

600 Series Program Library

262

VOLUME

**Wang 602
Plotting
Utility
Package**

WANG

Volume 262 Model 600

Wang 602 Plotting Utility Package

© Wang Laboratories, Inc., 1972

WANG

LABORATORIES, INC.

836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL. (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

Warranty Disclaimer and Consequential Damages

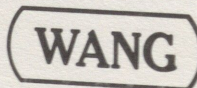
The programming staff of Wang Laboratories, Inc. has taken due care to prepare this program package, including research, development, and testing to ascertain its effectiveness. Wang Laboratories, Inc. and its subsidiaries make no expressed or implied warranty of any kind with regard to this program package and its related material. In no event shall Wang Laboratories, Inc. or its subsidiaries be liable for incidental or consequential damages in connection with or arising out of the furnishing, performance or use of any of its programs.

Proprietary Rights

This program package is a company proprietary item. Tape cassettes of programs may not be reproduced without the written consent of Wang Laboratories, Inc.

Payment Address

The fee for a package is to be remitted directly to Wang Laboratories, Inc. at 836 North Street, Tewksbury, Massachusetts 01876. No agent or representative is charged with the authority to accept payment on behalf of the administrative offices of Wang Laboratories, Inc.



LABORATORIES, INC.

836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL. (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

INTRODUCTION

The following was designed as a software package for the 602 which may be used in conjunction with either the 600-6 or 600-14.

- Side 1:
1. $y = f(x)$ in four quadrants
 2. $y = f(x)$ in the first quadrant
 3. Point Plotting in four quadrants
 4. Point Plotting in the first quadrant

- Side 2:
5. $\rho = f(\theta)$ in four quadrants
 6. $x = f(t)$ in four quadrants
 $y = g(t)$ in four quadrants
 7. Trajectory problem

Each plotting routine, except as noted, has an example enclosed with detailed instructions on how to use it.

For a person to utilize the above routines for his own function, he inserts his function in place of the example function being careful not to utilize Marks and Registers used in the mainline program.

A person may eliminate or add more coefficient storage subroutines as he sees fit within the bounds of program steps and/or storage registers available.

Because of the length of the mainline routine, the size and complexity of the function subroutine is somewhat limited when using the 600-6/602 combination. However, there should be no problem whatsoever when using the 600-14/602 combination.

Wherever possible a specific example is given step by step matching the steps of the general operating instructions. The general instructions appear on the left hand column of the page.

EXHIBIT C-1

The following information was obtained from the records of the Department of the Interior, Bureau of Land Management, for the period 1900 to 1909:

LAND ACQUIRED

1900 1,000.00 acres

1901 1,000.00 acres

1902 1,000.00 acres

1903 1,000.00 acres

1904 1,000.00 acres

1905 1,000.00 acres

1906 1,000.00 acres

1907 1,000.00 acres

1908 1,000.00 acres

1909 1,000.00 acres

The following information was obtained from the records of the Department of the Interior, Bureau of Land Management, for the period 1910 to 1919:

LAND ACQUIRED

1910 1,000.00 acres

1911 1,000.00 acres

1912 1,000.00 acres

1913 1,000.00 acres

1914 1,000.00 acres

1915 1,000.00 acres

1916 1,000.00 acres

1917 1,000.00 acres

1918 1,000.00 acres

1919 1,000.00 acres

The following information was obtained from the records of the Department of the Interior, Bureau of Land Management, for the period 1920 to 1929:

LAND ACQUIRED

1920 1,000.00 acres

1921 1,000.00 acres

1922 1,000.00 acres

1923 1,000.00 acres

1924 1,000.00 acres

1925 1,000.00 acres

1926 1,000.00 acres

1927 1,000.00 acres

1928 1,000.00 acres

1929 1,000.00 acres

BLOCK ASSIGNMENTS

<u>PROGRAM</u>	<u>SIDE</u>	<u>BLOCK NO.</u>	<u>VERIFY NO.</u>
1. STANDARDIZED PLOTTING ROUTINE for FOUR QUADRANTS - AUTOMATIC SCALING	1	1	6259
2. STANDARDIZED PLOTTING ROUTINE for FIRST QUADRANT - AUTOMATIC SCALING	1	2	5498
3. STANDARDIZED POINT PLOTTING ROUTINE for FOUR QUADRANTS - AUTOMATIC SCALING	1	3	4326
4. STANDARDIZED POINT PLOTTING ROUTINE for FIRST QUADRANT - AUTOMATIC SCALING	1	4	3113
5. STANDARDIZED POLAR PLOTTING ROUTINE - AUTOMATIC SCALING	2	1	6014
6. STANDARDIZED PLOTTING ROUTINE for PARAMETRIC EQUATIONS - AUTOMATIC SCALING	2	2	5811
7. TRAJECTORY PROBLEM	2	3	6084

TABLE OF CONTENTS

<u>PROGRAM NO.</u>	<u>TITLE OF PROGRAM</u>	<u>PAGE NO.</u>
PT. 07-600.06T-000B-1-0	Standardized Plotting Routine for Four Quadrants - Automatic Scaling	1
PT. 07-600.06T-000B-2-0	Standardized Plotting Routine for First Quadrant - Automatic Scaling	17
PT. 07-600.06T-000B-3-0	Standardized Point Plotting Routine for Four Quadrants - Automatic Scaling	32
PT. 07-600.06T-000B-4-0	Standardized Point Plotting Routine for First Quadrant - Automatic Scaling	37
PT. 07-600.06T-000B-4-0	Standardized Polar Plotting Routine Automatic Scaling	41
PT. 07-600.06T-000B-5-0	Standardized Plotting Routine for Parametric Equations - Automatic Scaling.	55
PT. 07-600.06T-000B-6-0	Trajectory Problem	71
	Appendix A	78
	Appendix B	79

WANG

SERIES PROGRAM

STANDARDIZED PLOTTING ROUTINE FOR FOUR QUADRANTS

TITLE

PT. 07-600.06T-000B-1-0

NUMBER

600-6, 600-14/602

DATE

EQUIPMENT

PROGRAM ABSTRACT This program is a standardized plotting routine for four quadrants with automatic scaling which enables the user to plot any curve, regardless of numerical values, which can be expressed as $y = f(x)$.

BLOCK		VERIFY NO.	NO. OF STEPS
1	Side 1	6259	673

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS

1. Load Program

- Depress RUN mode
- Insert tape cassette with Side 1 facing operator.
- Depress REWIND
- Depress TAPE READY

e) Key

PRIME

f) Key

LOAD
PROG

g) Key

VERIFY
PROG

h) The display should read:

+6259.000000

2. Key f(x)

00

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

1. Same as #1 of general instructions.

2. Key f(x)

00

The X and Y axes will be printed out and labeled. The program will stop with
-42.00000000 in the display when the axes are complete.

If you have a function which requires constants to be keyed in externally, then Key each constant followed by the corresponding key, such as:

3. Key b Value

Key f(x)

13

Key a Value

Key f(x)

14

4. Key INCREMENT

Key f(x)

01

Display is dark

3. Key 1

Key f(x)

13

Key . 3 5

Key f(x)

14

4. Key . 0 5

Key f(x)

01

Display is dark

OPERATING INSTRUCTIONS CONT'D.

Key INITIAL X

Key GO

Display is dark

Key FINAL X

Key GO

Do either 4(a) or 4(b)

4a. If you want automatic scaling,

Key f(x) 02

The program will calculate the X and Y Scale Factors and plot the function in the interval specified and then will return to the origin.

Note: If you select automatic scaling you should be aware that it does take time to compute the scaling factors and the plotting will not start immediately. The amount of time required between keying f(x) 02 and the start of the plot will vary depending upon the complexity of the function and the number of subroutines within the function subroutine, and the increment of plotting which is specified. In the case of the example given, the scaling takes a little more than 1 minute. If the function is a polynomial or something very simple, the scaling takes less than 30 seconds.

4b. If you want your own scale factors

Key X-SCALE FACTOR

Key f(x) 04

Key Y-SCALE FACTOR

Key f(x) 05

Key f(x) 03

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

Key 4

Key CHANGE
SIGN

Key GO

Display is dark

Key 4

Key GO

Do either 4(a) or 4(b)

4a. Key f(x) 02

4b. If you want to use an
X-Scale Factor = 100
Y-Scale Factor = 100

Key 1 0 0

Key f(x) 04

Key 1 0 0

Key f(x) 05

Key f(x) 03

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for $a = .35$ and $b = 1, 0, 2$ at an increment of .05 from -4 to +4.

The program will now plot the function in the interval and at the increment specified and then will return to the origin.

Note: If you want to use your own scale factors see section entitled "Criterion in Choosing A Proper Scale Factor"; See Appendix A.

Since the axes are always labeled -4 to +4 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore, the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5, then each division on the graph is actually 5 units and the axis would actually have a range of -20 to +20. For information on how the axis unit value is related to the scaling factor, see Appendix A.

If you just want to obtain the axis unit values,

5. Key f(x) 06

To obtain X-Axis unit value, Key the blue

RECALL on the left

Y-Axis Unit value, Key the blue

RECALL on the right

6. If you want to obtain the value of y for a given value of x

Key X-Value

Key f(x) 07

5. Key f(x) 06

Key RECALL on the left

READ: +1.000000000 in the display

This is the X-Axis unit value

Key RECALL on the right

READ: +1.000000000 in the display

This is the Y-Axis unit value

6. If $x = 0$

Key 0

Key f(x) 07

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

The Y-Value will appear in the display

The Y-Value of +1.000000000 will appear in the display.

If you want to replot the function with new constants on the same axis,

7. Key NEW CONSTANT

Key f(x) XX

where XX is the key which stores the appropriate constant

7. Key 0

Key f(x) 13

(Stores new b)

You may change all the coefficients or only a few according to above method; the ones you do not change will remain the same as for the new plot as in the previous plot.

With coefficient change, you are now ready to replot; however, you should first

Key f(x) 06 and record the X and Y axis values as they may change if you select auto scaling.

Key INCREMENT

Key f(x) 01

Display is dark

Key INITIAL X

Key GO

Display is dark

Key FINAL X

Key GO

Key . 0 5

Key f(x) 01

Display is dark

Key 4

Key CHANGE
SIGN

Key GO

Display is dark

Key 4

Key GO

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos (bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

If you want auto scaling Key f(x) 02

If you are sure that the new coefficient will not cause plotting to go outside confines of axes, then Key f(x) 03 as the scale factor computed on previous plot will still be in storage.

If you want to change the plotting symbol for each replot,

8. Depress LEARN mode switch

Key

SET
P.C.

Key 0 4 5 7

Key XX YY

Depress RUN mode switch

Note: Assure f(x) switch is depressed again.

8. Depress LEARN mode switch

Key

SET
P.C.

Key 0 4 5 7

Key 07 12 (plot *)

Depress RUN mode switch

Note: Assure f(x) switch is depressed again.

NOTE: The following is a list of the most useful plotting symbols and their codes:

<u>SYMBOL</u>	<u>CODE</u>
+	04 06
*	07 12
°	05 07
0	05 09
x	06 15

NOTE: The position of the different symbols relative to each other as keyed at the same point might be slightly off as they might occupy different position on the IBM ball relative to the striking center of the decimal point.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

9. Replot the function as described in Number 7.

9. Key 2 ,
Key f(x) 13 (stores new b)

Key . 0 5
Key f(x) 01

Key 4

Key CHANGE
SIGN

Key GO

Key 4

Key GO

Then Key either f(x) 02 for
auto scaling or f(x) 03 for no
scaling.

Note: Due to the construction of the machine, this example is limited to $bx \leq 10$. If a larger angle is to be used, consult Appendix B for steps to be put into the function subroutine to correct for this.

The following page has the output from the above example.

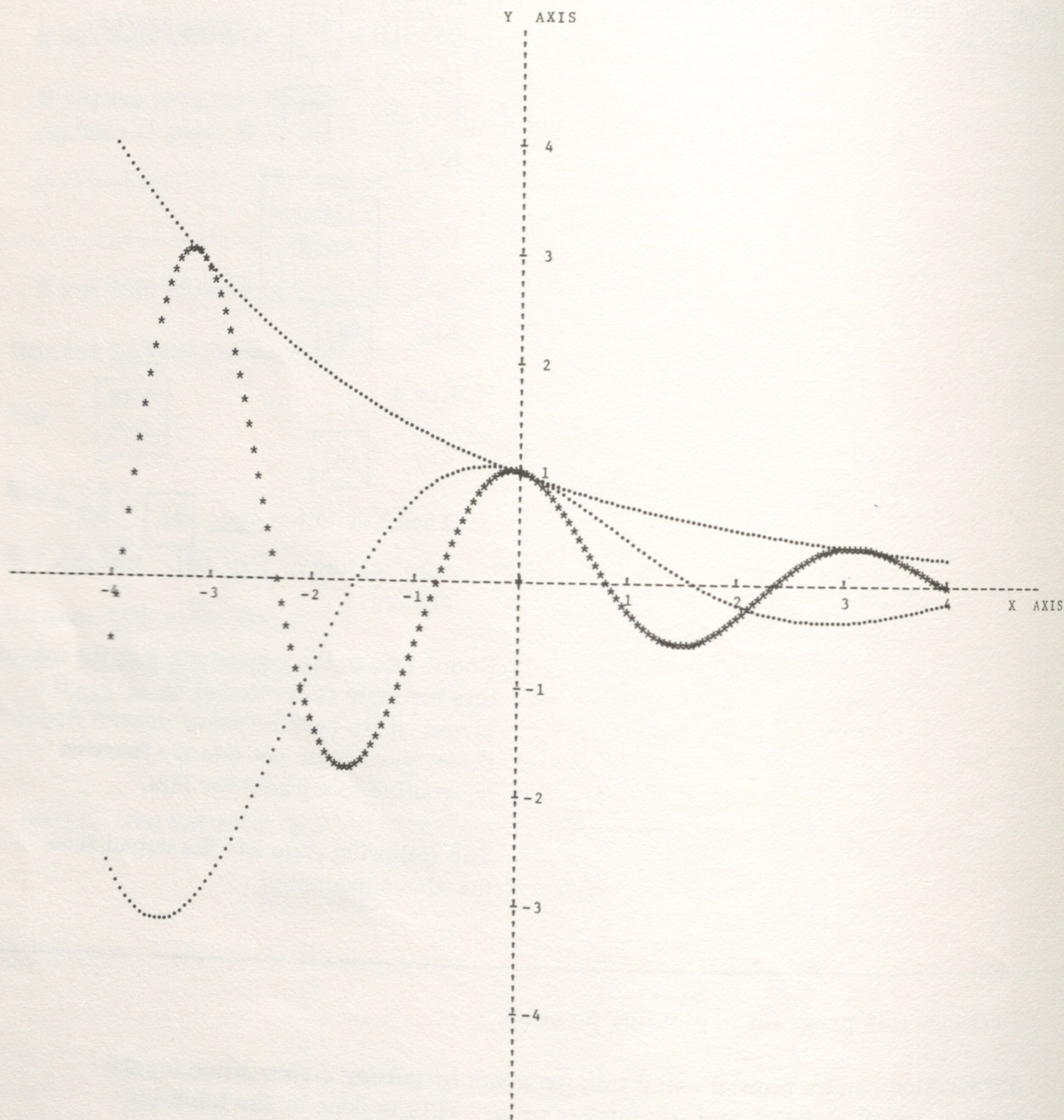
To change this program to plot any function:

Any function can be plotted using this program by putting a subroutine for the new function in place of that for the example. This is done by the following steps:

1. Depress LEARN mode switch

2. Key SET
P.C.

3. Key 0 6 5 2



OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos (bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

4. Key MARK

5. Key f(x) 08

6. Key in subroutine steps

(This subroutine should end with the commands RETURN

and END
PROG)

When writing the function subroutine, remember:

- a. The Mark number must be f(x) 08
(code 10 08)
- b. The value of X is stored in Register 05 and should, therefore, be recalled from Register 05 in the beginning of the subroutine.
- c. When the value of y is obtained, it must be stored in Register 06.
- d. Registers 00, 01, 09 and 14 may be used as work registers for calculations.
- e. Can use any marks within the subroutine which are not listed on page 15 .

The function subroutine on the tape is for the equation of $y = e^{-ax} \cos (bx)$ and involves the following steps:

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0652	0900	Mark	The function subroutine always has to have this mark number
0653	1009	f(x) 08	
0654	0705	RE 05	Recalls the newest value of x from Reg. 05
0655	0600	ST 00	where it is stored. Stores X in Reg. 00

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos (bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

0656	0801	RECALL	Recalls number stored in Reg. designated by the next step
0657	0106	Reg. 22	b has been stored in this Register
0658	0400	x 00	Multiplies b times X
0659	0809	RAD to DEG	Changes the product from radians to degrees
0660	0807	Cos	Gets cosine of (bx)
0661	0600	ST 00	Stores cosine in Register 00
0662	0705	RE 05	Recalls X again
0663	0614	ST 14	Stores X in Register 14
0664	0801	RECALL	Recalls number stored in following register.
0665	0104	REG 20	a has been stored in this Register
0666	0414	x 14	X is multiplied by a
0667	0012	CH SIGN	Changes the sign of ax
0668	0811	e^x	Finds the value of e^{-ax}
0669	0400	x 00	Multiplies cos(bx) by e^{-ax}
0670	0606	ST 06	The final value of y must be stored in Register 06
0671	0915	RETURN	
0672	0914	END PROGRAM	

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos(bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from -4 to +4.

As steps 0657 and 0665 indicated, the values of the constants a and b had to be stored before the use of two short subroutines which were placed just before the function subroutine and which involves the following steps:

STEP #	CODE	KEY	EXPLANATION
0642	0900	MARK	This subroutine could have any mark from
0643	1013	f(x) 13	f(x) 09 to f(x) 15
0644	0901	STORE	Stores the constant, b,
0645	0106	REG 22	in Register 22
0646	0915	RETURN	
0647	0900	MARK	Again this could have been any mark
0648	1014	f(x) 14	from f(x) 09 to f(x) 15
0649	0901	STORE	Stores the constant, a, in
0650	0104	REG 20	Register 20
0651	0915	RETURN	

If more constants are used in the function, then they may be stored by the use of similar subroutines which would be keyed in before the function subroutine. The general form would be:

MARK

f(x) XX

f(x) XX can be any mark from f(x) 09 to f(x) 15

SHIFT

STORE

Depress TSwitch

YY

YY can be any register from 03 to 15 with the T switch depressed; this will actually utilize registers 19 to 31

RETURN

Note: Do not forget to depress the f(x) switch before running the program.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$y = e^{-ax} \cos (bx)$$

Plot y for a = .35 and b = 1, 0, 2 at an increment of .05 from - 4 to + 4.

The number of these subroutines which can be added is entirely dependent upon the number of steps and registers used in the function subroutine. As these coefficient storage subroutines start at step 642 and the main program uses registers 00 through 18, this allows 158 steps in 600-6 and 1182 steps in 600-14 to be used for function and subroutine program steps and/or storage register, remembering that each storage register after 15 eliminates 8 program steps.

EXAMPLE:

$$y = x^3 - ax + b$$

The subroutines of f(x) 13 and f(x) 14 can be used to store the a and b values. The function subroutine would be:

0652	0900	MARK
0653	1008	f(x) 08
0654	0705	RE 05
0655	0600	ST 00
0656	0601	ST 01
0657	0812	x ²
0658	0400	x 00
0659	0801	RECALL
0660	0106	REG 22
0661	0401	x 01
0662	0300	- 00
0663	0801	RECALL

OPERATING INSTRUCTIONS CONT'D.

0664	0104	REG 20
0665	0200	+ 00
0666	0606	ST 06
0670	0915	RETURN
0671	0914	END PROG

If this were keyed into the machine instead of the function on the tape,
then the following page shows the plot when $a = 6$

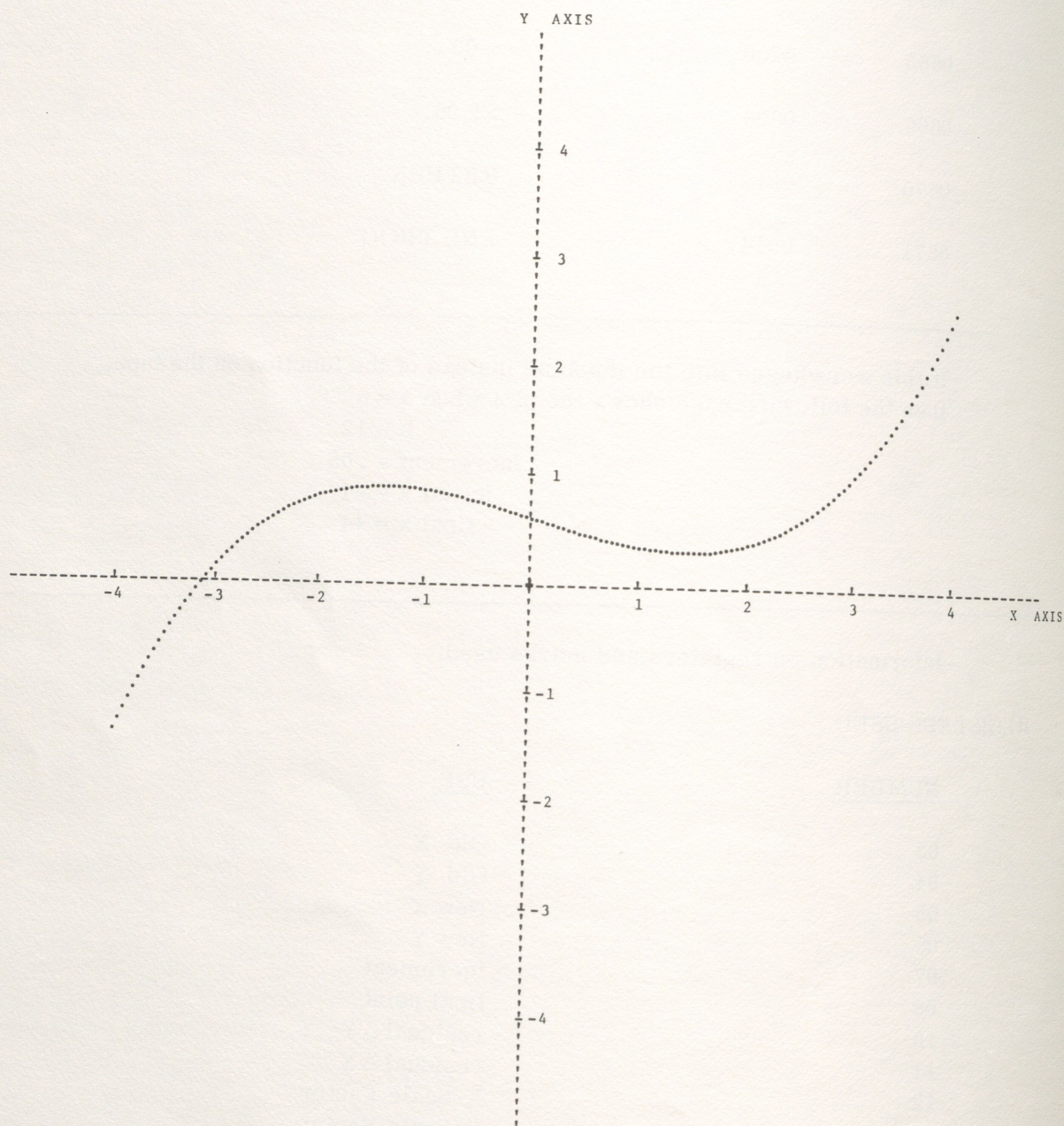
$b = 12$
 increment = .05
 initial $x = -4$
 final $x = +4$

Information on registers and marks used:

REGISTERS USED:

<u>NUMBER</u>	<u>USE</u>
03	Old X
04	Old Y
05	New X
06	New Y
07	increment
08	final point
10	residual ΔY
11	residual ΔX
12	X-Scale Factor
13	Y-Scale Factor

Other Registers used: 00, 01, 02, 09, 14-18



OPERATING INSTRUCTIONS CONT'D.

MARKS USED:

<u>SYMBOL</u>	<u>CODE</u>
1	0001
2	0002
3	0003
4	0004
5	0005
6	0006
7	0007
8	0008
9	0009
decimal point	0010
f(x) 00	1000
f(x) 01	1001
f(x) 02	1002
f(x) 03	1003
f(x) 04	1004
f(x) 05	1005
f(x) 06	1006
f(x) 07	1007
f(x) 08	1008
f(x) 13	1013
f(x) 14	1014
F(x) 00	1100
F(x) 01	1101
F(x) 02	1102
F(x) 03	1103
F(x) 04	1104
F(x) 05	1105
F(x) 06	1106
F(x) 07	1107
F(x) 08	1108
F(x) 09	1109
F(x) 10	1110
F(x) 11	1111
F(x) 12	1112
F(x) 13	1113
F(x) 14	1114
F(x) 15	1115

This page intentionally left blank

WANG

SERIES PROGRAM

STANDARDIZED PLOTTING ROUTINE FOR FIRST QUADRANT
TITLE

PT. 07-600.06T-000B-2-0

NUMBER

DATE

600-6, 600-14/602

EQUIPMENT

PROGRAM ABSTRACT

This program is a standardized plotting routine for the first quadrant with automatic scaling which enables the user to plot any curve, regardless of numerical values, which can be expressed as $y = f(x)$.

BLOCK		VERIFY NO.	NO. OF STEPS
2	Side 1	5513	592

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS:

EXAMPLE ON TAPE is for return on investment:

$$\text{Present Value} = (P + nM) \left(1 + \frac{i}{1200}\right)^n$$

where
 P = initial investment
 M = monthly investment
 i = the annual interest in %
 n = the no. of months from initial investment.

Plot Present Value for P = \$600, M = \$35, i = 10%, and for P = 1000, M = 35, i = 5% for 0 to 100 months in 1 month intervals.

1. Load Program by:

- Depress RUN mode switch
- Insert tape cassette with Side 1 facing operator.
- Depress REWIND
- Depress TAPE READY

e. Key PRIME

f. Key LOAD
PROG, Key LOAD
PROG

g. Key VERIFY
PROG

h. The display should read:

+5513.000000

2. Key f(x) 00. The X and Y axes will be printed out and labeled. The program will stop with +1.000000000 in the display when the axes are complete.

1. Same as #1 of general instructions.

2. Same as #2 of general instructions.

If you have a function which requires constants to be keyed in externally, then key each constant followed by the corresponding key, such as:

3. Key P Value

Key f(x) 13

Key M Value

3. Key 6 0 0

Key f(x) 13 (Store P)

Key 3 5

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investment:

$$\text{Present Value} = (P + nM) \left(1 + \frac{i}{1200}\right)^n$$

where P = initial investment
M = monthly investment
i = the annual interest in %
n = the no. of months from initial investment.

Plot Present Value for P = \$600, M = \$35, i = 10%, and for P = 1000, M = 35, i = 5% for 0 to 100 months in 1 month intervals.

Key f(x) 14

Key i Value

Key f(x) 15

Key f(x) 14 (Store M)

Key 1 0

Key f(x) 15 (Store i)

The interest, i, is the annual interest in %, i.e. 8% would be keyed in as 8 not . 0 8

4. Key INCREMENT

Key f(x) 01

Display is dark

Key INITIAL X

Key GO

Display is dark

Key FINAL X

Key GO

Do either 4(a) or 4(b)

4a. If you want automatic scaling

Key f(x) 02

4a.

Key f(x) 02

The program will calculate the X and Y Scale Factors and plot the function in the interval and at the increment specified.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investment:

$$\text{Present Value} = (P + nM) \left(1 + \frac{i}{1200}\right)^n$$

where P = initial investment
M = monthly investment
i = the annual interest
n = the no. of months from initial investment

Plot Present Value for P = \$600, M = \$35, i = 10%, and for P = 1000, M = 35, i = 5% for 0 to 100 months in 1 month intervals.

NOTE: If you select automatic scaling you should be aware that it does take time to compute the scaling factors and the plotting will not start immediately. The amount of time required between keying f(x) 02 and the start of the plot will vary depending upon the complexity of the function and the number of subroutines within the function subroutine, and the increment of plotting which is specified. In the event that the function involves a trigonometric routine, the scaling will take longer as the trigonometric routines are approximations in themselves. If the function is a polynomial or something very simple, the scaling takes only about 10 - 15 seconds.

4b. If you want your own scale factors,

4b. If you want to use an
X-Scale Factor = 10
Y-Scale Factor = .1

Key X-Scale Factor

Key f(x) 04

Key Y-SCALE FACTOR

Key f(x) 05

Key f(x) 03

Key 1 0

Key f(x) 04

Key . 1

Key f(x) 05

Key f(x) 03

The program will now plot the function in the interval and at the increment specified and then will return to the origin.

NOTE: If you want to use your own scale factors, see Section entitled "Criterion In Choosing A Proper Scaling Factor". Appendix A.

Since the axes are always labeled 0 to 10 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore, the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5 then each division on the graph

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investment:

$$\text{Present Value} = (P + nM) \left(1 + \frac{i}{1200}\right)^n$$

where P = initial investment
 M = monthly investment
 i = the annual interest in %
 n = the no. of months from initial investment

Plot Present Value for $P = \$600$, $M = \$35$
 $i = 10\%$, and for $P = 1000$, $M = 35$, $i = 5\%$
for 0 to 100 months in 1 month intervals.

is actually 5 units and the axis would actually have a range of 0 to +50. For information on how the axis unit value is related to the scaling factor, see Appendix A.

If you just want to obtain the axis unit values, Key $f(x)$ 06

5. To obtain

X-Axis Unit Value, Key the blue

RECALL on the left

Y-Axis Unit Value, Key the blue

RECALL on the right

5.

Key RECALL on the left

READ: +10.00000000 in the display

This is the X-Axis Unit Value

Key RECALL on the right

READ: + 1000.000000 in the display

This is the Y-Axis Unit Value

6. If you want to obtain the value of Y for a given value of X,

Key X-Value

Key $f(x)$ 07

The Y-Value will appear in the display

6. If 1 month has gone by, then $n = 1$

Key 1

Key $f(x)$ 07

The Y-Value of +640.2916666

will appear in the display.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investment:

$$\text{Present Value} = (P + nM)(1 + \frac{i}{1200})^n$$

Where P = initial investment
M = monthly investment
i = the annual interest in %
n = the no. of months from initial investment

Plot present value for P = \$600, M = \$35
i = 10%, and for P = 1000, M = 35, i = 5%
for 0 to 100 months in 1 month intervals.

If you want to replot the function with new constants on the same axis,

7. Key NEW CONSTANT

Key f(x) XX

Where XX is the key which stores the appropriate constant

7. Key 1 0 0 0

Key f(x) 13

Key 5

Key f(x) 15

You may change all the coefficients or only a few according to above method; the ones you do not change will remain the same as for the new plot as in the previous plot.

With coefficient change, you are now ready to replot; however you should first

Key f(x) 06

and record the X and Y axis values as they may change if you select auto scaling.

Key INCREMENT

Key f(x) 01

Display is dark

Key INITIAL X

Key GO

Display is dark

Key 1

Key f(x) 01

Display is dark

Key 0

Key GO

Display is dark

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investments:

$$\text{Present Value} = (P + nM)(1 + \frac{i}{1200})^n$$

Where P = initial investment
M = monthly investment
i = the annual interest in %
n = the no. of months from initial investment.

Plot Present Value for P = \$600, M = \$35, i = 10%, and for P = 1000, M = 35, i = 5% for 0 to 100 months in 1 month intervals.

Key FINAL X

Key 1 0 0

Key GO

Key GO

If you want auto scaling:

Key f(x) 02

If you are sure that the new coefficient will not cause plotting to go outside confines of axes then

Key f(x) 03

as the scale factor computed on previous plot will still be in storage.

If you want to change the plotting symbol for each replot,

8. Depress LEARN mode switch

8. Depress LEARN mode switch

Key SET
P.C.

Key SET
P.C.

Key 0 3 4 7

Key 0 3 4 7

Key XX YY

Key 07 12 (plot *)

Depress RUN mode switch

Depress RUN mode switch

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investments:

$$\text{Present Value} = (P + nM)(1 + \frac{i}{1200})^n$$

Where P = initial investment
M = monthly investment
i = the annual interest in %
n = the no. of months from initial investment

Plot present value for P = \$600, M = \$35
i = 10%, and for P = 1000, M = 35, i = 5%
for 0 to 100 months in 1 month intervals.

NOTE: Assure f(x) switch is depressed again.

NOTE: The following is a list of the most useful plotting symbols and codes:

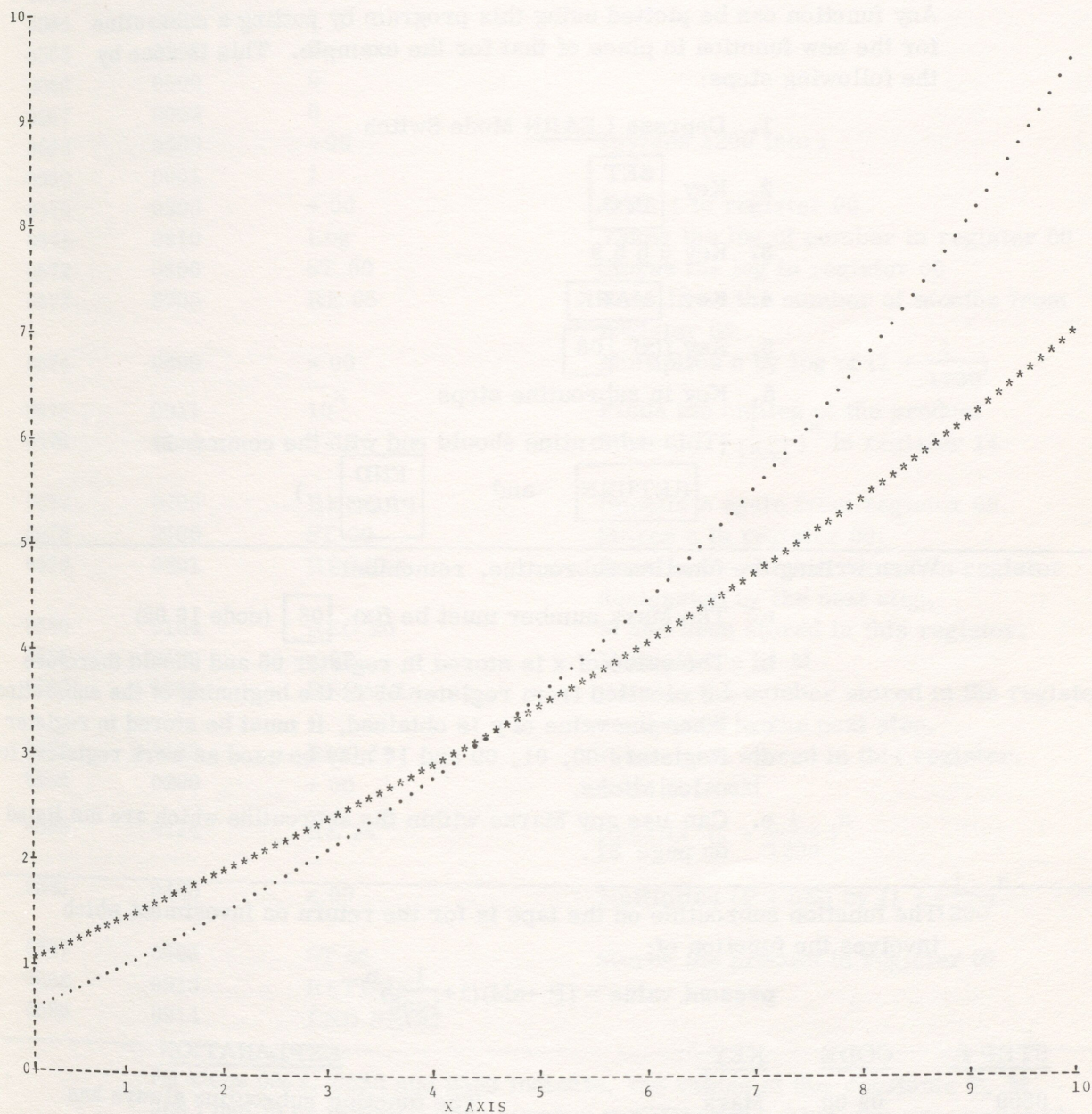
<u>SYMBOL</u>	<u>CODE</u>
+	04 06
*	07 12
°	05 07
0	05 09
x	06 15

The position of the different symbols relative to each other as keyed at the same point might be slightly off as they might occupy different position on the IBM ball relative to the striking center of the decimal point.

9. This may be followed by a replot of the function as described in #7.

9. The following page has the output of the above example.

Y AXIS



© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE is for return on investments:

$$\text{Present Value} = (P + nM)(1 + \frac{i}{1200})^n$$

Changing this program to plot any function:

Any function can be plotted using this program by putting a subroutine for the new function in place of that for the example. This is done by the following steps:

1. Depress LEARN Mode Switch

2. Key SET
P.C.

3. Key 0 5 5 9

4. Key MARK

5. Key f(x) 08

6. Key in subroutine steps

(This subroutine should end with the commands

RETURN

and

END
PROG

)

When writing the function subroutine, remember:

- The Mark number must be f(x) 08 (code 10 08)
- The value of x is stored in register 05 and should therefore be recalled from register 05 in the beginning of the subroutine.
- When the value of y is obtained, it must be stored in register 06.
- Registers 00, 01, 09 and 14 may be used as work registers for calculations.
- Can use any Marks within the subroutine which are not listed on page 31.

The function subroutine on the tape is for the return on investment which involves the function of:

$$\text{present value} = (P + nM)(1 + \frac{i}{1200})^n$$

STEP #	CODE	KEY	EXPLANATION
0559	09 00	Mark	The function subroutine always has to have this mark number.
0560	10 08	f(x) 08	

OPERATING INSTRUCTIONS CONT'D.

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0561	0801	RECALL	Recalls the number stored in register designated by the next step.
0562	0105	REG 21	i has been stored in this register.
0563	0600	ST 00	Stores i in Register 00
0564	0001	1	
0565	0002	2	
0566	0000	0	
0567	0000	0	
0568	0500	÷ 00	Divides 1200 into i
0569	0001	1	
0570	0200	+ 00	Adds 1 to register 00
0571	0910	Log	Takes the log of number in register 00
0572	0600	ST 00	Stores the log in register 00
0573	0705	RE 05	Recalls n, the number of months from register 05.
0574	0400	x 00	Multiplies n by log of $(1 + \frac{i}{1200})$
0575	0911	10^x	Finds the antilog of the product
0576	0614	ST 14	Stores $(1 + \frac{i}{1200})^n$ in register 14
0577	0705	RE 05	Recalls n again from register 05.
0578	0600	ST 00	Stores n in register 00.
0579	0801	RECALL	Recalls the number stored in register designated by the next step.
0580	0104	REG 20	M has been stored in this register.
0581	0400	x 00	Multiplies n by M
0582	0801	RECALL	Recalls the number stored in the register designated by the next step.
0583	0103	REG 19	P has been stored in this register.
0584	0200	+ 00	Adds P to nM
0585	0714	RE 14	Recalls $(1 + \frac{i}{1200})^n$
0586	0400	x 00	Multiplies $(P + nM)$ by $(1 + \frac{i}{1200})^n$
0587	0606	ST 06	Stores the product in register 06
0588	0915	RETURN	
0589	0914	END PROG	

As steps 0562, 0580 and 0583 indicate, the values of the constants P, M and i had to be stored before running the program. This was accomplished by the use of three short subroutines which were placed just before the function subroutine and which involve the following steps:

<u>STEP</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0544	0900	Mark	This subroutine could have any mark from
0545	1013	f(x) 13	f(x) 09 to f(x) 15

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

STEP	CODE	KEY	EXPLANATION
0546	0901	STORE	Stores P in register 19
0547	0103	REG 19	
0548	0915	RETURN	This subroutine could have any mark from f(x) 09 to f(x) 15
0549	0900	MARK	
0550	1014	f(x) 14	
0551	0901	STORE	Stores i in Register 20
0552	0104	REG 20	
0553	0915	RETURN	This subroutine could have any mark from f(x) 09 to f(x) 15
0554	0900	Mark	
0555	1015	f(x) 15	
0556	0901	STORE	Stores i in register 21
0557	0105	REG 21	
0558	0915	RETURN	

If more constants are used in the function, then they may be stored by the use of similar subroutines which would be keyed in before the function subroutine. The general form would be:

MARK
f(x) XX f(x) XX can be any mark from f(x) 09 to f(x) 15

SHIFT

STORE

Depress T switch

YY YY can be any register from 03 to 15

RETURN With the T switch depressed, this will actually utilize registers 19 to 31.

NOTE: Do not forget to depress the f(x) switch before running the program.

The number of these subroutines which can be added is entirely dependent upon the number of steps and registers used in the function subroutine. As these coefficients storage subroutines start at step 244 and the main program uses registers 00 through 18, this allows only steps 256 steps in 600-6 and 1280 steps in 600-14 to be used for function and subroutine programs steps and/or storage registers. Remembering that each storage register after 15 eliminates 8 program steps.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE: $y = x^3 + a$

The subroutine of f(x) 13 can be used to store a. The other storage subroutines, f(x) 14 and f(x) 15, will not be used and therefore they can either be ignored or deleted. The function subroutine would be:

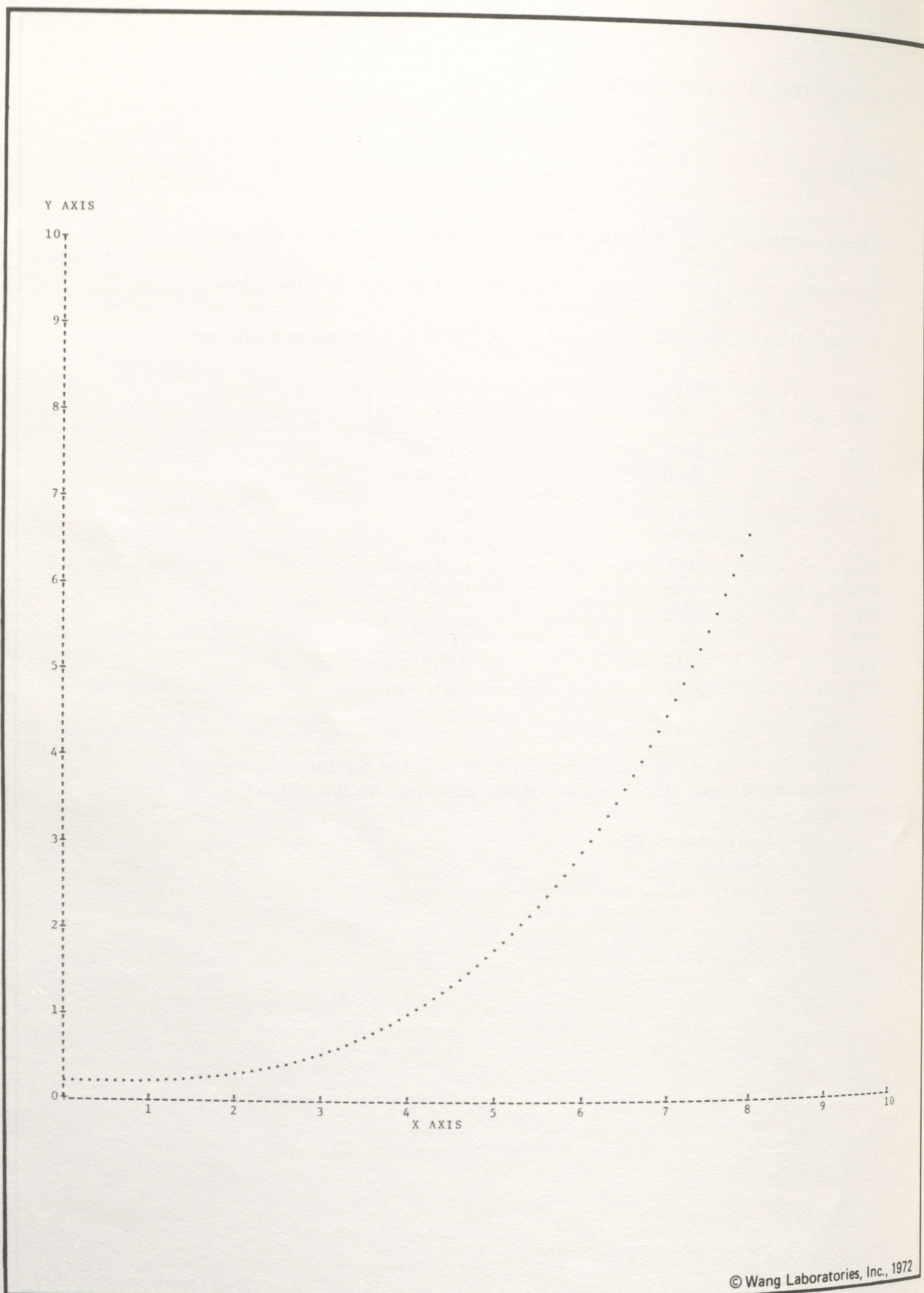
0559	0900	Mark
0560	1008	f(x) 08
0561	0705	RE 05
0562	0600	ST 00
0563	0812	x^2
0564	0400	x 00
0565	0801	RECALL
0566	0103	REG 19
0567	0200	+ 00
0568	0606	ST 06
0569	0915	RETURN
0570	0914	END PROG

If this function were keyed into the machine instead of the function subroutine on the tape, then the plot will be the same as the following page when $a = 2$

increment = .05

Initial X = 0

Final X = 4



OPERATING INSTRUCTIONS CONT'D.

Information on Marks and Registers Used:

REGISTERS USED:

03	Old X
04	Old Y
05	New X
06	New Y
07	Increment
08	Final Point
10	Residual ΔX
11	Residual ΔY
12	X-Scale Factor
13	Y-Scale Factor

Other registers used: 00, 01, 02, 09, 14-18

MARKS USED:

<u>SYMBOL</u>	<u>CODE</u>	<u>SYMBOL</u>	<u>CODE</u>
1	0001	F(x) 00	1100
2	0002	F(x) 01	1101
3	0003	F(x) 03	1103
4	0004	F(x) 04	1104
f(x) 00	1000	F(x) 05	1105
f(x) 01	1001	F(x) 06	1106
f(x) 02	1002	F(x) 08	1108
f(x) 03	1003	F(x) 09	1109
f(x) 04	1004	F(x) 12	1112
f(x) 05	1005	F(x) 13	1113
f(x) 06	1006	F(x) 14	1114
f(x) 07	1007	F(x) 15	1115
f(x) 08	1008		
f(x) 13	1013		
f(x) 14	1014		
f(x) 15	1015		

WANG

SERIES PROGRAM

STANDARDIZED POINT PLOTTING
ROUTINE FOR FOUR QUADRANTS

TITLE

PT. 06-600.06T-000B-3-0

NUMBER

600-6, 600-14/602

DATE

EQUIPMENT

PROGRAM ABSTRACT This program allows one to plot discrete points in four quadrants with automatic scaling, so the size of the numbers does not matter.

BLOCK		VERIFY NO.	NO. OF STEPS
3	Side 1	4326	517

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS

1. To load program:

- a. Depress RUN mode switch
- b. Insert tape cassette with Side 1 facing operator.
- c. Depress REWIND
- d. Depress TAPE READY

e. Key PRIME

f. Key 2
SHIFT

Key α

Key LOAD
PROG

g. Key VERIFY
PROG

h. The display should read +4326.000000

2. Key f(x) 00

The X and Y axes will be printed out and labeled. The program will stop with the display dark when the axes are complete.

3a. If you desire automatic scaling, then scan your (x,y) values for the largest and smallest values of x and y, then:

Key LARGEST x, GO

When display is dark,

Key SMALLEST x, GO

X-Scale Factor is calculated and then display is dark

Key LARGEST y, GO, display is dark

Key SMALLEST y, GO

Y-Scale Factor is calculated and program is ready to accept (x,y) values for plotting when the display is dark.

Skip to 4.

OPERATING INSTRUCTIONS CONT'D.

3b. If you want your own scale factors, do the following:

Key X-SCALE FACTOR, Key f(x) 04

Key Y-SCALE FACTOR, Key f(x) 05

Then Key f(x) 03

The program will stop with the display dark.

Skip to 4.

NOTE: If you want to use your own scale factors, see section entitled "Criterion in Choosing A Proper Scaling Factor." Appendix A.

4. You are now ready to plot the discrete points.

Simply: Key x, GO

Display is dark

Key y, GO

The point (x,y) will be plotted and the plotter will return to origin; the program will stop with the display dark when it is ready to accept next data point.

Repeat step 4 for each (x,y) point.

4a. Since the axes are always labeled -4 to +4 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore, the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5, then each division on the graph is actually 5 units and the axis would actually have a range of -20 to +20. For information on how the axis unit value is related to the scaling factor, see Appendix A.

Key f(x) 06

The X-Axis Unit Value is obtained by Keying the blue
on the left.

RECALL

The Y-Axis Unit Value is obtained by Keying the blue
on the right.

RECALL

OPERATING INSTRUCTIONS CONT'D.

- 4b. In the eventuality that some may be interested in changing the plotting symbol for each replot; here is the procedure to follow:

Depress LEARN mode switch

SET P.C. 0 4 8 0

Key xx yy

Depress RUN mode switch

Note: Do not forget to depress the f(x) switch again.

If the new points are within the range of the previous set:

Key f(x) 03

and proceed as in 4.

If the new points are outside the range of the previous set and you want auto scaling, proceed as in 3a. except that after keying LARGEST x, Key f(x) 02

If the new points are outside the range of the previous set and you want your own scale factor, proceed as in 3b.

The following is a list of the most useful plotting symbols and codes.

<u>SYMBOL</u>	<u>xx yy</u>
.	0506
*	0712
o	0507
0	0509
x	0615

There is no example, as you may use any set of (x,y) points you choose.

This page intentionally left blank

WANG

SERIES PROGRAM

STANDARDIZED POINT PLOTTING
ROUTINE FOR THE FIRST QUADRANT

TITLE

PT.07-600.06T-000B-4-0

NUMBER

600-6, 600-14/602

DATE

EQUIPMENT

PROGRAM ABSTRACT This program allows one to plot discrete points in the first quadrant with automatic scaling, so the size of the numbers does not matter.

BLOCK		VERIFY NO.	NO. OF STEPS
4	Side 1	3113	372

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS

1. To load program

- a. Depress RUN mode switch
- b. Insert the tape cassette with Side 1 facing the operator.
- c. Depress REWIND
- d. Depress TAPE READY
- e. Key PRIME
- f. Key 3
SHIFT
Key α
- g. Key LOAD
PROG
VERIFY
PROG
- h. The display should read: + 3113.000000

2. Key f(x) 00

The X and Y axes will be printed out and labeled. The program will stop with the display dark when the axes are complete.

- 2a. If you desire automatic scaling, then scan your (x,y) values for the largest and smallest values of x and y then:

Key LARGEST x, GO, X-Scale factor is calculated and display is dark

Key LARGEST y, GO

Y-Scale Factor is calculated and program is ready to accept (x,y) values for plotting when the display is dark.

Skip to 3.

- 2b. If you want your own scale factors, do the following:

Key X-SCALE FACTOR, Key f(x) 04

Key Y-SCALE FACTOR, Key f(x) 05

Then Key f(x) 03

OPERATING INSTRUCTIONS CONT'D.

The program will stop with the display dark.

Skip to 3.

NOTE: If you want to use your own scale factors, see section entitled "Criterion In Choosing A Proper Scaling Factor." Appendix A.

3. You are now ready to plot the discrete points.

Simply: Key x ,

Display is dark

Key y ,

The point (x,y) will be plotted and the plotter will return to origin;
The program will stop with the display dark when it is ready to accept next data point.

Repeat step 3 for each (x,y) point.

4a. Since the axes are always labeled 0 to 10 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore, the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5, then each division on the graph is actually 5 units and the axis would actually have a range of 0 to +50. For information on how the axis unit value is related to the scaling factor, see Appendix A.

If you wish to know the value of the X and Y axis units:

Key f(x)

The X-Axis Unit Value will be obtained by keying the blue
on the left.

The Y-Axis Unit Value will be obtained by keying the blue
on the right.

4b. In the eventuality that some may be interested in changing the plotting symbol for each replot, here is the procedure to follow:

Depress LEARN mode switch

SET P.C. 0 3 3 4

OPERATING INSTRUCTIONS CONT'D.

Key xx yy

Depress RUN mode switch

If the new points are within the range of the previous set:

Key f(x) 03

Note: Do not forget to depress f(x) switch again
and proceed as in 3.

If the new points are outside the range of the previous set,
and you want auto scaling, proceed as in 2a. except that after
keying LARGEST x, Key f(x) 02 .

If the new points are outside the range of the previous set and
you want your own scale factor, proceed as in 2b.

The following is a list of the most useful plotting symbols and codes.

SYMBOL

xx yy

.	05 06
*	07 12
o	05 07
0	05 09
x	06 15

There is no example, as you may use any set of (x,y) points you choose.

WANG

SERIES PROGRAM

STANDARDIZED POLAR PLOTTING ROUTINE

TITLE

PT. 07-600.06T-000B-5-0

NUMBER

DATE

600-6, 600-14/602

EQUIPMENT

PROGRAM ABSTRACT This program is a standardized polar plotting routine with automatic scaling which enables the user to plot any curve, regardless of numerical values, which can be expressed as $\rho = f(\theta)$

BLOCK		VERIFY NO.	NO. OF STEPS
1	Side 2	6014	654

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS

EXAMPLE ON TAPE: $\rho = a \sin(b \theta)$
Plot for $a = 4$, $b = 2$ and $a = 5$, $b = 4$ in
increments of 2° from 0 to 360

1. Load Program by:

- a. Depress RUN mode switch
- b. Insert tape cassette with
Side 2 facing operator.
- c. Depress REWIND
- d. Depress TAPE READY
- e. Key PRIME
- f. Key LOAD
PROG
- g. Key VERIFY
PROG
- h. The display should read

+6014.000000

2. Key f(x) 00

The X and Y axes will be printed
out and labeled. The program will
stop with -42.00000000 in the
display when the axes are complete.

1. Same as #1 of general instructions.

2. Same as #2 of general instructions.

If you have a function which requires constants to be keyed in externally, then
Key each constant followed by corresponding key. Such as;

3. Key b Value

Key f(x) 14

Key a Value

Key f(x) 15

3. Key 2

Key f(x) 14 (Store b)

Key 4

Key f(x) 15 (Store a)

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE: $\rho = a \sin(b \theta)$
Plot for $a = 4$, $b = 2$, and $a = 5$, $b = 4$
in increments of 2° from 0 to 360.

4. Key $f(x)$ 01

Note: θ is in decimal degrees

Key INCREMENT

Key GO

Display is dark

Key INITIAL θ , Key GO

Display is dark

Key FINAL θ

Key GO

Do either 4a or 4b

4. Key $f(x)$ 01

Key 2

Key GO

Display is dark

Key 0 , GO

Display is dark

Key 3 6 0

Key GO

Do either 4a or 4b

If you want automatic scaling;

4a. Key $f(x)$ 02

The program will calculate the X and Y scale factors and plot the function in the interval specified according to the increment specified then return to the origin.

4a. Key $f(x)$ 02

NOTE: If you select automatic scaling you should be aware that it does take time to compute the scaling factors and the plotting will not start immediately. The amount of time required between keying

$f(x)$ 02 and the start of the plot will vary depending upon the

complexity of the function and the number of subroutines within the function subroutine, and the increment of plotting which is specified. In the case of the example given, the scaling takes about 1 minute as the function has a sine calculation which in itself is an approximation. If the function is a polynomial or something very simple, the scaling takes only about 15 seconds.

4b. If you want your own scale factors:

Key X-SCALE FACTOR

Key $f(x)$ 04

Key Y-SCALE FACTOR

Key $f(x)$ 05

4b. If you want to use an

X-Scale Factor = 100

Y-Scale Factor = 100

Key 1 0 0

Key $f(x)$ 04

Key 1 0 0

Key $f(x)$ 05

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE: $\rho = a \sin(b \theta)$
Plot for $a = 4$, $b = 2$ and $a = 5$, $b = 4$ in increments of 2° from 0 to 360.

Key $f(x)$ 03

Key $f(x)$ 03

The program will now plot the function in the interval and at the increment specified and then will return to the origin.

NOTE: If you want to use your own scale factors see section entitled "Criterion In Choosing A Proper Scale Factor". Appendix A.

Since the axes are always labeled -4 to +4 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5, then each division on the graph is actually 5 units and the axis would actually have a range of -20 to +20. For information on how this axis unit value is related to the scaling factor, see Appendix A.

5. Key $f(x)$ 06

5. Key $f(x)$ 06

To obtain

X-Axis Unit Value, Key the blue

RECALL on the left

Key RECALL on the left

READ: +1.000000000 in the display

This is the X-Axis Unit Value

Y-Axis Unit Value, Key the blue

RECALL on the right

Key RECALL on the right

READ: +1.000000000 in the display

This is the Y-Axis Unit Value

6. If you want to obtain the value of ρ for a given value of θ ,

Key θ Value

Key $f(x)$ 07

the ρ -Value will appear in the display

Key GO

6. If $\theta = 45^\circ$, then

Key 4 5

Key $f(x)$ 07

The ρ -Value of +4.000000000 will appear in the display.

Key GO

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE: $\rho = a \sin(b \theta)$
 Plot for $a = 4$, $b = 2$ and $a = 5$, $b = 4$ in
 increments of 2° from 0 to 360.

To obtain ρ and θ in rectangular coordinates:

Read X-Value by keying the blue

RECALL on the left

Key **RECALL** on the left

READ: +2.828427124

This is the X-Value in rectangular
 coordinates

Read Y-value by keying the blue

RECALL on the right

Key **RECALL** on the right

READ: +2.828427124

This is the Y-value in rectangular
 coordinates.

If you want to replot the function with new constants on the same axis;

7. Key NEW CONSTANT

Key f(x) **XX**

Where **XX** is the key which stores
 the appropriate constant.

7. Key 4

Key f(x) **14** (stores new b)

Key 5

Key f(x) **15** (stores new a)

You may change all the coefficients or only a few according to
 above method; the ones you do not change will remain the same
 as for the new plot as in the previous plot.

With coefficient change, you are now ready to replot; however
 you should first

Key f(x) **06**

and record the X and Y Axis values as they may change if you
 select auto scaling.

Key f(x) **01**

Key INCREMENT

Key **GO**

Display is dark

Key INITIAL θ

Key **GO**

Key f(x) **01**

Key 2

Key **GO**

Display is dark

Key 0

Key **GO**

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE: $\rho = a \sin(b\theta)$
 Plot for $a = 4$, $b = 2$ and $a = 5$, $b = 4$ in
 increments of 2° from 0 to 360.

Display is dark

Key FINAL 0

Key GO

Display is dark

Key 3 6 0

Key GO

If you want auto scaling,

Key f(x) 02

If you are sure that the new coefficient will not cause plotting
 to go outside confines of axes then

Key f(x) 03

as the scale factor computed on previous plot will still be in
 storage.

If you want to change the plotting symbol for each replot,

8. Depress LEARN mode switch

Key SET
P.C.

Key 0 5 5 3

Key xx yy

Depress RUN mode switch

8. Depress LEARN mode switch

Key SET
P.C.

Key 0 5 5 3

READ: 0553 05 06 in display

Key 07 12 (plot *)

Depress RUN mode switch

NOTE: Assure f(x) switch is depressed again.

The following is a list of the most useful plotting symbols and codes.

SYMBOL

+
*
o
0
x

CODE

04 06
07 12
05 07
05 09
06 15

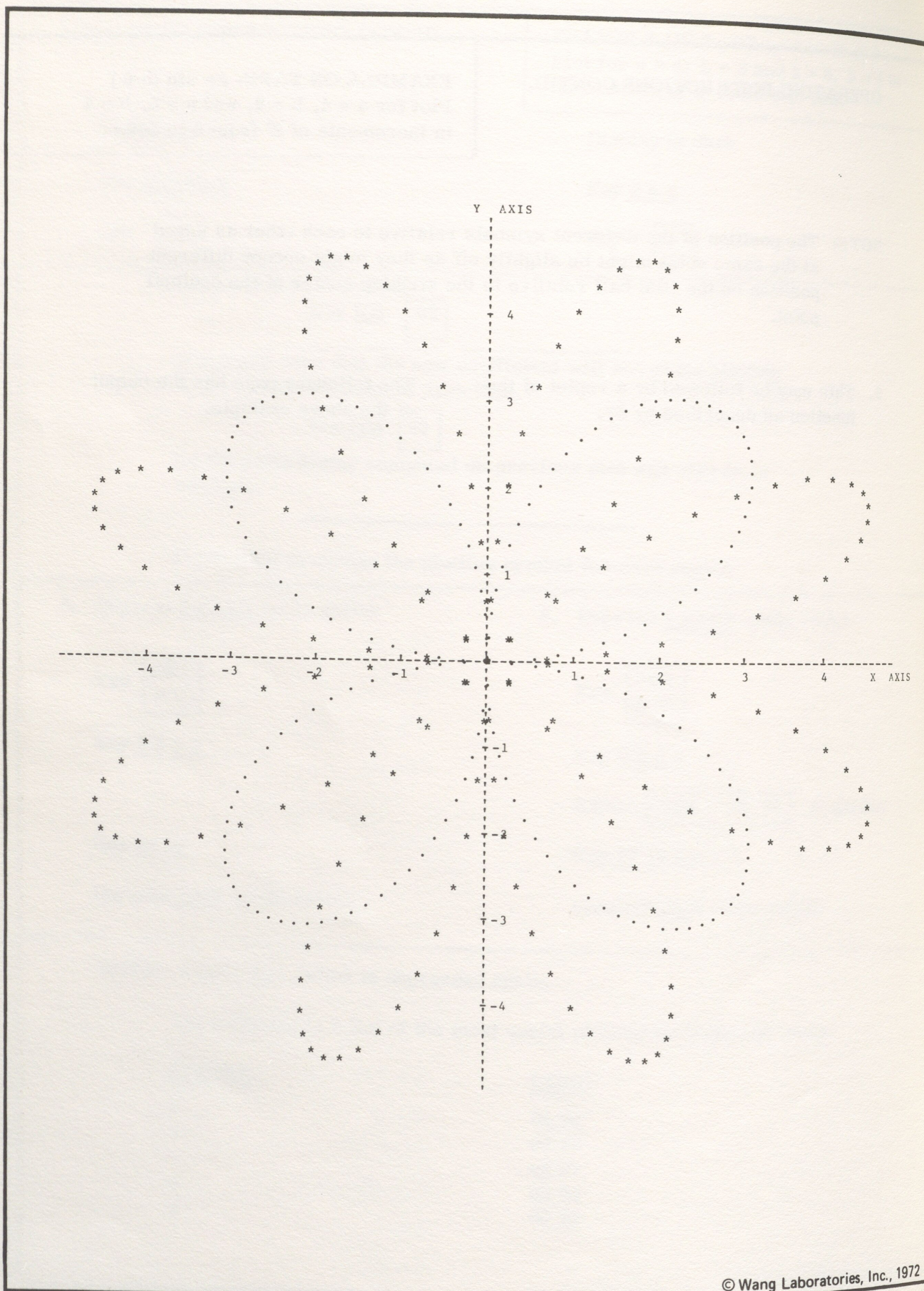
OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE: $\rho = \sin(b \theta)$
Plot for $a = 4$, $b = 2$, and $a = 5$, $b = 4$
in increments of 2° from 0 to 360.

NOTE: The position of the different symbols relative to each other as keyed at the same point might be slightly off as they might occupy different position on the IBM ball relative to the striking center of the decimal point.

9. This may be followed by a replot of the function as described by #7.

The following page has the output of the above example.



© Wang Laboratories, Inc., 1972

EXAMPLE ON TAPE: $\rho = a \sin(b \theta)$
Plot for $a = 4$, $b = 2$, and $a = 5$, $b = 4$,
in increments of 2° from 0 to 360° .

To Change This Program to Plot Any $f(\theta)$

Any $f(\theta)$ can be plotted using this program by putting a subroutine for the new function in place of that for the example. This is done by the following steps:

1. Depress LEARN mode switch
2. Key

SET
P. C.
3. Key 0 6 2 7
4. Key

MARK

5. Key $f(x)$

08

6. Key in subroutine steps. (This subroutine should end with the commands

RETURN

 and

END
PROG

)

When writing the function subroutine remember:

- a. The Mark number must be $f(x)$

08

 (code 1008)
- b. The value of θ is stored in register 08 and should always be recalled from register 08 in the beginning of the subroutine.
- c. When the value of ρ is obtained, it must be stored in register 19 (Register 19 is with T switch depressed, Key

03

)
- d. Registers 00, 01, 14 and 18 may be used as work registers for calculations.
- e. Can use any Marks within the subroutine which are not listed on page 54 .
- f. Due to the characteristics of this machine, the sine, cosine and tangent keys will only operate correctly for angles less than 570° . Therefore, it is necessary to put in some steps to correct for this, such as steps 634 - 644 on the next page. See also Appendix B.

The function subroutine on the tape is for the equation of $\rho = a \sin(b\theta)$ and involves the following steps:

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0627	0900	Mark	The function subroutine always has to have this mark number. Recalls the newest value of θ from register 08.
0628	1008	f(x) 08	
0629	0708	RE 08	
0630	0600	ST 00	Stores θ in register 00
0631	0801	RECALL	Recalls the number stored in register designated by the next step.
0632	0105	REG 21	b has been stored in this register.
0633	0400	x 00	Multiplies θ by b
0634	0003	3	
0635	0006	6	
0636	0000	0	
0637	0901	STORE	Stores 360 in the register designated by the next step.
0638	0102	REG 18	
0639	0500	÷ 00	Divides $(b\theta)$ by 360
0640	0912	INT X	Gets the integer of the quotient
0641	0300	- 00	Subtracts the integer from quotient leaving the decimal portion.
0642	0801	RECALL	Recalls the number stored in the register designated by the next step
0643	0102	REG 18	360 has been stored in this register
0644	0400	x 00	Multiplies the decimal portion by 360 to get an angle equivalent to $(b\theta)$
0645	0806	SIN	Takes the sin of the angle
0646	0600	ST 00	Stores the sin in register 00
0647	0801	RECALL	Recalls the number stored in the register designated by the next step.
0648	0106	REG 22	a has been stored in this register.
0649	0400	x 00	Multiplies $\sin(b\theta)$ by a .
0650	0901	STORE	Stores the value of ρ in register 19
0651	0103	REG 19	
0652	0915	RETURN	
0653	0914	END PROG	

As steps 0632 and 0648 indicate, the values of the constants a and b had to be stored before running the program. This was accomplished by the use of two short subroutines which were placed just before the function subroutine and which involve the following steps:

STEP #	CODE	KEY	EXPLANATION
0617	0900	MARK	This subroutine could have any mark
0618	1014	f(x) 14	from f(x) 09 to f(x) 15
0619	0901	STORE	Stores the constant, b, in
0620	0105	REG 21	register 21
0621	0915	RETURN	
0622	0900	MARK	This subroutine could have any mark
0623	1015	f(x) 15	from f(x) 09 to f(x) 15
0624	0901	STORE	Stores the constant, a, in
0625	0106	REG 22	register 22
0626	0915	RETURN	

If more constants are used in the function then they may be stored by the use of similar subroutines which would be keyed in before the function subroutine. The general form would be:

MARK	
f(x) XX	f(x) XX can be any mark from f(x) 09
SHIFT	to f(x) 15
STORE	
Depress T switch	
YY	YY can be any register from 05 to 15 .
	With the T switch depressed, this will
	actually utilize registers 21 - 31.
RETURN	

NOTE: Do not forget to depress the f(x) switch before running the program.

The number of these subroutines which can be added is entirely dependent upon the number of steps and registers used in the function subroutine. As these coefficient storage subroutines start at step 617 and the main program uses registers 00 through 22, this allows 151 steps in 600-6 and 1175 steps in 600-14 to be used for function and subroutine program steps and/or storage register, remembering that each storage register used after register 15 eliminates 8 program steps.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE:

$$\rho = a (1 - \cos \theta)$$

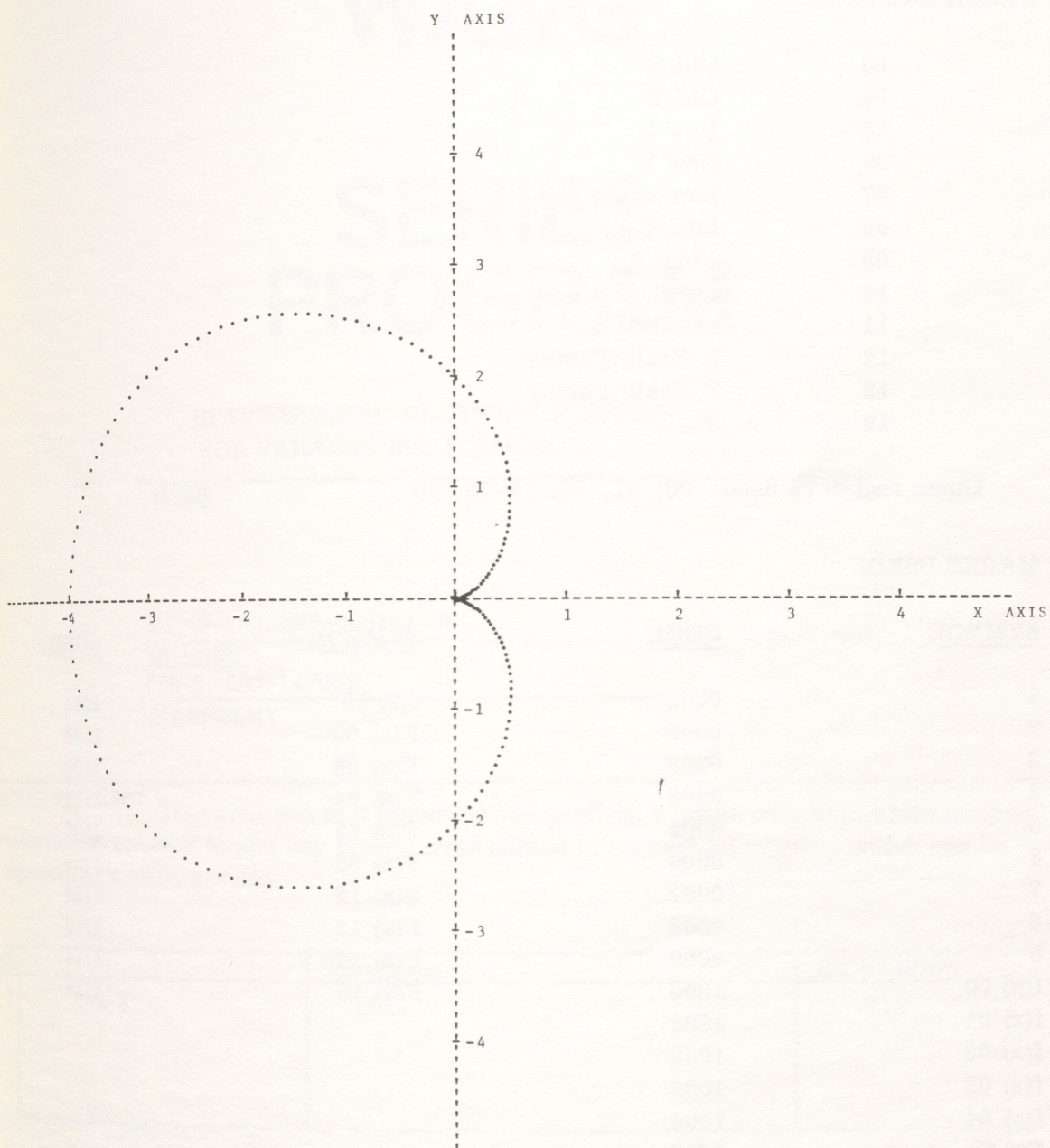
The subroutine of $f(x)$ 14 can be used to store a . The other storage subroutine, $f(x)$ 15, will not be used, and therefore it can either be ignored or deleted.

The function subroutine would be:

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>
0627	0900	Mark
0628	1008	$f(x)$ 08
0629	0001	1
0630	0600	ST 00
0631	0608	RE 08
0632	0807	cos
0633	0300	- 00
0634	0801	RECALL
0635	0105	REG 21
0636	0400	x 00
0637	0901	STORE
0638	0103	REG 19
0639	0915	RETURN
0640	0914	END PROG

If this function were keyed into the machine instead of the function subroutine on the tape, then the plot will be the same as the following page when

$a = 2$
 increment = 2
 initial $\theta = 0^\circ$
 final $\theta = 360^\circ$



OPERATING INSTRUCTIONS CONT'D.

Information on marks and registers used:

REGISTERS USED:

03	Old X
04	Old Y
05	New X
06	New Y
07	Increment of θ
08	Initial θ
09	Final θ
10	residual ΔY
11	residual ΔX
12	X-Scale Factor
13	Y-Scale Factor
19	ρ

Other registers used: 00, 01, 02, 14-18, 20

MARKS USED:

<u>SYMBOL</u>	<u>CODE</u>	<u>SYMBOL</u>	<u>CODE</u>
1	0001	f(x) 15	1015
2	0002	F(x) 00	1100
3	0003	F(x) 03	1103
4	0004	F(x) 04	1104
5	0005	F(x) 05	1105
6	0006	F(x) 06	1106
7	0007	F(x) 12	1112
8	0008	F(x) 13	1113
9	0009	F(x) 14	1114
f(x) 00	1000	F(x) 15	1115
f(x) 01	1001		
f(x) 02	1002		
f(x) 03	1003		
f(x) 04	1004		
f(x) 05	1005		
f(x) 06	1006		
f(x) 07	1007		
f(x) 08	1008		
f(x) 14	1014		

WANG

SERIES PROGRAM

STANDARDIZED PLOTTING ROUTINE
FOR PARAMETRIC EQUATIONS

TITLE

PT. 06-600.06T-000B-6-0

NUMBER

DATE

600-6, 600-14/602

EQUIPMENT

PROGRAM ABSTRACT This program is a standardized plotting routine with automatic scaling which enables the user to plot any curve, regardless of numerical values, which can be expressed as $x = f(t)$, $y = g(t)$

BLOCK		VERIFY NO.	NO. OF STEPS
2	Side 2	5811	642

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS:

1. Load Program by:

a. Depress RUN mode switch

b. Insert tape cassette with
Side 2 facing operator

c. Depress REWIND

d. Depress TAPE READY

e. Key PRIME

f. Key LOAD
PROG , LOAD
PROG

g. Key VERIFY
PROG

h. The display should read:

+5961.000000

2. Key f(x) 00

The X and Y axes will be printed
out and labeled. The program will

stop with -42.00000000 in the
display when the axes are complete.

3. If you have a function which requires
constants to be keyed in externally,
then Key each constant followed by
the corresponding key. Such as:

Key a Value

Key f(x) 10

EXAMPLE ON TAPE:

Given $y = \frac{t^3}{t^2 + 1}$ and $x = \frac{t}{e + t}$
 $\frac{t}{e + 2}$

Plot y as a function of x for t = - 3.5 to
t = + 3.0 in increments of .05 (for this
particular example $-15 \leq t \leq +15$)

1. Same as #1 of general instructions.

2. Same as #2 of general instructions

3. This particular example has no
constants, so skip this section.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2+1}} \text{ and } x = \frac{e^t + t}{e^{t+2}}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

4. Key INCREMENT

Key f(x) 01

Display is dark

Key INITIAL t

Key GO

Display is dark

Key FINAL t

Key GO

Do either 4a or 4b

If you want automatic scaling;

4a. Key f(x) 02

4. Key . 0 5

Key f(x) 01

Display is dark

Key CHANGE
SIGN

Key 3 . 5

Key GO

Display is dark

Key 3

Key GO

Do either 4a or 4b

The program will calculate the X and Y scale factors and plot the function in the interval specified according to the increment specified then return to the origin.

NOTE: If you select automatic scaling you should be aware that it does take time to compute the scaling factors and the plotting will not start

immediately. The amount of time required between keying f(x) 02

and the start of the plot will vary depending upon the complexity of the function and the number of subroutines within the function subroutine, and the increment of plotting which is specified. In the event that the function involves a trigonometric routine, the scaling will take longer as the trigonometric routines are approximations in themselves. If the function is a polynomial or something very simple, the scaling takes only about 15 - 30 seconds.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2} + 1} \quad \text{and } x = \frac{e^t + t}{e^t + 2}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

4b. If you want your own scale factors:

Key X-SCALE FACTOR

Key f(x) 04

Key Y-SCALE FACTOR

Key f(x) 05

Key f(x) 03

4b. If you want to use an
X-Scale Factor = 250
Y-Scale Factor = 1000

Key 2 5 0

Key f(x) 04

Key 1 0 0 0

Key f(x) 05

Key f(x) 03

The program will now plot the function in the interval and at increment specified and then return to the origin.

NOTE: If you want to use your own scale factors see section entitled "Criterion In Choosing A Proper Scale Factor." Appendix A.

Since the axes are always labeled -4 to +4 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore, the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5 then each division on the graph is actually 5 units and the axis would actually have a range of -20 to +20. For information on how the axis unit value is related to the scaling factor see Appendix A.

If you just want to obtain the axis unit values,

5. Key f(x) 06

5. Key f(x) 06

To obtain

X-Axis Unit value, Key the blue

RECALL on the left

Key RECALL on the left

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2} + 1} \text{ and } x = \frac{e^t + t}{e^t + 2}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

READ: +.4000000000 in the display
This is the X-Axis Unit Value

Y-Axis Unit Value, Key the blue

RECALL on the right

Key RECALL on the right

READ: +.1000000000 in the display
This is the Y-Axis Unit Value

6. If you want to obtain the value of x and y for a given value of t, then

Key t VALUE

Key f(x) 07

The x-Value is obtained by keying the blue RECALL on the left

The y-Value is obtained by keying the blue RECALL on the right

6. If $t = 0$, then

Key 0

Key f(x) 07

Key RECALL on the left
READ: +.3333333333 in the display
This is the x Value

Key RECALL on the right
READ: +0.0000000000 in the display
This is the y-Value.

7. If you want to replot the function with new constants on the same axis,

Key NEW CONSTANT

Key f(x) XX

Where XX is the key which stores the appropriate constant.

7. Does not apply to this example.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2} + 1} \quad \text{and } x = \frac{e^t + t}{e^t + 2}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

You may change all the coefficients or only a few according to above method; the ones you do not change will remain the same for the new plot as in the previous plot.

With coefficient change, you are now ready to replot; however you should first

Key f(x) 06

and record the X and Y axis values as they may change if you select auto plotting.

Then

Key INCREMENT

Key f(x) 01

Display is dark

Key INITIAL t, GO

Display is dark

Key FINAL t, GO

If you want auto scaling

Key f(x) 02

If you are sure that the new coefficient will not cause plotting to go outside confines of axes then

Key f(x) 03

as the scale factor computed on previous plot will still be in storage.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2} + 1} \text{ and } x = \frac{e^t + t}{e^t + 2}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

If you want to change the plotting symbol for each replot,

Depress LEARN mode switch

Key SET
P.C.

Key 0 5 2 9

Key xx yy

Depress RUN mode switch

NOTE: Assure f(x) switch is depressed again.

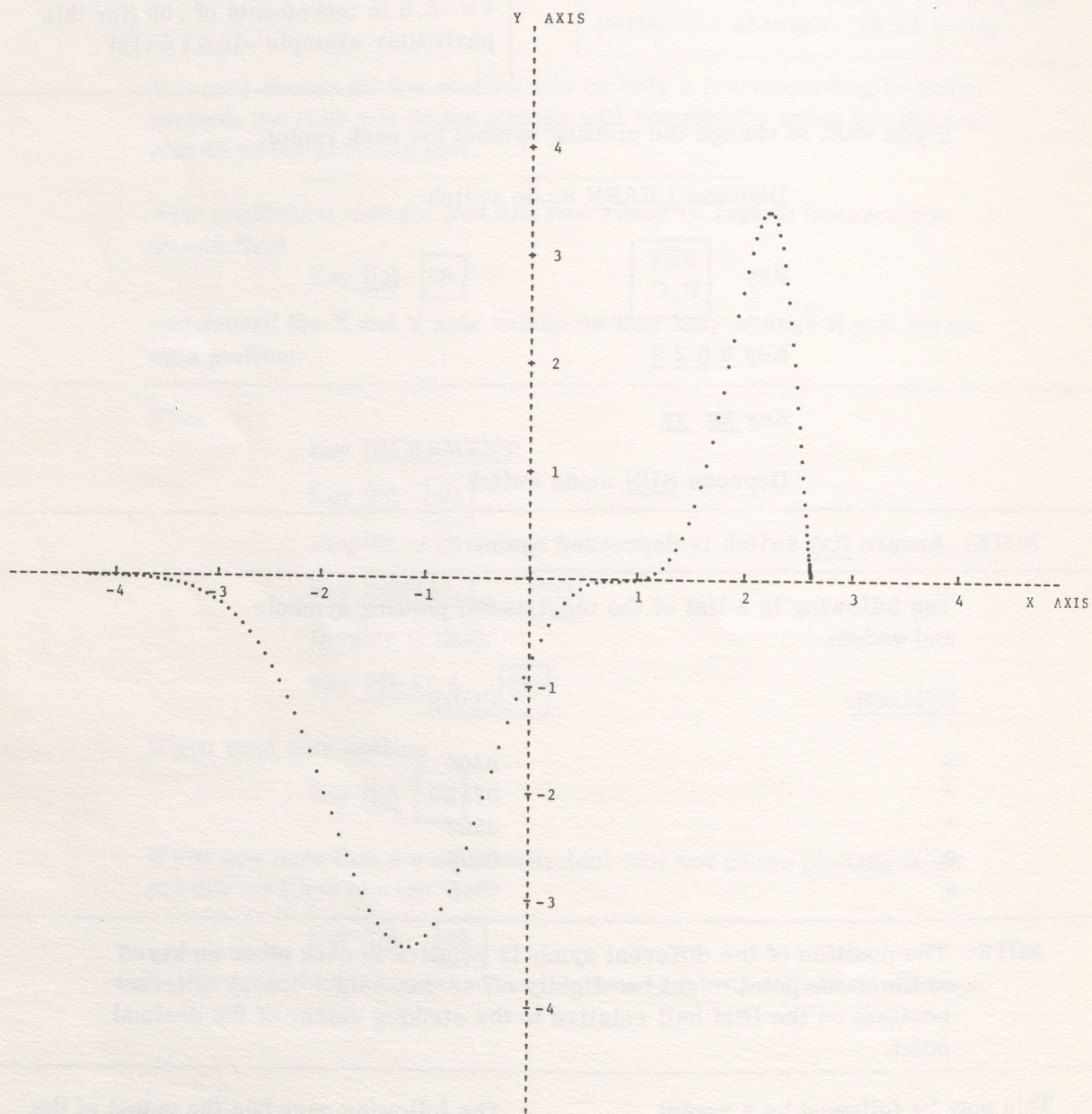
The following is a list of the most useful plotting symbols and codes:

<u>SYMBOL</u>	<u>CODE</u>
+	0406
*	0712
o	0507
0	0509
x	0615

NOTE: The position of the different symbols relative to each other as keyed at the same point might be slightly off as they might occupy different position on the IBM ball relative to the striking center of the decimal point.

8. This may be followed by a replot of the function as described in #7.

The following page has the output of the above example.



OPERATING INSTRUCTIONS CONT'D.

EXAMPLE ON TAPE:

$$\text{Given } y = \frac{t^3}{e^{t^2} + 1} \quad \text{and } x = \frac{e^t + t}{e^t + 2}$$

Plot y as a function of x for $t = -3.5$ to $t = +3.0$ in increments of .05 (for this particular example $-15 \leq t \leq +15$)

To change this program to plot any $f(t)$

Any parametric equations can be plotted using this program by putting a subroutine for the new functions in place of that for the example. This is done by the following steps:

1. Depress LEARN mode switch
2. Key SET
P.C.
3. Key 0 6 1 7
4. Key MARK
5. Key f(x) 08
6. Key in subroutine steps. (This subroutine should end with the commands RETURN and END
PROG)

When writing the function subroutine remember:

- a. The Mark number must be $f(x)$ 08 (code 1008)
- b. The value of t is stored in register 09 and therefore should always be recalled from register 09 in the subroutine function.
- c. When the value of y is obtained, it must be stored in register 06.
- d. When the value of x is obtained, it must be stored in register 05.
- e. Registers 00, 01, 14 and 16 may be used as work registers for calculations.
- f. Can use any marks within the subroutine which are not on page 70.

OPERATING INSTRUCTIONS CONT'D.

The function subroutine on the tape is for plotting y as a function of x when

$$y = \frac{t^3}{e^{t^2} + 1} \quad \text{and} \quad x = \frac{e^t + t}{e^t + 2}$$

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0617	0900	Mark	The function subroutine always has to have this mark number.
0618	1008	f(x) 08	
0619	0709	RE 09	Recalls t from register 09
0620	0600	ST 00	Stores t in register 00
0621	0812	x^2	Gets t^2
0622	0601	ST 01	Stores t^2 in register 01
0623	0400	x 00	Multiplies t by t^2 to get t^3
0624	0701	RE 01	Recalls t^2 from register 01
0625	0811	e^x	Finds the value of e^{t^2}
0626	0614	ST 14	Stores e^{t^2} in register 14
0627	0001	1	Adds 1 to e^{t^2}
0628	0214	+ 14	
0629	0500	÷ 00	Divides ($e^{t^2} + 1$) into t^3
0630	0606	ST 06	Stores y in register 06
0631	0709	RE 09	Recalls t from register 09
0632	0600	ST 00	Stores t in register 00
0633	0811	e^x	Finds the value of e^t
0634	0601	ST 01	Stores e^t in register 01
0635	0200	+ 00	Adds e^t to t
0636	0002	2	Adds 2 to e^t
0637	0201	+ 01	
0638	0500	÷ 00	Divides ($e^t + 2$) into ($e^t + t$)
0639	0605	ST 05	Stores x in register 05
0640	0915	RETURN	
0641	0914	END PROG	

This particular example does not happen to use any constants. However there are many cases where the values of constants have to be stored before the program is run. This is accomplished by the use of short subroutines which would be placed just before the function subroutine and which would involve the following general form:

MARK

f(x) XX

f(x) XX can be any mark from
f(x) 09 to f(x) 15

SHIFT

STORE

Depress T switch

YY

YY can be any register from 03 to

RETURN

15 . With the T switch depressed,
this will actually utilize registers 19
to 31.

NOTE: Do not forget to depress the f(x) switch before running the program.

The number of these subroutines which can be added is entirely dependent upon the number of steps and registers used in the function subroutine. As these coefficient storage subroutines could start at step 617 and the main program uses registers 00 through 18, this allows 183 steps in 600-6 and 1207 steps in 600-14 to be used for function and subroutine program steps and/or storage registers, remembering that each storage register after 15 eliminates 8 program steps.

The advantage of this method of putting in coefficients is that nothing in the mainline program has to be changed if more coefficients are needed in the function subroutine. Put in more coefficient storage subroutines then load in function subroutine.

EXAMPLE:

$$x = A \cos (B \theta + C)$$
$$y = A' \cos (B'\theta + C')$$

These two functions involve six constants for which there will have to be storage subroutines. These will be keyed in before the function subroutine .

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0617	0900	Mark	Mark f(x) 09 stores A in register 19
0618	1009	f(x) 09	
0619	0901	STORE	
0620	0103	REG 19	
0621	0915	RETURN	

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

STEP #	CODE	KEY	EXPLANATION
0622	0900	Mark	Mark $f(x)$ 10 stores B in
0623	1010	$f(x)$ 10	register 20
0624	0901	STORE	
0625	0104	REG 20	
0626	0915	RETURN	
0627	0900	Mark	Mark $f(x)$ 11 stores C in
0628	1011	$f(x)$ 11	register 21
0629	0901	STORE	
0630	0105	REG 21	
0631	0915	RETURN	
0632	0900	Mark	Mark $f(x)$ 12 stores A' in
0633	1012	$f(x)$ 12	register 22.
0634	0901	STORE	
0635	0106	REG 22	
0636	0915	RETURN	
0637	0900	Mark	Mark $f(x)$ 13 stores B' in
0638	1013	$f(x)$ 13	register 23
0639	0901	STORE	
0640	0107	REG 23	
0641	0915	RETURN	
0642	0900	Mark	Mark $f(x)$ 14 stores C' in
0643	1014	$f(x)$ 14	register 24
0644	0901	STORE	
0645	0108	REG 24	
0646	0915	RETURN	
0647	0900	Mark	
0648	0108	$f(x)$ 08	
0649	0709	RE 09	Recalls θ from register 09
0650	0600	ST 00	Stores θ in register 00
0651	0801	RECALL	Recalls B' from register 23
0652	0107	REG 23	
0653	0400	x 00	Multiplies θ by B'
0654	0801	RECALL	Recalls C' from register 24
0655	0108	REG 24	
0656	0200	+ 00	Adds C' to B' θ
0657	0003	3	Steps 0657 through 0664
0658	0006	6	change any angle greater than
0659	0000	0	360° to its equivalent less than
0660	0601	ST 01	360° (see Appendix B)
0661	0500	÷ 00	
0662	0912	INT X	
0663	0300	- 00	
0664	0401	x 01	
0665	0807	cos	Gets cos (B' θ + C')

OPERATING INSTRUCTIONS CONT'D.

<u>STEP #</u>	<u>CODE</u>	<u>KEY</u>	<u>EXPLANATION</u>
0666	0600	ST 00	Stores in register 00
0667	0801	RECALL	Recalls A' from register 22
0668	0106	REG 22	
0669	0400	x 00	Multiplies cos (B' θ + C') by A'
0670	0606	ST 06	Stores y in register 06
0671	0709	RE 09	Recalls θ from register 09
0672	0600	ST 00	Stores θ in register 00
0673	0801	RECALL	Recalls B from register 20
0674	0104	REG 20	
0675	0400	x 00	Multiplies θ by B
0676	0801	RECALL	Recalls C from register 21
0677	0105	REG 21	
0678	0200	+ 00	Adds C to B θ
0679	0003	3	Steps 0679 through 0686 change
0680	0006	6	any angle greater than 360°
0681	0000	0	to its equivalent less than 360° (see Appendix B)
0682	0601	ST 01	
0683	0500	÷ 00	
0684	0912	INT X	
0685	0300	- 00	
0686	0401	x 01	
0687	0807	cos	Gets cos (B θ + C)
0688	0600	ST 00	Stores cos (B θ + C) in register 00
0689	0801	RECALL	Recalls A from Register 19
0690	0103	REG 19	
0691	0400	x 00	Multiplies cos (B θ + C) by A
0692	0605	ST 05	Stores x in register 05
0693	0915	RETURN	
0694	0914	END PROG	

OPERATING INSTRUCTIONS CONT'D.

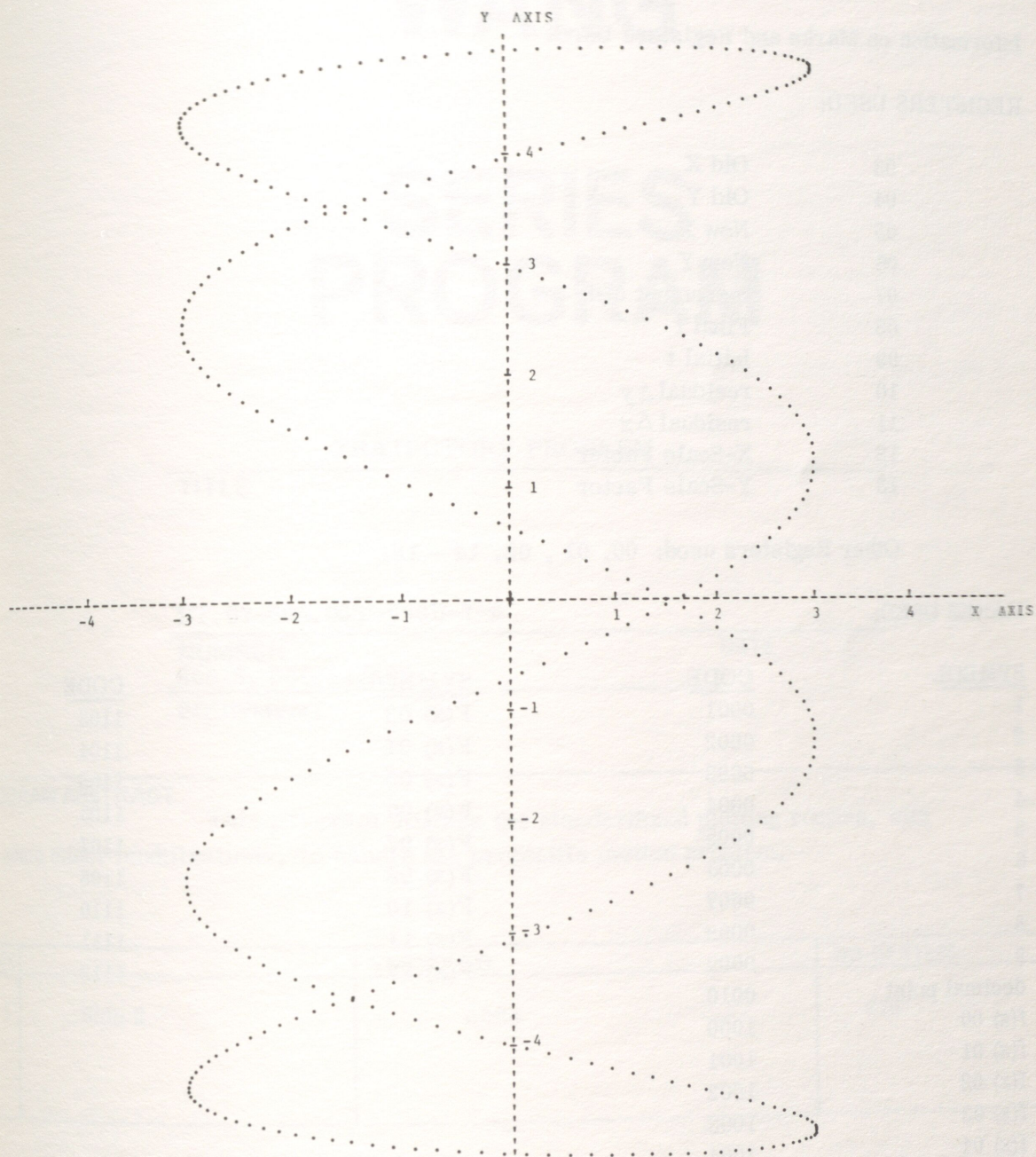
If this function were keyed into the machine instead of the function subroutine on the tape, then the plot will look like that on the following page when

A = 3	A' = 1
B = 2	B' = .5
C = 60°	C' = 30°
Increment = 2°	
Initial θ = 0°	
Final θ = 720°	

When running the program, store the constants by:

Key 3
 Key f(x) 09
 Key 2
 Key f(x) 10
 Key 6 0
 Key f(x) 11
 Key 1
 Key f(x) 12
 Key . 5
 Key f(x) 13
 Key 3 0
 Key f(x) 14
 Key 2 (the increment)
 Key f(x) 01
 Key 0 (initial θ)
 Key GO
 Key 7 2 0
 Key GO (final θ)
 Key f(x) 02 for automatic scaling

NOTE: Since the cosine function is an approximation and takes longer than most things to calculate, it will take the machine 2 to 3 minutes to find the scaling factors.



OPERATING INSTRUCTIONS CONT'D.

Information on Marks and Registers Used:

REGISTERS USED:

03	Old X
04	Old Y
05	New X
06	New Y
07	Increment of t
08	Final t
09	Initial t
10	residual Δy
11	residual Δx
12	X-Scale Factor
13	Y-Scale Factor

Other Registers used: 00, 01 , 02, 14 - 18.

MARKS USED:

<u>SYMBOL</u>	<u>CODE</u>	<u>SYMBOL</u>	<u>CODE</u>
1	0001	F(x) 03	1103
2	0002	F(x) 04	1104
3	0003	F(x) 05	1105
4	0004	F(x) 06	1106
5	0005	F(x) 07	1107
6	0006	F(x) 08	1108
7	0007	F(x) 10	1110
8	0008	F(x) 11	1111
9	0009	F(x) 12	1112
decimal point	0010		
f(x) 00	1000		
f(x) 01	1001		
f(x) 02	1002		
f(x) 03	1003		
f(x) 04	1004		
f(x) 05	1005		
f(x) 06	1006		
f(x) 07	1007		
f(x) 08	1008		

WANG

SERIES PROGRAM

TRAJECTORY PROBLEM

TITLE

PT. 07-600.06T-000B-7-0

NUMBER

600-6, 600-14/602

DATE

EQUIPMENT

PROGRAM ABSTRACT

This program utilizes the standardized plotting routine, with some minor modifications, to handle the projectile motion problem.

BLOCK		VERIFY NO.	NO. OF STEPS
3	Side 2	6084	676

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS:

EXAMPLE: Suppose we have a cannon shooting from atop a hill which is 600 feet high. The gun has a muzzle velocity of 300 ft./sec. What is the range if the gun is aimed 45° above horizontal and 60° above horizontal.

1. Load Program by:

- Depress RUN mode switch
- Insert tape cassette with Side 2 facing operator.
- Depress REWIND
- Depress TAPE READY

e. Key PRIME

f. Key 2

Key SHIFT

Key α

Key

LOAD
PROG

g. Key

VERIFY
PROG

+6084.000000 will appear
in the display.

2. Key f(x) 00

The X-Y Axis will be printed out and labeled. The program will stop with

+1.000000000 in display when
axis is complete.

1. Same as #1 of general instructions.

2. Same as #2 of general instructions.

Now we are ready to key in the values of the variable parameters h , v_0 , θ_0 which are explained below. The term h is the height above ground level. If we have an airplane, h represents the altitude; if we have a cannon at ground level zero, $h = 0$; and if we have a cannon on a hill, h represents the height of the cannon above ground level zero. The term v_0 is the initial velocity of the projectile. If we have an airplane: a) v_0 represents the speed of the plane dropping a bomb, b) firing a rocket, v_0 represents the speed of plane

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE: Suppose we have a cannon shooting from atop a hill which is 600 feet high. The gun has a muzzle velocity of 300 ft./sec. What is the range if the gun is aimed 45° above horizontal and 60° above horizontal.

plus initial velocity of the rocket.

If we have a cannon, v_o represents the muzzle velocity of the cannon projectile. The term θ_o is the angle of elevation or depression of firing, relative to the horizontal plane. If we have an airplane on a horizontal path, $\theta_o = 0$, if the plane is climbing during release $\theta_o > 0$, if the plane is diving during release $\theta_o < 0$. If we have a cannon, a) on a hill θ_o can be > 0 , $= 0$, < 0 . b) at ground level θ_o can be only > 0 . In all cases θ_o must have the following constraint $-90^\circ < \theta_o < 90^\circ$. In the problem you can make use of any of the above combinations of h , θ_o , v_o which make sense. (i.e. cannot have $h = 0$ and $\theta_o < 0$ as you would be firing into the ground in front of you.)

You are now ready to key in h , v_o , and θ_o according to:

3. Key h -Value,

When display is dark

Key v_o -Value,

When display is dark

Key θ_o Value,

θ_o in decimal degrees

The program calculates the maximum range on the basis of inputted data and stores it as the final x . It will also calculate and store the constants, a , b , c as the $y = f(x)$ for the trajectory problem can be written as:

$$y = a + bx + cx^2 \text{ where}$$

$$a = h, b = \tan \theta_o, c = -\frac{g}{2(v_o \cos \theta_o)^2}$$

3. Key 6 0 0, Key

When display is dark

Key 3 0 0, Key

When display is dark

Key 4 5, Key

The program will stop with

in display. This is the maximum range.

OPERATING INSTRUCTIONS CONT'D.

EXAMPLE: Suppose we have a cannon shooting from atop a hill which is 600 feet high. The gun has a muzzle velocity of 300 ft./sec. What is the range if the gun is aimed 45° above horizontal and 60° above horizontal.

It will show the maximum range in the display.

Upon seeing the maximum range, you key in the increment which you would like to see plotted out. A good way to judge the best increment is to divide the range by 100 and then take the next most reasonable number which is a multiple of 10 of 1, 2, 2.5, 5. (i.e. if you read 3500.00 for maximum range then either 25 or 50 would be good plot increments.)

4. Key INCREMENT,

4. You now select an increment of 50 feet.

Key 50,

a) If you desire automatic scaling, Key f(x)

The program will execute and plot out path of projectile. When the projectile crosses ground level zero the range will be printed out.

b) If you wish to use your own scaling factors,

Key X-SCALE FACTOR, Key f(x)

Key Y-SCALE FACTOR, Key f(x)

Key f(x)

Then program will execute and plot out path of projectile. When projectile crosses the ground level zero the range will be printed out.

Note: In using own scaling factors, see section entitled "Criterion in Choosing a Proper Scaling Factor." Appendix A.

Since the axes are always labeled 0 to 10 and since the scaling factors adjust the plots to fit in the given space, each division, i.e. from 0 to 1, does not necessarily have a value of one. Therefore the axis unit value has to be obtained. This tells the number of units into which each division is divided. As an example, if the axis unit value = 5, then each division on the graph is actually 5 units and the axis would actually have a range of 0 to +50. For information on how the axis unit value is related to the scaling factor, see Appendix A.

© Wang Laboratories, Inc., 1972

OPERATING INSTRUCTIONS CONT'D.

Note: Before you restart any plot

Key f(x) 06 so that you will get X-Axis value by keying the blue RECALL on the left and Y-Axis by keying the blue RECALL on the right.

EXAMPLE: Suppose we have a cannon shooting from atop a hill which is 600 feet high. The gun has a muzzle velocity of 300 ft./sec. What is the range if the gun is aimed 45° above horizontal and 60° above horizontal.

Key f(x) 06, Key RECALL on the left.

READ: +500.0000000 in the display

This is the X-axis unit value.

Key RECALL on the right.

READ: +200.0000000 in the display.

This is the Y-Axis unit value.

5. a) If you wish to plot new trajectory on same axis:

Key h-Value, Key f(x) 01

Then continue as in section 3 starting with

Key v₀ - value, GO

Key 6 0 0, Key f(x) 01

Key 3 0 0, GO

Key 6 0, GO

The program will stop with

+2743.267607 in the display.

Key 5 0

Key GO

As this plot will stay within the confines of the previously run plot

Key f(x) 03

The path of the projectile will be plotted out and the maximum range labeled.

b) If you wish to find height of the projectile at a given distance from height firing point,

Key DISTANCE, Key f(x) 07

The height will appear in the Display.

To find the height of the projectile 100 feet from the firing point

Key 1 0 0, Key f(x) 07

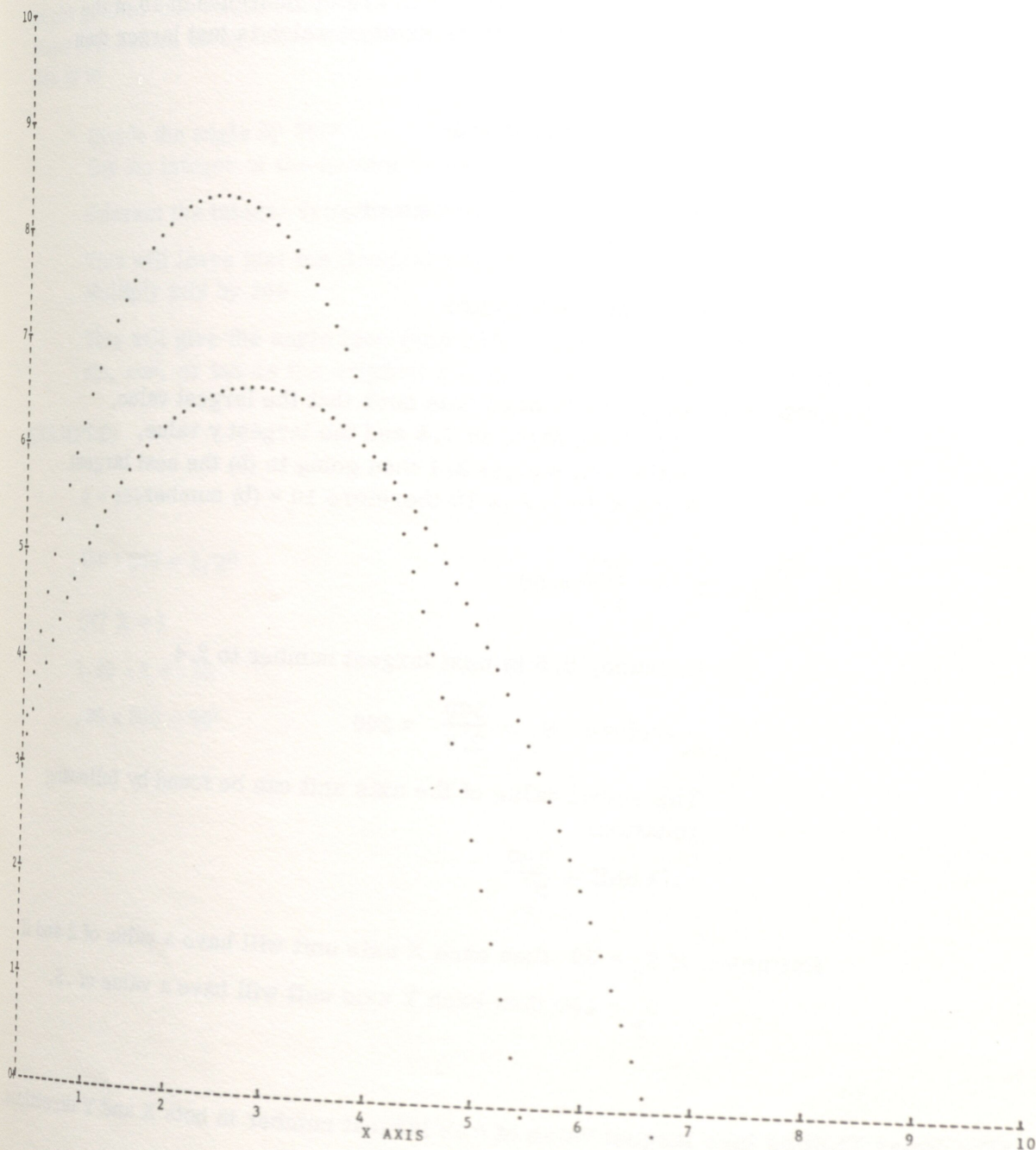
OPERATING INSTRUCTIONS CONT'D.

EXAMPLE: Suppose we have a cannon shooting from atop a hill which is 600 feet high. The gun has a muzzle velocity of 300 ft./sec. What is the range if the gun is aimed 45° above horizontal and 60° above horizontal.

The height of +766.0939696 will appear in the display.

The following page has the output of the above example.

Y AXIS



RANGE = 2743.267
RANGE = 3320.679

© Wang Laboratories, Inc., 1972

Appendix A: CRITERION IN CHOOSING A PROPER SCALING FACTOR

In choosing a scale factor use the following criterion:

- a) Scan your x data* and take the largest number neglecting the sign
- b) Compare the number in (a) to 1, 2, 2.5, 5 or multiples of 10 of the above 4 numbers, and select the number which is just larger than the number in (a).

Then use the following equation:

$$\frac{500^{**}}{\text{b number}} = S_i \quad i = x \text{ or } y$$

S_i is the scale factor

- c) do the same for y data
- d) Example: Suppose you have data such that the largest value, neglecting sign, is 7.8 and the largest y value, neglecting sign, is 2.4 then going to (b) the next largest number to 7.8 is 10 therefore $10 = (\text{b}) \text{ number}$.

$$S_x = \frac{500}{10} = 50$$

likewise, 2.5 is next largest number to 2.4

$$\text{therefore } S_y = \frac{500}{2.5} = 200$$

The actual value of the axis unit can be found by following equation:

$$\text{axis unit} = \frac{100}{S_i}$$

Example: If $S_x = 50$ then each X axis unit will have a value of 2 and if $S_y = 200$ then each Y axis unit will have a value of .5.

*For Polar Plotting take largest value of ρ as largest number in both X and Y directions.

**If you are dealing with a 1 quadrant plot substitute 1000 for the 500.

APPENDIX B

Due to the characteristics of the Wang 600, the sin, cos, and tan keys only operate correctly for angles less than 572° or 10 radians. Therefore, whenever writing programs which will utilize these keys in any cases that might go over this maximum, it is necessary to insert some corrective steps just before using these keys. One of the best ways to correct for this is to

Divide the angle by 360°

Get the integer of the quotient (Key INT X)

Subtract the integer from the quotient

This will leave just the decimal portion

Multiply this by 360

This will give the angle less than 360° which will have the same sin, cos, or tan as the original angle.

EXAMPLE:

$$\theta = 450^\circ$$

$$450 \div 360 = 1.25$$

$$\text{INT X} = 1$$

$$1.25 - 1 = .25$$

$$.25 \times 360 = 90^\circ$$

APPENDIX

This is the corrected value of the weight of the sample, which is obtained by dividing the weight of the sample by the correction factor. The correction factor is obtained by dividing the weight of the sample by the weight of the sample in the original state. The correction factor is obtained by dividing the weight of the sample by the weight of the sample in the original state.

Divide the value by 100
and the number of the sample (1000)

Subtract the value from 1000

This will give the value of the sample

Multiply this by 100

This will give the value of the sample

the rest of the value of the sample

EXAMPLE

1000

1000

1000

1000

1000

**WANG LABORATORIES
(CANADA) LTD.**

180 Duncan Mill Road
Don Mills, Ontario
TELEPHONE (416) 449-7890
TELEX 06-21-7549

WANG EUROPE, S.A.

Rue Anatole France 115-121
1030 Brussels, Belgium
TELEPHONE 15.48.01/02/03

WANG ELECTRONICS LTD.

40-44 High Street
Northwood, Middlesex, England
TELEPHONE Northwood 27677

WANG FRANCE SARL

47, Rue de la Chapelle
Paris 18, France
TELEPHONE 203.27.94 or 203.25.94

WANG LABORATORIES GMBH

Moselstrasse No. 4
6000 Frankfurt am Main
West Germany
TELEPHONE (611) 23-00-40

WANG SKANDINAVISKA AB

Fredsgaten 17
S-172 33
Sundbyberg, Sweden
TELEPHONE 98-12-45

WANG NEDERLAND N.V.

Damstraat 2
Utrecht, Netherlands
TELEPHONE 030-930947

WANG PACIFIC LTD.

61, King Yip Street, 1st Floor
Kwun Tong, Kowloon, Hong Kong
TELEPHONE K-450528

WANG INDUSTRIAL CO., LTD.

110-118 Kuang-Fu N. Rd.
Taipei, Taiwan
Republic of China
TELEPHONE 77.96.19 or 71.35.78

WANG GESELLSCHAFT MBH

Grinzing Allee 16
1190 Vienna 19
Austria
TELEPHONE (0222) 32.42.43

WANG COMPUTER PTY. LTD.

25 Bridge Street
Pymble, NSW 2073
Australia
TELEPHONE 449-6388

WANG MEDICAL SYSTEMS, INC.

836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

WANG MEMORY SYSTEMS, INC.

836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

**WANG INTERNATIONAL
TRADE, INC.**

836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

PHI COMPUTER SERVICES, INC.

800 Massachusetts Avenue
Arlington, Massachusetts 02174
TELEPHONE (617) 648-8550

836 North Street
Tewksbury, Massachusetts 01876
TELEPHONE (617) 851-4111
TWX 710-343-6769
TELEX 94-7421

WANG

LABORATORIES, INC.

836 NORTH STREET, TEWKSBURY, MASSACHUSETTS 01876, TEL (617) 851-4111, TWX 710 343-6769, TELEX 94-7421

Printed in U.S.A.
700-0883

12-72-6C
Package Price \$100.00
Book Price \$15.00