WANG

2212 ANALOG FLATBED PLOTTER REFERENCE MANUAL

SYSTEM 2200

REFERENCE INFORMATION ONLY

NOT CONTROLLED

2212
Analog Flatbed Plotter Reference Manual

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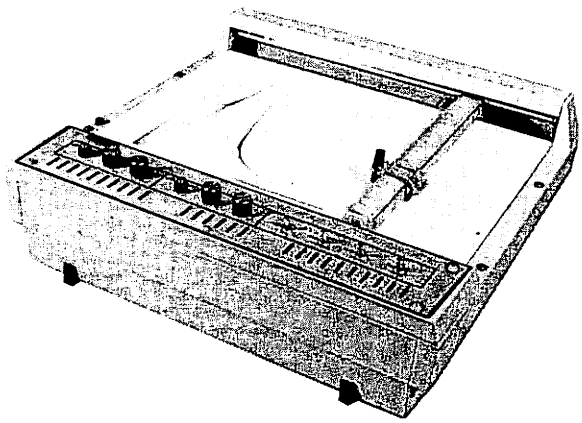
HOW TO USE THIS MANUAL

This manual provides the user with a concise reference to the operational features of the Model 2212 Analog Flatbed Plotter. The Model 2212 can be used both to print alphanumeric characters and, in conjunction with the WANG System 2200B, to operate as an accurate, high-speed plotter of mathematical functions. This manual has been arranged in four sections in order to assist the user in answering questions that may arise. It is assumed that the user of the WANG Model 2212 is familiar with the BASIC language of the System 2200B. A discussion of System 2200B BASIC commands and statements can be found in the System 2200A/B Reference Manual. Specifications are provided in Appendix A; cleaning and maintenance procedures are found in Appendix B.



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UNPACKING AND INSPECTION

Carefully unpack your equipment and inspect all units for shipping damage. If damage is noticed, do not proceed unpacking. Notify the shipping agency. Check each unit received against the purchase order. Decals specifying model numbers can be found on all WANG equipment and peripherals, usually on the back side of each unit.

INSTALLATION

To install the Model 2212, your WANG Service Representative uses the following procedure (see Figure I-1):

1. Plug the peripheral connector cable for the Model 2212 Analog Flatbed Plotter into the CPU (Central Processing Unit). The male Amphenol connector on the cable attaches to the female Amphenol connector on the controller board labeled "2212 Plotter Controller". Make sure the lock clips are properly snapped shut.

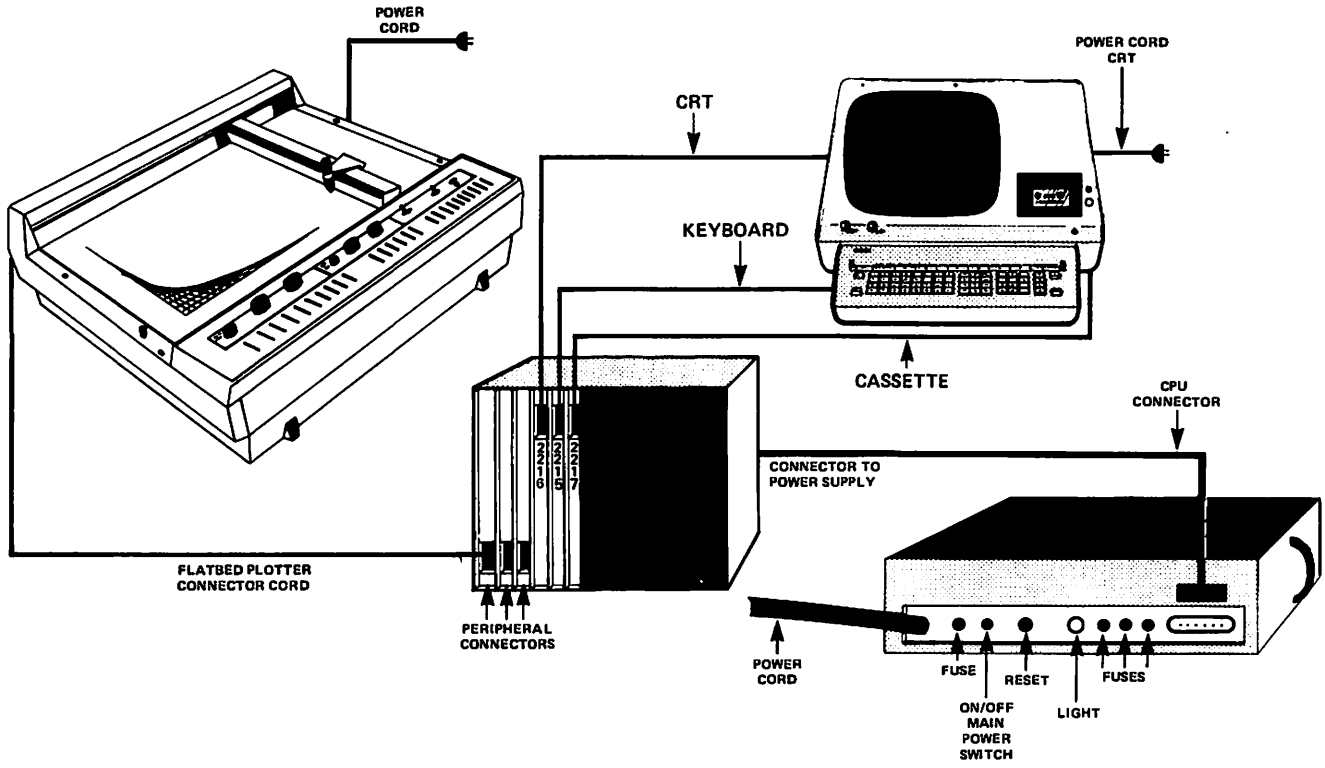


Figure I-1. System 2200 With Model 2212

2. Plug the main power cord of the CPU chassis into the Power Supply Unit.
3. Detach the protective clamp from the movable arm. The clamp is used only during shipping to protect the unit.
4. Remove the power cord from the plastic bag containing the Accessory Kit. Attach the female end to the three prongs located inside the opening on the rear of the Plotter (see Figure I-2). Plug the male end into a wall outlet (115 VAC ± 10%).

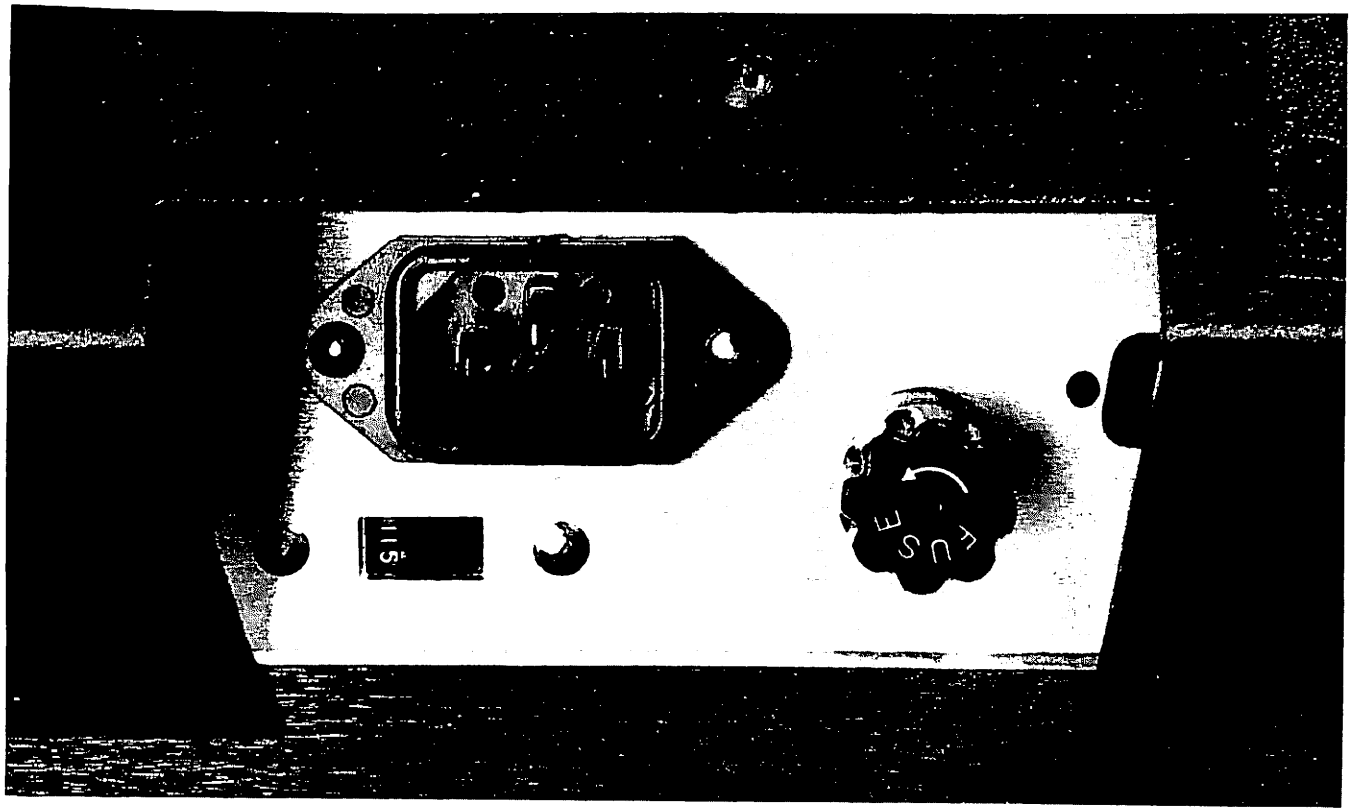


Figure I-2. Location of Three Prongs for Power Cord on Rear of Plotter

5. Plug the Power Supply Unit into a wall outlet (115 VAC ± 10%).

POWER ON PROCEDURE

1. Turn power switches ON for all peripherals, including the CRT.
2. Move the main switch on the Power Supply to the ON position (light on the Power Supply illuminates). This step Master Initializes the System 2200B.

GENERAL DESCRIPTION

The Model 2212 Analog Flatbed Plotter is composed of a plotting surface capable of holding an 11 x 16 inch piece of paper, and a movable slide attached to a movable arm. A felt tip pen, attached to the movable slide, draws the plots. The maximum, or full scale plotting area is 10 x 15 inches.

Packages of three red and three blue pens are included in the Accessory Kit. Install one pen in the slide. Make sure the protective cap is on the pen when not in use. Additional pens, three to a package, can be ordered when needed. The part numbers are:

Red	615-1163
Blue	615-1162
Green	725-0456
Black	725-0457

SECTION I–GENERAL INFORMATION

The Model 2212 accepts a variety of papers; best results are obtained on paper with a smooth surface. The paper can be positioned anywhere on the plotting surface. The use of graph paper is described on pages 40 through 42. The part numbers for plotting paper available through WANG Laboratories are:

725-0450	English Lightweight	(100 sheets)
725-0451	English Heavyweight	(100 sheets)
725-0452	Metric Lightweight	(100 sheets)
725-0453	Metric Heavyweight	(100 sheets)

CLEANING THE MODEL 2212

The Model 2212 is a precision device and should be kept free from dust and covered when not in use. Periodic cleaning and lubrication of certain components of the instrument are necessary for accurate, trouble-free operation. If the Model 2212 is covered by a Maintenance Agreement, periodic maintenance is performed by a WANG Service Representative, at no extra charge. Appendix B includes the information necessary for the owner to perform periodic maintenance and cleaning.

PLOTTER CONTROLS

Three toggle switches are mounted on a panel on the lower face of the Model 2212 (see Figure I-3). From left to right, they perform the following tasks:

1. POWER ON/OFF - A toggle switch which activates the Model 2212 after the System 2200B is Master Initialized. Since the Model 2212 contains electrical motors which can overheat, do not leave the Plotter ON overnight.
2. CHART HOLD/RELEASE - A toggle switch which holds the paper on the plotting surface. When in the HOLD position, used during actual operation, a low voltage potential (not dangerous to touch) is set across the plotting surface which secures the paper flat against the plotter bed for smoother operation. The RELEASE position is used when changing paper.
3. PEN UP/DOWN - A toggle switch which must be in the DOWN position in order to activate the plot. See the "D" (DOWN) command in Section II.

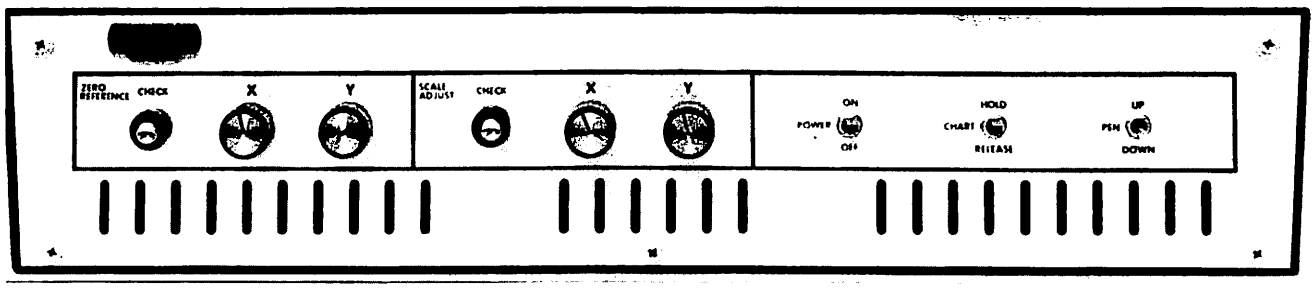


Figure I-3. Control Panel of Model 2212

PLOTTING CONTROLS

In order to adjust the Model 2212 to the size paper and graph you wish to use, two sets of controls are provided, the ZERO REFERENCE and the SCALE ADJUST controls.

Zero Reference Controls

The Zero Reference controls consist of an X-axis dial and a Y-axis dial, and a zero reference check button (see Figure I-3). These controls are used to establish the lower left-hand "reference point" of the plot. Also, from this location, the extent (total length) of the X- and Y-axes is measured.

To establish the Zero Reference point for a graph (see Figure I-4), place a piece of plotting paper under the movable arm, and set it flush against the lower edge of the plotting area. Flip the CHART switch to the HOLD position. Use the following procedures.

1. Depress the Zero Reference Check button which returns the plotting pen back from any position on the grid to the current Zero Reference point.
2. Set the new X and Y coordinates of the Zero Reference point by turning the X- and Y-axes dials, located directly to the right of the Zero Reference Check button. The actual location of the reference point can be anywhere on the page.

   By changing the reference point, the entire graph can be moved from one location to another.

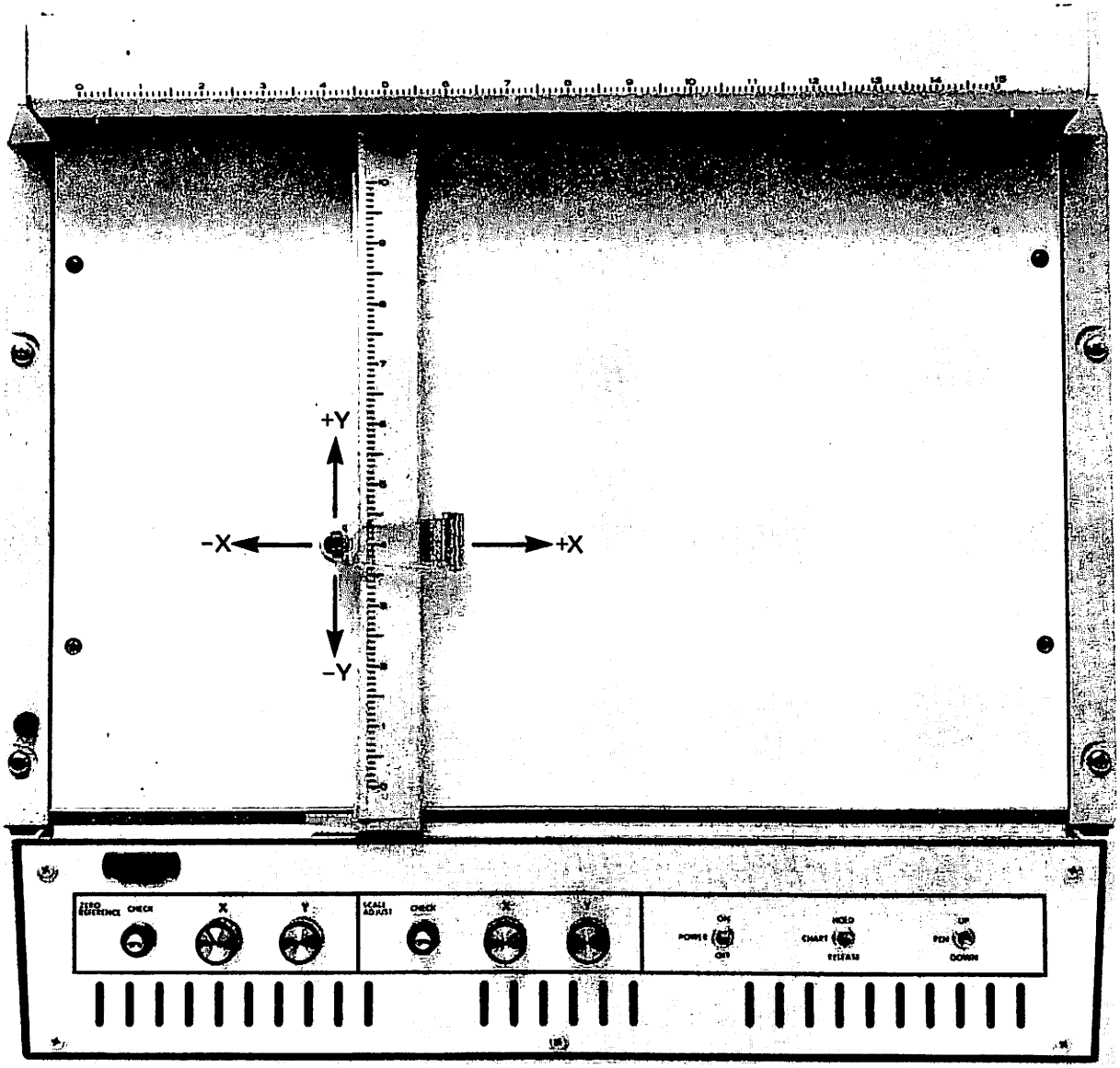


Figure I-4. The Zero Reference Point

Scale Adjust Controls

Once the Zero Reference point has been established, it is necessary to set the Scale point, generally associated with the upper right-hand corner of a plotted graph. This point establishes what is called the scale of the graph or the Scale point. To set the Scale point for a graph (see Figure I-5), use the following procedure:

1. Depress the Scale Adjust Check button, which brings the plotting pen from any position on the grid to the current Scale point.
2. To readjust the position of the Scale point, set the new X and Y scaling coordinates by turning the X- and Y-axes dials, located directly to the right of the Scale Adjust Check button.

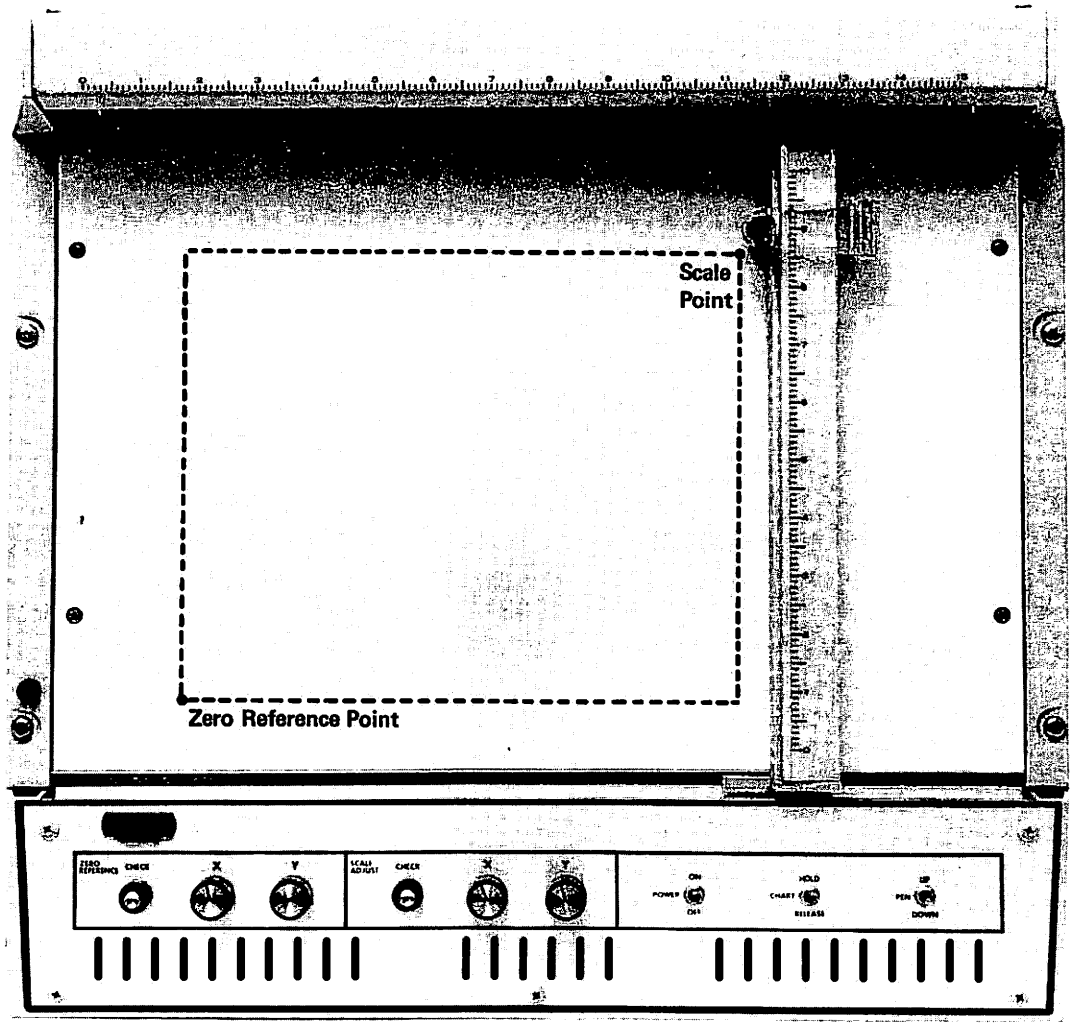
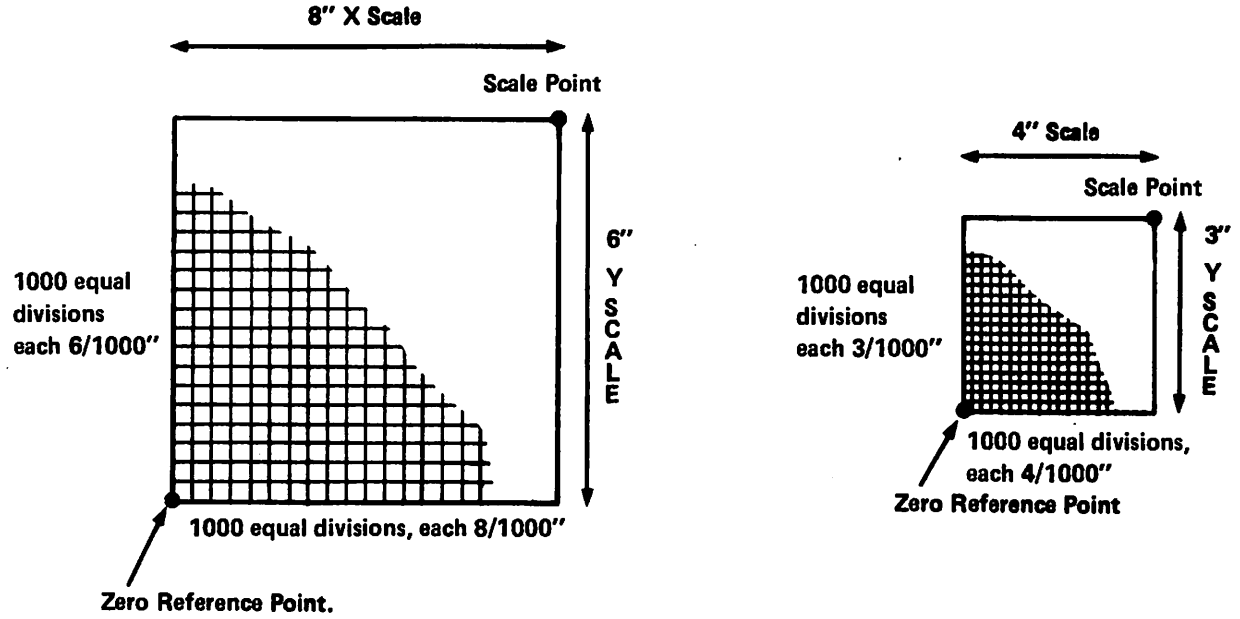


Figure I-5. The Zero Reference and Scale Points

By moving the Scale Adjust dials, the relative proportions of the graph are changed. The Model 2212 always divides the described reference axes into exactly 1000 equal divisions, regardless of the length set for each axis. The Plotter moves the pen 1/1000 of the described scale each time an instruction is given it to move one unit length. The actual distance the pen moves depends upon the size of the scaling area, which depends upon the length set for each axis.

Figure I-6 gives two examples of different scaling areas.



A. 6-inch by 8-inch Scaling Area

B. 3-inch by 4-inch Scaling Area

Figure I-6. Different Scaling Areas

SELECTING THE MODEL 2212

The Device Address for the Model 2212 is factory set at 413. All PLOT statements and commands (Section II), and the Utility Routines (Section III) operate directly on a Model 2212 with a Device Address of 413; selecting is unnecessary (i.e., a System 2200B PLOT command will assume an address of 413 if no other address has been selected). However, a few Model 2212 Plotters were shipped with the Device Address set at 414. Check your 2212 Plotter Controller board. If the address is 414, the Plotter can be activated by the following procedure:

1. Master Initialize the System 2200B.
2. Place the Model 2212 POWER switch in the ON position.
3. Key in SELECT PLOT 414 on the Model 2215 or 2222 Keyboard.
4. SELECT PLOT 414 must be keyed in each time the System 2200B or the Model 2212 is turned OFF, then ON again.

The Plotter Utility Package (Section III) operates only with the Device Address 413. To operate with a Plotter set at Device Address 414, all SELECT PLOT 413 and SELECT PRINT 413 statements in the program must be changed to 414.

At customer request, your WANG Service Representative can change a controller board with a Device Address of 414 to 413.

Section II
PLOT Statements and Commands

PLOT STATEMENT

"NULL" COMMAND

"U" (UP) COMMAND

"D" (DOWN) COMMAND

"R" (RESET) COMMAND

"C" (CHARACTER) COMMAND

"S" (SPACING) COMMAND

PRINT AND PRINTUSING

CONVERT STATEMENT

ROUND-OFF ERROR

SECTION II — PLOT STATEMENTS AND COMMANDS

THE PLOT STATEMENT

The Model 2212 Analog Flatbed Plotter is controlled with one BASIC statement. This PLOT statement has the following general form:

General Form: PLOT[expression 0]<[expression 1],[expression 2] { 'null' / literal string / alpha string / U / D / C / S / R } >,<...>

Where:

expression 0	represents the replication factor, or the number of times the values in < > are plotted (1 < expression 0 < 1000). If omitted, expression 1 is assumed to be 1.
expression 1	normally represents (for full-scale plotting) ΔX increments of .015" (−1000 < expression 2 < 1000).
expression 2	normally represents (for full-scale plotting) ΔY increments of .01" (−1000 < expression 2 < 1000).

If omitted, expression 1 and 2 are assumed to be 0.

All three expressions are truncated to integer values.

THE "null" COMMAND

If expression 2 in the PLOT statement is followed only by a comma, then this "null" command (i.e., no argument) instructs the Model 2212 to move the distances ΔX and ΔY with the pen in UP position. Thus, nothing is plotted until the pen is lowered.

Example 1:

```
:10 X=200
:20 PLOT<X, 300,>
:RUN
```

Result:

The pen advances ΔX = 200 and ΔY = 300 increments while in the UP position.

Example 2:

```
:10 PLOT 2<300, ,>
:RUN
```

Result:

The pen advances ΔX = 300 and ΔY = 0 increments in the UP position. No line drawn. This is repeated once.

THE "U" (UP) COMMAND

This "U" command is essentially identical to the 'null' command, but is easier to recognize. It is used to move the pen without drawing a line.

Example 1:

```
:20 X=150
:30 Y=15
:40 PLOT<X, Y↑2, U>
:RUN
```

Result:

The pen advances ΔX=150 increments (of .015") and ΔY=225 increments (of .01") with the pen in the UP position.

Example 2:

```
:10 PLOT < 114, , >
:20 X=200
:30 Y=300
:40 PLOT < X, Y, U >
:RUN
```

Result:

The pen in the UP position moves ΔX=114 and ΔY=0 increments. The pen, still UP, advances ΔX=200 and ΔY=300 increments.

THE "D" (DOWN) COMMAND

The "D" specification in the PLOT statement calls for pen DOWN; that is, a line to be drawn while the plotter advances the ΔX and ΔY distances given by expressions 1 and 2. After Master Initialization the pen is UP and remains UP until given the DOWN command.

Example 1:

```
:20  PLOT < 200, 600, D >
:RUN
```

Result:

The pen advances ΔX=200 (that is .030") and ΔY=600 (that is .06") with pen DOWN. A straight line is drawn.

Example 2:

```
10   A=50
20   B=200
30   PLOT < 2*A, B, D >
```

Result:

The pen advances ΔX=100 (that is .015") and ΔY=200 (that is .030") with the pen DOWN. A straight line is drawn.

THE "R" (RESET) COMMAND

An "R" command RESETS the pen to the plotter's ZERO REFERENCE which is set manually with the ZERO REFERENCE (X,Y) dials on the bottom left-hand corner of the Model 2212. This RESET command is sometimes useful for:

1. Beginning a series of plots (for example, a series of monthly payments plots for fixed principal but variable interest rates and months) from the same point. This establishes a fixed reference point on the plot.
2. The R Command is much faster than the normal U Command.

Example 1:

```
:20  PLOT 2 <, , R >
:RUN
```

Result:

The pen advances from its present position to the manually preset origin. During the second cycle (note the replication factor 2) nothing will change, because the pen is already at RESET.

Example 2:

```
:10  PLOT <, , R >
:20  FOR Y=1 TO 20
:30  X=Y
:40  PLOT < X, Y, D >
:50  NEXT Y
:60  PLOT <, , R>
:RUN
```

Result:

This program resets the pen to the origin, then plots X=Y. Statement 60, again, resets the pen.

THE "C" (CHARACTER) COMMAND

The "C" command is used to set the size of plotted characters. The following characters may be plotted (that is, drawn automatically with the pen):

ABCDEFGHIJKLMNOPQRSTUVWXYZ'0123456789():.,?=+–/ *space*

"C" determines the character size according to the value given by expression 1. Since expressions 0, 1 and 2 are truncated, only integer values can be chosen for "C". For character plotting, this integer must range between 1 and 15 inclusive. The value of 1 assigned to expression 1 commands the smallest size letter/character (.01" X .13"), whereas the value of 15 assigned to expression 1 corresponds with the largest (1.5" X 1.95").* The user should always beware that the character does not overextend the boundaries of the plotting paper. If this occurs, press the HALT/STEP button on the Model 2215 or 2222 Keyboard to terminate execution and redesign the appropriate PLOT statement(s). The HALT/STEP will stop execution only after the entire statement is executed.

NOTE:

**This assumes full-scale plotting. See SCALE ADJUST CHECK in Section I.*

Example 1:

```
:10 PLOT<9,,C>
:RUN
```

Result:

This statement sets the character size equal to 9.

Example 2:

```
:10 PLOT<8,,C>
:20 PLOT<,,"A">
:RUN
```

Result:

An "A" of size 8 is printed with its center at the present location.

NOTE:

Alphanumeric characters should not be printed when the plot pen is on the border of the paper. The pen position is considered the center of a character so that, if on the left border, the left half of the character is not correctly printed.

THE "S" (SPACING) COMMAND

An "S" following expression 2 of the PLOT statement sets the horizontal and vertical SPACING between printed characters. Expression 1 specifies the horizontal spacing and expression 2 specifies the vertical spacing. If doing horizontal spacing expression 1 should be 13 to 15 times the character size. If doing vertical spacing, expression 2 should be –15 to –18 times the character size.

Example 1:

```
:10 PLOT<80, 110, S>
:RUN
```

Result:

This sets a horizontal spacing of 80 and a vertical of 110 for character printing.

Example 2:

```
:10 A$="PLOT"
:20 B$="THIS"
:30 PLOT <, ,R >,< 150, 150, U >,
    < 5, ,C >,< 60, ,S >,<, ,A$ >
:40 PLOT < 155, 170, U >,<2, ,C >,
    < 24, ,S >,<, ,B$>
:RUN
```

Result:

This program resets the pen to the origin, advances 150 increments to the right and up with pen UP, sets character size to 5, spacing to 60 horizontal and 0 vertical and prints: PLOT. All the above takes place through statement 30. Statement 40 spaces ΔX=155 and ΔY=170 increments (which is towards the upper right hand corner) from the plotted word "PLOT" and plots: THIS (in character size 2 and with spacing 24).

PRINT AND PRINTUSING

The Model 2212 Analog Flatbed Plotter also can be used to print characters with the PRINT or PRINTUSING statements. In order to do this the plotter must be selected with the statement:

SELECT PRINT 413

The size of characters and spacing within a line, however is controlled by the parameters in the PLOT commands, namely the "C" (character) and "S" (spacing) parameters.

When directing the Model 2212 to print output, each PRINT or PRINTUSING statement must be written with a trailing semicolon in order to suppress the output of a carriage return (CR) and line feed (LF) character. The Model 2212 treats the CR code, HEX(OD), as a character size command and treats a LF code, HEX(OA), as a spacing command. If a CR or LF code is encountered, the subsequent PLOT and PRINT statements are performed with character size of 0 and spacing of 0. The semicolon is therefore used to suppress the CR and LF codes and the PLOT statements are used to set character size and spacing.

Example 1:

PRINT and PLOT of the Model 2212 Character Set Using Varying Syntax

```
10 SELECT PLOT 413; PRINT 413
20 PLOT <,,R>
30 PLOT <2,,C>,<26,,S>,<20,800,U>
40 PLOT <,,"ABC">,<,,"DEF">
50 A$="GHI":B$="JKL"
60 PLOT <,,A$>:PLOT <,,B$>
70 PLOT <,,R>,<20,700,U>
80 X=20.231
90 PRINT "COEFFICIENT=";01*X;
100 PLOT <,,R>,<20,600,U>
110 B$="JOHN JONES":A=1793.25
120 PRINTUSING 130,B$,A;
130 %NAME- ############  AMOUNT- $#,###.##
```

ABCDEFGHIJKL

COEFFICIENT= 20.231

NAME- JOHN JONES AMOUNT- 1,793.25

Figure II-1. Samples of Printed Characters and Numbers

CONVERT STATEMENT

It is often desirable to label the points along the X or Y axis with numeric values. This can be done in any of several ways depending on the output form desired.

For output with a fixed sign and insignificant leading zeroes the CONVERT statement can be used in conjunction with PRINT or PLOT. Examples using the form –01.00 are given in examples 1 and 2 below.

For output with a floating sign in a fixed format and leading spaces in the form –1.00 is given in example 3 below.

```
10 SELECT PLOT 413,PRINT 413
20 PLOT <,,R>
30 PLOT <2,,C>,<26,,S>
40 REM *****
50 REM *****EXAMPLE 1*****
60 PLOT <,,R>,<20,800,U>
70 FOR X=1 TO 5
80 CONVERT X TO X$,(-##.##)
90 PRINT X$; :PLOT <100,,U>
100 NEXT X
110 REM *****
120 REM *****EXAMPLE 2*****
130 PLOT <,,R>,<20,700,U>
140 FOR X=1 TO 5
150 CONVERT X TO X$,(-##.##)
160 PLOT <,,X$>,<100,,U>
170 NEXT X
180 REM *****
190 REM *****EXAMPLE 3*****
200 PLOT <,,R>,<20,600,U>
210 FOR X=1 TO 5
220 %-##.##
230 PRINTUSING 220,X; :PLOT <100,,U>
240 NEXT X
250 STOP
```

Example 1:

Example 2:

Example 3:

Example 1:

Ø1.ØØ Ø2.ØØ Ø3.ØØ Ø4.ØØ Ø5.ØØ

Example 2:

Ø1.ØØ Ø2.ØØ Ø3.ØØ Ø4.ØØ Ø5.ØØ

Example 3:

1.ØØ 2.ØØ 3.ØØ 4.ØØ 5.ØØ

Figure II-2. Samples of Printed Numbers

ROUND-OFF ERROR

The Model 2212 is an incremental plotter and will plot only at regular plot positions. When programming the System 2200 to plot, round-off error must be taken into account. The Plotter Utility Package in the next section shows how to compensate for round-off error. The procedure is: If a curve is being plotted, either the ΔX or ΔY increments, or both, are not generally integer values. Since the plotter can accept only integer values, the increments are rounded to the nearest integer value. The fractional differences between the actual and rounded increments are then saved and added into the next increments. This is repeated for all successive points in the curve.

Section III
Utility Routines

PLOTTER PROGRAM PACKAGE
PLOTTER UTILITY PACKAGE

PLOTTER PROGRAM PACKAGE
Library Number: VMi.09-2200.01B-0F1D-00
Tape Number: 701-0159
SOURCE TAPE
Library Number: VMi.09-2200.01B-0F1D-0-0
Tape Number: 701-0160

SECTION III—UTILITY ROUTINES

INTRODUCTION

WANG Laboratories, Inc. has designed a set of Utility Routines to provide users of the Model 2212 Analog Flatbed Plotter with full plotting capabilities. The routines are divided into two sections: the Plotter Program Package and the Plotter Utility Package.

The Plotter Program Package is a group of stand-alone programs, furnished on a tape cassette, which scale, plot and alphanumerically label rectangular, parametric, or polar equations; bar charts; pie charts; point plots; and line graphs. The user can select either linear, logarithmic or polar scales for special plots. No technical programming background is necessary to produce the graphs. Full instructions are provided.

For the user with knowledge of System 2200B BASIC programming techniques, the Plotter Utility Package is a listing and description of the various internal subroutines used in the Plotter Program Package to perform the plotting functions. It is provided as an aid to the programmer who wants to develop a custom program package. A listing of the source tape also is included at the end of the section. Users without technical programming knowledge can skip the Plotter Utility Package subsection.

The entire program package requires 12K bytes of memory. However, through program chaining, the Plotter Program Package operates on a System 2200B with a 8K CPU.

PLOTTER PROGRAM PACKAGE

The Plotter Program Package, furnished on a tape cassette, provides full plotting capabilities for the Model 2212 Analog Flatbed Plotter.

Each step of the graph generation process is controlled by depressing a Special Function Key (the row of gray keys across the top of the Model 2215 or 2222 Keyboard). The steps and their Special Function Key numbers are:

STEP	SPECIAL FUNCTION KEY
Choose Options	'0
Enter Data	'1
Review/Correct Data	'2
Scaling	'3
Draw Graph	'4
Draw and Number Axes	'5
Print A Character String	'6
Character String Centered	'7
Find Limits on X And Y	'8
Move Pen Lower Left	'14
Move Pen Upper Right	'15

Special Function Keys '0 through '7 control the basic operating procedure for almost all the graphs generated by the Plotter Program Package. Special Function Keys '14 and '15 are used to move the plotting arm (see page 49 for a detailed explanation of their use). The use of Special Function Key '8, for finding the limits on X and Y in a computed function, is detailed on pages 44 through 49.

Preparing The System

1. Install the Special Function Strip provided with the Plotter Program Package.
2. Master Initialize the System 2200B and place the POWER switch on the Model 2212 in the ON position.
3. Make sure the protective cover is off the plotting pen and the PEN switch is in the DOWN position.

4. Position your paper on the plotting surface and place the CHART switch in the HOLD position.
5. Press the Zero Reference Check button and rotate the Zero Reference dials until the pen is in the lower left-hand corner of the paper (leave about a 1/2 inch margin).
6. Press the Scale Adjust Check button and rotate the Scale Adjust dials until the pen is in the upper right-hand corner of the paper (again, leave a 1/2 inch margin).
7. The use of graph paper is explained on page 40.

Preparing Your Information

The System 2200B with the Model 2212 is prepared for use. Now you must prepare your information for entry into the Plotter Program Package.

The Plotter Program Package offers a number of options as to the type of graph, type of scale, the kind of axes, and the labelling format. You must know what you want to plot before you begin. Collect your data, decide on the type of options you want to work with, and make a rough hand-drawing of the graph you want to generate.

Preparing The Program Tape

Insert the Plotter Program Package program tape into the Model 2217 Tape Cassette Drive receiver door, and close the door. Key in LOAD.

When loading is complete (colon and cursor appear on line below LOAD command), touch the RUN and EXECUTE keys. The tape initialization program is loaded into memory, and the CRT screen displays the following requests, one at a time:

CHOOSE UTILITY PROGRAMS

LINE GRAPH?
POINT GRAPH?
LINEAR REGRESSION?
BAR CHART?
COMPUTED FUNCTION?
PIE CHART?
X- AND Y-AXES?
HORIZONTAL LINES?
HATCHED AXES?
ALPHA LABELING?
DRAW GRAPH?
DRAW AXES?
PRINT CHARACTERS?

The tape initialization program enables the 12K memory Plotter Utility Package also to be used on a 4K and 8K CPU, by selecting only the programs necessary to generate a specific graph. The method is called program chaining.

Users with a 12K machine can load the entire package into memory, by keying in 1 and touching the EXECUTE key after each request. The System 2200B searches the tape and loads in the appropriate programs, in this case all of them. While loading the programs, the CRT screen displays: SEARCHING THE TAPE. All plots now can be generated and the program does not need to be cleared to generate a different plot. Reloading is necessary only after system shutdown or Master Initialization.

Users with a 4K CPU, however, can load only the programs necessary for generating one type of plot at a time. For example, to generate a titled line graph, linear/linear scale, with labeled X- and Y- axes, key in 1 and touch the EXECUTE key after:

LINE GRAPH?
X- AND Y-AXES?
ALPHA LABELING?
DRAW GRAPH?
DRAW AXES?
PRINT CHARACTERS?

After all other requests, touch EXECUTE only. If later you want to generate a point graph, linear/linear scale, with X- and Y-axes and no labeling, the procedure is:

1. Touch CLEAR and EXECUTE
2. Key in REWIND, touch EXECUTE
3. Key in LOAD, touch EXECUTE
4. Touch RUN and EXECUTE
5. Key in 1 and touch EXECUTE for the requests:

   POINT GRAPH?
   X- AND Y-AXES?
   DRAW GRAPH?
   DRAW AXES?

6. Touch EXECUTE for all other requests.

Each time you want to generate a different type of graph, the memory first must be cleared. Then rewind and reload the tape, and select the appropriate programs.

Users with an 8K CPU can load programs for two or three different graphs at once, depending on the graph. Experiment with your machine and see how many of the various options can be loaded into memory at one time. If you load more programs than your memory can handle, after displaying SEARCHING THE TAPE, the CRT screen will display either ERR 01 (Text Overflow) or ERR 02 (Table Overflow). Clear the memory, rewind and reload the tape, and reselect fewer program options.

Once you have initialized the program tape, you are ready to generate graphs. Included in this section are examples of each type of graph the package generates, with full instructions for operating procedures. The first example a labeled line graph, linear/linear scale with X- and Y-axes, explains, step by step in detail, the basic operating procedures for Special Function Keys '0 through '7. The procedures are used to generate all types of graphs. Any additional unique instructions are included in the examples of the other types of graphs. All examples in this section assume the use of a 12K CPU. If your System 2200B has a smaller CPU, you must initialize the tape and select the proper programs before generating each of the example graphs.

EXAMPLE 1
LINE GRAPH
LINEAR/LINEAR SCALE
X- AND Y-AXES

This example explains, step by step, the use of Special Function Keys '0 through '7, by generating a graph, appropriately labeled, of the sales of Widget Co. from 1960 through 1973 (see Figure III-1). The sales data are:

1960	2.2	1967	5.8
1961	2.8	1968	5.9
1962	3.7	1969	6.4
1963	4.5	1970	7.7
1964	5.3	1971	9.6
1965	5.9	1972	10.2
1966	6.3	1973	11.3

A. CHOOSING THE OPTIONS
(Special Function Key '0)

Several options are available as to the type of graph you want to draw, the type of scale to use, and the labeling information.

1. When program initialization is complete (STOP appears on the CRT screen), depress Special Function Key '0. The CRT screen displays:

> **NOTE:**
>
> *If, at any time, you depress the wrong Special Function Key, touch the RESET key, followed by the correct Special Function Key.*

2. Enter the graph option number desired by touching the numeric key indicated in the chart. If, when choosing any of the options, you key in an invalid option number (for this example, 27, 8), the CRT displays:

```
CHOOSING THE TYPE OF GRAPH
ENTER OPTION NUMBER
?_

NO.   TYPE OF GRAPH
 1    LINE GRAPH
 2    POINT GRAPH
 3    LINEAR REGRESSION
 4    BAR CHART
 5    COMPUTED FUNCTION
 6    PIE CHART
```

```
CHOOSING THE TYPE OF GRAPH
ENTER OPTION NUMBER
?_
***ERROR – ILLEGAL OPTION NUMBER***
```

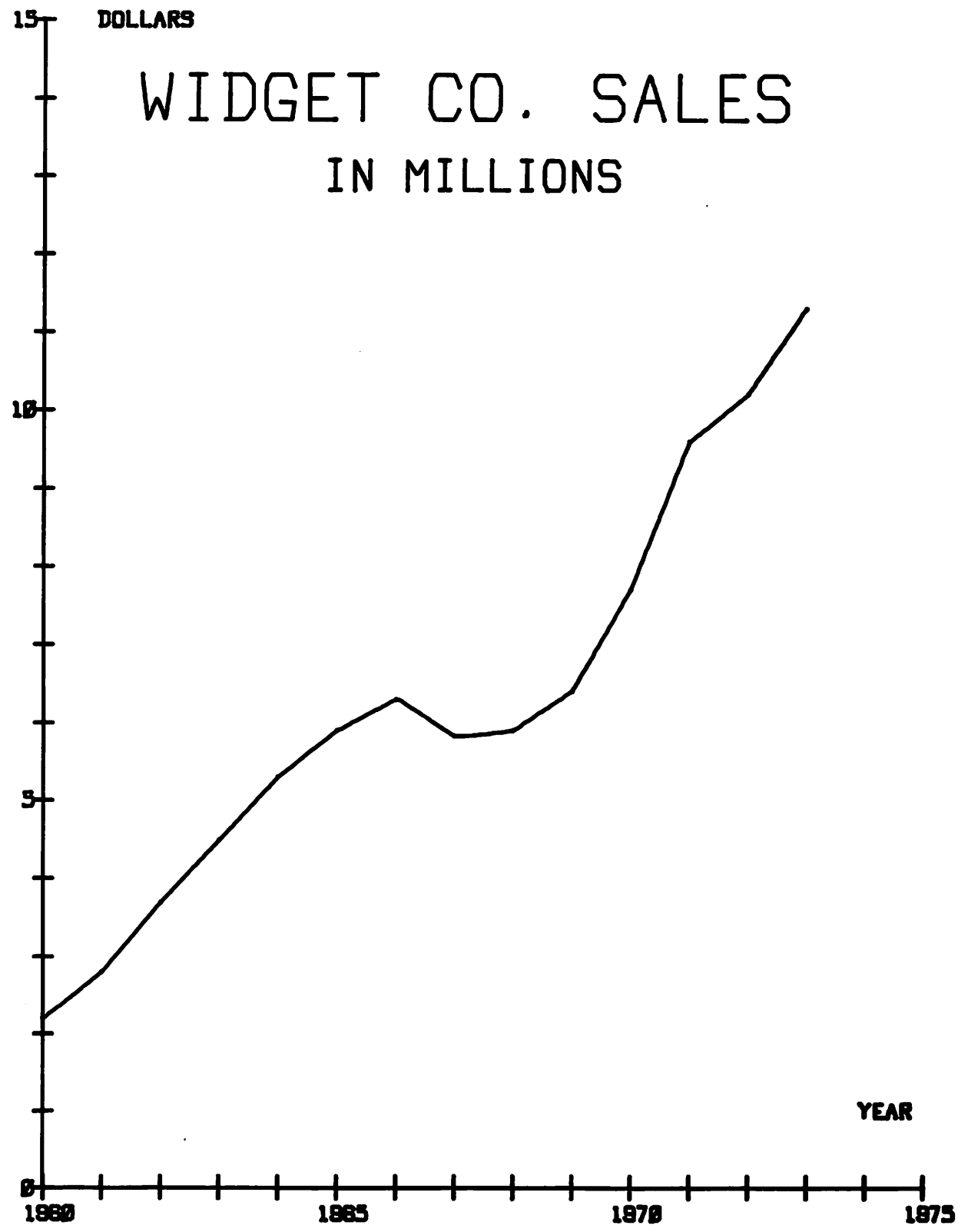


Figure III-1. Line Graph, Linear/Linear Scale

Key in the valid option number. For this example, to generate a line graph, key in 1 and touch EXECUTE. After selecting the type of graph, the CRT screen displays:

```
CHOOSING THE TYPE OF GRAPH
ENTER OPTION NUMBER
?_

NO.   TYPE OF SCALE
1     LIN/LIN
2     LIN/LOG
3     LOG/LIN
4     LOG/LOG
5     POLAR
```

3. Enter the scale option number desired by touching the numeric key indicated on the chart. For the example, to generate a linear/linear scale, key in 1 and touch EXECUTE. After selecting the scale option, the CRT screen displays:

```
CHOOSING THE TYPE OF GRAPH
ENTER OPTION NUMBER
?_

NO.   TYPE OF AXES
1     X- AND Y-AXES
2     HORIZONTAL LINES
3     HATCHED AXES
```

4. Enter the axes number option desired by touching the numeric key indicated on the chart. To generate a X- and Y- axes, key in 1 and touch EXECUTE. After selecting the type of axes, the CRT screen displays:

NOTE:

The format option selects the size and format of the numbers used to label the axes of the graph. Size 2 is 32 characters per line; size 1 is 64 characters per line. Format 1 allows ± numbers of two integers; format 2, ± numbers of five integers; and format 3, ± numbers with two integers and two decimal places These are the only available format options for labeling the axes.

```
CHOOSING THE TYPE OF GRAPH
ENTER OPTION NUMBER
?_

NO.   SIZE #   FORMAT
1     2        (-##)
2     1        (-#####)
3     1        (-##.##)
```

5. Enter the format option desired by touching the numeric key indicated on the chart. For this example, key in 2 and touch EXECUTE. After selecting the format option, the CRT screen displays:

```
END OF PROGRAM
:_
```

The END OF PROGRAM message appears each time you are ready to go on to the next key, in this example, Special Function Key '1.

The options specified under Special Function Key '0 are used in all plots until the program is re-run to specify new options. Special Function Key '0 must be depressed, and all options selected, before running any other programs in the Plotter Utility Package.

B. ENTERING DATA
(Special Function Key '1)

Special Function Key '1 is used to store data in the System 2200B memory to be used for plotting at a later time.

1. Depress Special Function Key '1. The CRT screen displays:

```
ENTERING THE DATA
NUMBER OF POINTS TO BE ENTERED
?_
```

2. Enter the number of points (pairs of numbers) you want to graph. For this example, key in 14 and touch EXECUTE.

> **NOTE:**
>
> *The program currently allows up to 50 points to be stored. The number can be increased by changing the DIM of X( ) and Y( ) in statement 140 of the program (see Plotting Utility Package, page 67). However, you cannot change the statement to exceed the memory capacity of your System 2200B.*

After entering the number of points the CRT screen displays:

```
ENTERING THE DATA
NUMBER OF POINTS TO BE ENTERED
 1          ?
 I         X(I)          Y(I)
---   --------      --------
```

3. The number 1 is a counter for the points you are to enter. The display screen visually keeps track of each entered value of X and Y. The first pair of points to be entered in the example have a value of (1960, 2.2). Key in 1960 and touch EXECUTE. The CRT screen displays:

```
ENTERING THE DATA
NUMBER OF POINTS TO BE ENTERED
 1          ?1960      ?_
 I         X(I)        Y(I)
---   --------      --------
```

4. Key in 2.2 and touch EXECUTE. The CRT screen displays:

```
ENTERING THE DATA
NUMBER OF POINTS TO BE ENTERED
 2          ?_

 I          X(I)          Y(I)
---    --------      --------

 1          1960          2.2
```

5. Enter your data in order. If you make an entry error, do not stop. Continue on to the next value. Key in the values:

1961	EXECUTE	2.8	EXECUTE
1962	EXECUTE	3.7	EXECUTE
1963	EXECUTE	4.5	EXECUTE
1964	EXECUTE	5.3	EXECUTE
1965	EXECUTE	5.9	EXECUTE
1966	EXECUTE	6.3	EXECUTE
1967	EXECUTE	5.8	EXECUTE
1968	EXECUTE	5.9	EXECUTE
1969	EXECUTE	6.4	EXECUTE
1970	EXECUTE	7.7	EXECUTE
1971	EXECUTE	9.6	EXECUTE
1972	EXECUTE	10.2	EXECUTE
1973	EXECUTE	11.3	EXECUTE

When all the points are entered, the CRT screen displays:

```
END OF PROGRAM
:_

 I          X(I)          Y(I)
---    --------      --------

 11         1970          7.7
 12         1971          9.6
 13         1972          10.2
 14         1973          11.3
```

The data is now in the System 2200B memory and can be used for plotting.

C. REVIEW/CORRECT DATA
(Special Function Key '2)

Special Function Key '2 allows you to review and, if necessary, correct the data stored in the System 2200B memory.

1. Fourteen items of data were entered, each with two values. To review the data for errors, depress Special Function Key '2. For the example, if item 6 was entered incorrectly, the CRT screen displays:

DATA REVIEW/CORRECTION
CORRECTION ?
?_

I	X(I)	Y(I)
1	1960	2.2
2	1961	2.8
3	1962	3.7
4	1963	4.5
5	1964	5.3
6	1975	5.9
7	1966	6.3
8	1967	5.8
9	1968	5.9
10	1969	6.4

2. The data entered into memory is displayed on the CRT screen, 10 items at a time. Verify the data against the CRT screen. If you made an entry error, it can be corrected now. In this example, to change line 6, key in the item number and the correct data as follows:

   6 and EXECUTE
   1965 and EXECUTE
   5.9 and EXECUTE

The line is changed on the CRT screen and the corrected data replaces the erroneous data in memory. Continue correcting any other errors by entering the line number and the two correct data values, each separated by EXECUTE.

3. When no more corrections are necessary, key in 0 and touch EXECUTE.

4. The next 10 items are displayed on the CRT screen. In this example, the CRT should display:

DATA REVIEW/CORRECTION
CORRECTION?
?_

I	X(I)	Y(I)
11	1970	7.7
12	1971	9.6
13	1972	10.2
14	1973	11.3

Again make any necessary corrections.

5. After completing all necessary corrections, key in 0 and touch EXECUTE. The END OF PROGRAM message is displayed on the screen. The data is now ready for use.

D. SCALING
(Special Function Key '3)

This program scales the plot. In order for the Plotter Program Package to be as useful as possible, it must work with numbers over either a very small range or a very large range. The program called by Special Function Key '3 requests the range of numbers you are working with.

1. Depress Special Function Key '3. The CRT screen displays:

```
SCALING
X-MIN
?_
```

2. In this example, the range of X is from 1960 to 1973 (years) and the range of Y is from 2.2 to 11.3 ($ billions). For asthetic purposes, round off the numbers Key in:

1960	EXECUTE
1975	EXECUTE
0	EXECUTE
15	EXECUTE

You are now ready to go on to the next step.

NOTE:

For most graphs, use round numbers for the limits on X and Y. For example, if the range of values for X are 8 to 92, give the limits on X as 0 to 100. It makes the graph more readable. Also, if you draw axes for the graph, hash marks are placed at regular intervals along the axes starting at the minimum value. It is easier reading a graph labeled 0, 10, 20, etc. than one labeled 8, 18, 28, etc.

E. DRAWING THE GRAPH
(Special Function Key '4)

Once the plotting options have been selected, the data (if any) entered, and the scaling completed, this program draws the desired graph on the plotter. For line graphs, pie charts, point graphs, and linear regressions, the only action required is to depress Special Function Key '4.

1. Since the example is a line graph, depress Special Function Key '4. The CRT screen displays:

DRAWING THE GRAPH
_

and the plotter pen moves on the paper, producing the graph. Upon completion of the graph, the END OF PROGRAM message is displayed. You are ready to go on to the next step.

F. DRAWING AND NUMBERING THE AXES (Special Function Key '5)

If you use plain paper for your graph, this program draws and numbers the axes, as specified when you chose the plotting options.

The program for drawing the X- and Y- axes draws the X-axis from X-Min to X-Max, with hash marks, starting at X-Min, at intervals of Delta X. It draws the Y-axis from Y-Min to Y-Max with hash marks, starting at Y-Min, at intervals of Delta Y. The point of intersection of the axes can be specified so the axes do not have to intersect at the origin.

1. Depress Special Function Key '5. The CRT screen displays:

DRAW X- AND Y- AXES INTERSECTING AT (X,Y)
X
?_

The program asks first for X, then Y, then Delta X and Delta Y. You must key in the value of the abscissa of the intersection of the axes, the ordinate of the intersection of the axes, the value of the increment of X and the value of the increment of Y. The values of X-Min, X-Max, Y-Min and Y-Max are not requested, since they were entered into memory during the Scaling procedure.

2. In this example, X ranges from 1960 to 1975, and Y ranges from 0 to 15. The axes are to intersect at point (1960, 0). Hash marks are used for each year and each million. Key in:

1960	EXECUTE
0	EXECUTE
1	EXECUTE
1	EXECUTE

The plotter pen now draws the X and Y axes, with hash marks at one unit intervals.

This program also numbers the axes just drawn, using the letter size and format chosen in the plotting options.

After the axes are drawn, the CRT screen displays:

```
NUMBER THE AXES?
```

1. If you want to number the axes, key in 1 and touch EXECUTE; if not, just touch EXECUTE. If you choose to number the axes, the CRT screen displays:

```
NUMBERING THE AXES
FIRST X
?_
```

2. The program asks for First X, then Last X, Delta X, First Y, Last Y, and Delta Y. In the example, X (years) goes from 1960 to 1975. The numbers are to be printed in five year intervals. Y (millions) goes from 0 to 15, again to be printed in five million intervals. Key in:

1960	EXECUTE
1975	EXECUTE
0	EXECUTE
15	EXECUTE
5	EXECUTE

The CRT screen now displays:

```
NUMBERING THE AXES
ENTER LETTER SIZE OPTION FOR THE
      Y-AXIS (IF DIFFERENT FROM X-).
?_
```

3. If the range of Y is much larger than the range of X, a format allowing more digits is needed. If you want the format letter size option on the Y-axis different from the X-axis, key in the desired option and touch EXECUTE (consult the chart to the right).

OPTIONS

OPTION	LETTER SIZE	FORMAT
1	2	-##
2	1	-#####
3	1	-##.##

Since the same format for X and Y is used in the example, touch EXECUTE. The plotting pen labels the axes. You are ready to go on to the next step.

NOTE:

If plotting on four quadrants, and the point Y=0 is being labeled on the X-axis, the number 0 is drawn over the X-axis. If Option 1 is used, the point X=0 is labeled on the Y-axis. If you do not want to label the point (0,0), run the program twice. The first time label the third quadrant and the second time label the first quadrant.

G. PRINTING A CHARACTER STRING (Special Function Key '6)

For labeling purposes, this program prints a character string (words or characters), starting at the location (X,Y). It can be used to label any part of the graph you choose: the X and Y axes; a point on the plot; the top of a bar chart; et cetera.

The character string can contain only legal Model 2212 characters. They are the letters A through Z; the digits 0 through 9; and the 12 special characters ( ) : . , / + – ' = ? and *space.*

1. Depress Special Function Key '6. The CRT screen displays:

PRINT A CHARACTER STRING STARTING AT THE LOCATION (X,Y).

STRING
?_

2. To label the X-axis with YEAR, key in:

   YEAR and EXECUTE

NOTE:

If the character string includes a comma or a leading blank, you must enclose it in quotation marks.

3. The program now asks for the X and Y values at which the first letter of the character string is to be printed, and the size of the characters. In deciding what character size to use, consult the table to the right, which shows how many characters will fit on a line 900 plot positions long (the length of the X-axis). For the example, key in:

1974	and EXECUTE
1	and EXECUTE
1	and EXECUTE

The plotter pen writes YEAR at the specified position (above the end of the X-axis).

NOTE:

If more than 28 characters are used to label an axis, the extra characters disappear from the screen when the location of X is entered. They are, however, kept in memory.

4. Since the program accepts only one character string at a time, to print DOLLARS at the top of the Y-axis, again depress Special Function Key '6. For the example, key in:

DOLLARS	and EXECUTE
1961	and EXECUTE
15	and EXECUTE
1	and EXECUTE

The plotter pen prints DOLLARS at the specified position. You are ready to go on to the next step.

H. PRINTING A CHARACTER STRING CENTERED
(Special Function Key '7)

For labeling purposes, this program prints a character string, using any character size, centered at the location (X,Y). Again, it can label any part of the graph, but is used to print a centered title on the graph. The operating procedures are identical to Special Function Key '6.

Letter Size	Characters Per Line
1	64
2	32
3	21
4	16
5	12
6	10
7	9
8	8
9	7
10	6
11	5
12	5
13	4
14	4
15	4

1. Depress Special Function Key '7. The CRT screen displays:

PRINT A CHARACTER STRING CENTERED AT THE LOCATION (X,Y).

STRING
?_

2. In this example, title the graph WIDGET CO. SALES, in large letters. Key in:

WIDGET CO. SALES	EXECUTE
1967.5	EXECUTE
14	EXECUTE
3	EXECUTE

The pen prints the heading, centered over the graph.

3. To print the subheading IN MILLIONS, again depress Special Function Key '7 and key in:

IN MILLIONS	EXECUTE
1967.5	EXECUTE
13	EXECUTE
2	EXECUTE

The plotter pen prints the subheading centered underneath the heading, in the next smaller character size. The graph is now complete.

EXAMPLE 2
LINE GRAPH
LINEAR/LINEAR SCALE
X- AND Y-AXES
HATCHED AXES

The hatched axes subroutine draws a hatched network of horizontal and vertical lines underneath a line graph (see Figure III-2). The four restrictions on the use of this subroutine are:

1. It can be used effectively only with a line graph.
2. The data points must be stored in order according to the values stored in X( ).
3. X(1) must be used for X-Min and X(last) must be used for X-Max when scaling.
4. X and Y must be linear scales.

This example again generates the graph in Example 1, adding hatched axes. Go through each of the steps in Example 1, making only one change: for the location of the character string YEAR, enter X=1974, Y=–.5, and Char Size = 1. With hatched axes, the label looks better under the X-axis.

Again, depress Special Function Key '0. Key in 1 for Type of Graph, 1 for Type of Scale, 3 for Type of Axes, and 2 for Format. Depress Special Function Key '3. X-Min = 1960, X-Max = 1075, Y-Min = 0, and Y-Max = 15. Enter the values.

Depress Special Function Key '5. Delta X is the separation between vertical lines, and Delta Y is the separation between horizontal lines. For this example, Delta X = .2, Delta Y = .1. Key in the values. The plotter draws the hatched axes. The graph is complete.

EXAMPLE 3
BAR CHART
LINEAR/LINEAR SCALE
X- AND Y-AXES
HORIZONTAL LINE AXES

To plot a bar chart of the way people travel to work, in percentages, with X- and Y-axes and horizontal lines (see Figure III-3), use the data:

Ride Alone	42%
Mass Transit	38%
Car Pool	18%
Walk	2%

Depress Special Function Key '0. Key in 4 for Type of Graph, 1 for Type of Scale, 1 for Type of Axes, and 1 for Format.

Depress Special Function Key '1. Key in 4 for Number of Points To Be Entered. When generating bar charts, X(I) requested in this program is the location of the center of the bar, and Y(I) is the height of the bar. Key in:

X(I)	Y(I)
1	42
2	38
3	18
4	2

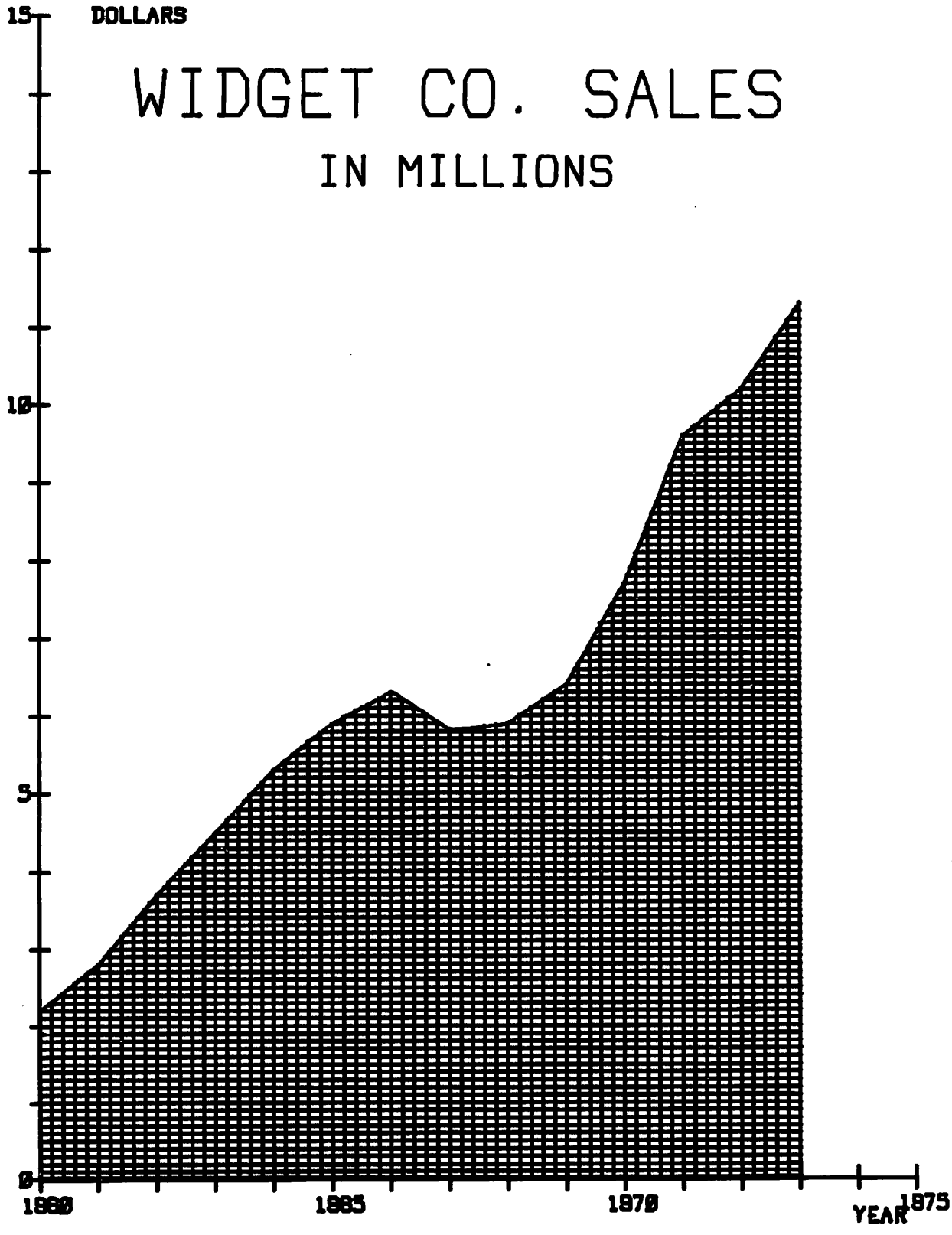


Figure III-2. Hatched Line Graph, Linear/Linear Scale

If necessary, depress Special Function Key '2; review and correct the data.

Depress Special Function Key '3. To make sure the bar chart sits entirely on the line (X-axis), the plot must be scaled properly. Allow at least one unit on each side of the minimum and maximum ranges of the bar locations. Since the graph is four bars, located at 1, 2, 3, and 4, X-Min=0 and X-Max=5. None of the percentages are greater than 50 percent, so Y-Min=0 and Y-Max=50. Key in the values.

Depress Special Function Key '4. When producing a bar chart, this program does not immediately plot the graph. The CRT screen displays:

```
DRAWING THE GRAPH
INPUT WIDTH OF BAR
?
```

You can select any width in X-units that looks esthetically pleasing with your graph. For this example, since the scale is from 1 to 5, with four bars, key in .5. The plotter now draws the graph.

Depress Special Function Key '5. Since Option 1 was selected initially, draw the X- and Y-axes first. X and Y intersect at 0,0. Delta X is 1, and Delta Y, for appearance, is 2. Key in the values. The graph has four bars; the first X=1, last X=4, and Delta X=1. Because the percentages range from 0 to 50, first Y=0, last Y=50, and Delta Y, again for appearance, equals 10. Key in the values. Since the size of the lettering on the X- and Y-axes is the same, touch EXECUTE after the CRT displays the request for the Y-axis letter size option.

To draw the horizontal lines on the graph, depress Special Function Key '0 again, and key in 4 for Type of Graph, 1 for Type of Scale, *2* for Types of Axes, and 1 for Format. Your data is still in memory.

Depress Special Function Key '5. The subroutine for horizontal lines draws the lines from X-Min to X-Max. The bottom line is Y-Min and the top line is Y-Max, with the separation between lines as Delta Y. Hash marks are drawn at intervals of Delta X. Horizontal lines for axes are most effective with bar charts; they sometimes can be used with a line graph. They are never used with other graphs. In the example, Delta X for the hash marks in X direction must be the same as the Delta X used when drawing the X- and Y-axes, in this case 1. Delta Y for separation of lines should be the same as the Delta Y of the numbering for the Y-axis, 10. Key in the values.

To label the graph, depress Special Function Key '6. You want to label the X-axis "PERCENT". Key in the string PERCENT. The location of X and Y, the beginning of the string, is X=1, Y=50.5, the character size=1. Key in the values.

To center titles over each bar, depress Special Function Key '7. For the first bar, use the information DRIVE ALONE, X=1, Y=43, character size = 1. Repeat the process for each bar. The values are:

BAR 2	BAR 3	BAR 4
MASS TRANSIT	CAR POOL	WALK
X=2	X=3	X=4
Y=39	Y=19	Y=3
Char Size = 1	Char Size = 1	Char Size = 1

Again, depress Special Function Key '7 to create a title for the graph. For our example, enter MEANS OF TRANSPORT TO WORK, X=2.5, Y=–3, Char Size = 2. The graph is complete.

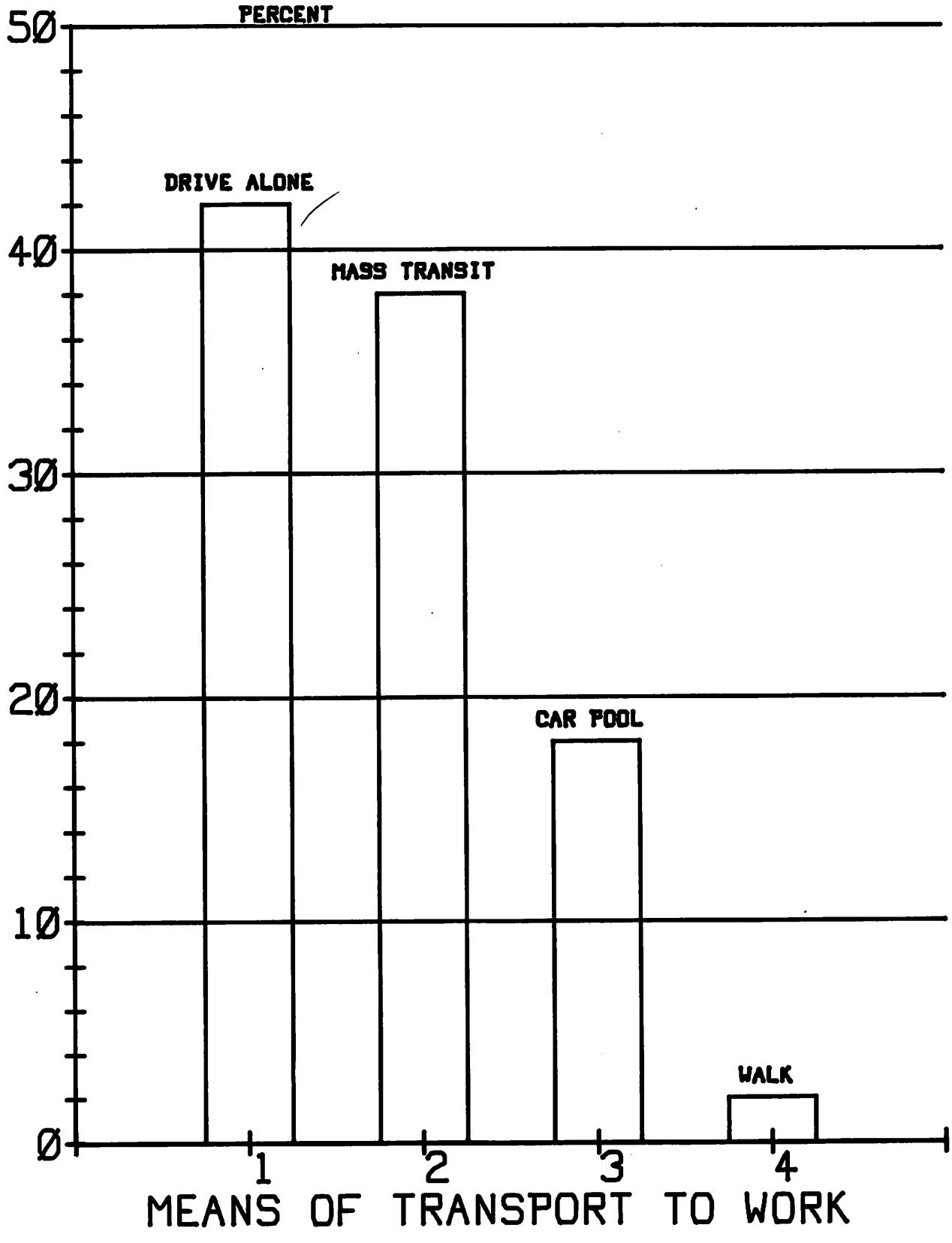


Figure III-3. Bar Chart, Linear/Linear Scale, Horizontal Axis

EXAMPLE 4
PIE CHART
LINEAR/LINEAR SCALE

This graph is a typical pie chart showing how a tax dollar is spent (see Figure III-5).

Depress Special Function Key '0. Key in 6 for Type of Graph. Since no other options are necessary, the CRT screen displays:

END OF PROGRAM
:_

Depress Special Function Key '1 and enter 3 for the Number of Points, and the values 48, 30, and 22. When generating a pie chart, the program does not ask for the values of Y.

The scaling program is not used, but you must manually scale the plotting surface to equal a sqaure, using the zero reference check button and dials, and the scale adjust check button and dials. If the plotting surface is not scaled square, the pie chart will be an ellipse rather than a circle.

Depress Special Function Key '4. The plotter draws the pie chart and prints the appropriate percentages.

Labelling the pie chart is done by estimating the values of X and Y. The ranges of the pie chart are illustrated in Figure III-4.

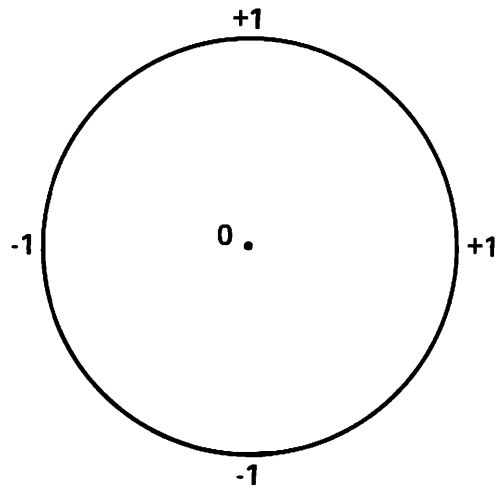


Figure III-4. Ranges of the Pie Chart

To label this example, use Special Function Key '7 and key in the values:

STRING	X	Y	CHAR SIZE
SCHOOLS	.5	-.15	2
POLICE AND	-.4	-.5	2
FIRE	-.4	-.6	2
SERVICES	-.35	.25	2

Also use Special Function Key '7 to title the graph. Key in the values:

STRING	X	Y	CHAR SIZE
TAX DOLLAR	0	1.05	3

The example is complete.

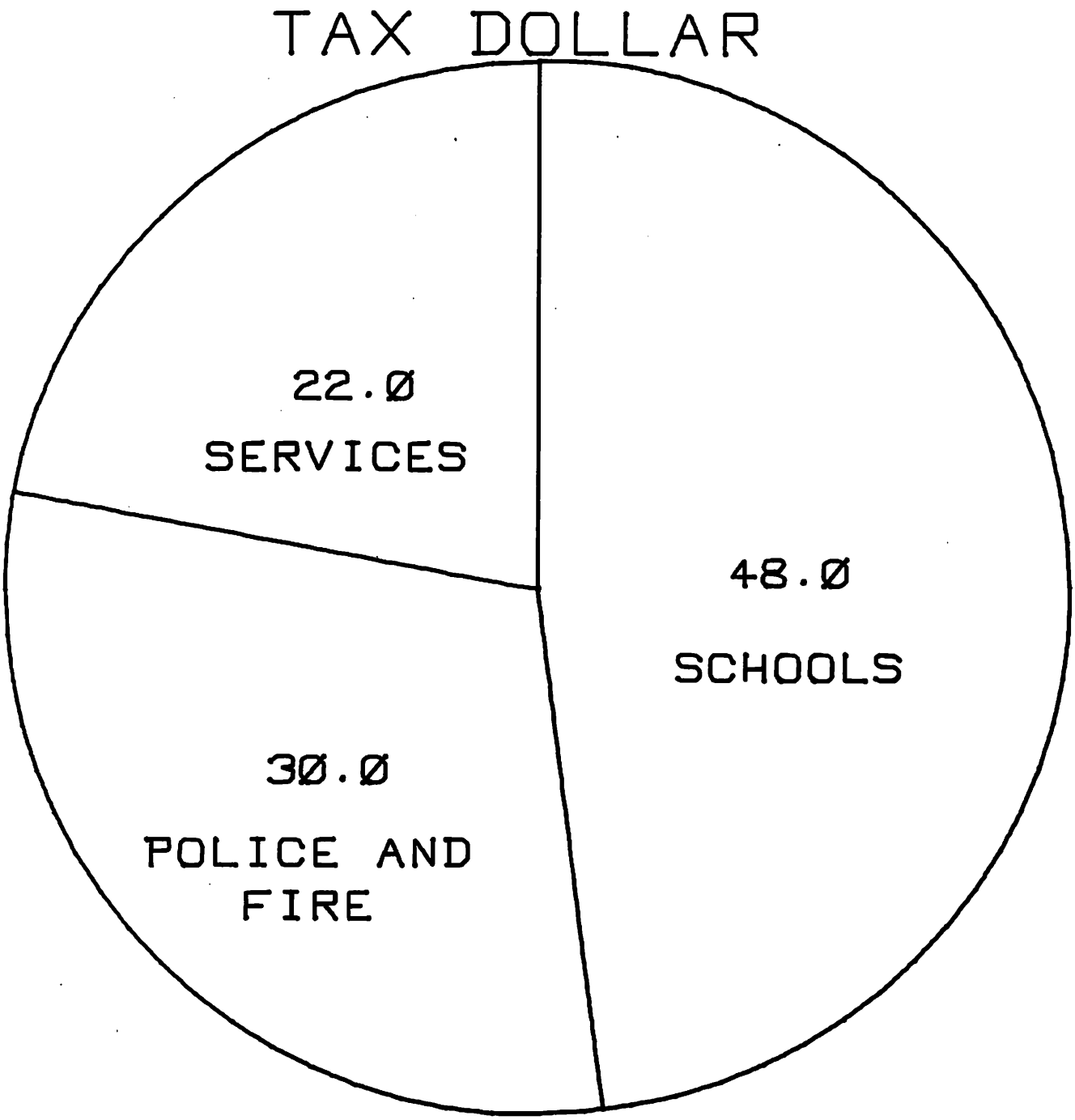


Figure III-5. Pie Chart, Linear/Linear Scale

EXAMPLE 5
POINT GRAPH
LINEAR/LINEAR SCALE
USING GRAPH PAPER

Example 5 (see Figure III-6) generates on graph paper a point graph, with linear/linear scale, of the points:

X	Y
.5	2.3
1.8	5.6
2.2	3.7
2.3	4.8
3.0	6.9
3.5	4.8
5.9	2.9
6.3	7.5
5.7	6.8
7.9	7.7
8.3	4.2
9.2	8.6
8.7	7.3

Depress Special Function Key '0 and select the proper options. Key in 2 for the Type of Graph, 1 for the Type of Scale, 1 for the Type of Axes, and 1 for the Format. When using graph paper you do not need to draw the axes; they are provided by the lines on the paper. The axes cannot be labelled in the normal manner, because of the necessary scaling procedure. But you must select an option for Type of Axes and Format to complete the program.

Enter the data into memory by depressing Special Function Key '1 and keying in the values. Use Special Function Key '2 to review and, if necessary, correct the data.

Place your graph paper on the plotting surface. Line up the left edge of the paper with the right edge of the two screw holes on the left side of the plotting surface. Make sure the bottom edge of the paper abuts the silver metal ridge at the base of the plotting surface.

Special scaling is needed when using graph paper. First, depress Special Function Key '3 and run the scaling program. The values for the example are:

X-Min = 0
X-Max = 10
Y-Min = 0
Y-Max = 10

Immediately depress the zero reference check button and adjust the zero reference dials so the plotting pen is positioned directly over the point on the graph paper you want to be the intersection of X and Y, the point (X-Min, Y-Min). To be sure of the exact location of the pen, gently press down on the plotting arm until the pen tip touches the paper. The amount of accuracy of the graph depends on the accuracy of your position. Then depress Special Function Key '15 and rotate the scale adjust dials until the pen is positioned directly over the point (X-Max, Y-Max). Again, be very accurate. In this example, using 10x10 to the inch graph paper, (X-Min, Y-Min) is the lower left-hand corner of the graph paper lines, and (X-Max, Y-Max) is the upper edge, ten large boxes over. You are now ready to plot. Depress Special Function Key '4.

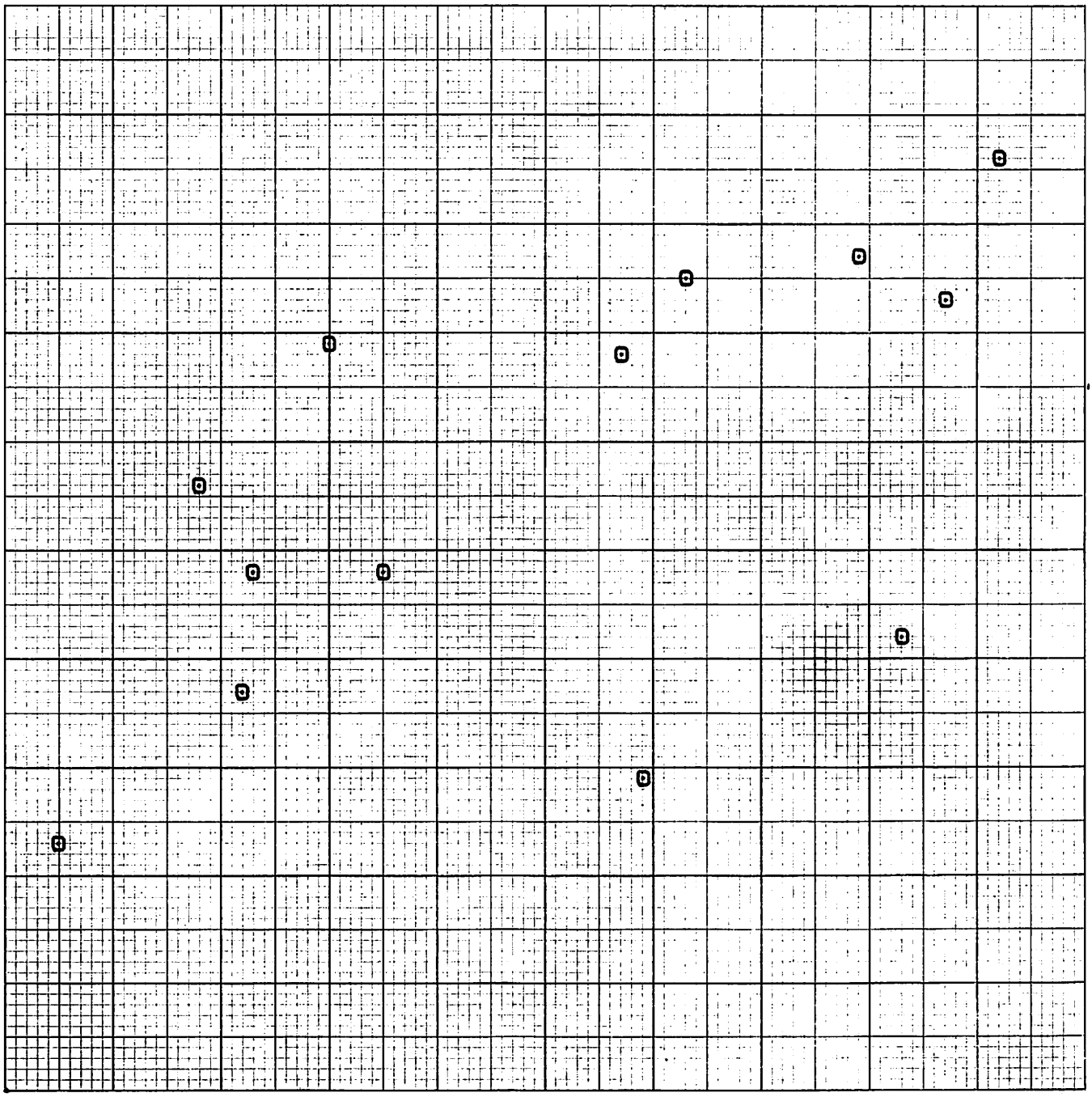
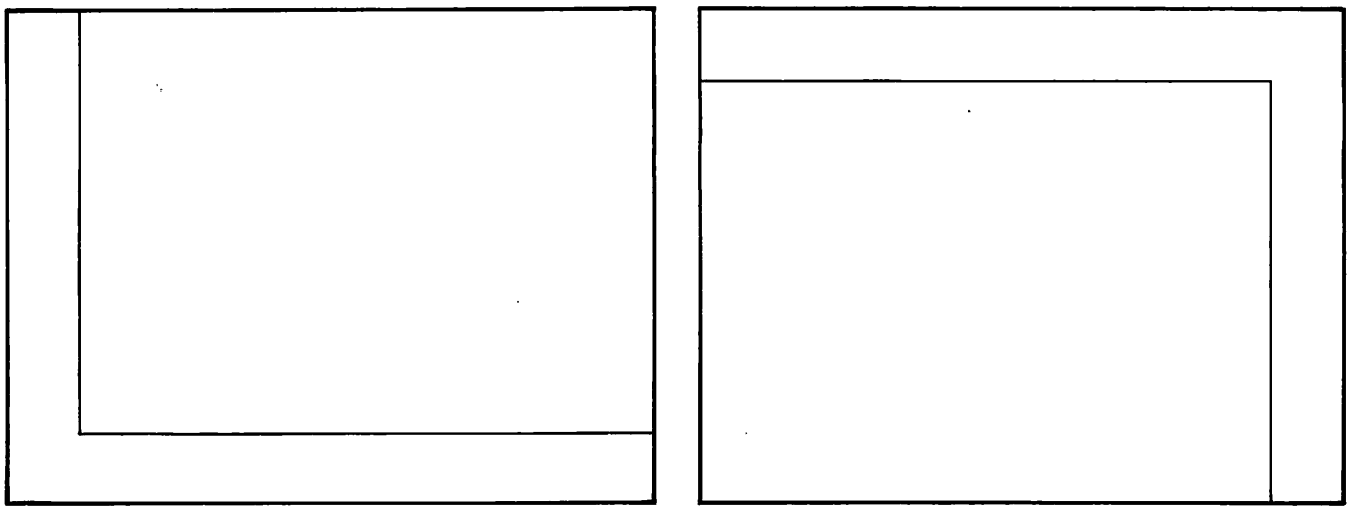


Figure III-6. Point Graph, Linear/Linear Scale

As mentioned earlier, when using graph paper you cannot label the axes in the normal manner. When generating plots without graph paper, the normal scaling procedure leaves a margin to the left and below the actual plotting area (see Figure III-7A). When using the special scaling procedure for graph paper, the program does not allow the margin, in order to position the graph paper lines properly (see Figure III-7B).



A. Normal B. With Graph Paper

Figure III-7. Plotting Margins

You can label the graph paper by hand, or use Special Function Keys '6 and '7, which print both alpha and numeric strings (see Figure III-8). For example, using Special Function Key '6, enter each Y-axis point:

STRING	X	Y	CHAR SIZE
0	.1	.1	1
1	.1	1	1
2	.1	2	1
3	.1	3	1
.			
.			
.			
10	.1	9.8	1

You must label 10 at(.1, 9.8) because the pen cannot go outside the range of Y-Max. The points on the X-axis can be labelled in the same manner. Likewise, you can label the axes. Depress Special Function Key '6, and enter the values:

STRING	X	Y	CHAR SIZE
Y-AXIS	.5	9.9	1
X-AXIS	9	.5	1

You also can label each point, depending on where the points fall. For example, using Special Function Key '6, enter:

STRING	X	Y	CHAR SIZE
" (.5, 2.3)"	.5	2.3	1

Be sure to leave one space between the quotation mark and the parenthesis.

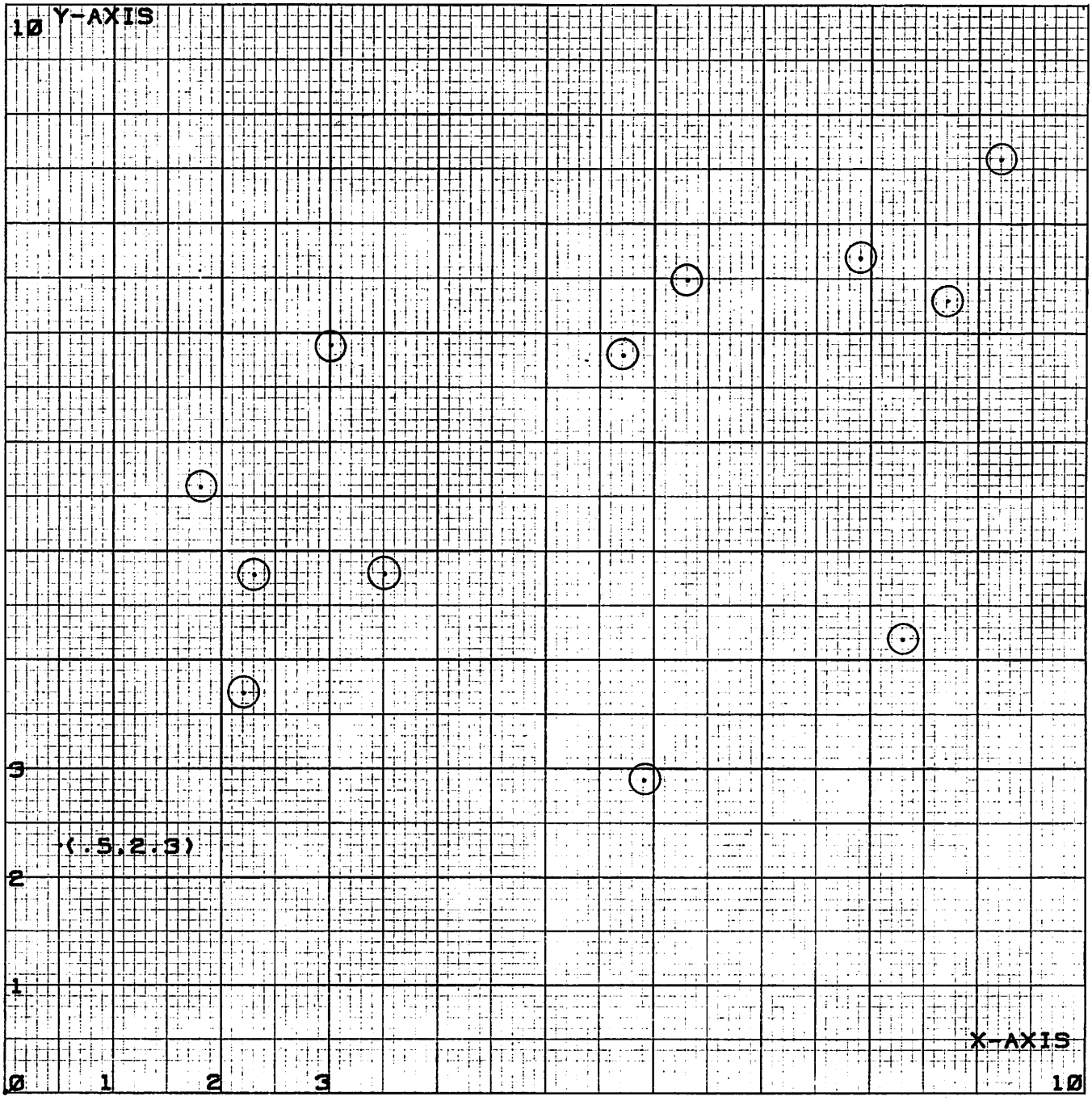


Figure III-8. Labeled Point Graph, Linear/Linear Scale

EXAMPLE 6
LINEAR REGRESSION
LINEAR/LINEAR SCALE
X- AND Y- AXES

This example plots the linear regression of the points in Example 5, using plain paper (see Figure III-9).

Depress Special Function Key '0. Key in 3 for Type of Graph, 1 for Type of Scale, 1 for Type of Axes, and 1 for Format.

Enter the data (see page 40) into memory by depressing Special Function Key '1 and keying in the values. Review and correct the data, if necessary (Special Function Key '2).

Depress Special Function Key '3. X-Min = 0, X-Max = 10, Y-Min = 0, and Y-Max = 10. Key in the values. Depress Special Function Key '4. The plotter draws the graph.

To draw and label the axes, depress Special Function Key '5. The axes intersect at X = 0, Y = 0. Delta X and Delta Y for the hash marks = 1. Key in the values. The plotter draws the axes. To label the axes, First X=0, Last X=10, Delta X=1, First Y=0, Last Y=10, and Delta Y=1. Key in the values. Since the letter size is the same for both axes, touch EXECUTE. The plotter labels the axes.

Depress Special Function Key '7 to title the graph. Enter the values:

STRING	X	Y	CHAR SIZE
LINEAR REGRESSION	5	9.5	2

The graph is complete.

EXAMPLE 7
COMPUTED FUNCTION
LINEAR/LOGARITHMIC SCALE
X- AND Y- AXES

This example is a graph of the loan balance versus time, using linear/logarithmic scale, of a $5,000 loan, with $150 monthly payments, 7-1/2 percent interest rate, over 36 months (see Figure III-10).

1. Depress Special Function Key '0 and key in 5 for Type of Graph, 2 for Type of Scale, 1 for Type of Axes, and 1 for Format.
2. For plotting a computed function, three items of information are needed: T-Min, T-Max, and Delta T, where T is the range for the values to be computed. For example, if plotting Y as a function of X, then Y is computed for values of X starting with T-Min and going to T-Max in increments of Delta T. Before running the program to plot Y as a function of X, the following lines must be keyed in:

   1010 Y = Expression Involving X

   For this example, key in:

   1010 Y=5000*(1+7.5/1200)↑X-150*((1+7.5/1200)↑X-1)/(7.5/1200))
3. Depress Special Function Key '8. The CRT screen displays:

   FIND LIMITS ON X AND Y

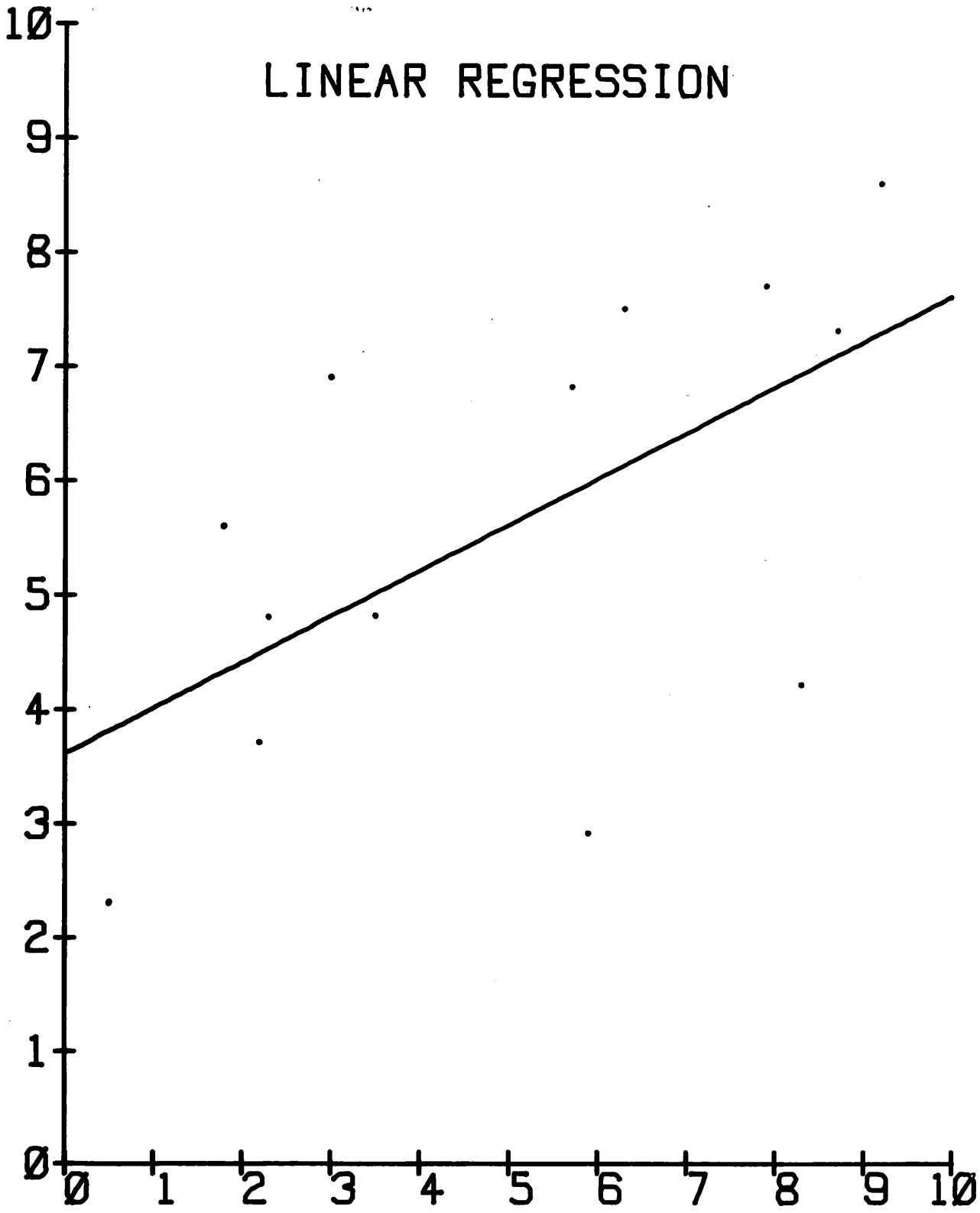


Figure III-9. Linear Regression, Linear/Linear Scale

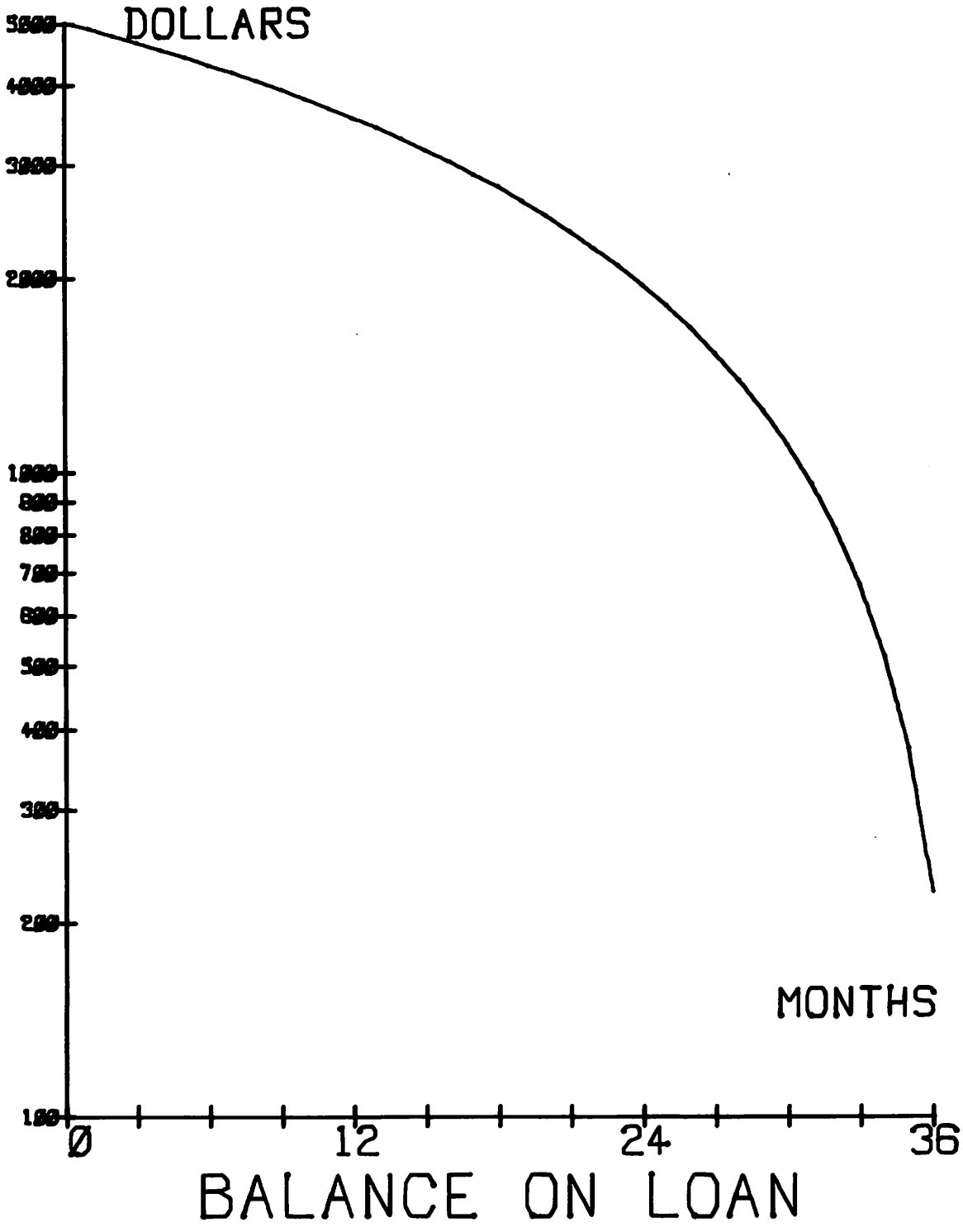


Figure III-10. Computed Function, Linar/Logarithmic Scale

The CRT asks for the values of T-Min, T-Max, and Delta T. In this example, the range of the time of the loan is from 0 to 36 months, in increments of one month. Enter the values:

T-Min = 0
T-Max = 36
Delta T = 1

After a short pause, the CRT screen displays the END OF PROGRAM message and the values for X-Min, X-Max, Y-Min and Y-Max. In the example, the values are:

X-Min = 0
X-Max = 36
Y-Min = 222.5234255
Y-Max = 5000

4. Depress Special Function Key '3. To scale the example graph, X-Min = 0, X-Max = 36, Y-Min = 100 and Y-Max = 5000. Key in the values.
5. Depress Special Function Key '4. The CRT screen asks for the values of T-Min, T-Max and Delta T. For the example, enter the values T-Min = 0, T-Max = 36, Delta T = 1.
6. To draw and number the axes, depress Special Function Key '5. X and Y intersect at X = 0, Y = 100. Delta X = 3, Delta Y = 100. Key in the values. The plotter draws the axes. To label the axes, First X=0, Last X=36, Delta X=12, First Y=100, Last Y=5000, Delta Y=100. The Letter Size Option=2. Key in the values. The plotter labels the axes.

> **NOTE:**
>
> *When using the logarithmic scale Y-Min (or X-Min if logarithmic on the X-axes) should be a power of 10, and Delta Y (Delta X) should be one, three or nine times a power of 10. This is necessary if the logarithmic scale is multi-phased.*

7. To title the axes, depress Special Function Key '6 for each string and enter the values:

STRING	X	Y	CHAR SIZE
MONTHS	30	150	2
DOLLARS	3	5000	2

8. Depress Special Function Key '7 to title the graph. Key in the values:

STRING	X	Y	CHAR SIZE
BALANCE ON LOAN	18	75	3

The graph is complete.

EXAMPLE 8
COMPUTED FUNCTION
POLAR SCALE

This example is a plot of a pair of parametric equations, using polar scale (see Figure III-11).

1. Depress Special Function Key '0 and key in 5 for Type of Graph and 5 for Type of Scale. The END

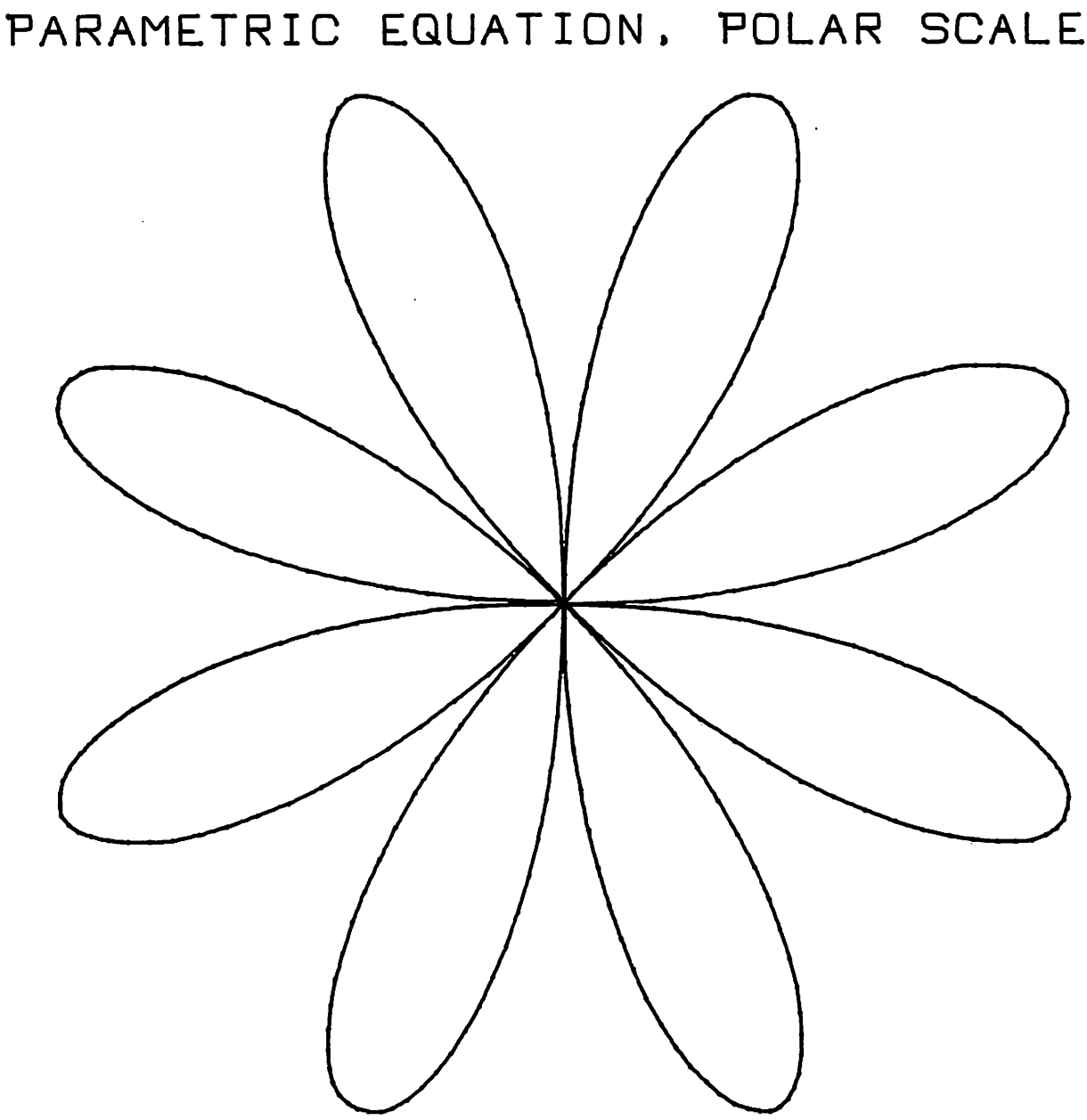


Figure III-11. Computed Function, Polar Scale

OF PROGRAM message appears on the CRT screen; no other options are necessary.

2. Before running the program to plot the curve of a pair of parametric equations, it is necessary to key in the following lines:

```
1000 X = Expression Involving T
1010 Y = Expression Involving T
```

In this example, key in the lines:

```
1000 X = SIN (4*T)
1010 Y = T
```

X = the radius and Y = the angle.

3. Place your paper on the plotting surface. Manually scale the plotting area to equal a square (the same procedure as the manual scaling for a pie chart in Example 4).

> **NOTE:**
>
> *In this example we work in Radians. Therefore, the command SELECT R must be executed before the next step. If working in Degrees, you must execute the command SELECT D.*

4. Depress Special Function Key '3. The CRT requests the value for the MAXIMUM RADIUS. Key in 1.
5. To draw the graph, depress Special Function Key '4. In this example, T-Min = 0, T-Max = 6.28 and Delta T = .02. Key in the values.
6. Depress Special Function Key '7 to title the graph. Key in the values:

STRING	X	Y	CHAR SIZE
"PARAMETRIC EQUATION, POLAR SCALE"	1.05	1.57	2

The graph is complete.

MOVE PEN LOWER LEFT
(Special Function Key '14)

When completing any one of the plotting steps, the plotting bar might stop at a position which obscures part of the graph. In order to inspect the graph, you must move the plotting bar.

If you move the plotting bar with the zero reference check button or dials, or the scale adjust check button or dials, the program "loses" the current position of the plotting pen; it no longer knows where the plotting pen is located. Any further plots will not be positioned properly on the graph.

Special Function Key '14 moves the plotting pen to the lower left-hand corner of the plotter bed, and retains a record of the new position of the plotting pen.

MOVE PEN UPPER RIGHT
(Special Function Key '15)

Special Function Key '15 is identical in purpose to Special Function Key '14, except it moves the plotting pen to the upper right-hand corner of the plotter bed, instead of the lower left-hand corner.

SECTION III—UTILITY ROUTINES

PLOTTER UTILITY PACKAGE

The Plotter Utility Package is a listing and description of the internal subroutines utilized in the Plotter Program Package. It is provided to assist the programmer who wants to write a custom plotter program.

The following subroutines are described in the Plotter Utility Package:

Subroutine Number	Function
'10	Calculates the distance the plotter is to move.
'11	Moves plotter to a point with the pen up.
'12	Moves plotter to a point with the pen down.
'13	Converts the point to be plotted into linear scale point.
'16	Draws a pie chart showing the relative amounts for the numbers stored in the X array.
'18	Performs scaling and plotter initialization.
'19	Plots a curve with points that can be computed by a subroutine.
'20	Draws intersecting X and Y axes.
'21	Labels the X and Y axes.
'23	Prints the contents of a character string on a graph.
'24	Prints a character string centered about a point.
'25	Prints a bar chart of data stored in arrays X and Y.
'26	Prints a point graph of data stored in arrays X and Y.
'27	Same as (26), then computes and draws the "best fit" straight line.
'28	Draws a line graph of data stored in arrays X and Y.
'29	Draws horizontal lines for axes with evenly spaced hash marks along bottom line.
'30	Draws hatched axes under a line graph curve.

GOSUB' 10 (X,Y)

PURPOSE:

This subroutine has two purposes; it calculates Delta X and Delta Y, the distance to the right and up that the plotter is to move from its present position (source point). It also calculates and saves the new position (destination point) of (X,Y) in the units that the plotter uses.

GOSUB' 10 provides the basic bookkeeping required by the plotter. It is used by many other subroutines in the Plotter Program Package and should be transparent to the user. It must be core resident when using the Plotter Program Package.

INPUT:

X = Abscissa of the destination point (X,Y).
Y = Ordinate of the destination point (X,Y).
06 = The scale option. 06 must be set once, before calling subroutine '10. This determines the type of scale being used (e.g., lin/lin or lin/log). If 06 is not specified, the default is lin/lin.

OPTION	FUNCTION
1	Linear on X and Y.
2	Linear on X and logarithmic on Y.
3	Logarithmic on X and linear on Y.
4	Logarithmic on X and Y.
5	Polar Co-ordinates.

OUTPUT:

X0 = Current X-plotter position.
Y0 = Current Y-plotter position.
X1 = Delta X.
Y1 = Delta Y.

```
100 REM -      WANG 2212 PLOTTER UTILITY PACKAGE
110 REM -      COPYRIGHT WANG LABORATORIES, INC. DEC. 28, 1973
120 REM -      VERSION #1
125 REM *      REVISED 1505 03/05/74.
130 REM -      PROGRAMMED BY JAMES B. HARMON
135 REM
140 COM Q6$64, Q8$1, X(50), Y(50), V$64, X0, Y0, F1, F2
145 COM 01, 02, 03, 04, 05, 06, 07, 08, 09, 00
150 REM ------------------------------
160 REM *     THIS SUBROUTINE COMPUTES DELTA X AND DELTA Y
170 REM *     INPUT TO THIS SUBROUTINE IS THE POINT (X,Y) TO
180 REM *          WHICH YOU WANT THE PLOTTER TO MOVE.
190 REM *
200 REM *     OUTPUT IS (X1,Y1), THE # OF PLOT POSITIONS TO THE
210 REM *          RIGHT AND UP THAT THE PLOTTER IS TO MOVE;
220 REM *          AND (X0,Y0), THE CURRENT PLOTTER POSITION
230 REM *          AFTER THE MOVE TAKES PLACE.
240 REM
250   DEFFN'10(X,Y)
260     GOSUB '13(X,Y)
270     X1 = INT(F1*X - X0 + .5)
280     Y1 = INT(F2*Y - Y0 + .5)
290     X0 = X0 + X1
300     Y0 = Y0 + Y1
310   RETURN
```

GOSUB' 11 (X,Y)

PURPOSE:

This subroutine causes the plotter to move to the point (X, Y) with the pen up.

INPUT:

X = The abscissa of the destination point. If polar coordinates are being used, the radius.
Y = The ordinate of the destination point. If polar coordinates are being used, the angle.

OUTPUT:

The plotter moves the point (X,Y) with the pen up.
X is converted to a linear scale.
Y is converted to a linear scale.

```
420 REM ------------------------------
430 REM *     MOVE PLOTTER TO THE LOCATION (X,Y)
440 REM *          WITH THE PEN UP.
450 REM
460   DEFFN'11(X,Y)
470     GOSUB '10(X,Y)
480     PLOT (X1,Y1,U)
490   RETURN
```

GOSUB' 12 (X,Y)

PURPOSE:

This subroutine causes the plotter to move to the point (X,Y) with the pen down.

INPUT:

X = The abscissa of the destination point. If polar coordinates are being used, the radius.
Y = The ordinate of the destination point. If polar coordinates are being used, the angle.

OUTPUT:

The plotter moves to the point (X,Y) with the pen down.
X is converted to a linear scale.
Y is converted to a linear scale.

```
500 REM ------------------------------
510 REM *     MOVE PLOTTER TO THE LOCATION (X,Y)
520 REM *          WITH THE PEN DOWN.
530 REM
540   DEFFN'12(X,Y)
550     GOSUB '10(X,Y)
560     PLOT (X1,Y1,D)
570   RETURN
```

GOSUB' 13 (X,Y)

PURPOSE:

Since the Model 2212 is an X- Y-plotter that uses linear scales on X and Y, it is necessary that points being plotted be given in a coordinate system that is linear in X and Y. Therefore, this subroutine converts the given X and Y to a linear scale X and Y.

INPUT:

X = Actual value of X, or if polar coordinates are being used, the radius.
Y = Actual value of Y, or if polar coordinates are being used, the angle.

OUTPUT:

X = The linear scale value of X.
Y = The linear scale value of Y.

```
320 REM ------------------------------
330   DEFFN'13(X,Y)
340     ON 06 GOTO 410,350,370,360,380
```

```
345      RETURN
350      Y = LOG(Y) : RETURN
360      Y = LOG(Y)
370      X = LOG(X) : RETURN
380      V9 = X * COS(Y)
390      Y  = X * SIN(Y)
400      X = V9
410    RETURN
```

GOSUB' 16

PURPOSE:

This subroutine draws a pie chart showing the relative amounts for the numbers stored in the X() array. Each section of the pie is labeled with the percent it represents.

INPUT:

The X() array must contain the values the user is comparing and the scalar 00 must contain the number of points stored in X() before calling the subroutine.

OUTPUT:

A pie chart is drawn with each section labeled with a percentage to show its relative size.

```
3420 REM ------------------------------
3430 REM *     THIS SUBROUTINE DRAWS A PIE CHART
3440 REM *          USING THE VALUES IN THE X()
3450 REM *          ARRAY.   EACH SECTION OF THE PIE
3460 REM *          IS LABELED WITH A PERCENTAGE TO
3470 REM *          REPRESENT ITS RELATIVE SIZE.
3480    DEFFN'16
3490      V0 = 0
3500      FOR V = 1 TO 00
3510       V0 = V0 + X(V)
3520      NEXT V
3530      SELECT D , PLOT 413 , PRINT 413
3540      PLOT <2,,C>,<26,,S>
3550     GOSUB '18(-1,1,-1,1)
3560      V1 = SIN(5)
3570      V2 = COS(5)
3580      V3 = 0
3590      V4 = 1
3600      GOSUB '11(0,1)
3610      FOR V = 0 TO 72
3620        GOSUB '12(V3,V4)
3630        V5 = V2*V3 + V1*V4
3640        V4 = V2*V4 - V1*V3
3650        V3 = V5
3660      NEXT V
3670      V5, V6 = 0
3680      FOR V = 1 TO 00
3690        V6 = V6 + X(V)
3700        GOSUB '11(0,0)
3710        GOSUB '12(SIN(360*V6/V0),COS(360*V6/V0))
```

```
3720        V7 = 360*(( (V5 + V6)/2 )/V0)
3730        GOSUB '10(.5*SIN(V7),.5*COS(V7))
3740        X1 = X1 - 52
3750        X0 = X0 + 52
3760        PLOT <X1,Y1,U>
3770        PRINTUSING 3780,100*X(V)/V0+.05;
3780        %##.#
3790         V5 = V6
3800       NEXT V
3810     GOSUB '15
3820    SELECT PRINT 005
3830  RETURN
```

GOSUB' 18 (01,02,03,04)

PURPOSE:

This subroutine performs the scaling and plotter initialization. The user manually sets the zero reference point of the plotter to the lower left-hand corner of the area in which the plotting is to be performed. The scale reference point is then set to the upper right-hand corner of the area in which the plotting is to be performed. This physically represents 1,000 plot positions. The plotting area is divided into two parts. The first part is a square plotting area 900 by 900 plot positions in the upper right-hand corner of the plotting area. Essentially, all plotting is done in this area. A margin of 100 plot positions runs down the left-hand side and across the bottom of the plotting area.

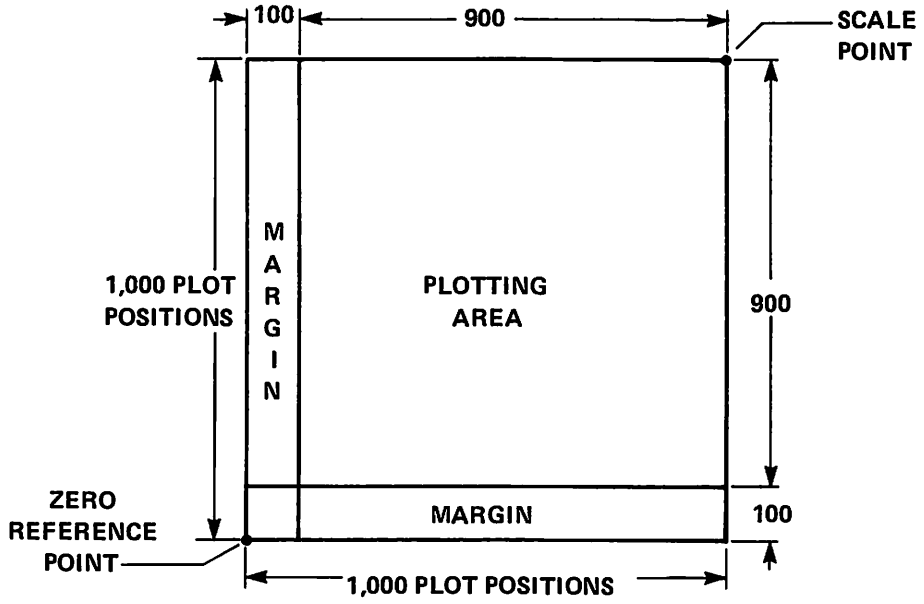


Figure III-12. Plotting Area Layout

GOSUB' 18 computes the scaling factors F1 and F2 which are used to compute the corresponding plotter positions for a pair of coordinates (X,Y). It also selects the plotter so it will receive commands from the calculator. Since the plotter physically can be located anywhere on the page, the subroutine moves the plotter to the fixed point (X-min, Y-min) and stores the value of these points in X0, Y0.

INPUT:

01 = X-min, the smallest value that X will ever have.
02 = X-max, the largest value that X will ever have.
03 = Y-min, the smallest value that Y will ever have.
04 = Y-max, the largest value that Y will ever have.

OUTPUT:

F1 = The scaling factor for X.
F2 = The scaling factor for Y.

The plotter moves to the point (01,03) with the pen up. The System 2200 now "knows" where the plotter is located. If the plotter is moved by anything other than the utility subroutines, or if a user tries to plot outside of the range specified by the scaling subroutine, the plotter can become "lost". That is, the internal pointers of the program located the plotter at one position when it actually is located at another position. Running the scaling subroutine corrects this situation.

```
580 REM ------------------------------
590 REM *     SCALING & PLOTTER INITIALIZATION
600 REM *           01 = X-MIN
610 REM *           02 = X-MAX
620 REM *           03 = Y-MIN
630 REM *           04 = Y-MAX
640 REM
650   DEFFN'18(01,02,03,04)
660     GOSUB '13(02,04)
670     X2 = X
680     Y2 = Y
690     GOSUB '13(01,03)
700     F1 = 900/(X2-X)
710     F2 = 900/(Y2-Y)
720     SELECT PLOT 413
730     PLOT <,,R>,<100,100,U>
740     GOSUB '10(01,03)
750   RETURN
```

GOSUB' 19 (V1, V2, V3)

PURPOSE:

The purpose of the subroutine is to plot any type of curve with points that can be computed by a subroutine. It computes the curve when given either a statement defining Y as a function of X, or a pair of statements defining X and Y as functions of a parameter T.

INPUT:

V1 = The starting (minimum) value of T.
V2 = The limit (maximum value) of T.
V3 = The increment on T.

OUTPUT:

A curve is drawn connecting the computed points going from the starting value of T to the limit of T.

RESTRICTION:

Before using this subroutine, the user must either enter a single statement defining Y as a function of X, or a pair of statements defining X and Y as functions of a parameter T.

Examples:

```
1010  Y = (3*X + 5)*(2*X - 7)
```

or

```
1000  X = EXP(T)
1010  Y = EXP(T)/T
```

```
760 REM ------------------------------
770 REM *     PLOT A COMPUTED FUNCTION.
780 REM *          ANY FUNCTION THAT CAN BE COMPUTED BY
790 REM *          A SUBROUTINE CAN BE PLOTTED.
800 REM *
810 REM *     TO PLOT Y = F(X) REQUIRED THE FOLLOWING STATEMENT
820 REM *         1010 Y = F(X)
830 REM *
840 REM *     TO PLOT A CURVE DEFINED BY TWO PARAMETRIC
850 REM *          EQUATIONS REQUIRES THE FOLLOWING STATEMENTS
860 REM *          1000 X = F(T)
870 REM *          1010 Y = G(T).
880 REM ************************************************************
890 REM
900    DEFFN'19(V1,V2,V3)
910      T = V1
920      GOSUB 1000
930      GOSUB '11(X,Y)
940      FOR T = V1+V3 TO V2 STEP V3
950        GOSUB 1000
960        GOSUB '12(X,Y)
970      NEXT T
980      PLOT <,,U>
990    RETURN
1000      X = T
1005 REM
1010      Y = X
1015 REM
1020    RETURN
```

GOSUB' 20 (V1, V2, V3, V4)

PURPOSE:

This subroutine draws intersecting X- and Y-axes.

INPUT:

V1 = Abscissa of the intersection of the axes.
V2 = Ordinate of the intersection of the axes.

V3 = Separation of the hash marks on the X-axis.
V4 = Separation of the hash marks on the Y-axis.

OUTPUT:

The plotter draws a pair of axes intersecting at the point (V1,V2). First, hash marks are placed on the X-axis every V3 units of X starting with X-min. Then hash marks are placed on the Y-axis every V4 units of Y starting with Y-min.

> **NOTE:**
>
> *For the most esthetically pleasing results, the difference between X-min and X-max must be divisible by V3 and the difference between Y-min and Y-max must be divisible by V4.*

```
1030 REM ------------------------------
1040 REM *     DRAW THE X- AND Y- AXES THROUGH THE POINT (V1,V2)
1050 REM *        STARTING AT X-MIN, PLACE A HASH MARK EVERY
1060 REM *          V3 UNITS ON THE X-AXIS.
1070 REM *        STARTING AT Y-MIN, PLACE A HASH MARK EVERY
1080 REM *          V4 UNITS ON THE Y-AXIS.
1090 REM
1100   DEFFN'20(V1,V2,V3,V4)
1110     GOSUB '11(01,V2)
1120       V5 = 01
1130         GOSUB '12(V5,V2)
1140         PLOT <,10,D>,<,-20,D>,<,10,D>
1150       V5 = V5 + V3
1151       IF (06-3)*(06-4) <> 0 THEN 1155
1152       PACK(#.###^^^^) V$ FROM V5
1153       IF STR(V$,1,2) <> HEX(1000) THEN 1155
1154       V3 = 10*V3
1155       IF V5 <= 02 THEN 1130
1160     GOSUB '11(V1,03)
1170       V5 = 03
1180         GOSUB '12(V1,V5)
1190         PLOT <10,,D>,<-20,,D>,<10,,D>
1200       V5 = V5 + V4
1201       IF (06-2)*(06-4) <> 0 THEN 1205
1202       PACK(#.###^^^^) V$ FROM V5
1203       IF STR(V$,1,2) <> HEX(1000) THEN 1205
1204       V4 = 10*V4
1205       IF V5 <= 04 THEN 1180
1210       PLOT <,,U>
1220   RETURN
```

GOSUB' 21 (V1, V2, V3, V4, V5, V6, V7, V8, 08, 09)

PURPOSE:

This subroutine labels the axes that just have been plotted.

INPUT:

V1 = Abscissa of the intersection of the axes.
V2 = Ordinate of the intersection of the axes.
V3 = First number to be printed on the X-axis.
V4 = Last number to be printed on the X-axis.
V5 = Difference between consecutive numbers written. V4–V3 must be divisible by V5.
V6 = First number to be printed on the Y-axis.
V7 = Last number to be printed on the Y-axis.
V8 = Difference between consecutive numbers written. V7–V6 must be divisible by V8.
08 = Numbering option for the X-axis.
09 = Numbering option for the Y-axis.

OPTION	LETTER SIZE	FORMAT
1	2	-##
2	1	-#####
3	1	-##.##

OUTPUT:

The X- and Y-axes are numbered.

> **NOTE:**
>
> *If plotting on four quadrants, and the point Y=0 is labeled on the Y-axis, the number 0 is drawn over the X-axis. Also, if option #1 is used, the point X=0 is labeled on the Y-axis. In this case, it is desirable not to label the point (0,0). This can be done by running the program twice; the first execution labels the third quadrant and the second execution labels the first quadrant.*

```
1230 REM ------------------------------
1240 REM *     THIS SUBROUTINE NUMBERS THE AXES
1250 REM *          THE X-AXIS IS NUMBERED FROM V3 TO V4
1260 REM *          IN INCREMENTS OF V5.
1270 REM *          THE Y-AXIS IS NUMBERED FROM V6 TO V7
1280 REM *          IN INCREMENTS OF V8.
1290 REM *
1300 REM *     (V1,V2) IS THE INTERSECTION OF THE X- AND Y-
1310 REM *          AXES.
1320 REM *          08 IS THE NUMBERING OPTION FOR THE X-AXIS.
1330 REM *          09 IS THE NUMBERING OPTION FOR THE Y-AXIS.
1340 REM
1350   DEFFN'21(V1,V2,V3,V4,V5,V6,V7,V8,08,09)
1360     SELECT PRINT 413
1370     ON 08 GOSUB 1620, 1630, 1630 : REM CHOOSE LETTER SIZE
1380     V9 = V3
1390       GOSUB '10(V9,V2)
1400       X1 = X1 - 39
1410       X0 = X0 + 39
1420       Y1 = Y1 - 20
1430       Y0 = Y0 - 20
1440       PLOT (X1,Y1,U)
```

```
1450        O = V9
1460        ON O8 GOSUB 1650, 1660, 1670 : REM PRINT X
1470      V9 = V9 + V5
1471      IF (O6-3)*(O6-4) <> 0 THEN 1475
1472      PACK(#.###^^^^) V$ FROM V9
1473      IF STR(V$,1,2) <> HEX(1000) THEN 1475
1474      V5 = 10*V5
1475      IF V9 <= V4 THEN 1390
1480      GOSUB '11(V1,V2)
1490      ON O9 GOSUB 1620, 1630, 1630 : REM CHOOSE LETTER SIZE
1500      V9 = V6
1510        GOSUB '10(V1,V9)
1520        X1 = X1 - 80
1530        X0 = X0 -  2
1540        PLOT (X1,Y1,U)
1550        O = V9
1560        ON O9 GOSUB 1650, 1660, 1670 : REM PRINT Y
1570      V9 = V9 + V8
1571      IF (O6-2)*(O6-4) <> 0 THEN 1575
1572      PACK(#.###^^^^) V$ FROM V9
1573      IF STR(V$,1,2) <> HEX(1000) THEN 1575
1574      V8 = 10*V8
1575      IF V9 <= V7 THEN 1510
1580      SELECT PRINT 005
1590    RETURN
1600 REM ------------------------------
1610 REM -   SELECT LETTER SIZE
1620    PLOT (2,,C),(26,,S) : RETURN
1630    PLOT (1,,C),(13,,S) : RETURN
1640 REM -    PRINT THE NUMBER
1650    PRINTUSING 1680,O; : RETURN
1660    PRINTUSING 1690,O; : RETURN
1670    PRINTUSING 1700,O; : RETURN
1680 %-##
1690 %-#####
1700 %-##.##
```

GOSUB' 23 (V1, V2, V3, V$)

PURPOSE:

This subroutine prints the contents of the character string V$, starting at the location (V1,V2) and using letter size V3. The characters are printed horizontally, from left to right.

INPUT:

V1 = Abscissa of the starting letter of the character string.
V2 = Ordinate of the starting letter of the character string.
V3 = Letter size to be used in printing the character string.

To help select the proper letter size, the following table shows how many letters can be printed in a space the length of the X-axis (900 plot positions).

LETTER SIZE	CHARACTERS PER LINE
1	64
2	32
3	21
4	16
5	12
6	10
7	9
8	8
9	7
10	6
11	5
12	5
13	4
14	4
15	4

OUTPUT:

The character string V$ is printed out on the plotter.

```
1810 REM ------------------------------
1820 REM *     PRINT THE CHARACTER STRING V$
1830 REM *     STARTING AT THE LOCATION (V1,V2)
1840 REM *     USING CHARACTER SIZE V3.
1850 REM *
1860    DEFFN'23(V1,V2,V3,V$)
1870       SELECT PRINT 413
1880       GOSUB '11(V1,V2)
1890       PLOT <V3,,C>,<14*V3,,S>
1900       PRINT V$;
1910       X0 = X0 + 14*V3*LEN(V$)
1920       SELECT PRINT 005
1930    RETURN
```

GOSUB' 24 (V1, V2, V3, V$)

PURPOSE:

This subroutine prints out the character string V$ centered about the point (V1,V2) using letter size V3. GOSUB' 24 is particularly useful in printing headings for graphs with all subsequent lines centered beneath the first line.

INPUT:

V1 = Abscissa of the center of the character string.
V2 = Ordinate of the center of the character string.
V3 = Letter size to be used in printing the character string.
V$ = Character string to be printed.

OUTPUT:

The character string V$ is printed out on the Plotter.

```
1940 REM ------------------------------
1950 REM *     PRINT THE CHARACTER STRING V$
1960 REM *     CENTERED ABOUT THE POINT (V1,V2)
1970 REM *     USING CHARACTER SIZE V3.
1980 REM *
1990   DEFFN'24(V1,V2,V3,V$)
2000     X0 = X0 + 7*V3*(LEN(V$)-1)
2010     GOSUB 1870
2020     X0 = X0 - 7*V3*(LEN(V$)-1)
2030   RETURN
```

GOSUB' 25 (V1)

PURPOSE:

This subroutine prints a bar chart of the data stored in the arrays X() and Y(). For the most pleasing visual effect, the width of the bar printed out is variable and can be set to any size selected by the user.

INPUT:

V1 = Width of bar.
X() contains the abscissa for the center of each bar.
Y() contains the height of each bar.
00 = the number of items stored in X() and Y().
X(), Y(), and 00 are contained in common and must have the data stored in them before the subroutine is called.

OUTPUT:

A bar chart of the data stored in the X() and Y() arrays is drawn on the plotter.

> **NOTE:**
>
> *In order to prevent the bars at each end of the graph from "hanging over" the end of the axes, it is necessary that X-min be at least the width of one bar less than the smallest value of X, and X-max be at least the width of one bar greater than the largest value of X.*

```
2040 REM ------------------------------
2050 REM *     THIS SUBROUTINE WILL DRAW A BAR CHART
2060 REM *          WITH A BAR OF WIDTH V1
2070 REM *
2080   DEFFN'25(V1)
2090     FOR V = 1 TO 00
2100       GOSUB '11(X(V)-V1/2,03)
2110       GOSUB '12(X(V)-V1/2,Y(V))
2120       GOSUB '12(X(V)+V1/2,Y(V))
```

```
2130        GOSUB '12(X(V)+V1/2,03)
2140      NEXT V
2150      PLOT <,,U>
2160    RETURN
```

GOSUB' 26

PURPOSE:

This subroutine draws a point graph of the points stored in the arrays X() and Y().

INPUT:

The data points must have been stored in the X() and Y() arrays before calling the subroutine, and the scalar 00 must contain the number of points stored in the arrays.

OUTPUT:

A point graph of the points stored in the X() and Y() arrays is drawn on the plotter.

```
2170 REM ------------------------------
2180 REM *     DRAW A POINT GRAPH
2190    DEFFN'26
2200      FOR V = 1 TO 00
2210        GOSUB '11(X(V),Y(V))
2220        PLOT <,,D>,<,,U>
2230      NEXT V
2240    RETURN
```

GOSUB' 27

PURPOSE:

This subroutine plots the points stored in the X() and Y() arrays in a point graph. It then computes and draws the "best fit" straight line by the method of least squares on Y.

INPUT:

The data points must have been stored in the X() and Y() arrays before calling the subroutine, and the scalar 00 must contain the number of points stored in the arrays.

OUTPUT:

A point graph of the points stored in the X() and Y() arrays is drawn on the plotter. The "best fit" straight line then is drawn through these points

A = Slope of the "best fit" straight line.
B = Y-intercept of the "best fit" straight line.
S1 = Sum of X.
S2 = Sum of X squared.
S3 = Sum of Y.
S4 = Sum of X * Y.

RESTRICTION:

The best fit straight line is drawn from the minimum value of X to the maximum value of X. Therefore, it is necessary to scale Y-min and Y-max so that the line stays in range, or modify the program.

```
2250 REM ------------------------------
2260 REM *     LINEAR REGRESSION
2270 REM *          THE POINTS IN THE X() AND Y() ARRAYS
2280 REM *          ARE PLOTTED AND THE "BEST FIT" STRAIGHT
2290 REM *          LINE IS DRAWN THROUGH THEM.
2300 REM *       A = SLOPE OF BEST LINE.
2310 REM *       B = Y-INTERCEPT OF BEST LINE.
2320 REM *       S1 = SUM OF X
2330 REM *       S2 = SUM OF X SQUARED
2340 REM *       S3 = SUM OF Y
2350 REM *       S4 = SUM OF X * Y
2360 REM *       00 = NUMBER OF POINTS
2370   DEFFN'27
2380     GOSUB '26
2390     S1,S2,S3,S4 = 0
2400     FOR V = 1 TO 00
2410       S1 = S1 + X(V)
2420       S2 = S2 + X(V)*X(V)
2430       S3 = S3 + Y(V)
2440       S4 = S4 + X(V)*Y(V)
2450     NEXT V
2460     B = (S1*S4-S2*S3)/(S1*S1-00*S2)
2470     A = (S3-00*B)/S1
2480     GOSUB '11(01,A*01+B)
2490     GOSUB '12(02,A*02+B)
2500     PLOT <,,U>
2510   RETURN
```

GOSUB' 28

PURPOSE:

This subroutine plots a line graph through the points stored in the X() and Y() arrays. The graph is made by connecting the points with line segments in the order that the points are stored. By storing the points in a particular order, it is possible to graph any desired polygon or figure made up of continuous line segments.

INPUT:

The data points must have been stored in the X() and Y() arrays before calling the subroutine, and the scalar 00 must contain the number of points contained in the arrays.

OUTPUT:

A line graph connecting the given data points is drawn on the plotter.

```
2520 REM ------------------------------
2530 REM *     THIS SUBROUTINE DRAWS A LINE GRAPH
2540 REM *
```

```
2550    DEFFN'28
2560      GOSUB '11(X(1),Y(1))
2570      FOR V = 2 TO 00
2580        GOSUB '12(X(V),Y(V))
2590      NEXT V
2600      PLOT <,,U>
2610    RETURN
```

GOSUB' 29 (V1, V2)

PURPOSE:

This subroutine draws horizontal lines for the axes with evenly spaced hash marks along the bottom line. It is used effectively with the bar chart and sometimes a line graph.

INPUT:

V1 = The distance between hash marks on the X-axis.
V2 = The horizontal separation between lines.

OUTPUT:

Horizontal lines are drawn on the plotter to be used for axes.

```
2620 REM ------------------------------
2630 REM *     THIS SUBROUTINE DRAWS HORIZONTAL LINES FOR
2640 REM *     THE Y-AXIS.   THE HORIZONTAL LINES ARE SPACED
2650 REM *     IN INCREMENTS OF V2.   HASH MARKS ARE ON THE
2660 REM *     BOTTOM LINE IN INCREMENTS OF V1.
2670    DEFFN'29(V1,V2)
2680      GOSUB '11(01,03)
2690      V = 01
2700        GOSUB '12(V,03)
2710        PLOT <,10,D>,<,-20,D>,<,10,D>
2720      V = V + V1
2721      IF (06-3)*(06-4) <> 0 THEN 2725
2722      PACK(#.###^^^^) V$ FROM V
2723      IF STR(V$,1,2) <> HEX(1000) THEN 2725
2724      V1 = 10*V1
2725      IF V <= 02 THEN 2700
2730      V = 03 + V2
2740        GOSUB '11(01,V)
2750        GOSUB '12(02,V)
2760      V = V + V2
2761      IF (06-2)*(06-4) <> 0 THEN 2765
2762      PACK(#.###^^^^) V$ FROM V
2763      IF STR(V$,1,2) <> HEX(1000) THEN 1765
2764      V2 = 10*V2
2765      IF V <= 04 THEN 2740
2770      PLOT <,,U>
2780      V1 = 01
2790      V2 = 03
2800    RETURN
```

GOSUB' 30

PURPOSE:

This subroutine draws hatched axes under a line graph curve.

INPUT:

The same data points that are used to draw the line graph must be in the X() and Y() arrays and the number of points stored in the arrays must be stored in the scalar 00.

V1 = The separation between vertical lines.
V2 = the separation between horizontal lines.

OUTPUT:

Hatched axes under the curve are drawn on the plotter.

RESTRICTIONS:

GOSUB' 30 should be utilized with a line graph. The output is meaningless with other graphs.

The data points must be stored in order, according to the values in X().

X(1) should be X-min and X(00) should be X-max when scaling.

X and Y must be linear scales.

```
2810 REM ------------------------------
2820 REM *     THIS SUBROUTINE DRAWS HATCHED AXES UNDER
2830 REM *          A LINE GRAPH.
2840 REM *          V1 = INCREMENT ON X.
2850 REM *          V2 = INCREMENT ON Y.
2860 REM *
2870   DEFFN'30
2880     FOR V = 01 TO 02 STEP V1
2890       IF V < X(1) THEN 2940
2900       IF V > X(00) THEN 2940
2910       GOSUB 3210
2920       GOSUB '11(V,03)
2930       GOSUB '12(V,V0)
2940     NEXT V
2950     FOR V = 03 TO 04 STEP V2
2960       GOSUB '11(01,V)
2970       FOR V5 = 1 TO 00-1
2980         IF V < Y(V5) THEN 3070
2990         IF V < Y(V5+1) THEN 3030
3000 REM *     AXIS IS ABOVE BOTH END POINTS
3010           GOTO 3140
3020 REM *     AXIS IS ABOVE FIRST POINT
3030         GOSUB 3280
3040         GOSUB '11(V0,V)
3050         GOSUB '12(X(V5+1),V)
3060         GOTO 3140
3070         IF V < Y(V5+1) THEN 3130
3080 REM *     AXIS IS ABOVE SECOND POINT
3090         GOSUB 3280
3100           GOSUB '12(V0,V)
3110           GOTO 3140
3120 REM *     AXIS IS BELOW BOTH POINTS
```

```
3130          GOSUB '12(X(V5+1),V)
3140        NEXT V5
3150      NEXT V
3160      PLOT <,,U>
3170      V1 = 01
3180      V2 = 03
3190    RETURN
3200 REM -     INTERPOLATE ON X
3210      FOR V8 = 2 TO 00
3220        V5 = V8
3230        IF X(V5) >= V THEN 3250
3240      NEXT V8
3250      V0 = Y(V5-1)+(Y(V5)-Y(V5-1))/(X(V5)-X(V5-1))*(V-X(V5-1)
)
3260    RETURN
3270 REM -     INTERPOLATE ON X
3280    V0 = X(V5)+(X(V5+1)-X(V5))/(Y(V5+1)-Y(V5))*(V-Y(V5))
3290    RETURN
```

Section IV
Appendices

APPENDIX A
Specifications

APPENDIX B
Cleaning and Maintenance

SECTION IV, APPENDIX A – Specifications

Paper Capacity
11 x 16.5 in. (27.9 x 41.9 cm)
Plotting Area
10 x 15 in. (25.4 x 38.1 cm)
Plot Accuracy
±0.2% of full scale
0.01 in. (0.025 cm) from one point to the next
Linearity
±0.1% of full scale
Resetability
0.1% of full scale
Acceleration (Peak)
1500 in./sec^2 (38.1 m/sec^2)
Plotting Time
6 in./sec (average) - dependent on the System 2200 program being executed.
Size

Height	6½ in. (16.5 cm)
Width	19 in. (48.3 cm)
Depth	17¼ in. (43.8 cm)

Weight
35 lb (15.9 kg)
Power Requirements
115 or 230 VAC ± 10%
50 or 60 Hz ± ½cycle
Connecting Cables
8 ft (2.43 m) cable with 24 pin connector to System output jack.
Output Jack
24 pin output jack.
Operating Environment

Temperature	50° F - 90° F (10° C - 32° C)
Humidity	40% to 60% Relative Humidity

SECTION IV, APPENDIX B – Cleaning and Maintenance

The WANG Analog Flatbed Plotter is a precision device and should be kept free from dust and covered when not in use.

Turn the System 2200 power OFF and remove the Model 2212 power cord from the wall outlet before executing any of the following procedures.

CLEANING AUTOGRIP TABLE

The following method is recommended for cleaning Autogrip table. Dust and other accumulation of foreign film on the table surface will lower the paper holding force. The film may be removed and the table holding ability restored by using the cleaning procedure. If strong chemicals, abrasives, or too much water are used, the table may be permanently damaged.

1. Remove pen and paper from Plotter.
2. Select a mild liquid soap. Do not use products with abrasive or corrosive chemicals.
3. Use a soft cloth that will not scratch the surface but will absorb water.
4. Saturate the cloth in warm, soapy water. Wring cloth until most of the water has been removed.
5. Wipe Autogrip table surface with damp cloth until clean.

> **CAUTION**
>
> Never let water stand on Autogrip surface. It may permanently damage the table.

6. Wipe moisture from surface.
7. Allow to dry a few minutes before using.

> **CAUTION**
>
> Do not use solvents or silicone-based cleaners of any type on the Autogrip platen.

POTENTIOMETER CLEANING

Irregular or jittery recordings on a properly adjusted Plotter may indicate worn or dirty potentiometers or wipers.

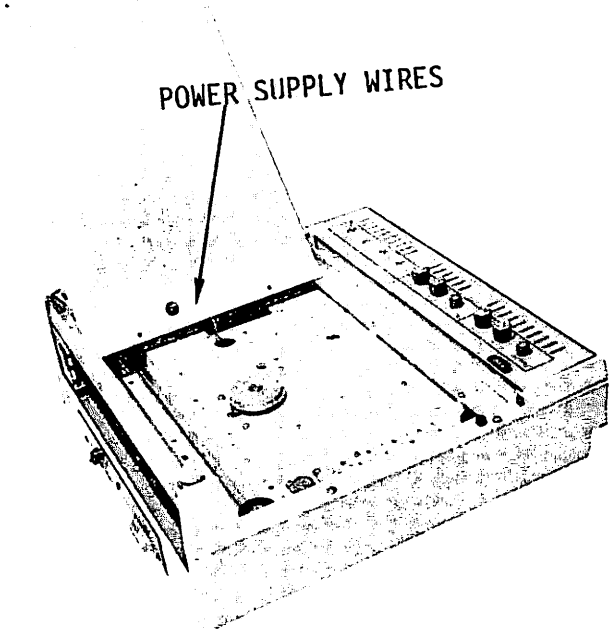
Access to X-Axis Potentiometer And Wiper

1. Slide pen carrier to extreme right.
2. Remove the rear hood by removing the two screws on the rear of the cover. The rear hood is shown in Figure B-1. It is the cover with the Y scale printed on it.
3. Life pen holder. Raise pen scale. Slidewire and wiper are now accessible. See Figures B-1, B-2 and B-5.
4. Refer to Section on CLEANING AND LUBRICATION OF POTENTIOMETERS for cleaning procedures.

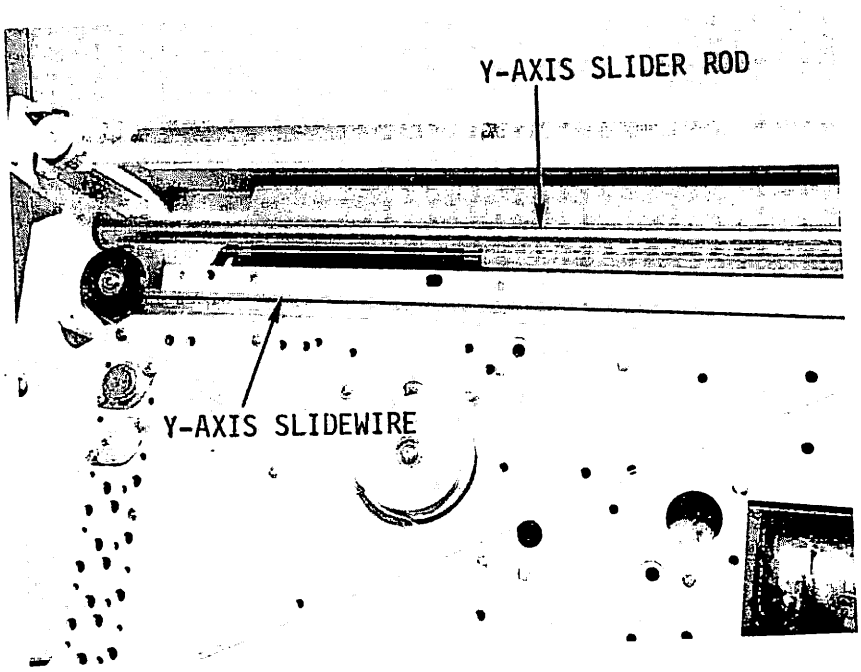
> **CAUTION**
>
> DO NOT APPLY POWER to the Plotter with pen and scale raised. Damage to the scale may occur.

Access to Y-Axis Potentiometer

1. Remove the four screws on top of the AUTOGRIP table (platen).
2. Slide pen carrier to extreme right.



Fiugre B-1. Hood Removed and Scale Swing Away



Fiugre B-2. Potentiometer Slidewire Now Accessible

3. Ease platen up and slightly to the left. Disconnect power supply wires beneath the platen before easing the platen all the way out. See Figure B-3. The wiper and slidewire are now accessible. See Figures B-4 and B-5.
4. Follow directions in the next section for cleaning and lubrication.

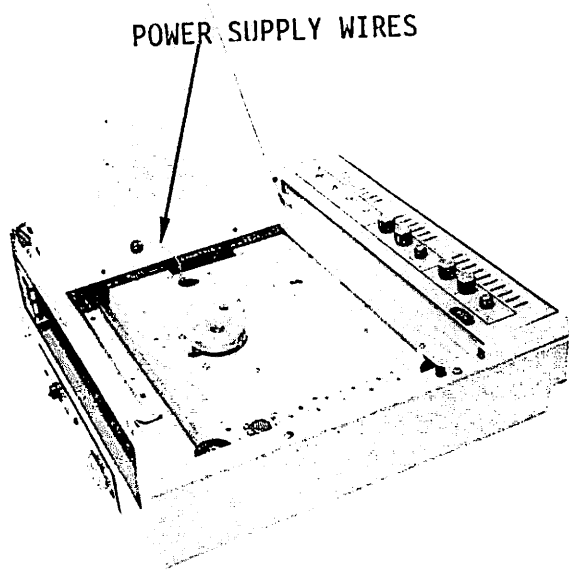


Figure B-3. Platen Removed

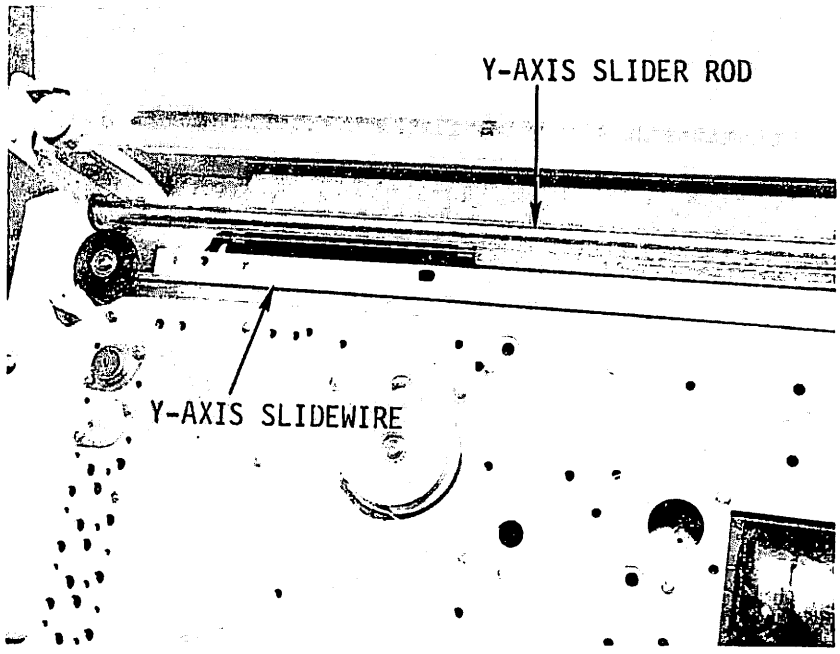
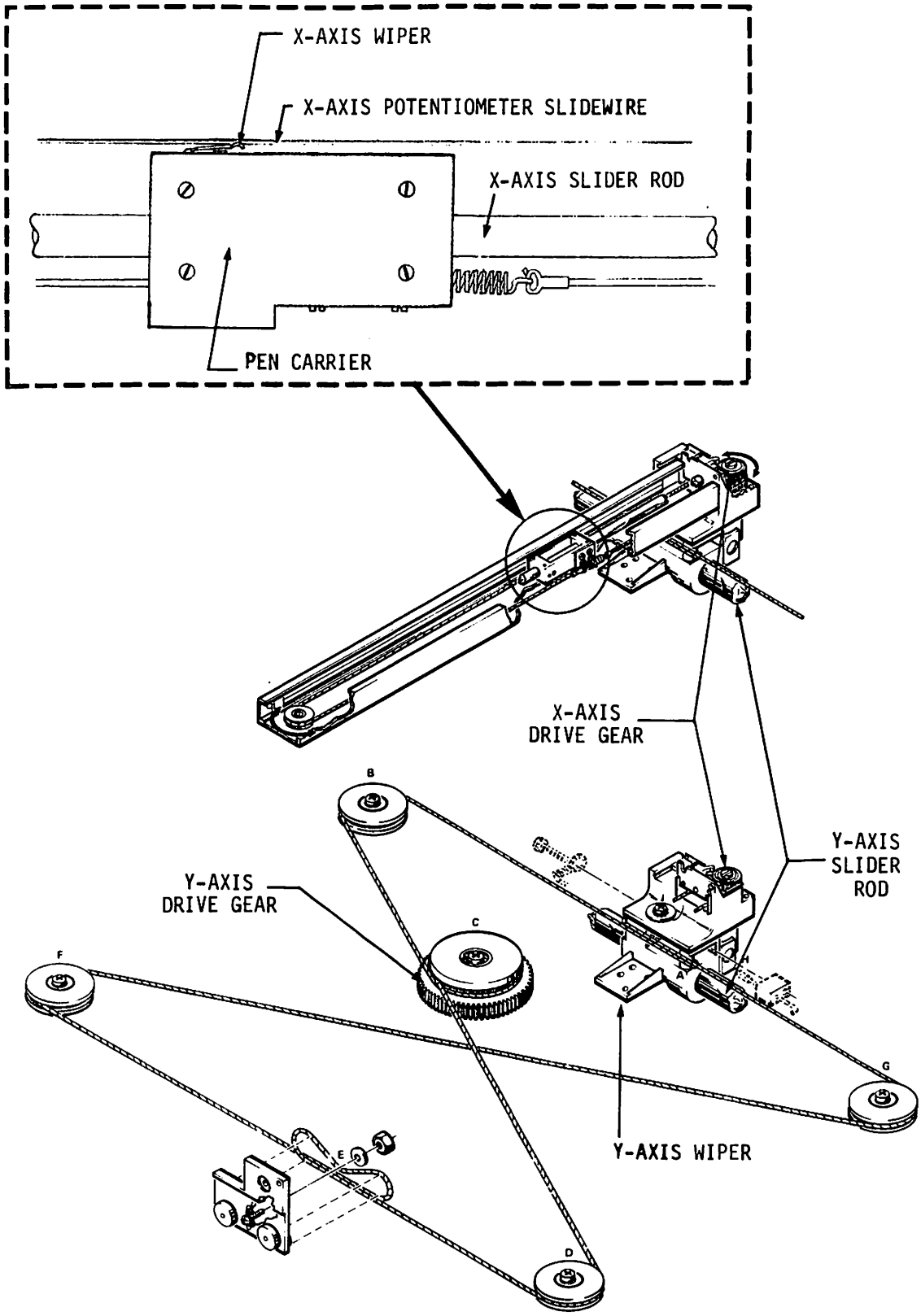


Figure B-4. Slidewire Accessible



Fiugre B-5. X- and Y- Axis Drive Mechanisms

Cleaning And Lubrication Of Potentiometers

1. Spray the entire X potentiometer and wiper with Slidewire Cleaner. Rapidly move the pen carriage through several excursions and spray again.

> **CAUTION**
>
> Avoid spraying nearby components of the Plotter with the cleaning fluid. The cleaner is designed for removing lubricants. Other components may be damaged if their lubricants are removed by accident.

2. Thoroughly saturate a Kimwipe or cotton swab with cleaner. Rub potentiometer along entire length with tissue or swab.

> **NOTE:**
>
> *If there is discoloration of tissue or swab, repeat until there is no stain. Then clean once more to ensure all contaminants are removed.*

3. After cleaning, lubricate with Slidewire Lubricant, to reduce wear and chemical contamination.
4. Repeat steps 1 through 3 above for the Y potentiometer.
5. Do not re-assemble if gears are to be lubricated (see next section).

LUBRICATION OF RODS AND DRIVE GEARS

The Plotter is a precision instrument. Gears and other moving parts have very close tolerances. Intervals between periodic lubrication are determined by the type of operation, local air contamination, and climatic conditions. All ball bearings are pre-lubricated and require no grease.

1. Clean and lubricate drive gears (Figure B-5) and the wire shield under Y-axis slider rod (Figure B-6) with light grade silicon grease. GE Silicon Verselube #G322-L is the suggested lubricant. It also may be obtained from Hewlett Packard (HP Number 6040-0297).
2. Clean and lubricate Y-axis slider rod with instrument oil. Anderol 795 (by Teneco, Inc.) is suggested. This is also carried by Hewlett Packard (HP #6040-0220). See Figures B-5 and B-6.
3. Clean X-axis slider rod with dry Kimwipe; do not lubricate (see Figure B-5).

> **CAUTION**
>
> Do not lubricate X-axis slider rod.

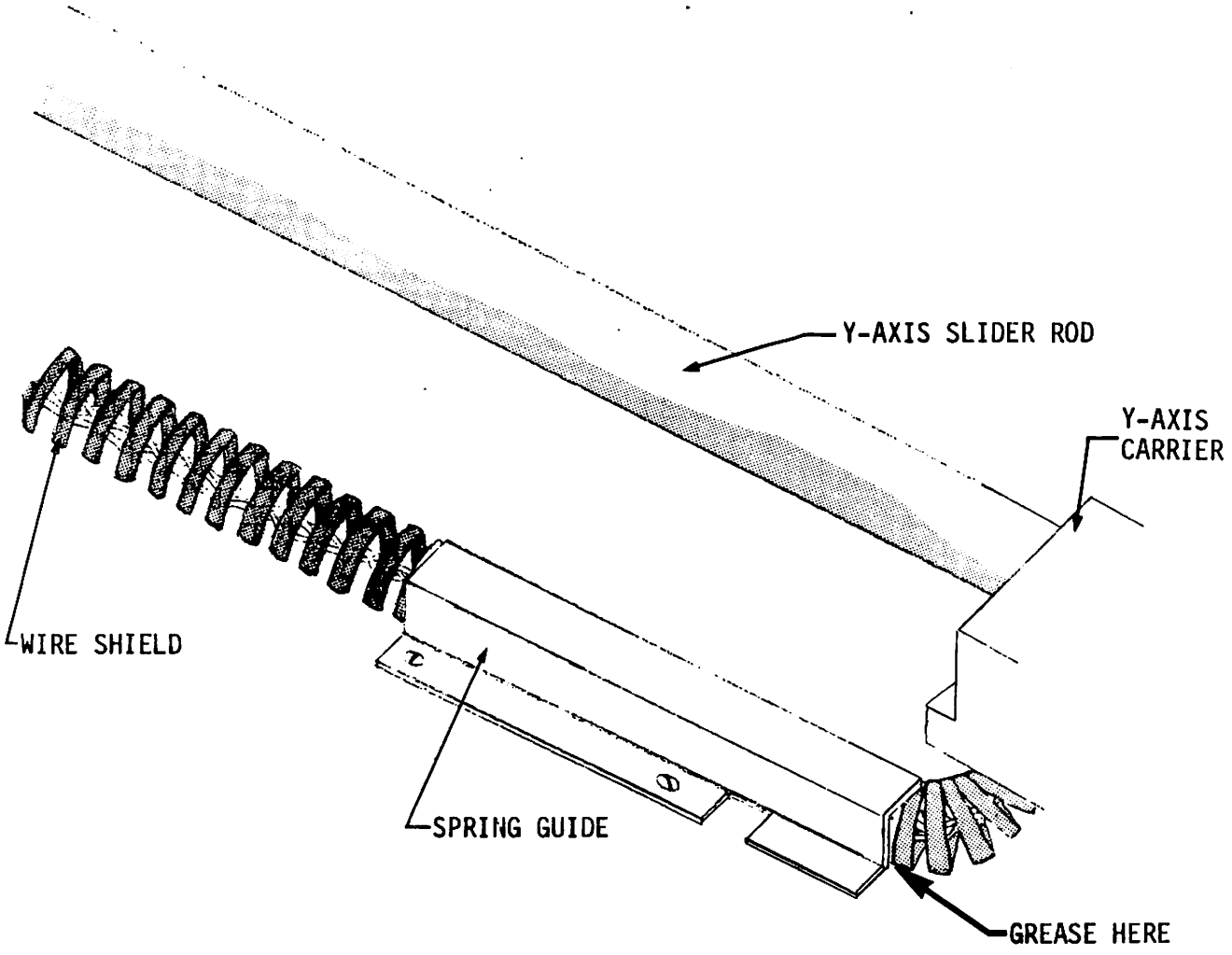


Figure B-6. Y-Axis Slider Rod and Spring Guide

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