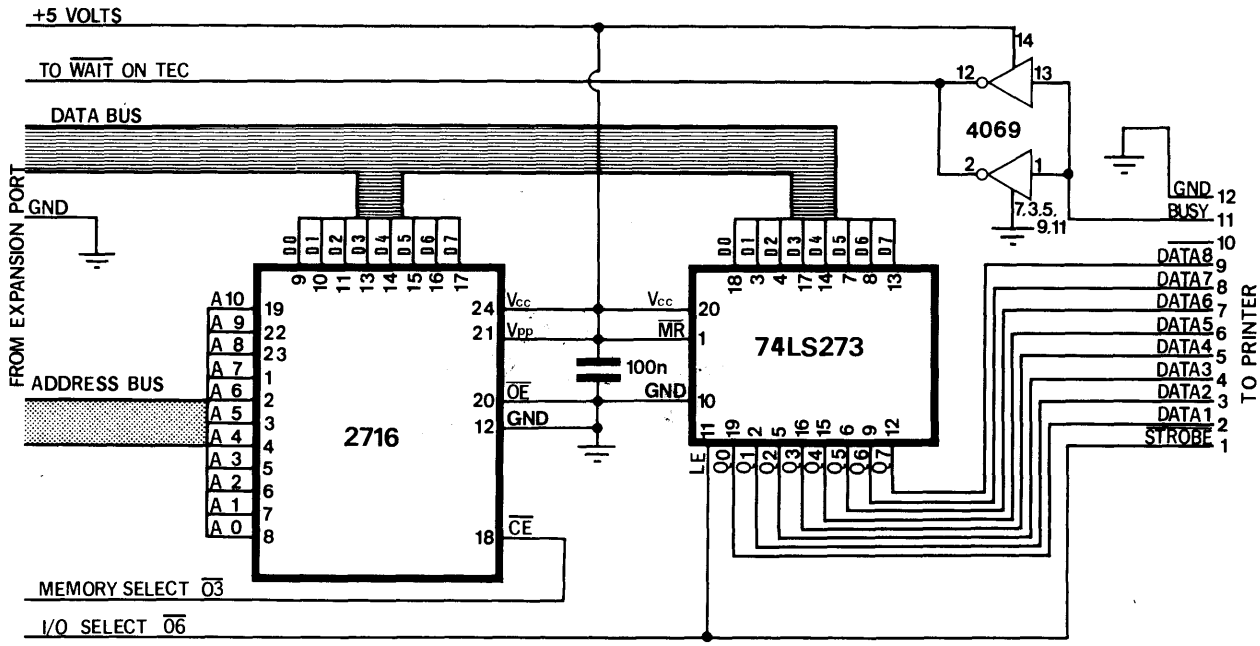
Connecting the TEC to a:

Parts: $24.80 PC board: $3.80

PRINTER/PLOTTER



Printer/Plotter circuit

Buy a Dick Smith VZ 200 Printer-Plotter.

This project explains how to directly access (talk to) a PRINTER/PLOTTER. We have used the most readily available printer/plotter as it is not only the cheapest, but can be obtained from a number of suppliers.

Talking to one of these clever little performers is not very involved when you know how. But without the correct information it will remain completely DEAD. When you know how to supply it with the right stuff, it will do practically anything bar talk to you.

Actually you only have to send it the necessary codes to produce the character, all the creation of the shape of the symbol is done by the chip within the printer.

Not only do these printer/plotters accept instructions to produce numbers letters and symbols, but they can also be told to rotate, plot, vary the size of the characters and move in almost any direction.

There is a two-way interaction between printer and computer. Data is sent to the printer faster than it can be executed and to save holding up the computer, it is deposited in a FIFO register in blocks of about 4 bytes (in our case). Larger computers can be instructed to go away and execute other work while the FIFO register empties.

Bursts of data are transmitted like this until the whole program is executed.

As we have used a standard printer, it is obvious that it has been designed to connect to any computer which has a normal, full-size, key-board so that each key will produce the corresponding letter on the paper.

But this luxury is not absolutely necessary as the computer merely produces a code number which is sent to the printer.

The code number (or value) is called an ASCII number or ASCII CODE and fortunately is identical for all types and models of personal computers.

The secret to getting the printer to work on the TEC is the latch chip. It holds the data long enough for the printer to read it.

PARTS LIST

1 - 100n mono block

1 - 4049
1 - 74LS273
1 - 2716 (programmed)

1 - 14 pin IC socket
1 - 20 pin IC socket
1 - 24 pin IC socket
1 - 24 pin wire-wrap socket
1 - 24 pin DIP HEADER

1 - 36 pin Centronics type plug.

tinned copper wire
hook-up flex
3 - 'quick connect' pins and sockets

PRINTER INTERFACE PC BOARD

This means all we have to do is produce the same set of ASCII numbers (or codes) and the printer will produce the correct set of shapes on the paper.

Thus we don't need a full-size computer at all.

It may be a bit slow pressing the keys on the TEC, but all the printing capabilities will be possible, and that's all we want.

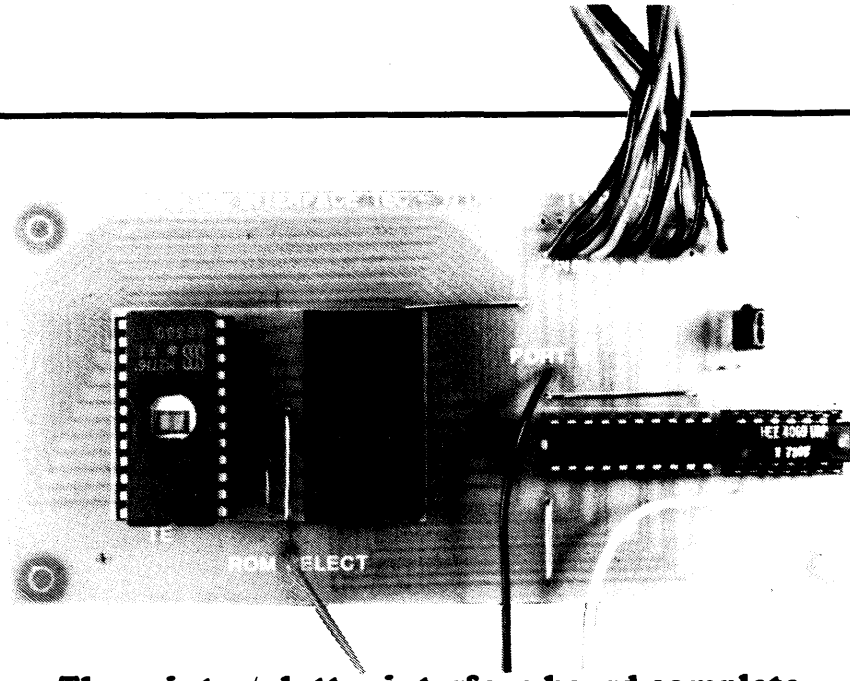
In this series of articles, we will explore the functions of the printer/plotter and create some amazing effects.

The most important aspect of this is realizing you can create a CONTROL PROGRAM with machine code listings and thus fill the minimum amount of memory for any given effect.

In this way you can produce you own system and expand it as much as you like without having to resort to buying a ready-made console. This will produce a cheaper and more compact system and will gain you much more respect from your boss or customer.

The first part of this project requires assembly of the printer interface board. This board contains a latch and EPROM (filled with a number of handy programs). This will give you a run-up program to test the interface board and provide instant transfer of data from computer to paper to reduce the amount of button-pushing.

The other chip on the board provides an inverted WAIT signal to halt the Z80. This basically keeps the two units in synchronisation.



The printer/plotter interface board complete and ready for plugging into the TEC & printer.

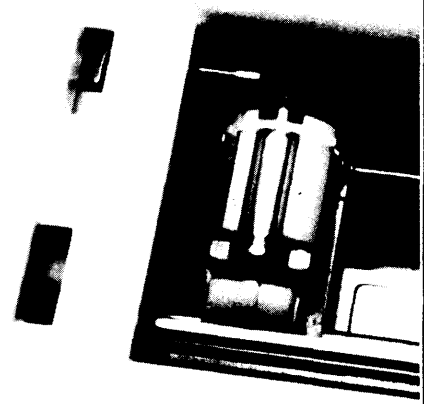
Set out all the parts on your bench and check everything. Solder the sockets, cap and 6 jumper links to the board. Mount the wire-wrap socket through the board so that the long pins act as 'stand-offs' for the component header plug. See the RELAY DRIVER BOARD article and photos for details of how this is done.

The final task involves connecting the board to the 36 pin Centronics plug.

WIRING THE PLUG

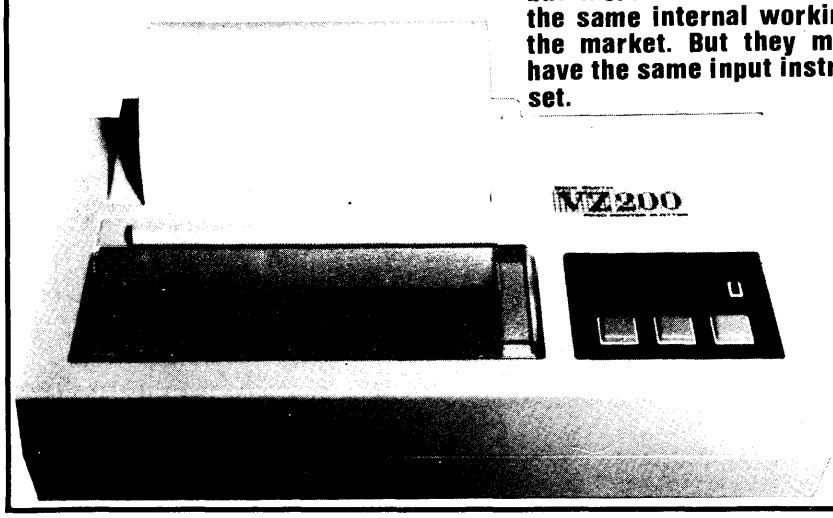
Wiring the Centronics-types plug to the printer interface is very easy. On the printer interface PC board there are 24 holes. Twelve of these are numbered. These numbers correspond to the numbers on the Centronics plug. Solder a length of hook-up wire between each hole and a corresponding hole on the connector plug. Pin 10 is not used, so no lead is needed. It is not necessary to use special connecting flex such as twisted pairs or screened lead. Our prototype worked perfectly with ordinary hook-up flex. It's best to use different coloured flex for each line to make tracing easier. These leads can be about 50 cm long and kept together with ties or tape at regular intervals.

The pens use water-based ink and tend to dry-out fairly easily. If they fail to start: open them up, add a drop of water, heat them up and fit them back into the printer.



A close-up of the 4-pen print head.

We used a VZ 200 printer/plotter but there are other units with the same internal workings on the market. But they may not have the same input instruction set.



The only remaining wires left are the 3 control lines. These are:

Memory select 03,
I/O select 06, and
WAIT.

These are fitted with 'quick connect' terminals which push onto matrix pins on the main PC board. Heat-shrink tubing can be placed over the terminals to strengthen the solder joint and make them easier to handle.

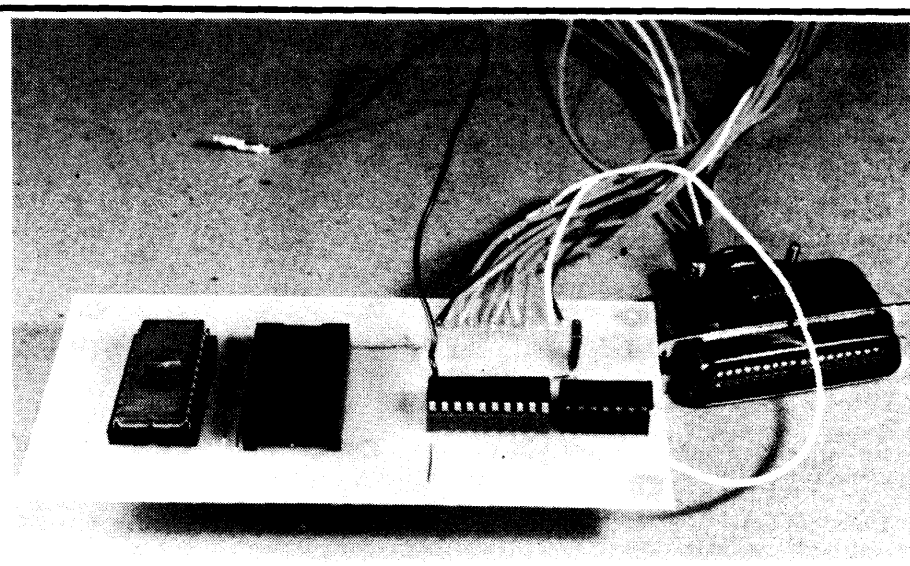
When the printer is first turned on it runs through an initial program (from its internal memory) which feeds the paper, sets the pen colours and starts the ink flowing by producing a box with each pen.

After this, there is very little else you can do via the buttons on the unit, except forward feed, change the colour of the pens and/or remove them.

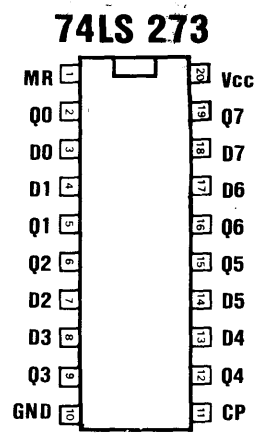
All the rest of the action must come in the form of data from an outside source.

This is why we need the TEC. It supplies data at high speed to get the print-head moving.

Connect the centronics plug into the rear of the printer and fit the PRINTER INTERFACE PC BOARD to the computer. Connect the 3 flying leads as shown in the diagram:

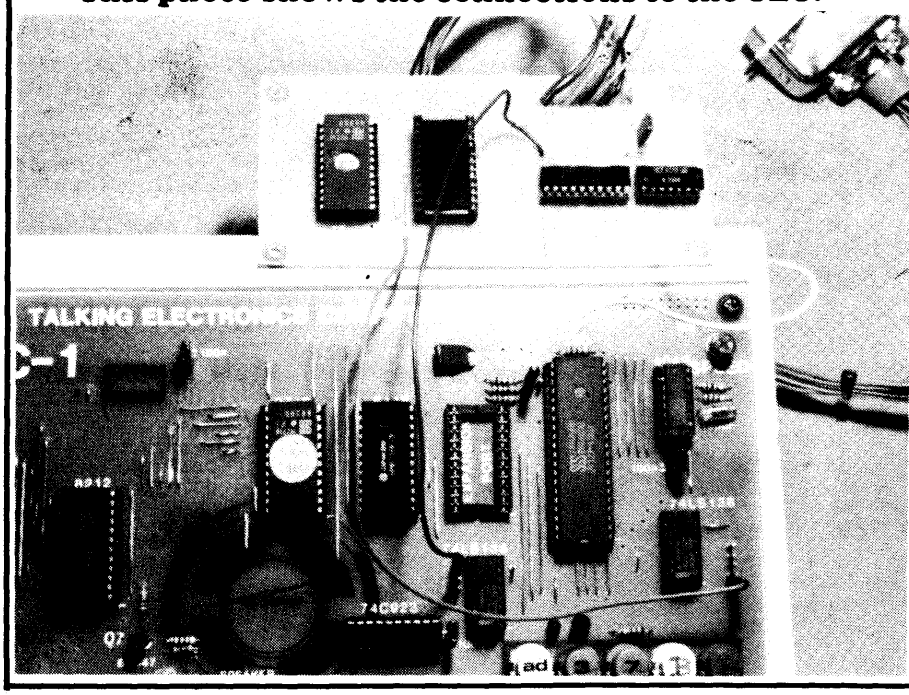


All the parts shown are included in the kit.



Pin-out for 74LS273

This photo shows the connections to the TEC.



To get something interesting out of the printer you will need to send it a program. The first of these is:

KEN's START-UP PROGRAM:

Make sure the print-head is to the left of the printer as when the printer has been switched on.

Push **ADdress 18A0 GO GO.**

Watch the result.

This type of program is beyond us at the moment but you will be capable of similar effects after reading this article.

For now, the next step is to be able to get letters and characters onto the paper.

PRODUCING LETTERS etc. . .

All information is fed to the printer in ASCII code. If you want a particular character, the correct code must be sent to the printer. Even if you want to send a number to the printer, such as 150, you must send it in the form of ASCII. This means 150 translates to 31 35 30, as you will see later from the table.

A small program is required to interpret your button pushing and send it to an output port. This is similar to making a segment on the display illuminate and the program for this is contained in the PRINTER/ PLOTTER EPROM at 1980.

To use this program:

Press **ADdress 1980 GO GO**

The display will go blank and the TEC will be ready for conveying your key-board instructions directly to the printer.

Each of the letters, numbers and symbols is shown in the table below and the corresponding hex value must be used for the symbol to appear on the paper.

Try obtaining all the letters, numbers and characters by following through the table.

PRINTER/PLOTTER ASCII VALUES:

SPACE 20	0 30	@ 40	P 50	` 60	p 70
BACK SPACE 08	! 21	1 31	A 41	Q 51	a 61	q 71
LINE FEED 0A	" 22	2 32	B 42	R 52	b 62	r 72
CR 0D	# 23	3 33	C 43	S 53	c 63	s 73
DC1 11	$ 24	4 34	D 44	T 54	d 64	t 74
DC2 12	% 25	5 35	E 45	U 55	e 65	u 75
NEW COLOUR 1D	& 26	6 36	F 46	V 56	f 66	v 76
	' 27	7 37	G 47	W 57	g 67	w 77
	(28	8 38	H 48	X 58	h 68	x 78
	) 29	9 39	I 49	Y 59	i 69	y 79
	* 2A	: 3A	J 4A	Z 5A	j 6A	z 7A
LINE BEFORE 0B	+ 2B	; 3B	K 4B	[5B	k 6B	{ 7B
	, 2C	< 3C	L 4C	\ 5C	l 6C	| 7C
	- 2D	= 3D	M 4D	] 5D	m 6D	} 7D
	. 2E	> 3E	N 4E	^ 5E	n 6E	~ 7E
	/ 2F	? 3F	O 4F	_ 5F	o 6F	⊠ 7F

Try the following sequence and you will see a word appear:
49 4E 43 52 45 44 49 42 4C 45

For the hex value **49**, the letter I will be printed. Press each number only ONCE. The first press will appear to have no effect, but as soon as the second button is pressed, the letter I will be printed.

Be very careful not to press button-sequence **11** or **12** as this will cause the mode to change and everything will appear to 'lock-out'.

Try writing a sentence using the hex key pad. It's slow but eventually gets you there. A space between words is created by typing **20.**

Any sentence you send to the printer via the keyboard can be re-presented again and again if placed into memory before-hand. It can also be corrected and adjusted (within limits). To do this, place the data at **0800** and call a program at **1880.**

Insert the following at **0800:**

49 4E 43 52 45 44 49 42 4C 45 20 20 48 55 4C 4B 0D 0A 1D FF.

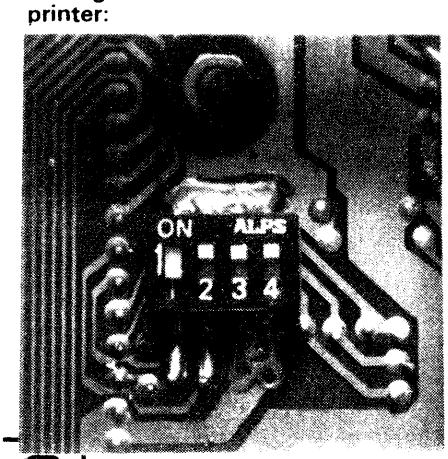
Push **ADdress 1880 GO GO.**

Recall it again by pressing:
ADdress 1880 GO GO.

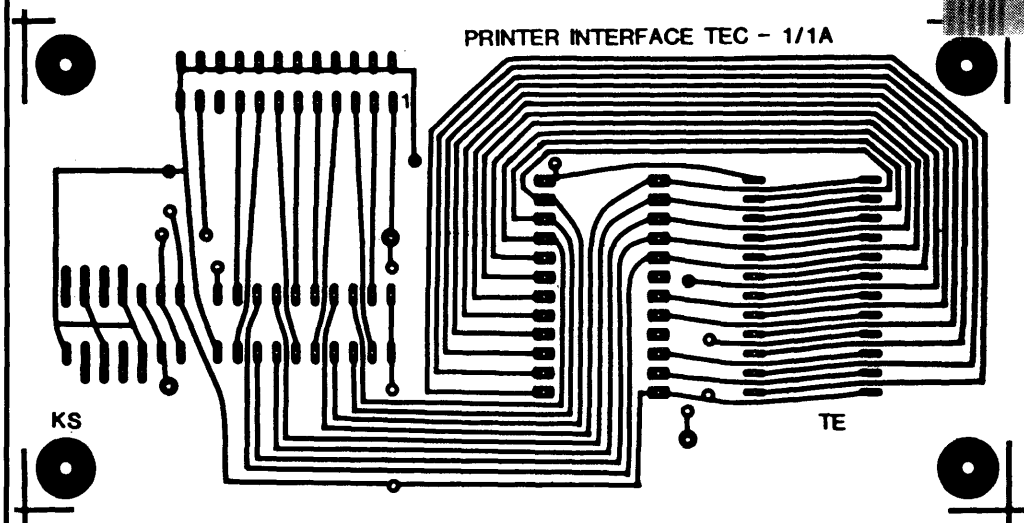
THE LIST PROGRAM

This program lists any part of the EPROM, RAM or any additional memory you add to your TEC. In fact the first thing you can do is get a print-out of your MONitor ROM. Many readers have written requesting a listing of the MONitor and now they can produce it themselves.

But before you can get a listing, you must make a modification to the operation to the printer. This involves setting the two switches under the printer:



PRINTER INTERFACE TEC - 1/1A



The PC layout for the Printer/Plotter. The overlay and parts positioning can be gained from the photo on P 31.

This is how to do it.

On the bottom of the printer is a small plate. Undo the screws and remove the plate. Inside you will find a bank of 4 switches. Switch 1 should be in the OFF position and switch 2 in the ON position. Don't worry about switch 3 and 4.

When the switches are set like this, CR (carriage Return) will set the print-head to the left of the paper without feeding the paper forward. The paper can then be fed forward by using LF (Line Feed). The switches should be set like this because the program in ROM automatically line feeds after each carriage return. If the switches are not set like this, the typing will be double line spaced.

Enter the following into the TEC:
ADdress 1800 GO GO:

The display will go blank and the printer will CR and LF. Now enter **0000** and the printer will start printing out characters in pairs. This is a listing of the contents of your monitor ROM.

If you want a listing of any of the programs you have typed into memory, start at **0800** or where your program starts, and enter a 4-digit number into the keyboard. It must be 4 digits, so don't forget the leading 0.

The text mode is not very interesting. After all, we have seen electric/electronic typewriters for years, But for a print-head to produce GRAPHICS! That's different!

GRAPHICS MODE

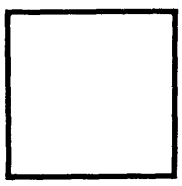
The program at **1880** can also be used to generate graphics on the printer.

Remember, all information must be programmed into the printer in ASCII.

Type the program below into the TEC's memory at **0800.** An **FF** is placed after the last piece of data to signify the end of a program. Now run the program at **1880** by pressing **ADdress 1880 GO GO.**

at 0800: 0A 0D 12 49 2C 44 38 30 2C 30 2C 38 30 2C 2D 38 30 2C 30 2C 2D 38 30 2C 30 2C 30 0D FF.

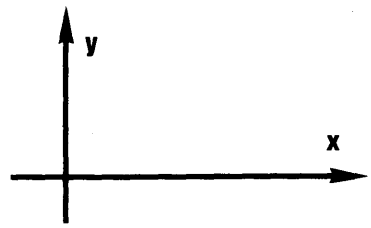
The printer will draw a square.



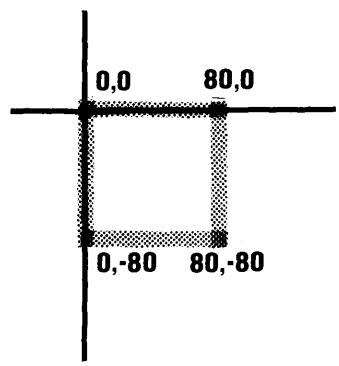
Look at the listing. It may look complex but can be easily decoded using the table. It will decode to this:

OA = LF = Line Feed.
OD = CR = Carriage Return
12 = DC2 = Graphic Mode
49 = I = sets the pen's location as co-ordinates 0,0.
2C = , =Separates I from D
44 = D = draw from present location to the co-ordinate given by the next byte(s) of data.
38 = 8
30 = 0
2C = ,
30 = 0
2C = ,
38 = 8
30 = 0
2C = ,
2D = -
38 = 8
30 = 0
2C = ,
30 = 0
2C = ,
2D = -
38 = 8
30 = 0
2C = ,
30 = 0
2C = ,
30 = 0
OD = CR = carriage return
FF = signifies end of program.

The printer uses a co-ordinate system exactly like the x,y axis used to draw graphs. The origin is 0,0 (or 00,00) and the positive direction of x and y is shown on the diagram.



The co-ordinates of the corners of the box are shown in this diagram. This clearly shows how the values are obtained.



The program can be separated into 4 sections, each drawing one side of the box.This will show how the program goes together.

The following program produces the top of the square:

at 0800 type: **0A 0D 12 49 2C 44 38 30 0D FF.**

ADdress 1880 GO GO.

The result will be:

Let us produce a line the full width of the paper. For this you will need a 3-digit value. The printer is capable of accepting a value as high as 999 (also -999) but this will be too high for our width of paper. Try 300.

The ASCII value is 33 30 30.

at **0800:**
0A 0D 12 49 2C 44 33 30 30 2C 30 0D FF.
Press **ADdress 1880 GO GO.**

The final **0D** is important to get the printer to execute the graphics command.

The value **300** will not quite reach the far side of the paper. Try **450.** This will be about the longest line possible and don't forget to use the ASCII values in the program.

Shorten the side of the box to 80 and continue with the experiment.

The second side of the box will be produced at an angle other than 90° by inserting the following co-ordinates: 50, -80

at **0800:**
0A 0D 12 49 2C 44 38 30 2C 30 2C 35 30 2C 2D 38 30 0D FF.

Run the program. Does it produce two sides of an irregular figure?

The next side will be produced as follows:

0A 0D 12 49 2C 44 38 30 2C 30 2C 35 30 2C 2D 38 30 2C 31 35 30 2C 2D 38 30 0D FF.

Run the program and see the result.

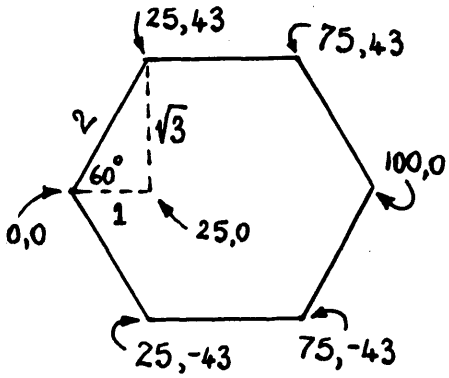
Finally:
0A 0D 12 49 2C 44 38 30 2C 30 2C 35 30 2C 2D 38 30 2C 31 35 30 2C 2D 38 30 2C 0A 0D 11 1D 0D FF.

Produce other shapes and you will understand how to plot co-ordinates.

HEX

The second shape we will investigate is a HEXAGON.

To produce this shape you need to know the value of the internal angle and produce a 30° 60° 90° triangle as shown. This will give you the length of the sides of the triangle and from this the first set of co-ordinates can be obtained (25,43) These values are 1/4 of 100, 173, which are the lengths of the sides of the triangle.

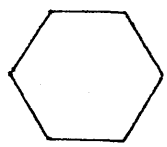


The second co-ordinate, 75,43 is found by adding 50 to the value 25. Continue around the hex shape until the figure is closed.

This is the listing for the printer:

at 0800:

```
12 49 0D 44 32 35 2C 34 33 2C 37
35 2C 34 33 2C 31 30 30 2C 30 2C
37 35 2C 2D 34 33 2C 32 35 2C 2D
34 33 2C 30 2C 30 0D FF.
```



0's and X's

The new instruction with this shape is the MOVE command.— 4D

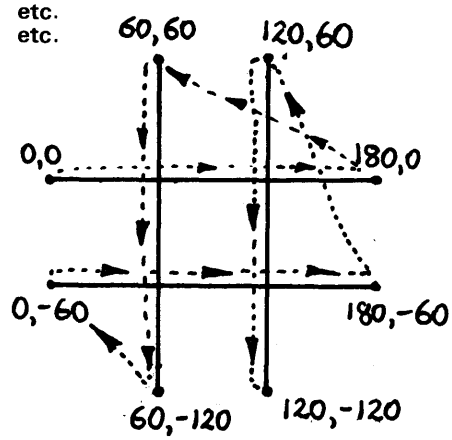
This instructs the pen to lift from the page and move to a specified location without drawing on the paper.

Here is the listing and the shape which will be drawn:

```
0800 0A 0D 12 49 0D 44 31 38
0808 30 2C 30 0D 4D 36 30 2C
0810 36 30 0D 44 36 30 2C 2D
0818 31 32 30 0D 4D 30 2C 2D
0820 36 30 0D 44 31 38 30 2C
0828 2D 36 30 0D 4D 31 32 30
0830 2C 36 30 0D 44 31 32 30
0838 2C 2D 31 32 30 0D FF
```

This is a decoding of the first part of the listing. This will be sufficient to understand how the program is written.

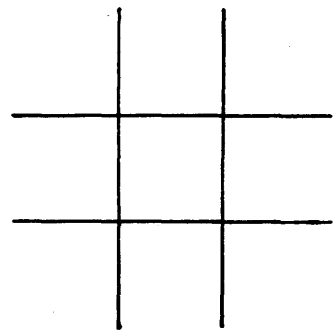
0A = LF =Line Feed
0D = CR =Carriage Return
12 = DC2 = Graphics Mode
49 = I = initialize the co-ords 0,0
0D = CR = signifies the end of the previous command. It does not cause the carriage to return but enables the previous command to be carried out.
44 = D = Draw
31 = 1
38 = 8
30 = 0
2C = ,
30 = 0
0D = CR = end of draw statement.
4D = M = Move. The pen is instructed to move without drawing.
36 = 6
30 = 0
2C = ,
36 = 6
30 = 0
0D = CR End of Move statement.
44 = D = Draw
36 = 6
30 = 0
etc.
etc.



This diagram shows the value of the co-ordinates required to draw the shape.

Copy out the complete listing and decode it to prove that the path taken by the print-head is as shown in the diagram.

ADdress 1880 to use.



WAR GAMER'S DELIGHT

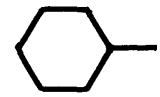
The full impact of this effect is shown on the next page.

The first thing you notice about the program is a set of values at the beginning which the printer does not recognise. This means they must be Machine Code values for an 'operations' program for the Z80. And they are.

The program produces a honey-comb pattern.

Anyone into war games will soon recognise the possibilities of the honey-comb as a playing board. The reason is each block has 6 borders, increasing the possible moves and thus the strategy, over a regular field of squares.

This shape is created using a picture element of a hexagon attached to a straight line thus:



This pattern is repeated 4 times across the paper and then a move to a new starting point -450,-86 down the paper.

The co-ordinates of the new starting point can be explained as follows:

After each picture element is drawn, the printer is initialized. This means that the present co-ordinate of the pen is taken as 00,00.

This gives us a value of 450,00 for the commencement of the 4th picture element with reference to the origin.

The next row of hexagons commence at the left-hand edge, which is -450 with reference to the above X co-ordinate and a y value of -86, with reference to the y value above.

The only way to understand how the honey-comb has been produced is to decode the listing.It contains two loops, one to draw the picture element and the other to count-to-4 across the screen.

Write each of the ASCII codes in a single file and alongside it place the printer value it represents.

You can experiment further by making the hexagons smaller. This will use a 2-digit ASCII value for the length of the sides. In the program, the original 3-digit ASCII values have been converted to 2-digit by using 00 for the 3rd value.

The first 18H bytes (31 bytes is the MAIN program and this contains the instructions to fetch one byte of data from the printer program and send it to the printer.

Data for the printer is stored in the form of a BYTE TABLE and starts at **0820.**

The main program is divided into two separate parts. **0800 - 080F** is a loop which loads the printer program and runs it 4 times.

811 - 81D loads the data for the MOVE commands and each piece of data is sent to the printer until **FF** is detected.

The count-to-4 operation is performed by **DJNZ** (at **80F**) which automatically decrements register B by ONE on each pass of the loop until it becomes zero.

The program then advances to loading HL register-pair with the contents of memory location **0860** and this instruct the print-head to move to the left-hand edge and down the paper to a new starting point. The main program then jumps to the start (**0800**) via instruction **JR Z E7** (at **817**).

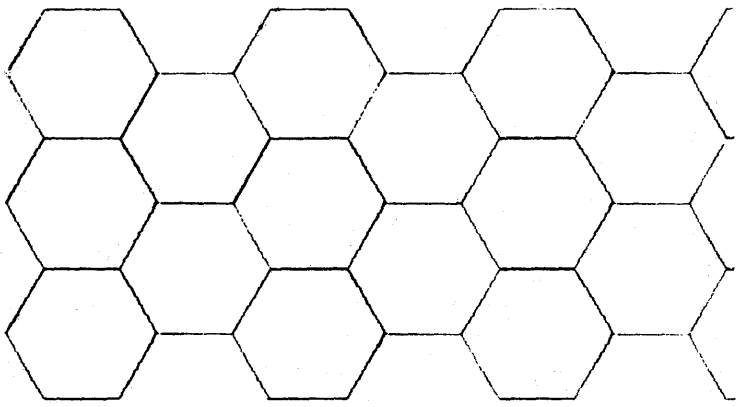
800	06	LD B,04
801	04	
802	21	LD HL,0820
803	20	
804	08	
805	7E	LD A,(HL)
806	FE	CP FF
807	FF	
808	28	JR Z 05
809	05	
80A	D3	OUT (06),A
80B	06	
80C	23	INC HL
80D	18	JR F6 (to 805)
80E	F6	
80F	10	DJNZ F1 (to 802)
810	F1	
811	21	LD HL 0860
812	60	
813	08	
814	7E	LD A,(HL)
815	FE	CP FF
816	FF	
817	28	JR Z E7 (to start)
818	E7	
819	D3	OUT (06),A
81A	06	
81B	23	INC HL
81C	18	JR F6 (to 814)
81D	F6	
81E	FF	NOT USED
81F	FF	NOT USED

DATA FOR PRINTER:

820	12	Graphics Mode
821	49	Initialize
822	0D	CR
823	44	Draw
824	32	2
825	35	5
826	2C	,
827	34	4
828	33	3
829	2C	,
82A	37	7
82B	35	5
82C	2C	,
82D	34	4
82E	33	3
82F	2C	,
830	31	1
831	30	0
832	30	0
833	2C	,
834	30	0
835	2C	,
836	37	7
837	35	5
838	2C	,
839	2D	-
83A	34	4
83B	33	3
83C	2C	,
83D	32	2
83E	35	5
83F	2C	,
840	2D	-
841	34	4
842	33	3
843	2C	,
844	30	0
845	2C	,
846	30	0
847	0D	CR
848	4D	Move
849	31	1
84A	30	0
84B	30	0
84C	2C	,
84D	30	0
84E	0D	CR
84F	44	Draw
850	31	1
851	35	5
852	30	0
853	2C	,
854	30	0
855	0D	CR
856	FF	End

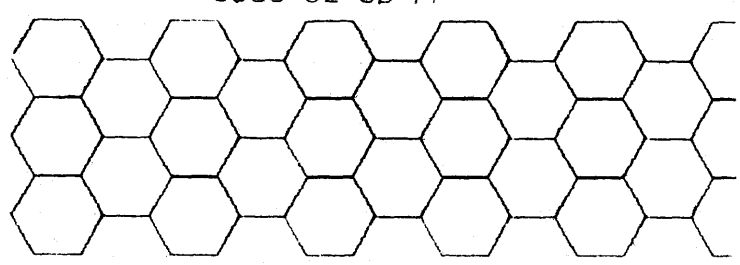
Data for MOVE COMMANDS:

860	4D	Move
861	2D	-
862	34	4
863	35	5
864	30	0
865	2C	,
866	2D	-
867	38	8
868	36	6
869	0D	CR
86A	FF	End

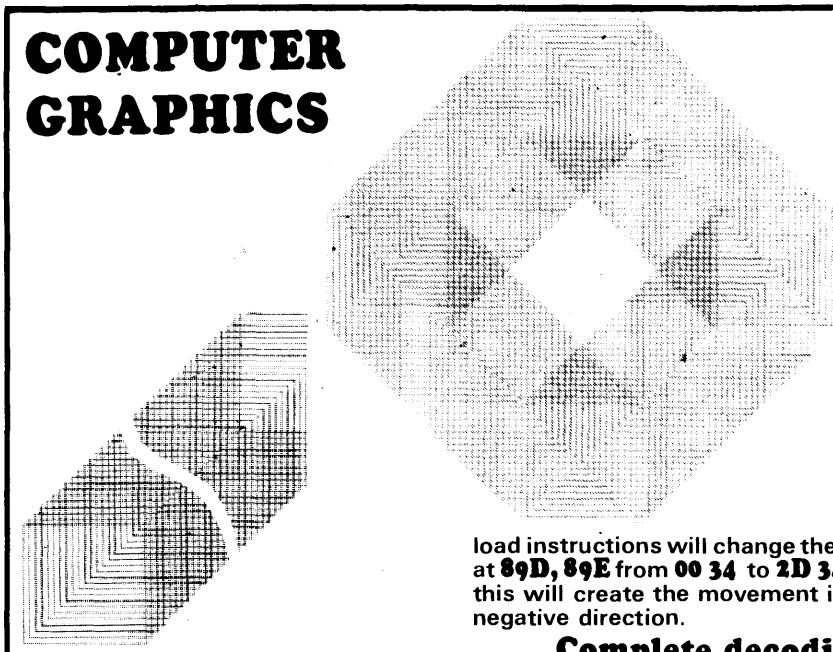


```
0800 06 04 21 20 08 7E FE FF
0808 28 05 D3 06 23 18 F6 10
0810 F1 21 60 08 7E FE FF 28
0818 E7 D3 06 23 18 F6 FF FF
0820 12 49 0D 44 32 35 2C 34
0828 33 2C 37 35 2C 34 33 2C
0830 31 30 30 2C 30 2C 37 35
0838 2C 2D 34 33 2C 32 35 2C
0840 2D 34 33 2C 30 2C 30 0D
0848 4D 31 30 30 2C 30 0D 44
0850 31 35 30 2C 30 0D FF FF
0858 FF FF FF FF FF FF FF FF
0860 4D 2D 34 35 30 2C 2D 38
0868 36 0D FF
```

```
0800 06 06 21 20 08 7E FE FF
0808 28 05 D3 06 23 18 F6 10
0810 F1 21 60 08 7E FE FF 28
0818 E7 D3 06 23 18 F6 FF FF
0820 12 49 0D 44 31 35 2C 32
0828 36 2C 34 35 2C 32 36 2C
0830 00 36 30 2C 30 2C 34 35
0838 2C 2D 32 36 2C 31 35 2C
0840 2D 32 36 2C 30 2C 30 0D
0848 4D 00 36 30 2C 30 0D FF
0850 39 30 00 2C 30 0D FF FF
0858 FF FF FF FF FF FF FF FF
0860 4D 2D 34 35 30 2C 2D 35
0868 32 0D FF
```



COMPUTER GRAPHICS



800	06	06	3E	0A	D3	06	10	FC
808	3E	12	D3	06	11	60	08	06
810	08	C5	06	04	21	80	08	7E
818	FE	FF	CA	23	08	D3	06	23
820	C3	17	08	10	EF	3E	11	D3
828	06	3E	1D	D3	06	AF	D3	06
830	3E	12	D3	06	C1	10	DA	1A
838	FE	FF	C2	42	08	3E	11	D3
840	06	C7	32	9A	08	13	1A	32
848	9B	08	13	1A	32	9D	08	13
850	1A	32	9E	08	13	C3	0F	08
858	00	FF	00	FF	00	FF	00	FF
860	00	34	2D	34	2D	34	2D	34
868	2D	34	00	34	FF	FF	FF	FF
870	FF	FF	FF	FF	FF	FF	FF	FF
878	FF	FF	FF	FF	FF	FF	FF	FF
880	49	2C	44	38	30	2C	30	2C
888	38	30	2C	2D	38	30	2C	30
890	2C	2D	38	30	2C	30	2C	30
898	0D	4D	00	34	2C	00	34	0D
8A0	FF	FF	FF	FF	FF	FF	FF	FF

The Machine Code listing required to produce the DIAMOND.

load instructions will change the data at **89D, 89E** from **00 34** to **2D 34** and this will create the movement in the negative direction.

Being able to draw some of the basic shapes (as we have shown), opens up a whole new world of computer graphics.

If we take the box-shape, we can produce a very effective pattern simply by re-defining the start co-ordinates and repeating the shape many times. The result can be anything from a 'check-tie' to an irregular octogon.

The colourful patterns which can be obtained (of which we can only see the result in black and white) is produced by a combination of drawing, shifting and colour-changing. The first of these to be investigated will be an irregular octogon or DIAMOND.

We have already outlined the structure of the program and briefly it is a set of instructions which are loops. Each sets a particular condition and then decrements on each pass.

For the diamond shape, a square is generated at the origin, 00,00 via the program at **0880. The lengths of the sides of the square are 80.** When the 4 sides have been drawn, the pen lifts off the paper and moves to a new origin with co-ordinates 04,04. The program is now up to location **083C.** It then jumps to **0842.** The contents of the accumulator (which is the value at location **0860** i.e. **00**) is loaded into **089A.** Register pair DE is incremented and now looks at location **0861.** The value **34** is loaded into the accumulator. At **0847** the contents of the accumulator is loaded into location **089B.**

So far, the program at **0880** has not been altered but the next two sets of

Complete decoding of the above listing, with explanations.

800	06	06	LD B,06	Load B with 6
802	3E	0A	LD A,0A	Load A with the Forward Feed instruction
804	D3	06	OUT (06),A	OUT to the printer port
806	10	FC	DJNZ 0804	create 6 loops of forward feed
808	3E	12	LD A,12	Select the Graphics Mode
80A	D3	06	OUT (06),A	OUT to the printer
80C	11	60 08	LD DE,0860	Load DE with start of Direction Change TABLE
80F	06	08	LD B,08	Sets number of colour changes before a direction change
811	C5		PUSH BC	Save B. B must be paired with C to be saved
812	06	04	LD B,04	Sets number of squares for each colour
814	21	80 08	LD HL,0880	Load HL with start of DRAWING TABLE
817	7E		LD A,(HL)	Load the data at 880 into A
818	FE	FF	CP FF	detects end of TABLE
81A	CA	23 08	JP Z,0823	At end of table, jump to 823
81D	D3	06	OUT (06),A	OUT data value at 880 to printer
81F	23		INC HL	Increment to 881, 882 etc
820	C3	17 08	JP 0817	Jump to 817 to increment through Drawing Table
823	10	EF	DJNZ 0814	Loop DRAWING TABLE 4 times
825	3E	11	LD A,11	Change to TEXT MODE
827	D3	06	OUT (06),A	OUT to printer
829	3E	1D	LD A,1D	NEXT COLOUR
82B	D3	06	OUT (06),A	OUT to printer
82D	AF		XOR A	Clear A
82E	D3	06	OUT (06),A	OUT to printer
830	3E	12	LD A,12	Select GRAPHICS MODE
832	D3	06	OUT (06),A	OUT to printer
834	C1		POP BC	Get B from STACK. Actually BC.
835	10	DA	DJNZ 0811	Decrement B and jump to 811 for 6 loops
837	1A		LD A,(DE)	Load A with data at 860 etc
838	FE	FF	CP FF	Detects end of DIRECTION CHANGE program
83A	C2	42 08	JP NZ,0842	If not zero, jumps to 842
83D	3E	11	LD A,11	If zero, change to TEXT MODE
83F	D3	06	OUT (06),A	OUT to printer
841	C7		RST 0	END OF PROGRAM.★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★
842	32	9A 08	LD (089A),A	Load first byte of Dircetion Change table into location 089A
845	13		INC DE	Increment DIRECTION CHANGE table
846	1A		LD A,(DE)	Load next byte of Direction Change table into A
847	32	9B	LD (089B),A	Load this byte into location 089B
84A	13		INC DE	Increment the DIRECTION CHANGE table
84B	1A		LD A,(DE)	Load the third byte into the accumulator
84C	32	9D 08	LD (089D),A	Load this third byte into loaction 089D
84D	13		INC DE	Increment the DIRECTION CHANGE TABLE
84E	1A		LD A,(DE)	Load the fourth byte of the direction change table into A
84F	32	9E 08	LD (089E),A	Load this fourth byte into location 089E
850	13		INC DE	Increment the DIRECTION CHANGE table ready for next
851	C3	0F 08	JP 080F	Jump to 80F to commence the next direction

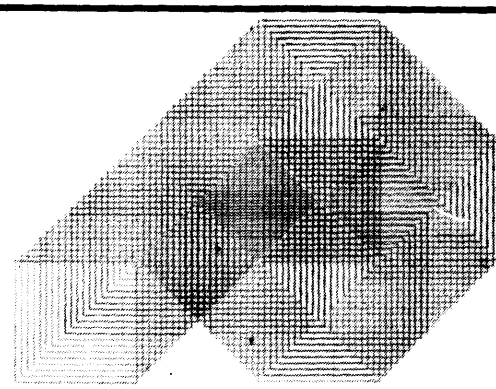
The program will then jump to **80F** and draw the second side of the diamond.

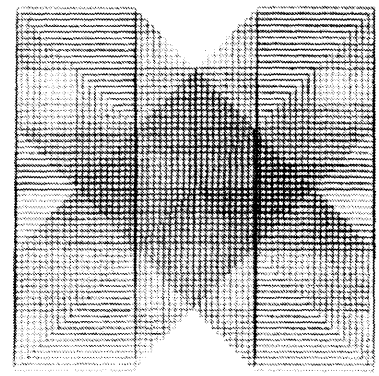
On the next pass, the register pair DE will be looking at locations **0864, 0865, 0866,** and **0867.** This will change locations **089A, 089B, 089D** and **089E** to **2D 34 2D 34** and thus the third side of the diamond will be drawn.

Via the same reasoning, the 4th side of the diamond will be completed.

Try experimenting and changing this program to produce other patterns. We have included two examples on the right and will be continuing with these and more 'add-ons' in the next issue.

The aim of COMPUTER GRAPHICS is to be able to produce 'forms' and ruled work for invoices etc. and place information in correct locations. It also gives you an understanding of ROBOT movement, an area we all would like to investigate.





```
860  00  0        880  49  = I      88C  38  = 8      898  0D  = CR
861  34  4        881  2C  = ,      88D  30  = 0      899  4D  = Move
862  2D  -        882  44  = Draw   88E  2C  = ,      89A  00  = 0
863  34  4        883  38  = 8      88F  30  = 0      89B  34  = 4
864  2D  -        884  30  = 0      890  2C  = ,      89C  2C  = ,
865  34  4        885  2C  = ,      891  2D  = -      89D  00  = 0
866  2D  -        886  30  = 0      892  38  = 8      89E  34  = 4
867  34  4        887  2C  = ,      893  30  = 0      89F  0D  = CR
868  2D  -        888  38  = 8      894  2C  = ,      8A0  FF  = end
869  34  4        889  30  = 0      895  30  = 0
86A  00  0        88A  2C  = ,X     896  2C  = ,
86B  34  4        88B  2D  = -      897  30  = 0
```

The Direction Change table and Drawing table with decoded values.

MON-1B

LOOKING AT THE REGISTERS

The MONITOR ROM for the TEC-1A (it can also be fitted to the TEC-1) is a MON-1B. This ROM has the facility for looking at the registers.

This ROM is the result of a number of requests from readers who needed to look at the contents of the various registers during the running of a program.

If you would like one of these updated ROMs, send your MON-1 or MON-1A plus $3.00 postage and we will re-burn your EPROM to include the additional instructions.

There is a limit to when and where you can use the register facility but it can help enormously with debugging programs.

For instance, it can let you know the progress of a program or delay routine simply by interrupting it part way through.

The way this facility works is as follows:

If you reset the computer while it is executing a program, by pressing the reset button ONCE, the contents of each of the registers is pushed onto a stack.

This stack starts at **0FF0** and increases downwards to **0FD8.**

To look at any of the registers, press reset once and key the address of the register you want to look at.

The following list identifies the location of each register:

Mem ADD:	Reg:
0FF0	
0FEF	A
0FEE	F
0FED	B
0FEC	C
0FEB	D
0FEA	E
0FE9	H
0FE8	L
0FE7	IX MSB
0FE6	IX LSB
0FE5	IY MSB
0FE4	IY LSB
0FE3	A'
0FE2	F'
0FE1	B'
0FE0	C'
0FDF	D'
0FDE	E'
0FDD	H'
0FDC	L'
0FDB	I
0FDA	-
0FD9	Stack Pointer MSB
0FD8	Stack Pointer LSB

Note: Reset clears the I register and thus it will always equal 00.

Use **JP 0000** if you wish to look at **I.**

An alternate method of saving the registers is to insert a **JP 00 00** instruction in the program at the position you wish to investigate. This will cause a JUMP to the beginning of the MONITOR ROM where it will find a jump to the register-save routine.

This will enable you to exit a program at a pre-determined point and look at the registers. The contents will be shown in the data displays.

Pushing Reset twice will destroy the information.

This is the program at **05F0** which performs the 'REGISTER-SAVE' operation. Don't forget the Monitor ROM has an instruction at 0000 to Jump to **05F0.**

```
05F0   ED   LD (0FD8),SP
05F4   31   LD SP,0FF0
05F7   F5   PUSH AF
05F8   C5   PUSH BC
05F9   D5   PUSH DE
05FA   E5   PUSH HL
05FB   DD   PUSH IX
05FD   FD   PUSH IY
05FF   08   EX AF,AF'
0600   D9   EXX
0601   F5   PUSH AF
0602   C5   PUSH BC
0603   D5   PUSH DE
0604   E5   PUSH HL
0605   ED   LD A,I
0607   F5   PUSH AF
0608   C3   JP 0580
060B   FF   RST 38H
```