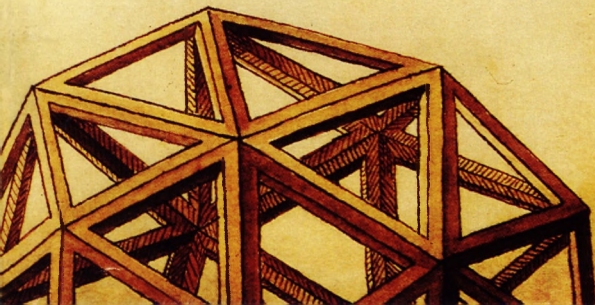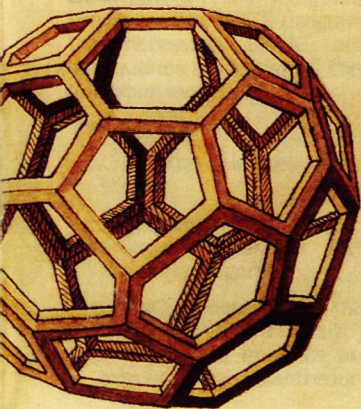# Leonardo

LEONARDO

LEONARDO is a complete graphics utility package which enables you to create complex pictures and graphic elements using the full capabilities of the Spectrum computer. A wide range of facilities for drawing, colouring and subsequent modification are provided. Pictures and picture elements so produced can be stored on cassette tape either for later re-use within **LEONARDO** or for incorporation within your own programs. The USER program supplied contains the necessary BASIC and machine code subroutines to display all the stored graphics as and when required.

You can create:–

Complete pictures occupying the whole screen.

User-defined graphics and complete alternative character sets suitable for fast arcade-style games.

Picture elements, which may range in size from a single pixel to a full size picture, suitable for slower-paced graphics applications such as adventure games and educational programs.

GETTING STARTED

1 **LEONARDO** requires a 48K Spectrum.

2 Before switching on the Spectrum connect the joystick if it is to be used.

3 Put the tape into the cassette recorder and rewind to the beginning.

4 Check that the EAR lead is correctly connected and that the volume level of the tape recorder is set correctly.

5 Type LOAD"" (do not leave a space between the quotes), then press ENTER.

6 Press PLAY on the tape recorder.

7 When the program has finished loading press STOP on the cassette recorder.

8 If the program does not load successfully, try adjusting the volume setting of the tape recorder and repeat the above from step 3. If the problem persists, refer to Chapter 6 of the Spectrum Introduction Manual.

CONTROLS

When the program has loaded you will be asked to select either keyboard control or the joystick interface you have connected. You can choose one from the following:—

0 Keys 5 to 8
1 Sinclair
2 Kempston
3 A.G.F.
4 Protek
5 Fuller

to control the drawing process.

All the other keys are also used to obtain the many functions available in **LEONARDO**. The keyboard layout chart at the end of the manual will help you.

Use the next part of this manual to learn how to use some of the features in **LEONARDO**. Follow the step by step instructions and you will soon be drawing your own pictures. If you accidentally press the wrong key and find yourself in an unfamiliar feature just press ENTER and you should return to where you were before the wrong key press. If the program stops for any reason, type GOTO 9999. Do not type RUN, as all **LEONARDO**'s variables will be lost.

STARTING TO DRAW

When you have chosen the keyboard or a joystick interface by pressing the appropriate number, you are ready to draw your first picture with **LEONARDO**. The first screen you see is the MAIN MENU. This shows the three options available to you. Choose option 1 CREATE GRAPHICS to draw your first picture.

The screen clears to white with a small flashing black dot in the centre. This is the PIXEL CURSOR. It shows the position of your pen. If you push your joystick forwards (or press 7 if you have chosen the keyboard), the cursor moves up. If you pull your joystick back (or 6) the cursor will move down. Similarly moving the joystick left or right (or 5 and 8) will make the cursor move to the left or to the right. You can also move the cursor diagonally. If you are using a joystick then push it to the left and forwards at the same time. The cursor will move diagonally up and left. Similarly the cursor will move in the other diagonal directions by pushing the joystick the desired way. If you are using the keyboard to control the cursor you can make it move diagonally by holding the Caps shift key (referred to as Shift from now on) down and pressing one of the four direction keys, 5 to 8. To move the cursor diagonally up and left, hold the Shift key down and press 5.

Now you can start to draw. **Press P** and move the cursor as explained above. You are now leaving a black line everywhere you move. This is PLOT mode. Now press the joystick button (or 0 if you selected keyboard). As you move now you are not drawing. This is CURSOR mode. Every time you press the joystick button (or 0) the drawing mode will swap between PLOT and CURSOR. You can think of this as putting your pen on the paper or lifting it off again.

4

If you press 2 while holding the Shift key down (**Shift 2**) a small display line appears at the top left of the screen. This is called the COORD WINDOW. It tells you the current mode and the cursor position measured in pixel units from the top left hand corner of the screen. If you press **Shift 4** the COORD WINDOW disappears. Pressing **Shift 3** reintroduces the COORD WINDOW at the bottom left of the screen. So, you can choose to have the window at the top or the bottom of the screen or not at all. For the moment leave it on at the top of the screen (**Shift 2**).

CHANGING THE SIZE OF YOUR BRUSH

Press M. The bottom third of the screen is now replaced by the INPUT WINDOW with instructions on the information you must key in to perform your chosen feature. In this case you are going to increase the size of your brush for drawing. To the prompt B*rush size x*, respond by keying 4 ENTER. The prompt B*rush size y* now appears. Respond with 4 ENTER. The INPUT WINDOW now disappears. Return to PLOT mode (P) and press the joystick button (or 0) twice and note that a black square 4 pixels across now replaces the flashing cursor. Now start to draw by moving the cursor and you will see that your 'pen' line is now 4 pixels wide.

Press I. Respond to the prompt S*tep x* with 4 ENTER and to S*tep y* with 4 ENTER. You have now changed the step size in which your pen moves. You can now draw rapidly in chunky graphics because your pen moves in steps of 4 pixels at a time.

By now your screen is probably getting rather crowded. Press the joystick button (or 0) to return to CURSOR mode. Now press the SYMBOL SHIFT key while holding the SHIFT key down (**Shift Symbol shift**). The screen will be cleared. Reset the brush size to x=1, y=1 (M).

DRAWING STRAIGHT LINES

Now let's draw some straight lines. To draw lines there has to be a beginning and an end. The cursor is one end and the other end is a hidden point called LAST PLOT. At the moment LAST PLOT is set to the middle of the screen. Move the cursor to a position away from the screen centre and press **Shift Q**. A line is drawn between the cursor and LAST PLOT at the centre of the screen. Now move the cursor and again press Shift Q. Another line is drawn between the new position of the cursor and LAST PLOT, which is still at the centre. Now **press Q** after each move of the cursor. You are drawing lines linked to each other. That is because Q sets LAST PLOT to the cursor position after each line draw.

Now let's make dotted lines. **Press F**. In response to the prompt *mark*, type 4 ENTER and to *space*, respond 2 ENTER. Now draw more lines as instructed above. All the lines consist of a repeating series of 4 linked marks followed by 2 spaces. This is called a MARK/SPACE ratio of 4/2.

7800

THE INFORMATION WINDOW

Now **press 1** and hold it down. The screen is replaced by the INFORMATION WINDOW. This shows the current state of the program. Let's examine it section by section.

At the top is the current mode which at the moment is PLOT and CURSOR.

Information about the PIXEL CURSOR is on the right. Its position (x = horizontal and y = vertical) from the top left of the screen, is followed by the STEP SIZE. Do you remember setting this to $x = 4$, $y = 4$? PIXEL states whether the pixel under the cursor is set (ink) or unset (paper). The position of LAST PLOT is shown measured in the same way as the PIXEL CURSOR. Finally the COLOUR of the character space occupied by the cursor is shown as four attributes:— ink (I) is black; paper (P) is white; bright (B) = 1 (on); and flash (F) = 0 (off).

Information about the drawing of lines is given on the left. The MARK and SPACE values that you set to 4 and 2, are shown. Below this is the current line mode. This determines the way the space part is drawn. Then you will see BOUNDARY OFF and DIRECTION FROM. These refer to two other aspects of line drawing that you will be introduced to later. The size and boundary mode of the brush with which you are drawing is shown. Do you remember resetting the size to $x = 1$, $y = 1$?

The remaining information under the heading PICTURE will be explained later.

Take your finger off key 1 and the display, with your line drawing, returns.

```
           mode: PLOT
               CURSOR

     LINE                  CURSOR

mark      = 4        x,y  =120,80
space     = 2        step=4,4
mode      = ADD      pixel SET

boundary  OFF   last plot=90,77
direction FROM  colour I█P B1F0

      BRUSH               PICTURE

  size=1,1              0   stored

  boundary OFF          no. = 0
                        mode= ADD
                        size= 0,0
```

Now here are five more useful keys to learn. Press them in turn.

Shift K; returns the cursor to the screen centre at x=128, y=96.

Shift Z; returns LAST PLOT to the current cursor position.

Shift I; resets step to x=1, y=1.

Shift F; resets the line drawing MARK/SPACE to 1/0.

Shift M; resets the brush size to x=1, y=1.

Press 1 and hold it down, to check on the information window that all these things have happened.

OTHER WAYS OF PLOTTING

You have seen how you can draw lines of any thickness in PLOT mode by keying P. You can also use your brush as an eraser by **pressing O**. This is UNPLOT mode and is identical to PLOT mode except that a white trail is left on a black background wherever previous drawing has been carried out. Try using PLOT and UNPLOT modes alternatively to draw and erase. It will probably be easier to see what you are doing if you use a bigger brush (press M).

There is another way of using your brush for direct drawing which can produce some very interesting effects. **Press Shift O**. You are now in INVERT mode. In this mode your brush acts both as a plotter and an eraser turning white areas into black and black into white. Try running across the screen in this mode with the BRUSH set to x=1 and y=1 and see what happens. If you now experiment with various values of STEP and BRUSH in INVERT mode you will see some very interesting effects. Try to work out what is happening.

When you have finished set the BRUSH size back to 1,1 (Shift M).

DRAWING CURVED LINES

Press P to return to PLOT mode and once again press the joystick button (or 0) for CURSOR mode. Clear the screen (Shift Symbol shift). Now let's draw some curved lines. Press Shift K to centre the cursor. **Press A**, and in response to *Radius* press 30 ENTER, whereupon a circle of 30 pixels radius is drawn with the centre at the cursor. Now move the cursor to a new position and repeat the circle drawing sequence, using perhaps a new number for the radius. While the circle was being drawn did you notice the yellow strip at the top left of the screen? This indicates that **LEONARDO** is busy, but you can interrupt the process by pressing SPACE. Try this on another circle.

Now here is another useful key. Suppose that the last circle you have drawn was a mistake and you would like to remove it. **Press Y** and see your mistake vanish. This is a valuable feature of **LEONARDO**. In almost all cases the last operation performed can be erased by pressing Y.

IT IS IMPORTANT TO DO THIS BEFORE PRESSING ANY OTHER KEY.

Now let's draw some arcs. As with lines, arcs require a beginning and an end, therefore they use the CURSOR as one end and LAST PLOT as the other end. Press Shift Z, to set LAST PLOT to the current cursor position. Look at the information window (1) to confirm that the cursor position and LAST PLOT coincide. Now move the cursor to a position an inch or two from LAST PLOT. **Press S**, and in response to *Arc angle* press 90 ENTER. A quarter circle is drawn between the cursor and LAST PLOT. Now repeat the arc drawing sequence but enter −90 for the angle. See the difference? Experiment with different angles and also see the effect of moving the cursor. Try changing the

brush size and mode! You can get very interesting effects.

When you have finished experimenting set the mode back to PLOT and the brush size back to 1,1

Once again, clear the screen and centre the cursor. Let's draw some ellipses. **Press Shift S** and respond to *Vertical radius* with 20 ENTER and then to *Horizontal radius* with 40 ENTER. Respond to *Rotation* with 45 ENTER and to *Start angle* with ENTER. Your ellipse is drawn rotated 45 degrees clockwise. Try different rotation angles. Remember to move the cursor around or to clear the screen to make space whenever you need it. Sometimes you may wish to draw only part of an ellipse. Try this. Press Shift S and respond to the first three prompts with 20 ENTER, 40 ENTER, and 0 ENTER. Respond to *Start angle* with 45 ENTER and to *Turn angle* with 180 ENTER. An upright ellipse of height 20, width 40 is drawn but only that part of it starting 45° clockwise from the vertical and finishing after the curve has turned 180° (half a circle). Try some other numbers until you understand all this. Here is a practical example for you. Clear the screen and centre the cursor. Draw an ellipse using the following numbers in sequence 40, 60, 30, − 15, 210. Now move the cursor to 116, 90 and draw another ellipse using these numbers 39, 10, 30, ENTER. Move the cursor to 141, 128 and draw one more ellipse with the following numbers 3, 38, ENTER. You have drawn the cup of a wine glass, at drinking angle, with some wine in it.

Cheers!

FILLING THINGS IN

Often you may wish to make solid shapes. Try this. Clear the screen and centre the cursor. Draw a circle (A) of radius 20. Now **press Shift U**; the circle is rapidly filled in. Press Y, the filling is removed. Move the cursor to just within the edge of the circle and draw another circle. Now press Shift U. See how FILL works? Press Y, and then try filling another part of the linked circles. Now move the cursor to a region outside the circles and try FILL. Don't be alarmed, you are filling the whole display except for the circled area. If you don't like the result just press Y.

OTHER WAYS OF DRAWING
STRAIGHT LINES

Let's take a look at some other aspects of line drawing. First clear the screen and centre the cursor and last plot. If you can't remember which keys to press, use your keyboard layout chart. Now draw a circle of radius, say, 30. Move the cursor to a point well outside the circle and press Shift Q. You have drawn a line between the cursor and last plot, at the centre of the circle. Press Y to remove this line. Now press R and use the INFORMATION WINDOW to check that, under the heading LINE, BOUNDARY is ON and DIRECTION is FROM. Now press Shift Q again. This time your line extends from the cursor to the edge of the circle where it stops. Press Y to remove the line. Now **press Shift R** and confirm on the INFORMATION WINDOW that DIRECTION is TO. Press Shift Q once again and see that now your line starts at last plot and stops when it reaches the circles edge. Press Y to remove the line. Now press R and Shift R once more each and confirm that BOUNDARY is OFF and DIRECTION is FROM.

Now clear the screen and draw a circle, radius 30. Move the cursor to some point well inside the circle and **press Shift W**. A vertical line is drawn up and down from your cursor to the circle's edge. Press Y to remove the line. Now **press W**, a similar horizontal line is drawn. Move the cursor around and try using these two keys.

Experiment with all these line drawing techniques, removing mistakes using Y when you wish to. Remember this only works if you do it before altering the display in any other way, including for example, viewing the information window.

Before moving on make sure you have some interesting drawing around the centre of the screen. You will need it in the following section.

WINDOWING AND PICTURE ELEMENTS

LEONARDO has a very useful feature known as WINDOWING. Let's see how it works. We are going to create a small rectangular window on the screen containing some of the drawing that you have been doing. First, make sure you are in CURSOR mode and then press Shift K to centre the cursor. Now **press 2**. You have just set the lower left corner of your window. Move the cursor up and right to position 160, 60 and **press 3**. You have now set the top right corner of the window. **Press 4** and a black rectangle will appear showing the outside edge of the window. **Press G** whereupon the picture element inside the window will be saved in the computer's memory as PICTURE NO. 1. When the element is being saved a magenta strip appears at the top left of the screen. This indicates that **LEONARDO** is busy.

Now clear the screen (Shift Symbol shift). Again press 4 to reveal the window. Now **press N** and in response to *Picture no.* Press 1 ENTER. **Now press Shift N**. The prompt *Mode (p,a,c,d)* appears. You must now choose the way in which your saved picture element will be brought into the display. These four modes are Print, Add, Common and Difference. Press P to choose print mode.

Use the INFORMATION WINDOW to check that under the heading PICTURE, no. = 1 and mode = PRINT as you have just entered. In addition the width and height of the picture element is given in pixels. Make a note of these 2 numbers. **Press Shift G** and see that the picture you have stored is returned to the window. Press 4 this time to remove the window outline. Now let's see what else we can do with this PICTURE ELEMENT.

Clear the display, centre the cursor and draw a circle, radius 20. Now fill the circle. Press Shift G. Note that the element obscured part of the circle. Remove the element with Y. Confirm (information window) that under the heading picture you have no. = 1 and mode = PRINT. Press Shift N, and respond to *Mode (p,a,c,d)* with C. Confirm the change (information window). Now press Shift G again, and you see only that part of the picture element that is within the circle. Remove the picture (Y). Change picture mode to D (Shift N) and again press Shift G. This time you will see that part of your picture element looks normal but that the part inside the circle is inverted. Remove the picture (Y). Now press Shift N and respond with A. Confirm the change (I). Press Shift G. This time the picture element is added to the circle. All these different modes of printing have their uses. For example mode C can be used to fill solid objects on the screen with any pattern that you have created and saved as a picture element.

Make x and y steps the same as the width and height of the PICTURE ELEMENT, (remember you should have noted these two numbers). Now **press L**. Toggle (press twice) the joystick button (or 0) or move the cursor and see your picture element appear with its top left corner at the cursor. Now move the cursor. It will move with the steps you have set up and each time it moves it will print the element and each printing will appear on top of whatever is already on the display. So now your BRUSH is your PICTURE ELEMENT. Experiment with different step values and see what you can do. As with the PLOT, UNPLOT and INVERT modes you can use the trigger on your joystick or 0 to turn your brush on or off. Press Shift N and then respond P ENTER

and see that now your picture is printed so as to obliterate whatever is already on the display. Similarly try using modes C and D. Can you understand the results?

When you have finished press P to get back to PLOT mode and press the joystick button (or 0) to return to CURSOR mode.

MAGNIFYING PARTS OF YOUR PICTURE

Now let's see how you can magnify a portion of the display and print the magnified image elsewhere. To do this you use the windowing technique again with a difference. The window only lasts as long as you are in MAGCOPY mode. As soon as you leave the mode the window disappears and must be reset next time. Choose a small area of the screen that you wish to magnify. A few words of caution however. If the area to be magnified is too large for the computer's memory, a message to that effect is displayed and you must reduce the size of the window. If the magnified image will not fit on the screen then no image is printed. Place the cursor at the lower left of the area to be copied and **press D**. Now move the cursor to the top right of the area and press D again. Now place the cursor away from the area to be magnified and **press Shift D**. Respond to Mag x with 3 ENTER and to Mag y with 2 ENTER. The invisible window will be printed with a horizontal and vertical magnification of 3 x 2 to the right and above the cursor position. Move the cursor around and repeat Shift D with different values for Mag x and Mag y. If you wish to print the window without magnification just press D. Try this. If the imaginary window is overprinted by a magnified image the next magnified printing will reflect the new contents of the window. Did you notice the signalling system in operation again? After each copy has been made the green strip tells you that **LEONARDO** is waiting for you to do something. You can either make another copy (D or Shift D) or you can return to CURSOR mode (ENTER).

When you have had enough of magnifying press ENTER to return to CURSOR mode.

COLOURING YOUR PICTURE

So far everything has been done in black and white; now let's see how we can use colour with **LEONARDO**.

Clear the screen, centre the cursor and **press B**. The flashing PIXEL CURSOR is replaced by the much larger CHARACTER CURSOR. Use the joystick (or cursor keys) to move the cursor around, and see that it moves in the same way as the pixel cursor, but one character space at a time. **Press Q** and respond to the prompts as follows; Ink – 6 (yellow), Paper – 3 (magenta), Bright – n (no change), Flash – 1 (on). Now **press W** and you are in COLOUR mode. Move the cursor around and see that you are leaving a trail of flashing yellow and magenta behind you. Use the joystick button (or 0) to turn your colour brush on and off.

CHARACTER INFORMATION WINDOW

Press I and you will see the information window for the character cursor. It is similar to the pixel cursor information window but much simpler. The current mode is COLOUR. The position of the cursor is shown in character spaces from the top left of the screen. The steps in which the cursor moves in horizontal and vertical character spaces are shown. The step values can be changed by pressing I. Try it and see. The colour of the screen at the position of the cursor is shown.

Under the heading COLOUR are shown the present colours selected. This defines the way in which the 4 attributes are changed on the screen at the cursor when in COLOUR mode. At the moment it shows Ink is 6 (yellow), Paper 3 (magenta), Bright – n (will not be changed) and Flash is I (on).

Let's change the colour. Press Q. Respond as follows: Ink n, Paper n, Bright n and Flash 0. Look at the information window, and see that colour change is In Pn Bn F0. Now move the cursor around and see that it has no effect except where you cross areas that are flashing from the effect of your last brush colour. These areas will stop flashing. So you see, you can change just one attribute if you wish, leaving the others as they are on the screen. Experiment with different combinations.

Press the joystick button (or 0) to return to CURSOR mode. Several other colour options are available in **LEONARDO**. Let's examine these in turn. You may wish to change the colour of the whole screen or of a part of it. To change the colour

of the whole screen, **press A** and respond to
Window/Screen w/s with S. Then key in the required
colour change. The whole screen responds to the
change. The setting of a specific set of attributes
is achieved by entering a value for each of the 4
attributes. Press Y to restore the colours and press
shift 4 to remove the coord window.

To operate on a portion of the screen it is
necessary first to define the area as a window.
Let's make a small COLOUR WINDOW several
characters wide by several deep in the top left of
the screen. Move the cursor to the left of the screen
and a few characters down from the top, and press
2. Now move to the top of the screen and a few
characters to the right. Press 3. Finally, press 4 to
reveal the window outline. Now press A. Select
Window by pressing W, and then enter your choice
of colour change and see the window change
accordingly.

Now **press S**. This is COLOUR SWAP. Select
Screen by keying S and respond to Old colour with
Ink 6, Paper 3, Bright 1, Flash 1. Now respond to
New colour with Ink 5, Paper 4, Bright 0, Flash 1. You
will see only those parts of the screen that you
originally painted (with flashing bright yellow and
magenta) change to flashing (but not bright) cyan
and green.

Finally, let's see how to create coloured
patterns with great ease. Clear the screen (Shift
Symbol shift) and then press 4, to reveal the
position of the colour window. Now use your
colour brush to paint a coloured pattern inside the
window. Move the cursor out of the window and
set the step size of your brush to be similar to the
size of the window. **Press F** and toggle the joystick

button (0). A copy of the colour window appears to the right of and below the cursor. Move the cursor around the screen, avoiding the colour window itself, and see your brush paint the pattern in the window all over the screen. Like MAGCOPY this process only applies when the window is actually present on the screen, because no copy of the window is stored in the computer. Press the joystick button (or 0) to return to cursor mode.

PRINTING WORDS AND UDG's

Now let's print some characters on the screen.
Press P and respond to the prompt by entering
your name, then toggle the joystick button (0).
Immediately your name is printed on the screen.
Now move the cursor around, and see that at each
step your name is printed. This may not seem very
useful but if instead of your name these were
graphics you had designed yourself, called User
Defined Graphics, then this could be very useful.
So, let's design some UDG's. **Press C** to return to
pixel cursor mode, then clear the screen. Now
using any of the plotting or drawing techniques
you have learned, create some small graphics.
Remember to press Y if you make a mistake. When
you have created your graphics, place the cursor to
a point at the top left of the area to be copied into
UDG's, then set the cursor step (I) to 8 wide by 8
deep. Now move the cursor 5 steps to the right
and 4 steps down. This marks the lower right of the
area we are going to copy into UDG's. Move the
cursor back to its starting position (4 steps up
and 5 steps left) and then **press T**. Respond to
UDG (a-u, 1-774) by keying A. Respond to the
prompt *Block size x* with 5 and then to the prompt
Block size y with 4. Your graphics have now been
copied into the Spectrum's user defined graphics
area. Now clear the screen and return to character
cursor mode (B). Try some more printing, but this
time enter some UDG's (Shift 9 for graphics mode)
and see that your UDG's are there.

TURNING THINGS ROUND AND MAKING MIRROR IMAGES

Finally, in this section let's see the real use for storing parts of the screen in this way. Clear the screen. **Press L** and respond to Print block (a-u, 1-774) by keying A. Then enter the block size as you did when making your UDG's. Now respond to the prompt Invert (h,v,n) by keying N. The letters h, v, n, stand for horizontal, vertical or no inversion. Respond to Turn (0,1,2,3) by keying 0. These numbers refer to the number of 90° rotations each character will be turned through. See that your whole block of UDG's are printed in the form in which they were copied. Clear the screen and repeat the above but choose H and 0 instead. See the result. Now work through each of the 12 combinations of h,v, or n with 0,1,2 or 3 and see that you can print your graphics in any combination of rotation and inversion that you choose. This can be very useful for writing sideways or upside down or for redrawing complex shapes as mirror-images, or lying on their side etc.

PROGRAMMED DRAWING – AN ADVANCED FEATURE

Return to pixel cursor mode (C), clear the screen and centre the cursor.

Suppose that you wish to draw a cycle wheel. Imagine trying to do this freehand! **LEONARDO** contains a special feature enabling such tasks to be done very easily. Let's now explore this most complex and powerful feature, PROGRAMMED DRAW. First let's draw the hub and rim of the wheel. Draw four circles, with the cursor at screen centre, of radii 2,8, 53 and 58. Now **press Shift E**. The display is replaced by the FIGURE TABLE. Press 0 and respond to prompt *Coord.0x* with 8 and to *Coord.0y* with 48. Press 1 and respond to *Coord.1x* with −8 and to *Coord.1y* with 48. Now press K. The FIGURE TABLE is replaced by the DRAW TABLE. Press 3 and respond to *Start x* with −4 and to *Start y* with 4. Press 5 and respond to *Link x* with 4 and to *Link y* with −4. Press 6 and respond to *Rotation inc.* with 20. Press 8 and respond to *Cycles* with 18. Finally press E. The display returns and 18 spokes of your wheel are drawn. While drawing is in progress a yellow strip is present at the top right of the screen. This indicates that the computer is busy but can be interrupted. When the 18 spokes have been drawn the yellow strip will change to green.

Now press E. The DRAW TABLE reappears. Press 3 and respond to *Start x* with 4 and to *Start y* with ENTER. Press 5 and respond to *Link x* with −4 and to *Link y* with ENTER. Press B and respond to *Coords from* with 1 and to *Coords to* with 1. Now press key E. The other 18 spokes of your cycle wheel will be drawn. When the green strip appears press ENTER to return to cursor mode.
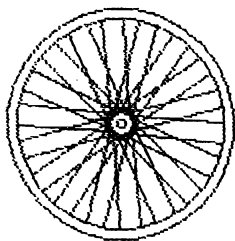
What you have just done is to replicate a defined shape (a single line in this case) moving along the path of a mathematical pattern. The defined shape is called a FIGURE. You can use PROGRAMMED DRAW in many different ways, replicating not only FIGURES, but also PICTURE ELEMENTS and BRUSHES. You can also, if you wish, just draw the patterns themselves.

To understand the operation of PROGRAMMED DRAW refer to part two of the manual and to the examples using this feature at the back of the manual.

Clear the screen and centre the cursor before going on.

DRAWING IN 3D

So far we have concentrated on drawing flat pictures. Let's now draw a 3D picture. We will first use FIGURE to create a 3D pyramid. Press Shift E to get the FIGURE TABLE. We will enter the five vectors for the pyramid. Press 1 and enter −30 and 8 to the prompts *Coord.1x* and *Coord.1y*. Press 2 and enter 28 and 28 for *Coord.2x* and *Coord.2y*. Similarly put in the coordinates for the remaining three vectors by pressing 3 then entering 26 and −22. Then press 4 and enter −24 and −14, and finally press 5 and enter −2 and 36. Press K to see the DRAW TABLE. Press B and enter 1 for *Coords from* and 5 for *Coords to*. This tells **LEONARDO** to use the five coordinates we have just set up to create the FIGURE. Press ENTER to get back to CURSOR mode. Set the step size (I) to 60,40. Now **press Shift L** and move the cursor. The 3D pyramid will appear with a corner of its base near the cursor. This is because the start x and y values are still set to 4,4.
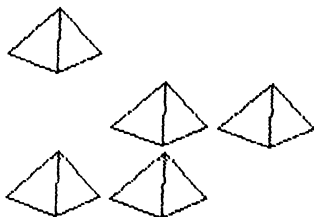
Now move the cursor. Each time you move a new pyramid is drawn. You now have a FIGURE as your brush. You can turn your brush on and off by pressing the joystick button (or 0). It is often extremely useful to use FIGURE as a brush, rather than using the same shape stored as a PICTURE ELEMENT. This is because FIGURES will obey the settings of scale, rotation and start position that can be set up within PROG. DRAW and will enable you to draw the same shape at different sizes and rotations. Clear the screen and use this facility to draw a desert scene. When you have drawn the Pharaoh's tomb press P and use the standard brush to draw a few palm trees. Are you ready for a holiday now?

SAVING YOUR WORK

It is time we saved some of these stunning graphics. We will save your last picture. If you want to make it look better now's your chance.

Are you ready now?

First you must check that your cassette tape recorder is connected properly. Remove the EAR lead and connect the MIC lead to the Spectrum and to your cassette player. Now place an empty cassette tape into your recorder and rewind it to the beginning. Check that the tape leader is wound passed the recording head. Make a note of the counter number, or reset it to zero.

Press X. This returns to the MAIN MENU. Do you remember that we saw this when we first started. Choose option 2 SAVE GRAPHICS. The SAVE MENU appears with the option to either save the SCREEN or to save the PICTURE ELEMENTS you created some time ago. Press 1 to save the screen. You must now think of a name to call the picture. Try to think of a name that will describe your picture, so that it will remind you later of what it contains. The name must not be more than ten characters long, but that should be plenty. Type in the name that you have chosen, followed by ENTER. Press PLAY and RECORD on your cassette deck and press any key on the Spectrum. You should see stripes at the edge of the screen as the picture is saved. When the picture has been saved, you will be asked to verify that it has been recorded properly. Rewind the tape to the number on the counter you noted earlier. Remove the MIC lead and reconnect the EAR lead and press PLAY on the cassette recorder. **LEONARDO** will check that you have successfully saved the picture. If for any reason the picture hasn't been saved properly then you must

try again, checking that the leads are connected correctly and that the volume control is adjusted appropriately.

When the picture has been verified the MAIN MENU will appear again. Let's get back to drawing. Choose option 1 CREATE GRAPHICS again and return to your picture.

MAKING THE CURSOR CLEARER

While you have been drawing you may have occasionally lost sight of the cursor. After all, it's only a small flashing pixel. **Press SPACE** and hold it down. You should now see a large flashing square which is very much easier to see. This is the character space at the current pixel cursor position. The flashing square shows alternately black and white, but the bright and flash attributes are always opposite to that of the display at that position. This is for maximum visual clarity in all situations. When you release the key the pixel cursor returns. Use this key to help you locate the cursor if you lose it.

Press V. A checkered pattern fills the screen behind your picture. Each square represents one character space. Press V to remove the pattern. Now **press Shift V**. Another checkered pattern fills the screen. This pattern may look the same as the first, but it isn't. The first pattern alters the bright attribute of each square only, alternating between light and dark. The second pattern however fills the screen with bright and dark white paper and black ink. Press V to remove the grid and colour your picture using some of the facilities we tried earlier. When you have finished colouring, stay in character cursor mode and press V, but hold the key down. Now let go. The grid appears only while you hold the key down. Hold down Shift V. Now can you see the difference between the grids? Let go of the key and return to the pixel cursor.

MOVING PARTS OF YOUR PICTURE

When you are drawing you may want to adjust the positioning of your picture, or perhaps move part of the picture. SCROLLING will help you do this. **LEONARDO** will let you scroll the whole picture or just that part within the window. Do you remember how you set up a window for saving a picture element? You may scroll in any direction by using a combination of Left, Right, Up or Down movements. Let's first create a picture to demonstrate this. Clear the screen and centre the cursor. Draw five circles radii 5, 15, 25, 35 and 45. Fill the centre circle and the two other rings so that you have a target shape. Now set up a window. Move the cursor 70 steps left and press 2. Move the cursor 60 steps up and 140 steps right and press 3. Press 4 and view your window. It should surround the top half of the picture. **Press J**. Respond to W*indow/Sc*reen *w/s* with W, to scroll only the contents of the window. Select a left scroll by keying L to the prompt (*l,r,u, or d*). Scroll the window by 20 pixels. See how the top half of the target, which was inside the window, has moved left. Press Y to get the target back. Now press J again, but move the contents of the window right by 40 pixels. Note that part of the target has scrolled out of the window and has disappeared. Be careful how you set up your window if you are to scroll a long way. Press 4 to remove the window outline. Press J again but this time choose to scroll the whole screen up. You are now asked to enter the distance in characters and pixels. Enter 5 characters and 5 pixels. Your picture will move close to the top of the screen. Experiment with different combinations of direction and distance until you feel that you understand what is happening.

So far we have only scrolled the picture. If you had had some colour in your picture then it would not have moved. To scroll the attributes you must be in character cursor mode. Try colouring some of the picture and then scroll the attributes (**press J**). Note that there is one extra prompt to determine the new attributes. These will enter the screen at the left edge if you are scrolling right, or the bottom edge if you are scrolling up etc. Try this and see what happens.

CREATING TEXTURES

We will use **LEONARDO** to create a textured pattern. First return to pixel cursor mode, clear the screen and centre the cursor. Draw a circle of radius 4 pixels. This will form the basis of our pattern. Set a window surrounding the top half of the circle, as we did before, and scroll the contents of the window left by 8 pixels. You should see an S shape on its side. Now we will create our textured pattern. **Press Shift J**. This is COVER and works in a similar way to scrolling. The picture will scroll the distance and in the direction you choose, but will repeatedly copy itself, filling to the edge of the screen. Let's see what happens. Select a full screen left COVER of step size 2 characters and 0 pixels. The shape repeats to the left edge of the screen. Press Shift J again and COVER right by 2 characters and 0 pixels. You should have a long wiggly line right across the screen. Press Shift J for the third time and COVER down by 1 character and 0 pixels. Press J again and COVER up by 8 characters and 0 pixels. The texture pattern should now fill the whole screen. Let's store this to use later. **LEONARDO** has two storage areas for holding images. There is a BACKUP STORE and a MAIN STORE. The BACKUP STORE holds both the pixel and colour data of one screen. **LEONARDO** backs up the screen into this storage area before a new function is performed. When you press Y, to correct a mistake, the picture in the BACKUP STORE is loaded onto the screen. You can make **LEONARDO** backup your picture at anytime by **pressing H.** For instance, while in PLOT mode, the screen will not be updated as you draw, only when you enter another function (such as CIRCLE). You may wish, therefore, to backup your picture each time you finish drawing a line segment. The MAIN STORE holds either one picture, a number

of picture elements, or up to 774 UDG's. The store can only be used for one type of storage at a time. Currently we are using the MAIN STORE to hold picture elements. Do you remember setting up a picture element using the window? We will store the pattern in the MAIN STORE.

Press Shift H. LEONARDO remembers that you had used the store for picture elements and reminds you that they will be lost if you store your pattern there. You could at this time save those picture elements on cassette tape by going back to the MAIN MENU, but we don't need them any longer. Press Y to save your pattern. A picture that is stored in MAIN STORE is saved without colour. If you want to save a picture with colour then you must store it on cassette tape.

Now clear the screen and centre the cursor. Draw a circle (A) of radius 30 and fill it (Shift U). Move the cursor down 4 pixels and draw another circle of radius 30. Invert the screen by **pressing U** and choosing the screen (S). Everything is reversed. This is a very useful feature which is explained later. Now **press Shift Y**. This will bring back the picture in MAIN STORE in one of three different ways.

This is similar to bringing back a picture element. You can either Add the MAIN STORE to the screen, you can obtain what is Common between the MAIN STORE and the screen, or you can obtain the Difference between the MAIN STORE and the screen. Press A and add the MAIN STORE to the screen. Reverse the screen again (U).

Have a chocolate biscuit for your efforts!
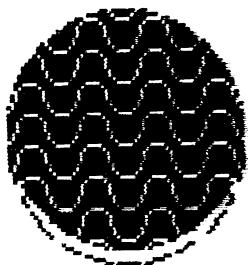
MAKING A HARD COPY

If you have a ZX printer connected to your Spectrum then you can make hard copies of your pictures to send to your friends or to hang on the wall. **Press C**. The whole screen will be copied to the ZX printer. If the printer is not attached, then pressing this key has no effect.

ERASING MISTAKES

It is frequently desirable to be able to erase selected regions of the screen, in order to change the graphics or to rectify errors. There are a number of ways of achieving this.

Straight lines can be erased by redrawing them using UNPLOT or INVERT mode. Plotted lines can be erased by using a brush in UNPLOT mode (0).

If you first reverse the screen (U), any drawing operation will effectively be in inverse mode when the screen is reversed a second time to return it to its original state.

Any character space areas can be erased by printing the desired number of spaces to the screen.

Magcopy (Shift D) in PRINT mode can be used to erase any rectangular area as follows. Place the cursor at the lower left of the area to be erased. **Press Shift P** to reset the pixel at the cursor if it is SET. Press D twice to make that pixel into a window. Press Shift D and input the horizontal and vertical dimensions to be erased. That area will then be erased. Press ENTER to return to the pixel cursor.

Any closed shapes can be erased using a combination of fill (Shift U) and reverse (U). First fill the shape to be erased. Then reverse the screen. Fill the shape again. Reverse the screen again and the shape will have vanished.

GOING SOLO

You have now been guided through many of the features of **LEONARDO**. The step by step instructions should have given you the confidence to 'go solo'. Use the keyboard layout charts at the back of this manual as a ready reference to the many function keys, and use the second part of the manual to reference the function if you don't know how to use it.

GOOD LUCK!

PART 2

CONTENTS

CURSOR CONTROL

Moving the cursor is achieved as follows:–

If you have selected a JOYSTICK to use then push it in one of the eight possible directions.

Forwards for up and backwards for down.

If you have selected the KEYBOARD to use then press one of the following:–

5	Left	**Shift 5**	Left and up
6	Down	**Shift 6**	Down and left
7	Up	**Shift 7**	Up and right
8	Right	**Shift 8**	Right and down

Press the joystick button or **press 0** to SUSPEND or activate the drawing mode you are currently in.

When first entering a drawing mode the selected drawing operation will not occur until either the cursor is moved, or the SUSPEND operation is toggled (pressing the joystick button or 0 twice).

The step size for either the pixel or character cursor is changed in the relevant cursor mode. Each step size remains active until changed, even when cursor modes are altered.

I   SET STEP.

Prompts for input of x (or row) and y (or line) values for the size of the cursor movement.

Shift I   RESET STEP.

Sets the step size to x or r = 1.
and y or l = 1.

K   SET CURSOR.

Prompts for the input of x and y values (pixel cursor) or row and line values (character cursor) to position the cursor.

Shift K   CENTRE CURSOR.

Repositions the cursor to the centre of the screen (x= 128, y=96 in pixel cursor mode or row= 16, line= 12 in character cursor mode).

Shift SPACE   HOME CURSOR.

Sets the pixel cursor's position to the top left corner of the character square in which it is currently located.

SPACE   DISPLAY CURSOR.

Displays the current character square in which the cursor is located.

Z   SET LAST PLOT.

Prompts for input of x and y values for the position of last plot.

Shift Z   RESET LAST PLOT.

Places last plot at the current pixel cursor position.

ENTER   CURSOR

Returns to the current cursor mode.

VIEWING INFORMATION

The following functions to view the drawing parameters can be used in either pixel or character cursor modes.

Shift 2   TOP

Sets the Coord. window to be displayed at the top left of the screen.

Shift 3   BOTTOM

Sets the Coord. window to be displayed at the bottom left of the screen.

Shift 4   OFF

Switches the Coord. window off.

1   INFO. WINDOW

When held down displays the information window.

WINDOWS

The following keys are used to set either the pixel window or the colour window depending on which cursor mode **LEONARDO** is currently in.

2   LOWER LEFT

Sets the lower left corner of the window.

3   TOP RIGHT

Sets the top right corner of the window.

4   DISPLAY

Displays or removes the window outline. The window outline completely surrounds the windowed area. If part of the outline is off the screen a message will be displayed to indicate the exact position of the window.

POINT PLOTTING

The following commands are set from pixel cursor mode. The plotting modes can be suspended by pressing the joystick button (or 0).

P   PLOT MODE.

Pixels under the cursor will be set to ink.

O   UNPLOT MODE.

Pixels under the cursor will be set to paper.

Shift O   INVERT MODE.

Pixels under the cursor will be inverted (i.e. Paper will become ink and ink will become paper).

Shift P   INVERT PIXEL.

The pixel under the cursor will be inverted but the pixel cursor's current plotting mode will not alter.

M   SET BRUSH.

Prompts for input of the dimensions of the rectangular brush.

Shift M   RESET BRUSH.

Sets this brush size to 1 pixel by 1 pixel.

Shift X   BRUSH BOUNDARY.

Switches the brush boundary flag ON and OFF. The flag effects the drawing of both brushes and picture elements. If the flag is ON then, when drawing a brush, if a set pixel is found on a line the rest of that line is not drawn, and if a line begins with a set pixel, the brush stops drawing.

LINE DRAWING

When a straight line is drawn a brush is put at every point along the line. The drawing of a line can be interrupted each time the brush is deposited by pressing SPACE. All straight lines in **LEONARDO** are governed by the current settings of brush size, brush mode, brush boundary, line mode, line boundary and mark/space ratio. This includes the lines drawn in FIGURE.

Q   LINE 1.

Draws a straight line between the current position of the cursor and the position of last plot. Last plot is then updated to the current position of the cursor.

Shift Q   LINE 2.

Draws a straight line between the current position of the cursor and the position of last plot. Last plot is not updated.

W   HORIZONTAL LINE.

Draws a straight horizontal line from the cursor both left and right towards the edges of the screen until a boundary is met. The pixel at the cursor and those to the left of it, will form the first mark when in FROM mode, and the first space, if relevant, when in TO mode.

Shift W   VERTICAL LINE.

Draws a straight vertical line from the cursor both up and down towards the edges of the screen until a boundary is met. The pixel at the cursor and those above it will form the first mark when in FROM mode and the first space when in TO mode.

R   LINE BOUNDARY.

Switches the boundary flag ON and OFF. If the boundary flag is ON then straight lines drawn   47

with LINE 1, LINE 2 or PROG DRAW will stop when a boundary is met.

Shift R   DIRECTION.

Changes the direction flag between TO and FROM. If the direction flag is TO then LINE 1, LINE 2 of PROG DRAW will draw lines from last plot TO the cursor.

F   SET MARK/SPACE.

Prompts for input of values for MARK and for SPACE used in drawing straight lines. A value of 1/0 is a line draw with a brush in the current mode, and a value of 0/1 is a line drawn either with a brush in the opposite of the current mode or not drawn at all. (see LINE MODE).

Shift F   RESET MARK/SPACE.

Sets the mark/space ratio to 1/0, a solid line.

Shift C   LINE MODE.

Switches the mode of drawing straight lines between PRINT and ADD. The mark part of a straight line is drawn using the current mode, and the space part of a line is drawn using the modes outlined in Table 1.

	SPACE	
	LINE MODE	
MARK **(current mode)**	**PRINT**	**ADD**
PLOT	UNPLOT	SKIP
UNPLOT	PLOT	SKIP
INVERT	UNPLOT	SKIP

Table 1 Line modes with Mark/Space ratio.

CURVE DRAWING

When a curved line is drawn a brush is put at every point along the line. The drawing of a line can be interrupted each time the brush is deposited by pressing SPACE. All curved lines in **LEONARDO** are governed by the current settings of brush size, brush mode, brush boundary, line mode and mark/space ratio.

A   CIRCLE 1.

Prompts for input of the radius. A circle of the desired size is drawn with its centre at the cursor.

Shift A   CIRCLE 2.

A circle is drawn immediately with its centre at the cursor and its circumference through last plot.

S   ARC.

Prompts for the angle in degrees through which the circular arc will turn in travelling from last plot to the cursor.
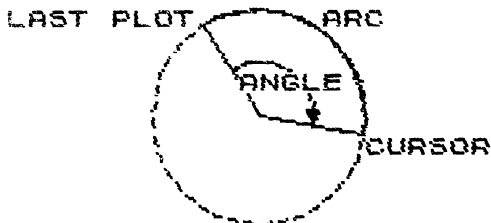
Shift S   ELLIPSE.

This is a comprehensive ellipse drawing feature. This function prompts for the following information:—

Vertical radius. This is the size of the up/down radius of the ellipse.

Horizontal radius. This is the size of the left/right radius of the ellipse.

Rotation. This is the angle in degrees through which the ellipse is rotated.

Start angle. This is for drawing incomplete ellipses. The start angle is the angle from the local vertical axis where drawing begins.

Turn angle. This is the angle through which the drawing process occurs.

If nothing is entered for either of the ellipse axis sizes, then the ellipse is not drawn. If nothing is entered for any of the remaining parameters then that parameter and any remaining parameters take their default values. These are 0° for the rotation and start angle and 360° for the turn angle.
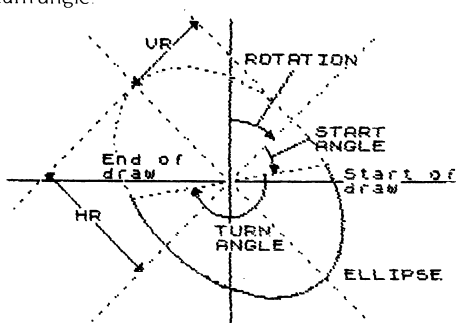
DRAWING AIDS

Shift
Symbol shift   CLEAR SCREEN

The whole screen is cleared to bright white paper and the ink colour is set to black.

U   REVERSE.

This feature enables the reversal of the screen (all set pixels are unset and all unset pixels are set) or the reversal, clearing or filling of the pixel window. The input window prompts the user to select either the window (W) or the screen (S). If the screen is selected then the whole screen is reversed immediately and the feature returns to pixel cursor mode. If the window is selected then the prompt *r, c, or f* appears. Select either reverse, clear or fill by pressing R, C or F. The area inside the pixel window will then either be reversed, cleared (set to paper colour) or filled (set to ink colour). Keying ENTER at any stage will return immediately to pixel cursor mode without performing the function.

Shift U   FILL.

This features fills with solid ink the region from the pixel cursor to a boundary line in all directions. If there is a gap in the wall of the shape to be filled the ink will 'escape' and may fill most of the screen. Once initiated the routine cannot be aborted. The picture before the fill was initiated can be retrieved by pressing Y immediately after the fill function has completed. FILL may stop before completely filling the area if the shape is very complex.

J   SCROLL.

The scroll function performs in two distinct ways depending on whether the feature is called while in pixel cursor mode or in character cursor mode. In pixel cursor mode the pixels on the screen are moved and in character cursor mode the attributes of the screen are moved.

PIXEL SCROLLING. Either the screen or the contents of the pixel window can be scrolled by selecting either window (W) or screen (S) when the prompt appears in the input window. In both cases the pixels can be scrolled in one of the four directions left (L), right (R), up (U) or down (D) by keying the appropriate letter. The function then prompts for a distance to scroll measured in character squares and pixels for a full screen scroll and in pixels for a window scroll. Remember that each character square is 8 pixels wide and 8 pixels high. The chosen area will then move. Any pixels moved off the edge of the scrolling area will disappear.

ATTRIBUTE SCROLLING. This works in exactly the same way as pixel scrolling, enabling the attributes of the whole screen or only those attributes within the colour window to be moved. Attributes can only move in character steps and so the function will only prompt for the scroll distance in character spaces. One further input is requested in attribute scrolling. That is the attributes of the characters that will be moved into the scrolling area. The user is prompted for the paper, ink, bright and flash attributes for these characters. A number between 0 and 7 should be entered for the paper and ink colours and either 0 or 1 should be entered for the bright and flash attributes.

Shift J   COVER.

This feature generates a repetitive pattern from a user defined pattern element. The feature can be applied to the screen or confined to the pixel window by keying W or S when the feature is initiated. The direction of cover should then be selected by keying L (left), R (right), U (up) or D (down). A prompt for the repetition interval in characters and pixels (screen) or pixels (window) is then displayed. The repetition interval determines the intervals at which the initial pattern will be copied across the screen. When the interval has been entered the whole screen or the pixel window will be repetitively copied, displaced each time by the repetition interval in the chosen direction, until the screen or window edge is reached.

NOTE. This feature uses **LEONARDO**'s backup store to build the repetitive pattern. Pressing Y after using this feature will not restore the original picture.

V   GRID 1.

Displays a grid of alternating bright and dark attributes. No other attribute is altered. When called from pixel cursor mode the grid can be removed by keying V again. In character cursor mode the grid will only appear while the key is held down.

Shift V   GRID 2.

Displays a grid of alternating bright and dark white paper with black ink. As with GRID 1, in pixel cursor mode the grid can be removed by pressing V and in character cursor mode the grid will only appear while the key is held down.

SAVING AND RESTORING

Saving and restoring the screen, pictures, picture elements and UDG's to cassette tape is discussed under the heading Permanent Storage. This section deals only with the storage and retrieval of images using the different stores within **LEONARDO**. There are two storage areas within **LEONARDO** as well as the screen. The screen is used to create each new part of the image. The backup store is the same size as the screen and is used to store a copy of the screen before entering a new feature. The main store has three uses, but can be used for only one at a time. It can hold UDG's or picture elements, or one picture (without attributes).

T   SAVE UDG.

This feature enables the user to save an area of the screen into either the Spectrum's built-in UDG area or into the main store. The Spectrum's UDG area can hold 21 characters defined by the letters a to u. The main store can hold up to 774 characters, over a full screen size, defined by the numbers 1 to 774. The user must respond to the prompt UDG (a-u, 1-774) with either a letter A to U or a number between 1 and 774 to determine where the created UDG's will be stored. The user can at this point abort the feature by keying ENTER. The letter or number entered would normally be the lowest available but it is left to the user to remember what has already been stored. If the user selects **LEONARDO**'s main store by keying a number, the function will first examine whether the store is being used to store pictures or picture elements. If the store has already been used for another purpose then a prompt to this effect will be displayed and the user must decide whether to overwrite the store with UDG's (Y) or

whether to return to pixel cursor mode (any key except Y). Once the starting character for copying has been chosen the input window prompts for the size of the rectangular block of UDG's to be copied such that x is the width in characters and y is the depth in characters. The pixel cursor marks the top left corner of the block. The block must be an exact number of character spaces wide and deep, but does not have to lie within character spaces.

L   PRINT BLOCK.

This feature can only be used while in character cursor mode. It enables the printing of UDG's. The graphics can be inverted and or rotated. The block is, however, confined to exact character spaces, as is all printing on the Spectrum. First it must be decided which UDG's to use, either those stored in the Spectrum's UDG area or those in **LEONARDO**'s main store. Keying a letter between A and U or a number between 1 and 774 will determine which store, and the first UDG, to use. Then, as in SAVE UDG, the size of the rectangular block of UDG's must be entered. The block can be inverted either horizontally or vertically or not at all by keying either H, V or N in response to the invert prompt. The block can also be rotated by keying a number between 0 and 3 to the turn prompt. 0 for no rotation, 1 for 90° clockwise, 2 for 180° clockwise and 3 for 270° clockwise. Printing begins such that the character space occupied by the cursor becomes the top left corner of the block. Using a combination of SAVE UDG and PRINT BLOCK any area of the screen may be inverted and or rotated.

H   BACKUP.

Pressing this key will copy the current screen to **LEONARDO**'s backup store. This also automatically happens before most features are initiated.

Y   RETRIEVE.

This copies the contents of **LEONARDO**'s backup store onto the screen. Pressing this key immediately after any function will restore the picture as it was before the function was entered. NOTE that COVER uses the backup store to build its pattern and so the original picture cannot be retrieved.

Shift H   SAVE.

This copies the current screen, without attributes, to **LEONARDO**'s main store. If the store is being used for any other purpose a message is displayed prompting the user to choose whether to overwrite the main store or to return to the pixel cursor.

Shift Y   MERGE.

This will bring back the picture in main store to the screen in one of three ways. You can ADD the main store to the screen. This sets all pixels on the screen that are set in the main store. You can take what is COMMON between the main store and the screen. This will only set those pixels which are set on the screen and in the main store. You can take the DIFFERENCE between the main store and the screen. This will only set those pixels which are set in either the main store or the screen but not in both. Press either A, C or D to get the two pictures merged together on the screen.

MAGNIFYING

This feature allows the setting of a temporary pixel window which can then be copied to a new display location with or without independent integer magnification in the horizontal and vertical axes. The feature is first entered when either D or Shift D is pressed. The first time one of these keys is pressed the lower left corner of the area to be copied is set. The next press of either of these keys will set the top right corner of the copy area. The user can then either press D to copy the area or Shift D to copy the area with magnification. The area will be copied in either PRINT or ADD mode determined by the line mode flag.

D   COPY.

The area inside the copy window will be copied with the current cursor position as the bottom left of the area, without any magnification.

Shift D   MAGCOPY.

The input window will prompt for the x and y magnification. The area inside the copy window will then be copied to the current cursor position at the set magnification.

When setting the top right corner of the imaginary magnification window, if the area of screen is too large for the computer's memory, a message is displayed and the user must reduce the size of the window. If the area to be copied will not fit onto the screen then no copy will take place. NOTE that when the imaginary window is overprinted the next copy will reflect the new contents of the copy window.

PICTURE ELEMENTS

Picture elements are pictures which can be stored to be used later in a variety of different ways. They are saved from within the pixel window and are stored in **LEONARDO's** main store. As many as 255 small picture elements can be saved at any one time. Picture elements follow the current setting of BRUSH BOUNDARY when being restored. They can be restored using the cursor, the pixel window or the pattern drawing facility PROG. DRAW.

G   SAVE ELEMENT.

The contents of the pixel window are copied into the first available location in the picture element store in **LEONARDO's** main store. If the main store is being used for a picture or for UDG's then a message is displayed asking whether to change the store's use. If there is not enough room in the store to hold the new element then the message 'No room' is displayed. When the picture element has been stored the function will display the picture number under which the element has been saved. The user must remember which pictures are stored in which elements.

Shift T   DELETE ELEMENT

Pressing this key displays the number of elements currently stored, and prompts for the number of elements to be saved. All elements above the number entered are deleted. Keying ENTER returns to pixel cursor mode without deleting any elements.

N   PICture NO.

Sets the element number to be used in future picture element restoring operations. To the prompt *Pic no.* the user should enter the number of the element to be used.

Shift N   PICture MODE.

Sets the mode in which the picture element is returned to the screen. This can be one of four different modes. PRINT puts both the set and the unset pixels from the element onto the screen. ADD puts only the set pixels from the element onto the screen. COMMON sets only those pixels which are set in both the element and in the area of the screen where the element is being placed. DIFFERENCE is similar to common but sets only those pixels which are different. The user can select one of these by keying the first letter of the mode (P, A, C or D).

Shift G   RESTORE ELEMENT.

The element chosen by PIC NO. is restored to the screen in the way described by PIC MODE. The element is restored such that the top left corner of the element coincides with the top left corner of the current pixel window.

L   PICTURE.

This feature will place the current picture element, as set by PIC NO., onto the cursor. The cursor will then act like a brush with the picture element being deposited onto the screen, in a manner described by PIC MODE, at the current pixel cursor position each time the cursor is moved.

FIGURES

Figures in **LEONARDO** are user defined shapes created from a string of up to ten segments. Each segment is a straight line drawn to a point defined by the x and y distance from the end of the previous segment. Right and Up being the positive x and y direction. All lines drawn in figure obey the current global settings for lines. When **LEONARDO** is first initiated there are 10 predefined coordinate pairs that can be used to define simple useful shapes.

These default values are:—

0	1,	1
1	0,	1
2	1,	0
3	0,	−1
4	−1,	0
5	−1,	−1
6	−1,	1
7	1,	1
8	1,	−1
9	−2,	0

Coords 1, 2, 3 and 4 form a square.
Coords 5, 6, 7, 8 form a diamond.
Coords 7, 8, 9 form a triangle.

60
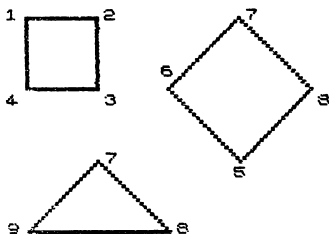
Shift E   DEFINE SHAPE.

Pressing this key will display the Figure Table. This is a table of the ten coordinate pairs representing the ten vectors which are used to create figures. Pressing a number from 0 to 9 will allow entry of a new x and y value. After keying the desired number the prompt for the x value is displayed. Keying ENTER will not change the value, but if a number is typed followed by ENTER the new value is noted and the prompt for the y value is displayed. Again this value need not be changed, but can be by typing the new value before pressing ENTER. Decimal and negative numbers are allowed. The user may then elect to change another vector by keying a number between 0 and 9, or may return to the pixel cursor by keying ENTER. All coordinate pairs can be initialised to their default values by pressing J. The Draw Table of PROGrammed DRAW may also be viewed by pressing K.

Shift L   FIGURE.

This feature will place the current figure, as defined in PROG DRAW, onto the cursor. The cursor will then act like a brush with the figure being deposited onto the screen at the current pixel cursor position each time the cursor is moved. The figure's scale, rotation and position relative to the cursor are also taken from values set in PROG DRAW.

PROGRAMMED DRAWING

LEONARDO provides a programmable feature for drawing patterns and shapes, singly or repetitively with facilities for non-linear scale expansion, translation and rotation. This feature makes the drawing of complex and repetitive shapes very easy. The patterns and shapes that this feature produces can be created from straight lines, rectangular brushes, figures and picture elements. It should be noted here that the parameters in PROG DRAW use a coordinate system with $+x$ and $+y$ right and up, not down as in the cursor modes. The many ways of using this feature are very complex to understand and so some examples of this facility in action can be found at the back of the manual.

E   PROGrammed DRAW.

When this key is pressed, or K is pressed from the Figure Table, a display of all the parameters within programmed draw fills the screen. This is called the Draw Table. It is a menu of available options within the feature. There are a number of items highlighted on the screen. These are the keys that should be pressed to change the parameter or to initiate the particular mode. At the top of the screen the numbers 1 to 8 are highlighted. These are the 8 major parameters and are considered in turn. After keying the desired number, one or two new values should be entered. Keying only ENTER will not change the parameter.

1   SCALE

This is the initial value for the x and y scale factors for the first drawing operation. Scaling is about the beginning point.

2   SCALE INCREMENT

This is the amount added to the x and y scale factors after each drawing operation.

3   START

This coordinate pair defines the position relative to the beginning point of the start of the next drawing process. The first beginning point will be at the cursor position.

4   LINK

This is the point relative to the start point from which successive drawing operations take their beginning point.

5   DISPLACEMENT

This, unlike START and LINK, is the absolute displacement for each successive drawing operation. This is not subject to scale, scale increment, rotation or rotation increment.

6   ROTATION

This is the initial rotation, in degrees, of the first drawing operation clockwise about the beginning point.

7   ROTATION INCREMENT

This is the additional amount of rotation that is applied to successive drawing operations.

8   CYCLES

This is a whole number and is the number of drawing operations to occur automatically.

The next three parameters are changed by keying a letter. These are the different brush modes.

A   PICTURE

This is the picture element number and the mode of drawing for use in the PICTURE mode of this function. These should not be confused with the picture number and mode used with the pixel cursor. They are not the same. The user must enter the picture element number desired and key the first letter of the mode in which the picture element will be restored. This can be Print, Add, Common or Difference.

B   COORDS

These are the first and last coord. pairs to be used to create a figure. The coord. pairs defined in the Figure Table from the first to the last will form the figure used in either FIGURE mode of this feature or on the brush of FIGURE mode in the pixel cursor. The user must enter a number between 0 and 9 for each of the parameters. Keying ENTER for either parameter will not alter its setting. If the first number is bigger than the last then they will be exchanged.

C   BRUSH MODE

This is the mode in which a rectangular brush will be used in this function if BRUSH is selected. The brush size will be determined by the scale factors, and the mode can be set independently. The user must key the first letter of the desired brush mode. This can be Plot, Unplot or Invert.

At the bottom of the table are the four drawing modes to the left and two other functions to the right. The drawing modes are the ways that programmed draw will produce its patterns. The two other functions are considered first.

H   RESET

Pressing this will reset the first eight parameters to their initial values. These values are:–

SCALE	x=1	y=1
SCALE INC.	x=0	y=0
START	x=0	y=0
LINK.	x=0	y=0
DISPLACEMENT	x=0	y=0
ROTATION	=0	
ROTATION INC.	=0	
CYCLES	=1	

I   FIGURE TABLE

This enables the user to view the Figure Table without returning to pixel cursor mode.

The four remaining options start the programmed draw operation. The different keys are the way to select what is to be drawn at each cycle of the feature.

D   LINE

This will join each cycle with a line.

E   FIGURE

This will draw the defined figure at each cycle of the programmed draw.

F   PICTURE

This will deposit the defined picture element at each cycle of the function.

G   BRUSH

This will draw the rectangular brush at each cycle of the programmed draw.

All lines drawn in line and figure mode follow the global line parameters. When the drawing process begins the yellow strip of the signalling system appears indicating that the drawing can be interrupted by pressing either E to return to the Draw Table, ENTER to return to the pixel cursor or SPACE to wait for further instructions. The drawing process can only be interrupted, with E or ENTER, after each cycle and so if a complex picture element or figure is being drawn the feature may not appear to respond to the interrupt for some time, and so the key must be held down. Pressing SPACE however will interrupt the line drawing process itself, and will respond much faster. When the desired number of cycles is reached, or when SPACE has been pressed, the strip will turn green. Again the user may either return to the Draw Table (E) or to the pixel cursor (ENTER). Also an extra cycle of the Programmed draw may be obtained by keying C. If the beginning point moves off the screen Prog Draw will immediately return to pixel cursor mode. On returning to the Draw Table, while still in PROG. DRAW mode, the currently accumulated values of scale and rotation are retained and cannot be reset by changing options 1 or 6. Any other parameter however may be changed and a new set of drawings started where the previous set had finished. This allows very complex designs to be drawn without exiting the feature.

NOTE that the use of the Y key to retrieve the last frame will remove ALL operations performed since the last viewing of the DRAW TABLE.

See the examples at the rear of the manual for more understanding of this very versatile feature.

COLOURING

B   CHARACTER CURSOR.

Changes from pixel cursor mode to character cursor mode.

The following keys can only be used while in character cursor mode.

Q   SET COLOUR.

Sets the colour of the character cursor brush and activates colouring mode. The character cursor brush will 'paint' colour into each character square it passes over. The colour of the brush need not define all four attributes, but can leave some attributes as they were. The user is prompted for the four attributes. Paper and ink require a number between 0 and 7 to set a colour, or N if no change is desired. Similarly, for bright and flash, either 0 or 1 should be entered if a change is to be made, or N if no change is required. The use of the colour brush can be suspended by pressing the joystick button (or 0). Once set the colours selected will remain unchanged until altered with this facility, even when a return to pixel cursor mode is made.

W   COLOUR.

This activates colour mode without changing the colour values of the brush.

A   CHANGE COLOUR.

This feature allows selective aspects of colour to be changed, either within the colour window or over the whole screen, without affecting the aspects not selected. First the window or screen must be selected by keying either W or S. Then each attribute must be given its new value or N if no change is required. Every character within the selected area will then be given only the chosen attributes.

S   SWAP COLOUR.

This feature can operate either across the whole screen or only within the colour window. After the desired area is chosen by keying W or S the feature prompts *Old colour.* The four values for the attributes to be changed should be entered. Next the feature prompts for *New colour.* The four values for the attributes that are to replace the old ones should be entered. All characters within the chosen area with exactly the old attributes will be given the new attributes.

F   COPY COLOUR WINDOW.

The colour window is copied so that the position of the character cursor defines the upper left corner of the copied window. If the cursor is then moved, new copies are deposited at the new position. If the contents of the colour window are overwritten during this process then the copies that result will be changed. This feature can be suspended by pressing the joystick button (or 0).

P   SET PRINT.

Sets a line of text that is repeatedly printed at the cursor position each time the cursor moves. This is called PRINT mode. The feature prompts for a line of text to be entered. Standard characters or UDG's from the Spectrum's UDG area can be used. Once the line of text has been entered it will remain set until changed or a return to pixel cursor mode is made. This feature can be suspended by pressing the joystick button (or 0).

O   PRINT.

This enters print mode without changing the line of text. If however no text has been set during this period in character cursor mode the feature will work in exactly the same way as SET PRINT.

C   PIXEL CURSOR.

Returns to pixel cursor mode. NOTE that the text line for print mode will be lost.

PERMANENT STORAGE

C   PRINTER.

Pressing this key will only have an effect if a ZX printer is attached to the Spectrum. The screen will be copied to the printer.

X   MENU.

Pressing this key returns to the MAIN MENU. The picture screen disappears and is replaced by the three options available on the main menu.

1 CREATE GRAPHICS

This will enter pixel cursor mode with the cursor and last point set at the centre of the screen. Any picture that was on the screen or has been loaded from cassette will now be visible. No other variables should be affected.

2 SAVE GRAPHICS

Pressing 2 allows the user to save work to cassette tape for permanent storage or later re-use. To use this feature the cassette tape recorder must be properly connected and adjusted. The MIC lead must connect the Spectrum to the cassette recorder, and the EAR lead must be temporarily disconnected. The cassette on which the data is to be stored must also be in the cassette recorder at the correct position. It is often useful to reset the counter to mark the start of a save opertion. The SAVE MENU appears with the available options. The screen can always be saved. If **LEONARDO**'s main store has been used for any graphics an option will appear stating that either a picture, picture elements or UDG's can be saved. If, however, nothing is to be saved, then pressing 0 returns to the main menu.

To save the screen press 1.

To save the main store, if the option is available, press 2.

When saving UDG's the prompt (a-u, 1-774) will appear. This determines whether to save from the Spectrum's UDG area or from **LEONARDO**'s UDG area and which UDG is the first character to save. Either a letter A to U, or a number between 1 and 774, should be entered. The last character to save is then requested. This must be of the same type as the first and must be within the range of letters or numbers. Whatever is to be saved the file must be named to enable it to be identiified on the cassette tape. The name must not be more than ten characters long. The name should also reflect the file's contents so that it can be recognised later. The name should be typed followed by ENTER. The PLAY and RECORD buttons on the cassette recorder should then be pressed, followed by any key on the Spectrum. When the file has been saved **LEONARDO** will then verify that the data has been saved correctly. The EAR lead should be reconnected and the MIC lead disconnected. The tape should then be rewound to the beginning of the file and the PLAY button pressed. After successfully verifying the saved data **LEONARDO** will return to the MAIN MENU. If however the verification fails a message is displayed and the user must try again, checking the leads and volume control.

3 LOAD GRAPHICS

This loads previously saved graphics from cassette tape. The cassette recorder must be connected, by the EAR lead to the Spectrum. The tape containing the required picture should be

ready for loading. When 3 is pressed the LOAD MENU appears with five options. 0 will return to the main menu. The remaining four options are to choose the type of saved graphics to load. It is very important that the file chosen to be loaded should be of the same type as that specified on the menu. **LEONARDO** cannot distinguish between different graphic types on tape, and if one type of file is loaded into the wrong store, then peculiar effects will occur. That is why sensible naming of the file at save time is essential. When loading UDGs, the prompt (*a-u*, 1-774) appears. This determines whether to load the saved UDGs into the Spectrum's or **LEONARDO**'S UDG area. Either a letter A to U, or a number between 1 and 774 should be entered. The letter or number entered will be the character into which the first UDG on tape is loaded. Subsequent UDGs are loaded into sequential characters.

When loading any non-screen graphic, the current use of MAIN STORE is checked. If a conflict of types arises from the load, a message will prompt the user to either continue loading, overwriting the store, or to return to the LOAD MENU. Pressing Y will overwrite the store and any other key press will return to the LOAD MENU. If a file is to be loaded, the name of that file must be typed in next. The exact name used when storing the graphics must be entered. If, however, no name is entered, **LEONARDO** will load the first file that it finds on the tape. When the name has been entered press PLAY on the cassette recorder and the file will be loaded. When the file has loaded successfully, the program will return to the main menu.

THE SIGNALLING SYSTEM

LEONARDO employs a signalling system to inform the user of the program's condition when performing various tasks. The signalling system draws a coloured strip at the top left corner of the screen. The colour of the strip indicates the program state.

MAGENTA –   The program is busy and cannot be interrupted.

YELLOW –   The program is busy but can be interrupted.

GREEN –   The program is waiting for the user to enter something.

RECOVERING FROM DISASTER

It is very difficult to lose graphics from **LEONARDO**'s stores, even when total disaster has struck and the program will no longer work. If the program stops for any reason do NOT type RUN to restart the program as all the internal values will be lost. Type GOTO 9999 under these circumstances, and the program should continue with the picture that was on the screen preserved and whatever was stored in main store still there. However if something has been keyed in wrongly and the program will not restart correctly it will have to be reloaded. The current pictures and stores can be saved to cassette tape before this is done by typing the following:—

To save the screen
    SAVE "name" CODE 44417,6912

To save the main store
    SAVE "name" CODE 51330,6197

To save any Spectrum UDG's
    SAVE "name" CODE 65368,168

After each graphic has been saved, it is advisable to VERIFY that they have been stored correctly. When all graphics have been saved, **LEONARDO** can be reloaded (see GETTING STARTED) and the graphics put back using the LOAD GRAPHICS option. This procedure can even be used if NEW has been typed as all graphics are stored above RAMTOP.

THE USER PROGRAM

The **USER** program consists of a number of BASIC subroutines and machine code routines to make use of the graphics data produced with **LEONARDO**. The user can use all the remaining space for their own BASIC and/or machine code program to make use of the graphics displayed by the user program.

LOADING

The **USER** program follows **LEONARDO** on the cassette tape. The program can be loaded by typing LOAD"USER" and loading in a similar way to **LEONARDO**. See GETTING STARTED.

THE BASIC SUBROUTINES

There are five subroutines supplied in the **USER** program. These subroutines are an interface between the user's own program and the **USER** machine code routines. The subroutines are used to manipulate graphics data that was created with **LEONARDO** and has been loaded into the user's program. The routines are called using the BASIC GOSUB instruction with the required parameters set to appropriate values in BASIC variables.

MOVING PICTURES

The first subroutine is for moving all or part of a full screen graphic to and from the display screen in various ways. Pictures that are to be transferred to the screen must have already been loaded somewhere in the user's program by using a command such as:–

LOAD"name"CODE nnnnn

where nnnnn is the address at which the file is to be loaded.

LEONARDO can save two types of picture to cassette tape. A 'screen' is saved as 6912 bytes containing 6144 bytes of pixel data and 768 bytes of attributes. A 'picture' is saved as 6144 bytes of pixel data only. The subroutine is called at 9900 and requires three BASIC variables to be set before the routine is called. These are:–

MO –   This is the mode of transfer and must be a whole number between 0 and 13. Any other numbers are ignored. The mode describes how much of the picture is to be moved. See Table 2 for details.

TY –   This is the type of transfer and must be a whole number between 0 and 8. The type describes the direction, what and how the transfer takes place. See Table 3 for details.

PIC –   This is the address in the user's graphic store where the picture is saved, or is to be saved. It is the start address of the whole graphic, even when transfers of less than the whole screen are to take place.

MO	User's graphic store	Screen
0	Full	Full
1	Top 2/3	Top 2/3
2	Top 2/3	Bottom 2/3
3	Bottom 2/3	Top 2/3
4	Bottom 2/3	Bottom 2/3
5	Top 1/3	Top 1/3
6	Top 1/3	Middle 1/3
7	Top 1/3	Bottom 1/3
8	Middle 1/3	Top 1/3
9	Middle 1/3	Middle 1/3
10	Middle 1/3	Bottom 1/3
11	Bottom 1/3	Top 1/3
12	Bottom 1/3	Middle 1/3
13	Bottom 1/3	Bottom 1/3

Table 2 MODE

TY	Type of transfer	Direction
0	Pixels and Colour	Store to screen
1	Pixels only	Store to screen
2	Colour only	Store to screen
3	Pixels and Colour	Screen to store
4	Pixels only	Screen to store
5	Colour only	Screen to store
6	Merge pixels Add	Store to screen
7	Merge pixels Common	Store to screen
8	Merge pixels Diff.	Store to screen

Table 3 TYPE

PICTURE ELEMENTS

The second subroutine is for transferring picture elements from a picture element store, created with **LEONARDO**, onto the screen. A picture element store must have been previously loaded from cassette tape into the user's graphic store area. A picture element store is 6197 bytes long. Pixel data is stored from the beginning of the area and a directory of stored data occupies the end of the area and extends backwards. The last five bytes form the element store permanent block. Before this each directory entry occupies 4 bytes, containing the start address in the store and the size of the element measured in pixels.
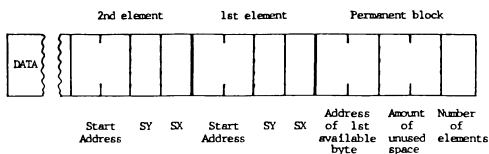
The subroutine is called at line 9905 and requires six BASIC variables to be set before the routine is called. These are:—

EN – This is the element number to be used. The number must be a whole number between 1 and the number of elements stored. If it is not within range then nothing will be transferred.

EX, EY – This is the element coordinate position and points to the location, measured in pixels from the top left corner of the screen, where the picture element is to be restored. The coordinates will be at the top left corner of the element.

EM – This is the element restore mode and must be a whole number between 0 and 3. The mode describes the way in which the transfer takes place. See Table 4 for details.

EB – This is the element boundary flag and must be either 0 for OFF or 1 for ON. See BRUSH BOUNDARY for an explanation.

EL – This is the address in the user's graphic store where the element table is stored.

EM	Type of transfer
0	Print
1	Merge: Add
2	Merge: Common
3	Merge: Difference

Table 4 ELEMENT MODE

CHANGING CHARACTER SETS

There are two subroutines to enable new character sets to be used. The required character sets should be loaded into the user's program before the calls are made. The first subroutine re-vectors the system variable CHARS so that characters that are printed will use the newly defined character set. The second of these subroutines resets CHARS to point back to the Spectrum's character set.

The first subroutine is called at line 9910 and requires two BASIC variables to be set before the routine is called. These are:—

CA – This is the address of the character set in the user's program. This normally is the address where the UDG file created with **LEONARDO** is loaded. The user may however build a character set by loading several small UDG files next to one another.

CN – This is the character number of the SPACE character within the user's character set. This must be a whole number between 1 and 774. **LEONARDO** can save a UDG file area containing from 1 to 774 characters. When saving only part of the UDG file area from **LEONARDO** the first character saved becomes character 1.

This routine also uses a temporary variable, for calculation, called TP.

The second subroutine is called at line 9915 and requires no BASIC variables. This routine resets CHARS back to the Spectrum's ROM character set.

After a call is made to the first subroutine all subsequent operations will use the newly defined character set. The user should reset the character set pointer with the second subroutine immediately after printing, in case any errors occur, because ALL printing on the Spectrum, including error messages, will use the new character set.

PRINTING BLOCKS

The last subroutine in the **USER** program is for printing blocks of UDG's. This is a way of easily drawing 'sprites' on the Spectrum. The print block subroutine works in a similar way to the print block of **LEONARDO**, except that characters cannot be rotated or inverted as it is assumed that **LEONARDO** has already done that if required. The appropriate character set must have been loaded before the call to the subroutine is made. The subroutine is called at line 9920 and requires seven variables to be set before the routine is called. These are:—

PA — This is the address of the UDG file and points to character 1.

PN — This is the number of the first character to be printed in the block. This must be a whole number between 1 and 774.

PX, PY — This is the size of the character block measured in characters. PX and PY must be whole numbers between 1 and 32 for PX (and 24 for PY). PX × PY is the number of characters that are to be printed.

PR, PL — This is the location on the screen at which the printing is to begin. The position is measured in characters as row and line from the top left corner of the screen. Both PR and PL must be whole numbers in the range 0 to 31 for PR (and 23 for PL). Any characters within the block that fall outside the screen area will not be printed.

PM—   This is the mode of printing and must be a whole number between 0 and 3. The mode describes the way in which the placing of the characters onto the screen takes place. See Table 5 for details and see Picture Elements in **LEONARDO** for more details of the modes.

PM	Type of printing
0	Print
1	Add
2	Common
3	Difference

Table 5 PRINT MODES

SAVING THE USER PROGRAM
WITH GRAPHICS

Lines 9998 and 9999 are supplied in the **USER** program to load and save itself and its machine code. When the program is loaded it automatically runs and sets RAMTOP to protect the machine code which it then loads. If the user writes his own BASIC program and/or his own machine code routines to use the **USER** subroutines he should change the CLEAR statement in line 9998 to protect any machine code and graphics that are to be, or have been, loaded. Then the LOAD and SAVE instructions in lines 9998 and 9999 should be changed to reflect the increase in machine code and data. Typing RUN 9999 will save the new **USER** program and the accompanying machine code.

EXAMPLES OF PROGRAMMED DRAW

In this section there are 9 examples of PROGrammed DRAW in action. These examples have been chosen to explain the use of the many parameters. In each example the relevant parameters and key presses are listed. Try the examples for yourself and then experiment by changing one parameter at a time

I THE SPIRAL

Clear the screen and centre the cursor and reset all the plotting and line drawing parameters. Enter PROG DRAW (E) and setup the following parameters:—

1	Scale	1,1
2	Scale Inc.	0,1
3	Start	0,1
4	Link	0,–1
5	Displacement	0,0
6	Rotation	0
7	Rotation Inc.	30
8	Cycles	49

Press D.
Press ENTER when the spiral has been drawn.

Clear the screen and enter PROG DRAW again and change the following:—

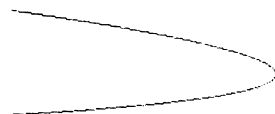|		
2	Scale Inc.	0,0.5
8	Cycles	97

Press D again.
Press ENTER when the spiral has been drawn.

2 THE PARABOLA

Clear the screen and move the cursor to 15,56 Enter PROG DRAW (E) and setup the following parameters:—

|		
1	Scale	20,0
2	Scale Inc.	−1,0
3	Start	0,0
4	Link	1.0
5	Displacement	0,−2
6	Rotation	0
7	Rotation Inc.	0
8	Cycles	42

Press D.

Press ENTER when the parabola has been drawn.

Clear the screen and draw a simple shape or pattern. Save as element 1 (G) in a window 24 by 32. Clear the screen again and move the cursor to 15,40. Enter PROG DRAW (E). Press A and enter the element number as 1 and the restore mode as Print.
Press F
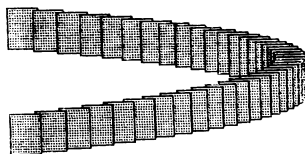
Press ENTER when the parabola has been drawn.

3 TRIANGULAR PATTERN

Clear the screen and centre the cursor. Enter DEFINE SHAPE (Shift E) and reset all the coords. (I). Then enter PROG DRAW (K) and set up the following parameters:—

1	Then	8,8
2	Scale Inc.	0,0
3	Start	−1,4
4	Link	1,−4
5	Displacement	0,0
6	Rotation	0
7	Rotation Inc	30
8	Cycles	12
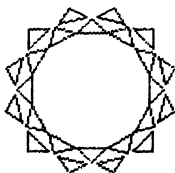
Press B and enter 7 and 9 to identify the triangular Figure.

Press E.

When the circle of triangles has been drawn press ENTER then E and change the following parameters:—

3	Start	−1,5
4	Link	1,−5
6	Rotation	15

Press E.

Press ENTER when the pattern has been drawn.

4 BAR CHART

Clear the screen and move the cursor to 4,115.
Enter DEFINE SHAPE (Shift E) and reset all the
coords (J). Enter PROG DRAW (K) and setup the
following parameters:—

1	Scale	4,40
2	Scale Inc.	1,−2
3	Start	0,0
4	Link	1,0
5	Displacement	0,0
6	Rotation	0
7	Rotation Inc.	0
8	Cycles	19
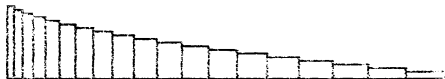
Press B and enter 1 and 4 to setup a square.

Press E.

Press ENTER when the bar chart has been
drawn.

5 SQUARES

Clear the screen, centre the cursor and enter DEFINE SHAPE (Shift E) and reset the coords (I). Then enter PROG DRAW (K) and setup the following parameters:—

1	Scale	12,12
2	Scale Inc.	0,0
3	Start	−0.5,−0.5
4	Link	1,1
5	Displacement	0,0
6	Rotation	0
7	Rotation Inc.	0
8	Cycles	10
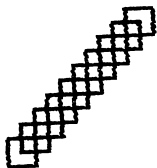
Press E.

Press ENTER when the squares have been drawn.

Clear the screen and enter PROG DRAW again and change the following:—

2	Scale Inc.	6,6
8	Cycles	6

Press E.

Press ENTER when the squares have been drawn.

Clear the screen and enter PROG DRAW and change the following:—

7	Rotation Inc.	30

Press E and see what happens.

Press ENTER when the new picture has been drawn.

6 CIRCULAR PATTERNS
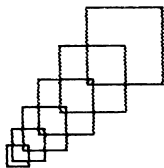
Draw a circle radius 12 and save as element 1(G) in a window 24 × 24. Clear the screen, centre the cursor and enter PROG DRAW (E). Setup the following parameters:—

1	Scale	0,16
2	Scale Inc.	0,0˙
3	Start	0,1
4	Link	0,–1
5	Displacement	0,0
6	Rotation	0
7	Rotation Inc.	30
8	Cycles	12
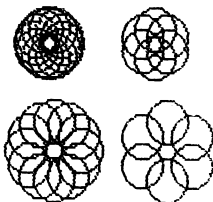
Press A and enter the element number as 1 and then restore mode as Add. Press F. Press ENTER when the first circular pattern has been drawn.

Clear the screen and enter PROG DRAW again. Change the following parameters.

7	Rotation Inc.	60
8	Cycles	6
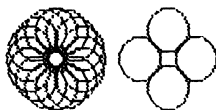
Press F for another pattern.

Do this twice more with the following two values:—

7	Rotation Inc.	90 and 22.5
8	Cycles	4 and 16
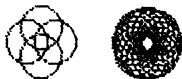
Try all four different rotation values again after changing

1	Scale to	6.8.

7 BUILDING SHAPES

Clear the screen, centre the cursor and set the Mark/Space ratio to 1/1. Enter DEFINE SHAPE (Shift E) and check that Coord. 0 is 1,1 (Default Value). Enter PROG DRAW (K) and setup the following parameters:—

1	Scale	0,18
2	Scale Inc.	0,2
3	Start	0,0
4	Link	0,0
5	Displacement	2,0
6	Rotation	0
7	Rotation Inc.	0
8	Cycles	11

Press B and enter 0 and 0. A single line figure.

Press E. When the drawing stops and the signal strip is green press E and change:—

2	Scale Inc.	0,−2
8	Cycles	10

Press E. Again change 2 Scale Inc. to 0.4 and Press E. When the drawing stops press E to go back to Parameter Table. Change:—

2	Scale Inc.	0,−4

Press E.

Press ENTER when the drawing stops.

8 BRUSHES

Clear the screen, centre the cursor and enter PROG DRAW (E). Setup the following parameters.

1	Scale	1,1
2	Scale Inc.	0.1,1
3	Start	0,1
4	Link	0,-1
5	Displacement	0,1
6	Rotation	0
7	Rotation Inc.	29
8	Cycles	49

Press C and select Invert mode.

It is best to watch this pattern draw. Press G.

Press ENTER when the drawing stops.

Look at the similarity between these parameters and those of the spiral!

9 DRAWING WITH CUBES

Clear the screen and reset all the drawing parameters. Enter DEFINE SHAPE and setup the following coords:—


```
0    0,  4
1    4,  1
2    0, -4
3   -4, -1
4   -3,  2
5    0,  4
6    3, -2
7    4,  1
8   -3,  2
9   -4, -1
```
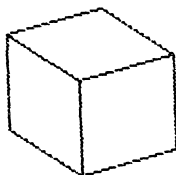
Press K to enter PROG DRAW (E) and reset all the parameters. Then enter a SCALE of 12,12.

Press B and define the figure as coords 0 to 9.

Press ENTER to return to the pixel cursor. Now choose FIGURE mode (Shift L) to draw with. Move the cursor. Now enter PROG DRAW and change the scale. Return to the pixel cursor and draw again. Try changing the rotation and start point in turn and see what happens!

CHARACTER CURSOR MODE

		WINDOW		
INFO WINDOW	LOWER LEFT	TOP RIGHT	DISPLAY	
1	2	3	4	OFF
SET COLOUR	TOP	COORD WINDOW	BOTTOM	

					SUSPEND
←	↑	SET STEP	9	SET PRINT	0
5	6	7	8	I	P
↓		RETRIEVE	RESET STEP	PRINT	

CHANGE COLOUR	SWAP COLOUR		COPY COLOUR WINDOW			RETRIEVE		SCROLL		PRINT	
Q	W	E	R	T	Y	U	I	O			

Q W E R T Y U I O P

A S D F G H J K L

CHANGE COLOUR — A
SWAP COLOUR — S
COPY COLOUR WINDOW — F
BACKUP — H
SCROLL — J
SET CURSOR — K CENTRE CURSOR
PRINT BLOCK — L CURSOR

CAPS SHIFT   Z X C V B N M SYMBOL SHIFT   BREAK SPACE   ENTER

PIXEL CURSOR — C
GRID 1 — V GRID 2
CLEAR SCREEN — M
DISPLAY CURSOR — SPACE

SPECTRUM 48K

Operations above the keys are obtained by pressing the key

Operations below the keys are obtained by pressing both the key and CAPS SHIFT

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PIXEL CURSOR MODE

SPECTRUM 48K

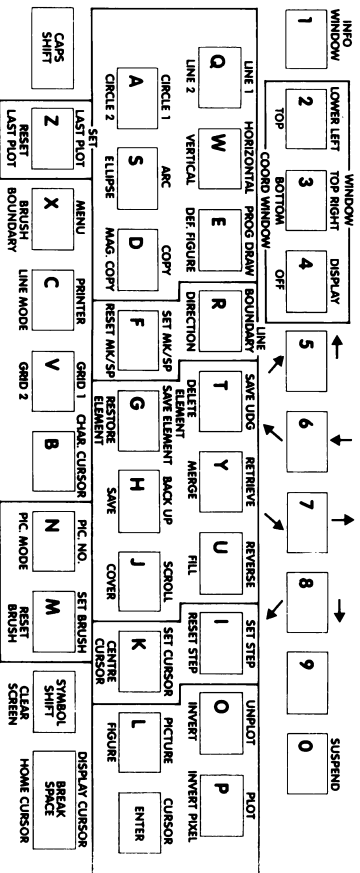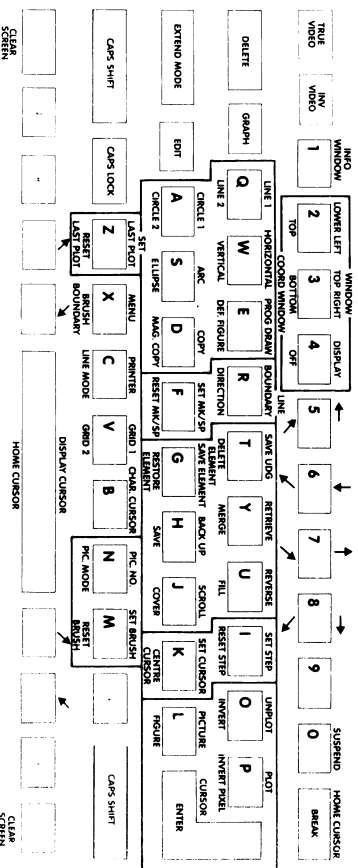| Key	Above key	Below key (with CAPS SHIFT)
1	INFO WINDOW	
2	LOWER LEFT	WINDOW-TOP
3	TOP RIGHT	WINDOW-BOTTOM
4	DISPLAY	WINDOW OFF
5	→	LINE BOUNDARY
6	←	
7	→	
8	→	
9		
0	SUSPEND	
Q	LINE 1 / LINE 2	CIRCLE 1
W	HORIZONTAL	VERTICAL
E	TOP / DEF. FIGURE	COORD WINDOW / BOTTOM
R	PROG DRAW	DIRECTION
T	SAVE UDG	DELETE ELEMENT / SAVE ELEMENT
Y	RETRIEVE	MERGE
U	REVERSE	BACK UP
I	SET STEP	RESET STEP
O	UNPLOT	INVERT
P	PLOT	INVERT PIXEL
A	CIRCLE 1 / CIRCLE 2	SET-LAST PLOT
S	ARC	ELLIPSE
D	COPY	MAG. COPY
F	SET MK/SP	RESET MK/SP
G	CHAR. CURSOR	RESTORE ELEMENT
H	SAVE	BACK UP
J	FILL	SCROLL
K	SET CURSOR	CENTRE CURSOR
L	FIGURE	PICTURE
CAPS SHIFT		
Z	RESET LAST PLOT	SET-LAST PLOT
X	MENU	BRUSH BOUNDARY
C	PRINTER	LINE MODE
V	GRID 1	GRID 2
B	CHAR. CURSOR	RESTORE ELEMENT
N	PIC MODE	PIC. NO.
M	RESET BRUSH	SET BRUSH / COVER
SYMBOL SHIFT	CLEAR SCREEN	
BREAK SPACE	DISPLAY CURSOR / HOME CURSOR	
ENTER	CURSOR	

Operations above the keys are obtained by pressing the key

Operations below the keys are obtained by pressing both the key and CAPS SHIFT

CHARACTER CURSOR MODE

TRUE VIDEO   INV VIDEO   GRAPH

INFO WINDOW — 1   LOWER LEFT — 2   WINDOW TOP RIGHT — 3   DISPLAY — 4

SET COLOUR — Q   COORD WINDOW — W   TOP — E   BOTTOM WINDOW — R   OFF

CHANGE COLOUR — A   SWAP COLOUR — S   COPY COLOUR WINDOW — F

PXEL CURSOR — C   GRID 1 — V   GRID 2 — B

5   6   7   8 — SET STEP   9   0 — SUSPEND

T   Y — RETRIEVE   U   I — SET STEP   O — PRINT   P — SET PRINT

G   H — BACKUP   J — SCROLL   K — RESET STEP / CENTRE CURSOR   L — PRINT BLOCK / SET CURSOR

CURSOR

N   M

DISPLAY CURSOR

DELETE   EDIT

EXTEND MODE   CAPS LOCK

CAPS SHIFT   CLEAR SCREEN

CAPS SHIFT   ENTER   BREAK   CLEAR SCREEN

Operations above the keys are obtained by pressing the key

Operations below the keys are obtained by pressing both the key and CAPS SHIFT

SPECTRUM PLUS

SPECTRUM PLUS

Operations above the keys are obtained by pressing the key

Operations below the keys are obtained by pressing both the key and CAPS SHIFT

TRUE VIDEO | INV VIDEO | GRAPH | EDIT | CAPS LOCK

EXTEND MODE | DELETE

CAPS SHIFT

CLEAR SCREEN

Key	Above	On key	Below
1	INFO WINDOW		
2	LOWER LEFT	WINDOW	
3	TOP RIGHT		
4	DISPLAY	OFF	
5	←		
6	↓		
7	↑		
8	→		
9			
0	SUSPEND		

TOP | COORD WINDOW | LINE | BOUNDARY | REVERSE | SET STEP | UNPLOT | PLOT

HOME CURSOR | BREAK

Q LINE 1 / CIRCLE 2
W HORIZONTAL / LINE 2 / CIRCLE 1
E VERTICAL / TOP / BOTTOM
R PROG DRAW / DEF FIGURE
T LINE / BOUNDARY / SET MK/SP
Y SAVE UDG / DELETE ELEMENT / SAVE ELEMENT
U RETRIEVE / MERGE
I REVERSE / BACK UP
O SET STEP / INVERT PICTURE
P PLOT / INVERT PIXEL

A CIRCLE 2 / LINE 1
S ELLIPSE / ARC
D COPY / MAG COPY
F DIRECTION / RESET MK/SP
G RESTORE ELEMENT / CHAR CURSOR
H SCROLL / SAVE
J FILL / COVER
K SET CURSOR / CENTRE CURSOR
L FIGURE / CURSOR

Z RESET LAST PLOT / SET LAST PLOT
X BRUSH BOUNDARY / MENU
C PRINTER / LINE MODE
V GRID 1 / GRID 2
B PIC NO. / PIC. MODE
N RESET BRUSH / SET BRUSH
M RESET STEP

DISPLAY GRID 2 | DISPLAY GRID 1 | CHAR CURSOR

HOME CURSOR

CLEAR SCREEN

CAPS SHIFT

ENTER

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LEONARDO was designed and written
by Mark Stoll, Clive Thomas and Peter Chandler.

The LEONARDO manual was written by Peter Chandler
along with all illustrative material contained therein.

While every effort has been made to ensure
the accuracy of both the software and manual,
we cannot accept liability for any errors
or ommissions which may have occurred.

CREATIVE SPARKS

FOR SPECTRUM 48K