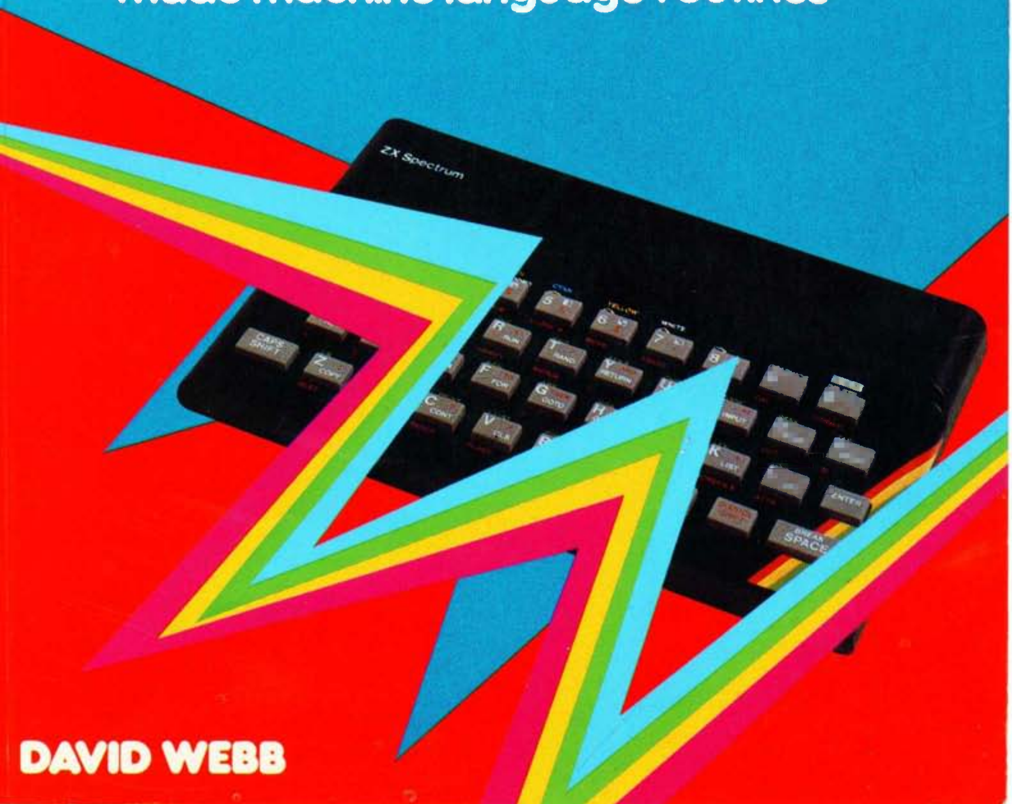
SUPER CHARGE YOUR SPECTRUM

Extend your Spectrum with ready-made machine language routines



DAVID WEBB

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SPECIAL NOTE

The programs and routines in this book represent a very unusual willingness on the part of a machine language programmer to disclose exactly how his routines are written.

David Webb has done so from a desire to help other programmers develop their own programs and to teach machine language programming by example. They are intended to be used as a tool for learning and for use in your own personal programs.

However, it is not the intention that these routines be used in any commercially produced programs, and we would like you to note that these programs and routines are covered by the laws of copyright.

After reading and working through this book, I am sure you will agree that David Webb has produced a work that will be of great assistance to Spectrum programmers everywhere.

Best regards,

Alfred Milgrom
Publisher

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PREFACE

Any reader who has purchased one of the multitude of machine-coded arcade games available for the ZX Spectrum will appreciate the vast difference in speed and power between machine language and BASIC programs. Until now the only way for a BASIC Programmer to achieve this power has been to 'buckle down' to the ominous task of actually learning to "speak the lingo".

In this book I aim to make machine code techniques freely available to the BASIC programmer without him or her needing to worry about how they work. Each of the routines is a small, self-contained block of machine code with full instructions on how to use it. In the first two chapters I provide all the information, programs and simple techniques you'll need to use the rest of the book. No knowledge of machine code is necessary, but for the reader who has such knowledge I have included a fully commented assembly mnemonic listing for each routine.

In response to the many requests I have seen for a full list of useful POKES and system variables on the ZX Spectrum, I have included the appropriate information in this book. Also included are machine language solutions to the problem of recognising graphic characters with the SCREEN$ function, and to that of using the erroneous PAUSE command.

I would like to extend my thanks to the following people:
- Mum and Dad, for seventeen years of unbelievable tolerance.

- Alfred Milgrom, my publisher, for his support and encouragement.

- My teachers at Woking 6th form College, for ignoring the slight absence of homework on the five A-levels and two S-levels for which I was studying while writing this book.

DAVID M. WEBB
WOKING, ENGLAND
JULY 1983

GETTING STARTED

CHAPTER 1
USING THE ROUTINES:- ALL YOU NEED TO KNOW

Unless you are fluent in machine code and have your own machine code monitor program, you will need to read this chapter and the next which contain all the information and programs necessary to use the routines in the rest of the book.

First let me explain a few simple ideas. Your computer probably has either 16K or 48K of Random Access Memory (RAM) in it, together with a 16K Read Only Memory (ROM) which houses the large machine language program that makes the Spectrum work in BASIC. The 'K' stands for 'Kilobyte', and one may be forgiven for equating this to 1000 bytes. In actual fact, because of the way computers count in binary (i.e. multiples of 1, 2, 4, 8...) 'Kilo-' means 2^{10} or 1024, so each 'K' of memory contains 1024 bytes. Each byte is like my bank account; it can store a whole number between 0 and 255. Now the computer needs to know where each of these numbers is stored, so it gives each byte a unique number which we call an ADDRESS (like a bank account no.).

The commands 'PEEK' and 'POKE' simply 'find out' and 'change' what is stored at a specified address, so entering the command:

```
PRINT PEEK 0
```

tells us what number is stored at the first address in the ROM (in the case of the Spectrum, 243).

The ZX-Spectrum has what is known as an eight-bit microprocessor, the Z-80A. This is the real 'brain' of the computer, the part which obeys all the machine language instructions in the ROM and RAM. Microprocessors do not work in BASIC. (BASIC is what is known as a 'high-level' language). It is easy for we mortals to write programs in BASIC, but in order for the microprocessor to understand our commands they have to be "translated" into a machine language program. The BASIC INTERPRETER breaks down the BASIC into a set of 'low-level' machine language instructions which can then be executed by the Z-80A.

All of this 'interpretation' takes time, a great deal in fact, which is why by writing out programs directly in machine language we can achieve an average speed increase in the order of 100 times.

In order to fetch data and instructions from the memory, the microprocessor must send the address of the required byte along what is known as the ADDRESS BUS. There are only 16 lines or 'seats' on this bus, and so the address can only be two Bytes long. (Eight bits per byte, one line per bit and each bit set to 1 or 0.)

The highest number that we can represent in two bytes is 65535, produced by filling both bytes with the 255 maximum. We let one byte count the 'units' (the LO byte of the address) and the other byte count the multiples of 256 (the HI byte). So

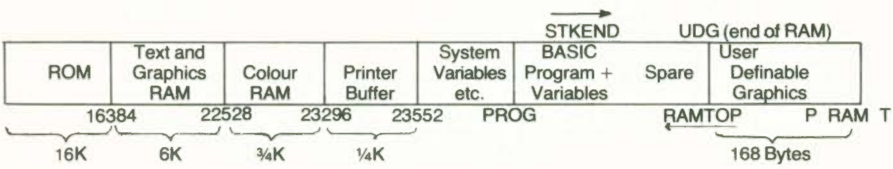
```
(255 x 256) + 255 = 65535
 HI            LO
```

The lowest number we can represent is, of course, zero, when both the hi and lo byte are zero. The concept of 'hi' and 'lo' bytes can be analogised to 'tens' and 'units' when we count in normal decimal arithmetic. We say then that

```
27 = (2 x 10)     + 7
     HI byte      LO byte
```

Now we can see that the maximum number of memory addresses that the Z-80A with its 16-bit address bus can access is 65536. On the Spectrum, addresses 0 to 16383 (the first 16K) are taken up by the ROM. 16K of RAM follows on from address 16384 to 32767, the first 6.75K of which is used up for screen memory. Finally, if you have a 48K machine, the last 32K of addresses up to 65535 are consumed by the extra RAM.

This allocation of addresses can be shown with a MEMORY MAP. Here is a memory map showing the areas we are chiefly concerned with (a more complete memory map can be found on page 165 of the official manual).



As you can see, between the BASIC area and the only thing normally in 'high memory', the user-definable graphics, is whatever spare memory you may have. Normally this is decreased by increasing the length of your program and/or producing larger BASIC variables (letting the program 'grow upwards' in memory). You can, however use up this spare memory by lowering the pointer shown as RAMTOP, beyond which no BASIC program is allowed to expand (the TOP of BASIC RAM). This operation has the effect of reserving and protecting the memory space between RAMTOP and UDG, which is another pointer indicating the start of the user graphics.

The values of these pointers are stored in the 'system variables' area. RAMTOP can be found by the command

```
PRINT PEEK 23730 + 256 * PEEK 23731
```

and will be 32599 on a 16K Spectrum or 65367 on a 48K machine at power-up.

UDG can be found with

```
PRINT PEEK 23675 + 256 * PEEK 23676
```

but far more easily with the command

```
PRINT USR "a"
```

Since this returns the address of the first user-defined character, "graphic a" which is naturally enough at the start of the user-definable graphics area. The value of UDG will be 32600 or 65368 at power-up, thereby showing that there is normally no space between RAMTOP and UDG.

To alter the value of RAMTOP we simply use the command CLEAR n, where n is the new address for RAMTOP.

When we have lowered RAMTOP with a CLEAR command then an area of memory between RAMTOP and UDG has been reserved, and it is in this space that we usually put machine code. Everything that is stored above RAMTOP is completely unaffected by anything we do in BASIC other than a POKE, which alters the contents of a specified address, including a NEW command. This means that we can store machine-code utility routines such as a 'renumber' program, above RAMTOP and never have to worry about losing them when we LOAD up a different program or do a NEW.

Machine Code in its raw form is simply a collection of numbers that the microprocessor interprets as instructions and obeys accordingly. We choose to represent these numbers in a form known as HEXADECIMAL, or base 16 (HEX for six, DEC for ten). We use the symbols 0 to 9 and A to F (for ten to fifteen), and with two hex. digits we can represent the numbers 0 to 255, or 00 to FF in hex.

All of the machine code routines in this book have a HEX LISTING; it is this column of hex numbers which should be typed into the computer. To make life easier we use a MONITOR program which supervises the entry of machine code and lets you do things like list entered code, save it, alter it and load it back from tape.

Below you will find a monitor program which I have called HEXAID. It will enable you to type in hex routines and manipulate them to your heart's content. It may seem a little long, but it is essential to the rest of the book. I will explain how to use it when you have typed it in!

```
 100 REM Hexaid (c) David M. Web
b 1982
 110 POKE 23658,8: CLS : GO SUB
870: PRINT '"Menu:"
 120 PRINT '"[1]:WRITE a new rou
tine"
 130 PRINT '"[2]:ALTER a routine
"
 140 PRINT '"[3]:LIST Hex. code"
 150 PRINT '"[4]:SAVE a routine"
 160 PRINT '"[5]:LOAD a routine"
 170 PRINT '"[6]:STOP this progr
am"
 180 PRINT '"[7]:CLEAR the machi
ne code area"
 190 PRINT #0;AT  1,0;"Please pr
ess appropriate key."
 200  IF INKEY$<>"" THEN  GO TO
200
 210 LET g$=INKEY$: IF g$="" OR
g$<"1" OR g$>"7" THEN  GO TO 210
 220 IF g$="6" THEN  STOP
 230 CLS : GO SUB 870: GO SUB 93
0
 250 GO TO (270 AND G$="1")+(460
 AND G$="2")+(500 AND G$="3")+(5
90 AND G$="4")+(710 AND G$="5")+
(820 AND G$="7")
 260 REM WRITE a new routine
 270 INPUT "Length of routine:";
 LINE a$: GO SUB M
 280 CLEAR RAMTOP-VAL  a$: GO SU
B 870: GO SUB 930:
 290 LET d=RAMTOP+1
 300 LET a$=""
 310 IF a$="" THEN  INPUT "Enter
 hex. code.";a$
 320 GO SUB M
 330 IF LEN a$/2<>INT (LEN a$/2)
 THEN  PRINT "Incorrect entry";:
 GO TO 300
```

```
 350 LET C=0: FOR f=1  TO  16 ST
EP 15
 360 LET a=CODE a$(1+(F=1))
 370 IF a<48 OR a>70 OR a>57 AND
 a<65 THEN  PRINT "Incorrect ent
ry";: GO TO 300
 380 LET c=c+f*((a<58)*(a-48)+(a
>64 AND a<71)*(a-55)): NEXT f
 400 POKE d,c: LET d=d+1
 410 PRINT a$( TO 2);"  ";
 420 LET a$=a$(3 TO )
 430 IF d=USR "a" THEN  PRINT "W
arning:you are now in user"'"gra
phic area!": GO TO 300
 440 GO TO 310
 450 REM ALTER a routine
 460 PRINT "Alter from address:"
;: INPUT  LINE a$: GO SUB M
 470 LET d=VAL a$: PRINT d
 480 GO TO 300
 490 REM LIST hex code
 500 LET b$="0123456789ABCDEF"
 510 PRINT '"list address:";: IN
PUT  LINE a$: GO SUB M: LET d=VA
L a$
 520 PRINT AT 4,22;"press";AT 7,
0;
 530 LET a=INT (PEEK d/16): LET
b=PEEK d-16*A
 540 PRINT d;TAB 7;b$(a+1);b$(b+
1)
 550 LET d=d+1
 560 IF INKEY$="M" THEN  RUN
 570 GO TO 530
 580 REM SAVE a routine
 590 PRINT '"save from address:"
;: INPUT  LINE a$: GO SUB M: LET
 a=VAL a$: PRINT a
 600 PRINT '"Length of routine:"
;: INPUT  LINE a$: GO SUB M: PRI
NT VAL A$
 610 PRINT '"Name of routine:";:
 INPUT n$: PRINT n$
 620 SAVE n$CODE a,VAL a$
 630 PRINT '"Do you wish to veri
fy (Y\N)?";
 640 PAUSE 0: LET v$=INKEY$: PRI
NT v$
 650 IF v$<>"Y" THEN  RUN
 660 PRINT '"Rewind and press ""
PLAY."""
 670 VERIFY n$CODE
 680 PRINT '"O.K.": PAUSE 50: RU
N
```

```
 700 REM LOAD a routine
 710 PRINT '"Shall I make extra
room in the"'"machine code area
(Y/N)?"
 720 IF INKEY$<>"" THEN  GO TO 7
20
 730 LET a$=INKEY$: IF a$="" THE
N  GO TO 730
 750 GO SUB M: IF a$<>"Y" THEN
GO TO 770
 760 INPUT "How many bytes?"; LI
NE a$: GO SUB M: CLEAR RAMTOP-VA
L a$: GO SUB 870: GO SUB 930
 770 PRINT '"Load to address:";:
 INPUT  LINE a$: GO SUB M: PRINT
 a$
 780 PRINT '"Routine name:";: IN
PUT n$: PRINT n$
 790 PRINT '"Press ""PLAY"" on t
ape."
 800 LOAD n$CODE VAL a$: GO TO 6
80
 810 REM  CLEAR the machine code
 area
 820 PRINT '"Are you sure (Y/N)?
"
 830 IF INKEY$<>"" THEN  GO TO 8
30
 840 LET a$=INKEY$: IF a$="" THE
N  GO TO 840
 850 IF a$<>"Y" THEN  RUN
 860 CLEAR USR "A"-1: RUN
 870 REM SETUP
 880 LET RAMTOP=PEEK 23730+256*P
EEK 23731
 900 PRINT "Start of M.C. area="
;RAMTOP+1
 910 PRINT '"Length of M.C. area
=";USR "A"-RAMTOP-1;" bytes."
 920 LET M=940: RETURN
 930 PRINT '"To return to the me
nu,enter ""M"".": RETURN
 940 IF a$="M" THEN  RUN
 950 RETURN
```

You are advised to save HEXAID before you go any further.

Hexaid works with the CAPS LOCK on: be careful not to go into lower case while you are running it. When the program is RUN it presents you with a menu of seven options. The first and most important is 'Write a new routine'. On selecting this you are asked to enter the length of the routine. This is the number of bytes of code in the 'HEX' column in each routine's listing, and is always found at the top right-hand corner of the listing.

When you INPUT the length the program automatically moves down RAMTOP with a CLEAR command (line 280) and thereby makes exactly enough space in the machine code area for the routine. (Between RAMTOP & UDG) You are then asked to "enter hex code". In response to this you simply read off the 'HEX' column of the routine and enter it into the program as many bytes at a time as you like, working across and down the column.

When you enter the length of the routine, the 'start of M.C. Area', printed at the top of the screen always decreases by the length of the routine. Make sure that you always note down this new value, as this is the START ADDRESS or "address of the first byte" of your routine, and will be used with the USR function later on.

When you have finished entering all the hex code for a routine, it is wise to check the printout on the screen against the listing in the book. The slightest error, a 3 entered instead of an 8 or an 8 instead of a B can change the entire meaning of an instruction and cause the computer to 'crash'. This doesn't do any permanent damage to your computer, if it happens, just 'reset' and start again.

You can list the routine at any time by returning to the menu, choosing option 3; 'list hex code' and entering the start address. This will induce a column of hex code with its locations to appear on the screen.

If you find that you have made an error in the hex. code then note down the address of the 'rogue' byte(s) from the 'list' option, return to the menu (by pressing 'm') and choose option 2: 'Alter a routine'.

Here again you are asked to input the address of the rogue byte(s) and then the hex code, to which you should reply with the corrected byte(s).

When you are satisfied that the code is correct, select option 4 in order to SAVE the routine to tape. You are asked successively for the start address, the length and the name of the routine; the latter should, as usual, not be longer than ten characters. The essential part of this section is the SAVE ... CODE command in line 620. What this does is to save a specified number of bytes of machine code from a specified start address. You could, in fact, perform exactly the same operation by entering, in immediate mode:

SAVE "(routine name)" CODE (start address), (routine length).

Hexaid then gives you the option of VERIFYING, again based on the simple command in line 670; equivalent to

VERIFY "(routine name)" CODE

Note that if the start address and routine length have not been altered then they need not be specified in the VERIFY command.

Option 5: "load a routine" lets you LOAD back a routine from tape. It is particularly useful if you have found that a routine you were using crashed the machine, as this usually means that you made a mistake in the hex. code and will need to LOAD it back, in order to detect the 'bug'.

On choosing the option you are asked if you want to make extra room in the machine code area. If the length of the M.C. area is longer than or equal to your routine and you don't mind overwriting part of what is already in that area then the answer is "no". If, however, the M.C. area is shorter than your routine or you don't want to alter what is already there then you do want to expand the M.C. area (answer Y).

If the answer was 'Y' then you must input the number of bytes by which the M.C. area is to be lengthened. This is usually equal to the length of the routine. The program will lower RAMTOP to the required address (1 less than the "start of M.C. area").

Finally you are asked "Load to address:" to which you will probably reply with the start of the M.C. area, as displayed at the top of the screen.

The essential part of this section is line 800, which can be emulated with the direct command

```
LOAD "(routine name)" CODE (start address)
```

You can make room for and load machine code from within your own programs by 'tagging on' a few simple lines:

```
9900 LET RAMTOP = PEEK 23730 + 256*PEEK 23731
9910 RETURN
9920 GOSUB 9900 : CLEAR RAMTOP - (routine
                  length)
9930 GOSUB 9900 : LOAD "(routine name)" CODE
                  RAMTOP+1
9940 RUN
```

Line 9920 makes room; line 9930 loads. The start address of the routine will now be RAMTOP + 1.

The last two options in Hexaid are option 6: "stop the program" and option 7: "clear the machine code area". The latter should be used with great care, as it will reset RAMTOP to its original position, immediately below the user graphics area, thereby deleting all of the machine code present. For this reason I have incorporated line 820; "are you sure?". So if you accidentally hit the 7 key all will not be lost. The essential line is 860, which CLEARS RAMTOP to USR "a" (UDG) minus one.

USING THE ROUTINES

All of the routines in this book have specific instructions with them that will enable you to use them to the full, so I will only talk in general terms here.

Many of the longer routines require some data in order to work, such as the corners of a rectangle for 'scrolling' routines or the first line number in a 'renumber' routine. This is either POKEd into the routine, or, more usually, into the PRINTER BUFFER, which is 256 bytes long from address 23296. As you might imagine, the printer also uses this memory, so if you use the printer while using the routines then any data will be lost and must be POKEd in again before CALLING the routine.

To CALL a routine means to execute it, and this is always done with the USR function, which is usually incorporated in a RAMDOMIZE or LET statement, thus:

```
      RANDOMIZE USR (start address)
or    LET L = USR   (start address)
```

USING HEXAID: A WORKING EXAMPLE

In order for you to practice using the Hexaid program and the techniques I have taught you to date, here is a short routine for you to enter.

```
HEX.      ;MYSTERY ROUTINE: LENGTH: 39 BYTES
3E02      MYSTERY LD      A,2
CD0116            CALL    1601H
3E12              LD      A,12H
D7                RST     10H
3E01              LD      A,1
D7                RST     10H
3E57              LD      A,57H
D7                RST     10H
3E45              LD      A,45H
D7                RST     10H
3E4C              LD      A,4CH
D7                RST     10H
3E4C              LD      A,4CH
D7                RST     10H
3E20              LD      A,20H
D7                RST     10H
3E44              LD      A,44H
D7                RST     10H
3E4F              LD      A,4FH
D7                RST     10H
3E4E              LD      A,4EH
D7                RST     10H
3E45              LD      A,45H
D7                RST     10H
C9                RET
                  END
```

Using option one of Hexaid, the "length of routine" will be 39 bytes. If the M.C. area was previously of zero length, then its length should now be 39 bytes and the start address of the routine and the M.C. area should be 32561 (16K) or 65329 (48K).

When you have SAVEd the routine using option four, you are ready to call the routine with

```
     RANDOMIZE USR 32561 (16K)
or   RANDOMIZE USR 65329 (48K)
or   RANDOMIZE USR (start address), if your start address is
```

different to the ones above. If you have done all this successfully, a brief message will appear on the screen. If not, then load the routine with option five and use options three and two to correct the code.

CHAPTER 2
BUILDING A DEDICATED TOOLKIT FROM A LIBRARY OF ROUTINES

To prevent yourself having to type in the same routines with Hexaid every time you want to use them for a different BASIC program, it is obviously a good idea to build up a 'library' of your favourite routines, adding to it with Hexaid each time you use a new routine. Then whenever you start writing a new program you can just select the routines that you think you will need and put them together in one 'Dedicated Toolkit', (a block of routines that has been purpose-designed for one particular program).

To help you to do that, I have written a program that reads the 'headers' in front of each routine on tape and then presents you with a 'catalogue' of all the routines, along with the addresses that they were saved from and their lengths. After each routine has been 'read' you have the option of stopping the catalogue and loading up any of the previous routines under program control or stopping the program altogether. In this way you can scan through the tape, picking up the routines that you want until you have a complete dedicated toolkit.

Before I go any further I'll let you have the listing. It's quite a long one, but it will save you a great deal of time in the long run (you can, of course, omit all the REMs).

```
   10 REM ROUTINE SELECTOR
   20 REM © DAVID M. WEBB,1983
   30 REM WARNING ONLY RUN THIS O
NCE. USE GOTO 100 THEREAFTER TO
 RE-ENTER PROGRAM
```

```
  40 POKE 23658,8: REM  PROGRAM
WILL ONLY WORK WHILE CAPS LOCK I
S ON
  50 REM CREATE M.C. AREA AND IN
ITIALIZE POINTERS
  60 GO SUB 420 : CLEAR RT-3000:
 GO SUB 420: LET MC=RT+3001: LET
 MCL=0: LET N=MCL: LET NB=MCL
  70 GO SUB 310: LET F=50: DIM A
$(F,10): DIM B$(F,10): DIM S(F):
 DIM T(F): DIM L(F): DIM M(F): R
EM F=NO. OF FILES
  80 REM A$,B$ HOLD NAMES,(S),(T
) HOLD START ADDRESSES,(L),(M)HO
LD LENGTHS.
  90 REM USE"GOTO100" TO REPRINT
 CATALOG
 100 PRINT TAB 8; INVERSE 1;"ROU
TINE CATALOG."'': PRINT " FILENA
ME";TAB 12;"FROM ADDRESS";TAB 26
;"LENGTH"
 110 FOR A=1 TO N: GO SUB 410: N
EXT A: REM PRINT CATALOG
 120 GO SUB 450: GO SUB 350
 130 LET N=N+1: LET A$(N)=N$: LE
T S(N)=S: LET L(N)=L
 140 LET A=N: GO SUB 410
 150 INPUT "": PRINT #0;"PRESS S
 NOW TO STOP CATALOG."
 160 FOR A=0 TO 400: IF INKEY$="
S" THEN  GO TO 180
 170 NEXT A: INPUT "": GO TO 120
 180 INPUT "LOAD A ROUTINE OR ST
OP PROGRAM (L/S)?";X$
 190 IF X$(1)="S" THEN  STOP
 200 POKE 23658,0: INPUT "PROUTI
NE NAME?";X$: POKE 23658,8
 210 LET X$=X$+"          "( TO
10-LEN X$): REM 10 SPACES
 220 FOR A=1 TO N: IF X$=A$(A) T
HEN  GO TO 240
 230 NEXT A: PRINT "NOT FOUND:-P
LEASE RETYPE": BEEP .25,10: GO T
O 200
 240 PRINT : GO SUB 410: GO SUB
430
 250 PRINT "OPTIONS:"'"[1] STAND
ARD LOAD INTO M.C. AREA[2] LOAD
TO THE SAVED ADDRESS    [3] SPECI
FY YOUR OWN ADDRESS."
 260 INPUT "CHOICE:";X$: LET V=V
AL X$: IF V<1 OR V>3  THEN  GO T
O 260
```

```
 270 IF V=1 THEN  LET MC=MC-L(A)
: LET MCL=MCL+L(A): LET S=MC: GO
 TO 300
 280 IF V=2 THEN  LET S=S(A): GO
 TO 300
 290 INPUT "LOAD TO ADDRESS.";S
 300 GO SUB 450: LOAD A$(A)CODE
S,L(A): LET NB=NB+1: LET B$(NB)=
A$(A): LET T(NB)=S: LET M(NB)=L(
A): GO SUB 470: GO SUB 430: GO T
O 100
 310 REM SET UP HEADER READER
 320 RESTORE : FOR A=0  TO 11: R
EAD B: POKE 23296+A,B: NEXT A
 330 DATA 221,33,224,91,17,17,0,
175,55,195,86,5
 340 RETURN
 350 REM READ HEADER
 360 RANDOMIZE USR 23296
 370 LET N$="": FOR A=0 TO 9: LE
T N$=N$+CHR$ PEEK (23521+A): NEX
T A: REM FILENAME
 380 LET L=PEEK 23531+256*PEEK 2
3532: REM LENGTH
 390 LET S=PEEK 23533+256*PEEK 2
3534: REM START ADDRESS
 410 POKE 23692,-1: PRINT A$(A);
TAB 14;S(A);TAB 27;L(A): RETURN
 420 LET RT=PEEK 23730+256*PEEK
23731: RETURN
 430 PRINT '"START OF M.C. AREA=
";RT+1'"ROUTINES START AT ADDRES
S";MC'"TOTAL LENGTH OF ROUTINES=
";MCL''
 440 RETURN
 450 INPUT "": PRINT #0;"START T
HE TAPE!!!": RETURN
 460 REM LIST LOADED ROUTINES
 470 PRINT TAB 8; INVERSE 1;"ROU
TINES LOADED:"'': PRINT " FILENA
ME";TAB 13;"AT ADDRESS";TAB 26;"
LENGTH"''
 480 FOR Y=1 TO NB
 490 PRINT B$(Y);TAB 14;T(Y);TAB
 27;M(Y)
 500 NEXT Y: PRINT : RETURN
 510 REM CALL THIS WITH GOTO 520
 TO LIST AND SAVE ALL THE ROUTIN
ES CURRENTLY LOADED IN THE M.C.
AREA
 520 GO SUB 470: GO SUB 430
 530 INPUT "FILE NAME?";X$
 540 SAVE X$CODE MC,MCL
```

```
 550 PRINT "TO LOAD THE ROUTINES
, USE"'; BRIGHT 1;"CLEAR ";MC-1
;": LOAD """;X$;"""CODE ";MC;","
;MCL
 560 INPUT "DO YOU WISH TO VERIF
Y (Y/N)?";A$: IF A$<>"Y" THEN  S
TOP
 570 VERIFY X$CODE
```

When 'Routine Selector' is first RUN it automatically reserves a machine code area of 3000 bytes at the top of memory, and sets up several arrays which store the names, addresses and lengths of the routines found and those loaded. For this reason you should only RUN the program once, or you will end up clearing all the arrays and trying to reserve another 3000 bytes, which is not possible on a 16K machine. To re-enter the program after a BREAK, use GOTO 100.

In its standard form, the program will read and load up to 50 routines into 3000 bytes of memory. In the unlikely event that you need more, variable F in line 70 controls the maximum number of routines, and increasing 3000 and 3001 in line 60 by the same amount will lengthen the M.C. area. If at any time you want to clear the machine code area, then use the command CLEAR 32599 (16K) or CLEAR 65367 (48K). You will then be able to RUN the program again if you wish.

When you have selected all of your routines, press "s" to get out of the catalogue or "Break" if the program is trying to read another header. Then type "GOTO 520" and put a blank tape in the recorder, ready to SAVE the block of routines. You will be asked for a file name, the program will save the block and then present you with the EXACT Basic line necessary to make room for and load back the toolkit from tape during your own program. It is well worth noting this down!

You are regularly presented with a list of the routines loaded into memory and their new addresses during the program. To get this list from 'immediate' mode, type

GOSUB 470

To get a list of all the routines found on tape (the catalog), type

GOTO 100

You will need the list of start addresses from the first GOSUB in order to call the routines with USR, so note them down! You are now fully equipped to use the rest of this book: So on with the routines!

ROUTINES FOR THE ATTRIBUTES

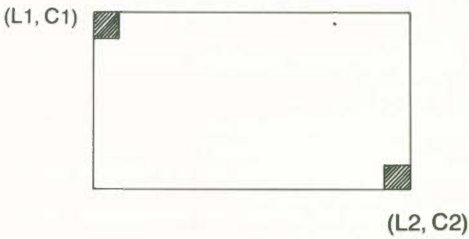
CHAPTER 3
COLOURFUL OPERATIONS ON THE ATTRIBUTES

As you probably know, you can choose one of eight colours on the Spectrum for the INK and PAPER. You can also specify whether the printing is BRIGHT or FLASHing. The one major problem, however, is that in BASIC you cannot easily change any of these ATTRIBUTES relating to a previously PRINTed character, without rePRINTing it using the new INK, PAPER, BRIGHT and FLASH values.

The following routine is a multi-purpose routine which allows you to change the attributes instantly, operating on a specified rectangle of the screen without affecting any text or graphics therein. I have called the routine "SCREENOP".

USING SCREENOP.

The routine operates on a specified rectangle of the screen, using the usual PRINT AT coordinates.



Referring to the diagram, we enter the coordinates (L1, C1) of the character position that forms the top left hand corner, and the coordinates (L2, C2) of the character position that forms the bottom right hand corner of the rectangle in which we want to change the attributes.

```
POKE 23332, L1 : POKE 23333, C1
POKE 23334, L2 : POKE 23335, C2
```

All of the colours on the Spectrum are derived from the three primary colours: green, blue and red. Their codes are:

1 = Blue
2 = Red
4 = Green

The other colours are made up as follows:

Colour		Code
Black	= nothing	0
Magenta	= Blue + Red	1 + 2 = 3
Cyan	= Blue + Green	1 + 4 = 5
Yellow	= Red + Green	2 + 4 = 6
White	= Red + Green + Blue	1 + 2 + 4 = 7

SCREENOP can perform any one of four operations on any of the various attributes. I will give these attributes a value:

Blue ink	1
Red ink	2
Green ink	4
Blue paper	8
Red paper	16
Green paper	32
BRIGHT	64
FLASH	128

The four possible operations are: turn the attribute "on".
turn the attribute "off".
alter the attribute.
leave the attribute as it is.

You need to poke the data into three seperate addresses, as follows:

```
POKE 23328, (sum of values of attributes to
             remain unaltered)
POKE 23329, (sum of values of attributes to be
             turned "on")
POKE 23331, (sum of values of attributes to be
             altered)
```

By "altering" the part, I mean turning it "on" if it's "off", and vice versa. There is one important point to remember: if you wish to alter, or COMPLEMENT one part of the attribute then you must also include it in the first POKE (otherwise the attribute will be turned "on" or "off" according to the second POKE).

EXAMPLE

You wish to highlight a rectangle (brightness "on"), leave any cyan ink that may occur (leave blue and green ink as they are), turn all the red ink "on" and complement (alter) all of the paper and the FLASH attributes. For this you must

```
POKE 23328, (1 + 4) + (8 + 16 + 32 + 128)
POKE 23329, 64 + 2
POKE 23331, 8 + 16 + 32 + 128
```

To run the machine code, use
RAND USR (first address of routine)
or LET L = USR

Here is the routine itself. Enter it using 'hexload' and then if you wish, enter the spectacular demonstration program.

```
HEX.        ;SCREENOP  LENGTH: 95 BYTES
21205B      START  LD    HL,5B20H    ;COMPLEMENT MASK THEN
7E                 LD    A,(HL)      ;AND THE NEW ATTRIBUTES.
2F                 CPL
23                 INC   HL
A6                 AND   (HL)
23                 INC   HL
77                 LD    (HL),A      ;STORE THE RESULT (1)
23                 INC   HL
23                 INC   HL
46                 LD    B,(HL)      ;FIND L1
23                 INC   HL
23                 INC   HL
7E                 LD    A,(HL)      ;FIND L2
FE18               CP    24          ;CHECK THAT L2 IS IN RANGE
D0                 RET   NC          ;RETURN IF NOT.
90                 SUB   B           ;(L2-L1)=
D8                 RET   C           ;RETURN IF NEGATIVE
3C                 INC   A           ;(L2-L1)+1=LENGTH OF
F5                 PUSH  AF          ;RECTANGLE (LINES)
04                 INC   B           ;IS L1 ZERO?
05                 DEC   B
E5                 PUSH  HL
210058             LD    HL,5800H
2806               JR    Z,HOP       ;IF SO THEN YOU DONT NEED
112000      NXT1   LD    DE,0020H    ;TO DESCEND TO TOP LINE OF
19                 ADD   HL,DE       ;RECTANGLE
10FA               DJNZ  NXT1
EB          HOP    EX    DE,HL
E1                 POP   HL
D5                 PUSH  DE
```

```
23              INC   HL
7E              LD    A,(HL)        ;FIND C2
FE20            CP    32            ;IS C2 IN RANGE?
3803            JR    C,OK          ;IF NOT THEN RETURN
C1              POP   BC
C1      ERRSTOP POP   BC
C9              RET
2B      OK      DEC   HL
2B              DEC   HL
4E              LD    C,(HL)        ;FIND C1.
E1              POP   HL            ;ADVANCE TO TOP LEFT CORNER
09              ADD   HL,BC         ;OF RECTANGLE.
91              SUB   C             ;(C2-C1)=
38F6            JR    C,ERRSTOP     ;RETURN IF NEGATIVE.
3C              INC   A             ;(C2-C1)+1=WIDTH OF
47              LD    B,A           ;RECTANGLE (COLUMNS).
3E20            LD    A,32          ;FIND THE GAP FROM THE
90              SUB   B             ;RIGHT SIDE OF ONE
5F              LD    E,A           ;RECTANGLE LINE TO THE
1600            LD    D,0           ;LEFT SIDE OF THE NEXT
C5      NXTLINE PUSH  BC            ;LINE.
D5              PUSH  DE
3A235B          LD    A,(5B23H)     ;THE COMPLEMENT BYTE (1)
57              LD    D,A
3A205B  NXT2    LD    A,(5B20H)     ;MASK
5F              LD    E,A
7E              LD    A,(HL)        ;TAKE ATTRIBUTES.
AA              XOR   D             ;COMPLEMENT WITH BYTE (1)
A3              AND   E             ;AND (THE MASK BYTE) TO
5F              LD    E,A           ;GIVE RESULT (2).
3A225B          LD    A,(5B21H)
83              ADD   A,E           ;ADD RESULT (1) TO (2)
77              LD    (HL),A        ;REPLACE ATTRIBUTES.
23              INC   HL            ;REPEAT FOR REST OF THIS
10F0            DJNZ  NXT2          ;LINE OF THE RECTANGLE.
D1              POP   DE
19              ADD   HL,DE         ;JUMP TO THE NEXT LINE OF
C1              POP   BC            ;THE RECTANGLE.
F1              POP   AF
3D              DEC   A             ;REPEAT UNTIL THE LAST LINE
C8              RET   Z             ;OF THE RECTANGLES IS DONE.
F5              PUSH  AF
18E1            JR    NXTLINE
                END
```

Here is the demonstration program:

```
  10 REM "Screenop" Demonstrati
on
  20 REM DEFINE USR GRAPHIC
  30 FOR A=0 TO 7
  40 POKE USR "A"+A,85+85*(A/2=I
NT (A/2))
  50 NEXT A
  60 REM FILL SCREEN
  70 FOR A=1 TO 704: PRINT CHR$
144;: NEXT A
```

```
  80 PRINT #0;AT 0,0;: FOR a=1
TO 64
  85 PRINT #0;CHR$ 144;: NEXT a
  90 LET SCREENOP=65200
 100 PRINT AT 8,10;"SUPERCHARGE"
;AT 10,13;"YOUR";
 105 PRINT AT 12,11;"SPECTRUM"
 110 RANDOMIZE
 120 REM DEFINE RECTANGLE
 130 REM (L1,C1)
 140 LET A=INT (RND*24): LET B=I
NT (RND*32)
 150 POKE 23332,A: POKE 23333,B
 160 REM (L2,C2)
 170 POKE 23334,A+INT (RND*(24-A
))
 175 POKE 23335,B+INT (RND*(32-B
))
 180 REM RANDOM OPERATION
 190 POKE 23328,INT (RND*256)
 200 POKE 23329,INT (RND*256)
 210 POKE 23331,INT (RND*256)
 220 LET L=USR SCREENOP
 230 GO TO 140
```

The program makes fairly random operations on a fairly random rectangle of the screen. Lines 15 to 50 define a 'chess-board' character (graphics U) and fill the screen with it: this allows you to produce up to 36 colours (or shades of grey) by combining paper and ink colours and is particularly effective on a colour TV. Line 70 defines the beginning of the routine: you must change this number according to where you store the routine.

APPLICATIONS

The routine can operate on any area from one character up to all twenty-four lines of the screen. One possibility would be to print a message using a different set of attributes to its surroundings and then 'alter' every attribute of the entire screen continually, using a PAUSE of around 30 between alterations to make the screen bearable (do not try this if you suffer from epileptic fits)!

SCREENOP 2

This routine is a minaturised version of SCREENOP: it operates in the same way but only on the whole screen (including the bottom two 'EDIT' lines).

USING SCREENOP 2

Use the same 'colour' POKEs and values as for SCREENOP, but do not define a rectangle. The routine is nearly a quarter the length of SCREENOP and only requires three POKEs to operate it, so it should be used whenever the more elaborate 'rectangle' facility is not required.

```
HEX.        ;SCREENOP2  LENGTH: 27 BYTES
ED4B205B    START   LD    BC,(5B20H)    ;AND THE COMPLEMENT OF THE
79                  LD    A,C           ;MASK WITH THE NEW
2F                  CPL                 ;ATTRIBUTES.
A0                  AND   B
47                  LD    B,A
21005B              LD    HL,5800H      ;HL=START OF ATTRIBUTES.
ED5B225B            LD    DE,(5B21H)    ;D IS THE COMPLEMENTER.
7E          NXTATT  LD    A,(HL)        ;TAKE ATTRIBUTES
AA                  XOR   D             ;OPERATE
A1                  AND   C
80                  ADD   A,B
77                  LD    (HL),A        ;REPLACE ATTRIBUTES.
23                  INC   HL            ;INCREMENT COUNTER.
7C                  LD    A,H           ;END OF ATTRIBUTES?
FE5B                CP    5BH
38F5                JR    C,NXTATT      ;IF NOT, NEXT ATTRIBUTE
C9                  RET                 ;RETURN TO BASIC.
                    END
```

CHAPTER 4
INVERTING THE ATTRIBUTES

This routine takes all the 'INK' and 'PAPER' of each character in the specified screen rectangle and swaps them around (e.g. red INK on green PAPER becomes green INK on red PAPER). The rectangle is specified in exactly the same way as for SCREENOP, as is the case for all of the routines that work on a colour-byte or 'attributes' rectangle. Apart from the four POKEs described in the previous routine (23332 to 23335...), no other preparation is required before calling the routine with "LET C = USR (start address)". I have also included a super-fast, super-short, whole screen version which requires no POKEs whatsoever.

```
HEX.          ;INVERSE RECTANGLE  LENGTH: 78 BYTES
ED4B245B      START  LD    BC,(5B24H)
2A265B               LD    HL,(5B26H)
7D                   LD    A,L          ;CHECK FOR LEGALITY OF
FE18                 CP    18H          ;L2 AND L1.
D0                   RET   NC
91                   SUB   C
D8                   RET   C
5F                   LD    E,A
7C                   LD    A,H          ;CHECK FOR LEGALITY OF
FE20                 CP    20H          ;C2 AND C1.
D0                   RET   NC
90                   SUB   B
D8                   RET   C
57                   LD    D,A
14                   INC   D            ;D=WIDTH OF RECTANGLE.
```

```
1C                INC     E             ;E=LENGTH OF RECTANGLE.
D5                PUSH    DE            ;STORE THEM.
210058            LD      HL,5800H      ;FIND FIRST LINE OF
AF                XOR     A             ;RECTANGLE.
B9                CP      C
112000            LD      DE,20H
2804              JR      Z,HOP1
19       NXT1     ADD     HL,DE
0D                DEC     C
20FC              JR      NZ,NXT1
B8       HOP1     CP      B             ;FIND TOP LEFTHAND CORNER
2803              JR      Z,HOP2        ;OF RECTANGLE.
23       NXT2     INC     HL
10FD              DJNZ    NXT2
C1       HOP2     POP     BC            ;B=WIDTH, C=LENGTH
D5       NXTLINE  PUSH    DE
E5                PUSH    HL
C5                PUSH    BC
3E07     NXT3     LD      A,7           ;TAKE INK.
A6                AND     (HL)
0F                RRCA
0F                RRCA
4F                LD      C,A           ;STORE IT.
3E38              LD      A,38H         ;TAKE PAPER.
A6                AND     (HL)
81                ADD     A,C           ;INK AND PAPER ARE NOW IN
0F                RRCA                  ;REVERSE ORDER.
0F                RRCA
0F                RRCA
4F                LD      C,A
3EC0              LD      A,0C0H        ;TAKE FLASH AND BRIGHT
A6                AND     (HL)          ;BITS.
81                ADD     A,C           ;PUT THEM IN THE NEW
77                LD      (HL),A        ;ATTRIBUTE UNCHANGED AND
23                INC     HL            ;STORE NEW ATTRIBUTE.
10EA              DJNZ    NXT3          ;NEXT CHARACTER.
C1                POP     BC
E1                POP     HL
D1                POP     DE
0D                DEC     C
19                ADD     HL,DE
20E0              JR      NZ,NXTLINE    ;REPEAT UNTIL END OF
C9                RET                   ;RECTANGLE. RETURN TO
                  END                   ;BASIC.
```

There now follows a mind-boggling demonstration program for INVERSE. Remember to alter the number in line 30 according to where you have located the routine. To see the program at neck-breaking full speed remove the PAUSE statement in line 190.

```
   10 REM INVERSE RECTANGLE
   20 REM DEMONSTRATION
   30 LET REVERSE=65200
   40 LET A=INT (RND*8): LET B=IN
T (RND*8): IF A=B THEN  GO TO 40
```

```
  50 PAPER A: INK B: BRIGHT RND:
 CLS
  60 PRINT AT 10,10;"Look into m
y";AT 11,10;">>>>eyes<<<<"
  70 LET B=0: LET C=10
  80 GO SUB 120: REM ZOOM OUT
  90 LET B=C: LET C=0
 100 GO SUB 120: REM ZOOM IN
 110 GO TO 40
 120 FOR D=B  TO C STEP SGN (C-B
)
 130 REM DEFINE RECTANGLE
 140 POKE 23332,10-D: REM L1
 150 POKE 23333,10-D: REM C1
 160 POKE 23334,11+D: REM L2
 170 POKE 23335,21+D: REM C2
 180  LET L=USR REVERSE
 190 PAUSE 4: NEXT D
 200 RETURN
```

FULL-SCREEN INVERSE

Here is the whole-screen version of INVERSE that I mentioned earlier. No POKEs needed, and it occupies a mere 29 bytes (this compares with line 40 of the above 'Inverse Demonstration' program, which takes 51 bytes of memory). You will probably need to use it with a PAUSE if in a 'flash' loop.

```
HEX.            ;FULL-SCREEN INVERSE  LENGTH: 29 BYTES
210058          START  LD     HL,5800H      ;BEGINNING OF ATTRIBUTES.
3E07            NXTATT LD     A,7
A6                     AND    (HL)          ;TAKE INK.
0F                     RRCA
0F                     RRCA
57                     LD     D,A           ;STORE IT.
3E38                   LD     A,38H
A6                     AND    (HL)          ;TAKE PAPER.
82                     ADD    A,D           ;PUT IN FRONT OF INK.
0F                     RRCA                 ;INK AND PAPER ARE NOW
0F                     RRCA                 ;REVERSED.
57                     LD     D,A           ;STORE THEM. TAKE
3EC0                   LD     A,0C0H        ;FLASH AND BRIGHT BITS.
A6                     AND    (HL)
82                     ADD    A,D           ;COMBINE WITH LAST RESULT.
77                     LD     (HL),A        ;STORE NEW ATTRIBUTES.
23                     INC    HL            ;INCREMENT COUNTER. ARE
7C                     LD     A,H           ;WE AT THE PRINTER BUFFER?
FE5B                   CP     5BH
38E8                   JR     C,NXTATT      ;IF NOT, THEN NEXT
C9                     RET                  ;ATTRIBUTE. RETURN TO BASIC.
                       END
```

CHAPTER 5
SCROLLING THE ATTRIBUTES IN ALL DIRECTIONS.

The following set of routines allows you to 'scroll' the colour bytes of the screen in any of the four directions LEFT, RIGHT, UP and DOWN. There are two routines for each direction: the first one allows you to scroll any rectangle of the screen area, and the second, shorter and simpler type will work on the entire screen only.

USING THE ROUTINES

For the 'rectangle' routines, define the rectangle in the same way as for SCREENOP (Chapter 3), using the same POKEs.

For all of the routines, you have three options:

0. 'leave' the line or column which is left behind by the scroll (e.g. the bottom line when scrolling the screen upwards) as it is;

1. 'roll' the line or column which would be deleted by the scroll back into the position left behind by the scroll (in this way you could continuously rotate a rectangle of attributes by 'scROLL-ing' them repeatedly in one direction);

2. 'fill' the line or column left behind by the scroll with a new attribute.

First define the rectangle if necessary, then execute the appropriate POKE(s):

```
                      ┌ 0 to 'leave'
POKE 23340,          <  1 to 'roll'
                      └ 2 to 'fill'
```

POKE 23341, sum of values of attributes to be used when 'filling'.

VALUES OF ATTRIBUTES WHEN 'ON':

Flash	= 128	Blue paper	= 8
Bright	= 64	Green ink	= 4
Green paper	= 32	Red ink	= 2
Red paper	= 16	Blue ink	= 1

APPLICATIONS

If you've ever watched ITV's "Crossroads", or even seen the credits come up as you defected from the other side to see if it had finished, then you will have seen the unusual manner in which the credits traverse the screen. An interesting exercise would be to imitate this motion with a 'BRIGHT' rectangle that approaches the centre of the screen from one side, stays in the middle to highlight a message of some kind, and then scrolls off by way of another side of the screen. There are many occasions when routines like these can enhance a program, so I'll leave further applications to your imagination.

Here are the routines:

Routines 1 and 2 : Scroll Attribute Rectangle Right and Left

The listing below is to scroll a rectangle to the RIGHT. To change the direction to LEFT, alter the lines labelled (i), (ii), and (iii) as follows:

	Mnemonic	Hex
(i)	NOP	00
(ii)	INC HL	23
(iii)	LDIR	EDBO

To change the routine from one direction to the other during a program (if you prefer not to store the two seperate routines) then do the following:

```
LET S = [start of routine]

LEFT               RIGHT
POKE S+23, 0       POKE S+23, 68
POKE S+55, 35      POKE S+55, 43
POKE S+57, 176     POKE S+57, 184
```

The above method, incidentally, takes about 70 bytes of RAM, so there is very little to choose between that and storing the hex. routines seperately (if you need to use the above POKEs more than once then it is "cheaper" to store the routines seperately instead).

Run the routines with the usual command:

LET C = USR S

```
HEX.            ;RIGHTSCROLL ATTRIBUTE RECTANGLE  LENGTH: 81 BYTES
                        ORG     6000H
ED4B245B        START   LD      BC,(5B24H)      ;C=L1, B=C1
2A265B                  LD      HL,(5B26H)      ;L=L2, H=C2
7D                      LD      A,L             ;CHECK FOR LEGALITY OF
FE18                    CP      18H             ;L1 AND L2, RETURN IF
D0                      RET     NC              ;ILLEGAL COORDINATES.
91                      SUB     C
D8                      RET     C
57                      LD      D,A
7C                      LD      A,H             ;CHECK FOR LEGALITY OF C1
FE20                    CP      20H             ;AND C2, RETURN IF ILLEGAL
D0                      RET     NC              ;COORDINATES.
90                      SUB     B
D8                      RET     C
5F                      LD      E,A             ;E=WIDTH OF RECTANGLE-1
14                      INC     D               ;D=LENGTH OF RECTANGLE.
D5                      PUSH    DE
44                  (i) LD      B,H             ;(I) SEE NOTES ABOVE
210058                  LD      HL,5800H        ;FIND THE TOP LINE OF THE
AF                      XOR     A               ;'SCROLL' RECTANGLE.
112000                  LD      DE,20H
B9                      CP      C
2804                    JR      Z,HOP1
19              NXT1    ADD     HL,DE
0D                      DEC     C
20FC                    JR      NZ,NXT1
B8              HOP1    CP      B               ;FIND TOPLEFT (LEFTSCROLL)
2803                    JR      Z,HOP2          ;OR TOPRIGHT (RIGHTSCROLL)
23              NXT2    INC     HL              ;CORNER OF RECTANGLE.
10FD                    DJNZ    NXT2
C1              HOP2    POP     BC              ;BC=WIDTH OF RECTANGLE-1
C5              NXTLINE PUSH BC
47                      LD      B,A             ;SET UP THE VARIABLES DE
D5                      PUSH    DE              ;AND HL, READY TO SCROLL
54                      LD      D,H             ;THE TOP LINE OF THE
5D                      LD      E,L             ;RECTANGLE.
D5                      PUSH    DE
B9                      CP      C
1A                      LD      A,(DE)
2803                    JR      Z,HOP3
2B                 (ii) DEC     HL              ;(II) SEE NOTES ABOVE
EDB8              (iii) LDDR                    ;(III) SEE NOTES ABOVE
ED4B2C5B        HOP3    LD      BC,(5B2CH)      ;HAVING SCROLLED THE
67                      LD      H,A             ;LINE, DECIDE WHETHER TO...
79                      LD      A,C
FE01                    CP      1
3805                    JR      C,LEAVIT
7C                      LD      A,H
2801                    JR      Z,ROLL
78              FILL    LD      A,B             ;... 'FILL' IT, ...
```

```
12          ROLL    LD      (DE),A          ;... 'ROLL' IT, ...
E1          LEAVIT  POP     HL              ;... OR 'LEAVE' IT.
D1                  POP     DE              ;PREPARE FOR NEXT LINE OF
C1                  POP     BC              ;RECTANGLE.
19                  ADD     HL,DE
AF                  XOR     A
10DD                DJNZ    NXTLINE         ;REPEAT UNTIL BOTTOM OF
C9                  RET                     ;RECTANGLE IS DONE, THEN
                    END                     ;RETURN TO BASIC.
```

Here is a little 'demo' program.

```
  10 REM RIGHT SCROLL ATTRIBUTES
  15 REM DEMONSTRATION
  20 LET RIGHTSCROLL=65200: REM
INSERT YOUR OWN START OF ROUTINE
  30  BORDER 2: CLS : FOR A=0 TO
 21
  40 FOR B=0 TO 7
  50 PRINT  PAPER B; INK 7-B;"
"
  60 NEXT B
  70 NEXT A
  80 PRINT  INK 8; PAPER 8;AT 10
,6;"I am not a test card"
  90 REM  DEFINE RECTANGLE
 100 POKE 23332,4: POKE 23334,17
: REM L1,L2
 110 POKE 23340,1: REM "ROLL"
 120 LET A=INT (RND*7)*4: REM C1
 130 LET B=A+7+INT (RND*(6-INT (
A/4)))*4: REM C2
 140 POKE 23333,A: POKE 23335,B
 150 FOR A=1 TO 4
 160 LET L=USR RIGHTSCROLL
 170 PAUSE 2: NEXT A
 180 PAUSE 30
 190 GO TO 120
```

In line 50 " " = space. You should plug in the appropriate value in line 20 to tell the Spectrum where the routine starts. On running the program the screen is filled with eight coloured stripes, the centre portions of which are then visually 'shuffled' by scrolling a random number of these portions four places to the right. You may like to try getting the program to randomly scroll left and right by randomly changing the three POKEs needed to alter the routine from one direction to the other (remember you must use only one set of these POKEs at a time: DO NOT mix them).

Routines 3 and 4: SCROLL ALL ATTRIBUTES RIGHT OR LEFT

If you only need to scroll the whole screen (including the EDIT lines), then the following two routines can be used. Since you do not define a rectangle, the only POKEs required for these routines are 23340 and 23341.

```
HEX.        ;RIGHTSCROLL ATTRIBUTES  LENGTH: 34 BYTES
11FF5A      START   LD    DE,5AFFH        ;BOTTOM-RIGHT CORNER
011F00      NXTLINE LD    BC,001FH
62                  LD    H,D
6B                  LD    L,E
2B                  DEC   HL
1A                  LD    A,(DE)
EDB8                LDDR                  ;SCROLL THE BOTTOM LINE.
ED4B2C5B            LD    BC,(5B2CH)      ;* C=(23340), B=(23341)
67                  LD    H,A
79                  LD    A,C
FE01                CP    1
3805                JR    C,LEAVIT        ;IF C=0 THEN 'LEAVE'
7C                  LD    A,H
2801                JR    Z,ROLL          ;IF C=1 THEN 'ROLL'
78          FILL    LD    A,B             ;ELSE 'FILL'
12          ROLL    LD    (DE),A
1B          LEAVIT  DEC   DE              ;FIND NEXT LINE UP.
7A                  LD    A,D             ;HAVE WE FINISHED?
FE57                CP    57H
20E2                JR    NZ,NXTLINE      ;IF NOT, THEN NXTLINE.
C9                  RET                   ;RETURN TO BASIC.
                    END
```

```
HEX.        ;LEFTSCROLL ATTRIBUTES  LENGTH: 34 BYTES
110058      START   LD    DE,5800H        ;TOP LEFTHAND CORNER.
011F00      NXTLINE LD    BC,001FH
62                  LD    H,D
6B                  LD    L,E
23                  INC   HL
1A                  LD    A,(DE)
EDB0                LDIR                  ;SCROLL TOP LINE.
ED4B2C5B            LD    BC,(5B2CH)      ;* C=(23340), B=(23341)
67                  LD    H,A
79                  LD    A,C
FE01                CP    1
3805                JR    C,LEAVIT        ;IF C=0 THEN 'LEAVE'
7C                  LD    A,H
2801                JR    Z,ROLL          ;IF C=1 THEN 'ROLL'
78          FILL    LD    A,B             ;ELSE 'FILL'
12          ROLL    LD    (DE),A
13          LEAVIT  INC   DE              ;FIND NEXT LINE DOWN.
7A                  LD    A,D             ;HAS IT REACHED THE PRINTER
FE5B                CP    5BH             ;BUFFER?
20E2                JR    NZ,NXTLINE      ;IF NOT, THEN NXTLINE.
C9                  RET                   ;RETURN TO BASIC.
                    END
```

ROUTINES 5 AND 6: SCROLL ATTRIBUTE WINDOW DOWN OR UP

The listing below is to scroll a rectangle of the attributes DOWN. To change this to UP, alter the lines (i) and (ii) as follows:

	HEX.
(i) NOP	00
(ii) LD HL, 2020H	21 20 00

If you do not wish to store them as two seperate routines, you can convert one to the other as follows:

LET S = (start of routine)

DOWN	UP
POKE S + 22, 77	POKE S + 22, 0
POKE S + 61, 224	POKE S + 61, 32
POKE S + 62, 255	POKE S + 62, 0

As usual, run with

LET C = USR S

```
HEX.       ;DOWNSCROLL ATTRIBUTE RECTANGLE  LENGTH: 105 BYTES
ED4B245B   START   LD     BC,(5B24H)     ;C=L1, B=C1
2A265B             LD     HL,(5B26H)     ;L=L2, H=C2
7D                 LD     A,L            ;CHECK FOR LEGALITY OF L1
FE18               CP     18H            ;AND L2, RETURN IF ILLEGAL
D0                 RET    NC             ;COORDINATES.
91                 SUB    C
D8                 RET    C
57                 LD     D,A
7C                 LD     A,H            ;CHECK FOR LEGALITY OF
FE20               CP     20H            ;C1 AND C2, RETURN IF
D0                 RET    NC             ;ILLEGAL COORDINATES.
90                 SUB    B
D8                 RET    C
5F                 LD     E,A
1C                 INC    E              ;E=WIDTH OF RECTANGLE.
4D             (i) LD     C,L            ;(I) SEE NOTES ABOVE
D5                 PUSH   DE             ;FIND THE TOP (UPSCROLL)
210058             LD     HL,5800H       ;OR BOTTOM (DOWNSCROLL)
AF                 XOR    A              ;LINE OF RECTANGLE.
B9                 CP     C
2807               JR     Z,HOP1
112000             LD     DE,20H
19         NXT1    ADD    HL,DE
0D                 DEC    C
20FC               JR     NZ,NXT1
B8         HOP1    CP     B              ;ADVANCE TO TOP-LEFT OR
2803               JR     Z,HOP2         ;BOTTOM-LEFT CORNER.
23         NXT2    INC    HL
10FD               DJNZ   NXT2
C1         HOP2    POP    BC
C5                 PUSH   BC
47                 LD     B,A            ;BC=WIDTH OF RECTANGLE.
E5                 PUSH   HL             ;STORE THE LINE OF THE
11E05B             LD     DE,5BE0H       ;RECTANGLE ABOUT TO BE
EDB0               LDIR                  ;ERASED.
D1                 POP    DE
C1                 POP    BC
B8                 CP     B
280D               JR     Z,DONE
C5         NXTLINE PUSH   BC             ;BEGIN ACTUAL SCROLLING, BY
47                 LD     B,A            ;SETTING UP HL AND DE,...
```

```
21E0FF          (ii) LD     HL,0FFE0H     ;(II)
19                   ADD    HL,DE
E5                   PUSH   HL
EDB0                 LDIR                 ;THEN SCROLLING....
D1                   POP    DE
C1                   POP    BC
10F3                 DJNZ   NXTLINE       ;ONE LINE AT A TIME UNTIL
C5          DONE     PUSH   BC            ;THE WHOLE RECTANGLE IS
2A2C5B               LD     HL,(5B2CH)    ;DONE. DECIDE WHETHER TO
7D                   LD     A,L           ;'LEAVE', 'FILL' OR 'ROLL'.
FE01                 CP     1
380F                 JR     C,CLEANUP
2007                 JR     NZ,FILL
21E05B      ROLL     LD     HL,5BE0H      ;'ROLL' BY RETURNING THE
EDB0                 LDIR                 ;STORED LINE AND PUTTING
1806                 JR     CLEANUP       ;IT IN THE APPROPRIATE
EB          FILL     EX     DE,HL         ;PLACE. THEN GO TO THE
                                          ;'CLEANUP' AREA.
72          NXT3     LD     (HL),D        ;'FILL' THE LINE EXPOSED
23                   INC    HL            ;BY THE SCROLL.
0D                   DEC    C
20FB                 JR     NZ,NXT3
C1          CLEANUP  POP    BC            ;'CLEANUP' THE PRINTER
21E05B               LD     HL,5BE0H      ;BUFFER. USED TO STORE A
70          NXT4     LD     (HL),B        ;LINE OF THE RECTANGLE.
0D                   DEC    C
23                   INC    HL
20FB                 JR     NZ,NXT4
C9                   RET                  ;RETURN TO BASIC.
                     END
```

Warning: all of the 'downscroll' and 'upscroll' routines make use of the printer buffer (the area where LPRINT, LLIST and COPY information is temporarily stored on its way to the printer), so anything stored in the printer buffer will be lost on using the routines. This does not stop you from using the printer; just be sure that anything LPRINTed before you 'call' the routines has actually been sent out to the printer.

Here is a demonstration program for the 'downscroll' routine. If the colours make you feel ill then feel free to change them: the program was developed with a black and white TV. Line 30 should be altered appropriately to the beginning of the 'downscroll' routine (e.g. if your routine is at address 32400, then line 30 should read "LET DOWNSCROLL = 32400"). You will find that the program generates a recursive, 'kaleidoscopic' pattern.

```
  10 REM DOWNSCROLL ATTRIBUTES
  20 REM DEMONSTRATION
  30 LET DOWNSCROLL=65200
  40 REM PREPARE SCREEN
  50 BORDER 7: CLS : INVERSE 1
  60 FOR A=0 TO 168 STEP 8
  70 PLOT  INK 2; PAPER 2+3*(A>8
0);7,A
```

```
  80 DRAW  INK 2; PAPER 2+3*(A>8
0);241,0
  90 NEXT A: INVERSE 0
 100 PRINT  INK 8; PAPER 8;AT 10
,14;"FLIP";AT 11,14;"FLOP"
 110 POKE 23340,1: REM "ROLL"
 120 REM DEFINE RECTANGLE
 130 LET B=0
 140 LET A=1
 150 LET X=INT (B*5/7+0.5)
 160 POKE 23332,10-X: REM L1
 170 POKE 23333,14-B: REM C1
 180 POKE 23334,11+X: REM L2
 190 POKE 23335,17+B: REM C2
 200 FOR N=0 TO X
 210 RANDOMIZE USR DOWNSCROLL
 220 PAUSE 6: NEXT N
 230 LET B=B+A
 240 LET A=A+2*((B=0)-(B=14))
 250 PAUSE 50: GO TO 150
```

ROUTINES 7 AND 8: SCROLL ALL ATTRIBUTES DOWN OR UP

These routines are for use when the more lengthy 'rectangle' routines are unnecessary. They work on all 24 lines of the screen and as with the 'rectangle' routines, the contents of the printer buffer are erased along with anything not yet passed out to the printer. Use the usual POKEs, 23340 and 23341.

```
HEX.          ;DOWNSCROLL ATTRIBUTES  LENGTH: 54 BYTES
012000              LD      BC,20H          ;MOVE THE BOTTOM LINE
21FF5A              LD      HL,5AFFH        ;INTO THE PRINTER BUFFER.
11FF5B              LD      DE,5BFFH
D5                  PUSH    DE
E5                  PUSH    HL
EDB8                LDDR
D1                  POP     DE              ;NOW MOVE THE REST OF THE
01E002              LD      BC,02E0H        ;ATTRIBUTES DOWN A LINE.
EDB8                LDDR
3A2C5B              LD      A,(5B2CH)       ;A=(23340)
FE01                CP      1               ;DECIDE WHETHER TO ....
012000              LD      BC,20H
3810                JR      C,CLEANUP       ;.. LEAVE TOP LINE,
2006                JR      NZ,FILL         ;FILL IT, OR
E1            ROLL  POP     HL              ;ROLL THE BOTTOM LINE UP
E5                  PUSH    HL              ;TO THE TOP.
EDB8                LDDR
1808                JR      CLEANUP
3A2D5B        FILL  LD      A,(5B2DH)       ;A=(23341)
12            NXT   LD      (DE),A          ;FILL TOP LINE WITH A.
1B                  DEC     DE
0D                  DEC     C
20FB                JR      NZ,NXT
```

```
0620         CLEANUP LD     B,20H          ;CLEANUP THE PRINTER
AF                   XOR    A              ;BUFFER.
E1                   POP    HL
77           NXT2    LD     (HL),A
2B                   DEC    HL
10FC                 DJNZ   NXT2
C9                   RET                   ;RETURN TO BASIC.
                     END
```

Here's another amazing demonstration program to show off the above routine:

```
  10 REM WHOLE SCREEN DOWN
  20 REM SCROLL OF ATTRIBUTES
  30 REM DEMONSTRATION
  35 LET DOWNSCROLL=65200: POKE
23340,1: REM ROLL
  40 BRIGHT 1: FOR A=0 TO 21
  50 LET B=A-8*INT (A/8)
  60 PRINT  INK 7-B; PAPER B;"AM
AZING TECHNICOLOURED SCROLLING"
  70 NEXT A
  80 FOR A=0 TO 1
  90 PRINT #0;AT A,0; INK 7-A; P
APER A;"AMAZING TECHNICOLOURED S
CROLLING"
 100 NEXT A
 110 RANDOMIZE USR DOWNSCROLL
 120 PAUSE 5: GO TO 110
```

Don't forget to alter the number 65200 in line 35 to the start address of the routine. To produce the top speed, remove the pause statement in line 120 (it then becomes impossible to follow the pattern, since the scrolling will occur more often than a new television frame is displayed). Here is the equivalent upscroll routine:

```
HEX.         ;UPSCROLL ATTRIBUTES  LENGTH: 50 BYTES
210058       START   LD     HL,5800H       ;MOVE THE TOP LINE INTO
11E05B               LD     DE,5BE0H       ;THE PRINTER BUFFER.
D5                   PUSH   DE
E5                   PUSH   HL
012000               LD     BC,0020H
EDB0                 LDIR
D1                   POP    DE             ;NOW MOVE THE REST OF THE
01E002               LD     BC,02E0H       ;ATTRIBUTES UP A LINE.
EDB0                 LDIR
3A2C5B               LD     A,(5B2CH)      ;A=(23340)
FE01                 CP     1              ;DECIDE WHETHER TO ....
012000               LD     BC,20H
380F                 JR     C,CLEANUP      ;LEAVE BOTTOM LINE,
2006                 JR     NZ,FILL        ;FILL IT, OR
E1           ROLL    POP    HL             ;ROLL THE TOP LINE DOWN
E5                   PUSH   HL             ;FROM THE PRINTER BUFFER.
```

```
EDB0              LDIR
1807              JR      CLEANUP
3A2D5B   FILL     LD      A,(5B2DH)      ;A=(23341)
12       NXT1     LD      (DE),A         ;FILL BOTTOM LINE WITH A.
1C                INC     E
20FC              JR      NZ,NXT1
E1       CLEANUP  POP     HL             ;CLEANUP THE PRINTER
70       NXT2     LD      (HL),B         ;BUFFER.
2C                INC     L
20FC              JR      NZ,NXT2
C9                RET                    ;RETURN TO BASIC.
                  END
```

The same demonstration program used for 'Downscroll' will work with 'Upscroll'.

ROUTINES FOR THE TEXT AND GRAPHICS

CHAPTER 6
SCROLLING THE TEXT AND GRAPHICS

I have already provided you with a complete set of routines to scroll the 'colour' bytes or attributes; here then is a similar set that will allow you to do the same to the text and graphics present on the screen.

As for the attribute routines, there are two main types; the first and most complex routine works on any rectangle of the screen from one square to the full 24 x 32 size; the second, shorter routine works only on the whole screen.

USING THE ROUTINES

If you are using a 'rectangle' routine, then you must first define the rectangle using the same POKEs and in the same manner as for SCREENOP (see Chapter 3). Text will then only be scrolled if it is inside the rectangle. As for the attribute routines, you now have three options:

0. LEAVE the line or column which is 'left behind' by the scroll (e.g. the bottom line when scrolling upwards) as it is;

1. ROLL the line or column which would be deleted by the scroll back into the position left behind by the scroll;

2. FILL the line or column left behind by the scroll with one of 256 patterns.

In the last option, you define the pattern by POKEing into address 23347 a number between 0 and 255 (both inclusive). This is most easily accomplished by using the BIN function, as follows.

Imagine a character square being split into eight horizontal layers or 'rows'. Each of these rows would then consist of a line of eight PLOT positions, or 'pixels', thus:

The routine allows you to set each of these pixels to INK (1) or PAPER (0) and then replaces every row of every character square of every line or column 'left behind' by the scroll with the row of pixels that you have defined. In this way a series of vertical lines is produced whose thickness and spacing varies according to the row defined. In the diagram, alternate pixels of the row are INK, and a 'pinstripe trouser' pattern would be produced during repeated scrolls.

You must POKE 23347 with the 'pattern row' in BIN form:

POKE 23347, BIN 1 0 1 0 1 0 1 0

To choose which of the three options the routine is to use, use this command with the appropriate number:

```
POKE 23346,     0 to 'LEAVE'
                1 to 'ROLL'
                2 to 'FILL'
```

APPLICATIONS

At the end of this chapter you will find a demonstration program called CRISS-CROSS, which utilises each of the four 'rectangle' text-scrolling routines. The program is a computer-simulation of a puzzle that has sold in the millions (and has had a similar number of pictures printed on it). You have a four-by-four grid with fifteen tiles and one hole in it. The tiles are numbered from one to fifteen, and are 'jumbled up' by the computer by randomly and visually interchanging the 'hole' on the screen with one of its four next-door neighbours. The computer then leaves you to enter the moves and restore the tiles to their original positions.

The application above of 'scrolling' the tiles of the puzzle is only the tip of a spectronic iceberg. You could use the routines to make a 'plane fly (by scrolling the landscape underneath it using the 'ROLL' option), or perhaps in the classic invader-type game to speed up the movement of the block of invaders, the mother ship, the laser base and possibly even the bombs and missiles. With the extra speed added by these routines it should be possible to produce a quite acceptable game under BASIC control.

COORDINATION WITH ATTRIBUTE ROUTINES

If you wish to combine any of these routines with its corresponding 'colour' routine, thereby using only one USR call instead of two seperate ones, then you should follow this procedure:

1. Write the 'graphic' routine with Hexaid;

2. Immediately afterwards, write the corresponding 'attribute' routine (so that the attribute routine directly precedes the graphic routine in memory), changing the last line of the attribute routine

		HEX.
from	RET	C9
to	NOP	00

The combined routine is now accessed by the USR call

LET L = USR (start of attribute routine).

Now on to the tedious bit we have all come to hate; typing in the routines.

LEFT AND RIGHT FOR RECTANGLES

RIGHTR (R for rectangle), not surprisingly, scrolls to the right. To change the routine to 'LEFTR', alter lines (i), (ii) and (iii) as follows:

	NEW LINE	HEX.
(i)	NOP	00
(ii)	INC HL	23
(iii)	LDIR	ED BO

If you do not want to store the two routines seperately, you can convert from one to the other during a BASIC program or by direct commands as follows:

LET R = (start of routine)

LEFT	RIGHT
POKE R + 23, 0	POKE R + 23, 68
POKE R + 44, 35	POKE R + 44, 43
POKE R + 52, 176	POKE R + 52, 184

```
HEX.        ;RIGHTR  LENGTH: 89 BYTES
ED4B245B    START  LD    BC,(5B24H)    ;C=L1, B=C1
2A265B             LD    HL,(5B26H)    ;L=L2, H=C2
7D                 LD    A,L           ;CHECK FOR ILLEGAL
FE18               CP    18H           ;COORDINATES.
D0                 RET   NC
91                 SUB   C
D8                 RET   C
57                 LD    D,A
```

```
7C                  LD    A,H
FE20                CP    20H
D0                  RET   NC
90                  SUB   B
D8                  RET   C
5F                  LD    E,A          ;E=WIDTH OF RECTANGLE-1
14                  INC   D            ;D=NO. OF LINES.
D5                  PUSH  DE           ;STORE THEM!
44             (i)  LD    B,H          ;FIND THE ADDRESS OF
79                  LD    A,C          ;(L1,C2), THE TOP - RIGHT
E618                AND   18H          ;CORNER. FIRST FIND WHICH
C640                ADD   A,40H        ;THIRD OF THE SCREEN
67                  LD    H,A          ;IT IS IN.
79                  LD    A,C
87                  ADD   A,A          ;NOW WHICH LINE.....
87                  ADD   A,A
87                  ADD   A,A
87                  ADD   A,A
87                  ADD   A,A
80                  ADD   A,B
6F                  LD    L,A          ;AND FINALLY WHICH COLUMN
C1         NXTROWS  POP   BC
C5         NXTLINE  PUSH  BC
E5                  PUSH  HL
54                  LD    D,H
5D                  LD    E,L
7E                  LD    A,(HL)       ;STORE RIGHT-MOST ROW.
2B            (ii)  DEC   HL
08                  EX    AF,AF'
AF                  XOR   A
47                  LD    B,A          ;BC=WIDTH-1
B9                  CP    C            ;IF WIDTH=1 THEN DON'T
2802                JR    Z,HOP1       ;SCROLL.
EDB8         (iii)  LDDR               ;SCROLL THE LINE.
2A325B     HOP1     LD    HL,(5B32H)   ;DECIDE WHETHER TO...
7D                  LD    A,L
FE01                CP    1
3805                JR    C,LEAVIT     ;LEAVE,
7C                  LD    A,H
2001                JR    NZ,FILL      ;FILL, OR ELSE...ROLL
08         ROLL     EX    AF,AF'       ;RIGHT-MOST ROW INTO LEFT-
12         FILL     LD    (DE),A       ;MOST. FILL WITH SPECIFIED
E1         LEAVIT   POP   HL           ;PATTERN. ONTO THE NEXT
24                  INC   H            ;ROW OF EACH CHARACTER.
7C                  LD    A,H
E607                AND   7
20DD                JR    NZ,NXTROWS
1120F8              LD    DE,0F820H    ;THEN FIND THE NEXT
19                  ADD   HL,DE        ;LINE OF THE RECTANGLE.
7D                  LD    A,L
FE20                CP    20H
3003                JR    NC,NOTTHRD
0607                LD    B,7
09                  ADD   HL,BC
```

```
C1          NOTTHRD POP     BC
10CF                DJNZ    NXTLINE         ;REPEAT UNTIL LAST LINE HAS
C9                  RET                     ;BEEN SCROLLED, THEN RETURN
                    END                     ;TO BASIC.
```

LEFT AND RIGHT FOR THE WHOLE SCREEN

These two routines work on the whole screen and therefore require only two POKEs, 23346 and 23347. I have suffixed their name with "WS" for "whole-screen".

```
HEX.        ;LEFTWS  LENGTH: 33 BYTES
210040      START   LD      HL,4000H        ;HL=TOP-LEFT CORNER
011F00      NXTROWS LD      BC,001FH        ;BC=WIDTH OF SCREEN-1
7E                  LD      A,(HL)          ;STORE LEFT-MOST ROW.
54                  LD      D,H
5D                  LD      E,L
23                  INC     HL
EDB0                LDIR                    ;SCROLL LEFT
08                  EX      AF,AF'
ED4B325B            LD      BC,(5B32H)      ;TEST (23346) AND EITHER...
79                  LD      A,C
FE01                CP      1
3805                JR      C,LEAVIT        ;LEAVE OR ELSE
78                  LD      A,B
2001                JR      NZ,FILL         ;FILL OR
08          ROLL    EX      AF,AF'          ;ROLL
12          FILL    LD      (DE),A
7C          LEAVIT  LD      A,H             ;REPEAT UNTIL WHOLE SCREEN
FE58                CP      58H             ;IS SCROLLED.
38E3                JR      C,NXTROWS
C9                  RET                     ;RETURN TO BASIC.
                    END
```

```
HEX.        ;RIGHTWS  LENGTH: 33 BYTES
21FF57      START   LD      HL,57FFH        ;HL=BOTTOM-RIGHT CORNER
011F00      NXTROWS LD      BC,001FH        ;BC=WIDTH OF SCREEN-1
7E                  LD      A,(HL)          ;STORE RIGHT-MOST ROW.
54                  LD      D,H
5D                  LD      E,L
2B                  DEC     HL
EDB8                LDDR                    ;SCROLL RIGHT.
08                  EX      AF,AF'
ED4B325B            LD      BC,(5B32H)      ;TEST (23346) AND EITHER...
79                  LD      A,C
FE01                CP      1
3805                JR      C,LEAVIT        ;LEAVE OR
78                  LD      A,B
2001                JR      NZ,FILL         ;FILL OR ELSE
08          ROLL    EX      AF,AF'          ;ROLL
12          FILL    LD      (DE),A
7C          LEAVIT  LD      A,H             ;REPEAT UNTIL WHOLE SCREEN
FE58                CP      58H             ;IS SCROLLED.
38E3                JR      C,NXTROWS
C9                  RET                     ;RETURN TO BASIC.
                    END
```

UP AND DOWN FOR RECTANGLES

UPR and DOWNR are listed seperately because too many POKEs are required to make converting from one routine to the other worthwhile during a program. The contents of the last thirty-two bytes of the printer buffer are used by the routines, so don't store anything there or use an unterminated LPRINT command before calling the routines with the usual LET L = USR ... command.

```
HEX.        ;UPR  LENGTH: 108 BYTES
ED4B245B    START   LD    BC,(5B24H)    ;C=L1, B=C1
2A265B              LD    HL,(5B26H)    ;L=L2, H=C2
7D                  LD    A,L           ;CHECK FOR ILLEGAL
FE18                CP    18H           ;COORDINATES.
D0                  RET   NC
91                  SUB   C
D8                  RET   C
57                  LD    D,A
7C                  LD    A,H
FE20                CP    20H
D0                  RET   NC
90                  SUB   B
D8                  RET   C
5F                  LD    E,A
1C                  INC   E             ;E=WIDTH OF RECTANGLE.
D5                  PUSH  DE            ;D=NUMBER OF LINES-1
79                  LD    A,C           ;FIND THE ADDRESS OF THE
E618                AND   18H           ;TOP-LEFT CORNER (L1,C1).
C640                ADD   A,40H
67                  LD    H,A
79                  LD    A,C
87                  ADD   A,A
87                  ADD   A,A
87                  ADD   A,A
87                  ADD   A,A
87                  ADD   A,A
80                  ADD   A,B
6F                  LD    L,A
C1                  POP   BC
C5          NXTROWS PUSH  BC
E5                  PUSH  HL
C5                  PUSH  BC
AF                  XOR   A
11E05B              LD    DE,5BE0H      ;STORE THE TOP ROW OF THE
47                  LD    B,A           ;TOP LINE OF THE RECTANGLE
E5                  PUSH  HL            ;IN THE PRINTER BUFFER.
EDB0                LDIR
D1                  POP   DE
C1                  POP   BC
B8                  CP    B             ;IS THE RECTANGLE ONLY
2816                JR    Z,DONE        ;ONE LINE DEEP? IF SO THEN
C5          NXTLINE PUSH  BC            ;DON'T SCROLL.
212000              LD    HL,20H        ;FIND THE POSITION OF THE
44                  LD    B,H           ;ROWS IN MEMORY WHICH ARE
```

```
19                  ADD   HL,DE         ;BEING MOVED UP.
7D                  LD    A,L
FE20                CP    20H
3004                JR    NC,NOTTHRD
7C                  LD    A,H
C607                ADD   A,7
67                  LD    H,A
E5         NOTTHRD  PUSH  HL            ;NOW MOVE THE ROWS UP TO
EDB0                LDIR                ;THEIR NEW POSITION, AND...
D1                  POP   DE            ;REPEAT UNTIL ALL OF THE
C1                  POP   BC            ;TOP ROWS OF EACH
10EA                DJNZ  NXTLINE       ;CHARACTER HAVE BEEN
2A325B     DONE     LD    HL,(5B32H)    ;SCROLLED. TEST (23346).
7D                  LD    A,L
FE01                CP    1             ;DECIDE WHETHER TO
380F                JR    C,LEAVIT      ;LEAVE,
2007                JR    NZ,FILL       ;FILL OR
21E05B     ROLL     LD    HL,5BE0H      ;ROLL THE GRAPHICS.
EDB0                LDIR
1806                JR    LEAVIT
41         FILL     LD    B,C           ;FILL THE TOP-ROW OF EACH
7C                  LD    A,H           ;CHARACTER WITH THE DESIRED
12         NXT1     LD    (DE),A        ;PATTERN.
13                  INC   DE
10FC                DJNZ  NXT1
E1         LEAVIT   POP   HL            ;NOW REPEAT WHOLE OPERATION
C1                  POP   BC            ;FOR THE OTHER 7 ROWS OF
24                  INC   H             ;EACH CHARACTER IN THE
7C                  LD    A,H           ;RECTANGLE, AND...
E607                AND   7
20BB                JR    NZ,NXTROWS
C9                  RET                 ;RETURN TO BASIC.
                    END
```

```
HEX.       ;DOWNR   LENGTH: 109 BYTES
ED4B245B   START    LD    BC,(5B24H)    ;C=L1, B=C1
2A265B              LD    HL,(5B26H)    ;L=L2, H=C2
7D                  LD    A,L           ;CHECK FOR ILLEGAL
FE18                CP    18H           ;COORDINATES.
D0                  RET   NC
91                  SUB   C
D8                  RET   C
57                  LD    D,A
7C                  LD    A,H
FE20                CP    20H
D0                  RET   NC
90                  SUB   B
D8                  RET   C
5F                  LD    E,A
1C                  INC   E             ;E=WIDTH OF RECTANGLE.
D5                  PUSH  DE            ;D=NUMBER OF LINES-1
7D                  LD    A,L           ;FIND THE ADDRESS OF THE
E618                AND   18H           ;BOTTOM-LEFT CORNER
C640                ADD   A,40H         ;(L2,C1).
```

```
67              LD    H,A
7D              LD    A,L
87              ADD   A,A
87              ADD   A,A
87              ADD   A,A
87              ADD   A,A
87              ADD   A,A
80              ADD   A,B
6F              LD    L,A
C1              POP   BC
C5     NXTROWS  PUSH  BC
E5              PUSH  HL
C5              PUSH  BC
AF              XOR   A
11E05B          LD    DE,5BE0H       ;STORE THE TOP ROW OF THE
47              LD    B,A            ;BOTTOM LINE OF THE
E5              PUSH  HL             ;RECTANGLE IN THE PRINTER
EDB0            LDIR                 ;BUFFER.
D1              POP   DE
C1              POP   BC
B8              CP    B              ;IS THE RECTANGLE ONLY
2817            JR    Z,DONE         ;ONE LINE DEEP? IF SO THEN
C5     NXTLINE  PUSH  BC             ;DON'T SCROLL.
21E0FF          LD    HL,0FFE0H      ;FIND THE POSITION OF THE
0600            LD    B,0            ;ROWS IN MEMORY WHICH ARE
19              ADD   HL,DE          ;BEING MOVED DOWN.
7D              LD    A,L
FEE0            CP    0E0H
3804            JR    C,NOTTHRD
7C              LD    A,H
D607            SUB   7
67              LD    H,A
E5     NOTTHRD  PUSH  HL             ;NOW MOVE THE ROWS UP TO
EDB0            LDIR                 ;THEIR NEW POSITION, AND
D1              POP   DE             ;REPEAT UNTIL ALL OF THE
C1              POP   BC             ;TOP ROWS OF EACH
10E9            DJNZ  NXTLINE        ;CHARACTER HAVE BEEN
2A325B DONE     LD    HL,(5B32H)     ;SCROLLED. TEST (23346)
7D              LD    A,L
FE01            CP    1              ;DECIDE WHETHER TO
380F            JR    C,LEAVIT       ;LEAVE,
2007            JR    NZ,FILL        ;FILL OR
21E05B ROLL     LD    HL,5BE0H       ;ROLL THE GRAPHICS.
EDB0            LDIR
1806            JR    LEAVIT
41     FILL     LD    B,C            ;FILL THE TOP-ROW OF EACH
7C              LD    A,H            ;CHARACTER WITH THE
12     NXT1     LD    (DE),A         ;DESIRED PATTERN.
13              INC   DE
10FC            DJNZ  NXT1
E1     LEAVIT   POP   HL             ;NOW REPEAT WHOLE
C1              POP   BC             ;OPERATION FOR THE OTHER
24              INC   H              ;7 ROWS OF EACH CHARACTER
```

```
7C                 LD     A,H           ;IN THE RECTANGLE, AND...
E607               AND    7
20BA               JR     NZ,NXTROWS
C9                 RET                  ;RETURN TO BASIC.
                   END
```

UP AND DOWN FOR THE WHOLE SCREEN

The last two routines in this chapter are UPWS and DOWNWS (WS for Whole Screen). The only POKEs, of course, are 23346 and 23347. Both of the routines, like their 'rectangle' counterparts, erase the contents of the last thirty-two bytes of the printer buffer.

```
HEX.     ;UPWS  LENGTH: 67 BYTES
210040   START   LD     HL,4000H      ;BEGINNING OF DISPLAY RAM.
11E05B           LD     DE,5BE0H      ;PRINTER BUFFER.
D5       NXSLICE PUSH   DE
E5               PUSH HL
3E03             LD     A,3
012000           LD     BC,20H
C5       NXTHIRD PUSH   BC            ;STORE THE TOP 'SLICE'
E5               PUSH   HL            ;OF THE TOP LINE IN THE
EDB0             LDIR                 ;PRINTER BUFFER.
D1               POP    DE
0EE0             LD     C,0E0H
EDB0             LDIR                 ;NEXT 7 LINES (1-7) UP
0607             LD     B,7           ;INTO THE TOP 7 LINES
                                      ;(0-6). FIND THE FIRST
09               ADD    HL,BC         ;LINE OF THE NEXT THIRD OF
3D               DEC    A             ;THE SCREEN. REPEAT UNTIL
C1               POP    BC            ;ALL OF THE TOP SLICES HAVE
20F0             JR     NZ,NXTHIRD    ;BEEN SCROLLED UP A LINE.
3A325B           LD     A,(5B32H)     ;TEST(23346)
FE01             CP     1             ;DECIDE WHETHER TO ...
3811             JR     C,LEAVIT      ;LEAVE,
2007             JR     NZ,FILL       ;FILL OR
21E05B   ROLL    LD     HL,5BE0H      ;ROLL THE TOP SLICE DOWN
EDB0             LDIR                 ;INTO THE BOTTOM LINE.
1808             JR     LEAVIT
41       FILL    LD     B,C
3A335B           LD     A,(5B33H)     ;(23347) IS PLACED IN THE
12       NXT1    LD     (DE),A        ;BOTTOM LINE OF THE SCREEN.
13               INC    DE
10FC             DJNZ   NXT1
E1       LEAVIT  POP    HL            ;MOVE TO THE SECOND SLICE
D1               POP    DE            ;OF EACH LINE, AND REPEAT
24               INC    H             ;THE WHOLE OPERATION UNTIL
7C               LD     A,H           ;ALL 8 SLICES OF ALL 24
FE48             CP     48H           ;LINES HAVE BEEN SCROLLED.
38C9             JR     C,NXSLICE
EB       CLEANUP EX     DE,HL         ;CLEAN UP THE PRINTER
73       NXT2    LD     (HL),E        ;BUFFER.
2C               INC    L
20FC             JR     NZ,NXT2
C9               RET                  ;RETURN TO BASIC.
                 END
```

```
                ;DOWNWS  LENGTH: 69 BYTES
21FF57          START   LD      HL,57FFH        ;END OF DISPLAY RAM.
11FF5B                  LD      DE,5BFFH        ;PRINTER BUFFER.
D5              NXSLICE PUSH    DE
E5                      PUSH HL
3E03                    LD      A,3
012000                  LD      BC,20H
C5              NXTTHRD PUSH    BC              ;STORE THE BOTTOM 'SLICE'
E5                      PUSH    HL              ;OF THE BOTTOM LINE IN THE
EDB8                    LDDR                    ;PRINTER BUFFER.
D1                      POP     DE
0EE0                    LD      C,0E0H          ;MOVE THE BOTTOM SLICES OF
EDB8                    LDDR                    ;THE NEXT 7 LINES (22-16)
06F9                    LD      B,0F9H          ;DOWN INTO THE BOTTOM 7
09                      ADD     HL,BC           ;LINES (23-17). FIND THE
                                                ;BOTTOM LINE OF THE NEXT
                                                ;THIRD OF THE SCREEN.
C1                      POP     BC              ;REPEAT UNTIL ALL OF THE
3D                      DEC     A               ;BOTTOM SLICES HAVE BEEN
20F0                    JR      NZ,NXTTHRD      ;SCROLLED DOWN A LINE.
3A325B                  LD      A,(5B32H)       ;TEST(23346)
FE01                    CP      1               ;DECIDE WHETHER TO ...
3811                    JR      C,LEAVIT        ;LEAVE,
2007                    JR      NZ,FILL         ;FILL OR
21FF5B          ROLL    LD      HL,5BFFH        ;ROLL THE BOTTOM SLICE UP
EDB8                    LDDR                    ;INTO THE TOP LINE.
1808                    JR      LEAVIT
41              FILL    LD      B,C
3A335B                  LD      A,(5B33H)       ;(23347) IS PLACED IN THE
12              NXT1    LD      (DE),A          ;TOP LINE OF THE SCREEN.
1B                      DEC     DE
10FC                    DJNZ    NXT1
E1              LEAVIT  POP     HL              ;MOVE ON TO THE
                                                ;PENULTIMATE SLICE OF EACH
D1                      POP     DE              ;LINE AND REPEAT THE WHOLE
25                      DEC     H               ;THE WHOLE OPERATION UNTIL
7C                      LD      A,H             ;ALL 8 SLICES OF ALL 24
FE50                    CP      50H             ;LINES HAVE BEEN SCROLLED.
30C9                    JR      NC,NXSLICE
AF                      XOR     A               ;CLEAN UP THE PRINTER
0620                    LD      B,20H           ;BUFFER.
12              NXT2    LD      (DE),A
1B                      DEC     DE
10FC                    DJNZ    NXT2
C9                      RET                     ;RETURN TO BASIC.
                        END
```

DEMONSTRATION PROGRAM - CRISS-CROSS
Here then is the demonstration program as described under 'applications' at the beginning of this chapter.

Notes:
1) The numbers in line 20 are the locations of the four rectangle routines and will probably be different for you, depending on where and in what order you store them in memory.

2) The quotes in line 40 contain 5 spaces; those in line 70, one space.
Once the computer has jumbled up the tiles on the puzzle, enter the number on the appropriate cursor key in order to state which way you want the 'hole' in the grid to move. When you have put the tiles back into the right order, see if you can write a BASIC subroutine that makes the computer solve the puzzle, illustrating its moves as its goes.

```
  10 REM CRISS-CROSS © DAVID M.
WEBB 1982
  20 LET UP=65240: LET DOWN=6513
1: LET LEFT=65042: LET RIGHT=649
53
  30 RANDOMIZE
  40 BORDER 6: PAPER 5: CLS : PA
PER 6: FOR A=0 TO 21: PRINT AT A
,0;"     ";AT A,27;"     ";: NEX
T A
  50 PAPER 2
  60 FOR A=0 TO 20
  70 PRINT AT 0,5+A;" ";AT A,26;
" ";AT 21,26-A;" ";AT 21-A,5;" "
;
  80 NEXT A
  90 INK 4
 100 FOR A=8 TO 128 STEP 40
 110 PLOT 48,A: DRAW 159,0: PLOT
 48,A+39: DRAW 159,0
 120 PLOT 40+A,8: DRAW 0,159: PL
OT 79+A,8: DRAW 0,159
 130 NEXT A
 140 INK 0: PAPER 5: REM PRINT N
UMBERS
 150 FOR A=0 TO 3: FOR B=0 TO 3
 160 IF A*4+B+1=16 THEN  GO TO 1
90
 170 PRINT AT 3+A*5,8+B*5;A*4+B+
1
 180 NEXT B: NEXT A
 190 INK 0: PAPER 6
 200 PRINT AT 0,0;"Hang"'"on"'"w
hile"'"I mix"'"the"'"tiles"
 210 POKE 23346,1: REM roll
 220 LET X=21: LET Y=16
 230 FOR A=1 TO 300
 240 LET B=INT (RND*4)+5
 250 GO SUB 350
 260 NEXT A
 270 POKE 23333,0: POKE 23335,4:
 POKE 23336,2: POKE 23347,0: REM
 "FILL" WITH SPACES
 280 FOR A=0 TO 5: POKE 23332,A:
 POKE 23334,A
```

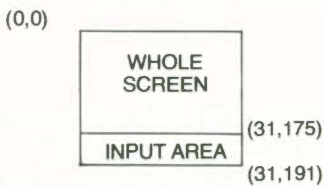
```
 290 FOR B=0 TO 4: LET L=USR LEF
T
 300 PAUSE 5: NEXT B
 310 NEXT A
 320 POKE 23346,1: REM "ROLL"
 330 INPUT "Which way (5/6/7/8)?
";B: IF B<5 OR B>8 THEN  GO TO 3
30
 340 GO SUB 350: GO TO 330
 350 IF B=8 AND X=21 OR B=5 AND
X=6 OR B=7 AND Y=1 OR B=6 AND Y=
16 THEN  RETURN
 360 POKE 23332,Y-5*(B=7): REM L
1
 370 POKE 23333,X-5*(B=5): REM C
1
 380 POKE 23334,Y+4+5*(B=6): REM
 L2
 390 POKE 23335,Y+4+5*(B=8): REM
 C2
 400 LET Y=Y+5*((B=6)-(B=7))
 410 LET X=X+5*((B=8)-(B=5))
 420 LET U=(LEFT AND B=5)+(RIGHT
 AND B=8)+(UP AND B=7)+(DOWN AND
 B=6)
 430 FOR Z=1 TO 5: LET L=USR U:
PAUSE 5: NEXT Z
 440 RETURN
```

CHAPTER 7
SCROLLING BY PIXELS

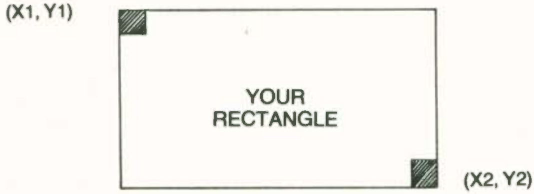
To complete the set of general-purpose scrolling routines in this book, here are four that allow you to scroll any window on the screen by just one pixel in any of four directions. This provides for much smoother animation in games, but I should warn you that even in machine code, with large areas of the screen being scrolled, it takes significantly longer to scroll eight times by one pixel than just once by one cell (eight pixels).

To use the routines you must first specify a window, unless you want the routine to default to the entire top 22 lines of the screen.

To define the window I have used a new system of coordinates. The columns are still numbered 0-31, but the "rows" or "lines of pixels" are numbered DOWN the screen from 0 to 191, thus:



Calling the top-left corner of your rectangle (x1, y1) and the bottom-right corner (x2, y2), both of which are included in the rectangle, then your screen should look like this:



If T is the start address of your routine, then these are the POKE addresses for your coordinates. I have prefixed the routine names with "PW" for "Pixel Window".

Routine name	Parameter X1	X2	Y1	Y2
PW LEFT	T + 41	T + 32	T + 1	T + 23
PW RIGHT	T + 32	T + 37	T + 1	T + 23
PW UP	T + 31	T + 36	T + 1	T + 23
PW DOWN	T + 31	T + 36	T + 27	T + 1

Hence to scroll the top four lines rightwards,

```
POKE T + 32, 0 : POKE T + 37, 31
POKE T + 1, 0 :  POKE T + 23, 31
```

The routines offer three different types of scrolling. These are:
LEAVE - the row or column of pixels exposed by the scroll as it is;
ROLL - the row or column "pushed out" of the rectangle back into the opposite end;
FILL - the exposed row or column with something new.

In the case of PW UP and PW DOWN, "Something new" means an eight-bit binary pattern that will go in the exposed row of each column, e.g.

```
BIN 1111 0000
```

would provide thick INK and PAPER vertical lines during repeated scrolling, while

```
BIN 0101 0101
```

would provide a fine "pinstripe" pattern. I'll call this binary pattern the FILLER byte. To "blank out" the exposed row (i.e. fill with paper), the filler will be zero. To "black in" the exposed row (i.e. fill with ink) the filler will be 255 (= BIN 1111 1111).

For PW LEFT and PW RIGHT, you may fill the exposed column with an INK pixel or a PAPER pixel. The "option number" defining which option you require is found from this table:

OPTION	PW LEFT, PW RIGHT	PW UP, PW DOWN
0	LEAVE	
1	ROLL	
2	Fill with PAPER	Fill with FILLER byte
3	Fill with INK	

The POKEs are as follows:

POKE 23361, [OPTION NO.]
POKE 23362, [Filler byte]

Here is the first one, PW LEFT, with a demonstration program.

```
HEX.        ;PW LEFT  LENGTH: 113 BYTES
            Y1     EQU    0
            Y2     EQU    0AFH
            X1     EQU    0
            X2     EQU    1FH
3E00        START  LD     A,Y1          ;LOCATE THE ADDRESS OF
4F                 LD     C,A           ;COLUMN 0 IN ROW Y1
E6C0               AND    0C0H
0F                 RRCA
0F                 RRCA
0F                 RRCA
C640               ADD    A,40H
67                 LD     H,A
79                 LD     A,C
E607               AND    7
84                 ADD    A,H
67                 LD     H,A
79                 LD     A,C
87                 ADD    A,A
87                 ADD    A,A
E6E0               AND    0E0H
6F                 LD     L,A
3EAF               LD     A,Y2          ;CHECK Y2 FOR LEGALITY
FEC0               CP     0C0H          ;THEN SUBTRACT Y1. IF
D0                 RET    NC            ;RESULT IS NEGATIVE THEN
91                 SUB    C             ;RETURN TO BASIC.
D8                 RET    C             ;OTHERWISE Y2-Y1+1=NUMBER
3C                 INC    A             ;OF ROWS TO BE SCROLLED.
4F                 LD     C,A
061F               LD     B,X2          ;FIND ADDRESS OF (X2,Y1)
7D                 LD     A,L
B0                 OR     B
6F                 LD     L,A
```

```
78              LD     A,B
FE20            CP     20H           ;CHECK X2 AND X1 FOR
D0              RET    NC            ;LEGALITY. X2-X1+1=NUMBER
D600            SUB    X1            ;OF COLUMNS TO BE
D8              RET    C             ;SCROLLED. STORE THIS
3C              INC    A             ;RESULT IN DE.
5F              LD     E,A
1600            LD     D,0
3A415B          LD     A,(5B41H)     ;PUT THE OPTION NUMBER
08              EX     AF,AF'        ;IN A'.
43      NXTROW  LD     B,E           ;SCROLL A ROW LEFTWARDS.
A7              AND    A
CB16    NXTCOL  RL     (HL)
2B              DEC    HL
10FB            DJNZ   NXTCOL
08              EX     AF,AF'        ;DECIDE ON WHETHER TO
19              ADD    HL,DE         ;LEAVE, ROLL OR FILL.
FE01            CP     1
3820            JR     C,LEAVE
2827            JR     Z,ROLL
CBC6            SET    0,(HL)        ;FILL ACCORDING TO BIT
CB47            BIT    0,A           ;0 OF THE OPTION NUMBER.
2002            JR     NZ,SET
CB86            RES    0,(HL)
08      SET     EX     AF,AF'
7C      INIT    LD     A,H           ;LOCATE THE X2
3C              INC    A             ;COLUMN OF THE NEXT
67              LD     H,A           ;ROW DOWN.
E607            AND    7
200A            JR     NZ,OUT
7D              LD     A,L
C620            ADD    A,20H
6F              LD     L,A
3804            JR     C,OUT
7C              LD     A,H
D608            SUB    8
67              LD     H,A
0D      OUT     DEC    C             ;REPEAT PROCEDURE UNTIL
20D4            JR     NZ,NXTROW     ;ALL ROWS OF RECTANGLE ARE
C9              RET                  ;SCROLLED, THEN RETURN TO
08      LEAVE   EX     AF,AF'        ;BASIC.
7E              LD     A,(HL)        ;LEAVE MOVES BIT 1 OF
E602            AND    2             ;COLUMN X2 BACK INTO
1F              RRA                  ;BIT 0.
B6              OR     (HL)
77              LD     (HL),A
18E2            JR     INIT          ;JUMP BACK TO NEXT ROW.
08      ROLL    EX     AF,AF'        ;ROLL THE LEFTMOST BIT OF
3E00            LD     A,0           ;COLUMN X1 OUT OF THE
17              RLA                  ;CARRY AND INTO BIT 0.
B6              OR     (HL)          ;OF COLUMN X2.
77              LD     (HL),A
18DA            JR     INIT          ;JUMP BACK TO NEXT ROW.
                END
```

Here is the demonstration; remember to change the start address in line 70 to your value.

```
  10 REM PIXEL WINDOW LEFT-SCROL
L DEMO
  20 REM  © DAVID M. WEBB,1983
  30 BRIGHT 1: FLASH 0: INVERSE
0: OVER 0: BORDER 4: PAPER 6: IN
K 4: CLS
  40 REM DEFINE USR GRAPHICS
  50 FOR A=0 TO 7: READ B: POKE
USR "A"+A,B: NEXT A
  60 DATA 0,BIN 10100000,BIN 100
10000,254,8,16,0,0
  70 LET PWL=65000: REM START AD
DRESS
  80 REM DRAW MOUNTAINS
  90 LET Y=28: PLOT 0,Y: FOR A=0
 TO 14
 100 LET DY=INT (RND*56)-Y
 110 DRAW 16,DY
 120 LET Y=Y+DY
 130 NEXT A
 140 DRAW 15,28-Y
 150 GO SUB 260: LET A$=CHR$ 144
: INK 2
 160 PRINT AT 10,15;A$;A$;A$;AT
9,14;A$;" ";A$;AT 11,14;A$;" ";A
$;AT 12,13;A$;AT 8,13;A$
 170 PRINT AT 0,1;"RED ARROWS IN
  VIGGEN FORMATION": PLOT 0,167:
 DRAW 255,0
 180 REM DEFINE WINDOW
 190 POKE PWL+1,119:     REM Y1
 200 POKE PWL+23,175:    REM Y2
 210 POKE PWL+41,0:      REM X1
 220 POKE PWL+32,31:     REM X2
 230 POKE 23361,1:      REM ROLL
 240 RANDOMIZE USR PWL: GO TO 24
0
 250 REM PAINT-IN MOUNTAINS
 260 FOR A=0 TO 255: LET B=0
 270 IF POINT (A,B) THEN  GO TO
290
 280 LET B=B+1: GO TO 270
 290 PLOT A,0: DRAW 0,B: NEXT A
 300 RETURN
```

RED ARROWS IN VIGGEN FORMATION

PW RIGHT is very similar to PW LEFT. You may like to try altering the demonstration program for PW LEFT so that the planes fly in the opposite direction, or perhaps leave the mountains stationary, define two windows 8 pixels by 32 columns in size and then produce a breath-taking display of two "solo" planes flying from opposite sides of the screen and crossing each other in mid-flight.

Another use for this routine would be to scroll messages across the screen, or maybe to move the landscape in a "Defender" or "Penetrator"-type game.

```
HEX.      ;PW RIGHT  LENGTH: 115 BYTES
          Y1      EQU     0
          Y2      EQU     0AFH
          X1      EQU     0
          X2      EQU     01FH
3E00      START   LD      A,Y1          ;LOCATE THE ADDRESS OF
4F                LD      C,A           ;COLUMN 0 IN ROW Y1.
E6C0              AND     0C0H
0F                RRCA
0F                RRCA
0F                RRCA
C640              ADD     A,40H
67                LD      H,A
79                LD      A,C
E607              AND     7
84                ADD     A,H
67                LD      H,A
79                LD      A,C
87                ADD     A,A
87                ADD     A,A
E6E0              AND     0E0H
6F                LD      L,A
```

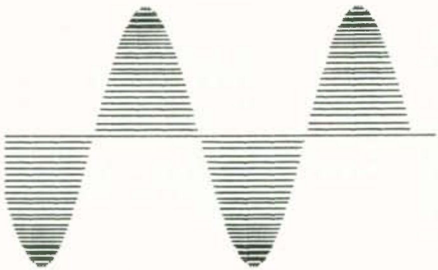
```
3EAF            LD      A,Y2            ;CHECK Y2 AND Y1
FEC0            CP      0C0H            ;FOR LEGALITY.
D0              RET     NC
91              SUB     C
D8              RET     C
3C              INC     A               ;Y2-Y1+1=NUMBER OF
4F              LD      C,A             ;ROWS TO BE SCROLLED.
0600            LD      B,X1            ;FIND ADDRESS OF (Y1,X1)
7D              LD      A,L
B0              OR      B
6F              LD      L,A
3E1F            LD      A,X2
FE20            CP      20H             ;CHECK X2 AND X1 FOR
D0              RET     NC              ;LEGALITY. X2-X1+1=NUMBER
90              SUB     B               ;OF COLUMNS TO BE
D8              RET     C               ;SCROLLED. STORE THIS
3C              INC     A               ;RESULT IN DE.
5F              LD      E,A
1600            LD      D,0
3A415B          LD      A,(5B41H)       ;PUT THE OPTION NUMBER
08              EX      AF,AF'          ;IN A'.
43      NXTROW  LD      B,E             ;SCROLL A ROW RIGHTWARDS.
A7              AND     A
CB1E    NXTCOL  RR      (HL)
23              INC     HL
10FB            DJNZ    NXTCOL
08              EX      AF,AF'          ;DECIDE ON WHETHER TO
A7              AND     A               ;LEAVE, ROLL OR FILL.
ED52            SBC     HL,DE
FE01            CP      1
3820            JR      C,LEAVE
2827            JR      Z.ROLL
CBFE            SET     7,(HL)          ;FILL ACCORDING TO BIT
CB47            BIT     0,A             ;0 OF THE OPTION NUMBER.
2002            JR      NZ.SET
CBBE            RES     7,(HL)
08      SET     EX      AF.AF'
7C      INIT    LD      A,H             ;LOCATE COLUMN X1 OF
3C              INC     A               ;THE NEXT ROW DONE.
67              LD      H,A
E607            AND     7
200A            JR      NZ,OUT
7D              LD      A,L
C620            ADD     A,20H
6F              LD      L,A
3804            JR      C,OUT
7C              LD      A,H
D608            SUB     8
67              LD      H,A
0D      OUT     DEC     C               ;REPEAT UNTIL ALL ROWS OF
20D2            JR      NZ,NXTROW       ;RECTANGLE ARE SCROLLED,
C9              RET                     ;THEN RETURN TO BASIC.
08      LEAVE   EX      AF,AF'          ;LEAVE MOVES BIT 6 OF
7E              LD      A,(HL)          ;COLUMN X1 BACK INTO
E640            AND     40H             ;BIT 7.
```

```
17                  RLA
B6                  OR    (HL)
77                  LD    (HL),A
18E2                JR    INIT        ;JUMP BACK TO NEXT ROW.
08          ROLL    EX    AF,AF'      ;ROLL THE RIGHTMOST BIT OF
3E00                LD    A,0         ;COLUMN X2 OUT OF THE
1F                  RRA               ;CARRY AND BACK INTO
B6                  OR    (HL)        ;BIT 7 OF COLUMN X1
77                  LD    (HL),A
18DA                JR    INIT        ;JUMP BACK TO NEXT ROW.
                    END
```

Here is a demonstration program for PW RIGHT.
I have included lines 180 to 210 as an example of how to make the program "auto-run" on loading. Don't forget to alter the start address in line 30 and the corresponding values in lines 170 to 210 to suit your own start address.

```
  10 REM PIXEL WINDOW RIGHT-SCRO
LL DEMO
  20 REM © DAVID M. WEBB, 1983
  30 LET PWR=65000: REM START AD
DRESS OF PIXEL WINDOW RIGHT
  40 OVER 1: PAPER 6: INK 2: BOR
DER 1 : CLS
  50 PRINT TAB 9;"OSCILLOSCOPE?"
  60 PLOT 0,87: DRAW 255,0: REM
AXIS
  70 REM DEFINE WINDOW
  80 POKE PWR+1,24:     REM Y1
  90 POKE PWR+23,152:   REM Y2
 100 POKE PWR+32,0:     REM X1
 110 POKE PWR+37,31:    REM X2
 120 POKE 23361,0: REM LEAVE OLD
 COLUMN
 130 FOR A=0 TO 252
 140 PLOT 0,87+64*SIN (A*PI/63):
 PLOT  OVER 0,0,87
 150 RANDOMIZE USR PWR: NEXT A
 160 POKE 23361,1: REM ROLL
 170 RANDOMIZE USR PWR: GO TO 17
 175 REM
 176 REM
 180 REM I USED THIS TO AUTO LOA
D THE MACHINE CODE......
 190 CLEAR 64999: LOAD "RPIXWIND
OW"CODE 65000,115: RUN
 200 REM ...AND THIS TO SAVE
 210 SAVE "PWR DEMO" LINE 180: S
AVE "RPIXWINDOW"CODE 65000,115
```

OSCILLOSCOPE?



Now for PW UP, which could be used highly effectively in "launching" a rocket from the bottom of the screen, or perhaps rotating the "fruit" dials in a fruit machine simulation. Two demonstration programs follow.

```
HEX.     ;PW UP  LENGTH: 115 BYTES
         Y1      EQU     0
         Y2      EQU     0AFH
         X1      EQU     0
         X2      EQU     1FH
3E00     START   LD      A,Y1         ;LOCATE THE ADDRESS OF
4F               LD      C,A          ;COLUMN 0 IN ROW Y1.
E6C0             AND     0C0H
0F               RRCA
0F               RRCA
0F               RRCA
C640             ADD     A,40H
67               LD      H,A
79               LD      A,C
E607             AND     7
84               ADD     A,H
67               LD      H,A
79               LD      A,C
87               ADD     A,A
87               ADD     A,A
E6E0             AND     0E0H
6F               LD      L,A
3EAF             LD      A,Y2         ;CHECK Y2 AND Y1
FEC0             CP      0C0H         ;FOR LEGALITY.
D0               RET     NC
91               SUB     C
D8               RET     C
08               EX      AF,AF'
0E00             LD      C,X1         ;FIND ADDRESS OF (X1,Y1).
7D               LD      A,L
B1               OR      C
6F               LD      L,A
3E1F             LD      A,X2
```

```
FE20              CP      20H           ;CHECK X2 AND X1 FOR
D0                RET     NC            ;LEGALITY.
91                SUB     C
D8                RET     C
3C                INC     A             ;X2-X1+1=WIDTH OF
4F                LD      C,A           ;RECTANGLE. STORE THIS IN
0600              LD      B,0           ;BC.
C5                PUSH    BC
E5                PUSH    HL
11E05B            LD      DE,5BE0H      ;MOVE THE TOP ROW OF THE
EDB0              LDIR                  ;RECTANGLE INTO THE PRINTER
E1                POP     HL            ;BUFFER.
C1                POP     BC
D9                EXX
08                EX      AF,AF'        ;IF THE WINDOW IS ONE
A7                AND     A             ;PIXEL HIGH THEN THERE IS
281E              JR      Z,NOSCROL     ;NOTHING LEFT TO SCROLL.
47                LD      B,A           ;B HOLDS THE NUMBER OF
D9        NXTROW  EXX                   ;ROWS LEFT TO SCROLL.
7C                LD      A,H           ;LOCATE THE COLUMN X1
3C                INC     A             ;OF THE NEXT ROW DOWN.
57                LD      D,A
5D                LD      E,L
E607              AND     7
200A              JR      NZ,OUT
7B                LD      A,E
C620              ADD     A,20H
5F                LD      E,A
3804              JR      C,OUT
7A                LD      A,D
D608              SUB     8
57                LD      D,A
EB        OUT     EX      DE,HL
E5                PUSH    HL            ;MOVE THIS ROW UP ONE
C5                PUSH    BC            ;PIXEL WITH A BLOCK-SHIFT
EDB0              LDIR                  ;INSTRUCTION.
C1                POP     BC
E1                POP     HL
D9                EXX                   ;REPEAT UNTIL ALL ROWS HAVE
10E3              DJNZ    NXTROW        ;BEEN SCROLLED.
D9        NOSCROL EXX
3A415B            LD      A,(5B41H)     ;DECIDE WHETHER TO FILL,
FE01              CP      1             ;ROLL OR LEAVE THE BOTTOM
D8                RET     C             ;ROW. IF THE LATTER, THEN
2007              JR      NZ,FILL       ;RETURN TO BASIC.
11E05B            LD      DE,5BE0H      ;ROLL THE ROW STORED IN THE
EB                EX      DE,HL         ;PRINTER BUFFER INTO THE
EDB0              LDIR                  ;BOTTOM ROW.
C9                RET                   ;RETURN TO BASIC.
3A425B    FILL    LD      A,(5B42H)     ;FILL THE BOTTOM ROW WITH
41                LD      B,C           ;THE FILLER BYTE.
77        NXTFILL LD      (HL),A
23                INC     HL
10FC              DJNZ    NXTFILL
C9                RET                   ;RETURN TO BASIC.
                  END
```

The first demonstration is a program that simply lets you "play around" with the size of a window and the type of scrolling, which will then take effect on a listing of the program itself. Line 90 forms an infinite loop, so to try a new window or setting BREAK out and re-RUN the program. You should alter the start address in line 30, and the corresponding values in the optional "auto-load" line, 100.

```
  10 REM UPWARDS PIXEL WINDOW-SC
ROLL DEMONSTRATION
  20 REM © DAVID M. WEBB, 1983
  30 LET X=65000: REM *** START
ADDRESS ***
  40 INPUT "X1 ";X1,"X2 ";X2,"Y1
 ";Y1,"Y2 ";Y2,"CONTROL ";C
  50 IF C=2 THEN  INPUT "FILLER
";F: POKE 23362,F
  60 POKE 23361,C: POKE X+1,Y1:
POKE X+23,Y2: POKE X+31,X1: POKE
 X+36,X2
  70 BORDER 3: PAPER 6: INK 2: C
LS : LIST 50: LIST 50
  80 REM
  90 RANDOMIZE USR X: GO TO 90
 100 CLEAR 64999: LOAD "UPIXWIND
OW"CODE 65000: RUN
```

The second demonstration program for PW UP is somewhat more spectacular, and shows a "number-dial" pixel-scrolling past a window in the centre of the screen, rather like a fruit machine dial past its display window.

I have used the trick of making INK and PAPER the same colour over the part of the screen (line 130) just below the display window, and then invisibly printing a number there after every eight pixel-scrolls, ready to be moved up into the display window.

Please remember, as always, to alter the start address in line 50 to your value. The scrolling may be speeded up by removing the PAUSE in line 130.

```
  10 REM UPWARDS PIXEL WINDOW-SC
ROLL DEMONSTRATION (2)
  20 REM © DAVID M. WEBB, 1983
  30 OVER 0: INVERSE 0: FLASH 0:
 BORDER 6: PAPER 6: CLS
  40 PRINT AT 11,15; INK 0; PAPE
R 7;"  "
  50 LET UP=65000: REM  ***START
 ADDRESS ***
  60 POKE UP+1,11*8:     REM Y1
  70 POKE UP+23,13*8:    REM Y2
```

```
  80 POKE UP+31,15:       REM X1
  90 POKE UP+36,16:       REM X2
 100 POKE 23361,0:        REM LEA
VE
 110 LET C=0: REM COUNTER
 120 PLOT 112,96: DRAW 31,0: DRA
W 0,-26: DRAW -31,0: DRAW 0,26
 130 PRINT  INK 6; PAPER 6;AT 12
,15;C: FOR A=0 TO 6: PAUSE 1: RA
NDOMIZE USR UP: NEXT A: LET C=C+
1: IF C=100 THEN  LET C=0
 140 RANDOMIZE USR UP: GO TO 130
```

I come now to the logical conclusion of this chapter, the routine PW DOWN. The two demonstration programs above may be easily adapted, using the information at the start of this chapter, to work with PW DOWN.

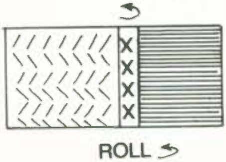
```
HEX.           ;PW DOWN  LENGTH: 116 BYTES
               Y1      EQU     0
               Y2      EQU     0AFH
               X1      EQU     0
               X2      EQU     1FH
                       ORG     8000H
3EAF           START   LD      A,Y2         ;LOCATE THE ADDRESS OF
FEC0                   CP      0C0H         ;COLUMN 0 IN ROW Y2.
D0                     RET     NC           ;CHECK Y2 FOR LEGALITY.
4F                     LD      C,A
E6C0                   AND     0C0H
0F                     RRCA
0F                     RRCA
0F                     RRCA
C640                   ADD     A,40H
67                     LD      H,A
79                     LD      A,C
E607                   AND     7
84                     ADD     A,H
67                     LD      H,A
79                     LD      A,C
87                     ADD     A,A
87                     ADD     A,A
E6E0                   AND     0E0H
6F                     LD      L,A
79                     LD      A,C
D600                   SUB     Y1           ;CHECK Y1 FOR LEGALITY.
D8                     RET     C
08                     EX      AF,AF'
0E00                   LD      C,X1         ;FIND ADDRESS OF (X1,Y2).
7D                     LD      A,L
B1                     OR      C
6F                     LD      L,A
3E1F                   LD      A,X2
FE20                   CP      20H          ;CHECK X2 AND X1 FOR
D0                     RET     NC           ;LEGALITY.
91                     SUB     C
```

```
D8                RET     C
3C                INC     A            ;X2-X1+1=WIDTH OF
4F                LD      C,A          ;RECTANGLE. STORE THIS
0600              LD      B,0          ;IN BC.
C5                PUSH    BC
E5                PUSH    HL
11E05B            LD      DE,5BE0H     ;MOVE THE BOTTOM ROW OF
EDB0              LDIR                 ;THE RECTANGLE INTO THE
E1                POP     HL           ;PRINTER BUFFER.
C1                POP     BC
D9                EXX
08                EX      AF,AF'       ;IF THE WINDOW IS ONE
A7                AND     A            ;PIXEL HIGH THEN THERE IS
281F              JR      Z,NOSCROL    ;NOTHING LEFT TO SCROLL.
47                LD      B,A          ;B HOLDS THE NUMBER OF
D9        NXTROW  EXX                  ;ROWS LEFT TO SCROLL.
7C                LD      A,H          ;LOCATE COLUMN X1 OF THE
3D                DEC     A            ;NEXT ROW UP.
57                LD      D,A
5D                LD      E,L
2F                CPL
E607              AND     7
200A              JR      NZ,OUT
7B                LD      A,E
D620              SUB     20H
5F                LD      E,A
3804              JR      C,OUT
7A                LD      A,D
C608              ADD     A,8
57                LD      D,A
EB        OUT     EX      DE,HL
E5                PUSH    HL           ;MOVE THIS ROW DOWN ONE
C5                PUSH    BC           ;PIXEL WITH A BLOCK-SHIFT
EDB0              LDIR                 ;INSTRUCTION.
C1                POP     BC
E1                POP     HL
D9                EXX                  ;REPEAT UNTIL THE WINDOW
10E2              DJNZ    NXTROW       ;HAS BEEN SCROLLED.
D9        NOSCROL EXX
3A415B            LD      A,(5B41H)    ;DECIDE WHETHER TO FILL,
FE01              CP      1            ;ROLL OR LEAVE THE TOP
D8                RET     C            ;ROW OF THE WINDOW. IF THE
2007              JR      NZ,FILL      ;LATTER, THEN RETURN TO
11E05B            LD      DE,5BE0H     ;BASIC. ROLL THE ROW OUT
EB                EX      DE,HL        ;OF THE PRINTER BUFFER
EDB0              LDIR                 ;INTO THE TOP ROW, THEN
C9                RET                  ;RETURN TO BASIC.
3A425B    FILL    LD      A,(5B42H)    ;FILL THE TOP ROW WITH
41                LD      B,C          ;THE FILLER BYTE.
77        NXTFILL LD      (HL),A
23                INC     HL
10FC              DJNZ    NXTFILL
C9                RET                  ;RETURN TO BASIC.
                  END
```

CHAPTER 8
CARPET-ROLL CLS

Here are two handy, novelty screen-clearing routines that can be used as direct substitutes for CLS.

Imagine, if you will, that the text and graphics on your screen are printed on a flat carpet, that the carpet is see-through, and that underneath it is a white lino (a blank screen). These routines take the carpet by one of the vertical edges and "roll" it up into a 1-column by 24-line roll, revealing as they go the "lino" or blank screen underneath. The "roll" of text makes its way from one side of the screen to the other, becoming visually darker as it "picks up" more text and graphics, until it eventually "falls off" the far edge of the screen, leaving a blank screen. The colour attributes are also altered according to the current INK, PAPER and BORDER colours as each column is cleared.



The first routine, RIGHT PEEL-OFF, clears the screen from left to right. You can vary the speed of the clear by means of a simple POKE, which controls the length of the PAUSE made after each column of the screen has been cleared.

If S = [start address], then
POKE S + 5, [length of pause]

Note that a value of 0 corresponds to a PAUSE of 256. To remove the PAUSE altogether, POKE S + 6, 0. To get it back, POKE S + 6, 118.

Here is RIGHT PEEL-OFF, followed by a demonstration program.

Call the routine with the usual

LET A = USR [start address]

```
HEX.        ;RIGHT PEEL-OFF  LENGTH: 78 BYTES
            ATTRP   EQU    5C8DH
            BORDCR  EQU    5C48H
2E00        START   LD     L,0          ;HL=TOP-LEFT CORNER OF
2640        NXTCOL  LD     H,40H        ;SCREEN.
0603                LD     B,3          ;DO A PAUSE
76          PAUSE   HALT
10FD                DJNZ   PAUSE
4E          NXTBYTE LD     C,(HL)       ;BLANK OUT THE CURRENT
3600                LD     (HL),0       ;COLUMN,...
0608                LD     B,8
CB19        NXTROT  RR     C            ;...PRODUCE ITS MIRROR
17                  RLA                 ;IMAGE...
10FB                DJNZ   NXTROT
23                  INC    HL           ;AND OR IT WITH THE
B6                  OR     (HL)         ;NEXT COLUMN TO THE RIGHT.
77                  LD     (HL),A
111F00              LD     DE,001FH     ;MOVE ONTO THE NEXT
19                  ADD    HL,DE        ;ROW OF THE SCREEN.
7C                  LD     A,H          ;ARE WE AT THE BOTTOM?
FE58                CP     58H
20EA                JR     NZ,NXTBYTE   ;IF NOT THEN REPEAT THE
13                  INC    DE           ;PROCESS.
0616                LD     B,16H        ;NOW TAKE THE INK
3A8D5C              LD     A,(ATTRP)    ;AND PAPER ETC., AND
77          NXTOP   LD     (HL),A       ;FILL OUT THE CURRENT
19                  ADD    HL,DE        ;COLUMN'S ATTRIBUTES.
10FC                DJNZ   NXTOP
3A485C              LD     A,(BORDCR)   ;USE THE BORDER COLOR
77                  LD     (HL),A       ;FOR THE BOTTOM TWO
19                  ADD    HL,DE        ;LINES.
77                  LD     (HL),A
19                  ADD    HL,DE
2C                  INC    L            ;HAVE WE REACHED THE LAST
7D                  LD     A,L          ;COLUMN OF THE SCREEN? IF
FE1F                CP     1FH          ;NOT THEN ROLL UP THE
20CC                JR     NZ,NXTCOL    ;NEXT COLUMN.
2640                LD     H,40H        ;BLANK OUT THE LAST
06C0                LD     B,0C0H       ;COLUMN,...
```

```
72          NXTROW LD     (HL),D
19                 ADD    HL,DE
10FC               DJNZ   NXTROW
3A8D5C             LD     A,(ATTRP)     ;FILL IN ITS ATTRIBUTES...
0616               LD     B,16H
77          NXTOP2 LD     (HL),A
19                 ADD    HL,DE
10FC               DJNZ   NXTOP2
3A485C             LD     A,(BORDCR)
77                 LD     (HL),A
19                 ADD    HL,DE
77                 LD     (HL),A
C9                 RET                  ;AND RETURN TO BASIC.
                   END
```

Note that as it stands, there is a PAUSE of 3 after clearing columns. This following demonstration uses a PAUSE of 20, and makes use of the fact that the routine also affects the attributes. It does this by changing the PAPER colour just before the routine is called, so that as the screen is "rolled back" it reveals a differently coloured blank screen underneath.

```
  10 REM RIGHT PEEL-OFF DEMO
  20 LET CLSB=65200: REM ENTER Y
OUR START ADDRESS
  30 PAPER 6: INK 2: CLS
  40 CIRCLE 128,87,87: PAPER 4:
REM PAPER ALTERED
  50 POKE CLSB+5,20: REM SET SPE
ED
  60 RANDOMIZE USR CLSB
```

Now I couldn't really resist giving you the luxurious choice of a carpet-roll CLS in two directions, so here for all left-handed or ambidextrous readers is "LEFT PEEL-OFF". All of the BASIC programming is the same as for RIGHT PEEL-OFF, and the same demonstration program will work (you can adjust the REM in line 10 if you wish!), so I'll just leave you with the code:

```
HEX.        ;LEFT PEEL-OFF  LENGTH: 75 BYTES
            ATTRP    EQU    5C8DH
            BORDCR   EQU    5C48H
2E1F        START    LD     L,1FH      ;HL=TOP-LEFT CORNER OF
2640        NXTCOL   LD     H,40H      ;SCREEN.
0603                 LD     B,3        ;DO A PAUSE
76          PAUSE    HALT
10FD                 DJNZ   PAUSE
4E          NXTBYTE  LD     C,(HL)     ;BLANK OUT THE CURRENT
3600                 LD     (HL),0     ;COLUMN,...
0608                 LD     B,8
CB19        NXTROT   RR     C          ;...PRODUCE ITS MIRROR
17                   RLA               ;IMAGE...
10FB                 DJNZ   NXTROT
```

```
2B              DEC   HL            ;AND OR IT WITH THE
B6              OR    (HL)          ;NEXT COLUMN TO THE LEFT.
77              LD    (HL),A
112100          LD    DE,0021H      ;MOVE ONTO THE NEXT
19              ADD   HL,DE         ;ROW OF THE SCREEN.
7C              LD    A,H           ;ARE WE AT THE BOTTOM?
FE58            CP    58H
20EA            JR    NZ,NXTBYTE    ;IF NOT THEN REPEAT THE
1B              DEC   DE            ;PROCESS.
0616            LD    B,16H         ;NOW TAKE THE INK
3A8D5C          LD    A,(ATTRP)     ;AND PAPER ETC., AND
77      NXTOP   LD    (HL),A        ;FILL OUT THE CURRENT
19              ADD   HL,DE         ;COLUMN'S ATTRIBUTES.
10FC            DJNZ  NXTOP
3A485C          LD    A,(BORDCR)    ;USE THE BORDER COLOR
77              LD    (HL),A        ;FOR THE BOTTOM TWO
19              ADD   HL,DE         ;LINES.
77              LD    (HL),A
19              ADD   HL,DE         ;HAVE WE REACHED THE LEFT-MOST COLUMN?
2D              DEC   L             ;IF NOT THEN
20CF            JR    NZ,NXTCOL     ;NEXT COLUMN
2640            LD    H,40H         ;BLANK OUT THE LAST
06C0            LD    B,0C0H        ;COLUMN,...
72      NXTROW  LD    (HL),D
19              ADD   HL,DE
10FC            DJNZ  NXTROW
3A8D5C          LD    A,(ATTRP)     ;FILL IN ITS ATTRIBUTES...
0616            LD    B,16H
77      NXTOP2  LD    (HL),A
19              ADD   HL,DE
10FC            DJNZ  NXTOP2
3A485C          LD    A,(BORDCR)
77              LD    (HL),A
19              ADD   HL,DE
77              LD    (HL),A
C9              RET                 ;AND RETURN TO BASIC.
                END
```

CHAPTER 9
MIRRORED CHARACTERS

Here is an amusing little routine whose sole effect is to reflect each character on the screen in an imaginary vertical axis dissecting each character cell. This gives the effect of 'mirror writing', and since the routine provides a reflection, the operation is self-inverse, i.e. calling the routine again will bring your characters back to normal.

The routine will also 'reflect' any graphics etc. that happen to be on the screen: this in itself could be used to produce some interesting kaleidoscopic effects.

Here is the code:

```
HEX.        ;MIRROR1  LENGTH: 19 BYTES
210040      START   LD    HL,4000H      ;START OF SCREEN.
4E          NXTCELL LD    C,(HL)        ;TAKE A ROW.
0608                LD    B,8           ;B COUNTS ROTATIONS.
CB11        NXTRTTN RL    C             ;MOVE LEFT-MOST BIT
1F                  RRA                 ;INTO CARRY AND THEN INTO A.
10FB                DJNZ  NXTRTTN       ;NEXT BIT
77                  LD    (HL),A        ;RESTORE THE ROW.
23                  INC   HL            ;NEXT BYTE OF MEMORY.
7C                  LD    A,H           ;HAVE WE REACHED THE
FE58                CP    58H           ;ATTRIBUTE AREA?
20F1                JR    NZ,NXTCELL    ;IF NOT THEN CARRY ON,
C9                  RET                 ;ELSE RETURN TO BASIC.
                    END
```

PUT THIS IN A STAMPED ENVELOPE AND SEND TO:

In the United States of America return page to:
Melbourne House Software Inc., 347 Reedwood Drive,
Nashville TN 37217.

In the United Kingdom return page to:
Melbourne House (Publishers) Ltd., Melbourne House, Church Yard,
Tring, Hertfordshire, HP23 5LU

In Australia & New Zealand return page to:
Melbourne House (Australia) Pty. Ltd., Suite 4, 75 Palmerston Crescent,
South Melbourne, Victoria, 3205.

reflect any number of consecutive user-definable graphics characters.

To use this routine, we must start by giving each graphic character a number. To make it easy, I've used A = 1, B = 2 and U = 21. A table of the alphabet may be useful:

A - 1	F - 6	K - 11	P - 16	U - 21
B - 2	G - 7	L - 12	Q - 17	
C - 3	H - 8	M - 13	R - 18	
D - 4	I - 9	N - 14	S - 19	
E - 5	J - 10	O - 15	T - 20	

If X is the start address, then POKE (X + 4) with the number of the first character to be reflected, and POKE (X + 14) with the number of characters to be reflected. As standard the routine will reflect all of the UDG characters, and here it is:

```
HEX.      ;MIRROR2  LENGTH: 33 BYTES
          N1      EQU   1
          N2      EQU   15H
2A7B5C    START   LD    HL,(5C7BH)    ;START OF THE UDG AREA.
3E01              LD    A,N1          ;CODE OF THE FIRST
3D                DEC   A             ;CHARACTER.
87                ADD   A,A           ;MULTIPLY BY 8.
87                ADD   A,A
87                ADD   A,A
5F                LD    E,A           ;ADD THE RESULT TO
1600              LD    D,0           ;THE UDG BASE.
19                ADD   HL,DE
3E15              LD    A,N2          ;THE NUMBER OF CHARACTERS
87                ADD   A,A           ;IS MULTIPLIED BY
87                ADD   A,A           ;8 TO GIVE THE NUMBER
87                ADD   A,A           ;OF BYTES.
4F                LD    C,A
0608      NXTROW  LD    B,8           ;B COUNTS THE BITS.
5E                LD    E,(HL)        ;REFLECT ONE BIT.
CB13      NXTBIT  RL    E
1F                RRA
10FB              DJNZ  NXTBIT        ;...EIGHT TIMES.
77                LD    (HL),A        ;RESTORE THE BYTE.
23                INC   HL            ;ON TO THE NEXT ROW
0D                DEC   C             ;UNTIL ALL IS DONE, THEN
20F3              JR    NZ,NXTROW
C9                RET                 ;RETURN TO BASIC.
                  END
```

CHAPTER 10
MORE SPECTACULAR WAYS TO CLEAR THE SCREEN

In chapter eight I presented a new way of clearing the screen, the 'carpet-roll' method. Here are two more techniques.
The first I have called "shifting" for want of a better word. Every byte of the display file represents a row of eight pixels. What the routine does is to shift those pixels along by one pixel to the right. The leftmost pixel is replaced by a PAPER pixel and the rightmost is lost. This process is repeated eight times in quick succession, so, that the resultant effect is a blank screen. The attributes file is then filled out in the same way as for the CLS command.
As I said, the direction of this shift is to the right. For slightly different effect (you guessed it, a shift to the left), if X is the start address,

    POKE X + 9,38 .

To restore the routine to its original form,

    POKE X + 9,62 .

As usual, the routine can be called with the command

    LET A=USR X .

```
HEX.     ;RIGHTSHIFT CLS     LENGTH : 40 BYTES
1608              LD      D,08H          ;FOR 8 BITS...
210040   NXTSHFT  LD      HL,4000H       ;HL=START OF DISPLAY
011800            LD      BC,0018H       ;FILE.
CB3E     NXT      SRL     (HL)           ;SHIFT THE BYTE
23                INC     HL
10FB              DJNZ    NXT            ;REPEAT 6143 TIMES
0D                DEC     C
20F8              JR      NZ,NXT
15                DEC     D              ;NEXT BIT
```

```
20EF                JR     NZ,NXTSHFT
3A8D5C              LD     A,(5C8DH)        ;TAKE S.V. ATTR P
77                  LD     (HL),A           ;FILL THE TOP 22 LINES
54                  LD     D,H              ;WITH IT
5D                  LD     E,L
13                  INC    DE
01C002              LD     BC,02C0H
EDB0                LDIR
3A485C              LD     A,(5C48H)        ;TAKE THE BORDER COLOUR
77                  LD     (HL),A           ;FILL THE BOTTOM 2
0E3F                LD     C,3FH            ;LINES WITH IT
EDB0                LDIR
C9                  RET                     ;RETURN TO BASIC
                    END
```

The second new method for screen-clearing is called 'fade-out' by virtue of its effect. No POKES are required and the result is highly satisfying.

```
HEX.      ;FADEOUT CLS     LENGTH : 47 BYTES
11FE08            LD       DE,08FEH         ;D COUNTS THE BITS
7B        NXTFADE LD       A,E              ;E IS A ROTATING MASK
07                RLCA                      ;WITH ONE BIT RESET
07                RLCA
07                RLCA
5F                LD       E,A
210040            LD       HL,4000H         ;HL=START OF DISPLAY FILE
011800            LD       BC,0018H
7E        NXT     LD       A,(HL)           ;TAKE A BYTE
A3                AND      E                ;AND THE MASK
77                LD       (HL),A           ;REPLACE THE BYTE
23                INC      HL
10FA              DJNZ     NXT              ;REPEAT 6143 TIMES
0D                DEC      C
20F7              JR       NZ,NXT
15                DEC      D                ;NEXT BIT
20E9              JR       NZ,NXTFADE       ;TAKE SYSTEM VARIABLE
3A8D5C            LD       A,(5C8DH)        ;ATTR P
77                LD       (HL),A           ;FILL THE TOP 22 LINES
54                LD       D,H              ;WITH IT
5D                LD       E,L
13                INC      DE
01C002            LD       BC,02C0H
EDB0              LDIR
3A485C            LD       A,(5C48H)        ;TAKE THE BORDER COLOUR
77                LD       (HL),A           ;FILL THE BOTTOM TWO
0E3F              LD       C,3FH            ;LINES WITH IT
EDB0              LDIR
C9                RET                       ;RETURN TO BASIC
                  END
```

A COMPLETE AND DETAILED BREAKDOWN OF USEFUL SYSTEM VARIABLES

CHAPTER 11
SYSTEM VARIABLES AND THE KEYBOARD

Between the area in the RAM of the Spectrum which is used to store the screen contents and that which is used to store your BASIC program is a section of memory called the SYSTEM VARIABLES area. It is here that the computer makes its 'notes for future reference' such as what colour the screen border is, which line of your program it is working on and which key is being pressed.

In this section I will explain how you can use the system variables to your advantage - and which ones to avoid! A full list of the system variables and their addresses can be found in Chapter 25 of the Spectrum Manual, here I shall elaborate on some of the descriptions to be found therein.

CONCERNING THE KEYBOARD

1. Address 23556 will hold either

a) 255 if no key is being pressed; or
b) The CODE of the character printed in white on the left-hand side of the key being pressed.

In the latter case the CODE can be thought of as that of the character that INKEY$ would produce if the CAPS LOCK were on and the key concerned were being pressed on its own.

This property can be used to advantage when using INKEY$ in your program. Enter this program and see what effect CAPS SHIFT or SYMBOL SHIFT has when pressed with another key:

```
10 REM To see how SHIFTS affect INKEY$
20 PRINT AT 0,0; INKEY$; "        ": REM
   4 spaces
30 GOTO 20
```

As you can see, the character produced depends not only on which key is being pressed but also on whether any SHIFT key is pressed. CAPS LOCK will also change the output. This leads to complicated lines when using INKEY$. E.g. (after a game)...

```
1000 PRINT "Do you want another game? (Y/N)":
 PAUSE 0:
     IF INKEY$ = "Y" or INKEY$ = "y" or
     INKEY$ = "AND" THEN RUN
1010 STOP
```

We can get round this awkwardness by PEEKing address 23556. Try this program.

```
10 REM Tidier INKEY$
20 PRINT AT 0, 0; CHR$ PEEK 23556; "      ";
30 GOTO 20.
```

You will find that whatever shift key is pressed, the character produced is that which appears on the left-hand side of the other key being pressed. Hence the solution to the above problem is:

```
1000 PRINT "Do you want another game (Y/N)?"
     : PAUSE 0:
     IF CHR$ PEEK 23556 = "Y" THEN RUN
1020 STOP.
```

There is one more invaluable benefit to be had from this technique; if more than one key on the board is pressed then CHR$ PEEK 23556 produces the character of the first key to make contact, rather than nothing, as in the case of INKEY$. This can be used to improve game control: so that if you accidentally press another key whilst moving your LASER-base out of the way of a bomb then you will survive to fight another battle, rather than stopping dead (pun evident).

If you intend to use this idea a lot in your program, then it might be as well to start off with

```
10 LET KEY = 23556
```

so that in future you will only need

```
IF CHR$ PEEK KEY = ...  THEN ...
```

Incidentally, this saves a small amount of memory (both yours and the machine's!).

2. LAST K: ADDRESS 23560

PEEKing this address will produce the CODE of the last key that was pressed, whether or not you are still pressing it. As in the case of address 23556, if more than one key is being pressed then the CODE of the first key to be pressed takes precedence. It is worth noting (perhaps) that although CAPS SHIFT or SYMBOL SHIFT on its own does not affect INKEY$ or the contents of 23560, together they produce CODE 14, which is normally used to signify a number in the Spectrum BASIC listing. These two keys affect the contents of location 23556 in the same way.

There are four other key combinations which produce values for PEEK 23560 and CODE INKEY$ which do not appear in the Spectrum Manual. These are as follows:

Keys normally used to produce ...	Value of CODE INKEY$
GRAPHICS (CAPS SHIFT & 9)	15
TRUE VIDEO (CAPS SHIFT & 3)	4
INV VIDEO (CAPS SHIFT & 4)	5
CAPS LOCK (CAPS SHIFT & 2)	6

3. REPDEL

This location address 23561, holds the time that a key must be held down before it begins to repeat. The time is measured in 50th of a second in Britain, 60th of a second in North America: these intervals correspond to the time taken for one cycle of mains current in the respective areas. REPDEL is initially set at 35, but can be altered by POKEing 23561 with any integer from 0 to 255. Note that the Spectrum takes the value of REPDEL, decrements it and then checks to see whether zero has been reached, so that POKEing REPDEL with zero will result in a PAUSE of 256 rather than zero before the key repeats.

4. REPPER

Located at 23562, this system variable works in the same fashion as REPDEL and controls the delay between successive repeats of a key once a key has begun to repeat. Note again that a value of 0 represents a PAUSE of 256 rather than zero. Some idea of the potential speed of key entry can be attained by POKEing REPDEL and REPPER with a value of one. This is best attempted only in a program, since it is almost impossible to type in the commands necessary to restore the variables to sensible values once they have been reduced to such a level!

Try this program:

```
  10 REM Changing REPPER and REP
DEL
  20 LET A=PEEK 23561: LET B=PEE
K 23562
  30 INPUT "Change REPPER to?";r
epper,"Change REPDEL to?";repdel
  40 POKE 23561,repdel: POKE 235
62,repper
  50 INPUT "Try this , input spe
ed";A$
```

```
  60 POKE 23561,A: POKE 23562,B
  70 PRINT "Values used:": PRINT
 : PRINT "REPDEL=";repdel,"REPPE
R=";repper
  80 INPUT "Another combination
(y/n)?";A$
  90 IF A$="y" THEN  GO TO 30
```

Using the program you will be able to select the combination of REPPER and REPDEL that suits you best. If you intend to do a lot of typing, it may well be worth POKEing in these values before you start. Note however, that NEW resets REPDEL to 35 and REPPER to its usual value of 5.

5. RASP

Location 23608 holds the length of that grating warning buzz that occurs when your INPUT has spilled off the bottom of the screen and you continue to try to enter the line. It may be of interest that although the buzz occurs on every keystroke after a screen overflow, the line is still being entered, and (providing the syntax of the BASIC line is correct) the string or BASIC line will still be acceptable to the Spectrum.

The value of RASP can be varied, from its initial 64 at power up, between 0 and 255, and each increment of the value corresponds to about one 65th of a second in the duration of the tone. Thus one way of entering a very large REM statement (in which to store machine code) would be to POKE RASP to its lowest value of 0 (to speed up proceedings) and then to enter the line all in one go. The following system variable should also be set to zero for speed:

6. PIP

This is the length of the sound emitted from the Spectrum (apart from the usual buzz) every time a key is pressed during an INPUT or while in direct command of the computer. Initially set at zero at power up, address 23609 can be POKEd to change PIP up to its maximum of 255, which corresponds to about one 3rd of a second. Hence each increment corresponds to about one 765th of a second.

Note that neither RASP or PIP are affected by the NEW command.

CHAPTER 12
FORCING ERROR REPORTS

As you know, whenever you do something in BASIC that your Spectrum does not like, it grinds to a halt and gives you one of those annoying but none-the-less very helpful messages. These are called 'Error Reports' and a list of them can be found in appendix B, page 189 of the Spectrum Manual.

Whenever the Spectrum decides that it is about to deliver unto you an error message, it gives the number or letter preceding the message (e.g. R in "R Tape loading error") a value, and stores this value as the system variable 'ERR NR' (for ERRor NumbeR).

ERR NR can be found in location 23610, and the value for each error report is decided as follows:

REPORT CODE	ERRNR Value
0 to 9	Subtract 1 from report code (0 becomes 255)
A to R	Add 8 to the position of the report code in the alphabet.

Hence code 9 has value 8, A has value 9, B has value 10 and so on.

There are essentially two ways to force the computer to stop with any required report code (apart from trying to make the required mistake!)

The first method is totally in BASIC. You simply POKE the appropriate value into ERR NR for the report required, and then make sure the program ends without producing any more reports (since these would alter the value of ERR NR). Perhaps the easiest way to do this is as follows:

```
(any line) POKE 23610, [appropriate value] :
     GOTO 9999
9999 REM
```

Note that the line 9999 is just a 'dummy' line whose sole purpose is to ensure that 'GOTO 9999' does not produce the report "0 OK". There is one small snag, however; the line number and statement number in the report will be "9999:1". To get around this, you can make use of the system variables PPC (locations 23621 and 23622) and SUBPPC (23623). PPC holds the current line number and SUBPPC the current statement number. Hence in the above example we can produce the exact line and statement numbers required in the report code, by POKEing in appropriate values of PPC and SUBPPC.

If L is the line number required, change line 9999 from

```
9999 REM
```

to

```
9999 POKE 23621, L - 256 * INT(L / 256):
     POKE 23622, INT(L / 256):
     POKE 23623, [statement number]
```

N.B. To cause a "0 OK" report on the current line, insert the command

```
POKE 23611, PEEK 23611 -128.
```

The second method involves one of the shortest pieces of machine code you are ever likely to come across. It goes like this:

Comment	Mnemonic	Hex
Call error routine	RST 8	CF
Data byte = value of ERRNR	DEFB	(FF)

This is so short that it can be POKEd into the two spare bytes to be found near the end of the system variables. They are locations 23728 and 23729.

Hence to force an error report at any time in a program, use the line:

```
(Line L)     POKE 23728, 207 : POKE 23729, [ appropriate value
                  of ERRNR] : RANDOMIZE USR 23728
```

The line number in the report will be L, the statement number will be three and the program will stop immediately.

NEWPPC, NSPPC

I have already mentioned PPC and SUBPPC, which store the current line number and statement number respectively. NEWPPC and NSPPC (not a charity) are normally used to store the line number and statement number to be jumped to when GOTO and GOSUB are being used.

One can use these variables to produce a sort of 'supercharged GOTO' in that you can force the computer to jump to any statement in any line.

NEWPPC is in locations 23618 and 23619, and NSPPC is in location 23620. Hence to force a jump within the program to (say) the 4th statement in line 10, use the line:

```
POKE 23618, 10: POKE 23619, 0: POKE 23620, 4.
```

Note that the POKE 23620, ... must always follow the other 2 POKES.

Generally, to force a jump to the nth statement in line L, use the line:

```
POKE 23618, L -256 * INT (L/256): POKE 23619,
                     INT (L/256): POKE 23620,n.
```

The second POKE may be omitted if L is less than 256. If you ever find yourself in a situation where you want to insert an extra line into a block of program, there is not a spare line number and no 'renumber' facility is available, then you could insert the extra line as an extra statement in the line above it and use the above technique to 'GOTO' the statement as required. This is however a cumbersome process and any possible use of a GOSUB to a subroutine in a 'less cluttered' part of the program is to be much preferred.

CHAPTER 13
CHANGING MODES

MODE

This system variable occupies location 23617 and despite the manual, the programmer can only use it to force a graphic (G) mode prompt or an extended (E) mode prompt in the next INPUT statement.

In graphics mode, MODE has the value 2 (bit 1 is set). In extended mode, MODE has the value 1 (bit 0 is set, only valid for one keystroke, as usual). Hence to force a graphic-mode INPUT for A$, use:

```
POKE 23617, 2: INPUT A$
```

For extended mode use:

```
POKE 23617, 1: INPUT A$.
```

Unless A$ in the latter example becomes the empty string, the E-mode will return to L-mode after the first keystroke. If however A$ is empty or G-mode has been 'forced', then the mode will remain the same for the next INPUT statement. Hence to restore the prompt to the normal 'L', we use:

```
POKE 23617, 0
```

POKEing extended mode before an INPUT can be particularly useful if repeated BIN functions are being entered.

CAPS LOCK

Having just mentioned how to produce G- and E-mode INPUTS, I will 'jump the gun' up to location 23658, which is one of those mysterious system variables given the description "more flags" in the Spectrum Manual.

When the CAPS LOCK is on, bit 3 (value 8) of this location is set. When the CAPS LOCK is taken off, the bit is reset (value 0). Hence to change all INPUTs and INKEY$ to capitals in a program, use:

```
POKE 23658, 8;
```

and to produce 'lower case' or 'small letter' INPUTs and INKEY$,

```
POKE 23658, 0.
```

This technique is a valuable alternative solution to the problem discussed on page 72 regarding the fact that INKEY$ = "Y" is different to INKEY$ = "y".

Hence instead of using the 'clumsy' lines such as:

```
120 IF INKEY$ = 'Y' OR INKEY$ = 'y' THEN PRINT
    "YES"
130 IF INKEY$ = 'N' OR INKEY$ = 'm' THEN PRINT
    "NO"
```

we can use:

```
120 POKE 23658, 8 : IF INKEY$ = 'Y' THEN PRINT
    "YES"
130 IF INKEY$ = 'N' THEN PRINT "NO"
```

The use of this concept is most efficient when dealing with a large number of conditional INPUT or INKEY$ statements.

CHAPTER 14
SCREEN COLOURS

BORDCR

Although the Spectrum normally protects the user from accidentally setting the INK and PAPER for the two INPUT lines at the bottom of the screen to the same colour, you can if you wish, do so by POKEing the system variable BORDCR, location 23624. This may prove particularly useful if your computer is on show and you wish to discourage prying little fingers from ruining your program listing.

To produce the required effect:

```
        POKE 23624, 8 * BORDERCOLOUR + INKCOLOUR : CLS
                        (the PAPER)
```

The CLS can be omitted if the computer is in 'direct command' mode. The above line will change the INK and PAPER of the bottom 2 lines of the screen, but to produce the appropriate BORDER colour at the same time the line should be preceeded by a BORDER command.

It is interesting to note that by using the above POKE location we can make the input lines FLASH and/or BRIGHTer by adding the following values to the number to be POKEd in:

```
        128 for FLASH 1
        64 for BRIGHT 1
```

The new value of BORDCR remains unaffected until the next BORDER or NEW command.

EXAMPLE

(This one is particularly sickly!) To produce a magenta border with yellow INK and magenta PAPER INPUT lines, FLASH 1 and BRIGHT 1, use the line

BORDER 3: POKE 23624, 128 + 64 + 3 * 8 + 6: CLS

ATTR P, MASK P, ATTR T, MASK T

These variables simply store the values of INK, PAPER, BRIGHT and FLASH that are currently being used. The 'P' stands for Permanent and the 'T' for Temporary (i.e. enclosed in and only operative on the current PRINT statement).

ATTR P and ATTR T are of little use; but for reference here are the values which are added to make them:

ATTR = 8 * (PAPER COLOUR) + INK Colour + (128 for FLASH 1) + (64 for BRIGHT 1)

ATTR P is in location 23693 and ATTR T is at address 23695.

MASK P and MASK T are more useful; any 'bit' of the one-byte variables that is a 1 shows that the corresponding attribute bit for PRINTing is to be taken from the cell at the current PRINT position on the screen (as in the case of INK, PAPER, BRIGHT and FLASH 8).

MASK P is at location 23694 and MASK T is at 23696. the main point of interest with these variables is that we can set not only the INK and PAPER to 8 but we can also restrict the effect to only 1 or 2 of the 3 primary (blue, red and green) colours that make up the eight available colours. This principle is explained more fully with the SCREENOP routines in Chapter 3. The constituent values for MASK P and MASK T are as follows:

BIT	EFFECT	VALUE
0	BLUE INK 8	1
1	RED INK 8	2
2	GREEN INK 8	4
3	BLUE PAPER 8	8
4	RED PAPER 8	16
5	GREEN PAPER 8	32
6	BRIGHT 8	64
7	FLASH 8	128

		255

CHAPTER 15
FRAMES:- THE HIDDEN TIMER

Hidden away in the darkest recesses of the system variables is a constantly changing counter called FRAMES. This counter is incremented 50 times per second in the U.K. and 60 times per second in N. America. This frequency is equal to the mains frequency in the area, and also to the number of times per second a new 'frame' is sent to the television to update the picture.

FRAMES starts off at zero when the computer is switched on and increments every 20 milliseconds (16 2/3 in N. America) unless a BEEP command, a cassette tape operation or one of the hardware add-ons to the Spectrum (e.g. printer) is being used. From this information we can at last see justification for the 1/50 or 1/60 of a second being the limit of a PAUSE statement. "PAUSE n" simply means "wait until FRAMES has increased by n".

FRAMES is located in 3 bytes: 23672, 23673, 23674. Each byte has eight bits and so the maximum value of FRAMES is $2^{24} - 1 =$ 16777215, which in the U.K. corresponds to a time of 3 days, 21 hours, 12 minutes and 24.3 seconds since the count was started. Hence if you leave your computer on for slightly longer than this then FRAMES will go back to zero and start counting again.

The value of FRAMES can be found with the line:

```
            PRINT PEEK 23672 + 256 * PEEK 23673 + 65536 *
PEEK 23674
```

This program demonstrates:

```
  10 REM *** To watch FRAMES ***
  20 LET FRAMES=23672
  30 POKE FRAMES,0: POKE FRAMES+
1,0: POKE FRAMES+2,0
  40 PRINT AT 11,11;"FRAMES=";
  50 PRINT AT 11,18;PEEK FRAMES+
256*PEEK (FRAMES+1)+65536*PEEK (
FRAMES+2)
  60 GO TO 50
```

The hidden potential of FRAMES is vast; it can be used to drive a clock, to monitor a time limit in a game, to power an 'alarm clock' (a good example of which can be found in "Over the Spectrum", another Melbourne House book) or to run a stopwatch, as in the following program. This program gives you all the features to be found on a normal electronic stopwatch, with a reading in tenths of a second. Since FRAMES is accurate to 0.01% (i.e. about 9 seconds a day), so is this stopwatch. More information on FRAMES can be found in Chapter 18, page 129 of the Spectrum Manual.

This listing is for areas with mains frequency 50 Hz; so if you live in N. America (60 Hz), change these values in line 150:

1.8 E5	to	2.16 E5
3 E3	to	3.6 E3
50	to	60
5	to	6

And in line 130:

4320 000 to 5184 000

```
  10 REM ** STOPWATCH *** © Davi
d M. Webb 1982
  20 PAPER 5: BORDER 5: INK 0: C
LS
  30 REM
  40 REM T=TIME
  50 REM
  60 PRINT AT 9,13; INK 2; PAPER
 6;"STOPWATCH"
  70 PRINT AT 0,0;"PRESS:": PRIN
T  BRIGHT 1;"L"; BRIGHT 0;" for
Lap time": PRINT  BRIGHT 1;"R";
BRIGHT 0;" to return to stopwatc
h": PRINT  BRIGHT 1;"S"; BRIGHT
0;" to Start": PRINT  BRIGHT 1;"
SPACE"; BRIGHT 0;" to stop, THEN
 ": PRINT  BRIGHT 1;"C"; BRIGHT
0;" to continue": PRINT  BRIGHT
1;"X"; BRIGHT 0;" to reset stopw
atch"
  80 POKE 23658,8: REM caps lock
```

```
  90 PLOT 100,89: DRAW 86,0: DRA
W 0,-12: DRAW -86,0: DRAW 0,12:
REM display window
 100 PRINT AT 11,13;"0 :0 :0.0 "
 110 PAUSE 0: IF INKEY$<>"S" THE
N  GO TO 100: REM START
 120 POKE 23672,0: POKE 23673,0:
 POKE 23674,0
 130 LET T=PEEK 23672+256*PEEK 2
3673+65536*PEEK 23674: IF T>4320
000 THEN  GO TO 120: REM ARE 24
HOURS UP?
 140 LET T1=T
 150 PRINT AT 11,13;INT (T/1.8E5
);TAB 15;":";: LET T=T-1.8E5*INT
 (T/1.8E5): PRINT INT (T/3E3);TA
B 18;":";
 155 LET T=T-3E3*INT (T/3E3): PR
INT INT (T/50);".";: LET T=T-50*
INT (T/50): PRINT INT (T/50);TAB
 23: IF INKEY$="L" THEN  PAUSE 0
 160 IF INKEY$<>" " THEN  GO TO
130
 170 LET F3=INT (T1/65536): LET
T1=T1-65536*F3: LET F2=INT (T1/2
56): LET F1=T1-256*F2: REM F1,F2
,F3 ARE FRAME VALUES WHEN WATCH
WAS STOPPED
 180 PAUSE 0: IF INKEY$="C" THEN
  POKE 23672,F1: POKE 23673,F2:
POKE 23674,F3: GO TO 130
 190 IF INKEY$="X" THEN  GO TO 1
00: REM RESET STOPWATCH
 200 GO TO 180
```

```
PRESS:
L for Lap time
R to return to stopwatch
S to Start
SPACE to stop, THEN
C to continue
X to reset stopwatch

            STOPWATCH
           |0 :1 :9.0 |
```

CHAPTER 16
SCROLLING THE SCREEN

One problem frequently encountered by BASIC programmers on the Spectrum is how to stop the "scroll?" prompt appearing and how to make the screen scroll at will, as the useful SCROLL command on the ZX-81 has for some reason been omitted from Spectrum BASIC.

There is a system variable called SCR CT (for SCRoll CounT), and this has a value of one more than the number of lines the screen will be scrolled upwards by before stopping with "scroll?" (hence normally SCR CT is less than or equal to 23). Therefore, to keep the computer from stopping, we must POKE a value of SCR CT greater than one (255 will do).

SCR CT can be found at location 23692. This little program shows you how it works:

```
10 PRINT AT 21, 31'
20 PRINT PEEK 23692
30 GOTO 20
```

Line 10 forces the first "scroll?" prompt. Note that the PEEK function in line 20 is evaluated before PRINTing starts, hence the value printed corresponds to the state of SCR CT after the previous number had been PRINTed.

To stop "scroll?" occuring use:

```
POKE 23692, 255
```

and preferably do this in a program loop so that the value of SCR CT never reaches 1, as it otherwise would after the screen had scrolled 254 times.

To simulate a ZX-81-type SCROLL, do this:

```
POKE 23692, 255: PRINT AT 21, 31 ' ' AT 21, 0;
```

(Note the two single apostrophes). This makes the computer prepare for printing on the next (as yet unseen) line below the bottom line of the user's screen area, and in doing so SCROLLS the screen up a line and sets the 'print position' at 21,0. Allow me to elucidate:

```
  10 LET a$="Press any key to SC
ROLL me."
  20 PRINT a$
  30 PAUSE 0: REM WAIT
  40 POKE 23692,255: PRINT AT 21
,31''AT 21,0;: REM SCROLL
  50 PRINT a$: REM PRINT POSITIO
N HAS BEEN SET TO 21,0
  60 GO TO 30
```

There is, in fact, another way of producing a SCROLL-type function. In the Spectrum ROM at address 3582 begins the routine that performs the actual scroll that we can force, as shown above, from BASIC. This machine-code routine can be called using the USR function, like so:

```
RANDOMIZE USR 3582.
```

This will scroll the screen up a line. Note that the PRINT position is unaltered, and so to imitate the ZX-81 SCROLL we must use:

```
RANDOMIZE USR 3582: PRINT AT 21, 0;
```

Incidently and conversely, if you wish to produce a "scroll?" prompt then:

```
POKE 23692, 1: PRINT AT 21, 31''
```

or the 'direct call' version,

```
RANDOMIZE USR 3213     .
```

will do nicely!

CHAPTER 17
REDEFINING THE CHARACTER SET: 96 MORE GRAPHICS

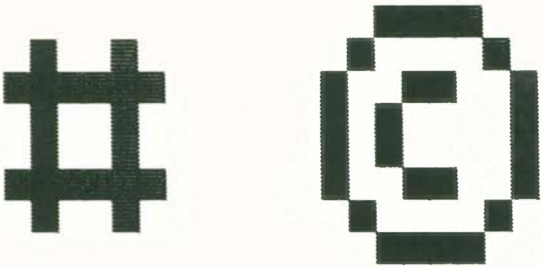
Apart from the fact that twenty-one user-definable graphic characters are available on the Spectrum, it is also possible to redefine the 96 characters (CODES 32 to 127, SPACE to (c)) whose normal "patterns" are held in a table in the ROM.

The character table begins at address 15616 and ends at address 16383 (the last byte of the ROM). Just like user defined graphic characters, the entry for each character in the table consists of eight consecutive bytes, one for each 'row' of the character. Each byte has, of course, eight bits, one for each column. The entries in the table are arranged in order of character CODE. Let me demonstrate with a program that examines the table and reproduces the characters at 16 times normal size:

```
  10 REM Letter, © David M. Webb
  20 PAPER 2: INK 7: BORDER 2: C
LS
  30 FOR A=15616 TO 15616+95*8 S
TEP 8: REM 96 CHARACTERS
  40 FOR B=A TO A+7: REM CHARACT
ERS HAS EIGHT ROWS
  50 LET B$="": LET C=PEEK B
  60 FOR D=0 TO 7: REM EACH ROW
HAS EIGHT BITS (1..0)
  70 LET B$=B$+("  " AND C*2<256
)+("  " AND C*2>=256): REM IS TH
E BIT AN INK(1) OR A PAPER(0) DO
T
```

```
 80 LET C=C*2-256*(C>127)
 90 NEXT D
100 PRINT B$'B$
110 NEXT B
120 BEEP .2,30
130 PRINT AT 0,0
140 NEXT A
```

Some copies of the screen:



There is a two-byte system variable called CHARS, the value of which is 256 less than the address of the character table (i.e. usually equal to 15360). CHARS can be found in locations 23606 and 23607, and hence its value can be checked by:

```
PRINT "CHARS = "; PEEK 23606 + 256 * PEEK 23607.
```

The great virtue of CHARS being a system variable is that we can move the 'base address' of the table to wherever we like by altering CHARS, and then if the new base address is in an appropriate area of spare RAM we can redefine part or all of the characters, just as we can with user-defined graphics.

This gimmicky little program "encodes" any phrase you INPUT by moving the base of the table up by one character (eight bytes) so that 'A' becomes 'B', 'C' becomes 'D' and so on. The string is printed out with the new character set and then CHARS is POKEd back to normal.

```
10 INPUT A$
20 PRINT "In code that is";
30 POKE 23606, 8
40 PRINT A$
50 POKE 23606, 0
```

It is very important to note that, although the 'pattern' representing each CODE is different if CHARS is altered, the actual meanings of all the command- and function-words are exactly the same; the computer simply represents these words with numbers or "tokens", so that while

PRINT A$ would look like QSJOU!B%

in the above program LISTing, it would still mean "print out A$ on the screen" to the computer. In other words, altering the character table does not affect normal usage of the machine - it just makes listings and text nearly impossible for the user to understand! To see what I mean, leave out line 50 of the above program and press (ENTER) after it has RUN.

Right then, enough of that gimmickry and on to more serious applications of CHARS. You may well find a time when you have used up all the 21 user-defined graphics available on the Spectrum, or when you want the BASIC SCREEN$ to recognise your graphic characters. This is the time to call on a technique for changing the character table.

First of all, we need to CLEAR an area of memory to accommodate the new table. Using all the characters, this will be 96 x 8 = 768 bytes long. Next it is usually a good idea to copy the existing table into the new table area. We then alter CHARS appropriately so that it is 256 less than the address of the start of the new table. At this stage things will appear as normal, since the new table is exactly the same as the old one. It is, however, in RAM. We can therefore redefine any character we like using the BIN function in a very similar way to that used with the user-defined graphic characters (see Chapter 14, page 92 of the Spectrum manual).

If at any time you wish to revert to the normal table,

POKE 23606, 0: POKE 23607, 60.

I have written the following program partly for its functional usefulness and partly to illustrate how to manipulate the character set using the procedure outlined above. With the program, you will be able to move, alter, SAVE and reLOAD any character set you desire. To exercise the SAVE option, enter as a direct command

GOTO 300

All other options are presented automatically when the program is RUN. Please feel free to make alterations and improvements to the program - you could for example add the option of defining the characters by moving a cursor over an 8 by 8 grid. It is obvious that having so many more graphics characters available dramatically improves the quality of many games: I leave it to the reader to further exploit CHARS.

```
  10 REM To redefine the cha
racter set
  20 REM first we clear some spa
ce
  30 GO SUB 310
  40 INPUT "Shall I clear some m
ore space?";A$: IF A$<>"Y" AND A
$<>"y" THEN  GO TO 60
```

```
  50 CLEAR RAMTOP-768: REM 768=8
*(NUMBER OF CHARACTERS ROUTINES)
  60 GO SUB 310
  70 REM NOW WE COPY UP THE OLD
TABLE
  80 INPUT "Shall I copy up the
old table ?";A$: IF A$<>"Y" AND
A$<>"y" THEN  GO TO 110
  90 INPUT "Shall I LOAD a table
 from tape?";A$: IF A$="Y" OR A$
="y" THEN  LOAD ""CODE RAMTOP+1,
768
 100 GO TO 150
 110 PRINT "Hang on...": FOR a=1
 TO 768
 120 POKE RAMTOP+a,PEEK (15615+a
)
 130 NEXT a
 140 REM THEN WE ALTER CHARS
 150 LET CHARS=RAMTOP+1-256
 160 POKE 23606,CHARS-256*INT (C
HARS/256)
 170 POKE 23607,INT (CHARS/256)
 180 PRINT "The value of CHARS i
s ";CHARS
 190 REM FINALLY WE DEFINE ANY C
HARACTERS
 200 GO SUB 310: INPUT "Alter wh
ich character?"; LINE A$
 205 PRINT CODE A$;A$
 210 IF LEN A$<>1 OR CODE A$<32
OR CODE A$>127 THEN  GO TO 200
 220 LET ENTRY=RAMTOP+1+8*(CODE
A$-32): REM THAT IS WHERE THE PA
TTERN IS
 230 FOR R=0 TO 7: REM ONE ROW A
T A TIME USE THE BIN FUNCTION TO
 INPUT THE PATTERN
 235 POKE 23617,1: REM EXTENDED
MODE
 240 INPUT ("ROW ";R;" ";);ROW:
IF ROW<0 OR ROW>255 THEN  GO TO
240
 250 POKE ENTRY+R,ROW
 260 NEXT R
 270 GO TO 200
 280 REM SPECIAL SAVE SECTION
 290 GO SUB 310
 300 SAVE "Characters"CODE RAMTO
P+1,768: STOP
 310 LET RAMTOP=PEEK 23730+256*P
EEK 23731
 320 RETURN
 330 REM © DAVID M. WEBB 1983
```

CHAPTER 18
MEMORY LABELS

There is a whole group of system variables or 'labels' which the computer uses to 'keep an eye' on the state of its memory for example to know where the program begins, where the BASIC variables start and so on. Most of these labels are of little interest to the programmer: detailed here are the ones that are worth noting.

1. PROG

Locations 23635 and 23636 tell the computer where the PROGram starts.

```
PRINT PEEK 23635 + 256 * PEEK 23636
```

gives the value of PROG. Add five to this and you have the location of the first character after the REM statement, if the first program line is

```
10 REM Lots of characters to store machine code in.
```

Hence if you wish to store machine code in a REM statement at the beginning of the program, then you simply create a long enough REM statement (one character per byte) and find the start address by adding five to the value of PROG. Note that without any microdrives etc. attached, PROG is always equal to 23755.

The other possible use of PROG is to produce a more permanent copyright statement at the beginning of the program. First enter the copyright line in the usual way at the beginning of the program, then evaluate PROG and finally

```
POKE (PROG), 0: POKE (PROG + 1), 0
```

If the old line number is less than 256 then the first of the 2 commands can be omitted. What the procedure does is to 'renumber' the first line of the program to zero, thereby making it impossible to EDIT or remove the line without POKEing the number back above zero again. A zero first line number can also be produced with the machine code renumber routine in this book, as explained in Chapter 24.

2. VARS

VARS holds the address of the BASIC VARiables, and is itself held in locations 23627 and 23628, so its value can be found by

```
PRINT PEEK 23627 + 256 * PEEK 23628
```

The BASIC variables are situated directly after the BASIC program in the Spectrum memory, and hence we can find the actual length of a program by subtracting PROG from VARS, thus:

```
PRINT "Program is"; 256 * (PEEK 23628 - PEEK
                                 23636)
    + PEEK 23627 - PEEK 23635; "bytes long".
```

- quite a mouthful but the only way in BASIC (see Chapter 23 for the equivalent machine code routine).

3. RAMTOP and STKEND

I have put these two otherwise unrelated system variables together because they can be used to estimate the amount of memory left to the user. Refering to page 165 of the Spectrum Manual you will notice that the only things between the pointers STKEND and RAMTOP on the memory map are spare memory and the usually small machine stack and GOSUB stack.

RAMTOP is evaluated by:

```
PRINT PEEK 23730 + 256 * PEEK 23731
```

and STKEND by:

```
PRINT PEEK 23653 + 256 * PEEK 23654
```

Alternatively, as luck would have it, the Spectrum ROM contains a routine that returns the value of STKEND, thus:

```
PRINT USR 7962
```

To estimate the amount of memory left then, just subtract STKEND from RAMTOP. All this can obviously be a tedious process, so if you intend to use the function frequently it is probably as well to use the more accurate (it doesn't count the 2 stacks) machine code routine in Chapter 23.

4. DATADD

If you have 'READ' an unknown way along a DATA line and suddenly have to do a CLEAR or a RESTORE command to another line then you will lose your position on the first DATA line. Should you wish to retain it, DATADD may be of use.

DATADD holds the address of the comma after the last DATA item that was READ in the program, and can be found at address 23639, so to store the position on the line,

```
LET DATADD = PEEK 23639 + 256 * PEEK 23640
```

Then whenever (if ever) you wish to go back to that position after DATADD has been altered, you can restore DATADD (excuse my pun) as follows:

```
POKE 23640, INT (DATADD/256)
POKE 23639, DATADD - 256 * INT (DATADD/256)
```

5. UDG

UDG holds the address of the first user-defined graphic character (CHR$ 144) and is itself held in locations 23675 and 23676. There are 21 user-defined characters, and hence the length of memory they ocupy is 21 x 8 bytes = 168 bytes. Conveniently enough, this is less than the 256 bytes to be found in the area normally used by the printer, the PRINTER BUFFER.

If you are:
a) running out of memory, and
b) not using the ZX printer,

then you can increase the spare memory left for your program by 168 bytes by moving the user defined graphics from the top of memory down to the printer buffer and then CLEARing RAMTOP to the last byte of free memory.

The printer buffer is 256 bytes long and begins at address 23296. Many of the routines in this book use the early part of the buffer as a storage area, so to 'play safe' we will take the last 168 bytes of the buffer in this case.

This program moves the graphics and alters UDG.

Note that, as always, UDG = USR "a"

```
10 REM 'GRAPHIC SHIFT'
20 LET NEWUDG = 23384
30 FOR A = 0 TO 167
40 POKE NEWUDG + A, PEEK (USR "a" + A)
50 NEXT A
```

```
60 REM ADJUST UDG
70 POKE 23676, INT (NEWUDG/256)
80 POKE 23675, NEWUDG - 256 * INT (NEWUDG/256)
```

Precisely the same function is fulfilled by a fast, short machine language routine:

```
HEX.        ;MEMORY LABELS  LENGTH: 16 BYTES
            UDG     EQU     5C7BH
2A7B5C      START   LD      HL,(UDG)        ;HL=OLD UDG.
ED5B585B            LD      DE,(5B58H)      ;DE=NEW UDG.
ED537B5C            LD      (UDG),DE        ;STORE NEW UDG.
01A800              LD      BC,168          ;BLOCK SHIFT 168 BYTES
EDB0                LDIR                    ;OF GRAPHICS.
C9                  RET                     ;RETURN TO BASIC.
                    END
```

We have not quite finished; to create new spare memory we must increase RAMTOP by 168 to its maximum value of 32767 (16K machines) or 65535 (48K). Simply do this with a CLEAR command:

CLEAR 32767 (16K) or CLEAR 65535 (48K)

It is perhaps worth mentioning that another way of doing a 'block shift' of the graphics (or any other data for that matter) is to SAVE it from one address using SAVE... CODE m,n and then LOAD back to another address using LOAD... CODE. This can be, and in most cases is, the slowest and clumsiest method for block shifting, but if you have a Microdrive then it may well prove to be highly practicable.

CHAPTER 19
DF SZ AND SOFTWARE PROTECTION.

DFSZ holds the number of lines in the lower INPUT part of the screen. This is normally two, but can be altered with care.

On the earlier ZX-81 machine it was quite feasible to PRINT on the two INPUT lines by POKEing DF SZ to zero and then using "PRINT AT 22,0..." or "PRINT AT 23,0...". In the case of the Spectrum, one must be more careful when DFSZ is set to zero, if one is to avoid a "crash".

Since DFSZ holds the number of lines in the INPUT and message area of the screen, if it is reduced right down to zero then there is no room for messages or "reports" to be printed, and whenever the computer tries to print in this area, due to the lack of a "failsafe" device in the ROM which would alter DFSZ to make room for the message, the computer crashes. So, if you must alter DFSZ to zero, then remember the following points:

1. Do not use any INPUTS or SAVE commands.

2. Do not allow the Spectrum to try and print "Scroll?".

3. Do not press "BREAK" or the Spectrum will try to print a report and line number, etc.

4. Do not use "PRINT AT 23,..." This is because for some reason the ROM has been programmed only to accept rows 0 to 22, and so "PRINT AT 23,..." would produce an attempt to print the error report "B Integer out of range".

DFSZ can be altered to between 1 and 24 with none of the above problems and if altered to 1 then "PRINT AT 22,..." is acceptable. In order to reach the very bottom line if DFSZ is zero, (PRINT AT 22, 31 ') will have to be used, since "PRINT AT 23,..." is unacceptable.

There is, as luck would have it, a far better solution to the problem hidden away in Sinclair BASIC. It would seem that whoever wrote the Spectrum manual either forgot to mention or didn't want us to know that there exists a function allowing you to print in the input area. I stumbled on it one day during one of those "I-can't-think-what-to-write" sessions.

To print in the area (using the "AT" coordinates found in some INPUT statements) use:

```
PRINT # 0 ; ( normal print items )
```

In fact there are 4 values that currently follow "#" (the Microdrives may use more), they are 0 and 1 for printing in the lower half of the screen, 2 for printing in the upper part (as normal) and 3 for sending items to the printer (as in LPRINT).

PROTECTING BASIC PROGRAMS

Point 3. above can come in handy if you want to stop people "breaking into" and copying your BASIC programs. By POKEing DFSZ to zero you ensure that any attempt to BREAK the program will produce a distinctly unconscious Spectrum. This idea would be best used in conjunction with the following SAVEing technique.

As you probably know, you can stop a program "auto-running" from tape when it has been stored with a SAVE... LINE... command by first NEWing the computer and then using MERGE " " rather than LOAD " ". This has proven to be rather a problem for software companies who were trying to prevent copying of their programs. One way round the problem is to SAVE the program as a block of code by inserting the following lines at the end of a program:

```
9010 LET STKEND = PEEK 23653 + 256 * PEEK 23654
9020 SAVE " [name] " CODE 23552, STKEND -23500
9030 RUN
```

This SAVEs the entire user area, including program, calculator stack, BASIC variables and system variables as a block of code onto tape, so that when the whole lot is brought back using a LOAD "(name)" CODE command the computer carries on exactly where it left off, i.e. by executing line 9030, RUN.

Now obviously you cannot MERGE a block of code, but it is not impossible for someone to CLEAR RAMTOP to a low enough address, LOAD the code up immediately above it, decipher the old value of STKEND in order to calculate the length of the block and then to re-SAVE it onto a new tape. In order to counter this possibility you could substitute the following lines:

```
9010 LET STKEND = PEEK 23653 + 256 * PEEK 23654
9020 LET A = INT(RND *  256)
9030 SAVE " [name] " CODE 23552 - A, STKEND -
     23500 + A
9040 RUN
```

This introduces a new element of randomness in that our phantom copier does not now know from which address the code is SAVEd, since a part of the printer buffer of random length A is also SAVEd at the beginning of the block of code, thereby dislodging STKEND to an unknown position in the block. Hopefully at this point our "pirate" will have given up and moved on to someone else's less-protected program, but it has to be said that ultimately it is possible to break into any program given time and patience - we can only make it harder to do so.

CHAPTER 20
MISCELLANEOUS SYSTEM VARIABLES

1. S TOP

S TOP, for Screen TOP, holds the number of the program line which appears at the top of the screen in automatic listings. STOP can be found in locations 23660 and 23661.

2. OLDPPC and OSPCC

OLDPPC and OSPCC hold the line number and statement number respectively that CONTINUE would jump to after a "BREAK into program". Hence if you have just stopped the program, pressed newline which deletes the message, and can't remember what line you were at, then these variables will tell you.

```
PRINT PEEK 23662 + 256 * PEEK 23663
```

will tell you which line number is next, and

```
PRINT PEEK 23664
```

will tell you which statement.

3. COORDS

Addresses 23677 and 23678 respectively hold the X and Y coordinates of the last point plotted. These can be treated as two extra BASIC variables when using a PLOTing or DRAWing program; if you start a program with

```
LET XO = 23677: LET YO = 23678
```

then whenever you need to know the last point plotted,

```
PEEK XO and PEEK YO will be fine.
```

To draw a line from the last point plotted to (A, B)

```
DRAW A - PEEK XO, B - PEEK YO
```

You can also POKE COORDS to alter the PLOT position without actually PLOTting a point or DRAWing a line.

S POSN

S POSN holds the current print position, but not in the way that you would expect. If you have just PRINTed at A, B then

```
location 23688 holds 33 - B,
location 23689 holds 24 - A.
```

Hence to find your current print position in the "conventional" format (A, B):

```
LET A = 24 - PEEK 23689
LET B = 33 - PEEK 23688
```

If you intend to use this a lot in any one program (perhaps in conjunction with SCREEN$), then it is worth using DEF FN statements for the two values, i.e.

```
:DEF FN Y() = 24 - PEEK 23689
:DEF FN X() = 33 - PEEK 23688
```

SEED

Seed is the system variable that was used to generate the last 'random' number, and is located at addresses 23670 and 23671. Try this:

```
PRINT RND, (PEEK 23670 + 256 * PEEK
23671)/65536.
```

You will see that the two values printed are equal. Every time RND is used, SEED is altered by the computer as follows:

```
New SEED = (75 (SEED + 1)) mod 65537 -1
```

This corresponds to the BASIC line

```
LET SEED = 75 * (SEED + 1): LET SEED = SEED
-65537 * INT (SEED/65537) -1
```

The new value of SEED is stored away and then divided by 65536 to produce a value of RND between 0 and 1, the latter being exclusive.

Whenever RANDOMIZE is used, this just moves the first two bytes of FRAMES into SEED, so that the next time RND is used the computer will produce a psuedo-random number at a different position in the sequence of 65536 different numbers that the above function generates.

This shows that FRAMES is moved into SEED by RANDOMIZE.

```
10 RANDOMIZE
20 LET SEED - PEEK 23670 + 256 * PEEK 23671
30 LET FRAMES = PEEK 23672 + 256 * PEEK 23673
40 PRINT "SEED ="; SEED, "FRAMES ="; FRAMES
```

There will be a small difference between SEED and FRAMES since FRAMES is still increasing while the program is being RUN.

DFCC and DFCCL

These two variables hold the address in the display file of the two print positions, one for the top part of the screen and the other for the INPUT area. Due to the odd arrangement of the display file it is not normally desirable to PEEK and POKE the screen; we have POINT, PRINT and SCREEN$ (see SCREEN$2, an improved function in this book) for that. The actual layout of the memory map is explained fully on page 164 of the Spectrum Manual, and as a consequence of this layout, if the print position is Y, X then

```
DFCC = 2048 * INT (Y/8 + 8) + (Y - 8 * INT
(Y/8)) * 32 + X.
```

Don't forget that each character on the screen is stored in eight bytes in memory (one for each row). The addresses of the eight bytes for any one character are 256 apart, and so if the first row is at DFCC, then the second is at DFCC + 256, the third at DFCC + 512 and so on. This program will illustrate; a graphic character is POKEd into a random position and then animated by further POKEing. Line 20 sets the print position and then line 30 reads DFCC, which is located at addresses 23684 and 23685. As you will see, the effect produced by POKEing instead of PRINTing is considerably slower than the latter and I can think of no reason to justify its substitution for the same in normal BASIC programming.

```
  10 REM POKING TO PRINT
  15 BORDER 0: PAPER 0: INK 6: C
LS
  20 PRINT AT INT (RND*22),INT (
RND*32);
  30 LET DFCC=PEEK 23684+256*PEE
K 23685
  40 FOR C=0 TO 1
  50 FOR A=DFCC TO DFCC+7*256 ST
EP 256
  60 READ B: POKE A,B: NEXT A
  70 NEXT C
```

```
  80 RESTORE : GO TO 40
  90 DATA 24,60,126,25,31,254,60
,24
 100 DATA 248,60,23,15,15,23,60,
248
```

PFLAG

This system variable holds the "switches" or FLAGS for the printing values PAPER 9, INK 9, INVERSE and OVER. There are two bits for each of these; one for the temporary value and one for the permanent one. The temporary values are those caused by inserting the functions into a PRINT statement in order to affect just that command, the permanent ones are used otherwise. Here are the values:

	TEMPORARY		PERMANENT	
FUNCTION	BIT	VALUE	BIT	VALUE
OVER 1	0	1	1	2
INVERSE 1	2	4	3	8
INK 9	4	16	5	32
PAPER 9	6	64	7	128

P FLAG is situated in location 23697, and by adding up the values of the functions desired from the table above, you can set them all in one go by POKEing P FLAG.

Hence to set a permanent OVER 1; INVERSE 1; INK 9; PAPER 9; just

POKE 23697, 170

- a lot more succinct, and memory-saving!

ROUTINES TO IMPROVE BASIC COMMANDS

CHAPTER 21
SCREEN $ 2

If you have ever tried to use the SCREEN$ function on the Spectrum to recognise a user-defined graphic character (such as a space invader) or one of those "chunky" graphic characters that consists of four squares or "blocks", each of which may be INK or PAPER, then you will have found that the function does not work and that the result is an empty string. This can be illustrated with a short program:

```
10 PRINT AT 10, 15; "▞"
20 PRINT AT 1, 1; "The character at (10, 15) is
   "; SCREEN$ (0,0)
```

In this case the character that the function does not recognise is CHR$ (137), but the same applies to all characters whose CODE ranges from 129 to 164 (if the CODE is greater than 164, then the corresponding "keyword" is made up of characters recognised by SCREEN$).

This deficiency in SCREEN$ makes it almost useless, since it is usually needed when writing graphical games (e.g. to detect whether you, the defender are about to be annihilated by an alien's carelessly placed mask grenade). For this reason I bring to you an alternative SCREEN$, named SCREEN$2 (points for imagination...?).

SCREEN$2 will look at any character 'cell' on the screen and come back to you with its CODE. If there is no character, but just a selection of PLOTted points on that cell, then the result will be zero.

HOW TO USE SCREEN$2

Take the coordinates of the cell (these range from (0, 0) to (23, 31) and POKE them into addresses 23354 and 23355 respectively. So for SCREEN$ (10, 21):

```
POKE 23354, 10
POKE 23355, 21
```

Now, if you intend to "call" the routine more than once, it is easiest to define a variable:

```
LET SCREEN = (start address of SCREEN$)
```

Thirdly and finally, you use the USR function to return the character at cell (L, C) (for Lines, Columns). This is best illustrated by showing a sample of program lines using SCREEN$ (most of which may not work) and their equivalents using the machine code routine (all of which will).

Using SCREEN$	Using SCREEN$2
LET L = 5 : LET C = 10	POKE 23354, 5 : POKE 23355 10
	LET SCREEEN=[start address]
LET A$=SCREEN$(L,C)	LET A$=CHR$ USR SCREEN
IF CODE SCREEN$(L,C) = 144 THEN PRINT "The character at (5, 10) is a graphic a"	IF USR SCREEN = 144 THEN PRINT "The character at (5, 10) is a graphic a"
PRINT AT 0,0;SCREEN$(L,C)	PRINT AT 0,0; CHR$ USR SCREEN

If there are character cells on your screen whose contents are unrecognisable as a character, and there is a possibility that your program will test those cells with SCREEN$2, then in that case the value zero will be sent back after using the routine.

Now obviously

```
PRINT CHR$ USR SCREEN
```

will not then make a great deal of sense to the Spectrum, and a question mark will be printed. To stop this occuring, you should incorporate the function "AND USR SCREEN" like so:

```
PRINT CHR$ (USR SCREEN) AND USR SCREEN
```

This means

```
"PRINT CHR$ (USR SCREEN) only if USR SCREEN > 0"
```

A longer-winded version would be:

```
IF USR SCREEN <>0 THEN PRINT CHR$ USR SCREEN.
```

Here then is the routine, followed by a short "demo" program.

```
HEX.        ;SCREEN$2  LENGTH: 129 BYTES
            CHARS   EQU     5C36H
            UDG     EQU     5C7BH
ED4B3A5B    START   LD      BC,(5B3AH)      ;C=LINE, B=COLUMN
79                  LD      A,C             ;LOCATE THE ADDRESS OF
E618                AND     18H             ;THE FIRST ROW OF THE
C640                ADD     A,40H           ;CHARACTER CELL IN THE
67                  LD      H,A             ;SCREEN MEMORY.
79                  LD      A,C
87                  ADD     A,A
87                  ADD     A,A
87                  ADD     A,A
87                  ADD     A,A
87                  ADD     A,A
80                  ADD     A,B
6F                  LD      L,A             ;SET THE 'CODE' TO 32
0E20                LD      C,20H           ;(SPACE) AND START SCANNING
ED5B365C            LD      DE,(CHARS)      ;THROUGH THE CHARACTER
14                  INC     D               ;TABLE.
E5          NXTCHAR PUSH    HL
0608                LD      B,8             ;COMPARE EACH ROW OF THE
1A          NXTROW  LD      A,(DE)          ;CURRENT CHARACTER IN THE
BE                  CP      (HL)            ;TABLE WITH THAT OF THE
2006                JR      NZ,HOP1         ;CHARACTER CELL, AND IF A
24                  INC     H               ;ROW IS NOT EQUAL TO THE
13                  INC     DE              ;CORRESPONDING ONE IN THE
10F8                DJNZ    NXTROW          ;CHARACTER CELL THEN MOVE
E1                  POP     HL              ;ON TO THE NEXT CHARACTER
                                            ;IN THE TABLE.
C9                  RET                     ;IF THE CHARACTER CODE
E1          HOP1    POP     HL              ;HAS BEEN FOUND THEN RETURN
13          NXT1    INC     DE              ;TO BASIC.
10FD                DJNZ    NXT1
0C                  INC     C
79                  LD      A,C
FEA5                CP      0A5H
280C                JR      Z,BLCKCHK
FE80                CP      80H
20E5                JR      NZ,NXTCHAR
0E90                LD      C,90H
ED5B7B5C            LD      DE,(UDG)        ;NOW CHECK FOR A USER -
1800                JR      NXTCHAR         ;DEFINED GRAPHIC CHARACTER.
E5          BLCKCHK PUSH    HL              ;NOW IT'S EITHER A 'CHUNKY'
0608                LD      B,8             ;GRAPHIC OR NOT A CHARACTER
7E          NXTROW2 LD      A,(HL)          ;IN THE CELL. SO CHECK TO
3C                  INC     A               ;SEE IF THE CELL DOESN'T
2810                JR      Z,OK            ;CONTAIN A 'CHUNKY
3D                  DEC     A               ;GRAPHIC', AND IF SO...
2800                JR      Z,OK
FE0F                CP      0FH
2809                JR      Z,OK
FEF0                CP      0F0H
2805                JR      Z,OK
```

```
010000   NOCODE  LD    BC,0        ;...THEN RETURN TO BASIC
E1               POP   HL          ;WITH CODE ZERO. THE
C9               RET               ;CHARACTER IS A 'CHUNKY'
24       OK      INC   H           ;GRAPHIC CHARACTER. THIS
10E9             DJNZ  NXTROW2     ;ALGORITHM TAKES DECIMAL
E1               POP   HL          ;128 AND ADDS ON THE VALUE
0E80             LD    C,80H       ;OF ANY OF THE FOUR BLOCKS
1601             LD    D,1         ;(1,2,4,8) THAT IS INK.
1E0F     NXTHALF LD    E,0FH       ;D HOLDS THE VALUE OF THE
E5       NXT2    PUSH  HL          ;CURRENT 'BLOCK' BEING
0604             LD    B,4         ;CHECKED. B COUNTS THE ROWS
7E       NXTROW3 LD    A,(HL)      ;- THE CHARACTER IS SCANNED
A3               AND   E           ;IN TWO HALVES:- TOP
BB               CP    E           ;AND BOTTOM.
2006             JR    NZ,HOP2
24               INC   H
10F8             DJNZ  NXTROW3
79               LD    A,C
82               ADD   A,D
4F               LD    C,A
CB22     HOP2    SLA   D           ;D IS DOUBLED.
7B               LD    A,E
87               ADD   A,A
87               ADD   A,A
87               ADD   A,A
87               ADD   A,A
5F               LD    E,A
E1               POP   HL
20E7             JR    NZ,NXT2
CB62             BIT   4,D         ;IF D<>16D THEN THE
2803             JR    Z,NOTDONE   ;CALCULATION IS NOT YET
0600     DONE    LD    B,0         ;FINISHED....
C9               RET
CBD4     NOTDONE SET   2,H         ;...SO MOVE ON TO THE NEXT
18DA             JR    NXTHALF     ;HALF OF THE CHARACTER.
                 END
```

Here is the demonstration program: not spectacular but it gives you a glimpse of the vastly improved potential of SCREEN$2 by displaying all of the characters available on the Spectrum and then using SCREEN$2 to place them elsewhere on the screen. Notice that line 30 depends upon where you have located the routine in memory.

```
  10 REM SCREEN$2 DEMONSTRATION
  20 FOR a=0 TO 167: POKE USR "a
"+a,INT (RND*256)
  25 NEXT a
  30 LET screen=65200
  40 POKE 23354,0: REM l
  50 POKE 23355,0: REM c
  60 FOR a=32 TO 164
  70 PRINT AT 0,0;CHR$ a
  80 PRINT AT 1,1;CHR$ (USR scre
en)  AND USR screen
  90 PAUSE 30
 100 NEXT a
```

CHAPTER 22
PAUSE MK.2

You may have noticed while programming with the PAUSE command on the ZX-Spectrum that it doesn't always work. PAUSE is supposed to wait for a given number of frames of the TV. (forever in the case of PAUSE 0) or until a key has been pressed. Unfortunately, a bug in the auto-repeat keyboard scanning routines in the original Spectrum ROM means that if you have been pressing keys just before a PAUSE line then the machine sometimes blunders blindly on into the rest of the program. This demonstration will show you what I mean; press a few keys while in the loop, stop when you hear the BEEP, and if the computer prints a message then PAUSE 0 has failed.

```
  10 FOR a=0 TO 1000
  15 REM  PRESS KEYS WHILE IN TH
IS LOOP
  20 NEXT a
  25 BEEP 1,10: REM   WHEN YOU H
EAR THIS, STOP PRESSING
  30 PAUSE 0: REM   SUPPOSED TO
WAIT FOR A KEY PRESS
  40 PRINT "I'VE FINISHED"
```

One partial solution to the problem is to substitute line 30 with

```
30 IF INKEY$ = "" THEN GOTO 30
```

Unfortunately this is only of use when the value after the PAUSE is zero, since it does not have any timing effect in it and will thus continue until a key is pressed rather than breaking out after a fixed number of TV. frames.

Well, you've probably guessed by now that there is a quick machine code solution to the problem, and here it is. PAUSE MK.2 will allow you a bug-free PAUSE of between 0 and 255 (around five seconds). If you need a longer PAUSE then you simply call the routine several times in succession.

To use the routine, it is a good idea to define a variable

LET PAUSE = (start address)

at the beginning of the program. Then to set the duration of the pause (zero meaning, as usual, forever),

POKE PAUSE + 1, (duration (0 - 255)).

Finally to call the routine and execute the PAUSE,

RANDOMIZE USR PAUSE
or LET A = USR PAUSE.

Now for the routine.

```
HEX.        ;PAUSE MK2  LENGTH: 25 BYTES
0600        START   LD      B,0         ;B IS THE PAUSE LENGTH.
78                  LD      A,B         ;IF B=0 THEN WAIT FOR
A7                  AND     A           ;A KEY PRESS.
280B                JR      Z,WAIT
AF                  XOR     A           ;OTHERWISE...
76          NXFRAME HALT                ;WAIT FOR AN INTERRUPT
DBFE                IN      A,(0FEH)    ;(LIKE PAUSE 1), THEN SCAN
2F                  CPL                 ;THE KEYBOARD.
E61F                AND     1FH
C0                  RET     NZ          ;IF NO KEYS ARE PRESSED
10F7                DJNZ    NXFRAME     ;THEN WAIT FOR THE NEXT TV
C9                  RET                 ;FRAME, UNLESS THE PAUSE
                                        ;COUNT IS ZERO, IN WHICH
                                        ;CASE, RETURN TO BASIC.
DBFE        WAIT    IN      A,(0FEH)    ;WAIT FOR A KEY PRESS.
2F                  CPL
E61F                AND     1FH
28F9                JR      Z,WAIT      ;WHEN ONE IS DETECTED,
C9                  RET                 ;RETURN TO BASIC.
                    END
```

Going back to our short demonstration program, using PAUSE MK.2 it should now look like this:

```
   5 LET PAUSE=65000: REM START
ADDRESS
  10 FOR a=0 TO 1000
```

```
  15 REM  PRESS KEYS WHILE IN TH
IS LOOP
  20 NEXT a
  25 BEEP 1,10: REM   WHEN YOU H
EAR THIS, STOP PRESSING
  30 POKE PAUSE+1,0: RANDOMIZE U
SR PAUSE: REM WAIT FOR A KEYPRES
S
  40 PRINT "I'VE FINISHED"
```

It occurred to me while writing PAUSE MK.2 that there may be occasions when you want to pause for an exact amount of time without the possibility of breaking out of the pause by accidentally touching the keyboard. Such a case could be where a pause was required between the notes of a sonata that your Spectrum was playing. If you used (say) PAUSE 5 then if you pressed any keys while the music was playing the "PAUSE 5"s would be continually broken out of and the music would speed up. Short of timing a FOR-NEXT loop such as

```
FOR A = 1 TO 10: NEXT A
```

there is no BASIC solution to the problem.

The following short machine code routine solves the problem nicely and allows you to have an un-interrupted PAUSE of between 1 and 256 (longer pauses obtainable by calling the routine more than once). I have called the routine 'TIMELOCK', since you can't break through it until a certain time has elapsed.

To use the routine,

```
                LET TIMELOCK = (start address)
                POKE TIMELOCK + 1, (duration)

then            RANDOMIZE USR TIMELOCK
  or            LET T = USR TIMELOCK
```

Here comes the code!

```
HEX.      ;TIMELOCK  LENGTH: 6 BYTES
0600      START  LD     B,0        ;B COUNTS THE PAUSE.
76        NXT    HALT              ;WAIT FOR INTERRUPT.
10FD             DJNZ   NXT        ;REPEAT UNTIL B=0.
C9               RET               ;RETURN TO BASIC.
                 END
```

Note that in this routine a value of 0 POKEd into TIMELOCK + 1 corresponds to a PAUSE of 256.

UTILITY ROUTINES

CHAPTER 23
FOR YOUR INFORMATION

This section contains three short, but useful routines that will give you information about the state of the memory in your machine.

The first is PROGLENGTH - the length of the BASIC program in bytes.

```
HEX.       ;PROGLENGTH  LENGTH: 13 BYTES
           VARS   EQU    5C4BH
           PROG   EQU    5C53H
2A4B5C     START  LD     HL,(VARS)
ED4B535C          LD     BC,(PROG)
A7                AND    A              ;RESET CARRY FLAG.
ED42              SBC    HL,BC          ;VARS-PROG=PROGLENGTH
44                LD     B,H            ;PROGLENGTH IS RETURNED IN
4D                LD     C,L            ;THE BC REGISTER PAIR.
C9                RET
                  END
```

To use PROGLENGTH, enter

```
PRINT "Program is "; USR (start address); "
bytes long."
```

The second is VARLENGTH - the number of bytes in the variables area.

```
HEX.            ;VARLENGTH  LENGTH: 13 BYTES  DATE: 1/7/83
                ELINE   EQU     5C59H
                VARS    EQU     5C4BH
2A595C          START   LD      HL,(ELINE)
ED4B4B5C                LD      BC,(VARS)
37                      SCF                     ;SET CARRY FLAG.
ED42                    SBC     HL,BC           ;ELINE-VARS-1=VARLENGTH
44                      LD      B,H             ;VARLENGTH IS RETURNED IN
4D                      LD      C,L             ;THE BC REGISTER PAIR.
C9                      RET
                        END
```

Use VARLENGTH by entering

PRINT "Variables are "; USR (start address); " bytes long."

The final routine is FREE, which tells you the number of bytes which you are actually free to use (discounting anything above RAMTOP). It does this by subtracting the system variable STKEND from the stack pointer (SP register pair).

```
HEX.            ;FREE  LENGTH: 13 BYTES
                STKEND  EQU     5C65H
210000          START   LD      HL,0
39                      ADD     HL,SP           ;TAKE STACK POINTER.
ED4B655C                LD      BC,(STKEND)
ED42                    SBC     HL,BC           ;SUBTRACT STKEND.
44                      LD      B,H             ;RETURN RESULT IN BC.
4D                      LD      C,L
C9                      RET
                        END
```

Use FREE by typing the following:

PRINT "you have "; USR (start address); " bytes free."

You can also find the total memory used by the computer by subtracting FREE from the amount of bytes of RAM available.

Thus:

16K : PRINT "Bytes used: "; 16 * 1024 - USR (start address)
48K : PRINT "Bytes used: "; 48 * 1024 - USR (start address)

CHAPTER 24
RENUMBERING YOUR PROGRAMS

This routine will renumber the line numbers of your BASIC programs, but you will have to renumber the GOSUBs, GOTOs, LISTs, LLISTs and RUNs yourself, as the machine code routine necessary to completely renumber a program is very long and complex. Nonetheless, this routine has proven very useful to me and I am sure it will be worth your while to LOAD it into the top of memory whenever you are writing BASIC programs. For those who are undaunted by a very long machine code listing the full renumber appears in Chapter 28.

USING RENUMBER

You must specify two parameters; the first line number and the "step" between line numbers (e.g. If you want the line numbers to read 100, 110, 120... then the first line number is 100, and the step is 10). The parameters are entered as follows:

```
POKE 23348, (First line no.)
POKE 23349, 0
POKE 23350, (step)
POKE 23351, 0
```

The above procedure works for all numbers between 0 and 255; if you wish either parameter to be greater than 255 then the procedure is different. For the first line number:

```
POKE 23348, (First line no.) -255 * INT ((first
line no.)/256)
```

POKE 23349, INT ((First line no.)/256)

Similarly, for the "step":

POKE 23350, (step) -256 * INT ((step)/256)
POKE 23351, INT ((step)/256)

In both cases, the renumbering is almost instant on entering

RANDOMIZE USR (start address of RENUMBER)

Be warned: do not use too big a first line number or step, or the last line number may be greater than the limit of 9999. This can have serious effects on your program when RUN, but you can correct such a mistake by renumbering using more appropriate parameters.

Here is the routine.

```
HEX.        ;RENUMBER  LENGTH: 37 BYTES
            PROG    EQU     5C53H
            VARS    EQU     5C4BH
2A535C      START   LD      HL,(PROG)       ;HL=BEGINNING OF PROGRAM.
ED5B345B            LD      DE,(5B34H)      ;DE=FIRST NUMBER.
ED4B365B            LD      BC,(5B36H)      ;BC=STEP
D5                  PUSH    DE
EB          NXTLINE EX      DE,HL           ;HAVE WE REACHED THE
2A4B5C              LD      HL,(VARS)       ;VARIABLES AREA?
A7                  AND     A
ED52                SBC     HL,DE
EB                  EX      DE,HL
D1                  POP     DE
C8                  RET     Z               ;IF SO, RETURN TO BASIC.
72                  LD      (HL),D          ;INSERT NEW LINE NO.
23                  INC     HL
73                  LD      (HL),E
23                  INC     HL
EB                  EX      DE,HL
09                  ADD     HL,BC           ;ADD 'STEP' TO LINE NUMBER,
EB                  EX      DE,HL           ;GIVING NEXT NUMBER.
D5                  PUSH    DE
5E                  LD      E,(HL)          ;TAKE LENGTH OF CURRENT
23                  INC     HL              ;LINE.
56                  LD      D,(HL)
23                  INC     HL
19                  ADD     HL,DE           ;ADD LENGTH OF LINE TO
18E7                JR      NXTLINE         ;COUNTER. PROCEED TO
                    END                     ;RENUMBER NEXT LINE.
```

APPLICATION

You may already know that if the first line number of a program is zero then it cannot be EDITed or removed without altering the line number by POKEing it. If you make the "first line number" in the renumber routine zero, and make the first line of your program a REM statement such as:

```
2 REM (c) David M. Webb, Hands off, pirates!!!!
```

then after renumbering the program, you will have a copyright line that cannot be EDITed.

CHAPTER 25
CASE CHANGE

This routine operates on the program rather than in it: it sets all of the letters occurring in the BASIC listing to either "Upper Case" (capitals) or "Lower Case" (small letters). This can be useful if you want to make a ZX-printer LLIST more legibly - just use the "Upper Case" mode and then LLIST away with clear capitals to your heart's content.

CHOOSING UPPER OR LOWER CASE

You need just one POKE:

```
POKE 23356,  16 for Upper Case
            240 for Lower Case
```

The routine does not operate on anything after a REM statement in a program line, in order to preserve any machine code that you may have stored there. This can be used to added advantage by temporarily inserting a REM statement before anything (such as a PRINT statement) that you wish to 'protect' from the action of the routine.

```
HEX.        ;CASE CHANGE  LENGTH: 77 BYTES
            PROG    EQU     5C53H
            VARS    EQU     5C4BH
2A535C      START   LD      HL,(PROG)      ;HAVE WE REACHED THE
ED5B4B5C    NXTLINE LD      DE,(VARS)      ;END OF THE PROGRAM?
EB                  EX      DE,HL
A7                  AND     A
```

```
ED52            SBC   HL,DE          ;IF SO, THEN RETURN TO
C8              RET   Z              ;BASIC.
EB              EX    DE,HL
23              INC   HL
23              INC   HL
5E              LD    E,(HL)         ;TAKE THE LENGTH OF
23              INC   HL             ;THE LINE IN REGISTER DE.
56              LD    D,(HL)
23              INC   HL
7E      COLON   LD    A,(HL)         ;HAVE WE A REM STATEMENT?
FEEA            CP    0EAH           ;IF SO, THEN SKIP THIS LINE
2832            JR    Z,REMFND
0E00            LD    C,0
3A3C58  NXTCHAR LD    A,(5B3CH)      ;LET B=PEEK 23356
47              LD    B,A
C650            ADD   A,50H          ;IS THE CHARACTER IN THE
BE              CP    (HL)           ;RANGE OF VALUES WHICH
3009            JR    NC,NOCHANG     ;MUST BE CHANGED FROM ONE
C61B            ADD   A,1BH          ;CASE TO THE OTHER?
BE              CP    (HL)
3804            JR    C,NOCHANG      ;IF NOT THEN SKIP THIS...
7E              LD    A,(HL)         ;CHANGE THE CASE OF THE
90              SUB   B              ;CHARACTER.
90              SUB   B
77              LD    (HL),A
7E      NOCHANG LD    A,(HL)         ;MOVE ON TO THE NEXT
23              INC   HL
1B              DEC   DE
FE22            CP    22H            ;CHECK WHETHER WE'RE
2001            JR    NZ,NTQUOTE     ;INSIDE A SET OF QUOTES.
0C              INC   C
CB41    NTQUOTE BIT   0,C            ;IF SO THEN NEXT CHARACTER,
20E2            JR    NZ,NXTCHAR     ;SINCE THE LINE CAN'T END
FE0E            CP    0EH            ;INSIDE A SET OF QUOTES.
2006            JR    NZ,NOTNUM      ;IF WE'VE FOUND A 5-BYTE
0605            LD    B,5            ;NUMBER THEN SKIP IT.
23      NXT1    INC   HL
1B              DEC   DE
10FC            DJNZ  NXT1
FE3A    NOTNUM  CP    3AH            ;IF WE'VE FOUND A COLON
28CD            JR    Z,COLON        ;'SEPERATOR' THEN CHECK FOR
FE0D            CP    0DH            ;A REM AGAIN. IF NOT END OF
20C9            JR    NZ,COLON       ;LINE THEN NEXT CHARACTER.
19      REMFND  ADD   HL,DE          ;MOVE ON TO THE NEXT
18B6            JR    NXTLINE        ;PROGRAM LINE.
                END
```

CHAPTER 26
FIND AND REPLACE

With this routine you can search through the BASIC program (instantly, naturally) looking for a specific key word or character and replacing it with a second byte. Thus two POKEs are required:

```
POKE 23352, CODE "(find character)"
POKE 23353, CODE "(replace character)"
```

If you had used some character frequently as part of a screen presentation, say "#" as the border for the screen, and wanted to see what other characters would look like in the same place, then it is far quicker to call up this routine to do the "donkey work" rather than manually EDITing all of the appropriate program lines.

EXAMPLE

change all the # symbols to & symbols in the program:

```
POKE 23352, CODE "#"
POKE 23353, CODE "&"
LET L = USR ... (start address of routine)
```

PROGRAMMING CONSIDERATIONS

The routine ignores anything after a REM statement in a program line in order to avoid mutilating any machine code the user may have stored therein. 'Find and Replace' may be called from within a program like most of the other routines in this book, so you may like to use it to alter a set of PRINT statements during a program and then to go back over that section of the program, thereby varying the screen display by overprinting the 'found' characters with the 'replaced' ones. Remember also that you can change key words as well as characters, so the routine could be used to change SIN functions into COS in a trigonometrical graph - drawing program, or maybe to turn all your PRINTs into REMs if you wished to temporarily speed up the BASIC program.

Right then, here's the listing - don't forget to SAVE it when entered!

```
HEX.        ;FIND AND REPLACE  LENGTH: 81 BYTES
            PROG    EQU    5C53H
            VARS    EQU    5C4BH
2A535C      START   LD     HL,(PROG)      ;START AT THE BEGINNING.
ED5B4B5C    NXTLINE LD     DE,(VARS)      ;ARE WE AT THE END OF THE
EB                  EX     DE,HL          ;PROGRAM?
A7                  AND    A              ;BACK TO BASIC IF SO.
ED52                SBC    HL,DE
C8                  RET    Z
EB                  EX     DE,HL
23                  INC    HL
23                  INC    HL
5E                  LD     E,(HL)         ;TAKE THE LENGTH OF THE
23                  INC    HL             ;PROGRAM LINE.
56                  LD     D,(HL)
23                  INC    HL
7E          COLON   LD     A,(HL)         ;TAKE THE FIRST CHARACTER
FEEA                CP     0EAH           ;OF THE CURRENT STATEMENT.
                                          ;IS IT A REM? IF SO, THEN
282D                JR     Z,REMFND       ;SKIP TO THE NEXT LINE.
0E00                LD     C,0            ;IF C IS ODD THEN WE ARE
7E          NXTCHAR LD     A,(HL)         ;INSIDE QUOTE MARKS.
FE22                CP     22H            ;IS THIS CHARACTER A QUOTE?
2001                JR     NZ,NTQUOTE     ;IF SO, THEN CHANGE C FROM
0C                  INC    C              ;ODD TO EVEN OR VICE VERSA.
3A385B      NTQUOTE LD     A,(5B38H)      ;TAKE 'FIND' CHARACTER.
BE                  CP     (HL)           ;IS THE CURRENT CHARACTER A
2004                JR     NZ,NOFIND      ;'FIND' CHARACTER?
3A395B              LD     A,(5B39H)      ;IS SO, THEN REPLACE IT
77                  LD     (HL),A         ;WITH THE NEW VALUE.
7E          NOFIND  LD     A,(HL)         ;MOVE THE POINTERS TO THE
23                  INC    HL             ;NEXT CHARACTER.
1B                  DEC    DE
CB41                BIT    0,C            ;ARE WE IN QUOTES?
20E9                JR     NZ,NXTCHAR     ;IS SO, THEN NEXT CHARACTER
FE0E                CP     0EH            ;OTHERWISE CHECK FOR 5-BYTE
2006                JR     NZ,NOTNUM      ;FLOATING POINT NUMBERS AND
0605                LD     B,5            ;SKIP THEM WHEN FOUND.
23          NXT     INC    HL
1B                  DEC    DE
10FC                DJNZ   NXT            ;NOW CHECK FOR A COLON, AND
FE3A        NOTNUM  CP     3AH            ;IF FOUND, GO AND CHECK FOR
2804                JR     Z,COLON        ;A REM. ARE WE AT THE END
```

```
FE0D                CP     0DH            ;OF THE LINE?
2007                JR     NZ,NXTCHAR     ;IF NOT, NEXT CHARACTER...
18BE                JR     NXTLINE        ;ELSE NEXT LINE.
ED4B385B   REMFND   LD     BC,(5B38H)     ;CHECK TO SEE IF THE REM
79                  LD     A,C            ;SHOULD BE REPLACED, AND IF
BE                  CP     (HL)           ;SO THEN DO SO.
2001                JR     NZ,NTRMFND
70                  LD     (HL),B
19         NTRMFND  ADD    HL,DE          ;SKIP ONTO THE NEXT LINE.
18B2                JR     NXTLINE
                    END
```

CHAPTER 27
LINE DELETE

LINE DELETE is another of those utility routines which no self-respecting BASIC programmer should be without. The short routine allows you to delete any part of the program from one line to all of it, instantly. Quite obviously to use the routine we must specify two values; the first and last line numbers to be deleted. Let's call the line we are deleting from F, and the line we are deleting to, T. Then the correct commands are:

```
POKE 23357, F - 256 * INT (F/256)
POKE 23358, INT (F/256)
POKE 23359, T - 256 * INT (T/256)
POKE 23360, INT (T/256)
```

Both values are included in the block deletion, and the second and/or fourth POKEs may be omitted if the corresponding line number is less than 256, since the number POKEd in would be zero (do not omit the commands if you have previously POKEd in non-zero values to 23358 or 23360!). To illustrate, if we were to delete from line 25 to line 515 (both inclusive), then

```
POKE 23357, 25: POKE 23359, 3: POKE 23360, 2.
(note: 515 = (2 x 256) + 3)
```

Call the routine with   RANDOMIZE USR (start address)
                      or   LET A = USR (start address)

If you are deleting just one line (and either it hasn't occurred to you to just type in the line number or you are doing so from within a program) then the two values will be the same.

If you wish to delete from a line to the end of the program, then any line number greater than the last line number will also do for the second value. Hence:

POKE 23360, 40

will ensure that this is the case, since 40 x 256 = 10240, which is greater than the highest possible line number.

One useful sideline to this routine is that it can be used to save all variables onto tape in one go. Simply run the BASIC program so that all the variables are defined, then use the routine to DELETE the entire program. The variables will be unaffected, and these can then be saved just like a program with the SAVE command. To load them back into the same or any other program, type CLEAR if you want to get rid of the existing variables, then MERGE "(filename)" to load up the old variables from tape.

Here is the routine.

```
HEX.          ;LINE DELETE  LENGTH: 70 BYTES
              PROG    EQU   5C53H
              VARS    EQU   5C4BH
2A535C        START   LD    HL,(PROG)
ED4B3D5B              LD    BC,(5B3DH)      ;TAKE THE 'FROM' NUMBER.
EB            NXTLN   EX    DE,HL           ;HAVE WE REACHED THE BASIC
2A4B5C                LD    HL,(VARS)       ;VARIABLES?
A7                    AND   A
ED52                  SBC   HL,DE
C8                    RET   Z               ;RETURN TO BASIC IF SO.
EB                    EX    DE,HL
56                    LD    D,(HL)          ;TAKE A LINE NUMBER.
23                    INC   HL
5E                    LD    E,(HL)
EB                    EX    DE,HL           ;COMPARE IT WITH THE 'FROM'
ED42                  SBC   HL,BC           ;NUMBER.
EB                    EX    DE,HL
3008                  JR    NC,FOUNDFR      ;IF IT'S LESS THEN NEXT LINE
23                    INC   HL              ;OTHERWISE GO AND LOOK FOR
5E                    LD    E,(HL)          ;THE 'TO' LINE.
23                    INC   HL              ;TO FIND THE NEXT LINE, ADD
56                    LD    D,(HL)          ;THE LINE LENGTH TO THE
23                    INC   HL              ;POINTER.
19                    ADD   HL,DE
18E6                  JR    NXTLN           ;LOOP BACK.
E5            FOUNDFR PUSH  HL              ;STORE POINTER FOR 'FROM'
ED4B3F5B              LD    BC,(5B3FH)      ;START LOOKING FOR 'TO'
23            NXTLN2  INC   HL              ;MOVE POINTER TO NEXT
5E                    LD    E,(HL)          ;LINE NUMBER.
23                    INC   HL
56                    LD    D,(HL)
```

```
23                 INC     HL
19                 ADD     HL,DE
EB                 EX      DE,HL             ;HAVE WE REACHED THE
2A4B5C             LD      HL,(VARS)         ;VARIABLES?
A7                 AND     A
ED52               SBC     HL,DE
EB                 EX      DE,HL
280B               JR      Z,FOUNEND         ;IF SO, THEN GO AND DELETE,
56                 LD      D,(HL)            ;OTHERWISE TAKE THE NEXT
23                 INC     HL                ;LINE NUMBER.
5E                 LD      E,(HL)
EB                 EX      DE,HL
37                 SCF                       ;COMPARE IT WITH 'TO'
ED42               SBC     HL,BC             ;NUMBER.
EB                 EX      DE,HL             ;IF CURRENT NUMBER IS LESS
38E6               JR      C,NXTLN2          ;THAN OR EQUAL TO 'TO'
2B                 DEC     HL                ;NUMBER THEN NEXT LINE.
D1         FOUNEND POP     DE                ;NOW WE ARE READY TO DELETE
1B                 DEC     DE                ;WITH A JUMP TO THE ROM
C3E519             JP      19E5H             ;WHICH MOVES DOWN
                   END                       ;EVERYTHING ABOVE HL TO DE.
```

CHAPTER 28
FULL RENUMBER

I consider this routine to be one of the most useful pieces in this book. The program renumbers all of the BASIC program and correctly adjusts all non-computed GOTO, GOSUB, RUN, LLIST, LIST, RESTORE and SAVE... LINE commands. "Computed" commands such as GOTO a * b/c cannot be renumbered since the routine has no way of knowing what values any variables will take in the program.

Due to the sheer complexity of renumbering a program with its GOTOs and so on, this routine at 411 bytes is just over eleven times as long as its 37-byte counterpart in Chapter 24, which only affects the line numbers. Do not, however, be put off by the length; it is well worth the effort of typing in the code and can be invaluable when "tidying up" your BASIC listing or when you need to make room for more BASIC lines, due to all the line numbers in that area having been used up.

USING FULL RENUMBER

Before calling the routine with

```
          RANDOMIZE USR (start address)
       or LET A = USR (start address)
```

you must specify two parameters; the first new line number and the 'step' between line numbers, thus:

```
          POKE 23348, L - 256 * INT (L/256)
          POKE 23349, INT (L/256)
```

```
POKE 23350, S - 256 * INT (S/256)
POKE 23351, INT (S/256)
```

Where L is the first line number and S is the step.

You may omit the second and/or fourth commands if L and/or S are/is less than 256, as is usually the case, since the value of the POKEs would be zero.

Hence to renumber starting at line 10 in steps of 10,

```
POKE 23348, 10: POKE 23350, 10.
```

If you have particularly high line numbers being renumbered to particularly low numbers, then the overall length of the program may reduce, since

GOTO 9999 takes 3 bytes more than GOTO 9.

If the reverse case happens, the length will increase. So for safety's sake (i.e. to prevent an irreversible crash) the routine incorporates a fail-safe device which returns to BASIC with "Error 4 - Out of Memory" if there are less than 256 bytes of free memory. If you wish you can find out how much free memory you have by using the short routine in Chapter 23.

The routine ignores anything after a REM statement in a BASIC line, so machine code buffs can still store code in REM statements. If your program has a reference to a non-existent BASIC line then it will be altered to the nearest line number above that line, or to the next logical number if that line was the last in the program. That may seem a bit complex, so allow me to illustrate:

Renumbering this program from line 10 in steps of 10,

```
15 GOTO 31   becomes   10 GOTO 20
43 GOTO 999            20 GOTO 30
```

FULL RENUMBER works on about 2K of program per second, and incidentally uses the three spare bytes in the system variables area, so don't use them for your own purposes or you will lose your data!

```
HEX.        ;FULL RENUMBER  LENGTH: 411 BYTES
            STKEND  EQU     5C65H
            VARS    EQU     5C4BH
            PROG    EQU     5C53H
AF          MEMTEST XOR     A               ;CHECK FOR 256 SPARE
67                  LD      H,A             ;BYTES BETWEEN THE STACK
6F                  LD      L,A             ;POINTER AND END OF BASIC.
39                  ADD     HL,SP           ;IF THERE ISN'T THEN
ED4B655C            LD      BC,(STKEND)     ;RETURN TO BASIC...
ED42                SBC     HL,BC
BC                  CP      H
2002                JR      NZ,ROOM
```

```
CF                RST     8              ;WITH ERROR 4 - "OUT OF
03                DEFB    3              ;"MEMORY".
2A4B5C   ROOM     LD      HL,(VARS)      ;FIND THE FIRST BYTE
7E                LD      A,(HL)         ;AFTER THE BASIC PROGRAM,
32815C            LD      (5C81H),A      ;STORE IT AND THEN REPLACE
36FF              LD      (HL),0FFH      ;IT WITH AN FF MARKER.
2A535C            LD      HL,(PROG)      ;THE SEARCH FOR GOTO'S
7E       LOOP4    LD      A,(HL)         ;ETC. BEGINS. IF AT END OF
3C                INC     A              ;PROGRAM THEN JUMP TO
2850              JR      Z,SRCHEND      ;SRCHEND.
010000            LD      BC,0           ;BC HOLDS THE ALTERATION TO
23                INC     HL             ;THE LENGTH OF THE CURRENT
23                INC     HL             ;LINE, WHICH VARIES AS THE
23                INC     HL             ;ARGUMENTS OF GOTO'S ARE
E5                PUSH    HL             ;EXPANDED OR CONTRACTED.
C5                PUSH    BC
23       ENTRY20  INC     HL
7E       ENTRY4   LD      A,(HL)
0E00              LD      C,0            ;C KEEPS A CHECK ON QUOTES.
FEEA              CP      0EAH           ;CHECK FOR A REM. IF FOUND
283E              JR      Z,NXSRCLN      ;THEN SKIP CURRENT LINE.
08       LOOP3    EX      AF,AF'
7E                LD      A,(HL)         ;C IS INCREMENTED EVERY
23                INC     HL             ;TIME A QUOTATION MARK IS
FE22              CP      22H            ;DETECTED.
2001              JR      NZ,NTQUOTE
0C                INC     C
CB41     NTQUOTE  BIT     0,C            ;IF C IS ODD DON'T CHECK
20F4              JR      NZ,LOOP3       ;FOR GOTO AS WE ARE INSIDE
FECA              CP      0CAH           ;QUOTE MARKS. CHECK FOR
2006              JR      NZ,ENTRY14     ;LINE.
08                EX      AF,AF'         ;IF LINE IS FOUND THEN
FEEE              CP      0EEH           ;UNLESS PREVIOUS BYTE WAS
205C              JR      NZ,ADJUST      ;INPUT, GO AND RENUMBER IT.
08                EX      AF,AF'
FE3A     ENTRY14  CP      3AH
280F              JR      Z,ENTRY4
FEF0              CP      0F0H           ;CHECK FOR LIST.
2853              JR      Z,ADJUST
FE0E              CP      0EH            ;IF WE'VE FOUND A FLOATING-
2004              JR      NZ,NOTNUM      ;POINT NUMBER THEN SKIP ITS
110500            LD      DE,5           ;FIVE BYTES.
19                ADD     HL,DE
FEEC     NOTNUM   CP      0ECH           ;CHECK FOR GOTO.
2847              JR      Z,ADJUST
FEED              CP      0EDH           ;CHECK FOR GOSUB.
2843              JR      Z,ADJUST
FEE5              CP      0E5H           ;CHECK FOR RESTORE.
283F              JR      Z,ADJUST
FEF7              CP      0F7H           ;CHECK FOR RUN.
283B              JR      Z,ADJUST
FEE1              CP      0E1H           ;CHECK LLIST
2837              JR      Z,ADJUST
FE0D              CP      0DH            ;END OF LINE? IF NOT, THEN
20C2     LINK1    JR      NZ,LOOP3       ;ON TO THE NEXT CHARACTER.
```

```
C1          NXSRCLN POP    BC             ;BC=CHANGE TO LINE LENGTH.
E1                  POP    HL             ;HL=ADDRESS OF LINE LENGTH.
56                  LD     D,(HL)         ;TAKE OLD LINE LENGTH.
2B                  DEC    HL
5E                  LD     E,(HL)
EB                  EX     DE,HL
09                  ADD    HL,BC          ;ADD ALTERATION TO LINE
EB                  EX     DE,HL          ;LENGTH.
73                  LD     (HL),E         ;STORE NEW LINE LENGTH.
23                  INC    HL
72                  LD     (HL),D
23                  INC    HL
19                  ADD    HL,DE          ;MOVE ONTO NEXT LINE.
189F                JR     LOOP4
ED5B345B    SRCHEND LD     DE,(5B34H)     ;ALL RENUMBERING OF GOTO'S
ED4B365B            LD     BC,(5B36H)     ;ETC IS FINISHED, SO NOW
2A535C              LD     HL,(PROG)      ;ALTER ALL LINE NUMBERS.
7E          NXTLN2  LD     A,(HL)
3C                  INC    A              ;END OF PROGRAM?
2005                JR     NZ,NOSTOP      ;IF SO, THEN REPLACE FIRST
3A815C              LD     A,(5C81H)      ;BYTE AFTER BASIC PROGRAM
77                  LD     (HL),A         ;AND RETURN TO BASIC.
C9                  RET
72          NOSTOP  LD     (HL),D         ;STORE FIRST LINE NUMBER.
23                  INC    HL
73                  LD     (HL),E
23                  INC    HL
EB                  EX     DE,HL
09                  ADD    HL,BC          ;ADD THE 'STEP' TO THE LINE
EB                  EX     DE,HL          ;NUMBER.
D5                  PUSH   DE
5E                  LD     E,(HL)         ;TAKE THE LINE LENGTH, AND
23                  INC    HL             ;ADD IT TO THE POINTER.
56                  LD     D,(HL)
23                  INC    HL
19                  ADD    HL,DE
D1                  POP    DE             ;NOW MOVE ON TO ALTER THE
18E7                JR     NXTLN2         ;NEXT LINE NUMBER. THIS
7E          ADJUST  LD     A,(HL)         ;PART ALTERS GOTO'S ETC.
FE3A                CP     3AH            ;LOOK FOR THE BEGINNING OF
2882        CHEAT   JR     Z,ENTRY20      ;THE ASCII - CODED NUMBER
FE0D                CP     0DH            ;(STORED ONE DIGIT TO ONE
28C4                JR     Z,NXSRCLN      ;BYTE).
23                  INC    HL
FE20                CP     20H
38F2                JR     C,ADJUST
2B                  DEC    HL
22B05C              LD     (5CB0H),HL     ;STORE THIS ADDRESS.
0600                LD     B,0            ;B COUNTS UP THE NUMBER
7E          LOOP6   LD     A,(HL)         ;OF DIGITS OR COLOR BYTES
23                  INC    HL             ;IN THE ARGUMENT OF THE
FE0E                CP     0EH            ;GOTO. COUNT THEM UNTIL
282E                JR     Z,NUMFOUN      ;A FLOATING POINT NUMBER IS
FE20                CP     20H            ;FOUND. IGNORE COLOR CODES
38F6                JR     C,LOOP6        ;ETC., THEN IF THE CURRENT
```

```
FE3A              CP     3AH            ;BYTE ISN'T AN ASCII
3007              JR     NC,NOGO        ;NUMBER WE CANNOT RENUMBER
FE30              CP     30H            ;THE STATEMENT (NOGO).
3803              JR     C,NOGO
04                INC    B
18EB              JR     LOOP6
7E       NOGO     LD     A,(HL)         ;LOOK ALONG THE BASIC
FE22              CP     22H            ;LINE UNTIL YOU FIND
2001              JR     NZ,NTQUOT2     ;A STATEMENT-SEPARATING
0C                INC    C              ;COLON OR THE END-OF-LINE
CB41     NTQUOT2  BIT    0,C            ;BYTE. IGNORE ANYTHING
2010              JR     NZ,NOTNUM2     ;INSIDE QUOTATION MARKS.
FE3A              CP     3AH
28CC              JR     Z,CHEAT
FE0D              CP     0DH
28C8              JR     Z,CHEAT
FE0E              CP     0EH
2004              JR     NZ,NOTNUM2
110500            LD     DE,5
19                ADD    HL,DE
23       NOTNUM2  INC    HL
18E3              JR     NOGO
1883     LINK2    JR     LINK1          ;PART OF A 3-STEP RELATIVE
110500   NUMFOUN  LD     DE,5           ;JUMP FROM END OF ROUTINE.
19                ADD    HL,DE          ;A FLOATING-PT. NUMBER HAS
7E                LD     A,(HL)         ;BEEN FOUND. IF IT'S NOT
FE0D              CP     0DH            ;FOLLOWED BY A COLON OR
2804              JR     Z,OK           ;END-OF-LINE BYTE THEN WE
FE3A              CP     3AH            ;CANNOT RENUMBER THE
20D4              JR     NZ,NOGO        ;CURRENT STATEMENT.
2B       OK       DEC    HL             ;TAKE THE LINE NUMBER
2B                DEC    HL             ;REFERRED TO IN THE CURRENT
C5                PUSH   BC             ;STATEMENT FROM ITS FIVE-
E5                PUSH   HL             ;BYTE FORM.
56                LD     D,(HL)
2B                DEC    HL
5E                LD     E,(HL)
ED4B345B          LD     BC,(5B34H)     ;BC=FIRST NEW LINE NUMBER.
C5                PUSH   BC
2A535C            LD     HL,(PROG)      ;CALCULATE THE NEW LINE
7E       NXT9     LD     A,(HL)         ;NUMBER BY ADDING THE
3C                INC    A              ;STEP TO THE FIRST LINE
281D              JR     Z,CNTDOWN      ;NUMBER AND WORKING
46                LD     B,(HL)         ;THROUGH THE LISTING UNTIL
23                INC    HL             ;WE FIND A LINE NUMBER
4E                LD     C,(HL)         ;GREATER THAN OR EQUAL
23                INC    HL             ;TO THE NUMBER REFERRED
EB                EX     DE,HL          ;TO IN THE CURRENT STATE-
E5                PUSH   HL             ;MENT.
37                SCF
ED42              SBC    HL,BC
E1                POP    HL
3811              JR     C,CNTDOWN
EB                EX     DE,HL
E3                EX     (SP),HL
```

```
ED4B365B              LD      BC,(5B36H)
09                    ADD     HL,BC
E3                    EX      (SP),HL
4E                    LD      C,(HL)
23                    INC     HL
46                    LD      B,(HL)
23                    INC     HL
09                    ADD     HL,BC
18E1                  JR      NXT9
18C1          LINK3   JR      LINK2          ;PART OF A 3-STEP RELATIVE
D1            CNTDOWN POP     DE             ;JUMP HAVING CALCULATED
E1                    POP     HL             ;THE NEW LINE NUMBER FOR
72                    LD      (HL),D         ;THE GOTO, STORE IT IN
2B                    DEC     HL             ;IT'S FIVE BYTE FORM.
73                    LD      (HL),E
3E01                  LD      A,1            ;NOW CALCULATE THE
21F6FF                LD      HL,0FFF6H      ;NUMBER OF DIGITS IN
19                    ADD     HL,DE          ;THE NEW LINE NUMBER,
300F                  JR      NC,STOPCNT     ;THE RESULT BEING STORED
3C                    INC     A              ;IN A.
219CFF                LD      HL,0FF9CH
19                    ADD     HL,DE
3008                  JR      NC,STOPCNT
3C                    INC     A
2118FC                LD      HL,0FC18H
19                    ADD     HL,DE
3001                  JR      NC,STOPCNT
3C                    INC     A
C1            STOPCNT POP     BC             ;B=# OF CHARS IN OLD NUMBER
E1                    POP     HL             ;HL=ALTERATION TO CURRENT
                                             ;LINE LENGTH.
F5                    PUSH    AF             ;STACK NO. OF CHARACTERS.
D5                    PUSH    DE             ;STACK NEW LINE NO.
ED5BB05C              LD      DE,(5CB0H)     ;DE=ADDRESS OF ASCII CODED
D5                    PUSH DE                ;LINE NUMBER.
90                    SUB     B              ;IF THE NEW LINE NUMBER
281C                  JR      Z,NOCHANG      ;HAS MORE OR LESS DIGITS
4F                    LD      C,A            ;THAN THE OLD THEN WE
D5                    PUSH    DE             ;MUST MOVE THE REST OF
3809                  JR      C,DOWN         ;THE BASIC PROGRAM AND
0600                  LD      B,0            ;VARIABLES UP OR DOWN THE
09                    ADD     HL,BC          ;MEMORY BY UP TO 3 BYTES.
E3                    EX      (SP),HL        ;CARE IS TAKEN TO ENSURE
CD5516                CALL    1655H          ;THAT ALL OF THE SYSTEM
180E                  JR      PLUGIN         ;VARAIBLE POINTERS ARE
2F            DOWN    CPL                    ;ADJUSTED ACCORDINGLY. THE
3C                    INC     A              ;ROUTINE AT 1655H IN THE
5F                    LD      E,A            ;ORIGINAL ROM MAKES BC
1600                  LD      D,0            ;SPACES FROM HL.
06FF                  LD      B,0FFH         ;THE ROUTINE AT 19E5H
09                    ADD     HL,BC          ;MOVES ALL PARTS OF BASIC
E3                    EX      (SP),HL        ;ABOVE HL DOWN FROM HL
EB                    EX      DE,HL          ;TO DE. BOTH ROUTINES CALL
19                    ADD     HL,DE          ;A ROUTINE WHICH ADJUSTS
```

```
CDE519          CALL  19E5H       ;THE POINTERS.
E1      PLUGIN  POP   HL
C1      NOCHANG POP   BC          ;CALCULATE THE ASCII CODE
D1              POP   DE          ;OF THE NEW NUMBER. DECIDE
F1              POP   AF          ;WHERE TO START, DEPENDING
E5              PUSH  HL          ;ON HOW MANY DIGITS
210100          LD    HL,1        ;THERE ARE. UNITS,
3D              DEC   A
2810            JR    Z,LOCKDON
E5              PUSH  HL
2E0A            LD    L,10        ;TENS,
3D              DEC   A
280A            JR    Z,LOCKDON
E5              PUSH  HL
2E64            LD    L,64H       ;HUNDREDS,
3D              DEC   A
2804            JR    Z,LOCKDON
E5              PUSH  HL
21E803          LD    HL,03E8H    ;THOUSANDS.
EB      LOCKDON EX    DE,HL       ;A STARTS WITH THE CODE OF
3E2F    NXTCHAR LD    A,2FH       ;"0" MINUS ONE.
A7              AND   A           ;SUBTRACT THE POWER OF TEN
ED52    LOOP10  SBC   HL,DE       ;FROM LINE NUMBER UNTIL
3C              INC   A           ;THERE IS A CARRY, INCRE-
30FB            JR    NC,LOOP10   ;MENTING THE DIGIT EACH
19              ADD   HL,DE       ;TIME. ADD THE POWER OF 10.
02              LD    (BC),A      ;STORE THE CURRENT DIGIT.
03              INC   BC          ;IF DE=1 THEN THE
1D              DEC   E           ;RENUMBERING IS COMPLETE
2006            JR    NZ,HOPIT    ;AND WE CAN MOVE ON TO THE
60              LD    H,B         ;NEXT STATEMENT IN THE
69              LD    L,C         ;PROGRAM, CLEARING C TO
4B              LD    C,E         ;INDICATE THAT WE ARE NOT
1C              INC   E           ;IN QUOTATION MARKS. MAKE A
188B            JR    LINK3       ;THREE-STEP RELATIVE JUMP.
D1      HOPIT   POP   DE          ;MOVE ON TO PRODUCE NEXT
18E9            JR    NXTCHAR     ;DIGIT.
                END
```

CHAPTER 29
THE SPECTRUM GETS A TRACE FUNCTION

This routine imitates the TRACE function often found on other microcomputers. When a BASIC program is being run, TRACE will automatically display the number of the line currently being interpreted at the top right-hand corner of the screen. In order to make the number stand out against whatever else is on the screen, the routine prints the number in inverse video. TRACE can be of great use when debugging your programs, as it allows you to follow the progress of the machine through your masterpiece without having to stop it.

For technical reasons, I have written two versions of TRACE; one for the 16K Spectrum and one for the larger machine. These routines are unique in this book in that they must be located at a specific address, that is to say they are LOCATION DEPENDENT.

To "turn on" the TRACE function, we use one USR call. To turn it off, we use another seperate one. The addresses of these calls are different for the two routines.

In order to enter the hex. code, first select option 7 of HEXAID and clear the machine code area. Now select option 1 ("write a routine"). In response to the "length of routine" prompt, enter 118 for TRACE 48, or 252 for TRACE 16. The latter number is not a misprint. Although TRACE 16 is physically only 114 bytes long, we must enter 252 in order to position the routine at the correct start address. Now enter the hex. code in the usual way.

Here is a table of start addresses and lengths for the SAVE option of HEXAID, together with the commands to turn the TRACE ON and OFF. Once the routine has been turned on, the current line number will be displayed automatically whenever a program is running. Note that you may turn TRACE on or off from within a program.

	TRACE 16	TRACE 48
Start address	32348	65250
Length	114	118
Command for TRACE ON	RANDOMIZE USR 32448	RANDOMIZE USR 65250
Command for TRACE OFF	RANDOMIZE USR 32455	RANDOMIZE USR 65257
Printing in INVERSE VIDEO	POKE 32441, 47	POKE 65361, 47
Printing in TRUE VIDEO	POKE 32441, 0	POKE 65361, 0

Now the the routines: make sure you get the right one!

```
HEX.        ;TRACE 16  LENGTH: See bottom paragraph on page 131.
FF          ENTRY  RST    38H          ;CALL THE USUAL INTERRUPT
F5                 PUSH   AF           ;ROUTINE. STORE REGISTERS.
E5                 PUSH   HL
2A455C             LD     HL,(23621)   ;SYSTEM VARIABLE PPC.
24                 INC    H            ;IF HI-BYTE=HEX FF THEN
2841               JR     Z,OUT        ;PROGRAM ISN'T BEING RUN
C5                 PUSH   BC           ;SO JUMP TO THE END
D5                 PUSH   DE           ;OF THE ROUTINE.
25                 DEC    H
AF                 XOR    A
47                 LD     B,A
4F                 LD     C,A
11E803             LD     DE,1000      ;CALCULATE THE THOUSAND'S
ED52        NXT1   SBC    HL,DE        ;DIGIT.
3C                 INC    A
30FB               JR     NC,NXT1
19                 ADD    HL,DE
3D                 DEC    A
E5                 PUSH   HL
CDA97E             CALL   PRNTNUM      ;PRINT IT.
E1                 POP    HL
116400             LD     DE,100       ;CALCULATE THE
AF                 XOR    A            ;HUNDRED'S DIGIT.
ED52        NXT2   SBC    HL,DE
3C                 INC    A
30FB               JR     NC,NXT2
19                 ADD    HL,DE
3D                 DEC    A
0E01               LD     C,1
E5                 PUSH   HL
CDA97E             CALL   PRNTNUM      ;PRINT IT.
E1                 POP    HL
110A00             LD     DE,10        ;CALCULATE THE
7D                 LD     A,L          ;TEN'S DIGIT.
```

```
93          NXT3    SUB     E
14                  INC     D
30FC                JR      NC,NXT3
15                  DEC     D
83                  ADD     A,E
67                  LD      H,A
E5                  PUSH    HL
0E02                LD      C,2
7A                  LD      A,D
CDA97E              CALL    PRNTNUM         ;PRINT IT.
F1                  POP     AF              ;WE'RE  LEFT WITH THE
0E03                LD      C,3             ;UNITS:-PRINT THEM
CDA97E              CALL    PRNTNUM
D1                  POP     DE              ;RESTORE THE REGISTERS
C1                  POP     BC
E1          OUT     POP     HL
F1                  POP     AF
C9                  RET                     ;RETURN FROM INTERRUPT.
211C40      PRNTNUM LD      HL,401CH        ;THE A REGISTER
09                  ADD     HL,BC           ;HOLD THE DIGIT TO BE
87                  ADD     A,A             ;PRINTED, THE C REGISTER
87                  ADD     A,A             ;HOLDS THE NUMBER OF
87                  ADD     A,A             ;THE DIGIT (0 TO 3).
EB                  EX      DE,HL
4F                  LD      C,A
21803D              LD      HL,3D80H
09                  ADD     HL,BC
0608                LD      B,8
7E          NXT     LD      A,(HL)
2F                  CPL                     ;THIS BYTE DETERMINES
12                  LD      (DE),A          ;INVERSE (CPL) OR TRUE
23                  INC     HL              ;(NOP) VIDEO.
14                  INC     D
10F9                DJNZ    NXT
C9                  RET
3E28        TRON    LD      A,28H           ;TRACE ON BY VECTORING
ED47                LD      I,A             ;THE INTERRUPTS VIA
ED5E                IM      2               ;28FF, WHERE BYTES
C9                  RET                     ;5C AND 7E ARE STORED.
ED56        TROFF   IM      1               ;TRACE OFF BY RESTORING
3E3F                LD      A,3FH           ;I TO ITS ORIGINAL VALUE
ED47                LD      I,A             ;AND RESELECTING
C9                  RET                     ;INTERRUPT MODE 1.
                    END
```

HEX.

```
            ;TRACE 48  LENGTH: 118 BYTES
3EFE        TRON    LD      A,0FEH          ;TRACE ON BY VECTORING
ED47                LD      I,A             ;THE INTERRUPTS VIA
ED5E                IM      2               ;FEFF TO FEF0, LABEL
C9                  RET                     ;ENTRY.
ED56        TROFF   IM      1               ;TRACE OFF BY RESTORING
3E3F                LD      A,3FH           ;I TO 3F AND RESELECTING
ED47                LD      I,A             ;INTERRUPT MODE 1.
C9                  RET
```

```
FF          ENTRY   RST     38H           ;CALL THE USUAL INTERRUPT
F5                  PUSH    AF            ;ROUTINE. STORE REGISTERS.
E5                  PUSH    HL
2A455C              LD      HL,(23621)    ;SYSTEM VARIABLE PPC.
24                  INC     H             ;IF HI-BYTE=HEX FF THEN
2845                JR      Z,OUT         ;PROGRAM ISN'T BEING RUN
C5                  PUSH    BC            ;SO JUMP TO THE END
D5                  PUSH    DE            ;OF THE ROUTINE.
25                  DEC     H
AF                  XOR     A
1802                JR      HOP           ;HOP AROUND THE INTERRUPT
F0FE                DEFW    0FEF0H        ;VECTOR ADDRESS.
47          HOP     LD      B,A
4F                  LD      C,A
11E803              LD      DE,1000       ;CALCULATE THE THOUSAND'S
ED52        NXT1    SBC     HL,DE         ;DIGIT.
3C                  INC     A
30FB                JR      NC,NXT1
19                  ADD     HL,DE
3D                  DEC     A
E5                  PUSH    HL
CD41FF              CALL    PRNTNUM       ;PRINT IT.
E1                  POP     HL
116400              LD      DE,100        ;CALCULATE THE
AF                  XOR     A             ;HUNDRED'S DIGIT.
ED52        NXT2    SBC     HL,DE
3C                  INC     A
30FB                JR      NC,NXT2
19                  ADD     HL,DE
3D                  DEC     A
0E01                LD      C,1
E5                  PUSH    HL
CD41FF              CALL    PRNTNUM       ;PRINT IT.
E1                  POP     HL
110A00              LD      DE,10         ;CALCULATE THE
7D                  LD      A,L           ;TEN'S DIGIT.
93          NXT3    SUB     E
14                  INC     D
30FC                JR      NC,NXT3
15                  DEC     D
83                  ADD     A,E
67                  LD      H,A
E5                  PUSH    HL
0E02                LD      C,2
7A                  LD      A,D
CD41FF              CALL    PRNTNUM       ;PRINT IT.
F1                  POP     AF            ;WE'RE LEFT WITH THE
0E03                LD      C,3           ;UNITS:-PRINT THEM
CD41FF              CALL    PRNTNUM
D1                  POP     DE            ;RESTORE THE REGISTERS
C1                  POP     BC
E1          OUT     POP     HL
F1                  POP     AF
C9                  RET                   ;RETURN FROM INTERRUPT.
211C40      PRNTNUM LD      HL,401CH      ;THE A REGISTER
```

```
09                ADD   HL,BC       ;HOLDS THE DIGIT TO BE
87                ADD   A,A         ;PRINTED, THE C REGISTER
87                ADD   A,A         ;HOLDS THE NUMBER OF
87                ADD   A,A         ;THE DIGIT (0 TO 3).
EB                EX    DE,HL
4F                LD    C,A
21803D            LD    HL,3D80H
09                ADD   HL,BC
0608              LD    B,8
7E         NXT    LD    A,(HL)
2F                CPL               ;THIS BYTE DETERMINES
12                LD    (DE),A      ;INVERSE (CPL) OR TRUE
23                INC   HL          ;(NOP) VIDEO.
14                INC   D
10F9              DJNZ  NXT
C9                RET               ;END OF PRINT ROUTINE.
                  END
```

A NOTE FOR THE TECHNICALLY MINDED

Due to the phenomenon of picture break-up that occurs when the interrupt vector holds values between hex. 40 and 7F, it is necessary to vector interrupts under mode two via an address less than 4000H (i.e. in the ROM) on a 16K Spectrum. The data bus on a Spectrum always holds hex. FF at the time of an interrupt. This leaves us with a choice of 63 different interrupt tables each with one address in them. Of these, only seven are in the 16K RAM area, one of which is in the screen. Of the remaining six addresses, the only one remotely near the 32K boundary is that stored at addresses 28FF and 2900 hex. The value of this is hex. 7E5C, which is where I have put the entry point of TRACE 16.

ENHANCING YOUR PROGRAMS

CHAPTER 30
GEOGRAPHIC KEYBOARD SCANS

GEOGRAPHIC KEYBOARD SCANS

If you have read page 160 of the Spectrum Manual then you will know that it is possible to read the keyboard using the IN function. The great advantage of this against the INKEY$ function is that you can detect the depression of more than one key at any one time. In this way it is possible to combine (say) two direction keys to produce a diagonal movement in a game rather than presenting the player with the 'finger gymnastics' task of using eight different direction keys.

The one problem with IN is that it can be rather slow and clumsy to use, especially if you are reading only one key in a given 'half-row' of five keys. By now you will probably have guessed that machine code offers the solution: in fact IN and OUT are the most similar words in Spectrum BASIC to their counterparts in assembly language, namely the IN and OUT instructions on which they are based.

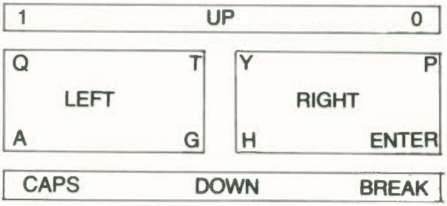
I have included in this chapter a suite of five machine-code keyboard routines to suit your every programming need. You use them with a command - such as:

```
LET A = USR (start address)
```

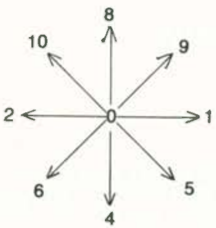
It is important to use LET rather than RANDOMIZE, since the value that A takes will be the number returned from the routine and can then be used in IF... THEN statements and so on.

The routines are called 'geographic' because they attempt to lay out the directions in corresponding areas of the keyboard, e.g. the top row of the keys can be used to move upwards.

The first routine, GEOSCAN1, offers the four directions (combinable to eight) and a keyboard layout like this:



The numbers returned are as follows:



GEOSCAN1 is ideal for Pac-Man type games!

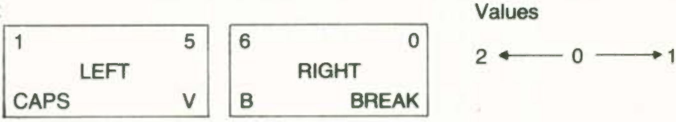
```
HEX.        ;GEOSCAN1  LENGTH: 48 BYTES
01001F      START   LD    BC,1F00H       ;B=MASK ON INPUT PORT,
3E9F                LD    A,9FH          ;C WILL HOLD THE RETURN
DBFE                IN    A,(0FEH)       ;VALUE.
2F                  CPL                  ;CHECK FOR 'RIGHT'....
A0                  AND   B
2803                JR    Z,NTRIGHT
0C                  INC   C              ;IF SO THEN LET C=1 AND
180A                JR    NOTLEFT        ;DON'T CHECK FOR 'LEFT'.
3EF9        NTRIGHT LD    A,0F9H         ;CHECK FOR 'LEFT'.
DBFE                IN    A,(0FEH)
2F                  CPL
A0                  AND   B
2802                JR    Z,NOTLEFT      ;IF LEFT THEN LET C=2
CBC9                SET   1,C
3E7E        NOTLEFT LD    A,7EH          ;CHECK FOR 'DOWN'.
DBFE                IN    A,(0FEH)
2F                  CPL
A0                  AND   B
0600                LD    B,0
2803                JR    Z,NOTDOWN
```

```
0022 CBD1           SET    2,C          ;IF 'DOWN' THEN C=C+4,
0024 C9             RET                 ;AND RETURN TO BASIC.
0025 3EE7  NOTDOWN  LD     A,0E7H       ;OTHERWISE CHECK FOR
0027 DBFE           IN     A,(0FEH)     ;'UP' ...
0029 2F             CPL
002A E61F           AND    1FH
002C C8             RET    Z            ;AND IF AN 'UP' KEY IS
002D CBD9           SET    3,C          ;PRESSED THEN LET C=C+8.
002F C9             RET                 ;RETURN TO BASIC.
0000                END
```

Note that in all of the GEOSCAN routines, I have given 'right' priority over 'left', and 'down' priority over 'up'.

The second GEOSCAN routine checks for just two sets of keys; in doing this it divides the keys vertically down the middle and then checks each of the two halves for a key-press. This routine would be at its best in a 'Breakout'-type game.

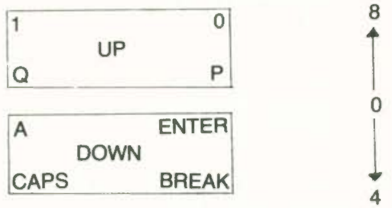
Layout **Values**



It should be realised at this point that the directions that I have attached to the values returned are entirely arbitrary; you could, for example, equally use the values from GEOSCAN2 to mean "turn anticlockwise" and "turn clockwise", or in a calculating program "print subtotals" and "don't print subtotals".

```
HEX.       ;GEOSCAN2  LENGTH: 25 BYTES
010000     START   LD    BC,0        ;BC HOLDS THE RETURN
3E0F               LD    A,0FH       ;VALUE. CHECK THE RIGHT-
DBFE               IN    A,(0FEH)    ;HAND HALF OF THE KEY-
2F                 CPL               ;BOARD.
E61F               AND   1FH
2802               JR    Z,NTRIGHT
0C                 INC   C           ;RETURN THE VALUE 1 IF
C9                 RET               ;PRESSED.
3EF0       NTRIGHT LD    A,0F0H      ;CHECK THE LEFT-HAND
DBFE               IN    A,(0FEH)    ;SIDE.
2F                 CPL
E61F               AND   1FH
C8                 RET   Z           ;RETURN IF NO KEY PRESS.
CBC9               SET   1,C         ;OTHERWISE RETURN VALUE
C9                 RET               ;2 IN BC TO BASIC.
                   END
```

The logical counterpart to GEOSCAN2 is (you guessed it) a routine which divides the keyboard into halves horizontally and is ideal for any game involving only vertical control, such as control of the up-down bat movement in a 'squash' game. Here are the layout and values...

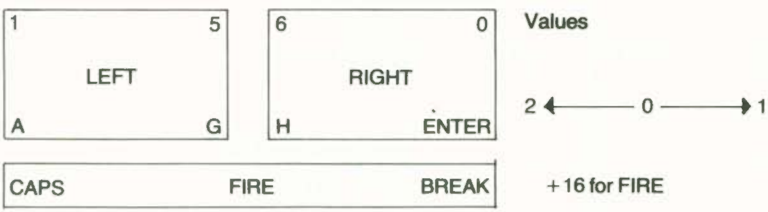


... and here is the routine. As usual, call it with

LET A = USR (start address)

```
HEX.      ;GEOSCAN3  LENGTH: 26 BYTES
010000    START   LD    BC,0       ;BC HOLDS THE RETURN
3E3C              LD    A,3CH      ;VALUE. CHECK THE BOTTOM
DBFE              IN    A,(0FEH)   ;HALF OF THE KEYBOARD.
2F                CPL
E61F              AND   1FH
2803              JR    Z,NOTDOWN
CBD1              SET   2,C        ;RETURN THE VALUE OF 4
C9                RET              ;IF PRESSED.
3EC3      NOTDOWN LD    A,0C3H     ;CHECK THE TOP HALF.
DBFE              IN    A,(0FEH)
2F                CPL
E61F              AND   1FH
C8                RET   Z          ;RETURN IF NO KEY PRESS.
CBD9              SET   3,C        ;OTHERWISE RETURN VALUE
C9                RET              ;8 IN BC TO BASIC.
                  END
```

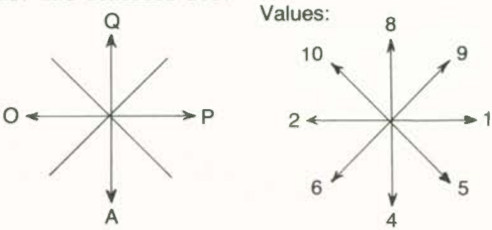
If you are a space-invader fan then this next keyboard routine is the one for you. It uses the bottom row of the keyboard for a 'fire' control and divides the other three rows down the middle, as before, into left and right laser-base control regions.



Note that this gives you the ability to detect movement and FIRE controls simultaneously (e.g. FIRE and LEFT gives value 18).

```
HEX.            ;GEOSCAN4  LENGTH: 36 BYTES
01001F          START   LD      BC,1F00H        ;B=MASK ON INPUT PORT,
3E8F                    LD      A,BFH           ;C WILL HOLD THE RETURN
DBFE                    IN      A,(0FEH)        ;VALUE. CHECK FOR 'RIGHT'
2F                      CPL                     ;CONTROL.
A0                      AND     B
2803                    JR      Z,NTRIGHT
0C                      INC     C               ;IF PRESSED, THEN LET C=1
180A                    JR      NOTLEFT         ;AND DON'T CHECK 'LEFT'.
3EF1            NTRIGHT LD      A,0F1H          ;CHECK FOR 'LEFT'.
DBFE                    IN      A,(0FEH)
2F                      CPL
A0                      AND     B
2802                    JR      Z,NOTLEFT       ;IF PRESSED, THEN LET
CBC9                    SET     1,C             ;C=2
3E7E            NOTLEFT LD      A,7EH           ;CHECK THE BOTTOM
DBFE                    IN      A,(0FEH)        ;ROW (FIRE).
2F                      CPL
A0                      AND     B
0600                    LD      B,0             ;IF PRESSED THEN ADD
C8                      RET     Z               ;16 TO THE VALUE AND
CBE1                    SET     4,C             ;RETURN IT IN BC TO
C9                      RET                     ;BASIC.
                        END
```

For the final GEOSCAN routine I have used a layout similar to that found on many popular arcade games for the ZX-Spectrum, including Melbourne House's No. 1-selling "Penetrator" game for the 48K machine. The controls are:



Bottom Row = FIRE   +16 for FIRE

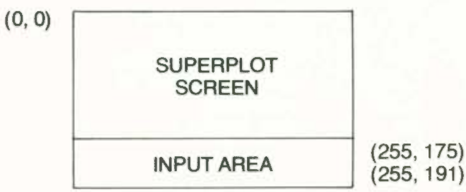
... and here is the routine.

```
HEX.            ;GEOSCAN5  LENGTH: 49 BYTES
010000          START   LD      BC,0            ;BC WILL HOLD THE RET-
3EDF                    LD      A,0DFH          ;URN VALUE. CHECK THE
DBFE                    IN      A,(0FEH)        ;"P" KEY.
1F                      RRA
3803                    JR      C,NTRIGHT
0C                      INC     C               ;IF PRESSED, THEN BC=1, AND
1805                    JR      NOTLEFT         ;DON'T CHECK FOR 'LEFT'.
1F              NTRIGHT RRA                     ;CHECK "O" KEY.
3802                    JR      C,NOTLEFT
CBC9                    SET     1,C             ;IF PRESSED THEN BC=2
3EFD            NOTLEFT LD      A,0FDH          ;CHECK THE "A" KEY.
```

```
DBFE                IN    A,(0FEH)
1F                  RRA
3804                JR    C,NOTDOWN      ;IF PRESSED THEN BC=BC+4,
CBD1                SET   2,C            ;AND DON'T CHECK "UP".
1809                JR    NOTUP
3EFB        NOTDOWN LD    A,0FBH         ;CHECK THE "Q" KEY. IF
DBFE                IN    A,(0FEH)       ;PRESSED, THEN BC=BC+8.
1F                  RRA
3802                JR    C,NOTUP
CBD9                SET   3,C
3E7E        NOTUP   LD    A,7EH
DBFE                IN    A,(0FEH)       ;CHECK FOR THE BOTTOM
2F                  CPL                  ;"FIRE" ROW.
E61F                AND   1FH            ;IF IT IS PRESSED THEN
C8                  RET   Z              ;ADD 16 TO RESULT
CBE1                SET   4,C
C9                  RET                  ;RETURN TO BASIC.
                    END
```

CHAPTER 31
SUPERPLOT 256 x 192

This routine lets you plot on the bottom two lines of the screen as well as the rest of it. I have used a new system of coordinates; the top-left corner of the screen is now (0,0), thus:



To use SUPERPLOT to plot a point (x,y):

```
POKE 23677, X : POKE 23678, Y
RANDOMIZE USR [start address]
```

The routine follows all the usual rules fôr the current INVERSE and OVER values, and does not affect the colour bytes. Here it is:

```
HEX.        ;SUPERPLOT 256*192 LENGTH: 68 BYTES
2A7D5C      START  LD    HL,(5C7DH)    ;SYSTEM VARIABLE COORDS
7C                 LD    A,H           ;L=X, H=Y
E6C0               AND   0C0H          ;LOCATE THE RIGHT
0F                 RRCA                ;THIRD OF THE SCREEN
0F                 RRCA
```

```
0F              RRCA
C640            ADD    A,40H
57              LD     D,A
7C              LD     A,H
E607            AND    07H          ;NOW FIND THE RIGHT ROW.....
82              ADD    A,D
57              LD     D,A
7C              LD     A,H          ;...OF THE RIGHT LINE
87              ADD    A,A          ;ON THE SCREEN
87              ADD    A,A
E6E0            AND    0E0H
5F              LD     E,A
7D              LD     A,L          ;FIND THE RIGHT COLUMN.
E6F8            AND    0F8H         ;NOW WE HAVE THE
0F              RRCA                ;ADDRESS OF THE BYTE OF
0F              RRCA                ;THE SCREEN TO BE
0F              RRCA                ;ALTERED
B3              OR     E
5F              LD     E,A
EB              EX     DE,HL
0EFE            LD     C,0FEH       ;C HOLDS THE MASK
AF              XOR    A            ;FOR THE OLD BYTE.
FDCB575E        BIT    3,(IY+57H)   ;A HOLDS THE NEW BIT.
2001            JR     NZ,HOP       ;IY+57H=SYSTEM
3C              INC    A            ;VARIABLE P FLAG. BIT
57        HOP   LD     D,A          ;3 SIGNIFIES INVERSE
7B              LD     A,E          ;VALUE.
E607            AND    07H
47              LD     B,A
04              INC    B
79              LD     A,C
CB0A      NXT   RRC    D            ;SHIFT THE MASK (NOW
0F              RRCA                ;IN A) AND THE NEW
10FB            DJNZ   NXT          ;BIT TO THE RIGHT POINT.
FDCB574E        BIT    1,(IY+57H)   ;BIT 1 OF P FLAG IS THE
2004            JR     NZ,OVER      ;OVER VALUE.
A6              AND    (HL)         ;PLOT OVER 0,X,Y.
B2              OR     D
77              LD     (HL),A
C9              RET                 ;RETURN TO BASIC.
7A        OVER  LD     A,D          ;PLOT OVER 1,X,Y.
AE              XOR    (HL)
77              LD     (HL),A
C9              RET                 ;RETURN TO BASIC
                END
```

The demonstration below will plot a sine curve, using the full screen. Don't forget to alter the start address in line 30.

Line 80 forms an infinite loop in order to stop the computer overwriting the bottom two lines of the screen with a report code. Press BREAK to end this.

```
  10 REM SUPERPLOT DEMO
  20 REM © DAVID M.WEBB, 1983
  30 LET PLOT=65000: REM START A
DDRESS
  40 FOR A=0 TO 255
  50 POKE 23677,A: POKE 23678,96
-95*SIN (A*PI/128): REM SET X,Y
COORDINATES
  60 RANDOMIZE USR PLOT
  70 NEXT A
  80 GO TO 80
```

CHAPTER 32
TAPE RELAY

The tiny Z-80 microprocessor or CPU (Central Processing Unit) at the heart of your Spectrum is linked to the outside world by what are known as INput and OUTput ports. In the case of the Spectrum these take the form of the EAR socket and keyboard (IN) and the MIC socket, television, loudspeaker (well O.K., quiet BEEPer) and printer (OUT).

These ports can be accessed from BASIC by use of the aptly-named IN and OUT commands (see Chapter 23, page 159 of the manual) but unfortunately BASIC cannot provide a fast enough sampling or "reading" rate to relay sound IN through the ear socket and OUT through the speaker. This can be demonstrated thus:

```
10 REM This relay program is too slow
20 OUT 254, 0: OUT 254, INT ((IN 254)/4): GOTO 20
```

You will find that although the above program produces a series of "clicks" when you play your favourite Beethoven sonata at full volume and high tone through the EAR socket, they are not frequent enough to produce a recognisable sound. For this we have to resort to machine code, because it "refreshes the ports at a speed that other languages cannot reach!"

The following routine was written to provide the highest possible sampling rate, in an effort to achieve the best possible "relay" sound quality. As a result the EAR port is "read" approximately once every 17 microseconds (a microsecond is a millionth of a second) and this produces a sampling rate of about 57000 times per second (57 Kilohertz). For reasons best known to the hardware enthusiasts amongst you, the signal output to the speaker can be very weak. I find the best sound reproduction is achieved as follows:

1. Disconnect the lead from the "MIC" socket on the tape recorder to that at the back of the Spectrum - this prevents 'feed-back' distorting the sound;

2. Connect the lead between the EAR sockets of the two devices in the normal fashion;

3. Put the volume control on maximum setting, and if you have a "tone" control then do likewise for that (the reason for the latter adjustment is that the circuitry inside the computer incorporates a "Schmitt trigger" which does wonders for filtering out background noise when LOADing but does have a habit of removing "low-tone" sound).

Before we go any further I'd better let you have the routine.

```
HEX.      ;TAPE RELAY  LENGTH: 27 BYTES
F3        START  DI                     ;STOP THE CLOCK AND KEYBOARD
010000           LD    BC,0             ;SCANS. FOR BC=0 TO -65536
DBFE      LOOP   IN    A,(0FEH)         ;LET A=IN(254)
0F               RRCA                   ;LET A=INT(A/4)
0F               RRCA
D3FE             OUT   (0FEH),A         ;OUT(254),A(SPEAKER 'ON')
AF               XOR   A                ;LET A=0
D3FE             OUT   (0FEH),A         ;OUT(254),A(SPEAKER 'OFF')
10F5             DJNZ  LOOP             ;NEXT BC
0D               DEC   C
20F2             JR    NZ,LOOP
3E7F             LD    A,7FH            ;TEST FOR BREAK KEY.
DBFE             IN    A,(0FEH)         ;IF NOT PRESSED THEN REPEAT
1F               RRA                    ;THE SEQUENCE.
38EB             JR    C,LOOP
FB               EI                     ;TURN THE CLOCK AND KEYBOARD
C9               RET                    ;SCANS BACK ON, RETURN TO
                 END                    ;BASIC.
```

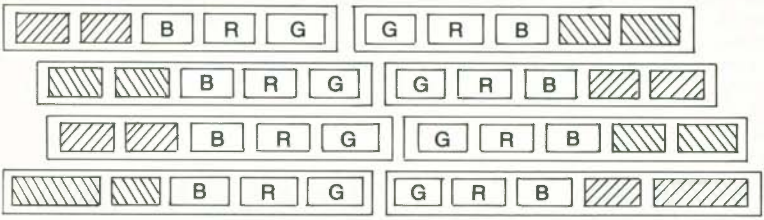
No POKEs are needed for this routine; to begin "listening" just use the line

LET L = USR (start address .of routine)

Start the tape player (Preferably with a tape in) and "boogie-on-down" to the merry old sound of Glen Miller (or whatever takes your fancy). To stop the routine, press the BREAK key (on its own, or with any other key) and the machine will come back into BASIC. Remember that if the routine was called from a BASIC program then the program itself will only normally stop if you press CAPS SHIFT as well as BREAK. The BREAK key is only checked once every second or so, therefore the computer will not always respond instantly when you press the key: hold it down until the return to BASIC has ocurred.

An interesting offshoot of this program is that every time the EAR socket is read part of the keyboard is also read. The values obtained from this are sent out through port 254, which apart from controlling the speaker also controls the BORDER colour of the TV screen. You will find that by pressing certain keys you can vary the BORDER colour (or shade, for the benefit of the non-coloured reader!).

It works like this:



The keyboard can be considered as being split up into eight 'half-rows', each of five keys. The three keys in each half-row that are nearest to the centre of the keyboard correspond to the three primary colours Green, Red and Blue, and these three colours used in various combinations produce all the other colours of the Spectrum (sorry!).

When a key is pressed the corresponding primary colour is removed from the 'palette' or border, leaving the resulting combination of the other two colours. Hence depressing a Red key leaves green and blue, which together make cyan. Note that when all three colours are removed (by pressing three keys) then black (or "total absence of colour") results, while depressing no keys leaves all three primary colours, thereby producing white.

CHAPTER 33
SPEECH REPRODUCTION

Following on from the 'Tape Relay' routine in the last chapter, I hereby reproduce a pair of routines that will let you store and reproduce speech on your Spectrum. No extra hardware is required.

The process works by taking the signal sent to the EAR socket on the Spectrum by your tape player, and turning it into a succession of 1s and 0s. These are then stored in groups of eight as bytes in the memory. When the sound is needed again these bytes are taken from the memory in the same sequence in which they were stored, broken back down to 1s and 0s and sent to the speaker (pun unavoidable). The resulting sound should be a good approximation of what was on the tape cassette.

Due to the high 'sampling rate' (the frequency at which the EAR socket is 'read') needed to produce intelligible speech, large amounts of memory are needed to store the shortest of words. Typically this equates to a memory consumption of 1 - 2K of RAM per second of sound.

For this reason, although it is perfectly feasible to store speech on the 16K machine, you will have to restrict yourself to two or three words in order to have room for a decent-sized BASIC program.

Before proceeding further on how to use the routines, I'll give you the pleasure of typing them in - don't forget to SAVE them when you've finished!

```
HEX.        ;LISTEN    LENGTH : 78 BYTES
            START   EQU    5AFFH
            LIMIT   EQU    4000H
            DELAY   EQU    0CH
            ;
21FF5A              LD     HL,START        ;SOUND IS STORED
110040              LD     DE,LIMIT        ;DOWNWARDS FROM
E5                  PUSH   HL              ;START AND NOT
A7                  AND    A               ;EXCEEDING LIMIT IN
ED52                SBC    HL,DE           ;MEMORY
23                  INC    HL
4C                  LD     C,H             ;BC HOLDS COUNT OF
45                  LD     B,L             ;SPARE BYTES REMAIN-
E1                  POP    HL              ;ING IN LO-HI ORDER
383A                JR     C,END2
0C                  INC    C
F3                  DI                     ;DISABLE INTERRUPTS
167F                LD     D,7FH           ;D IS USED IN BOTH
D9                  EXX                    ;REGISTER SETS FOR
1680                LD     D,80H           ;SPEED AS A CONSTANT
D9                  EXX
3E7F        WAIT    LD     A,7FH           ;TEST BREAK KEY
DBFE                IN     A,(0FEH)        ;AND RETURN TO BASIC
1F                  RRA                    ;IF HIT
302B                JR     NC,END2
CB6F                BIT    5,A             ;WAIT UNTIL A SOUND
20F5                JR     NZ,WAIT         ;IS DETECTED
D9          NXTBYTE EXX                    ;LOOP FOR EACH BYTE
5A                  LD     E,D
DBFE        NXTBIT  IN     A,(0FEH)        ;READ THE EAR SOCKET
CB17                RL     A               ;STORE THE RESULTING
CB17                RL     A               ;BIT IN THE E REGISTER
CB1B                RR     E
3806                JR     C,NODELAY       ;HAVE A TIMING DELAY
060C                LD     B,DELAY         ;UNLESS ON THE 8TH BIT
10FE        SELF    DJNZ   SELF
18F0                JR     NXTBIT          ;REPEAT FOR EACH BIT
7B          NODELAY LD     A,E
D9                  EXX
77                  LD     (HL),A          ;STORE THE FINISHED
2B                  DEC    HL              ;BYTE IN MEMORY
7A                  LD     A,D             ;TEST BREAK KEY
DBFE                IN     A,(0FEH)        ;IF HIT THEN RETURN
1F                  RRA                    ;TO BASIC OTHERWISE
3005                JR     NC,END          ;CONTINUE UNTIL ALL
10E2                DJNZ   NXTBYTE         ;RESERVED MEMORY IS
0D                  DEC    C               ;USED UP
20DF                JR     NZ,NXTBYTE
23          END     INC    HL              ;NOW TO CONSERVE
7E                  LD     A,(HL)          ;MEMORY BACKTRACK
3C                  INC    A               ;THE POINTER TO THE
28FB                JR     Z,END           ;LAST DETECTABLE SOUND
2B                  DEC    HL
44          END2    LD     B,H             ;RETURN THE ADDRESS
```

```
4D              LD      C,L             ;OF THE NEXT FREE
FB              EI                      ;BYTE TO BASIC
C9              RET
                END
```

```
HEX.    ;SPEAK   LENGTH : 69 BYTES
        START   EQU     5AFFH
        ENDD    EQU     4000H
        DELAY   EQU     0CH
        ;
21FF5A          LD      HL,START        ;START AND END
110040          LD      DE,ENDD         ;ADDRESSES OF SOUND
E5              PUSH    HL              ;IN MEMORY
A7              AND     A
ED52            SBC     HL,DE
23              INC     HL              ;BC HOLDS COUNT OF
4C              LD      C,H             ;BYTES OF SPEECH
45              LD      B,L             ;REMAINING IN LO-HI
E1              POP     HL              ;ORDER
0C              INC     C
3A485C          LD      A,(5C48H)       ;STORE THE BORDER
0F              RRCA                    ;COLOUR IN THE ALTERNATIVE
0F              RRCA                    ;C REGISTER
0F              RRCA
E607            AND     7
D9              EXX
4F              LD      C,A
E5              PUSH    HL              ;H' HOLDS CONSTANT
2610            LD      H,10H           ;10H USED AS A MASK
D9              EXX                     ;LATER
F3              DI
7E      NXTBYTE LD      A,(HL)          ;TAKE A BYTE OF SPEECH
0F              RRCA
0F              RRCA
0F              RRCA
0F              RRCA
D9              EXX
5F              LD      E,A
1608            LD      D,8             ;FOR 8 BITS
7B      NXTBIT  LD      A,E             ;STORE THE BIT IN BIT
A4              AND     H               ;4 OF A, PUT THE BORDER
B1              OR      C               ;COLOUR IN BITS 0-2 AND
D3FE            OUT     (0FEH),A        ;OUTPUT THE BYTE ON
CB0B            RRC     E               ;PORT 254
15              DEC     D               ;HAVE A TIMING DELAY
2806            JR      Z,NODELAY       ;UNLESS THE 8TH BIT
060C            LD      B,DELAY
10FE    SELF    DJNZ    SELF
18F0            JR      NXTBIT          ;NEXTBIT
D9      NODELAY EXX
2B              DEC     HL              ;LD A,00 IS A 7.T-STATE
3E00            LD      A,00            ;TIMING EQUALIZER WITH
10E1            DJNZ    NXTBYTE         ;THE LISTEN ROUTINE
0D              DEC     C
20DE            JR      NZ,NXTBYTE
```

```
D9          END    EXX
E1                 POP    HL          ;RETRIEVE HL' TO AVOID
D9                 EXX                ;A CRASH ON RETURNING
FB                 EI                 ;TO BASIC
C9                 RET
                   END
```

Before any speech can be stored you must reserve some RAM for it and tell the routines where that space is. We do this by lowering RAMTOP with the CLEAR instruction. RAMTOP will already be lower than usual since room was needed for the routines themselves.

We define the two ends of the area reserved for speech with the aid of the two variables, START and LIMIT. The sound is stored DOWNWARDS in memory, so START is the highest free bytes and LIMIT is the lowest. For example, let's suppose that the LISTEN routine is stored at 65290 (on a 48K machine) and SPEAK starts at 65221. Now assuming you haven't any other routines above RAMTOP, we can let START = 65220 (one less than SPEAK). Reserving, say, 20K of memory, we let

```
LIMIT = 65220 - (20 * 1024) + 1
      = 44741
```

and to reserve this space we must reduce RAMTOP to one less than the LIMIT, i.e.

```
CLEAR 44740
```

To use the parameters START and LIMIT in the LISTEN routine, we use a by now familiar looking set of POKEs. If LIS is the start of the routine,

```
POKE LIS + 1, START - 256 * INT(START / 256)
POKE LIS + 2, INT(START / 256)
POKE LIS + 4, LIMIT - 256 * INT(LIMIT / 256)
POKE LIS + 5, INT(LIMIT / 256)
```

In a similar way, we must define the START and END addresses of the speech to be replayed by the SPEAK routine. START will always be greater than or equal to END, and is the same value as that used in the LISTEN routine.
When the LISTEN routine is used, it returns the value of the next free byte below the speech just stored. As a result we can find END by using the command

```
LET END = (USR LIS) + 1
```

to call the LISTEN routine.

To set the START and END parameters of the routine with start address SPK,

```
POKE SPK + 1, START - 256 * INT(START / 256)
POKE SPK + 2, INT(START / 256)
```

```
POKE SPK + 4, END - 256 * INT(END / 256)
POKE SPK + 5, INT(END / 256)
```

The rate at which the LISTEN routine reads the EAR socket is controlled by the 'timing delay' in the central loop of the routine. This controls the length of time between samples, so the higher the delay value, the lower the sampling rate and the poorer the speech. There is an identical delay loop in the SPEAK routine, and I have carefully matched all other loops of the two routines so that given the same delay values, there will be no change of pitch between the input and output sound. The delay value ranges from 1 to 256, with 0 corresponding to 256. I find that values up to about 45 can produce intelligible speech, but this is largely a matter of personal preference. I have set the standard value as twelve, since I use this most often. To alter the delay value

```
POKE LIS + 48, [Delay value]
POKE SPK + 50, [Delay value]
```

It is worth bearing in mind that as the delay value decreases, the memory will be used up faster. In fact at a delay value of one the sampling rate is about 50 KHz (fifty thousand times per second) and the memory is used up at about 6K per second.

Now for the practicalities of using the routines. Any signal to the EAR socket will do as long as it is strong enough. I find the best signal using stardard equipment is produces as follows:

1) Insert a blank tape into the cassette player.

2) Set the recorder going in 'RECORD' mode, having first disconnected the MIC connection to the Spectrum.

3) Speak loudly and clearly into the microphone. You may need to shout, but if the recording is distorted then you are too close **to the microphone. The aim is to get as 'loud' a signal as possible, without distortion.**

4) Having made the recording, and leaving the MIC lead disconnected, connect the EAR socket of the tape recorder and the Spectrum.

5) Set the volume to maximum and the tone control (if you have one) to maximum treble. These levels are rough guides; you may need to experiment.

The LISTEN routine is what is known as "voice-activated", that is to say that once called with the USR function it will wait until it detects a signal on the EAR port before beginning to eat its way through your spare RAM. The routine will stop automatically when it reaches the LIMIT of RAM, but if you want to stop it beforehand (to prevent unwanted sound being stored, say) then just press the BREAK key. In either case, the routine will 'backtrack' up the memory until the last detected sound is found (said the poet who didn't know it) and return you the address below it, so as not to waste memory storing silence.

At the end of this chapter I have included a fully operational program that will let you build up and manipulate a vocabulary of speech, but for the impatient I have also included a short demonstration program. I have preset the standard values of START, LIMIT and END to cover the complete display and attribute files. Together these are 6 3/4K long, and so form an adequate and somewhat spectacular temporary store for speech.

Here is the program; don't forget to alter the start addresses to suit.

```
  10 REM SPEECH REPRODUCTION DEM
O
  20 REM START ADDRESSES
  30 LET LIS=65290: LET SPK=6522
1
  40 RANDOMIZE USR LIS: BORDER 2
  50 RANDOMIZE USR SPK
  60 PAUSE 30: GO TO 50
```

Having prepared your speech sample as previously described, set the player running and RUN the program. All being well, the screen will fill up with seemingly ramdom colours and patterns, then the border will turn red and the Spectrum will begin to speak. If nothing happens at all, then you have either made an error in entering the routines, in which case the machine has probably crashed, or the input level at the EAR socket is too low. Press BREAK and make a fresh sample in the latter case, shouting more loudly into the microphone.

It is worth mentioning at this point that pre-recorded cassettes will do just as well, as long as they are loud enough. Something else you might like to try is 'replaying' the 16K ROM by setting the START and END parameters of SPEAK to 16383 and 0 respectively, and then using the direct command:

```
RANDOMIZE USR SPK
```

I come now to one of the largest BASIC programs in this book, "Spectrum Speech". The program takes the effort out of using the routines by handling all the POKEs and calculation of the START, END and LIMIT parameters for you. While providing all the basic functions that I feel are necessary I have kept the program fairly concise in order to leave plenty of spare RAM for 16K users, hence the lack of a 'menu' and other frills.

Line 30 of the programs CLEARS RAMTOP to reserve storage area for the spoeech. I have arbitrarily chosen 32767 for RAMTOP; this reserves about 32K of RAM on a 48K machine. 16K owners will find that by omitting all the REM statements RAMTOP can be lowered to about 27000. That gives almost 5.5K of speech storage. You should set LIMIT in line 90 to one more than the value CLEARED, and START in line 80 one less than the lower of the start addresses LIS and SPK in lines 50 and 60, which should also be adjusted. Don't forget to leave room (by lowering START) for any other routines you may want to use.

The command RUN will clear all the variables and set up the system to build a vocabulary of speech (lines 100 to 200). You can view the contents of this vocabulary with the direct command GOTO 210 (not RUN 210, as this would clear the variables). The START and END addresses of each word along with the timing delay used will be shown. You should note these down, since you will need them to use the SPEAK routine in your own programs (by POKEing them back into the routine).

Any of the words on its own can be heard with the command GOTO 280, and the entry can be changed with GOTO 320. The central subroutines used by the program are lines 370 to 510 (LISTEN) and lines 520 to 590 (SPEAK).

It is there that all the POKEing is done.

Lines 600 and 610 are optional and simply used in conjuction with SAVE ... LINE 600 to make the program auto-run.

GOTO 620 lets you save any or all of the speech. You will be provided with the start address of the block of code; this should be noted down. When you come to reload this speech from your own program you should use the lines:

```
CLEAR [start address] - 1
LOAD "" CODE
```

in that order.

Array A() is used to hold three peices of data for each entry. The first is the delay value and a great deal of pleasure can be derived from altering it, thereby raising or lowering the pitch of your voice. The second entry is the value of START and the third is the value of END for that word.

I'll end with a summary of commands and this listing itself.

Command	Effect
RUN	Build a vocabulary
GOTO 210	View the vocabulary
GOTO 280	Hear any word
GOTO 320	Change any word
GOTO 620	SAVE speech
LET A(W,1) = K	Alter delay value of word W

```
  10 REM SPECTRUM SPEECH
  20 REM © DAVID M. WEBB, 1983

  30 CLEAR 32767: REM MEMORY RES
ERVED
  40 REM ROUTINE START ADDRESSES

  50 LET LIS=65000
  60 LET SPK=64900
  70 LET ZE=SIN PI: LET ON=SGN P
I: LET TW=ON+ON: LET TH=INT PI:
LET PO=256: REM CONSTANTS
  80 LET START=64899: REM FIRST
FREE BYTE
  90 LET LIMIT=32768: REM LAST F
REE BYTE
 100 REM BUILD A VOCABULARY ****

 110 INPUT "Maximum no. of words
:";M: IF M<ON THEN  GO TO 110
 120 INPUT "Maximum word length:
";N: IF N<ZE THEN  GO TO 120
 130 DIM A(M,TH): DIM N$(M,N): R
EM (A) HOLDS DELAY & START & END
 ADDRESS OF EACH WORD, (N$) HOLD
S WORD NAMES
 140 FOR C=ON TO M: REM  C COUNT
S WORDS
 150 INPUT "Please give word ";(
C);":";A$
 160 LET N$(C)=A$( TO (LEN A$ AN
D LEN A$<=N)+(N AND LEN A$>N))
 170 GO SUB 370: REM LISTEN
 180 IF A(C,TH)=LIMIT THEN  PRIN
T "Out of memory": STOP
 190 NEXT C
 200 PRINT "VOCABULARY COMPLETE"
: STOP
 210 REM *** VIEW VOCABULARY****

 220 CLS : PRINT "NO. WORD";TAB
15;"DELAY";TAB 21;"START";TAB 28
;"END"''
 230 FOR C=ON TO M
 240 PRINT C;TAB TH;N$(C);TAB 18
;A(C,ON);TAB 21;A(C,TW);TAB 27;A
(C,TH)
 250 GO SUB 520: REM SPEAK
 260 NEXT C
 270 STOP
 280 REM **** HEAR ANY WORD*****

 290 INPUT "Which of the ";(M);"
 words do you want"'"to hear?";C
```

```
 300 IF C>M OR C<ON THEN  GO TO
290
 310 GO SUB 520: STOP
 320 REM *** CHANGE ANY WORD ***

 330 INPUT "Which of the ";(M);"
 words do"'"you want to change?"
;C
 340 IF C>M OR C<ON THEN  GO TO
330
 350 LET START=A(C,TW): LET LIMI
T=A(C,TH)
 360 GO SUB 370: STOP
 370 REM ****** LISTEN *********

 380 POKE LIS+ON,START-PO*INT (S
TART/PO)
 390 POKE LIS+TW,INT (START/PO)
 400 POKE LIS+4,LIMIT-PO*INT (LI
MIT/PO)
 410 POKE LIS+5,INT (LIMIT/PO)
 420 INPUT "Timing delay (1-255)
:";D
 430 POKE LIS+48,D
 440 LET A(C,ON)=D: LET A(C,TW)=
START
 450 INPUT "Press ENTER to begin
 listening"; LINE a$
 460 CLS : PRINT "Press BREAK or
 just wait to end listening"
 470 LET A(C,TH)=(USR LIS)+ON
 480 IF A(C,TH)>START THEN  PRIN
T "No sound detected": LET C=C-O
N: RETURN
 490 GO SUB 520
 500 LET START=A(C,TH)-ON
 510 RETURN
 520 REM ******* SPEAK *********

 530 POKE SPK+ON,A(C,TW)-PO*INT
(A(C,TW)/PO)
 540 POKE SPK+TW,INT (A(C,TW)/PO
)
 550 POKE SPK+4,A(C,TH)-PO*INT (
A(C,TH)/PO)
 560 POKE SPK+5,INT (A(C,TH)/PO)
 570 POKE SPK+50,A(C,ON)
 580 LET A=USR SPK
 590 RETURN
 600 REM OPTIONAL AUTO-LOAD SECT
ION ****************************

 610 CLEAR 64899: LOAD "LISTEN"C
ODE 65000: LOAD "SPEAK"CODE 6490
0: RUN
```

```
 620 REM ***** SAVE SPEECH *****

 630 INPUT "SAVE from word no. "
;C1'"to word no. ";C2
 640 IF C1>M OR C2>M OR C1<ZE OR
 C2<ZE OR C1>C2 THEN  GO TO 630
 650 LET ST=A(C2,TH): LET LE=A(C
1,TW)-ST+ON
 660 IF LE<ZE THEN  PRINT "NEGAT
IVE LENGTH": GO TO 630
 670 CLS : PRINT "WRITE THIS DOW
N!"'"START ADDRESS=";ST
 680 INPUT "FILENAME:";A$
 690 IF A$="" OR LEN A$>10 THEN
 GO TO 680
 700 SAVE A$CODE ST,LE
```

CHAPTER 34
MULTICOLOURED BORDER

This following routine will produce for your visual delight a multi-coloured BORDER around your text. You thought it was impossible? Certainly not, indeed it can even be done in BASIC.

At this point may I ask readers with a 60 Hz mains supply (including North Americans) to read the values in brackets. Inside your computer is a very powerful chip which goes by the mysterious name of U.L.A. (Uncommitted Logic Array) which is responsible amongst other things for handling the television output from the Spectrum.

Inside a colour T.V. are three (or one in the case of a black and white set) electron guns, each responsible for one of the primary colours blue, red and green. In order to build up one "frame" of the television picture, the three beams move in unison from left to right of the screen at high speed, gradually moving down the screen and producing one very thin "scan line" for every horizontal sweep. Coated on the screen in an orderly fashion are three different types of phosphor, each emitting one of the three primary colours when the electron beam hits it. The lines of phosphor are so close together that their colours can mix to produce all the other colours that the eye sees, each colour being produced in accordance with the T.V. signal which effectively decides which of the electron beams are to be "switched on" for each point on the scan line.

All of the above operation is carried out at very high speed, since it takes just one fiftieth (sixtieth) of a second for the guns to build up each frame of the T.V., including the period during which the beam is in "flyback" from the bottom of the screen to the top.

Now the T.V. signal that I just mentioned is generated by the U.L.A., which reads the output port 254 in order to determine which colour to send out to the T.V. whenever the beam is producing the border. We can show this by way of the command

OUT 254, n

where n is the required border colour. The change of border is only temporary, since whenever the BASIC operating system detects a key-press it changes the colour according to the contents of location 23624.
Incidentally, the effect of BORDER n is simply to output the new value to port 254 and adjust location 23624.

The interrupts which scan the keyboard and update the real time clock occur 50 (60) times per second, exactly the same frequency as the T.V. frame-production, and also exactly in phase with the high-point of the beam's path.

We can use this identical frequency to synchronise border colour changes by way of the PAUSE 1 command, which has the effect of "wait for an interrupt". Immediately after this we can have as many border-colour changes as time will allow in the fiftieth (sixtieth) of a second before the next interrupt. If the program has not come back to the PAUSE by this time then severe flashing will occur since the port 254 will not then have the same value in it every time the television scan comes to any fixed point. Assuming that the program does get back to a PAUSE within a fiftieth (sixtieth) of a second, the effect will be a number of stationary coloured bands on the border, one for each BORDER change. This program will demonstrate how to produce a BASIC multi-coloured border; if you have a 60 Hz mains supply then you may need to remove one of the BORDER commands in line 30.

```
  10 REM BASIC MULTIBORDER
  20 GO TO 40
  30 PAUSE 1: BORDER 1: BORDER 2
: BORDER 3: BORDER 4: BORDER 5:
BORDER 6: BORDER 7: BORDER 0: BO
RDER 1: BORDER 2: GO TO 30
  40 BORDER 2: CLS
  50 FOR a=1 TO 8: READ B,C
  60 FOR d=1 TO b: PRINT  PAPER
C,,
  70 NEXT d: NEXT a
  80 PRINT #0;AT 0,0; PAPER 1,,
  90 GO TO 30
 100 DATA 1,2,3,3,4,4,3,5,3,6,3,
7,3,0,2,1
```

You may find that you cannot see the first stripe, which should be blue, or that it is thinner than the others. This is because immediately after the PAUSE the T.V. beam is still in "flyback" from the last frame, and it takes a millisecond or two before the beam comes down to the top of the screen.

As you can see from the program, the maximum number of stripes obtainable from BASIC is ten. this number decreases if you locate line 30 further down a BASIC listing, since in order to execute the GOTO at the end of the line the BASIC interpreter has to scan through the listing from the beginning until it finds the line. Obviously the further down the listing the line is, the longer it takes for the interpreter to find it and the less time there is to execute BORDER commands.

Incidentally, this serves as a good illustration of the fact that if you put any subroutines at or near the beginning of a program instead of at the end then the program will take less time to execute its GOSUBs and will run that much faster.

I come now to a machine-coded multi-coloured border, which as you would expect, is far more versatile than the BASIC one. You can have as many horizontal stripes as you like, and it is interesting to note that with more than 625 (525) stripes (the no. of T.V. scan lines per frame,) you are bound to get a change in colour along each scan line as well as between lines!

In order to use the routine, it is best to start with the line

```
LET X = (start address)
```

The range of colour values for the stripes is decided as follows:

```
POKE X + 6, (first colour's value)
POKE X + 5, (last colour's value)
```

Both values are inclusive and can be found by reading the number on the key below the appropriately coloured legend on the top row of the keyboard. The routine works in modulo eight, so if we want the sequence of stripes "yellow, white, black, blue" (6, 7, 0, 1), then:

```
POKE X + 6, 6: POKE X + 5, 1
```

The routine works like a PAUSE and could indeed be used as a colourful substitute in programs: it will either wait a fixed number of T.V. frames or stop when a key is pressed, whichever happens first. To define the length of the "pause", P,

```
POKE X + 1, P - 256 * INT (P/256)
POKE X + 2, INT (P/256)
```

omitting the last command if P is less than 256. Finally we have the two interlinked parameters of the number of border-changes per frame, and the length of time between changes (the depth of the stripe). Obviously the deeper the stripes the fewer you can fit on the screen.

As a general guide, the product of the depth and no. of stripes should not exceed a constant value, found from this table:

	Max. (stripes x depth)	Mains Supply 50 Hz	60 Hz
Location of routine in RAM	Bottom 16K	1920	1600
	Top 32K	2400	2000

Aha! I hear you cry, the value for a 16K machine is lower than for a 48K machine where the routine has been placed in the top 32K of memory. Allow me to explain.

The bottom 16K of RAM is located physically on eight 16K-bit memory chips, one for each of the eight bits that go to make up a byte. Hence any "reading" or "writing" to the bottom 16K of RAM involves accessing all of these chips. Now the memory that is used to store the screen is in this 16K, and 345600 (414720) times per second the ULA must "read" a byte from the screen memory in order to produce the display. Only one chip can have access to the RAM chips at any one instant, and since the U.L.A.'s job is time dependent and involves the incredibly accurate timing needed to produce a steady picture, it takes priority over the humble Z-80A micro-processor which is "brought to a halt" until it can use the RAM.
The Z-80A has to continually read the RAM chips in order to find out what its next instruction is, and for this reason machine-code placed in the lower 16K of RAM runs about 20% slower than identical code placed in the top 32K of a 48K machine, which the U.L.A. doesn't use.

Anyway, back to the script; to specify the number of stripes, N,

```
POKE X + 37, N - 256 * INT (N/256)
POKE X + 38, INT (N/256)
```

and to specify the depth of the stripe, D

```
POKE X + 52, D - 256 * INT (D/256)
POKE X + 53, INT (D/256)
```

As it stands, this routine produces for five (4 1/6) seconds 20 stripes with depth 80 and colours 3-6 (magenta to yellow) and so should work without flashing on any of the four memory/power supply combinations. Here it is, along with a demonstration program.

```
HEX.        ;MULTICOLORED BORDER  LENGTH: 68 BYTES
21FA00      START   LD    HL,00FAH        ;PAUSE LENGTH.
E5                  PUSH  HL
110603              LD    DE,0306H        ;D=FIRST COLOUR, E=LAST
7B                  LD    A,E             ;COLOUR.
3C                  INC   A
E607                AND   7
5F                  LD    E,A
E1          WAIT    POP   HL
AF                  XOR   A               ;TEST FOR A KEY-PRESS
DBFE                IN    A,(0FEH)        ;(INCLUDES EITHER OF THE
2F                  CPL                   ;SHIFT KEYS).
E61F                AND   1FH             ;IF A KEY IS PRESSED
2004                JR    NZ,STOP         ;THEN PREPARE TO STOP.
7C                  LD    A,H             ;IF THE PAUSE COUNT IS
B5                  OR    L               ;ZERO THEN PREPARE TO STOP.
2009                JR    NZ,NXFRAME
3A485C      STOP    LD    A,(5C48H)       ;TAKE NORMAL BORDER COLOUR
0F                  RRCA                  ;FROM SYSTEM VARIABLE
0F                  RRCA                  ;BORDER.
0F                  RRCA
D3FE                OUT   (0FEH),A        ;OUT 254,COLOUR.
C9                  RET                   ;RETURN TO BASIC.
2B          NXFRAME DEC   HL              ;DECREMENT PAUSE COUNTER.
E5                  PUSH  HL
211400              LD    HL,0014H        ;HL=NUMBER OF STRIPES.
76                  HALT                  ;WAIT FOR AN INTERRUPT.
7A          NXTSEQ  LD    A,D             ;A HOLDS THE BORDER COLOUR.
08          NXTCOL  EX    AF,AF'          ;IF WE'VE PRODUCED THE
7C                  LD    A,H             ;LAST STRIPE THEN GO BACK
B5                  OR    L               ;TO SCAN KEYBOARD AND
280E                JR    Z,WAIT          ;WAIT FOR AN INTERRUPT.
2B                  DEC   HL
08                  EX    AF,AF'
D3FE                OUT   (0FEH),A        ;CHANGE THE BORDER COLOUR.
08                  EX    AF,AF'
015000              LD    BC,0050H        ;A SHORT DELAY LETS A
78          DELAY   LD    A,B             ;STRIPE BE PRODUCED.
B1                  OR    C
0B                  DEC   BC
20FB                JR    NZ,DELAY
08                  EX    AF,AF'
3C                  INC   A               ;INCREMENT COLOUR COUNT. IF
E607                AND   7               ;WE'VE JUST USED THE LAST
BB                  CP    E               ;COLOUR THEN REPEAT THE
20E7                JR    NZ,NXTCOL       ;SEQUENCE. OTHERWISE NEXT
18E4                JR    NXTSEQ          ;BORDER COLOUR.
                    END
```

The table I gave you previously where the product of depth and no. of stripes should reach a constant in order to fill the screen is usually good enough for low numbers of stripes, but for higher values we must use a more accurate formula, as incorporated in the demonstration program. Now we have that, to avoid flashing,

$$0 \le \text{stripes} \times (117.5 + 26 \times \text{depth}) \le (\text{a constant})$$

That constant is given by the table following:

		Mains Supply	
		50 Hz	60 Hz
Location of routine in RAM	Bottom 16K	54800	45666
	Top 32K	65800	57083

Hence for a given number of stripes, N, and a constant K, to fill the screen,

DEPTH = (K/N - 117.5)/26

Note that depth should always be non-negative, so a line

IF SGN DEPTH = -1 THEN LET DEPTH = 0

should be incorporated, as in line 110 of the demonstration, if there is any chance of depth being negative.

Remember to adjust the start address in line 40 and the constant K in line 50. I have included lines 200 onwards as an example of one way to save and load the program and routine together.

```
  10 REM MULTICOLORED BORDER
  20 REM DEMONSTRATION
  30 REM © DAVID M. WEBB 1983
  40 LET MULTI=65368-68: REM STA
RT ADDRESS
  50 LET K=68500: REM CONSTANT F
OUND FROM TABLE BELOW. THIS IS F
OR A 48K MACHINE ON A 50HZ SUPPL
Y
  60 POKE MULTI+1,0: POKE MULTI+
2,2: REM PAUSE LENGTH
  70 POKE MULTI+6,1: REM BLUE IS
 FIRST COLOR
  80 POKE MULTI+5,0: REM BLACK I
S LAST COLOR
  85 PRINT AT 10,2;"THERE ARE NO
W";TAB 22;"STRIPES."
  90 FOR A=0 TO 9
 100 LET STRIPES=2+A: PRINT AT 1
0,17;STRIPES
```

```
 110 LET DEPTH=(K/STRIPES-117.5)
/26: IF SGN DEPTH=-1 THEN  LET D
EPTH=0: REM NOTE THE NEW DEPTH F
ORMULA
 120 LET HI=INT (STRIPES/256)
 130 POKE MULTI+37,STRIPES-256*H
I
 140 POKE MULTI+38,HI
 150 LET HI=INT (DEPTH/256)
 160 POKE MULTI+52,DEPTH-256*HI
 170 POKE MULTI+53,HI
 180 RANDOMIZE USR MULTI
 190 NEXT A: GO TO 9999
 200 REM I USED THIS TO LOAD THE
 ROUTINE FROM TAPE....
 210 CLEAR 65367-68: LOAD "MULTI
BORD"CODE 65368-68: RUN : REM 65
367 WAS RAMTOP
 220 REM ...AND THIS TO SAVE THI
S PROGRAM,WHICH AUTOLOADS THE RO
UTINE
 230 SAVE "MB DEMO" LINE 200: SA
VE "MULTIBORD"CODE 65368-68,68
```

CHAPTER 35
SOUND EFFECTS

The only sound effect available to you on a standard Spectrum is the BEEP command, so I thought one of the most useful inclusions in this book would be a versatile set of sound routines to enhance your programs.

There are three routines in this chapter, and for technical reasons they each sound different when placed above or at address 32768 to when placed below that address.

The reason for this is that the ULA chip (the one that produces the T.V. picture) and the Z-80 (the one that runs machine code) both need access to the memory chips that hold addresses up to 32767, and since the ULA has priority and only one chip can use the memory at any one time, the Z-80 has to wait until the ULA has finished. This "waiting" on the part of the Z-80 results in a rougher tone and a longer average delay between the "clicks" that produce the note, causing a lower pitch. Above address 32767, the note will be purer and have a higher pitch.

If you have a 16K machine, then the routine will always be below address 32768 (you have no RAM above that address). If, however, you have a 48K machine, then the routine will normally be above 32767, and you will get a purer tone. In order to try the rougher note (which in my opinion often sounds better), you'll need to CLEAR "RAMTOP" below 32768. To do this use the direct command:

```
CLEAR 32767.
```

Now RUN the Hexaid program, and use option one to enter the routine in the normal manner. The cost of this technique is that you only have as much room left for a BASIC program as you would on a 16K machine, so bear this in mind when using it.

The first routine produces a short "whooping" sound, and if called repeatedly in a short BASIC loop produces a very effective warning siren. No POKEs are required.

```
HEX.      ;SIREN   LENGTH: 21 BYTES
3A485C    START    LD    A,(5C48H)      ;TAKE BORDER COLOUR.
0F                 RRCA
0F                 RRCA
0F                 RRCA
1E00               LD    E,0
F3                 DI                   ;DISABLE INTERRUPTS.
D3FE      NXCLICK  OUT   (0FEH),A       ;CLICK.
EE10               XOR   10H
43                 LD    B,E            ;DELAY.
10FE      SELF     DJNZ  SELF
1D                 DEC   E              ;INCREASE PITCH UNTIL
20F6               JR    NZ,NXCLICK     ;MAXIMUM,....
FB                 EI                   ;THEN ENABLE INTERRUPTS
C9                 RET                  ;AND RETURN TO BASIC.
                   END
```

You can increase the pitch that the note starts off at (and hence shorten the sound) with a simple POKE. If "S" is the start address, then

POKE S + 7, [new value]

That "new value" is in the range 0 to 255, where 1 is the highest pitch, decreasing towards 255 and finally to 0, which can be thought of as 256, the lowest pitch and the value in the standard routine.

The second routine works in the exact opposite direction to SIREN and sounds like a space-age "laser shot" above address 32767, or a Winchester "rifle-shot" below it. Again, if "S" is the start address, then you can decrease the pitch that the note starts off at (shortening the sound) with the command.

POKE S + 7, [new value]

Where the new value is as described for SIREN.

```
HEX.      ;LASER SHOT  LENGTH: 21 BYTES
3A485C    START    LD    A,(5C48H)      ;TAKE BORDER COLOUR.
0F                 RRCA
0F                 RRCA
0F                 RRCA
1E01               LD    E,1
F3                 DI                   ;DISABLE INTERRUPTS.
D3FE      NXTCLIK  OUT   (0FEH),A       ;CLICK.
EE10               XOR   10H
```

```
43                  LD      B,E
10FE       SELF     DJNZ    SELF           ;DELAY
1C                  INC     E              ;DECREASE PITCH
20F6                JR      NZ,NXTCLIK     ;UNTIL MINIMUM
FB                  EI                     ;THEN ENABLE INTERRUPTS.
C9                  RET                    ;RETURN TO BASIC
                    END
```

The next routine is a WHITE NOISE generator. That is to say that it produces a series of clicks in quick succession but at varying and fairly random lengths of time apart. The resulting sound is a sound like an explosion or static picked up on a radio.

For the mathematicians among you, I have written a pseudo-random number generator producing a **cyclical sequence** of 256 numbers containing each integer in the range 0 to 255. Taking the Fermat prime 257 (= 2 to the power of 8 + 1) and one of its primitive roots, 254, the residue of

$$(254)^i \text{ modulo } 257 \qquad (0 <= i <= 255)$$

minus one is the sequence of 256 distinct numbers used. This can be illustrated with a simple BASIC program that generates the sequence:

```
  10 REM PSUEDO-RANDOM GENERATOR
  15 REM @ DAVID M. WEBB 1983
  20 LET P=257: LET A=254
  25 REM P IS PRIME, A IS THE PR
IMITIVE ROOT MODULO P
  30 LET SEED=A↑0
  40 FOR R=1 TO 256: PRINT R,SEE
D-1
  50 LET SEED=A*SEED: LET SEED=S
EED-P*INT (SEED/P): REM SEED=(SE
ED*A)MOD P
  60 NEXT R
```

The pseudo-random number generator is used in the routine to produce the delay between clicks.

To use the routine, the only parameter needed is the duration of the sound. Let this be "D", and the start address be "W". Then

```
POKE W + 12, INT(D / 256) :
POKE W + 11, D - 256 * INT(D / 256)
```

specifies the duration, the standard value of which is 128. Here is the routine, followed by some tips on how to get the most out of it, and a demonstration program.

```
HEX.      ;WHITE NOISE  LENGTH: 48 BYTES
F3        START   DI                     ;DISABLE INTERRUPTS.
3A485C            LD      A,(5C48H)      ;TAKE BORDER COLOUR.
0F                RRCA
0F                RRCA
0F                RRCA
08                EX      AF,AF'         ;H HOLDS (SEED-1)
2600              LD      H,0
018000            LD      BC,0080H       ;BC HOLDS DURATION.
08        NXTCLIC EX      AF,AF'         ;CLICK.
D3FE              OUT     (0FEH),A
EE10              XOR     10H
08                EX      AF,AF'
2E00              LD      L,0            ;LET HL=256*(SEED-1)
55                LD      D,L
5C                LD      E,H
A7                AND     A
ED52              SBC     HL,DE          ;LET HL=HL-2*(SEED-1), SO
ED52              SBC     HL,DE          ;HL=254*SEED-254
11FE00            LD      DE,254         ;LET HL=HL+254, SO
19                ADD     HL,DE          ;HL=254*SEED
7D                LD      A,L            ;LET H=HL MODULO 257
94                SUB     H
3801              JR      C,HOP
3D                DEC     A
67        HOP     LD      H,A            ;STORE NEW SEED IN H
3D        SELF    DEC     A              ;DELAY LOOP.
20FD              JR      NZ,SELF
0B                DEC     BC             ;REPEAT FOR DURATION
78                LD      A,B            ;OF SOUND.
B1                OR      C
20DF              JR      NZ,NXTCLIC
FB                EI                     ;ENABLE INTERRUPTS.
C9                RET                    ;RETURN TO BASIC.
                  END
```

Varying effects can be produced by altering the duration of the noise and then calling the routine within a short BASIC loop. Values of about 64 to 200 can sound like a machine gun, as shown by this program:

```
  10 LET NOISE=65000: REM INSERT
 YOUR OWN START ADDRESS
  20 INPUT "DURATION ";D
  30 POKE NOISE+11,D-256*INT (D/
256)
  40 POKE NOISE+12,INT (D/256)
  50 IF INKEY$<>"" THEN  RANDOMI
ZE USR NOISE
  60 GO TO 50
```

You can use the program to experiment with other durations, holding down a key to hear their repeated effect. A value of 2 sounds like a light aircraft in level flight; a value of about 10 is like a motorbike cruising on open roads; a value of 200-260 sounds like the starting motor on a car. Higher values can be used for explosions.

Obviously we cannot hope to exactly duplicate the real-life sounds described above, but you will probably find that the use of text or graphics illustrating the source of the simulated sound adds to the realism of the effect (e.g. animating an aeroplane whilst simulating its engine noise). This demonstration program will show you what I mean: don't forget to alter the start address of the routine in line 30!

```
  10 REM WHITE NOISE DEMO
  20 REM © DAVID M. WEBB 1983
  30 LET NOISE=65000: REM START
ADDRESS
  40 POKE NOISE+11,220: POKE NOI
SE+12,0: REM DELAY OF 220
  50 PRINT "A DAY IN THE LIFE OF
 A CAR......";AT 10,12;"START!!!
"
  60 FOR A=0 TO 3
  70 FOR B=0 TO 7+5*RND
  80 PAUSE 2: RANDOMIZE USR NOIS
E
  90 NEXT B
 100 IF A<>3 THEN  PAUSE 25+50*R
ND
 110 NEXT A
 120 PRINT AT 10,12;"BROOOM"
 130 POKE NOISE+11,2: REM LENGTH
 OF 2
 140 FOR A=0 TO 400: RANDOMIZE U
SR NOISE: NEXT A
 150 POKE NOISE+11,0: POKE NOISE
+12,12: REM LENGTH OF 2560
 160 PRINT AT 10,12;"SMASH!!!"
 170 RANDOMIZE USR NOISE
 180 STOP
 190 SAVE "NOISE DEMO" LINE 210:
 SAVE "NOISE"CODE 65000,48
 200 STOP
 210 CLEAR 64999: LOAD ""CODE 65
000: RUN
```

CHAPTER 36
PRINTER CONTROL USING OUT

You may have seen mentioned on page 160 of the Spectrum manual that the printer is addressed by port 251. I will elaborate on this.

Your ZX printer can run at three speeds; fast, slow and zero. The stylus which burns away the aluminium coating to reveal the black backing of the paper can either be on or off. The speed and stylus status can be controlled by OUT-putting a number to port 251. The output port is 'latched', that is to say that once a value is output it remains there until the next one is sent. For example, if you turn the printer motor on it will stay on until the value to turn it off is sent, whatever the Spectrum happens to be doing in the meantime.

The command to operate the printer is

```
OUT 251,N
```

and here are the values of N and their effects.

It is probably not a good idea to leave the stylus on for too long, or overheating may result.

VALUE Of N	EFFECTS
128	Motor fast, Stylus on.
0	Motor fast, Stylus off.
130	Motor slow, Stylus on.
2	Motor slow, Stylus off.
4	STOP

I have included a little subroutine which can be used as a computer-controlled line feed.

```
9000 REM KEYBOARD PRINTER LINE-F
EED CONTROL SUBROUTINE
9010 REM PRESS AND HOLD DOWN L F
 OR LINE-FEED, X TO ESCAPE
9020 IF INKEY$="X" OR INKEY$="x"
 THEN  RETURN
9030 IF INKEY$="L" OR INKEY$="l"
 THEN  OUT 251,0: GO TO 9020
9040 OUT 251,4: GO TO 9020
```

APPENDIX A
A LIST OF ROUTINES WITH PAGE AND LENGTH

APPENDIX B
USING THIS BOOK WITH THE MICRODRIVE

Information on the Microdrive became available at too late a date for inclusion in the main text of this book, so here it is.

Although the increase in speed when saving short blocks of machine code is negligible, the Microdrive does have the advantage of taking less time to find the code when loading it back than for tape.
The Hexaid Program in chapter one is easily altered to SAVE and LOAD machine code on a Microdrive cartridge by making the following changes:

Where K is the Microdrive number.

```
615 PRINT "Insert cartridge and hit any Key":
    PAUSE 0
620 SAVE * "m"; K; n$ CODE A, VAL A$
Delete line 660
670 VERIFY * "m"; K; n$ CODE
790 PRINT "Insert cartridge and hit any Key":
    PAUSE 0
800 LOAD * "m"; K; n$ CODE VAL A$ :GO TO 680
```

The SPECTRUM SPEECH program in chapter 33 can be altered to SAVE speech on Microdrive K with the line

```
700 SAVE * "m"; K; A$ CODE ST,LE
```

Using a Microdrive to store the speech will speed things up considerably, due to the massive length of such blocks.
I would like to draw your attention to the list of system variables for coping with the Microdrive, Network and RS 232 Interface on page 47 of the ZX Interface 1 and ZX Microdrive manual. In particular, you can change the colour assumed by the border during input and output to the interface by the command:

```
POKE 23750,(colour number(0-7)).
```

APPENDIX C
FURTHER READING

In this book I have refrained from attempting to teach the reader how to program in machine language, but have instead, I hope, shown the vast increase in speed and power over BASIC that such an ability can offer. I have endeavoured to include all the routines a Basic programmer is ever likely to need for program enhancement, but if you would like to take the next logical step and begin writing YOUR OWN machine code then I would recommend the Melbourne House book, "Spectrum Machine Language For The Absolute Beginner".

The book takes you gently through the elementary ideas behind machine language and on to a thorough working knowledge of it, culminating in the step-by-step development of a fully - fledged machine code arcade game.

While the above-mentioned book adopts an informal approach to machine language with special reference to a particular computer, if you want a more clinical and technical approach to programming the Z-80 in general then Rodnay Zaks' "Programming The Z-80" is to be recommended.

Be warned, however; it can be rather heavy going for the beginner and is more appropriate as a reference aid to a fluent machine language programmer.

Also of interest to the reader who wants to know what makes the Spectrum tick (or should I say "buzz") is "Understanding Your Spectrum" by my colleague Dr Ian Logan and published by Melbourne House. This book explains concisely the rudiments of machine language and goes on to delve into the 16K Rom and reveal some very useful details on how the 'operating system' works, and how to use it to your advantage.

*　　*　　*　　*

NOTES

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