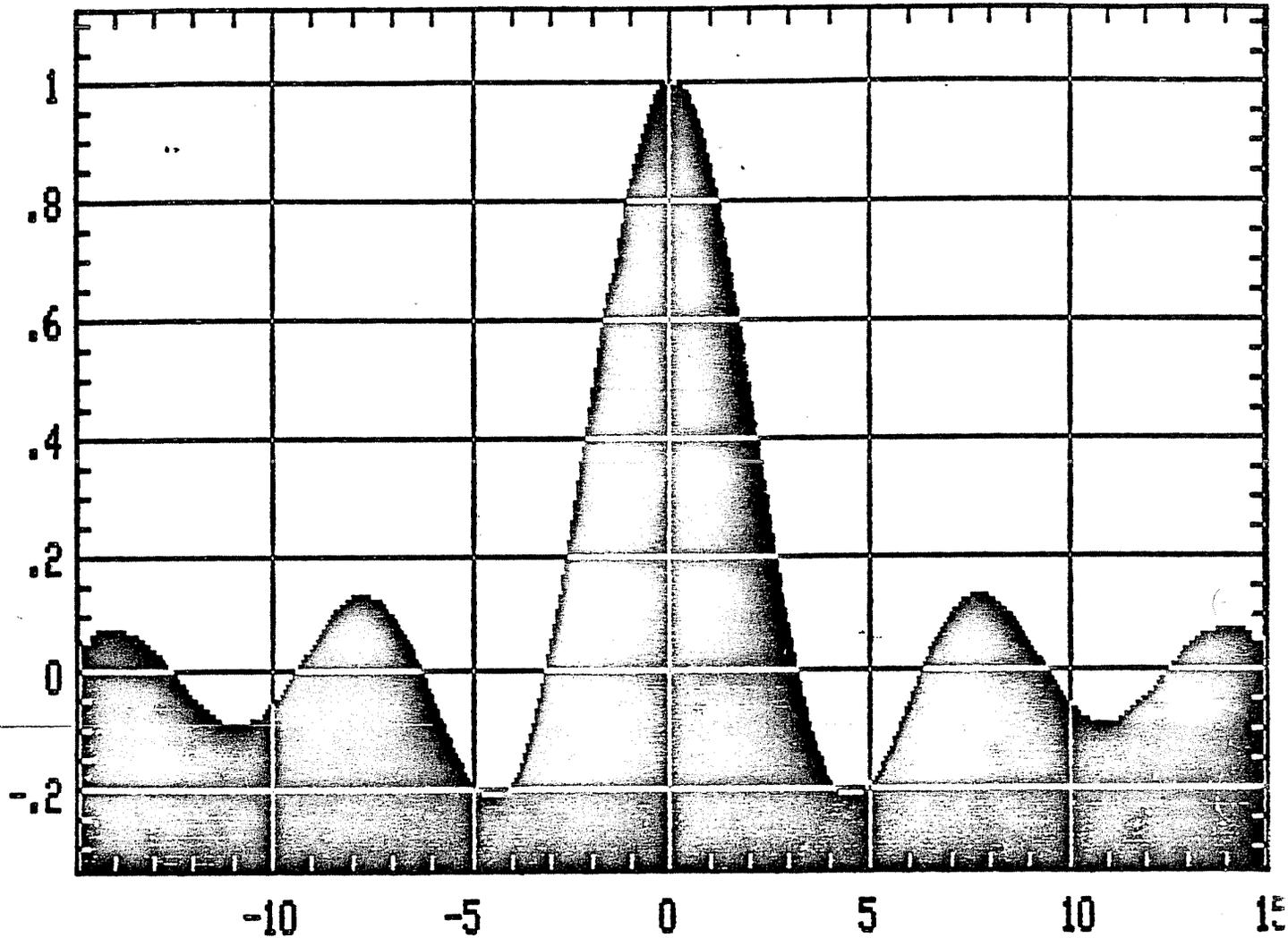


AUTO PLOT

VERSION 2.2

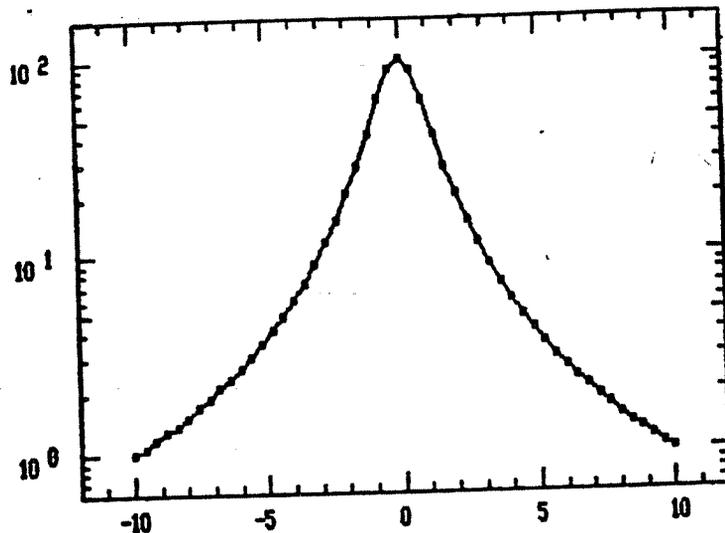


Automatic Curve-Plotter

for the TRS-80 Model I or Model III

and EPSON MX-80 Printer with GRAFTRAX

RETURN TO L PRINT



This graph was produced with less than two dozen keystrokes on a TRS-80 Model I with EPSON MX-80 printer plus GRAFTRAX.

YOU CAN DO IT TOO WITH **AUTO PLOT**, the sensational automatic curve plotter written in BASIC + fast machine language.

- Plot functions $y=f(x)$, $x=f(y)$, or $x=f(v)$, $y=g(v)$
- Plot data from keyboard or disk file
- Linear or logarithmic presentation
- Numeric integration or differentiation
- Automatic scaling and labelling of axes
- 4 different print sizes and formats
- Many more features

AUTO PLOT for TRS-80

(Model I or III with 48k, 1 disk drive)

on disk with 40 page manual \$79.50

AUTO PLOT for LNW-80

(+Hi-Res video graphics) \$99.50

CA. residents add 6% sales tax

Phone orders, VISA and MASTERCARD welcome

MENLO SYSTEMS

3790 El Camino Real, Suite 221
Palo Alto, CA. 94306, Tel. (415) 327-7424

TRS-80: TM of Tandy Corp. MX-80, GRAFTRAX: TM of EPSON Inc.

AUTO PLOT Automatic Curve-Plotter

Copyright (C) T. W. Hansch, Sept. 1981

Features:

- * Plots graphs of professional quality effortlessly
- * Plots any curve which can be described by a mathematical function
 $y = f(x)$, or
 $x = f(y)$, or
 $x = f(v): y = g(v)$.
- * Plots data from keyboard or disk file
- * Plots multiple curves
- * Graphics resolution: 480 x 192 dots.
- * Linear or logarithmic presentation
- * Numeric integration or differentiation.
- * Axes are automatically scaled and labelled
- * Optional grid overlay
- * 4 different print sizes and formats
- * Many other features

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1. WHAT HARDWARE IS REQUIRED?

AUTO PLOT is a highly automated curve-plotting program, written in user-friendly BASIC, and enhanced by fast machine language routines TGRAPH/CIM in high memory.

The standard versions of AUTO PLOT are written for the Radio Shack TRS-80 Model I or Model III microcomputer with level II BASIC, 48k RAM, and at least one disk drive. The machine language routines TGRAPH/CIM use RAM from B9F0 to EFFF (47600 to 61439 decimal), leaving the top 4k available for special drivers or user routines.

To produce high resolution graphics plots, AUTO PLOT requires an EPSON MX-80 or MX-80 F/T printer with GRAFTRAX 80 bit plot option.*

The programs for TRS-80 model I and model III are identical. However, if you own a model III, and if you forgot to specify the model number when ordering AUTO PLOT, you will have received a diskette in single-density format. You can still run AUTO PLOT on your machine if you convert the programs to double-density format. The TRS-DOS operating system provides the CONVERT routine for this purpose. Unfortunately, CONVERT requires two disk drives. If you only own one disk drive, you may want to enlist the help of a friend or a local Radio Shack store for the conversion.

* The GRAFTRAX PROMS for the EPSON MX-80 printer are available as a retrofit kit from many distributors. To find a dealer near you, contact

EPSON AMERICA INC.
3415 Kashiwa Street
Torrance, CA. 90505
(213) 539 9140

2. GETTING STARTED

At this time, the EPSON MX-80 printer with GRAFTRAX dot graphics should be connected to the parallel printer port of TRS-80 Model I or Model III microcomputer, the DIP switches inside the printer should be set as shown in APPENDIX A, and the printer should be turned on.

In order to use AUTO PLOT, we must first load the machine language routines TGRAPH/CIM into high memory, then request Disk Basic with a memory size of 47500 or less, and finally load and run the BASIC program AUTO PLOT.

Several operating systems such as NEWDOS by Apparat Inc. or DOSPLUS by Micro Systems Software Inc. can do all this automatically after power-on or reboot. Instructions are given in APPENDIX B.

From TRS-DOS we have to type

LOAD TGRAPH/CIM (ENTER) 

BASIC (ENTER) 

We can ignore the question 'how many files?' by pressing (ENTER).
To the question 'memory size?' we reply

47500 (ENTER) 

Once in BASIC, we type

RUN "AUTO PLOT" (ENTER) 

AUTO PLOT is now up and running. After a few seconds, the computer will respond with

```
EDIT LINE 5000 TO DEFINE FUNCTION  
TYPE 'RUN 2' TO PLOT
```

```
=====
```

5000

The function to be plotted has to be defined by a Disk Basic subroutine, starting with line number 5000. We are now in the EDIT-mode of BASIC. The available editing commands are explained in the Radio Shack BASIC reference manual. For instance, if we press 'L', the computer lists the current function

5000 Y = SIN(X)/X

If we are satisfied with this function we press

(ENTER) 

to finish editing.

To continue, we type

RUN 2 (ENTER) 

AUTO PLOT responds with the question

VARIABLE MINIMUM? MAXIMUM?

The computer needs to know, where to start and stop plotting. We have to tell it the minimum and maximum value of the independent variable X. For instance, we may answer

-15,15 (ENTER) 

Next, the computer shows a display of plotting options and their current settings (Fig. 1). In many instances, the initial settings will produce rather satisfactory results and need not be changed. To start plotting, we simply press

(ENTER) 

PRESS 'ENTER' TO START PLOT

V	VARIABLE	-15 TO 15
S	STEPS	50
P	PLOT	LINE
E	EPSON PLOT FORMAT	SMALL
G	GRID	NO
K	KIND OF PLOT	X=LIN. Y=LIN.
A	ADJUST SCALES	AUTO
N	NUMBER OF CURVES	1
M	MODE	FUNCTION
L	LIST FUNCTION	NO
T	TITLE	NO

R FEED PAPER

Q QUIT

Fig. 1

The computer first calculates all function values and determines the proper scales for plotting. During this operation, the display will look like

```
FUNCTION NUMBER 1
CALCULATING STEP 23 OF 50
```

with the counter in line 2 advancing from 0 to 50, the default number of calculated points.

After the calculations are complete, a relatively crude plot will appear on the video screen. Next, the EPSON MX-80 printer will start and produce the graph shown in Fig. 2.

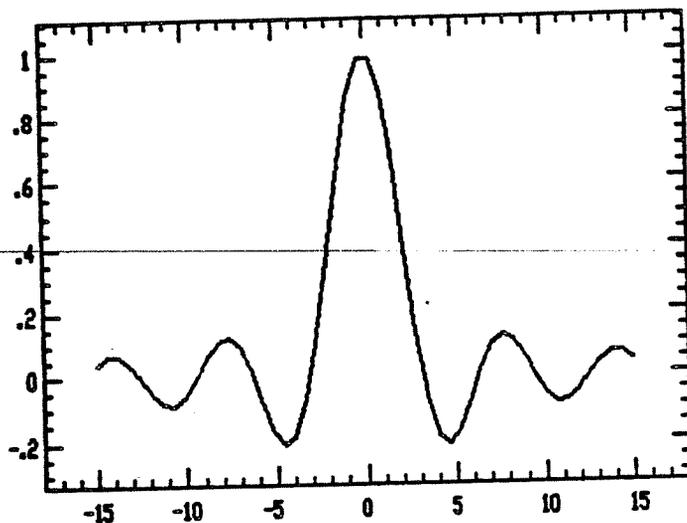


Fig. 2

After the printing is finished, the computer returns to the menu of options. If we want to plot a different function, we can press 'Q'. This will run AUTO PLOT again from the beginning.

3. DEFINING FUNCTIONS

The curve plotted in our initial example was described by a function $Y = f(X)$, i.e. X is the independent variable, and the result is returned in the variable Y .

AUTO PLOT also accepts functions $X = f(Y)$. To try this feature, we edit line 5000 to read

```
5000 X = SIN(Y)/Y
```

AUTO PLOT will now treat Y as the independent variable. By repeating all other steps of our first example, we obtain the plot shown in Fig. 3.

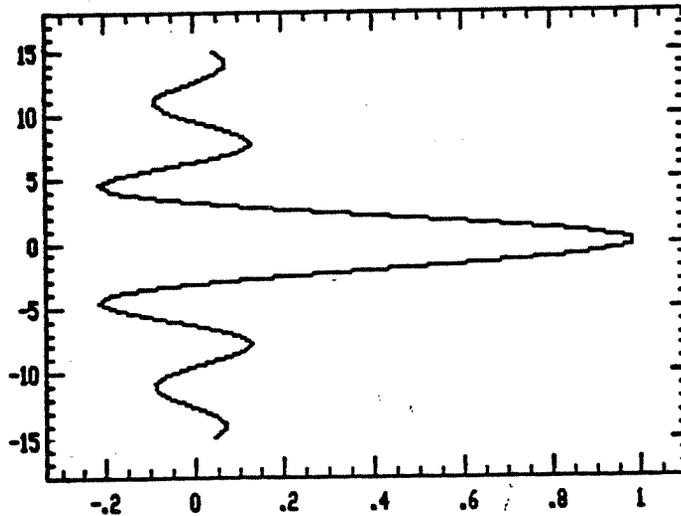


Fig. 3

Finally, we can describe the curve by giving both X and Y as functions of an independent variable V: $X = f(V)$ and $Y = g(V)$. To try this feature we edit line 5000 to read

```
5000 X = V * SIN(V)
```

Then we add an additional line

```
5010 Y = V * COS(V)
```

and type 'RUN 2'. To the question 'VARIABLE MINIMUM? MAXIMUM?' we reply '0,25 (ENTER)'. The computer will draw the spiral of Fig. 4.

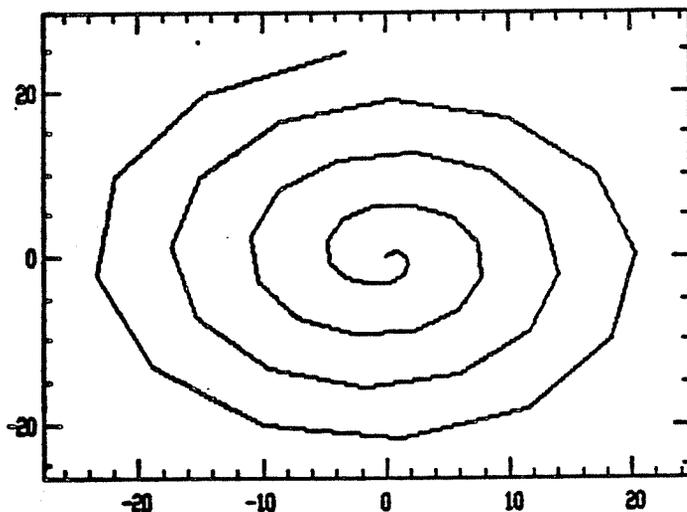


Fig. 4

The last example illustrates that the equations which describe our function need not be limited to a single BASIC line. Complicated expressions can extend over many lines, starting with line number 5000, and ending with a RETURN statement.

If we type

LIST 5000-

the computer lists the complete definition of our function

```
5000 X = V * SIN(V)
5010 Y = V * COS(V)
6000 RETURN
```

The RETURN statement at the end is necessary, because the computer reaches line 5000 from a GOSUB statement.

4. MORE THAN ONE CURVE

It is possible to plot several curves in the same diagram. AUTO PLOT provides an integer parameter M for this purpose which takes on values 1, 2, 3, ... for successive curves.

The parameter M can be used to define completely independent functions. For example

```
5000 ON M GOTO 5100, 5200
5100 Y = X * X: RETURN
5200 X = Y * Y: RETURN
```

After typing 'RUN 2' and selecting a variable range of -1,1, we arrive at the menu and find a line

```
N NUMBER OF CURVES          1
```

If we type 'N' the computer responds with

```
USE INTEGER PARAMETER M = 1, 2, 3, ...
TO DEFINE MORE THAN ONE CURVE
```

```
NUMBER OF CURVES TO PLOT?
```

Since we want to plot two curves, we answer

2 (ENTER)

and the computer returns to the menu. We now press (ENTER) again, and obtain the graph shown in Fig. 5.

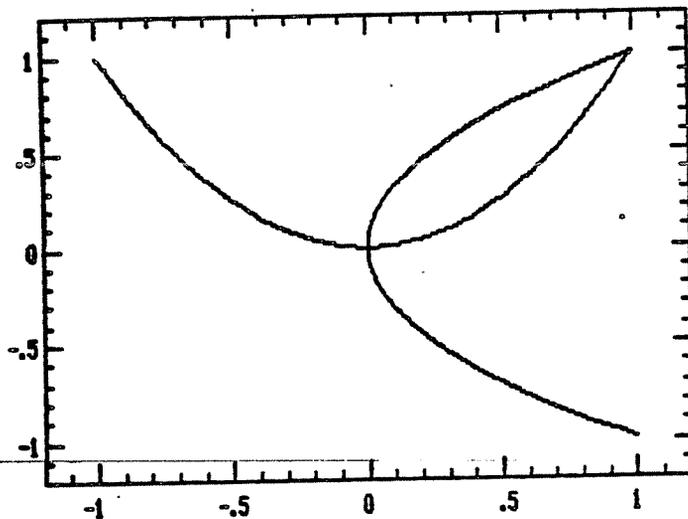


Fig. 5

Sometimes, we would simply like to change some parameter in our expression in steps, and plot curves for different parameter values. The integer M can easily be used for this purpose. As an illustration, we define

$$5000 \text{ Y} = \text{X} * \text{M}$$

After typing 'RUN 2 (ENTER)' and selecting a variable range '0,10 (ENTER)' we arrive at the menu. We type 'N' and request 4 curves. Finally we press (ENTER), and the computer will produce a graph as shown in Fig. 6. We see four straight lines corresponding to $Y = X$; $Y = 2 * X$; $Y = 3 * X$; and $Y = 4 * X$.

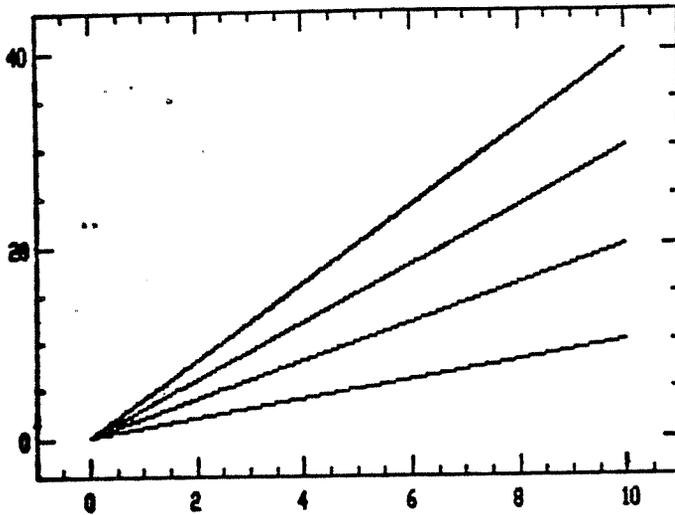


Fig. 6

5. SAVING AND LOADING FUNCTIONS

After typing in a complicated function, we may want to save it on disk for later use. One simple possibility is to save the entire AUTO PLOT program, including lines 5000,.... Unfortunately, this wastes a lot of disk space. For a more economical approach, we can type

```
(BREAK)
```

```
DELETE 1-4999
```

```
SAVE "FUNCTION",A
```

The BASIC program with name "FUNCTION" now contains only the lines with numbers of 5000 or higher. The 'A' in the last line requests saving as an ASCII file.

If we later want to plot the function again, we type

```
LOAD "AUTOLOT"
```

```
DELETE 5000-6000
```

```
MERGE "FUNCTION"
```

```
RUN 2
```

6. PLOTTING DATA FROM KEYBOARD

Rather than defining a mathematical function, lines 5000,... can also request coordinate pairs to be input from the keyboard. This can be useful if we want to plot tabulated data.

An example for keyboard entry is given in the following program lines:

```
5000 CLS: PRINT "POINT # "; II+1
5010 INPUT "X=?, Y="; X, Y
5020 INPUT "ENTER 'E' TO END"; E$
5030 IF E$ = "E" THEN NS = II
```

The variable II is used by AUTOLOT as a point counter. The variable NS equals the total number of plotted points minus 1. The default value of NS is determined by the number of steps shown in the menu. Lines 5020 and 5030 allow us to terminate the gathering of coordinate pairs at any time by setting NS equal to the current point counter II.

After we type 'RUN 2' we can ignore the question

```
VARIABLE MINIMUM? MAXIMUM?
```

by simply pressing (ENTER). After arriving at the menu, we press (ENTER) once more to start the collection of coordinate pairs.

The computer responds with

POINT # 1
X=?, Y=?

We can now enter the first pair of X- and Y- coordinates, for instance

1.5, 1.3 (ENTER)

The computer responds with

PRESS 'E' TO END

If we want to input more data, we ignore this request by simply pressing (ENTER), and the computer will ask for the next coordinate pair. In this way, we may enter a series points, e.g.

2,3
2.5,6
3,8

After the last point has been input, we type

E (ENTER)

and the computer will produce the graph shown in Fig. 7.

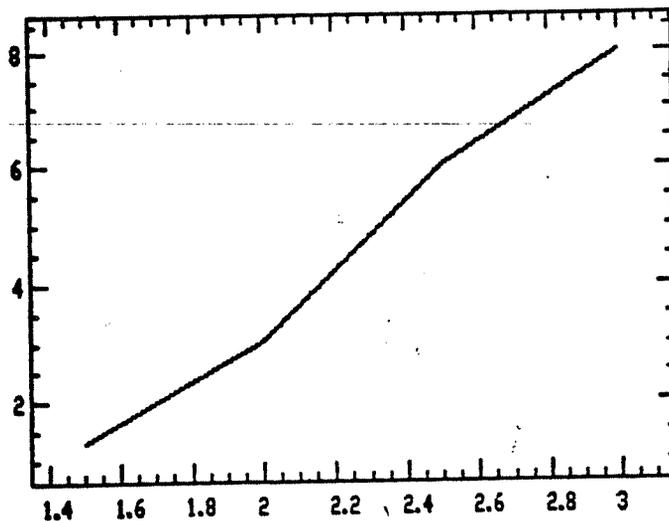


Fig. 7

7. PLOTTING DATA FROM A DISK-FILE

Lines 5000, ... can also be used to read tabulated data from a disk file. To give an example, we prepare a short data file with the BASIC program

```
10 OPEN "O",1,"TEST"           :REM OPEN SEQUENTIAL FILE
20 N=30: PRINT#1, N             :REM STORE NUMBER OF POINTS
30 FOR I=0 TO N
40 X=I: Y=SIN(I/8)
50 PRINT#1, X, Y               :REM STORE COORDINATE PAIR
60 NEXT I
70 CLOSE                       :REM CLOSE FILE
80 END
```

AUTO PLOT will read and plot this file with the following program lines

```
5000 IF S=1 GOTO 5040
5010 S=1: CLS: INPUT"FILENAME ";F$
5020 OPEN "I",1,F$
5030 INPUT#1, N: PRINT N;" POINTS": NS=N-1
5040 INPUT#1, X, Y
5050 IF II=N THEN CLOSE
```

Line 5030 sets the number of points to be acquired, and line 5050 closes the file once all points have been read.

After typing 'RUN 2' we can again ignore the question

VARIABLE MINIMUM?, MAXIMUM?

by pressing (ENTER), and after the menu appears, we request a plot by pressing (ENTER) once more. During the first pass through lines 5000,... the computer requests

FILENAME?

to which we reply

TEST (ENTER)

AUOPLOT then proceeds to produce the graph shown in Fig. 8.

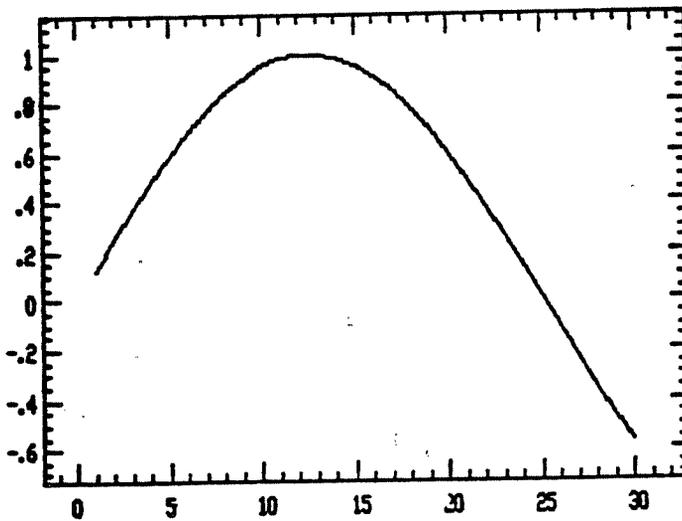


Fig. 8

8. OPTIONS

The menu lists a number of plotting options. We illustrate their use by plotting the function

$$5000 \cdot Y = X * X$$

over a variable range from 0.1 to 10.

The default settings produce the graph in Fig. 9.

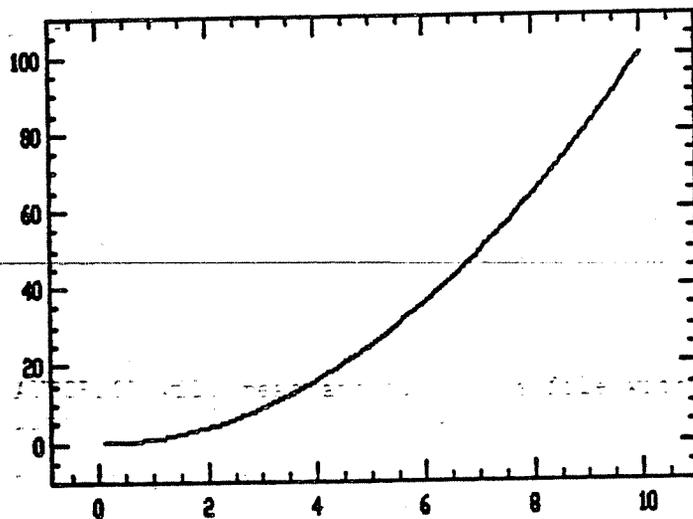


Fig. 9

V VARIABLE 0.1 to 10

Pressing 'V' allows us to change our mind and enter different minimum and maximum values for the independent variable

S STEPS

50

In the initial setting, the computer will calculate 50 points for our curve. If we type 'S', the computer asks

NUMBER OF STEPS ?

and we can request a different number of points. For instance, if we type '4 (ENTER) (ENTER)' we obtain Fig. 10.

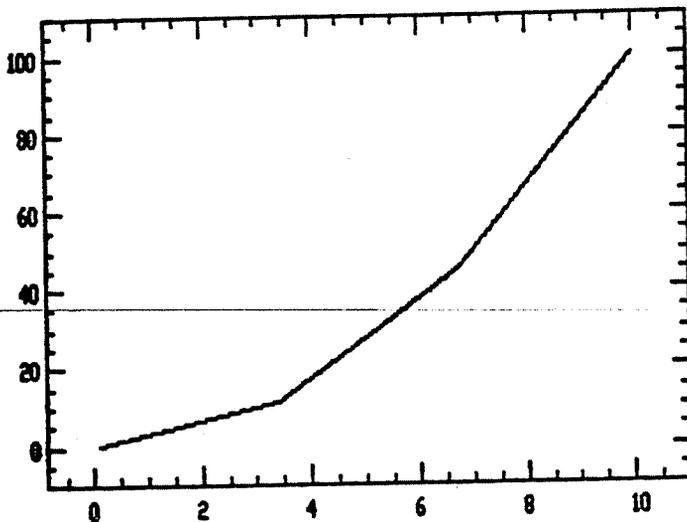


Fig. 10

'(ENTER) S 50 (ENTER)' restores the original number of steps.

A larger number of steps produces 'smoother' and more accurate graphs, but increases the necessary computing time. The available free RAM limits the maximum number of steps for a single curve to about 500. If more than one curve are plotted, this maximum has to be divided by the number of curves.

P PLOT

LINE

In the default setting, the computer connects the calculated points with straight lines.

Pressing 'P' changes 'LINE' to 'LINE & MARK', 'MARK', 'DOT', 'SOLID', 'MULTI' and back to 'LINE'.

Graphs obtained with plot modes 'LINE & MARK', 'MARK', 'DOT', and 'SOLID' are shown in Figs. 11 to 14.

'MULTI' uses different plot modes for different curves in graphs with more than one curve. Fig. 15 illustrates this capability with the example of Fig. 6.

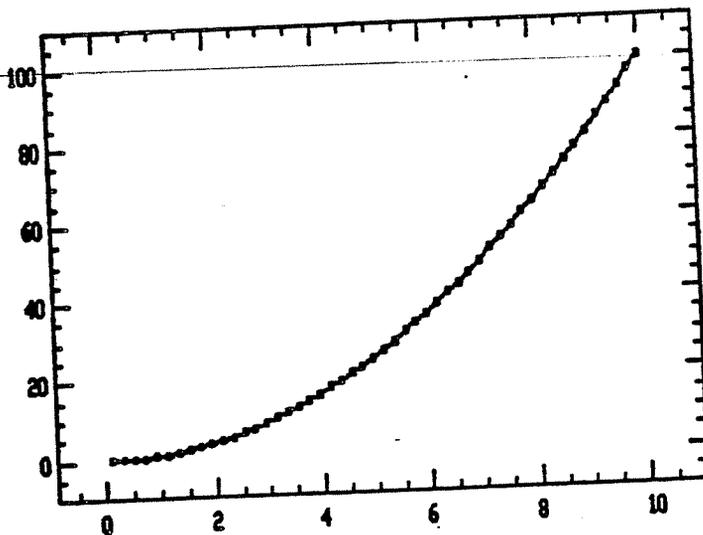


Fig. 11

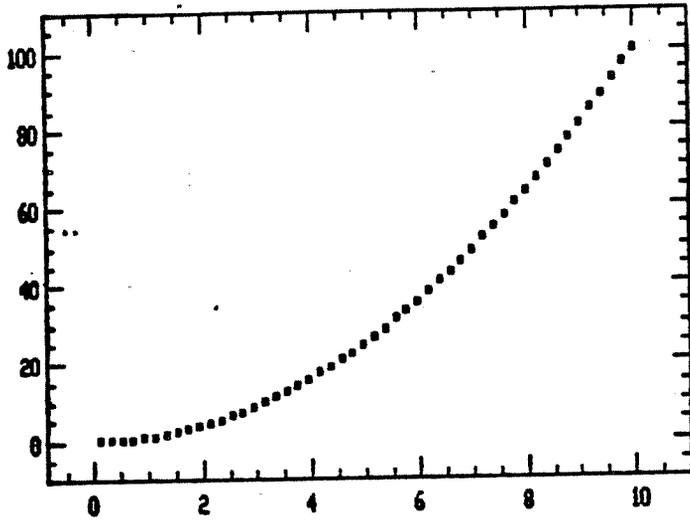


Fig. 12

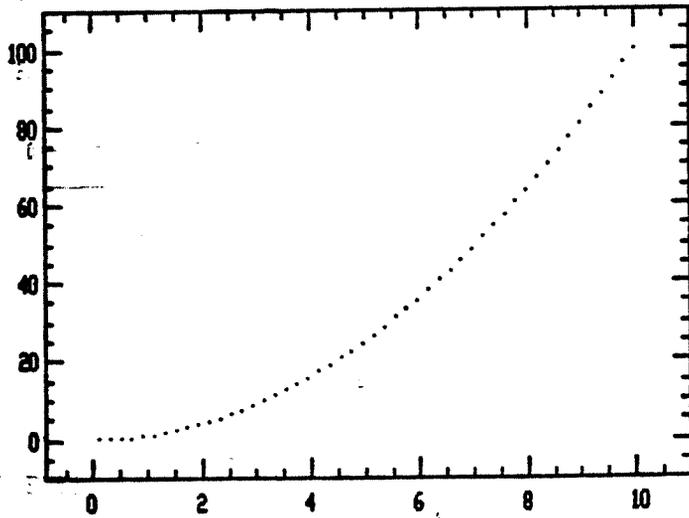


Fig. 13

100
 80
 60
 40
 20
 0

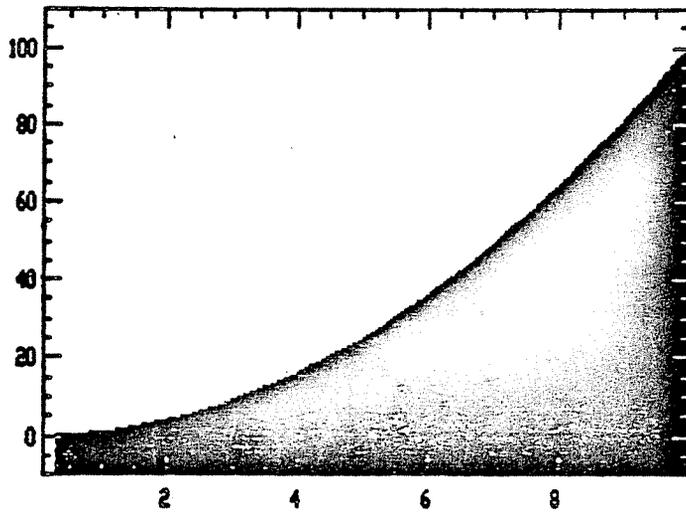


Fig. 14

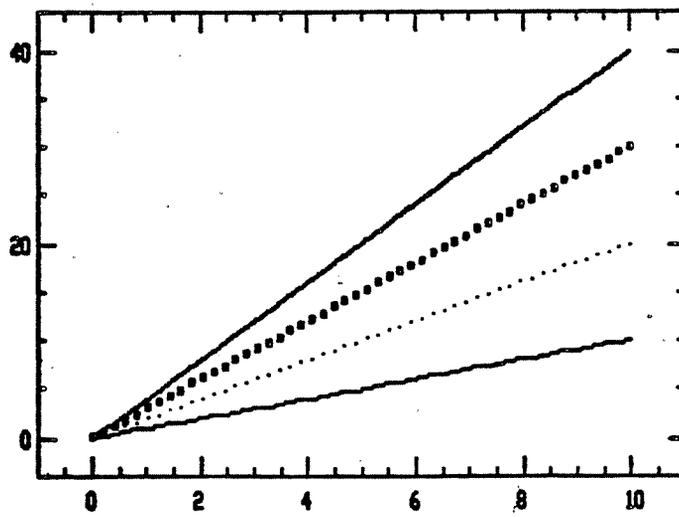


Fig. 15

The 'E'-option makes it possible to select different print formats for the EPSON MX-80

Pressing 'E' changes 'SMALL' to 'LARGE', 'LARGE, DENSE', 'WIDE', and back to 'SMALL'.

Printouts for the 'WIDE', 'LARGE, DENSE', and 'LARGE' settings are shown in Figs. 16 to 18.

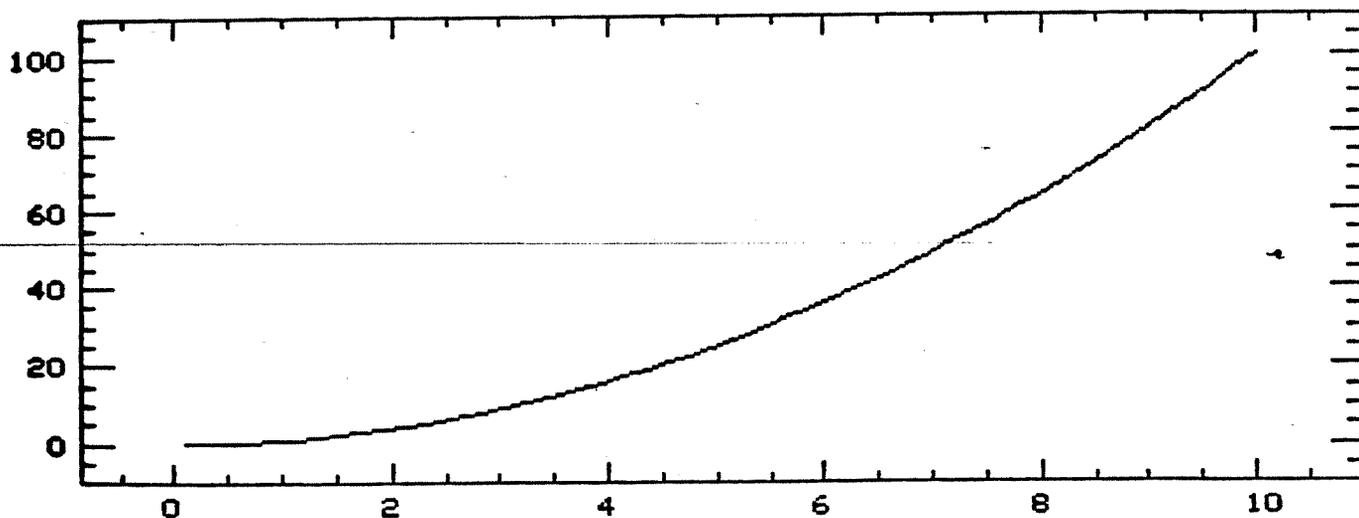


Fig. 16

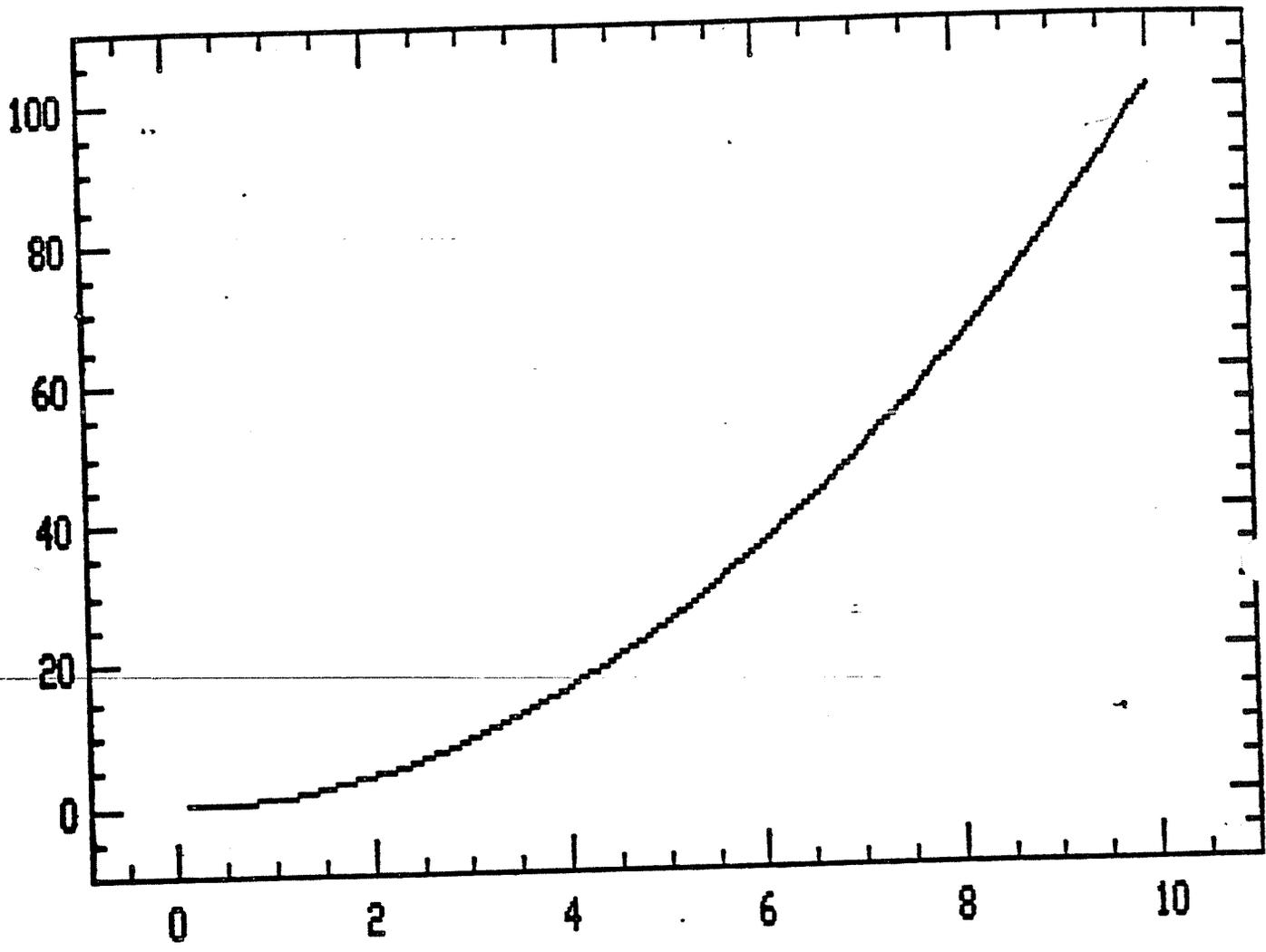


Fig. 17

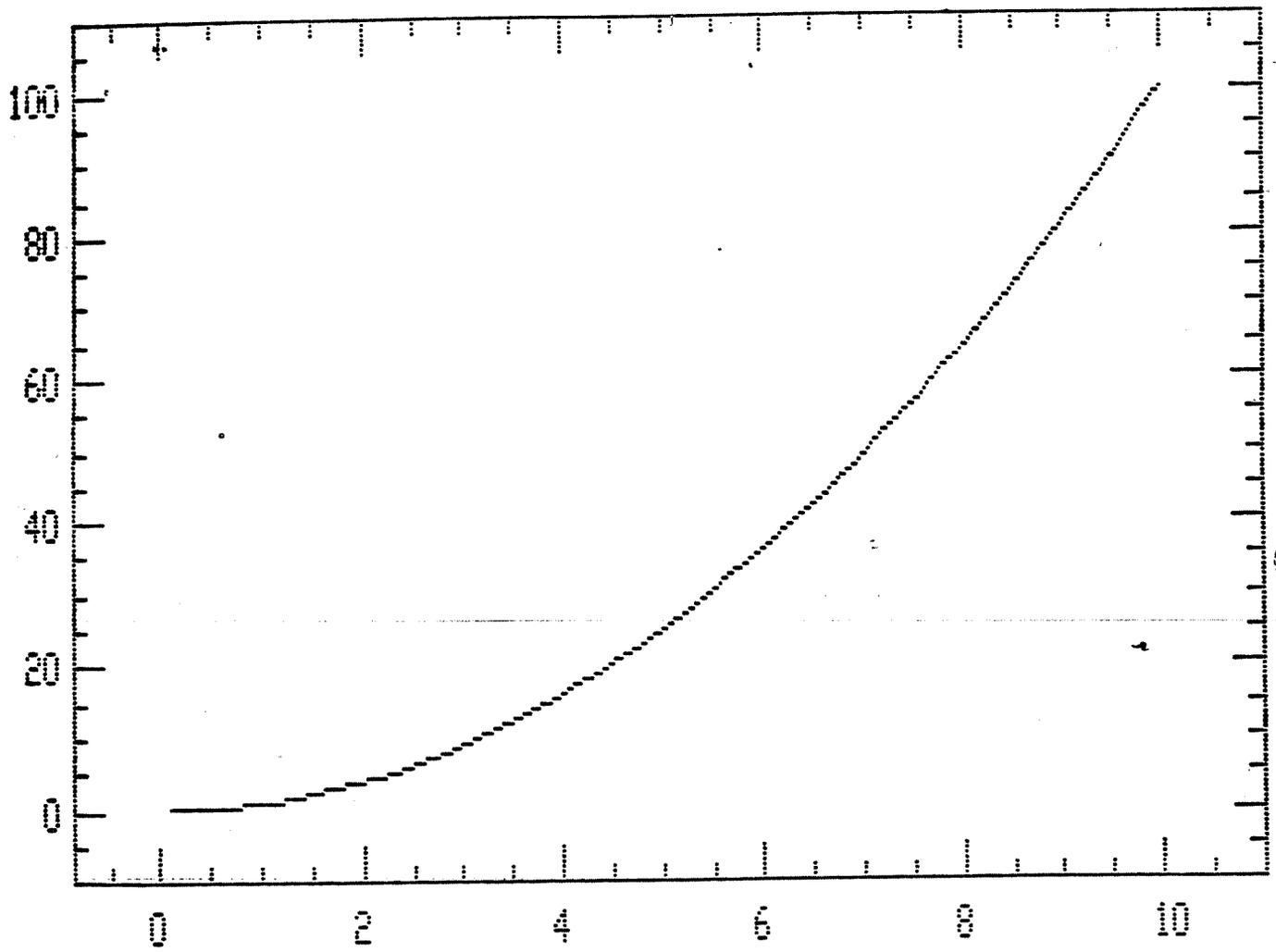


Fig. 18

G GRID

NO

Normally, the graphs do not come with a coordinate grid. Pressing G' changes 'NO' to 'YES', and a grid is drawn, as illustrated in Fig. 19.

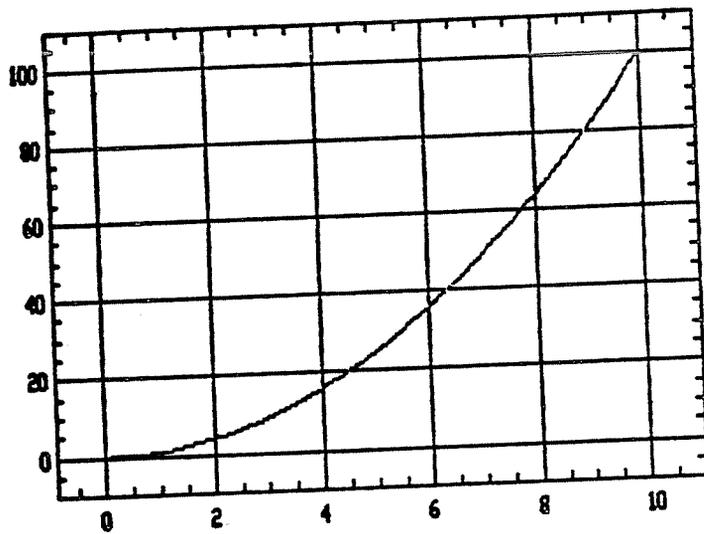


Fig. 19

K KIND OF PLOT

X=LIN. Y=LIN.

Normally, both X- and Y-axis are divided linearly. Pressing 'K' changes the KIND OF PLOT line to

K KIND OF PLOT

X=LIN. Y=LOG

and (ENTER) produces Fig. 20 with a logarithmic Y-scale.

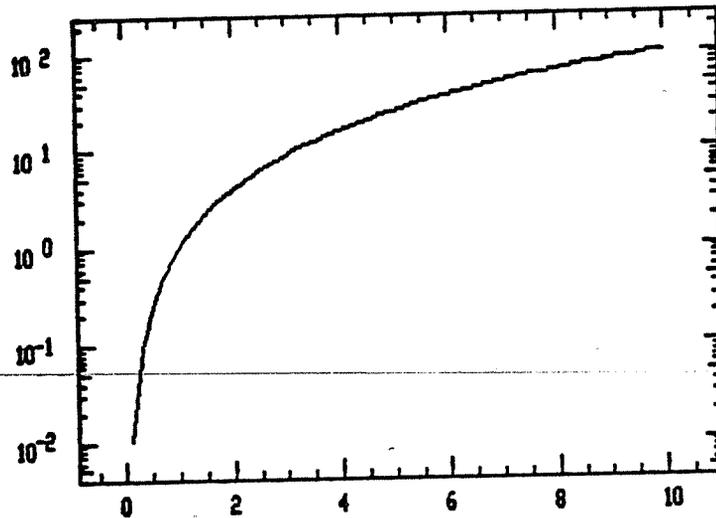


Fig. 20

By pressing 'K' once more, we can select

K KIND OF PLOT

X=LOG. Y=LIN.

which produces Fig. 21.

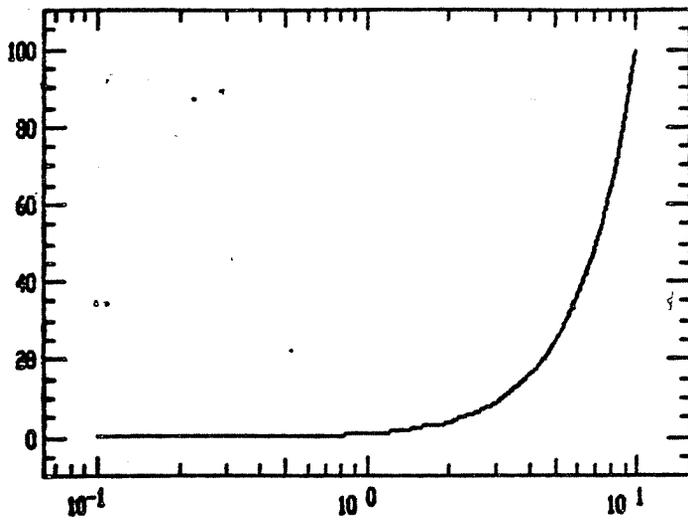


Fig. 21

Another 'K' selects

K KIND OF PLOT

X=LOG. Y=LOG.

which gives Fig. 22.

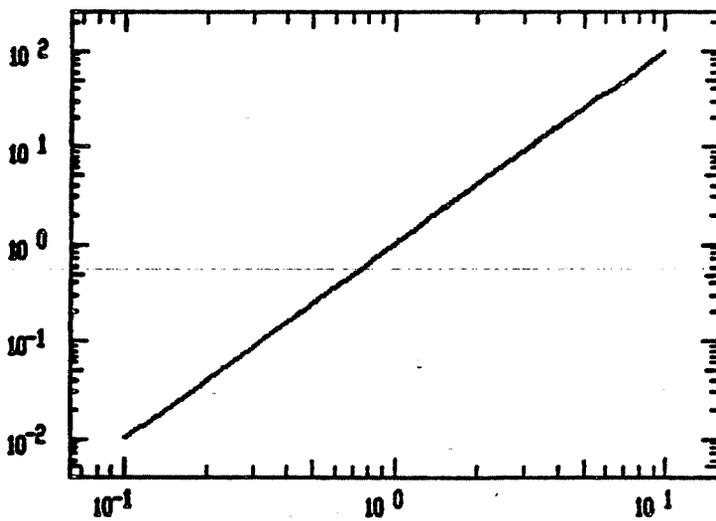


Fig. 22

A final 'K' returns to the default settings

A ADJUST SCALES

YES

This option makes it possible to override the automatic adjustment of the X- and Y-scales. After we press 'A', the computer asks

SCALE XMIN?, XMAX?

An answer '0,15', for instance, requests an X-axis reaching from 0 to 15. The next question is

YMIN?, YMAX?

A reply '-10,100' requests a Y-axis from -10 to 100.

If portions of the function fall outside these chosen boundaries, they are simply ignored during plotting. Our choices result in the plot of Fig. 23.

Typing 'A' again restores automatic scaling

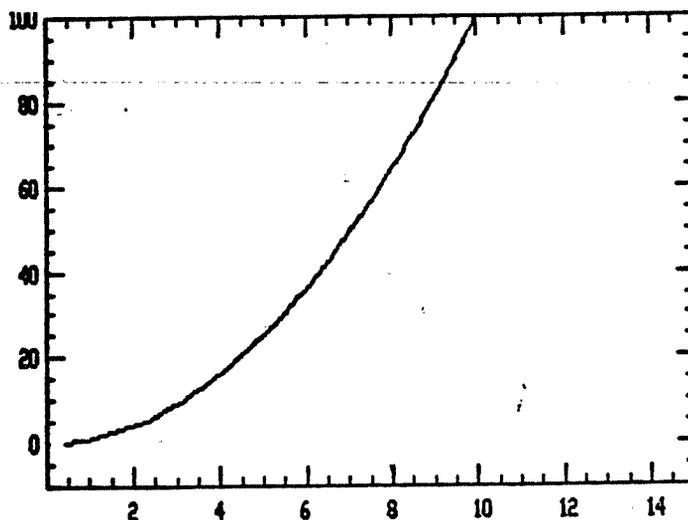


Fig. 23

N NUMBER OF CURVES 1

This options permit the plotting of more than one curve. Its use has been explained in Section 4.

M MODE FUNCTION

Normally, the computer produces a plot of the function(s) defined in lines 5000, ...

Pressing 'M' changes 'FUNCTION' to 'INTEGRAL', and the computer will plot the numerically calculated integral over the independent variable. Fig. 24 has been produced with this setting.

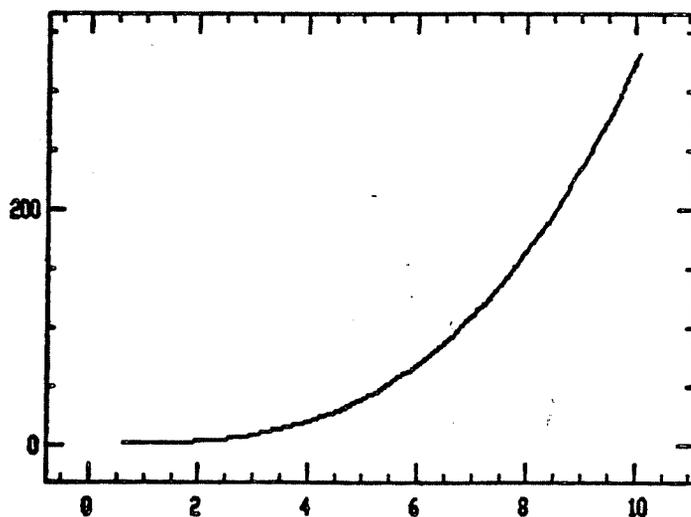


Fig. 24

Pressing 'M' once more requests 'DERIVATIVE', i.e. numerical differentiation. Fig. 25 has been generated in this way.

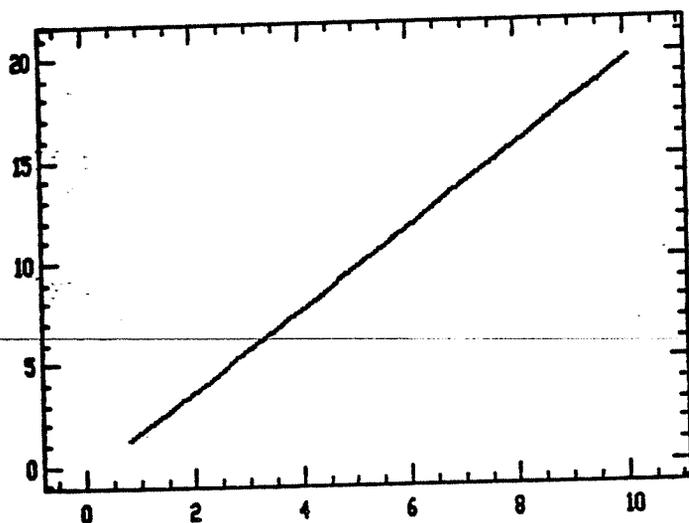


Fig. 25

Another 'M' gives 'INTEGRATE X, Y'. This setting permits it to calculate both X and Y as integrals over functions of an independent variable V. The Cornu spiral in the examples of APPENDIX D illustrates the use of this option

L LIST FUNCTION

NO

Typing 'L' changes 'NO' to 'YES', and a listing of the program lines 5000,... is automatically printed below the diagram (Fig. 25). Such a listing terminates AUTOPLLOT, and we have to type 'RUN' or 'RUN 2' to start again.

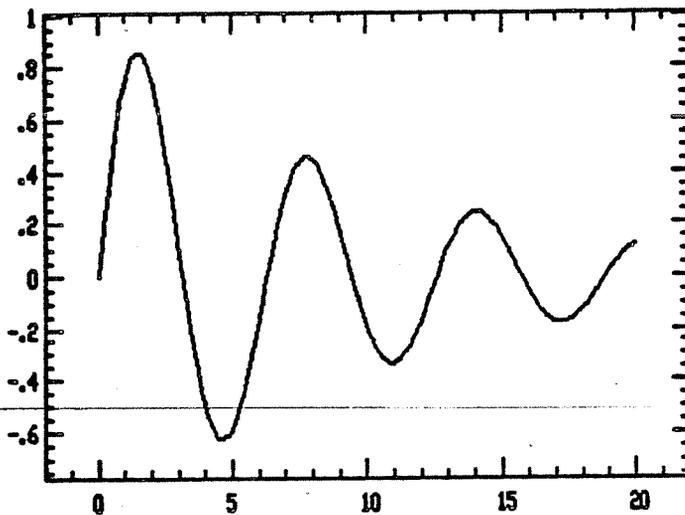


Fig. 26

AUTOPLLOT (C) T.W.H. 1981

FUNCTION
5000 Y=SIN(X)*EXP(-X/10)
6000 RETURN

T TITLE

NO

Pressing 'T' results in the question

TITLE TO APPEAR ON TOP OF PAGE?

Any message typed in response will appear in the EPSON printout as a title above the plot. Examples are found in APPENDIX D

9. TROUBLE

If you discover a 'bug' in AUTOLOT, please write and tell us about it. As a reward, you will receive an updated and corrected version of this program.

Sometimes, problems occur without fault of the program. One common difficulty is the 'DIVISION BY ZERO' error, which is encountered if we attempt to plot functions like

5000 Y = SIN(X)/X

over a range, say, from -10 to 10, and using an odd number of points. When the computer reaches $X = 0$, it issues an error message. In the given example, we can avoid this problem by choosing an even number of steps, or by selecting a range from -10.001 to 10, so that X never equals exactly zero.

Other problems may occur, when the program lines 5000 and higher make improper use of variable names which are reserved or which are already assigned elsewhere in the program.

The single letter names X, Y, V, and M are reserved for x-coordinate, y-coordinate, independent variable, and integer parameter, respectively, as explained in sections 3. and 4. All other single letter names can be used freely.

The following double-letter names are used elsewhere in the program and should be avoided:

A\$ AA\$ AF% AL AX AY
BB\$
CL% CC CH
DD
EP%
FF
G\$ GF%
ID II IS IT
J\$
L4 L5 L6 L7 LT LX LY
M\$ MM% MM MX MY
NG% NN% NO% N1 N2 NN NP NS
PS\$ PS% PC PI PM
Q\$ QQ
RP% RU
ST SX SY
TS% TT TX TY
X\$ XO% X4 X5 XB XI XJ XL XM XO XP XQ XR XT XX
Y\$ YO% YY% Y1 Y2 Y4 Y5 YD YI YL YM YO YP YQ YR

If the graphics on the video screen or a partly printed diagram show that we have made a mistake in defining the function or selecting options, we can interrupt AUTO PLOT by pressing the space bar (up to 4 times), until the menu reappears. (To interrupt the printer, keep the space bar depressed until the printhead reaches the end of a line.)

If the program appears to act erratically, we may have a wrong bit somewhere in RAM, and it may help to turn the power of the computer off for about 15 seconds, and to reload TGRAPH/CIM and AUTO PLOT from scratch.

APPENDIX A

Settings of the DIP switches inside the EPSON MX-80 printer

ON SW-2 OFF

4		X
3	X	
2		X
1		X

ON SW-1 OFF

8	X	
7		X
6	X	
5		X
4		X
3	X	
2	X	
1		X

ON

OFF

SW1-1 132 C/LINE
 SW1-2 CR=PRINT
 SW1-3 BUFFER FULL=PRINT
 SW1-4 ITALIC
 SW1-5 EMPHASIZED
 SW1-6 BUZZER ON
 SW1-7 SLASHED ZERO
 SW1-8 SELECT FIXED

80 C/LINE
 CR=PRINT + LF
 BUFFER FULL=PRINT +LF
 NORMAL
 NORMAL
 BUZZER OFF
 REGULAR ZERO
 SELECT NOT FIXED

SW2-1 NOT USED
 SW2-2 NOT USED
 SW2-3 AUTO LF WITH CR
 SW2-4 TRS-80 MODE

NOT USED
 NOT USED
 LF MUST BE FROM HOST
 NORMAL MODE

APPENDIX B

SIMPLIFYING THE LOADING OF A U T O P L O T

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A number of disk operating systems for the TRS-80, such as NEWDOS, NEWDOS80, or DOSPLUS permit DOS-commands from BASIC and will automatically load the machine language routines TGRAPH/CIM into high memory.

Following the instructions of your operating system, you can copy TGRAPH/CIM and AUTO PLOT onto a diskette which contains your system. If you use NEWDOS, you then only have to type

```
BASIC 47500 AUTO PLOT
```

to load and run AUTO PLOT.

Similarly, DOSPLUS only requires the command

```
BASIC AUTO PLOT -M:47500
```

If you type

```
AUTO BASIC 47500 AUTO PLOT
```

from NEWDOS or

```
AUTO BASIC AUTO PLOT -M:47500
```

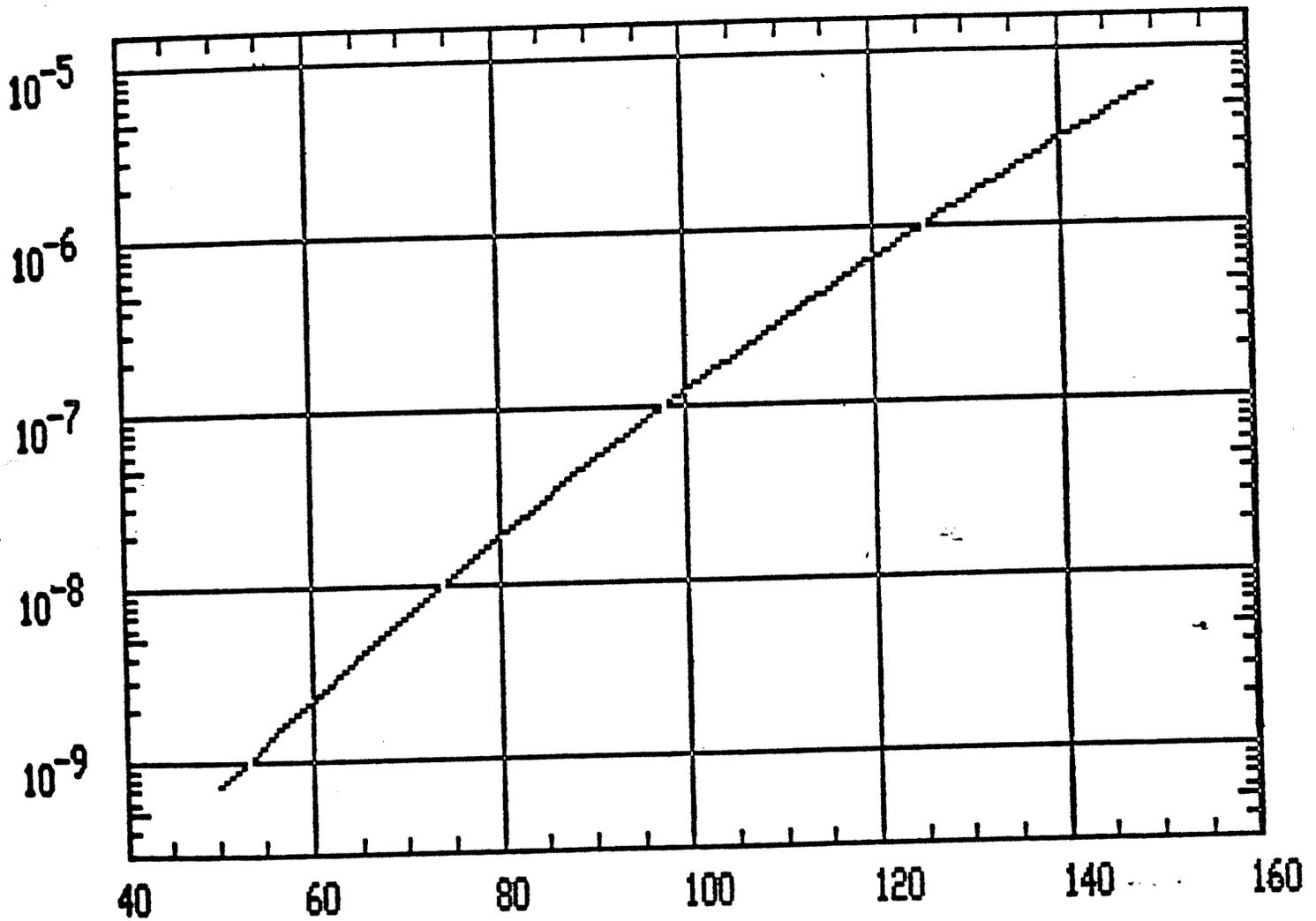
from DOSPLUS, the computer will automatically load and run AUTO PLOT after power-on or reboot.

NOTE: AUTO PLOT 'senses' the presence of TGRAPH/CIM with its line number 10. If TGRAPH/CIM is not present, AUTO PLOT attempts to load it with line 15. If your operating system cannot load machine language routines from BASIC, line 15 will produce a SYNTAX error. In this case, follow the loading instructions of Section 2.

APPENDIX C

Further Examples

VAPOR PRESSURE OF SODIUM
TORR VERSUS DEGREES CENTIGRADE

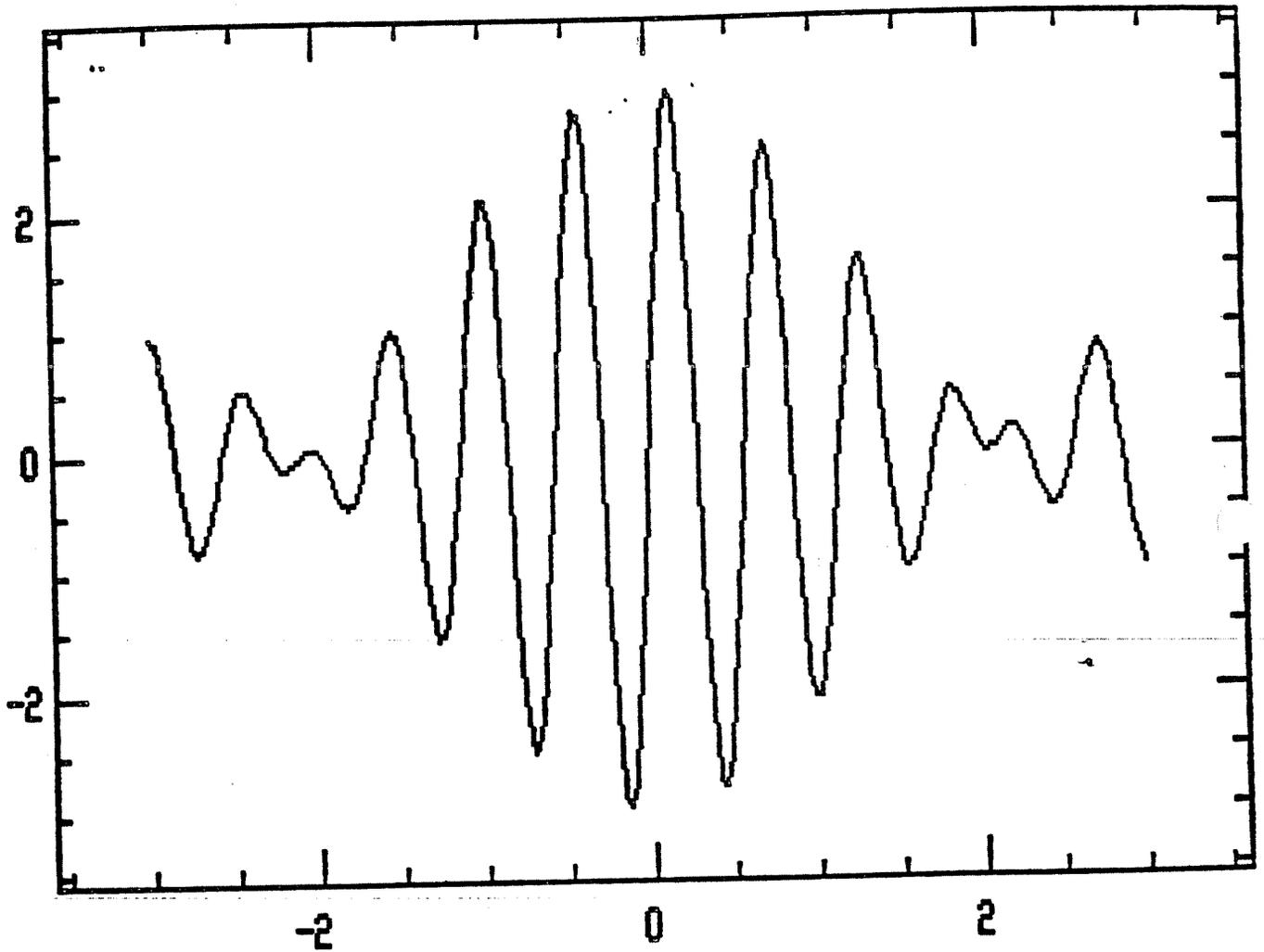


AUTO PLOT (C) T.W.H. 1981

FUNCTION

5000 A=24689: B=7.553: Y=10⁺(-.2185*A/(X+273.15)+B)
6000 RETURN

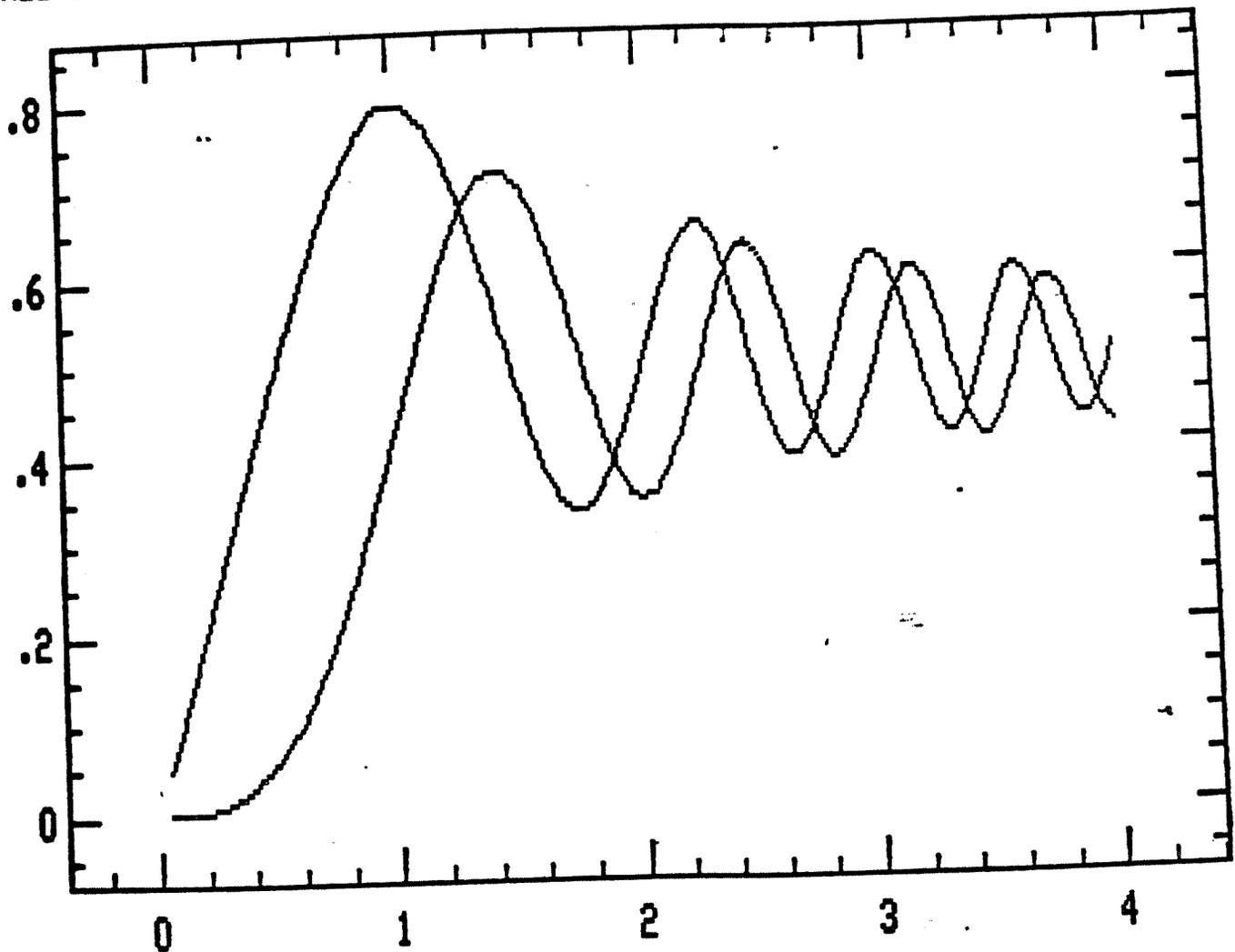
WAVE PACKET



AUTO PLOT (C) T.W.H. 1981

FUNCTION
5000 $Y = \sin(10 * X) + \sin(11 * X) + \sin(12 * X)$
6000 RETURN

FRESNEL INTEGRALS



AUTO PLOT (C) T.W.H. 1981

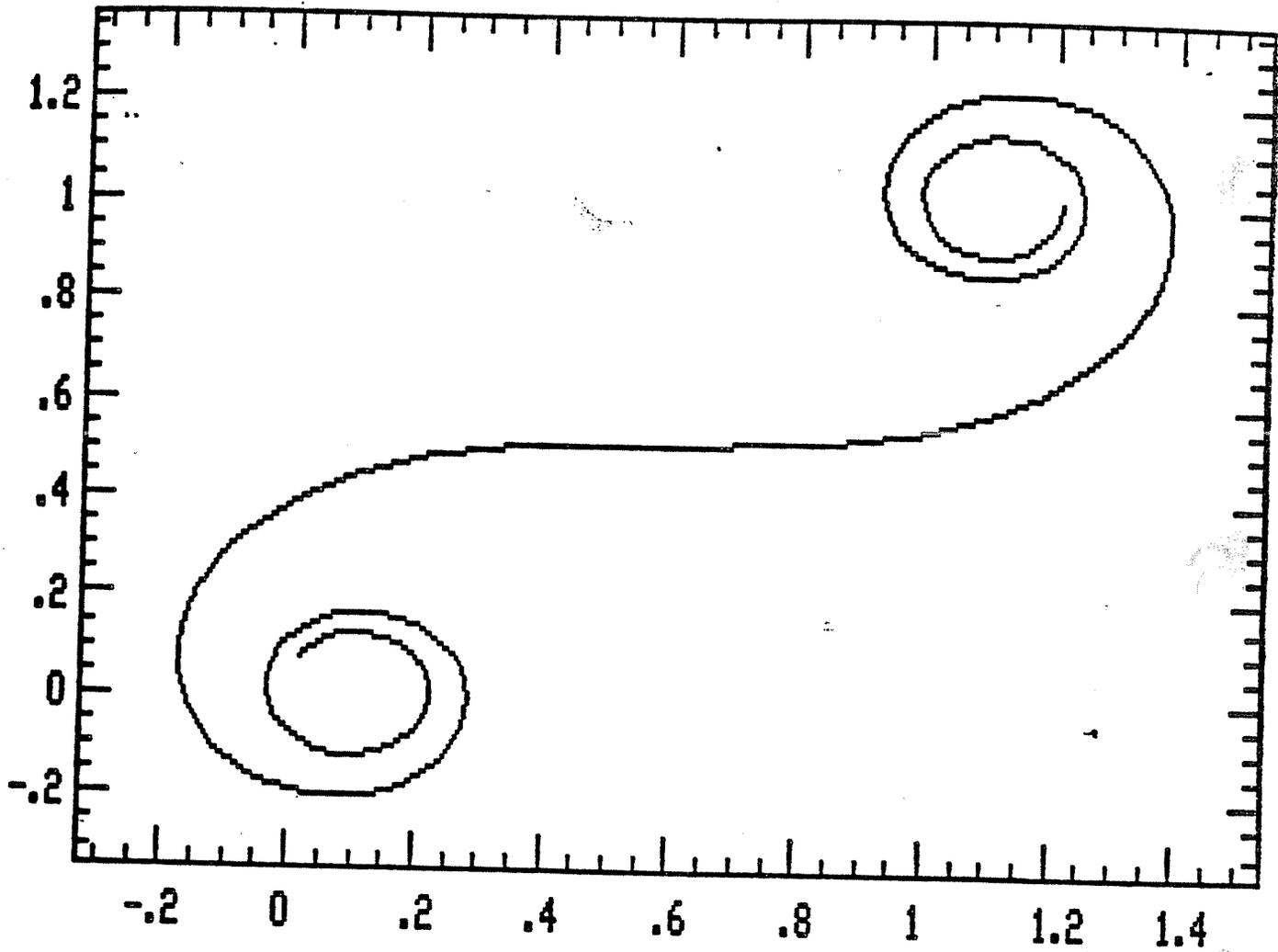
INTEGRAL

5000 PI=3.14159:

IF M=1 THEN Y=COS(X*X*PI/2) ELSE Y=SIN(X*X*PI/2)

6)00 RETURN

CORNU'S SPIRAL



AUTO PLOT (C) T.W.H. 1981

INTEGRATE X,Y
5000 PI=3.14159: X=COS(V*V*PI/2): Y=SIN(V*V*PI/2)
6000 RETURN