST IT IS CHECKED IF THE FIND
F48E 2B         1010 BACK   DEC  HL :          IS IN THE ALLOWED AREA
F48F 22F0F4     1020        LD   (MEMPOS),HL
F492 23         1030        INC  HL
F493 E5         1040        PUSH HL
F494 ED5BF2F4   1050        LD   DE,(LIMIT)
F498 A7         1060        AND  A
F499 ED52       1070        SBC  HL,DE
F49B 3014       1080        JR   NC,NOTFND ; AND IF NOT IT IS DISALLOWED
F49D E1         1090        POP  HL
F49E 2B         1100 BACKMO DEC  HL :        BEFORE THE ENTRY CAN BE PRINTED
F49F CB7E       1110        BIT  7,(HL) :    THE START MUST BE FOUND
F4A1 28FB       1120        JR   Z,BACKMO
F4A3 23         1130        INC  HL
F4A4 E5         1140        PUSH HL
F4A5 E5         1150        PUSH HL
F4A6 CD6B0D     1160        CALL 3435 :      CLEAR THE WHOLE SCREEN
F4A9 D1         1170        POP  DE
F4AA 3EFF       1180        LD   A,#FF :     SIGNAL TO PRINT ROUTINE THE ADDRESS
F4AC CD24F4     1190        CALL PMESS :     IN DE IS TO BE USED
F4AF C1         1200        POP  BC
F4B0 C9         1210        RET
F4B1 3E03       1220 NOTFND LD   A,3 :       PRINT MESSAGE 3
F4B3 CD33F4     1230        CALL PRINAT
F4B6 E1         1240        POP  HL
F4B7 010000     1250        LD   BC,0
F4BA C9         1260        RET
                1270 :
F4BB 21CBF4     1280 CONTLK LD   HL,SCHAR :  THIS IS THE ENTRY POINT TO LOOK FOR A
F4BE E5         1290        PUSH HL :        FURTHER OCCURENCE OF THE FIND STRING
F4BF 7E         1300        LD   A,(HL)
F4C0 ED4BECF4   1310        LD   BC,(LOCCNT)
F4C4 2AEEF4     1320        LD   HL,(LOCFND)
F4C7 23         1330        INC  HL
F4C8 C367F4     1340        JP   LOOKON
                1350 :
                1360 :
F4CB            1370 SCHAR  DEFS 33
F4EC 0000       1380 LOCCNT DEFW 0 :     THE COUNT LEFT AFTER A SEARCH
F4EE 3275       1390 LOCFND DEFW 30002 : THE LOCATION OF A FIND
F4F0 3175       1400 MEMPOS DEFW 30001 : ONE BEFORE THE FIND LOCATION
F4F2 C0F3       1410 LIMIT  DEFW 62400 : THE LIMIT OF MEMORY THAT CAN BE USED
F424            1420 PMESS  EQU  #F424 : MESSAGE PRINTING ROUTINE, SEE PREVIOUS
F433            1430 PRINAT EQU  #F433 : SUBROUTINE IN THIS APPENDIX
```

```
Pass 2 errors: 00

BACKMO F49E   CONTLK F4BB
FINDIT F450   FOUND  F48A
LIMIT  F4F2   LOCCNT F4EC
LOCFND F4EE   LOOKMO F466
LOOKON F467   MAYBE  F475
MC2    C770   MEMPOS F4F0
NOTFND F4B1   PMESS  F424
PRINAT F433   SCHAR  F4CB


Pass 1 errors: 00

                1360 ; THIS SUBROUTINE WILL ERASE A RECORD WHEN USED WITH THE
                1370 ; PREVIOUS SUBROUTINE
                1380 ;
                1390 ; ON EXIT THE BC REGISTERS WILL CONTAIN THE AMOUNT OF MEMORY
                1400 ; RECLAIMED
                1410 ;
                1420 ;
F4CB            1430 MC3    ORG  #F4CB
F4CB CDCBF4     1440 XREC   CALL FINDIT ;       THIS IS USED TO FIND
F4CE 78         1450 XRECON LD   A,B ;          THE ENTRY TO BE ERASED
F4CF B1         1460        OR   C
F4D0 C8         1470        RET  Z ;            BC = 0 IF NOT FOUND
F4D1 E5         1480        PUSH HL
F4D2 C5         1490        PUSH BC
F4D3 3E02       1500        LD   A,2 ;          MESSAGE 2
F4D5 CDD5F4     1510        CALL PRINAT
F4D8 3E7F       1520 CHECKB LD   A,127 ;        THIS IS ONE WAY OF SCANNING
                1530 ;                          FOR KEYS PRESSED, SEE CHAPTER 2
F4DA DBFE       1540        IN   A,(#FE)
F4DC 1F         1550        RRA
F4DD 3030       1560        JR   NC,BREAK
F4DF 3E7F       1570        LD   A,127
F4E1 DBFE       1580        IN   A,(#FE)
F4E3 CB5F       1590        BIT  3,A
F4E5 282E       1600        JR   Z,NEXTR
F4E7 3EFE       1610        LD   A,254
F4E9 DBFE       1620        IN   A,(#FE)
F4EB CB57       1630        BIT  2,A
F4ED 20E9       1640        JR   NZ,CHECKB
F4EF C1         1650        POP  BC
F4F0 E1         1660        POP  HL
F4F1 C5         1670        PUSH BC
F4F2 C5         1680        PUSH BC ;           BC = START OF RECORD
F4F3 E1         1690        POP  HL
F4F4 010000     1700        LD   BC,0
F4F7 CB7E       1710 F_END  BIT  7,(HL)
F4F9 23         1720        INC  HL
F4FA 03         1730        INC  BC ;           THE END OF THE RECORD
F4FB 28FA       1740        JR   Z,F_END ;      MUST BE FOUND
F4FD D1         1750        POP  DE ;           NOW EVERYTHING ABOVE THE
F4FE C5         1760        PUSH BC ;           RECORD UP TO LIMIT CAN BE BROUGHT
F4FF E5         1770        PUSH HL ; DOWN TO DELETE THE RECORD
F500 C1         1780        POP  BC
F501 E5         1790        PUSH HL
F502 2A02F5     1800        LD   HL,(LIMIT)
F505 A7         1810        AND  A
F506 ED42       1820        SBC  HL,BC
F508 E5         1830        PUSH HL
F509 C1         1840        POP  BC
F50A E1         1850        POP  HL
F50B EDB0       1860        LDIR
F50D C1         1870        POP  BC ;           THE AMOUNT OF GAINED SPACE
F50E C9         1880        RET
F50F E1         1890 BREAK  POP  HL ;           CLEAR THE STACK AND SHOW NOT FOUND
F510 C1         1900        POP  BC
```



```
F511 010000     1910        LD   BC,0
F514 C9         1920        RET
F515 E1         1930 NEXTR  POP  HL ;           RESTORE THE OLD DETAILS AND LOOK ON
F516 C1         1940        POP  BC
F517 CD17F5     1950        CALL CONTLK
F51A C3CEF4     1960        JP   XRECON

Pass 2 errors: 00

*WARNING* FINDIT absent
*WARNING* PRINAT absent
*WARNING* LIMIT absent
*WARNING* CONTLK absent
Table used:   147  from   267

Pass 1 errors: 00

                1970 ; THIS ROUTINE ALLOWS KEYBOARD INPUT TO BE PLACED INTO MEMORY
                1980 ; AS WELL AS ECHOED TO THE SCREEN.
                1990 ;
                2000 ;
                2010 ; IT CATERS FOR FORWARD AND BACKWARD CURSOR MOVEMENT
                2020 ; AND INSERTION AND DELETION OF CHARACTERS
                2030 ;
                2040 ; IT ALSO OFFERS A HELP PAGE AND A MENU
                2050 ;
                2060 ; AS SHOWN HERE IT IS FOR USE WITH THE OTHER ROUTINES
                2070 ; IN THIS SECTION AS A DATABASE,
                2080 ; BUT IT CAN EASILY BE TAILORED TO SUIT MANY PURPOSES.
                2090 ;
                2100 ; THE ROUTINE CHECKS FOR MEMORY OVER THE LIMIT BEING USED
                2110 ; AND WILL STOP INPUT AT THIS STAGE
                2120 ;
                2130 ; I HAVE PUT A SECOND INPUT ROUTINE IN FOR FIND INPUT
                2140 ; AS WELL AS EXTRA INPUT ROUTINES FOR SELECTION OF OPTIONS
                2150 ; THIS IS INTENDED TO DEMONSTRATE THE DIFFERENT WAYS
                2160 ; OF GETTING INPUT, AND SOME OF THE PROBLEMS MENTIONED
                2170 ; IN THE MAIN TEXT OF THE BOOK
                2180 ;
                2190 ;
                2200 ; THIS IS THE CALL ADDRESS FROM BASIC.
                2210 ;
F51D            2220 MC4    ORG  #F51D
F51D 3EA0       2230 USR    LD   A,#A0 ;        FIRST FREE MEMORY IS CHECKED
F51F 2A1FF5     2240        LD   HL,(LIMIT)
F522 ED5B22F5   2250        LD   DE,(CHPOS)
F526 A7         2260        AND  A
F527 ED52       2270        SBC  HL,DE
F529 D234F5     2280        JP   NC,NOTFUL
F52C 3E09       2290        LD   A,9 ;          MESSAGE 9
F52E CD2EF5     2300        CALL PRINAT
F531 C3DFF6     2310        JP   PMESS4
F534 E5         2320 NOTFUL PUSH HL ;           AND ALL MEMORY ABOVE THE LAST RECORD
F535 C1         2330        POP  BC ;           AND BELOW LIMIT IS CLEARED
F536 D5         2340        PUSH DE ;           AND MARKED AS FREE
F537 E1         2350        POP  HL
F538 13         2360        INC  DE
F539 77         2370        LD   (HL),A
F53A EDB0       2380        LDIR
F53C 2A22F5     2390 INPUTA LD   HL,(CHPOS) ;   AND THE START OF THE NEXT RECORD
F53F 2B         2400        DEC  HL
F540 7E         2410        LD   A,(HL)
F541 FE8D       2420        CP   #8D
F543 2801       2430        JR   Z,ATBEG
F545 23         2440        INC  HL
F546 368D       2450 ATBEG  LD   (HL),#8D
F548 224BF5     2460        LD   (CUPOS),HL ;   IS MARKED, AND THE START NOTED
F54B CD6B0D     2470        CALL 3435 ;         THE SCREEN IS CLEARED
F54E CD4EF5     2480        CALL OPEN1
```

```
F551 012118    2490         LD   BC,#1821 :   AND THE PRINT POSITION IN THE
F554 CD0900    2500         CALL 3545 :       LOWER SCREEN SET TO THE TOP LEFT
F557 3E07      2510         LD   A,7 :        MESSAGE 7
F559 CD59F5    2520         CALL PRINT
F55C 3E01      2530         LD   A,1 :          THE COPYRIGHT
F55E CD5EF5    2540         CALL PMESS
F561 AF        2550         XOR  A :          AND THE EDIT MODE FLAG IS CLEARED
F562 3262F5    2560         LD   (WFLAG),A
F565 012116    2570         LD   BC,#1621 :   SET LINE 2 COLUMN 0
F568 CD0900    2580         CALL 3545
F56B 3E3E      2590         LD   A,">"
F56D D7        2600         RST  16
F56E CD02F7    2610         CALL CURSOR
F571 CD4EF5    2620 INPUT   CALL OPEN1
F574 CDAB10    2630 INP1    CALL #10AB :      THIS IS THE KEYBOARD INPUT
F577 3806      2640         JR   C,KEYPRE :   ROUTINE, CARRY SET IF NEW KEY PRESSED
F579 FDCB029E  2650         RES  3,(IY+2) :   THIS IS TV FLAG, SEE WAIT INPUT CHAP.2
F57D 18F5      2660         JR   INP1
F57F FE0B      2670 KEYPRE  CP   B :          NOW ANY SPECIAL FUNCTION KEYS PICKED
F581 2B4E      2680         JR   Z,BACK1
F583 FE09      2690         CP   9
F585 CA11F7    2700         JP   Z,RIGHT1
F588 FE0C      2710         CP   12 :         CAPS SHIFT AND 0
F58A CA5CF7    2720         JP   Z,DELETE
F58D FEC5      2730         CP   197 :        OR
F58F C8        2740         RET  Z
F590 FECD      2750         CP   205 :        STEP
F592 CACFF7    2760         JP   Z,HELP
F595 FEC6      2770         CP   198
F597 CABEF7    2780         JP   Z,AND
F59A FEC3      2790         CP   195 :        NOT
F59C CAD9F6    2800         JP   Z,LOOKM
F59F FECC      2810         CP   204 :        TO
F5A1 CA87F7    2820         JP   Z,LPRINT
F5A4 2A48F5    2830         LD   HL,(CUPOS)
F5A7 23        2840         INC  HL :         NOW IT OS CHECKED THAT THE END OF A
F5A8 F5        2850         PUSH AF :         RECORD HAS NOT BEEN REACHED. IF IT HAS
F5A9 3A62F5    2860         LD   A,(WFLAG) :  NO MORE INPUT IS ALLOWED
F5AC A7        2870         AND  A
F5AD 2806      2880         JR   Z,OKTHEN :   BUT IF NOT IN EDIT MODE IT MUST BE
F5AF 7E        2890         LD   A,(HL) :     FREE MEMORY
F5B0 FE8D      2900         CP   #8D
F5B2 CA40F7    2910         JP   Z,ENDREC
F5B5 F1        2920 OKTHEN  POP  AF
F5B6 FEE2      2930         CP   226 :        STOP WHICH ENDS INPUT
F5B8 2838      2940         JR   Z,STOP
F5BA 77        2950         LD   (HL),A :     THE CHARACTER CODE IS PUT INTO THE
F5BB 2248F5    2960         LD   (CUPOS),HL : CURRENT MEMORY POSITION AND THIS IS
               2970 ;                         UPDATED FOR NEXT TIME
F5BE FE0D      2980         CP   13
F5C0 2006      2990         JR   NZ,KEYOUT :  IF AN ENTER REMOVE THE OLD CURSOR
F5C2 CDC2F5    3000         CALL OPEN2
F5C5 CD02F7    3010         CALL CURSOR
F5C8 CDC2F5    3020 KEYOUT  CALL OPEN2
F5CB D7        3030         RST  16 :         ECHO THE KEY TO THE SCREEN
F5CC CD02F7    3040         CALL CURSOR :     AND MOVE THE CURSOR ALONG
F5CF 18A0      3050         JR   INPUT :      GO BACK FOR THE NEXT KEY
               3060 ;
               3070 ;
F5D1 2A48F5    3080 BACK1   LD   HL,(CUPOS) : THIS MOVES THE CURSOR AND CURRENT
F5D4 7E        3090         LD   A,(HL) :     MEMORY POSITION BACK
F5D5 CB7F      3100         BIT  7,A
F5D7 2098      3110         JR   NZ,INPUT
F5D9 FE0D      3120         CP   13
F5DB 2B        3130         DEC  HL
F5DC 2248F5    3140         LD   (CUPOS),HL
F5DF 2005      3150         JR   NZ,B_ON
F5E1 CDE1F5    3160         CALL BACK :       BUT GOING BACK PAST AN ENTER
F5E4 1B6F      3170         JR   FINRET :     MEANS A RE-PRINT AND CHANGE OF MODE
F5E6 CDC2F5    3180 B_ON    CALL OPEN2
```



```
F5E9 CD02F7    3190         CALL CURSOR
F5EC 3E08      3200         LD   A,8
F5EE D7        3210         RST  16
F5EF CD02F7    3220         CALL CURSOR
F5F2 C371F5    3230         JP   INPUT :      BACK FOR NEXT CHARACTER
               3240 ;
               3250 ;
F5F5 E5        3260 STOP    PUSH HL :         IF STOP IS PRESSED THE END OF THE
F5F6 2B        3270         DEC  HL :         RECORD MUST ONLY BE MARKED
F5F7 7E        3280 ENDIS   LD   A,(HL) :     IF IT WAS A NEW ENTRY, BUT IN ALL
F5F8 23        3290         INC  HL :         CASES THE START OF FREE MEMORY
F5F9 FEA0      3300         CP   #A0 :        FOUND AND THE POINTER UPDATED
F5FB 20FA      3310         JR   NZ,ENDIS
F5FD 2B        3320         DEC  HL
F5FE 2222F5    3330         LD   (CHPOS),HL
F601 E1        3340         POP  HL
F602 3A62F5    3350         LD   A,(WFLAG)
F605 A7        3360         AND  A
F606 23        3370         INC  HL
F607 2007      3380         JR   NZ,STOPON
F609 2222F5    3390         LD   (CHPOS),HL
F60C 2B        3400         DEC  HL
F60D 3E8D      3410         LD   A,#8D
F60F 77        3420         LD   (HL),A
F610 CD6B0D    3430 STOPON  CALL 3435 :       THE SCREEN IS CLEARED
F613 AF        3440         XOR  A :          THE MODE FLAG CLEARED
F614 3262F5    3450         LD   (WFLAG),A
F617 3E04      3460         LD   A,4 :        AND THE MENU DISPLAYED
F619 CD5EF5    3470         CALL PMESS
F61C CD4EF5    3480 MENUIN  CALL OPEN1
F61F CD0E15    3490         CALL #15DE :      THE WAIT INPUT ROUTINE, SEE CHAPTER 2
F622 FE0D      3500         CP   13
F624 CA1DF5    3510         JP   Z,USR
F627 F620      3520         OR   #20
F629 FE65      3530         CP   "e"
F62B 2B10      3540         JR   Z,XINPUT
F62D FE66      3550         CP   "f"
F62F 2B1E      3560         JR   Z,FINPUT
F631 FE63      3570         CP   "c"
F633 CAD9F6    3580         JP   Z,LOOKM
F636 FE73      3590         CP   "s"
F638 CA3BF6    3600         JP   Z,SAVEL
F63B 18DF      3610         JR   MENUIN
               3620 ;
               3630 ;
F63D CDA0F6    3640 XINPUT  CALL FINPT :      THIS IS THE ERASE ENTRY ROUTINE START
F640 CD40F6    3650         CALL XREC
F643 2A22F5    3660         LD   HL,(CHPOS) : THE GAINED SPACE IS ALLOWED FOR BY
F646 A7        3670         AND  A :          MOVING THE START OF FREE MEMORY
F647 ED42      3680         SBC  HL,BC :      DOWN BY THAT AMOUNT
F649 2222F5    3690         LD   (CHPOS),HL
F64C C3DFF6    3700         JP   PMESS4
               3710 ;
               3720 ;
F64F CDA0F6    3730 FINPUT  CALL FINPT :      THE START OF THE FIND ENTRY ROUTINE
F652 CD52F6    3740         CALL FINDIT
F655 78        3750 FINRET  LD   A,B :        IF THE ENTRY IS NOT FOUND GOTO MENU
F656 B1        3760         OR   C
F657 CADFF6    3770         JP   Z,PMESS4
F65A 0B        3780         DEC  BC
F65B ED4348F5  3790         LD   (CUPOS),BC : OTHERWISE SET EDIT MODE WITH THE
F65F 2A5FF6    3800         LD   HL,(MEMPOS) : CURSOR UNDER THE START OF THE FIND
F662 A7        3810         AND  A
F663 ED42      3820         SBC  HL,BC
F665 2265F6    3830         LD   (CURSF),HL
F668 3E01      3840         LD   A,1
F66A 3262F5    3850         LD   (WFLAG),A
F66D CD4EF5    3860         CALL OPEN1
F670 012118    3870         LD   BC,#1821
```

```
F673 CD090D   3880          CALL 3545
F676 3E08     3890          LD   A,8
F678 CD59F5   3900          CALL PRINT
F67B 3E07     3910          LD   A,7
F67D CD59F5   3920          CALL PRINT
F680 CDC2F5   3930          CALL OPEN2
F683 012118   3940          LD   BC,#1821
F686 CD090D   3950          CALL 3545
F689 3E0D     3960          LD   A,13
F68B D7       3970          RST  16
F68C CD02F7   3980          CALL CURSOR
F68F ED4B65F6 3990          LD   BC,(CURSP)
F693 78       4000 RIMORE   LD   A,B
F694 B1       4010          OR   C
F695 CA71F5   4020          JP   Z,INPUT
F698 C5       4030          PUSH BC
F699 CD17F7   4040          CALL RIGHTS
F69C C1       4050          POP  BC
F69D 0B       4060          DEC  BC
F69E 18F3     4070          JR   RIMORE
              4080 ;
              4090 ;
F6A0 CD6B0D   4100 FINPT    CALL 3435 ;       THIS IS SIMILAR TO THE INPUT
F6A3 3E05     4110          LD   A,5 ;        INPUT ROUTINE EARLIER BUT IT DOES NOT
F6A5 CD5EF5   4120          CALL PMESS ;      ALLOW ANY ALTERATIONS
F6A8 3E3E     4130          LD   A,62 ;       AND LIMITS THE INPUT BY STOPPING
F6AA D7       4140          RST  16 ;         WHEN THE POSITION REACHES IN_LIM
F6AB 21CBF6   4150          LD   HL,SCHAR+32
F6AE 22AEF6   4160          LD   (IN_LIM),HL
F6B1 21ABF6   4170          LD   HL,SCHAR
              4180 ;
              4190 ;
F6B4 E5       4200 INPUTF   PUSH HL ;         THE ACTUAL INPUT SUBROUTINE
F6B5 CD4EF5   4210          CALL OPEN1
F6B8 CDDE15   4220          CALL #15DE
F6BB E1       4230          POP  HL
F6BC FE0D     4240          CP   13 ;         TERMINATED BY PRESSING ENTER
F6BE 2B16     4250          JR   Z,SETFIN
F6C0 FE20     4260          CP   32
F6C2 3BF0     4270          JR   C,INPUTF
F6C4 77       4280          LD   (HL),A
F6C5 23       4290          INC  HL
F6C6 E5       4300          PUSH HL
F6C7 CDC2F5   4310          CALL OPEN2
F6CA D7       4320          RST  16
F6CB E1       4330          POP  HL
F6CC EB       4340          EX   DE,HL
F6CD 2AAEF6   4350          LD   HL,(IN_LIM)
F6D0 A7       4360          AND  A
F6D1 ED52     4370          SBC  HL,DE
F6D3 EB       4380          EX   DE,HL
F6D4 20DE     4390          JR   NZ,INPUTF
F6D6 36FF     4400 SETFIN   LD   (HL),255
F6D8 C9       4410          RET
              4420 ;
              4430 ;
F6D9 CDD9F6   4440 LOOKM    CALL CONTLK ;     THIS LOOKS FOR A FURTHER OCCURENCE OF
F6DC C355F6   4450          JP   FINRET ;     A FIND STRING
              4460 ;
              4470 ;
F6DF 0603     4480 PMESS4   LD   B,3 ;        CLEAR THE BOTTOM THREE SCREEN LINES
F6E1 CD440E   4490          CALL 3652 ;       CHAPTER 2 EXPLAINS
F6E4 3E04     4500          LD   A,4 ;        THE MENU
F6E6 CD2EF5   4510          CALL PRINAT
F6E9 C31CF6   4520          JP   MENUIN
              4530 ;
              4540 ;
              4550 ;                          OVER1 AND OVER 2 REPRODUCE THE
              4560 ;                          SAME BASIC COMMANDS, BY PRINTING
              4570 ; THE CONTROL CODES
```



```
F6EC F5       4580 OVER1    PUSH AF
F6ED E5       4590          PUSH HL
F6EE 3E15     4600          LD   A,21
F6F0 D7       4610          RST  16
F6F1 3E01     4620          LD   A,1
F6F3 D7       4630          RST  16
F6F4 E1       4640          POP  HL
F6F5 F1       4650          POP  AF
F6F6 C9       4660          RET
F6F7 F5       4670 OVER0    PUSH AF
F6F8 E5       4680          PUSH HL
F6F9 3E15     4690          LD   A,21
F6FB D7       4700          RST  16
F6FC 3E00     4710          LD   A,0
F6FE D7       4720          RST  16
F6FF E1       4730          POP  HL
F700 F1       4740          POP  AF
F701 C9       4750          RET
F702 F5       4760 CURSDR   PUSH AF ;         THIS PRINTS THE CURSOR AND MOVES
F703 CDECF6   4770          CALL OVER1 ;      THE PRINT POSITION BACK OVER IT
F706 3E5F     4780          LD   A,95
F708 D7       4790          RST  16
F709 3E08     4800          LD   A,8
F70B D7       4810          RST  16
F70C CDF7F6   4820          CALL OVER0
F70F F1       4830          POP  AF
F710 C9       4840          RET
F711 CD17F7   4850 RIGHT1   CALL RIGHTS
F714 C371F5   4860          JP   INPUT
F717 CDC2F5   4870 RIGHTS   CALL OPEN2 ;      THIS SUBROUTINE MOVES THE CURSOR
F71A 2A48F5   4880          LD   HL,(CUPOS) ; RIGHT ONE POSITION AND POINTS THE
F71D 23       4890          INC  HL ;         MEMORY POINTER TO THE NEW CHARACTER
F71E 7E       4900          LD   A,(HL)
F71F CB7F     4910          BIT  7,A
F721 C0       4920          RET  NZ
F722 FE7F     4930          CP   127
F724 C8       4940          RET  Z
F725 FE0D     4950          CP   13
F727 2803     4960          JR   Z,ONRITE
F729 FE20     4970          CP   32
F72B D8       4980          RET  C
F72C 2248F5   4990 ONRITE   LD   (CUPOS),HL
F72F CD02F7   5000          CALL CURSOR
F732 FE0D     5010          CP   13
F734 2805     5020          JR   Z,RITEON
F736 CDECF6   5030          CALL OVER1
F739 3E20     5040          LD   A,32
F73B D7       5050 RITEON   RST  16
F73C CD02F7   5060          CALL CURSOR
F73F C9       5070          RET
              5080 ;
              5090 ;
F740 E5       5100 ENDREC   PUSH HL ;         IF ENTRY IS ATTEMPTED BEYOND THE
F741 0603     5110          LD   B,3 ;        END OF A RECORD A WARNING IS FLASHED
F743 CD440E   5120          CALL 3652 ;       THE BOTTOM OF THE SCREEN IS CLEARED
F746 3E06     5130          LD   A,6
F748 CD5EF5   5140          CALL PMESS
F74B FB       5150          EI   ;              JUST IN CASE IF THEY WERE OFF
F74C 0632     5160          LD   B,50 ;       THIS 1 SEC PAUSE WOULD BE FOREVER
F74E 76       5170 WAIT1    HALT
F74F 10FD     5180          DJNZ WAIT1
F751 E1       5190          POP  HL
F752 F1       5200          POP  AF
F753 2153F7   5210 REENTR   LD   HL,LOCFND
F756 35       5220          DEC  (HL)
F757 2B       5230          DEC  HL
F758 34       5240          INC  (HL)
F759 C3D9F6   5250          JP   LOOKM
              5260 ;
              5270 ;
```

```
F75C 2A48F5    5280 DELETE LD   HL,(CUPOS) :  THIS WORKS THE SAME AS THE DELETE
F75F 23        5290        INC  HL ;         RECORD BUT FOR ONE CHARACTER
F760 7E        5300        LD   A,(HL)
F761 CB7F      5310        BIT  7,A
F763 C271F5    5320        JP   NZ,INPUT
F766 E5        5330        PUSH HL
F767 E5        5340        PUSH HL
F768 2A1FF5    5350        LD   HL,(LIMIT)
F76B D1        5360        POP  DE
F76C A7        5370        AND  A
F76D ED52      5380        SBC  HL,DE
F76F E5        5390        PUSH HL
F770 C1        5400        POP  BC
F771 D1        5410        POP  DE
F772 DA71F5    5420        JP   C,INPUT
F775 CA71F5    5430        JP   Z,INPUT
F778 D5        5440        PUSH DE
F779 E1        5450        POP  HL
F77A 23        5460        INC  HL
F77B EDB0      5470        LDIR
F77D 2A22F5    5480        LD   HL,(CHPOS)
F780 2B        5490        DEC  HL
F781 2222F5    5500        LD   (CHPOS),HL
F784 2A48F5    5510        LD   HL,(CUPOS)
F787 23        5520        INC  HL
F788 CDE1F5    5530        CALL BACK
F78B C355F6    5540        JP   FINRET
               5550 ;
               5560 ;
F78E 2A48F5    5570 AND    LD   HL,(CUPOS) :  AND THIS IS THE SAME IN REVERSE
F791 22        5580        INC  HL
F792 E5        5590        PUSH HL
F793 2A1FF5    5600        LD   HL,(LIMIT)
F796 D1        5610        POP  DE
F797 A7        5620        AND  A
F798 ED52      5630        SBC  HL,DE
F79A E5        5640        PUSH HL
F79B C1        5650        POP  BC
F79C D5        5660        PUSH DE
F79D ED5B1FF5  5670        LD   DE,(LIMIT)
F7A1 D5        5680        PUSH DE
F7A2 E1        5690        POP  HL
F7A3 2B        5700        DEC  HL
F7A4 EDB8      5710        LDDR
F7A6 2A22F5    5720        LD   HL,(CHPOS)
F7A9 23        5730        INC  HL
F7AA 2222F5    5740        LD   (CHPOS),HL
F7AD E1        5750        POP  HL
F7AE 3E20      5760        LD   A,32
F7B0 77        5770        LD   (HL),A
F7B1 CDE1F5    5780        CALL BACK
F7B4 C355F6    5790        JP   FINRET
               5800 ;
               5810 ;
F7B7 2A48F5    5820 LPRINT LD   HL,(CUPOS) ;  THIS USES STREAM THREE IN AN IDENTICAL
F7BA 23        5830        INC  HL ;         WAY AS STREAM 2 FOR THE SCREEN.
F7BB CDE1F5    5840        CALL BACK ;       IF AN INTERFACE IS CONNECTED
F7BE C5        5850        PUSH BC ;         WHICH RECOGNISES LPRINT IT WILL WORK
F7BF 3E03      5860        LD   A,3
F7C1 CD0116    5870        CALL #1601
F7C4 D1        5880        POP  DE
F7C5 D5        5890        PUSH DE
F7C6 1B        5900        DEC  DE
F7C7 AF        5910        XOR  A
F7C8 CDCBF7    5920        CALL PRINTP
F7CB C1        5930        POP  BC
F7CC C355F6    5940        JP   FINRET
               5950 ;
               5960 ;
F7CF CD6B0D    5970 HELP   CALL 3435
```



```
F7D2 3E0A      5980        LD   A,10 :       THE HELP PAGE
F7D4 CD5EF5    5990        CALL PMESS
F7D7 3EBF      6000 WAITE  LD   A,#BF
F7D9 DBFE      6010        IN   A,(#FE)
F7DB E601      6020        AND  1
F7DD 20F8      6030        JR   NZ,WAITE
F7DF 2A48F5    6040        LD   HL,(CUPOS)
F7E2 2253F7    6050        LD   (LOCFND),HL
F7E5 23        6060        INC  HL
F7E6 7E        6070        LD   A,(HL)
F7E7 21ABF6    6080        LD   HL,SCHAR
F7EA 77        6090        LD   (HL),A
F7EB 23        6100        INC  HL
F7EC 36FF      6110        LD   (HL),#FF
F7EE C353F7    6120        JP   REENTR

Pass 2 errors: 00

*WARNING* LIMIT absent
*WARNING* CHPOS absent
*WARNING* PRINAT absent
*WARNING* CUPOS absent
*WARNING* OPEN1 absent
*WARNING* PRINT absent
*WARNING* PMESS absent
*WARNING* WFLAG absent
*WARNING* OPEN2 absent
*WARNING* BACK absent
*WARNING* SAVEL absent
*WARNING* XREC absent
*WARNING* FINDIT absent
*WARNING* MEMPOS absent
*WARNING* CURSP absent
*WARNING* SCHAR absent
*WARNING* IN_LIM absent
*WARNING* CONTLK absent
*WARNING* LOCFND absent
*WARNING* PRINTP absent
Table used:   751  from  1219


Pass 1 errors: 00

               6130 : THIS IS THE START OF THE SAVE AND LOAD ROUTINES
               6140
               6150 : FIRST THE LENGTH OF THE RECORDS IS CALCULATED,
               6160 : WITH AN OVERHEAD FOR AN END-MARKER
               6170 : AND LENGTH BYTES FOR RE-ENTRY AFTER LOADING
               6180 ;
               6190 ;
F7F1           6200 MC5    ORG  #F7F1
F7F1 2AF1F7    6210 SAVEL  LD   HL,(CHPOS) :  FIRST THE END OF RECORDS IS PUT INTO
F7F4 222E75    6220        LD   (29998),HL ;  THE START OF THE AREA TO BE SAVED OR
F7F7 112E75    6230        LD   DE,29998 ;    LOADED
F7FA A7        6240        AND  A
F7FB ED52      6250        SBC  HL,DE
F7FD 23        6260        INC  HL
F7FE 23        6270        INC  HL
F7FF E5        6280        PUSH HL
F800 3E0B      6290        LD   A,11
F802 CD02F8    6300        CALL PMESS
F805 0619      6310        LD   B,25 :        25 INTERRUPTS 1/2 SECOND
F807 FB        6320        EI   ;             JUST IN CASE
               6330 ;
               6340
               6350 ;                        THIS WOULD BE BAD PLANNING
               6360 ;                        BUT IT IS TO DEMONSTRATE THE
               6370 ;                        USE OF THE HALT FOR TIMING
               6380 ;
```

```
F808 76       6390 HOLDIT HALT ;            TO MAKE SURE THAT S IS NOT TAKEN
F809 10FD     6400        DJNZ HOLDIT ;     FROM THE MAIN MENU KEYPUSH
              6410 ;                        NOW THE KEYBOARD IS SCANNED
              6420 ;
F80B 3EBF     6430 SOLDEC LD   A,#BF
F80D DBFE     6440        IN   A,(#FE)
F80F E602     6450        AND  2
F811 CA11FB   6460        JP   Z,LOAD
F814 3EFD     6470        LD   A,#FD
F816 DBFE     6480        IN   A,(#FE)
F818 E602     6490        AND  2
F81A 20EF     6500        JR   NZ,SOLDEC
              6510 ;
```

Pass 2 errors: 00

```
*WARNING* CHPOS absent
*WARNING* PMESS absent
*WARNING* LOAD absent
*WARNING* M_OR_T absent
*WARNING* LORET absent
*WARNING* HLSAV absent
*WARNING* BCSAV absent
*WARNING* MHEAD absent
Table used:   243  from   521
```

Pass 1 errors: 00

```
              6520 ; THIS IS THE DECISION MAKER FOR TAPE OR MICRODRIVE
              6530 ;
              6540 ;
F81C          6550        ORG  #F81C
F81C C1       6560 SAVE   POP  BC
F81D CD1DF8   6570        CALL M_OR_T ;     RETURNS WITH CARRY SET IF M PRESSED
              6580 ;                        ALSO SETS THE HEADER
              6590 ;
F820 3838     6600        JR   C,MSAVE
              6610 ;
              6620 ; THIS IS TO SAVE A HEADER AND A MAIN DATA BLOCK TO TAPE
              6630 ; THE HEADER IS SPECIAL, SEE SAVEing & LOADing
              6640 ; IN CHAPTER 2
              6650 ;
F822 C5       6660 TSAVE  PUSH BC ;         BC = LENGTH OF THE MAIN BLOCK
              6670 ;                        IX IS ALREADY SET TO THE START
F823 110D00   6680        LD   DE,13 ;      THE HEADER IS ONLY 13 BYTES LONG
F826 AF       6690        XOR  A ;          A TO BE 0 SIGNALLING HEADER
F827 CDC604   6700        CALL 1222 ;       R.O.M. ROUTINE DETAILED IN CHAPTER 2
              6710 ;                        TO SAVE HEADER
F82A D1       6720        POP  DE ;         RESTORE THE LENGTH OF THE MAIN BLOCK
F82B DD212E75 6730        LD   IX,29998 ;   POINT IX TO THE
              6740 ;                        ADDRESS TO START SAVEing FROM
F82F 3EFF     6750        LD   A,#FF ;      SIGNAL MAIN BLOCK
F831 CDC604   6760        CALL 1222 ;       USE THE R.O.M. ROUTINE AGAIN
F834 FB       6770        EI   ;              IT RETURNS WITH INTERRUPTS OFF
F835 C33FF8   6780        JP   LORET
```

Pass 2 errors: 00

```
*WARNING* M_OR_T absent
*WARNING* LORET absent
*WARNING* HLSAV absent
*WARNING* BCSAV absent
*WARNING* MHEAD absent
Table used:   180  from   407
```


Pass 1 errors: 00

```
              6790 ;
              6800 ;                        THIS PAGES OUT THE 16K R.O.M.
              6810 ;                        SEE CHAPTER 3 FOR FULL DETAILS
              6820 ;
              6830 ;
F838          6840        ORG  #F838
F838 2149F8   6850 RSWAP  LD   HL,ROMOUT
F83B 22ED5C   6860        LD   (23789),HL ; THE SUBROUTINE USED BY THE R.O.M.
              6870 ;                        IS USED BY HOOK CODE 32
              6880 ;                        SO SET TO RETURN TO THIS ROUTINE
F83E D9       6890        EXX  ;            THE STACK IS TO BE MUCKED ABOUT
F83F 223FF8   6900        LD   (HLSAV),HL ; SO IT IS SAFER THIS WAY
F842 D9       6910        EXX
F843 ED4343F8 6920        LD   (BCSAV),BC
F847 CF       6930        RST  8 ;          USE THE HOOK CODE
F848 32       6940        DEFB #32
F849 E1       6950 ROMOUT POP  HL ;         THE TWO RETURN ADDRESSES
F84A E1       6960        POP  HL ;         MUST BE REMOVED
F84B D1       6970        POP  DE ;         AND THE RETURN FROM THIS SUBROUTINE
F84C 2A3D5C   6980        LD   HL,(23613) ; THIS IS ERR SP SEE CHAPTER 4
F84F E5       6990        PUSH HL ;         SAVE THE POSITION OF THE ERROR RETURN
              7000 ;              ;         ON THE STACK FOR LATER
F850 216AFB   7010        LD   HL,MSLRET
F853 E5       7020        PUSH HL ;         STACK THE NEW ERROR RETURN ADDRESS
F854 ED733D5C 7030        LD   (23613),SP ; AND POINT ERR SP TO THAT
F858 D5       7040        PUSH DE ; RESTORE THE RETURN ADDRESS
F859 C9       7050        RET
```

Pass 2 errors: 00

```
*WARNING* HLSAV absent
*WARNING* BCSAV absent
*WARNING* MHEAD absent
*WARNING* LORET absent
Table used:   124  from   287
```

Pass 1 errors: 00

```
              7060 ; THIS IS THE SUBROUTINE TO SAVE TO MICRODRIVE, SEE CHAP 3
              7070 ;
              7080 ;
F85A          7090        ORG  #F85A
F85A CD5AF8   7100 MSAVE  CALL RSWAP
F85D CD5DF8   7110        CALL MHEAD ;      SET THE HEADER
F860 CD60F8   7120        CALL VARSET ;     AND THE SYSTEM VARIABLES
F863 FDCB37EE 7130        SET  5,(IY+124) ; SIGNAL SAVE WITH FLAGS 3
F867 CD7F1E   7140        CALL #1E7F ;      IN FACT A CALL IS NOT NEEDED
              7150 ;                        AS RETURN IS VIA THE 16K ERROR 0 OR
F86A E1       7160 MSLRET POP  HL ;         RESTORE THE ERR SP SYSTEM VARIABLE
F86B 223D5C   7170        LD   (23613),HL ; ERR SP
F86E FB       7180        EI   ;              TOTALLY UNNECESSARY BUT SAFE
F86F D9       7190        EXX
F870 2A70F8   7200        LD   HL,(HLSAV) ; AND THE HL' REGISTERS
F873 D9       7210        EXX  ;              NOTE THAT THE 16K R.O.M. IS NOW
F874 C374F8   7220        JP   LORET ;        PAGED IN, BECAUSE OF THE RETURN VIA
              7230 ;                        A BASIC ERROR IN THE 16K R.O.M.
```

Pass 2 errors: 00

```
*WARNING* RSWAP absent
*WARNING* MHEAD absent
*WARNING* VARSET absent
*WARNING* HLSAV absent
*WARNING* LORET absent
Table used:    99  from   188
```

```
Pass 1 errors: 00

F877            7240        ORG  #F877
F877 21D95C     7250 VARSET LD   HL,23769 :    THIS IS DETAILED FULLY IN CHAPTER 3
F87A 364D       7260        LD   (HL),"M"
F87C 210A00     7270        LD   HL,10
F87F 22DA5C     7280        LD   (23770),HL
F882 2172F9     7290        LD   HL,SCHAR+1
F885 22DC5C     7300        LD   (23772),HL
F888 210100     7310        LD   HL,1
F88B 22D65C     7320        LD   (23766),HL
F88E C9         7330        RET
                7340 :
                7350 :
                7360 :
                7370 : THIS IS THE ROUTINE TO LOAD FROM A MICRODRIVE
                7380 : FULL DETAILS ARE GIVEN IN CHAPTER 3
                7390 :
                7400 :
F88F 010000     7410 MLOAD  LD   BC,0 :         THE DETAILS ON THE HEADER ARE TO
F892 CD92F8     7420        CALL RSWAP :        BE USED AS THEY ARE NOT KNOWN
F895 CDA5F8     7430        CALL MHEAD
F898 CD77F8     7440        CALL VARSET
F89B FDCB7CE6   7450        SET  4,(IY+124) :   THIS SIGNALS LOAD
F89F CDAF08     7460        CALL #8AF :         CALL THE LOAD ROUTINE
F8A2 C3A2F8     7470        JP   MSLRET :       IN FACT IT IS UNLIKELY TO GET HERE
                7480 :
                7490 :
                7500 :
                7510 : THIS SETS THE MICRODRIVE HEADER, FULL DETAILS ARE IN
                7520 : CHAPTER 3
                7530 :
                7540 :
F8A5 21E65C     7550 MHEAD  LD   HL,23782
F8A8 3603       7560        LD   (HL),3
F8AA 23         7570        INC  HL
F8AB ED5B5CF9   7580        LD   DE,(BCSAV)
F8AF 73         7590        LD   (HL),E
F8B0 23         7600        INC  HL
F8B1 72         7610        LD   (HL),D
F8B2 23         7620        INC  HL
F8B3 112E75     7630        LD   DE,29998
F8B6 73         7640        LD   (HL),E
F8B7 23         7650        INC  HL
F8B8 72         7660        LD   (HL),D
F8B9 23         7670        INC  HL
F8BA 3680       7680        LD   (HL),#80
F8BC C9         7690        RET
                7700 :
                7710 :
                7720 :
                7730 :
                7740 : THE LOAD DECISION BETWEEN MICRODRIVE AND TAPE
                7750 :
                7760 :
                7770 : LOADING FROM TAPE AS DETAILED IN CHAPTER 2
                7780 :
F8BD C1         7790 LOAD   POP  BC
F8BE CD05F9     7800        CALL M_OR_T
F8C1 38CC       7810        JR   C,MLOAD
F8C3 AF         7820 TLOAD  XOR  A :            SIGNAL HEADER
F8C4 37         7830        SCF  :              SIGNAL LOAD
F8C5 110D00     7840        LD   DE,13
F8C8 14         7850        INC  D
F8C9 08         7860        EX   AF,AF'
F8CA 15         7870        DEC  D
F8CB F3         7880        DI
F8CC DD2180F9   7890        LD   IX,SCHAR+15
F8D0 CD6205     7900        CALL #562
F8D3 FB         7910        EI
```



```
F8D4 CD541F     7920        CALL 8020
F8D7 D0         7930        RET  NC :           BREAK PRESSED
F8D8 DD2171F9   7940 TESTHE LD   IX,SCHAR :    THE HEADER NAME IS NOW CHECKED
F8DC 2180F9     7950        LD   HL,SCHAR+15
F8DF 0608       7960        LD   B,11
F8E1 7E         7970 TESTLP LD   A,(HL)
F8E2 DDBE00     7980        CP   (IX+00)
F8E5 20DC       7990        JR   NZ,TLOAD :     MISMATCH SO WRONG HEADER
F8E7 DD23       8000        INC  IX :           THE HEADER MATCHES SO DO THE LOAD
F8E9 23         8010        INC  HL
F8EA 10F5       8020        DJNZ TESTLP
F8EC DD212E75   8030        LD   IX,29998
F8F0 5E         8040        LD   E,(HL)
F8F1 23         8050        INC  HL
F8F2 56         8060        LD   D,(HL)
F8F3 37         8070        SCF  :              SIGNAL LOAD
F8F4 3EFF       8080        LD   A,#FF :        MAIN DATA BLOCK
F8F6 14         8090        INC  D
F8F7 08         8100        EX   AF,AF'
F8F8 15         8110        DEC  D
F8F9 F3         8120        DI
F8FA CD6205     8130        CALL #562
F8FD FB         8140        EI
F8FE CD541F     8150        CALL 8020
F901 D0         8160        RET  NC :           BREAK PRESSED
F902 C325F9     8170        JP   LORET :        LOADED SO RE-ENTER
                8180 :
                8190 :
                8200 :
                8210 : THIS ROUTINE ASKS FOR THE FILENAME AND IF MICRODRIVE
                8220 : OR TAPE IS TO BE USED
                8230 :
                8240 :
F905 CD2EF9     8250 M_OR_T CALL SAVET
F908 C5         8260        PUSH BC
F909 DDE5       8270        PUSH IX
F90B 3E0C       8280        LD   A,12
F90D CD0DF9     8290        CALL PRINAT
F910 3E7F       8300 MIORTA LD   A,#7F
F912 DBFE       8310        IN   A,(#FE)
F914 E604       8320        AND  4
F916 37         8330        SCF
F917 2808       8340        JR   Z,MOTFIN
F919 3EFB       8350        LD   A,#FB
F91B DBFE       8360        IN   A,(#FE)
F91D E610       8370        AND  16
F91F 20EF       8380        JR   NZ,MIORTA
F921 DDE1       8390 MOTFIN POP  IX
F923 C1         8400        POP  BC
F924 C9         8410        RET
                8420 :
                8430 :
                8440 :
                8450 : THIS PICKS UP THE LENGTH DETAILS FROM THE
                8460 : START OF THE MEMORY LOADED
                8470 : OR FROM WHAT WAS PUT THERE WHEN IT WAS SAVED
                8480 :
F925 2A2E75     8490 LORET  LD   HL,(29998)
F928 2260F9     8500        LD   (CHPOS),HL
F92B C32BF9     8510        JP   USR
                8520 :
                8530 :
                8540 :
                8550 : THIS ROUTINE CREATES A HEADER IN THE SCHAR AREA OF MEMORY
                8560 :
                8570 :
F92E 2171F9     8580 SAVET  LD   HL,SCHAR
F931 C5         8590        PUSH BC
F932 E5         8600        PUSH HL
F933 E5         8610        PUSH HL
```

```
F934 3603       8620        LD   (HL),3
F936 C5         8630        PUSH BC
F937 060A       8640        LD   B,10
F939 3E20       8650        LD   A,32
F93B 23         8660 SETHED INC  HL
F93C 77         8670        LD   (HL),A
F93D 10FC       8680        DJNZ SETHED
F93F E5         8690        PUSH HL
F940 2264F9     8700        LD   (IN_LIM),HL
F943 E1         8710        POP  HL
F944 C1         8720        POP  BC
F945 23         8730        INC  HL
F946 71         8740        LD   (HL),C
F947 23         8750        INC  HL
F948 70         8760        LD   (HL),B
F949 CD6B0D     8770        CALL 3435
F94C 3E0D       8780        LD   A,13
F94E CD4EF9     8790        CALL PMESS
F951 E1         8800        POP  HL
F952 23         8810        INC  HL
F953 CD53F9     8820        CALL INPUTF
F956 3620       8830        LD   (HL),32
F958 DDE1       8840        POP  IX
F95A C1         8850        POP  BC
F95B C9         8860        RET
                8870 ;
                8880 ;
                8890 ;
F95C 0000       8900 BCSAV  DEFW 0
F95E 0000       8910 CUPOS  DEFW 0
F960 3175       8920 CHPOS  DEFW 30001
F962 0000       8930 HLSAV  DEFW 0
F964 0000       8940 IN_LIM DEFW 0
F966 30F2       8950 LIMIT  DEFW 62000
F968 0000       8960 LOCCNT DEFW 0
F96A 0000       8970 LOCFND DEFW 0
F96C 00         8980 WFLAG  DEFB 0
F96D 3175       8990 MEMPOS DEFW 30001
F96F 211B       9000 CURSP  DEFW #1B21
F971            9010 SCHAR  DEFS 33
F992 80         9020 MESSM1 DEFB #80
F993 80         9030 MESS   DEFB #80
F994 44654241   9040 MESS1  DEFM "DeBASE COPYRIGHT SGH 1984"
F9AD 8D         9050        DEFB #8D
F9AE 1001       9060 MESS2  DEFW #110
F9B0 50524553   9070        DEFM "PRESS SPACE TO ABORT"
F9C4 0D         9080        DEFB 13
F9C5 5820544F   9090        DEFM "X TO ERASE OR N FOR NEXT RECORD"
F9E4 1000       9100        DEFW #10
F9E6 8D         9110        DEFB #8D
F9E7 1002       9120 MESS3  DEFW #210
F9E9 4E4F5420   9130        DEFM "NOT FOUND"
F9F2 1000       9140        DEFW #10
F9F4 8D         9150        DEFB #8D
F9F5 1001       9160 MESS4  DEFW #110
F9F7 20202020   9170        DEFM "                MENU"
FA0A 0D0D       9180        DEFW #0D0D
FA0C 50524553   9190        DEFM "PRESS"
FA11 0D0D       9200        DEFW #0D0D
FA13 46202020   9210        DEFM "F       TO FIND"
FA21 0D0D       9220        DEFW #0D0D
FA23 45202020   9230        DEFM "E       TO ERASE"
FA32 0D0D       9240        DEFW #0D0D
FA34 43202020   9250        DEFM "C       TO CONTINUE SEARCH"
FA4D 0D0D       9260        DEFW #0D0D
FA4F 454E5445   9270        DEFM "ENTER   TO MAKE ANOTHER ENTRY"
FA6B 0D0D       9280        DEFW #0D0D
FA6D 53202020   9290        DEFM "S       TO SAVE OR LOAD"
FA83 1000       9300        DEFW #10
FA85 8D         9310        DEFB #8D
```



```
FA86 454E5445   9320 MESS5  DEFM "ENTER DETAILS TO FIND"
FA9B 8D         9330        DEFB #8D
FA9C 1002       9340 MESS6  DEFW #210
FA9E 0D         9350        DEFB 13
FA9F 454E4420   9360        DEFM "END OF RECORD, NO MORE INPUT"
FABB 0D         9370        DEFB 13
FABC 504F5353   9380        DEFM "POSSIBLE"
FAC4 8D         9390        DEFB #8D
FAC5 1001       9400 MESS7  DEFW #110
FAC7 50524553   9410        DEFM "PRESS "
FACD 1002       9420        DEFW #210
FACF 53544F50   9430        DEFM "STOP "
FAD4 1001       9440        DEFW #110
FAD6 464F5220   9450        DEFM "FOR MENU, "
FAE0 1002       9460        DEFW #210
FAE2 02         9470        DEFB 2
FAE3 544F20     9480        DEFM "TO "
FAE6 1001       9490        DEFW #110
FAE8 544F2050   9500        DEFM "TO PRINTOR "
FAF3 1002       9510        DEFW #210
FAF5 53544550   9520        DEFM "STEP "
FAFA 1001       9530        DEFW #110
FAFC 464F5220   9540        DEFM "FOR HELP"
FB04 A0         9550        DEFB #A0
FB05 1003       9560 MESS8  DEFW #310
FB07 594F5520   9570        DEFM "YOU ARE IN EDIT MODE"
FB1B 8D         9580 MC9    DEFB #8D
FB1C 1002       9590 MESS9  DEFW #210
FB1E 594F5520   9600        DEFM "YOU JUST RAN OUT OF MEMORY"
FB38 0D         9610        DEFB 13
FB39 53415645   9620        DEFM "SAVE THE RECORDS OR SOMETHING"
FB56 1000       9630        DEFW #10
FB58 8D         9640        DEFB #8D
FB59 5748454E   9650 MESS10 DEFM "WHEN YOU ARE IN EDIT MODE"
FB72 0D         9660        DEFB 13
FB73 50524553   9670        DEFM "PRESSING "
FB7C 1002       9680        DEFW #210
FB7E 4E4F5420   9690        DEFM "NOT "
FB82 1000       9700        DEFW #010
FB84 57494C4C   9710        DEFM "WILL FIND THE NEXT OCCURENCE OF THE LAST STRING"
FBB3 20202020   9720        DEFM "    THAT WAS SOUGHT"
FBC6 0D0D       9730        DEFW #0D0D
FBC8 1002       9740        DEFW #210
FBCA 414E4420   9750        DEFM "AND "
FBCE 1000       9760        DEFW #010
FBD0 57494C4C   9770        DEFM "WILL INSERT A CHARACTER"
FBE7 0D         9780        DEFB 13
FBE8 41542054   9790        DEFM "AT THE CURRENT CURSOR POSITION."
FC07 0D0D       9800        DEFW #0D0D
FC09 44454C45   9810        DEFM "DELETE WILL REMOVE THE CHARACTER"
FC29 0D         9820        DEFB 13
FC2A 41542054   9830        DEFM "AT THE CURRENT CURSOR POSITION."
FC49 0D0D       9840        DEFW #0D0D
FC4B 49462054   9850        DEFM "IF THERE IS NO SPACE IN A RECORD"
FC6B 0D         9860        DEFB 13
FC6C 594F5520   9870        DEFM "YOU ARE ALTERING USE THE INSERT"
FC8B 0D         9880        DEFB 13
FC8C 4E554E43   9890        DEFM "FUNCTION TO MAKE SOME SPACE."
FCAB 0D0D       9900        DEFW #0D0D
FCAA 54484520   9910        DEFM "THE CURSOR KEYS ALLOW YOU TO"
FCC6 0D         9920        DEFB 13
FCC7 4D4F5645   9930        DEFM "MOVE THROUGH THE TEXT BUT YOU"
FCE4 0D         9940        DEFB 13
FCE5 43414E4E   9950        DEFM "CANNOT GO BACK PAST AN ENTER."
FD02 0D0D       9960        DEFW #0D0D
FD04 1004       9970        DEFW #410
FD06 50524553   9980        DEFM "PRESS ENTER TO RETURN TO TEXT"
FD23 1000       9990        DEFW #10
FD25 8D        10000        DEFB #8D
FD26 50524553 10010 MESS11 DEFM "PRESS S TO SAVE L TO LOAD"
```

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FD3F 8D         10020           DEFB #8D
FD40 50524553 53 10030 MESS12   DEFM "PRESS M FOR M/DRIVE"
FD53 0D         10040           DEFB 13
FD54 4F522054 41 10050          DEFM "OR T FOR TAPE"
FD61 8D         10060           DEFB #8D
FD62 494E5055 54 10070 MESS13   DEFM "INPUT FILE-NAME"
FD71 8D         10080           DEFB #8D
FD72 8D         10090 ZEND      DEFB #8D

Pass 2 errors: 00

*WARNING* RSWAP absent
*WARNING* MSLRET absent
```

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