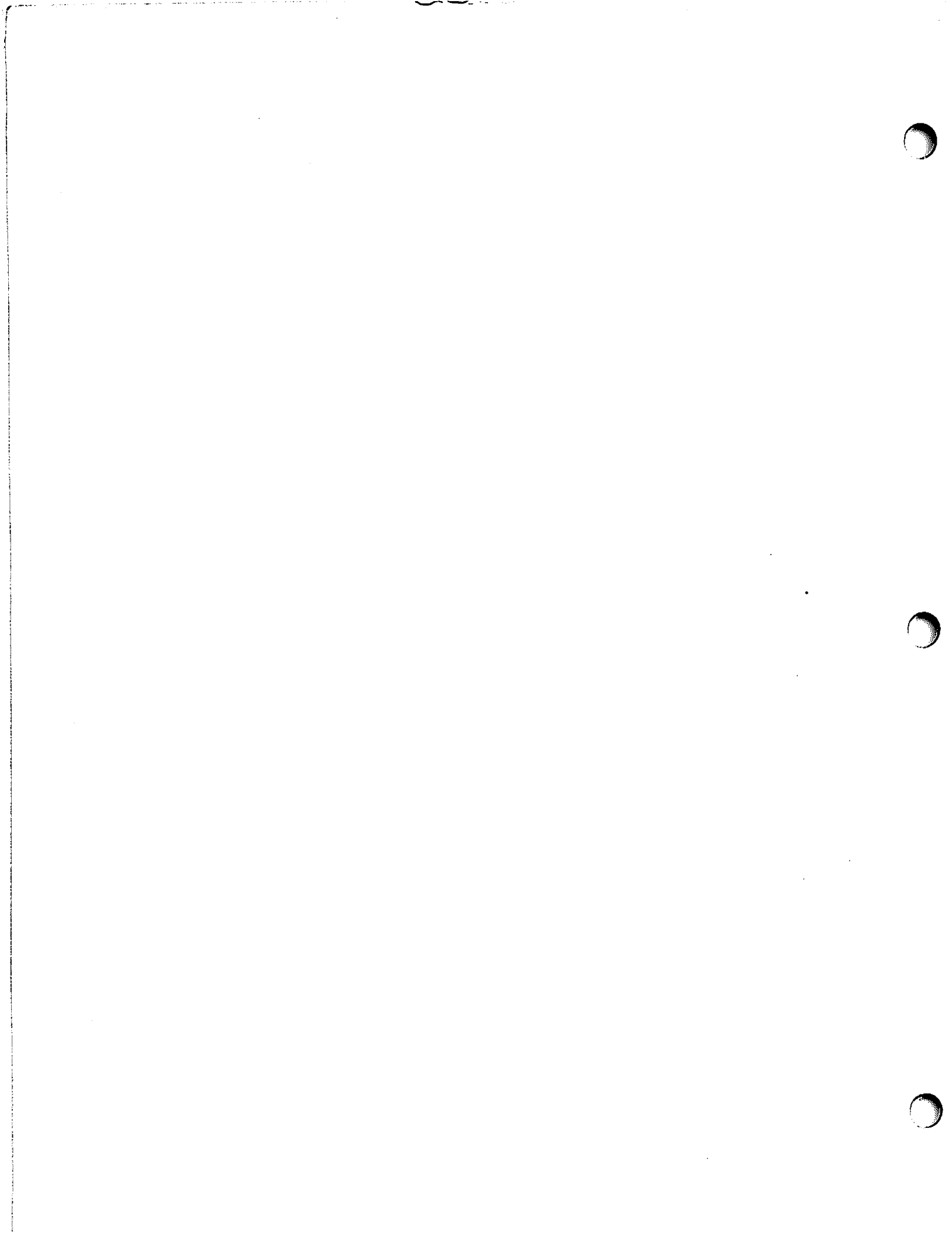


WANG

Graph Utility System (GUS) Manual (Release 4)





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LABORATORIES, INC.

ONE INDUSTRIAL AVENUE, LOWELL, MASSACHUSETTS 01851, TEL. (617) 459-5000, TWX 710 343-6789, TELEX 94-7421

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HOW TO USE THIS MANUAL

The Graph Utility System Manual provides operating instructions and program descriptions of each of the Graph Utility modules. The Graph Utility System is designed to operate on a 2200T, 2200VP, or single user MVP with a minimum 16K RAM (Random Access Memory), a dual diskette drive, and with a plotter (Models 2202, 2212, 2232, 2272, 2281P, 2282 or a Tektronix graphic display terminal). A minidiskette version of the Graph Utility System is also available for the PCS-II. The manual does not discuss the operation of individual plotters; general information concerning plotter operation and control can be found in the appropriate plotter user manual. It is recommended that the programmer become familiar with the operation of his plotter before attempting to use the Graph Utility System.

The Graph Utility System is designed to take advantage of the new features of the plotter subroutines described in the 2200 Plotter Utilities Manual (700-3838). Some of these features are:

- Virtual hardware independence
- More precise pen positioning
- Automatic clipping
- Character rotation and slant
- Customization of alphanumeric characters

NOTE:

This manual describes Graph Utility System, Release 4.

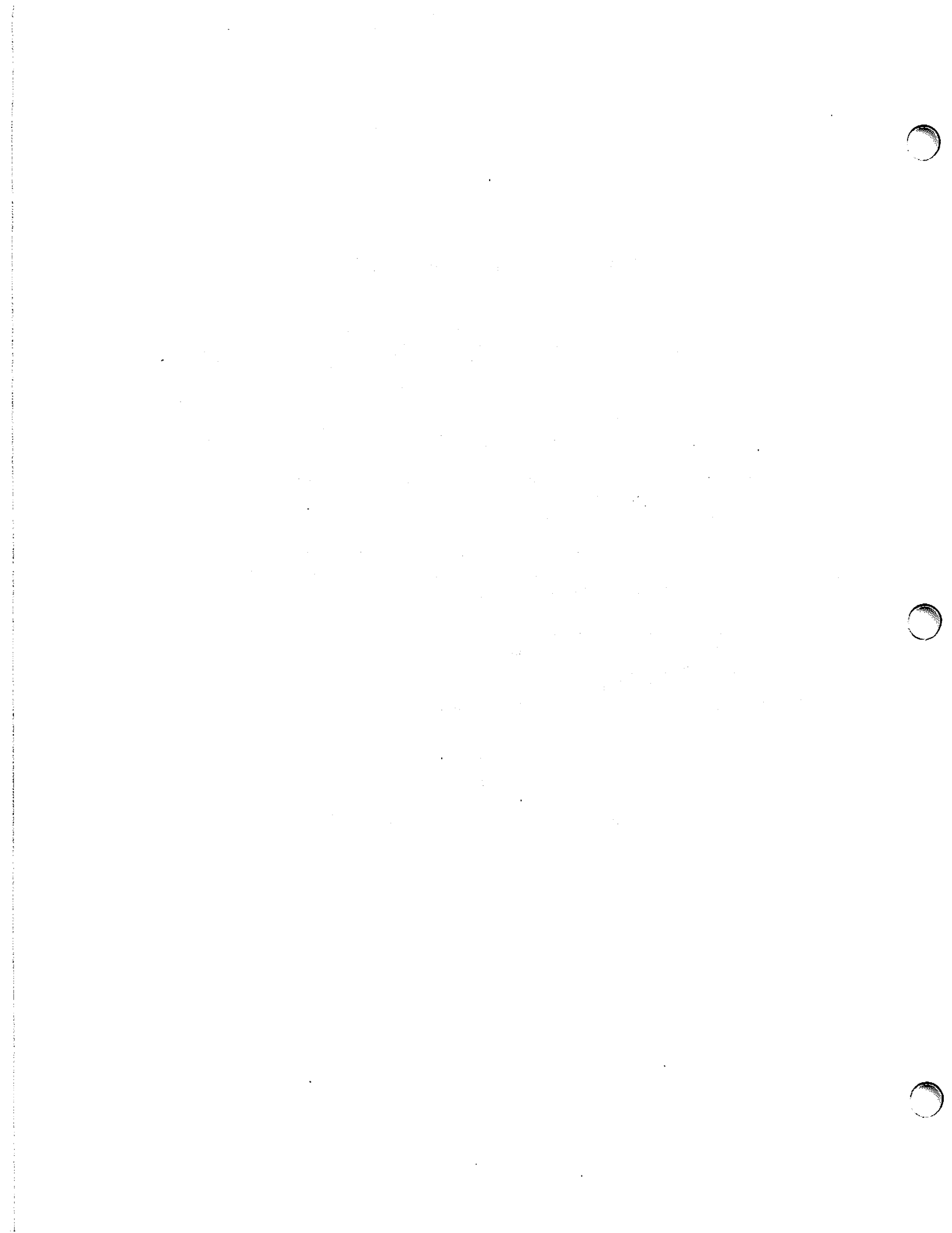
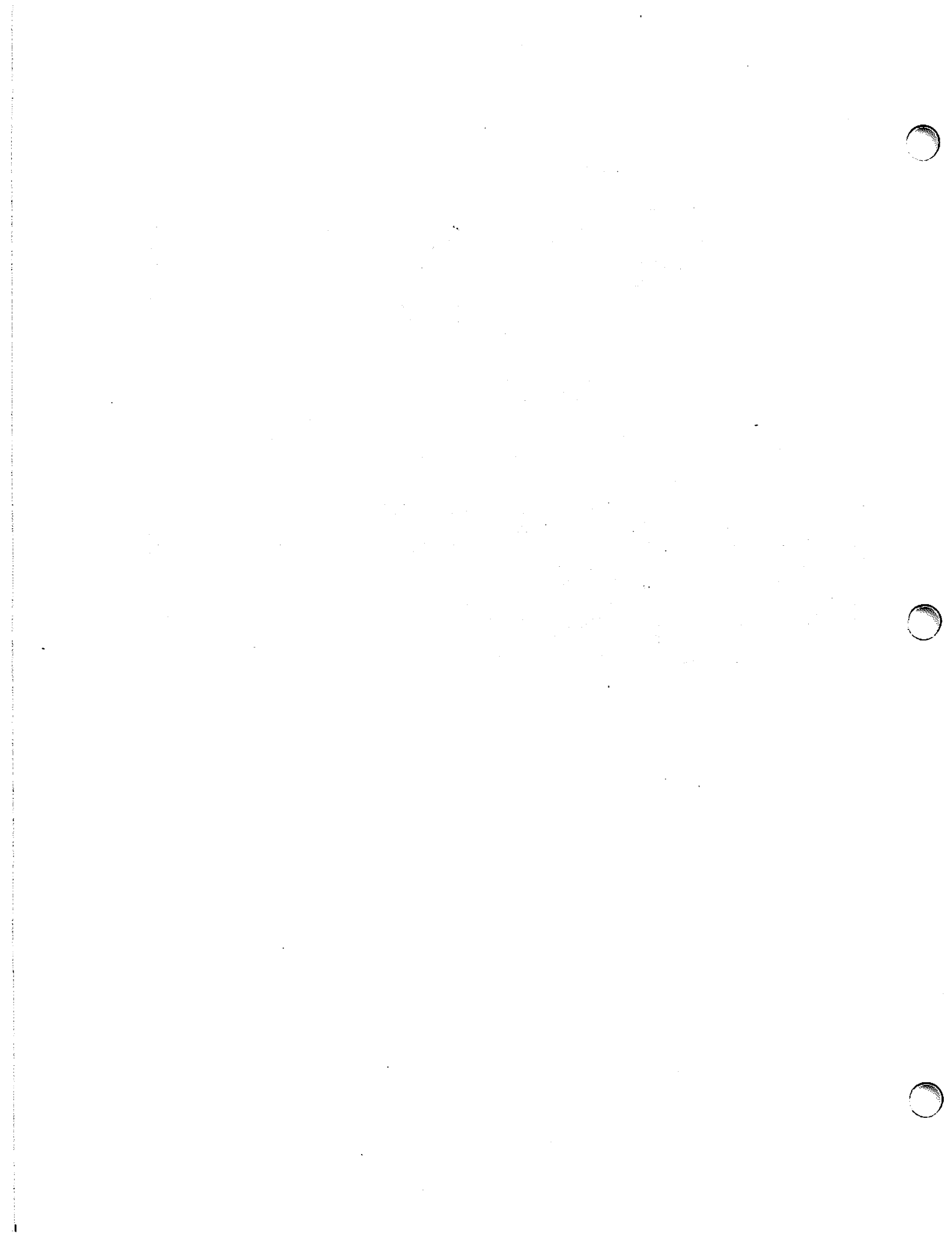


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CHAPTER 1

GENERAL INFORMATION

1.1 SYSTEM OVERVIEW

The Graph Utility System (GUS) is available on a single diskette and also on two minidiskettes. GUS is designed to enable the user to draw and label two- and three-dimensional graphs of several types, variable size, and from different data sources on any plotter currently supported by Wang. In the system, the user is asked to supply the information necessary for initiating a plot. Information defining plotter type, plotting parameters, data sources, and label configurations is entered directly into the system by the user. As items of information are collected, the information is saved in a disk file where it can be called upon at plotting time. When the appropriate parameter, data, and label files have been created, plotting may proceed. On any given execution of plotting, any combination of plotting axis, data set or computed function, and labels may be selected. When plotting is completed the system allows further selections to be made from the files created. For instance, in two-dimensional plotting, additional data may be plotted using a different "data point" symbol without the need to replot the axes and labeling. Alternately, a new graph utilizing the same data and labels may be drawn to a different scale or using a different graph type without reentry of unchanged filename information.

GUS provides the user with both two- and three-dimensional plotting capabilities. In two-dimensional plotting, it is possible to plot line graphs, point graphs, and bar graphs, using a set of data points or a mathematical expression (computed functions) to represent the graph. Data expressed in rectangular coordinates can be plotted on linear, logarithmic and semi-log axes. Alternately, data expressed in polar coordinate format can be plotted on a linear, rectangular axis system. In addition to sketches and drawings, character labeling can be generated from a character set contained in GUS or supplied by the user. Label characters can be sized, rotated, and slanted to enhance the plotted information.

In three-dimensional plotting, the user must supply a mathematical expression (computed functions) of the three-dimensional surface or object to be plotted. GUS produces a two-dimensional representation of the 3-D surface or object as a "stretchable net" on the plotter surface (see Figure 4-4). (This view is called a "projection" and is produced by a point by point "transformation" from the three-dimensional system into a two-dimensional system.) The original object exists in a three-dimensional coordinate system

called the "object" coordinate system represented by X, Y, Z. The image is transformed or projected onto the plotter paper (or CRT) and lies in a two-dimensional Cartesian coordinate system called the "image" coordinate system represented by X', Y'.

GUS consists of five modules; each module uses a table "fill-in" technique to enter data into the system. In the modules, the user simply selects an item number from the table and responds to the prompts requesting any information required by the selected item. If items are incorrectly entered, error prompts are displayed with a line of corrective information. Table items are filled in step by step, where each step prompts the operator to the options and choices available. The system will not proceed from a module unless all items are answered or defaulted, or unless the operation is canceled.

NOTE:

In the minidiskette version of GUS, not all five modules can be accessed from a particular minidiskette. When a module is not resident on the mounted minidiskette a prompt will request the user to mount the requisite minidiskette which contains the required module. See Appendix H.

Saving Information on Disk

The five modules of the Graph Utility System are - Initialize System, Enter Parameters, Data Points, Enter Labels and Start Plot. With the exception of the Start Plot module, collected information is saved in a disk file.

In the Initialize System Module entered information is saved on disk with a filename specified by the system. The information in this module describes the available hardware and is entered the very first time the system is run. Thereafter, it is changed only when necessary.

In contrast, the Enter Parameters, Data Points, and Enter Labels modules are constantly used for creating and modifying files of plotting information. These modules allow information to be read and stored in disk files with user created filenames. In these modules, after all item entries have been answered, the user assigns a unique filename to the information and the system stores it on his data disk. Several files each with different specifications can be created and saved on disk as the user's plotting requirements expand. In addition, each file can be recalled for examination or modification by the module that created it. Modified files may be assigned new filenames or retain old filenames before they are saved on disk. Optionally, after files are saved, the system permits the information to be output directly to a printer. This feature permits the user to retain hardcopies of all created files.

No information entered into the Start Plot module is saved on disk. The function of the Start Plot module is to coordinate the files input from the other modules, insert final adjustments to the plot, and initiate the plotting activity.

System Control

GUS has many built-in features that simplify the information entry procedure and wherever possible, validate input. For instance, errors detected while entering values can be corrected by simply reselecting the item number in question. If the user wishes to return to a previous step in the normal sequence of operations he simply depresses the Special Function Key '15. An important tool for directing module control and assisting the user in selecting menu options is the use of function letters. A function letter is simply a letter code entry from the keyboard that directs the system to perform or initiate a task. In all the modules, the function letter C is used to make changes in consecutive item entries. Function letters S, R, and A are used to initiate save file procedures in modules which create and store data files on disk. Depending on the letter selected, the S, R, and A functions direct system control between modules and the system menu (see Figure 2-1). Function letters N and P are used to direct system control within modules which have more than one screen display of information. In general, however, each module has function letters peculiar to its own operation. Letter functions are discussed in greater detail in Chapter 2.

1.2 SUMMARIES OF GUS MODULES

The Graph Utility System menu presents five modules that are activated via special function key:

SF KEY

00 - ENTER PARAMETER
01 - ENTER DATA POINTS
02 - ENTER LABELS

SF KEY

03 - START PLOT
04 - INITIALIZE SYSTEM
15 - CHANGE APPLICATIONS

00 - ENTER PARAMETERS

Enter Parameters is perhaps the most frequently used module in the system since it is here that the user provides most of the plotting information for two and three-dimensional applications. For two-dimensional plotting, this module solicits information defining the size of the plot area, graph type (e.g., line, point, or bar), scale type (e.g., linear, full log, semi-log, or polar), and the extreme values of the X and Y axes. In addition, options are provided for the generation of axis hash marks, axis numbering, and full-width grids. For three-dimensional plotting, information defining the type of coordinate system, direction of view, hidden points, and line options for scaling and plotting must be specified.

In this module, the user also identifies the type of data source used for a particular plot. For two-dimensional plotting, the available data sources are - standard data file, non-standard data file, and a computed function. A standard data file is one created by the entry procedures of the Data Points module. A non-standard data file is a unique user-created file of data points for which the user must supply a routine for reading the data into the system. The computed function is a program file which computes values of a function to be plotted. In three-dimensional plotting the data source must be a computed function.

The files created by this module are called parameter files. The individual items of information required by the Enter Parameter module are discussed in Chapter 4.

01 - ENTER DATA POINTS

The Data Points module is used only in two-dimensional plotting of data points. This module creates a file of data points known as a standard data file. In this module, the user enters a complete set of the X and Y coordinates of the data points to be plotted. Data points are entered as numeric pairs of values corresponding to X and Y coordinates (or r and θ if polar coordinates). Values at each data point can be specified in either decimal or exponential format with up to five significant digits. During data entry, if the data points are uniformly spaced along the X-axis, the user may elect to have the X-values automatically computed and entered. The entry and correction of data points is expedited by the use of specific function letters. With these function letters a data point or a series of data points may be changed, deleted, or inserted within or added to the end of an existing file.

The pertinent features of the Enter Data Points module are discussed in Chapter 5.

02 - ENTER LABELS

Activation of this module allows the user to create labels for plotting. Labels are the character strings that are plotted for all titles and special character information on the graph with the exception of axis numbering. (In two-dimensional plotting, axis numbering (an optional feature) is done automatically according to the axis parameters entered in ENTER PARAMETERS). The Enter Labels module asks the user for information concerning label text, character size and slant, text rotation, and the coordinate position of the label. Several labels can be created in one label file. Labels can be created from a standard character set provided with GUS and from hardware characters (Plotter models 2212, 2272 and 2282 only). On any plotter, the user can specify the standard character set provided with GUS or use his own character array to incorporate any special symbols or other alphabets as desired. (Note: GUS requires that some character set be provided even though no labeling is anticipated.) This module also has function letters for retrieving and deleting labels and for plotting the label currently on display.

The Enter Labels module is discussed in Chapter 6.

04 - INITIALIZE SYSTEM

This module is automatically activated the first time the system is run. It solicits information that is not likely to change during the long term operation of the system. These entries include the plotter type, plotting units, and the CRT width which is needed to position the menus in the center of the CRT. The information entered in this module is saved in a data file named GUS.INFO which resides on the system disk. Once the information is saved, the module must be called upon from the system menu (via the SF Key 04) when a change in plotter or CRT type is necessary. The Initialize System module is discussed in Chapter 3.

03 - START PLOT

This module requests the file names of the parameter, data points (or computed function program), and label files stored on the disk which are to be used for plotting. The information in these files is read and the system is ready to initiate the plot. In every case however, a parameter file must be specified to set up the plotting area on the plotter. In this module the user has the option of retrieving from disk only those additional files currently needed for plotting. For example, by only calling out a parameter file and specifying the "draw axis" option he will only plot a set of axes. Likewise by specifying the appropriate parameter and label files and suppressing the "draw axis" and "draw graph" options he can just plot labels as desired.

Before plotting begins the user can also select options to enhance the appearance of his plot. In two-dimensional plotting the user can specify the type and the size of symbol to be plotted at each data point. When plotting a line graph the user can specify that the line segments be represented by either dots, dashes, or dot/dash combinations. In addition, it is possible to have a linear regression line plotted with line, point, or bar type graphs.

In three-dimensional plotting, options are available for specifying the axis location with respect to the plotted surface, and for suppressing lettering on the axis.

Plotting is initiated via function letter G at which time the plotter is readied and the plotting begins. After the plotting has been executed, the program returns to the beginning of the Start Plot module to allow further selections to be made from the files stored on disk.

The features of the Start Plot module are discussed in Chapter 7.

15 - CHANGE APPLICATIONS

The purpose of this routine is to load the START module from the system disk. It can be used to start another application or to alter the disk addresses initially selected. In particular, it may be used to switch from the disk address for the standard character array to a user-defined character array and vice versa.

1.3 MEMORY REQUIREMENTS AND MINIMUM SYSTEM CONFIGURATION

The Graph Utilities System requires the following minimum system configuration:

CPU - 2200T, 2200VP, 2200MVP, or PCS-II

Memory - 16K

Peripherals - Two disks or diskette units, printer (optional), and any Wang plotter. (With the addition of a special interface, a Tektronix graphic display terminal also is supported.)

The printer (optional) is used to produce a hardcopy of the files created by GUS.

CHAPTER 2 SYSTEM OPERATION AND MENU STANDARD

2.1 LOADING THE "START" MODULE

The Graph Utilities System is accessed through the START module. After the diskette is placed into the disk drive, the system is activated by the following commands:

```
: CLEAR (EXECUTE)
: LOAD DCF "START" (assuming device address 310)
: RUN (EXECUTE)
```

When the START module is run, the system asks for the device addresses (e.g., 310, 320, etc.) used for:

1. The GUS disk containing the program modules. The GUS disk may include any user written program to read a non-standard data file.
2. The data disk containing the data files and program files. The data files include parameter files, data point files, and label files. The program files define computed function routines.
3. The disk containing the character arrays used to generate software characters for labeling. A standard character array is supplied on the system disk. If the user specifies this array, its address is the same as the GUS disk. The user may specify his own character array on the data disk or another disk. In any case, the program requires that some character array be provided even though no labeling is anticipated.

After the device addresses are specified and the disks are mounted, the system menu is displayed. If the system is being run for the very first time, the Initialize System module is activated. This module asks the operator to enter a choice of "PLOTTER TYPE", as it displays a menu of four items which are not likely to change during the lifetime of the system (see below). After a choice is made for "PLOTTER TYPE", the system sequences through the remaining items until all items are answered.

When the Initialize System is called from the system menu, the module asks the operator to "ENTER AN ITEM NUMBER OR A FUNCTION LETTER." By specifying a number from 1 to 4, the item corresponding to that number can be entered or changed. As an example, to enter or modify the first menu item (PLOTTER TYPE), the operator must enter the number 1. At the bottom of the screen, the system displays a table containing the seven valid plotter types. An appropriate question is displayed at the top of the screen with the cursor positioned on the second line awaiting operator input. When the operator selects one of the choices for plotter type the menu is redisplayed with the updated PLOTTER TYPE in item 1. In all the modules, any item displayed can be changed in this manner.

1. PLOTTER TYPE

?_

INITIALIZE SYSTEM

- 1...PLOTTER TYPE =
- 2...MEASURING UNIT =
- 3...RATIO OF UNITS = 0
- 4...CRT LINE LENGTH =64

- - - - -

PLOTTER TYPES

- 1. 2202 3. 2232 5. 2282 7. 2281P
- 2. 2212 4. 2272 6. TEKTRONIX

In each module, either the general direction is to answer the prompt "ENTER AN ITEM NUMBER OR FUNCTION LETTER" or to respond to a specific piece of information requested at the top of the screen. In all cases, the entered information is displayed on the second line of the screen. Whenever appropriate, information regarding the available choices for each item is displayed at the bottom of the screen.

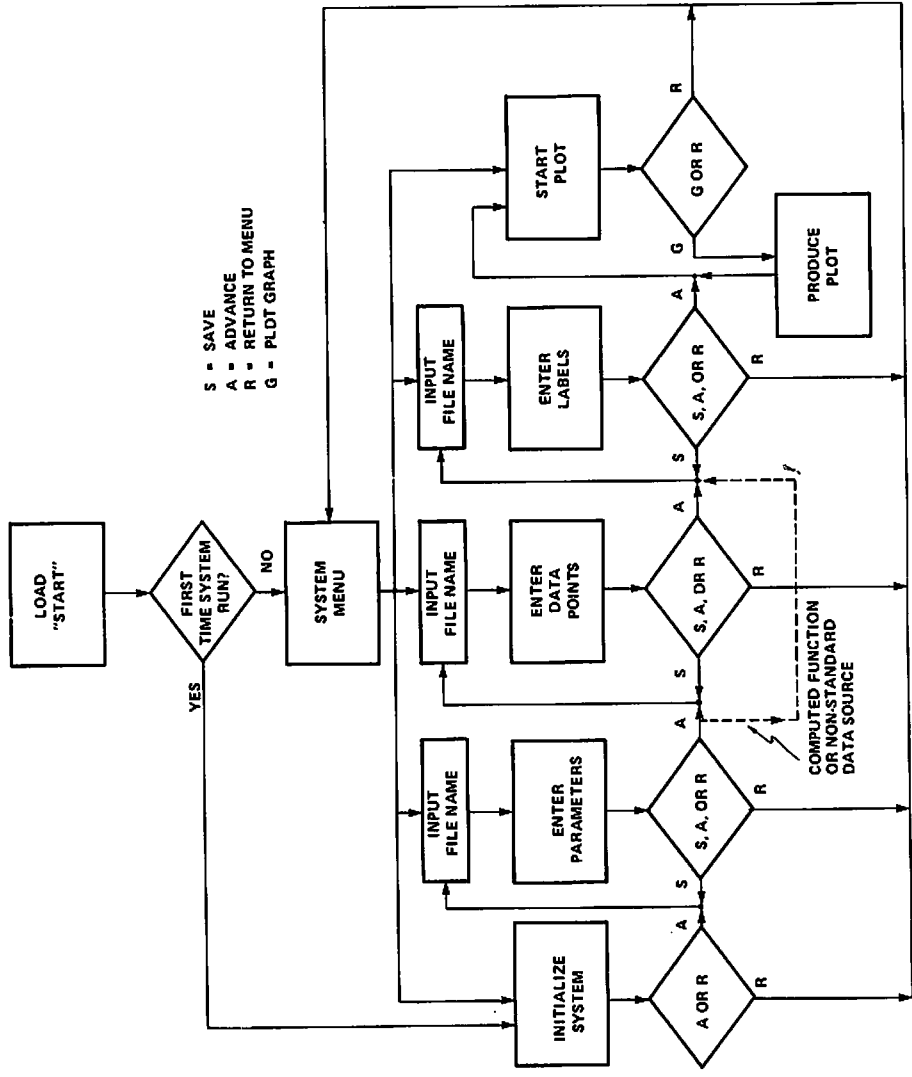


Figure 2-1. GUS Control Diagram

2.2 FUNCTION LETTERS

In each module, a table of numbered items or variables to be entered or modified is displayed on the screen. In addition to entering an item number, the operator can enter a function letter. The bottom portion of the screen displays the appropriate function letters and their functions whenever the prompt "ENTER AN ITEM NUMBER OR A FUNCTION LETTER" is displayed. If the function letter "C" is entered, the module allows the operator to change all items by sequencing automatically through all items in the menu. If the "C" is followed by a number, the system starts its automatic sequencing beginning with the item number specified. For instance, a "C2" sequences through all the items on display starting with item 2, omitting item 1.

SAVING DATA

At the completion of entering values in a module, the entered information may be saved by keying either S, A, or R (See Figure 2-1). Each of these letters initiates information storage. The difference between S, A, and R is that each permits the user to work through the system in a different way after the information is stored. "S" stands for "Save Data", it saves data and brings the user to the beginning of the current data module. Files pertaining to that module may be created or retrieved and modified. "R" stands for "Return to System Menu", it saves data and returns the user to the system menu. The user can select the next operation without regard to the system sequence of modules. "A" stands for "Advance to the Next Module", it saves data and advances the user directly to the next module. The sequence of module advancement for plotting from a standard data file is listed below.

<u>FROM</u>	<u>TO</u>
Initialize System	Enter Parameters
Enter Parameters	Enter Data Points
Enter Data Points	Enter Labels
Enter Labels	Start Plot

If a computed function or non-standard data file is selected in Enter Parameters, control goes from the Enter Parameters directly to Enter Labels when function letter A is used. (See Appendix H for minidiskette operation.)

MULTI-PAGE MODULES

The Initialize System is the only module in which all the required information can be displayed in one screen load or "page". The other modules have more than one page of items to be answered. The Enter Parameters module consists of three pages. There are two pages of prompts to be answered in the Start Plot module. In the Enter Data Points module each set of five data point coordinates constitute one page. The Labels module assigns one page to each label. In each of the modules, to move from one page to another, the function letter "N" or "P" must be used. "N" displays the Next Page. "P" brings in the Previous Page of values. Figure 2-2 illustrates the use of function letters "N" and "P" for the Enter Parameters module.

SPECIAL FUNCTION LETTERS

In the Labels module the letter code "FX" can be entered to retrieve the label #X and display it on the screen. The letter "L" is used to plot the label currently on the screen. To delete the label on display, the letter "D" is entered. To enter a new label, the letter "E" must be entered.

In the Enter Data Points module, new data points may be inserted between existing points via the function letter "IX", where X is the number greater than the last point to be left unchanged and will be the number of the first of the points to be inserted. Alternately points may be added to the end by entering "CX", where X is a number one greater than the current number of data points.

In the Enter Parameters module, function letters L and V facilitate the automatic scaling of a computed function.

The Start Plot module uses the function letter "G" to start the plotting procedure.

Further details on particular function letters are discussed in the sections on Letter Options in the following chapters.

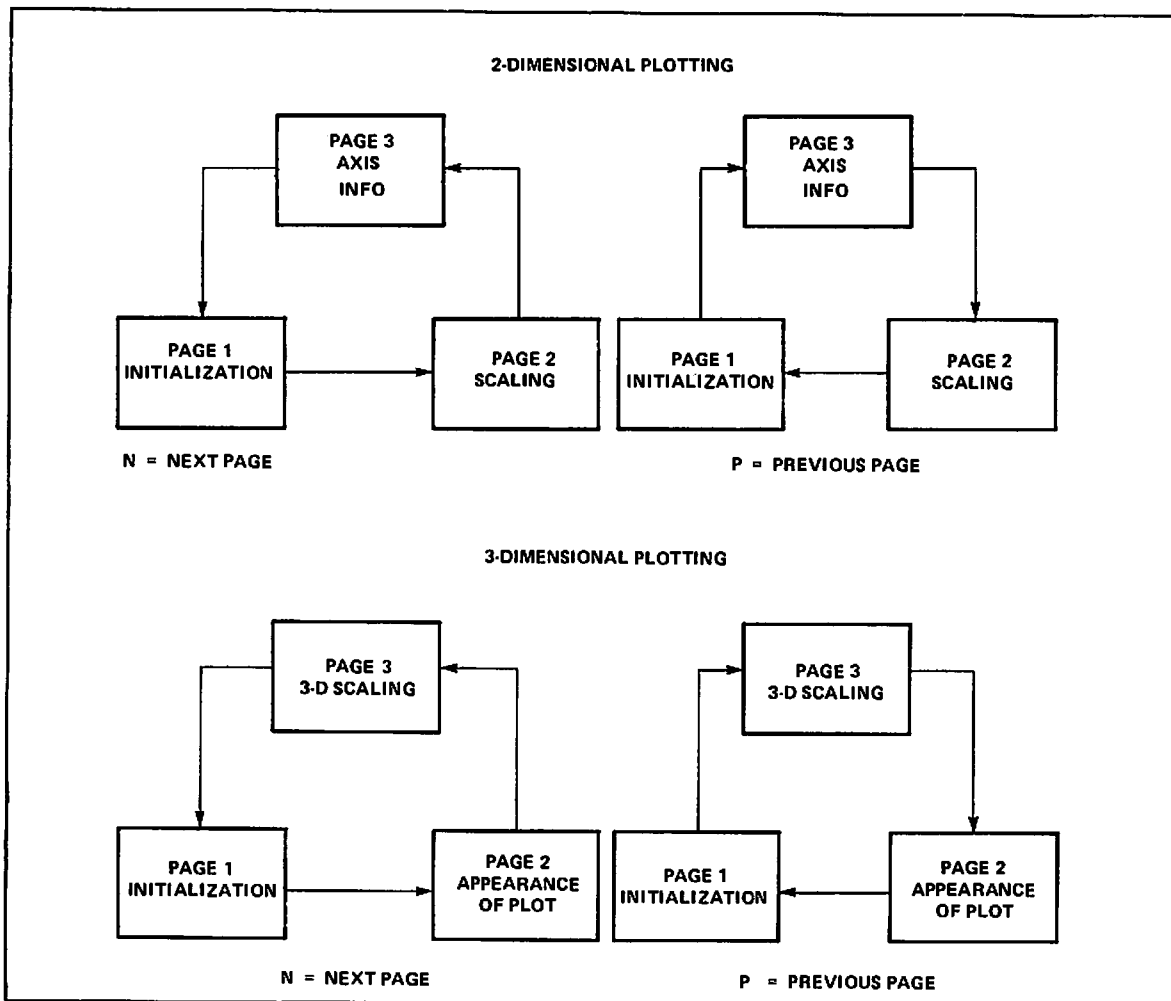


Figure 2-2. Enter Parameters Module - Function Letters "N" and "P"

2.3 DATA FILE CREATION

The Enter Parameters, Data Point, and Label modules allow data to be read and stored in disk files with variable names. The first prompt in these modules is for the name of the INPUT FILE rather than for any ITEM NUMBER OR FUNCTION LETTER. The first time the system is run there are no existing input files on the data disk and therefore a null response (RETURN (EXEC)) must be given. When a RETURN (EXEC) is entered, it is assumed that there is no input file and data (for the new file) is entered entirely from the keyboard.

When a file name is entered for the INPUT FILE prompt, the system verifies that the file exists on the device specified for data files. If the file exists, it is read and the first page of its data is displayed on the screen. Any value displayed as a numbered menu item can be modified by the operator.

When creation of a new file or modification of an existing file is complete, it can be saved in a disk file by entering any one of three Function Letters, "S", "R", or "A". After one of these letters is entered, the system asks for the name of the OUTPUT FILE. It is under this name that the data is saved. If an input file name was previously used and the operator wants to save the data back into the original input file, he must enter a null response to the output file.

If the data is to be stored into a different file or if no input file name was previously used, the operator must enter a name for the output file. Any eight characters may be used for a file name as long as it does not conflict with file names reserved for the system modules. The following file names are reserved and should not be used:

```
START
CHARF010
STATREAD
GUS.INFO (and any other name which starts with the four characters
          "GUS.")
```

NOTE:

It is anticipated that many filenames will be created in using GUS. Therefore, it is suggested that the user set up a naming convention so that parameter, data point, and label files may be distinguished from each other solely by their names. Thus all parameter files might start with the letter "P", all data point files with "D" and all label files with "L".

Once data has been saved on disk it can be retrieved for maintenance using the module that created it. For example, if the Enter Parameters Module created a parameter file named P-CURVE1 and saved it on disk, it can be recalled from the data disk by entering "P-CURVE1" in response to the prompt ENTER THE NAME OF THE INPUT FILE, IF ANY. In addition, Data and Label files can be created, saved, and recalled in this manner. In saving a file if the output file does not already exist on disk, the system allocates previously unused disk space for the creation of a new file. Likewise, if the file already exists, its previous contents will be destroyed as the new data is written on disk.

In the Enter Parameters, Data Point, and Labels modules, the user may elect to print a hardcopy of the information in the file after it has been saved. The prompt DO YOU WANT A HARDCOPY? is displayed immediately following the entry of an output file name. If the user responds positively, the system creates a copy of the file on a printer. The program resumes appropriately according to the save function letter used (S, A, or R).

2.4 SPECIAL FUNCTION KEY '15'

In all the modules, (except in the specific situations discussed below), the user can interrupt the program and return to a previous stage of operation through the use of Special Function Key '15. Keying Special Function Key '15 redisplayes the last question or menu directly preceding the current one. Through repeated use of SFK '15, the user may back-step sequentially through the entire program until the System Menu, with its provision of SFK '15 to load an application, is reached. (See Figure 2-3.)*

Example 1 Returning to the prompt "ENTER AN
ITEM NUMBER OR FUNCTION LETTER"

In all the modules, whenever the system asks for input to a menu item (e.g., "PLOTTER TYPE?" in Initialize System), depressing Special Function Key '15 leaves the old value in the item and control returns to the prompt "ENTER AN ITEM NUMBER OR FUNCTION LETTER".

Example 2 Returning the the System Menu

In the Initialize System and Start Plot modes where user named files are not created, the program returns to the System Menu whenever Special Function Key '15 is depressed in response to the prompt:

"ENTER AN ITEM NUMBER OR A FUNCTION LETTER"

In the Enter Parameters, Data Points, and Labels modules where user named files are created, the program returns to the System Menu whenever Special Function Key '15 is depressed in response to the prompt "ENTER THE NAME OF THE INPUT FILE, IF ANY".

* See Appendix H for special use of SFK '15 in the minidiskette version of GUS.

There are two exceptions concerning the Special Function Key '15, occurring at the same points in the Enter Parameters, Enter Data Points, and Enter Labels modules. These modules perform all their file creation work on a temporary file (called GUS.TEMP) until an S, R, or A function letter is issued and a save operation initiated.

The first exception occurs when the Special Function Key '15 is depressed in response to the prompt ENTER AN ITEM NUMBER OR FUNCTION LETTER. The system responds with the question DO YOU WANT TO CANCEL WORK JUST DONE? If the user enters "N", the program returns to ENTER AN ITEM NUMBER OR FUNCTION LETTER leaving everything as it was before Special Function Key '15 was depressed. If however, the response is "Y", the program destroys the temporary file containing the unwanted data, and returns to the first question of the module. Any file named as an INPUT FILE will remain as it was when editing commenced.

CAUTION:

Because the temporary file (GUS.TEMP) uses all unassigned space on the data disk during the construction of a file, it should always be removed with the Special Function Key '15 when a file creation operation is being aborted. It is therefore extremely important that the user terminate the use of GUS only when the System Menu is displayed. (The removal of GUS. TEMP occurs automatically when S, R, or A is selected.)

The second exception occurs when the prompt DO YOU WANT A HARDCOPY? is displayed immediately following entry of an output file name. If the Special Function Key '15 is entered to the prompt DO YOU WANT A HARDCOPY?, the prompt is redisplayed and a Y, N (or null) response is required to proceed. Since at this point the work has been accepted, the temporary file closed and the output file written and saved, it is no longer possible to undo the previous step. Thus in this case, the user is prevented from returning with Special Function Key '15.

NOTE:

The user may press HALT/STEP and Special Function Key '15 anytime when a graph is being plotted (for example when a pen runs dry.) At any other time Special Function Key '15 may only be used when the system is awaiting a response to a prompt. Use at other times may cause an error to occur which will require the complete reloading of the system.

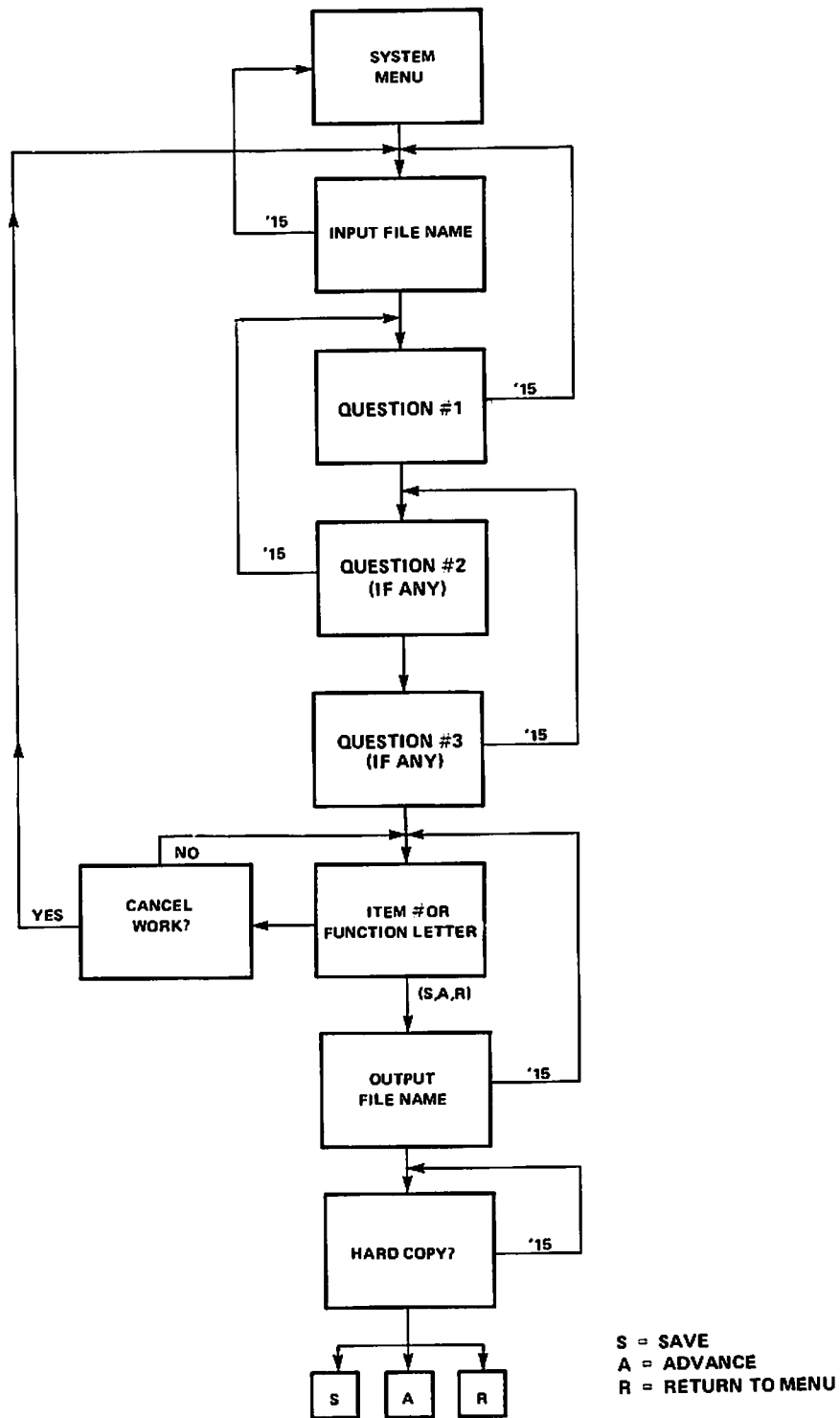


Figure 2-3. Program Control with Special Function Key '15

CHAPTER 3 INITIALIZE SYSTEM MODULE

3.1 INTRODUCTION

The Initialize System module allows the operator to enter general setup information concerning the plotting operation that is not likely to change throughout the use of the system. This information includes the choice of plotter model, CRT type, the physical plotting units associated with the user's graph, and the number of plotter units per physical unit. The module is activated the first time the system is run; thereafter it can be called from the system menu as required. This module need only be run once unless the user changes the physical system (e.g., CRT size or plotter model). Information entered in this module is saved in a file named GUS.INFO on the program disk. (Note: GUS.INFO is the only filename used in the Initialize System module; alternate filenames are not allowed.)

3.2 MENU ITEMS

Plotter Types

GUS can accommodate seven types of plotters: the Models 2202, 2212, 2232 (English and Metric), 2272 (English and Metric), 2281P, 2282 Graphic CRT, and the Tektronix graphic display terminal.

Physical Measuring Units

The unit of measure expresses the physical distances of the plotting surface. The distance is usually measured in inches or centimeters but can be expressed in any other units as desired. The name of the units has no effect on the graph produced. The name of the units specified here is displayed in prompts in the Enter Parameter module.

Number of Plotter Units per Physical Unit

This value is a function of both the physical unit of measure selected by the user and the plotting increment specified in the appropriate plotter manual. As an example the Model 2272 (English) has a plotting increment of 0.005 in. which translates to 200 plotter units per physical unit (inches). If the physical unit of measure is specified in centimeters, the value is $200/2.54 = 79$. For convenience, the values appropriate for inches and centimeters for the various English and Metric plotters are shown in the following table:

<u>Plotter</u>	<u>Inches</u>	<u>Centimeters</u>
2202	100	39
2212	100	39
2232 English	400	157
2232 Metric	508	200
2272 English	200	79
2272 Metric	254	100
2281P	60	24
2282	72	28
Tektronix	72	28

As an example, if a Model 2272 Metric is being used and the user wants his measurements in inches, a value of 254 should be entered.

CRT Line Length

The user must specify either 64 or 80 to correspond to the number of characters on each line of the CRT in his system. GUS uses this value to center displays on the CRT.

CHAPTER 4 ENTER PARAMETER MODULE

4.1 INTRODUCTION

The Enter Parameter module requests information for both two- and three-dimensional plotting. Whereas the four items in the Initialize System module fit on one screenload or "page" the items in this module are divided into three pages. For two-dimensional plotting the three pages are designated as PAGE 1 - INITIALIZATION, PAGE 2 - SCALING and PAGE 3 - AXIS PARAMETERS respectively. For three-dimensional plotting PAGE 1 is essentially the same as that for the two-dimensional plotting with the exception of a few item changes; the other two pages are called PAGE 2 - APPEARANCE OF PLOT, and PAGE 3 - 3-D SCALING.

When called from the system menu (or advanced from the Initialize System module), the Enter Parameters module displays the PAGE 1 - INITIALIZATION menu. The module asks:

ENTER THE NAME OF THE INPUT FILE, IF ANY

If a name is entered, the contents of the named file are read from the data disk and information for the items on PAGE 1 is displayed on the CRT for review or update. If no name is specified, all values must be keyed in manually from the keyboard to create a new parameter file. Typically, the operator may want to plot a set of related curves sharing most of the same physical features of the graph. The Enter Parameter module allows the operator to create and save individual files of these related parameters for automatic access at the time of plotting. The features incorporated in such a file (referred to as a parameter file) are discussed in the following sections.

ENTER THE NAME OF THE INPUT FILE,
IF ANY
?-----
_

PARAMETER FILE = (none)
PAGE 1 - INITIALIZATION

1...GRAPH TYPE =
2...SCALE TYPE =
3...DATA SOURCE =
4...X SIZE = 0
5...Y SIZE = 0
6...X OFFSET = 0
7...Y OFFSET = 0
8...X MARGIN = 0
9...Y MARGIN = 0

4.2 PAGE 1 - INITIALIZATION

Graph Type

Three types - Line, Point, and Bar are available for two-dimensional plotting.

Line Graph: A series of straight lines connect the plotted data. A solid line, dash, dotted, or dash/dotted line can be selected with an option of three sizes of inter-dot space or dash length.

Point Graph: A series of dots connect the data points. Any character in the standard character set provided with GUS or from hardware characters (Plotter Models 2212, 2272 and 2282) may be chosen to be plotted at the data points. Small, medium, or large size characters may be plotted.

Bar Graph: The plotted data is displayed as a series of vertical bars of user-specified width. The Scale Type for a bar graph must be one for which the X-axis is linear.

For three-dimensional plotting the Graph type option is 3-D Plot. The user selects 3-D Plot to signal that three-dimensional plotting information is to be entered in this module.

3-D Plot: This option provides for three-dimensional plotting of a computed function specified by the user. When this option is selected, the PAGE 1 - INITIALIZATION Menu displays COORDINATE SYSTEM instead of SCALE TYPE in item 2 and automatically selects the computed function as the data source in item 3.

Scale Type (Two-dimensional plotting)

For two-dimensional plotting the user may specify any of the following scale types for the X and Y axes:

- Linear - Linear in both X and Y.
- Log/Log - Log scale in both X and Y.
- Lin/Log - Linear X and Log Y Scale.
- Log/Lin - Log X and Linear Y Scale.
- Polar - Data received in polar coordinate format (r,θ) is plotted onto a scale linear in both X and Y.

Coordinate System (Three-dimensional plotting only)

There are three choices of coordinate systems available in three-dimensional plotting - rectangular, cylindrical and spherical. In each case, the user-specified computed function treats the two variables it receives as independent parameters and specifies the three coordinates of the point on the surface (See Appendix B.) Each point on the surface is expressed in the designated coordinate system. In the simplest application, the independent parameter variable, x and y , provided as input to the function can be taken to be two of the three coordinates, X and Y , of the point (X,Y,Z) in a rectangular coordinate system. The third coordinate Z is calculated from them (See Example 1 below).

NOTE:

In all three coordinate systems, GUS makes the transformation of the 3-dimensional system into the 2-dimensional rectangular coordinate system X', Y' .

Example 1: Given independent variables x and y as input to a computed function, calculate X , Y and Z as the coordinates of a point on the surface.

$$\begin{aligned} X &= x \\ Y &= y \\ Z &= \text{SQR}(x^2 + y^2)*2 \end{aligned}$$

This is the surface of a cone which is twice as deep as its radius at any given point; its axis is along the Z -axis and it has a point at origin. In this computed function, both the input and output variables are interpreted as coordinates of the object coordinate system.

Example 2: Given that cylindrical coordinates are chosen, a simple computed function utilizes the independent variables as radius r , and y as angle θ . The third variable z is computed as a function of these:

$$\begin{aligned} X &= x \\ Y &= y \\ z &= 2*x \end{aligned}$$

This surface is a cone which is twice as deep as its radius at a given point and with a point at the origin.

Data Source

Three options are available for two-dimensional plotting - Standard File, Computed Functions and Non-standard file.

Standard File

When Standard File is selected the data source is the Data Points Module. Data points may be keyed in, printed out, edited, and maintained in data point files created by the Data Points module of GUS. Data may be keyboard entered or read from a file previously created by the system. Data points are entered as numeric pairs of values corresponding to X and Y coordinates (or r and θ if polar coordinates).

Computed Function

When Computed Function is selected the data points are calculated from a mathematical expression representing the graph. The user must provide a program file containing a function and a subroutine to generate the data points. In two-dimensional plotting the subroutine calculates rectangular or polar coordinates from the function specified in parametric form. The construction of a Computed Function File for two-dimensional plotting is discussed in Appendix A. It is possible to automatically scan this function for the domain of the independent variable to produce the anticipated minimum and maximum values of the dependent variables to be used for automatic scaling of the graph. (See Section 4.4).

Non-Standard Data Files

When Non-Standard Data Files is selected the user signifies that he will provide a data source that does not conform to the format of the Enter Data Points Module. The user may desire to plot data points contained in a unique data file created in some arbitrary format. In this case, the user must provide a program which consists of a subroutine to read his data file, unpack the data points and provide the coordinates to the main line processor one point at a time as called. As an example of such a program, the system disk contains the routine (called STATREAD) necessary to read a file of statistical data created by the Wang statistical programs, thereby enabling immediate access to this data for plotting. See Appendix A, Example 3 for the construction of a program to read Non-Standard Data files.

In three-dimensional plotting the data source must be a Computed Function. Since no other choice is possible, COMP. FUNC. is automatically entered and displayed for DATA SOURCE (item 3) when 3-D is selected for GRAPH TYPE. An error message "DATA SOURCE MUST BE COMPUTED FUNCTION WITH 3-DIMENSIONAL PLOT" is displayed when item 3 is selected or by-passed if changing all answers. The construction of a Computed Function File for three-dimensional plotting is discussed in Appendix B. Scaling of the computed function is discussed in Section 4.7, 3-D Scaling.

Size of the Plot Area

The user specifies in his own physical units of measurement (i.e., units selected in the Initialize System module) the overall length and width of the active plot area. The active plot area is defined by the X SIZE and Y SIZE entries. Both these entries must be a positive value. No plotting is allowed outside the boundaries of the active plot area. Data, axis length, axis numbering and labeling are restricted to the specified spaces. (See Figure 4-1).

NOTE:

The functions letters N and P should not be used until items 1 through 5 on PAGE 1 are answered.

Position of the Plot Area

The position of the Plot area with respect to the plotter home location is defined by the X OFFSET and Y OFFSET entries (see Figure 4-1). X OFFSET is the horizontal distance from the plotter home position to the left edge of the active plot area. Y OFFSET is the vertical distance from the plotter home position to the bottom of the active plot area. Values for X OFFSET and Y OFFSET must be non-negative except for the Model 2272 plotter. In Model 2272 applications, the values can be positive or negative. The user should consult the appropriate Plotter Reference Manual for the "plotter home" position.

NOTE:

It is the user's responsibility to insure that the plot specified can be accommodated within the physical limits of the plotter. The system makes no attempt to check this.

Margins between Plotting Area and Graph

The user specifies in his own physical units of measurement the margin he wants reserved around the axis and data area for use in labeling the plot (see Figure 4-1). The margins are defined by entering non-negative values of X MARGIN and Y MARGIN.

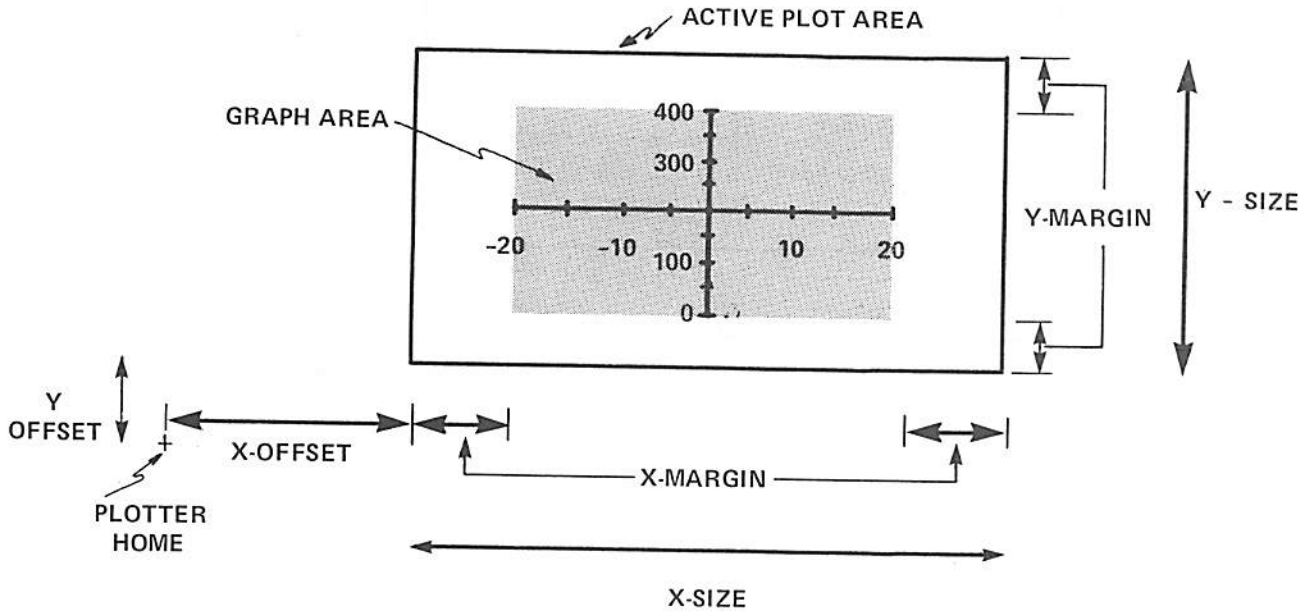
X MARGIN is the distance from the left or right side of the active plot area to the corresponding end of the X-axis. This may be used to reduce the area for the graph (i.e., the axis and data); thereby providing a margin within the active plot area which can be utilized for labeling and for numbering to the left edge of the graph. (See Figure 4-2).

Y MARGIN is the distance from the top or bottom of the active plot area to the corresponding end of the Y-axis. This may be used for labeling and for numbering below the X-axis. (See Figure 4-2).

Numbering of the axis will be suppressed by the program and an error message displayed at plotting time unless there is sufficient room within the active plot area to number the X-axis (below it) and the Y-axis (along the left side.)

NOTE:

The system distinguishes between the term Active Plot Area, (plotting area) which is the area specified by the size of the plot area (and includes the margin area) and the term Graph Area, which is used to indicate only the area inside the margins.



X MIN = - 20

X MAX = 20

Y MIN = 0

Y MAX = 400

X ORIGIN = 0

Y ORIGIN = 200

DELTA X = 5

DELTA Y = 50

X INCREMENT = 10

Y INCREMENT = 100

Figure 4-1. Plotting Area Parameters

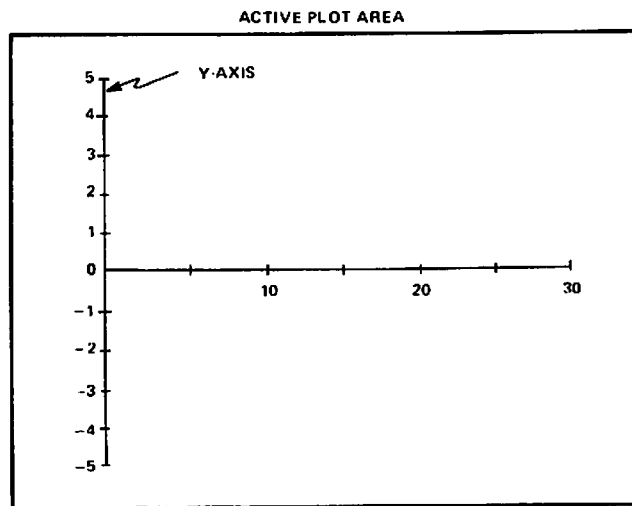
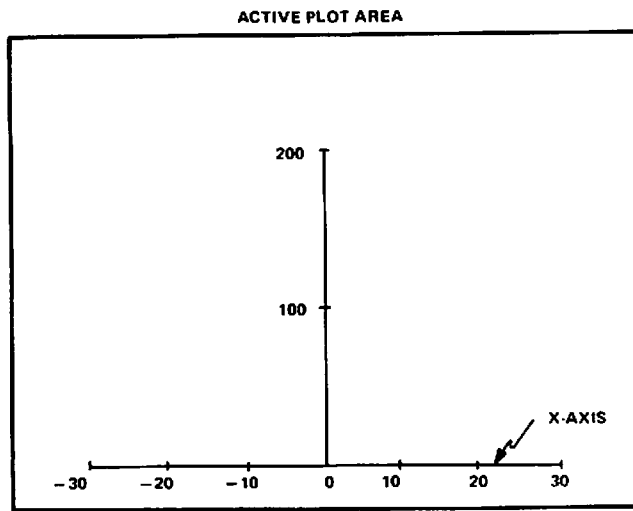
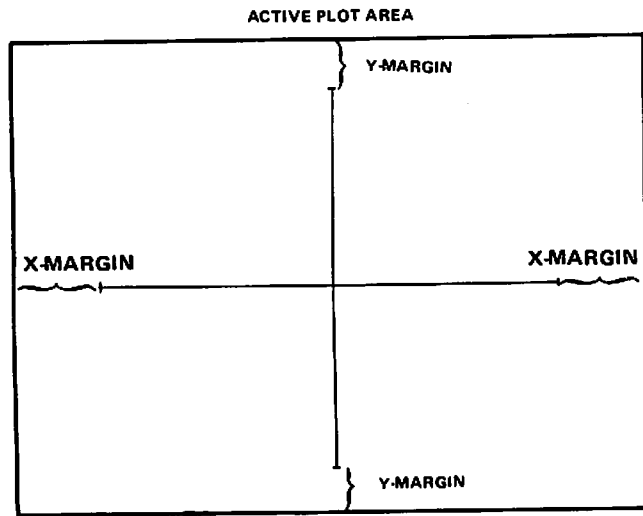


Figure 4-2. Margins along the Edge of the Graph Area

4.3 PAGE 2 - SCALING (NON-COMPUTED FUNCTIONS FOR 2-D PLOTTING)

Page 2 - Scaling is displayed in either of two forms depending on the Data Source type specified in Page 1. When a standard data file or a non-standard data file is specified in Page 1, the system displays the following form of Page 2.

```
ENTER AN ITEM NUMBER OR A FUNCTION  
LETTER  
?_
```

```
PARAMETER FILE = (NONE)  
PAGE 2 - SCALING
```

```
1.....X-MIN = 0  
2.....X-MAX = 0  
3.....Y-MIN = 0  
4.....Y-MAX = 0
```

```
-----  
C = CHANGE ALL ANSWERS  
N = NEXT PAGE  
P = PREVIOUS PAGE  
S = SAVE PARAMETERS  
A = ADVANCE TO DATA MODULE  
R = RETURN TO SYSTEM MENU
```

The information on this page is entered in graph units and not in the physical units of measure selected in the Initialize System module. Scaling data is entered in the units to be represented on the graph. Graph scale units are typically not a physical distance but may be any unit in which the data was measured, such as dollars, years, or miles per hour.

For scaling purposes the system must be provided with the greatest and least data values anticipated for each axis. The system draws a set of X and Y axes to provide for these values (See Figure 4-1). Although data may be entered as polar coordinates (See Chapter 5), the values entered on this page are always in rectangular coordinates. Values used for log scales must be positive.

The lower limit for the X axis is entered as X MIN while the upper limit is entered as X MAX. Likewise, the lower and upper limits of the Y axis are defined by Y MIN and Y MAX. (XMAX must be greater than XMIN and YMAX must be greater than YMIN.)

The graph units used in the X-direction need not be the same as the units in the Y-direction.

NOTE:

When BAR GRAPH is selected in Page 1 - INITIALIZATION, Page 2 - SCALING will display an item 5 - BAR WIDTH. The value for BAR WIDTH is entered in the graph units of the X - axis and must be non-negative.

4.4 PAGE 2 - SCALING (COMPUTED FUNCTION FOR 2-D PLOTTING)

ENTER AN ITEM NUMBER OR A FUNCTION
LETTER

?--
_

PARAMETER FILE = (NONE)
PAGE 2 - SCALING

1. T-MIN = 0
2. T-MAX = 0
3. # OF T INTERVALS = 0
5. X-MIN = 0
6. X-MAX = 0
7. Y-MIN = 0
8. Y-MAX = 0

C = CHANGE ALL ANSWERS
N = NEXT PAGE
P = PREVIOUS PAGE
V = COMPUTE VALUES OF X&Y
S = SAVE PARAMETERS
R = RETURN TO SYSTEM MENU
A = ADVANCE TO DATA MODULE
L = LOAD A FUNCTION FILE

T-MIN, T-MAX

The information in this form of page 2 is peculiar to a computed function and must be entered in graph units. For the computed function, the variables X and Y are parametric on the independent variable T. In computing the data point values from the function the upper and lower limits of the variable T must be specified. These values are entered as T-MIN and T-MAX. In addition, the number of increments in the range from T-MIN to T-MAX over which the computed function is to be plotted must be specified. This value is entered as the NUMBER OF T INTERVALS. For example, if the simple function $Y = X^2 + 5$ is to be computed starting at $X = -20$ and ending at $X = +20$, then T-MIN is -20 and T-MAX is entered as $+20$. (T-MAX must be greater than T-MIN). If the number of T intervals for this example is set equal to 10 then the function will be plotted at points $-20, -16, -12, -8, -4, 0, 4, 8, 12, 16,$ and 20 . The formula for the plotting increment is:

$$\text{INCREMENT} = \frac{(\text{T-MAX}) - (\text{T-MIN})}{\# \text{ of T Intervals}}$$

NOTE:

When BAR GRAPH is selected in Page 1 - INITIALIZATION, Page 2 - SCALING will display an item 4 - BAR WIDTH. The value for BAR WIDTH is entered in the graph units of the X-axis and must be non-negative.

Function Letters L and V

The remaining items in PAGE 2 - SCALING (Computed Function) the X-MIN, X-MAX, Y-MIN and Y-MAX parameters have the same meaning and limitations as in non-computed function scaling (Section 4.3). However, values for these parameters can be computed and entered automatically by using the function letters L and V.

The function letter L allows the operator to enter the name of a program file containing the computed function routine (see Appendix A). The program file must have been previously stored on the data disk. If the program file is not on the data disk, the user must back out of GUS (via S.F. key '15) to create the program file. When the system verifies that the program file exists on the data disk, the module loads the program file into memory. (Note: The name of the last entered program file appears as the default name.)

The function letter V activates the program file routine and causes values of T to be entered into the program according to the settings for T MIN, T MAX, and # of T INTERVALS. For each value of T, the corresponding values of X and Y are calculated and momentarily displayed on the screen. At the conclusion of the calculations, the extreme values of X and Y are automatically entered into the X-MIN, X-MAX, Y-MIN, and Y-MAX respectively (items 5 through 8). The user may leave these values as calculated or may reenter them to the next round number further out on the axis. For example, a computed X-MIN OF -1.463 might be lowered to -1.5.

NOTE:

If the user lowers the MAX or increases the MIN values in items 5 through 8, then some points may not be plotted as they no longer fall within the active plot area.

4.5 PAGE 3 - AXIS INFO (2-DIMENSIONAL PLOTTING ONLY)

ENTER AN ITEM NUMBER OR A FUNCTION
LETTER

?_

PARAMETER FILE = (NONE)
PAGE 3 - AXIS INFO

1.....X-ORIGIN = 0
2.....Y-ORIGIN = 0
3.....DELTA X = 0
4.....DELTA Y = 0
5.....HORIZONTAL LINES? = N
6.....VERTICAL LINES? = N
7.....NUMBER THE AXES? = N
8.....X INCREMENT = 0
9.....Y INCREMENT = 0

C = CHANGE ALL ANSWERS
N = NEXT PAGE
P = PREVIOUS PAGE
S = SAVE PARAMETERS
A = ADVANCE TO DATA MODULE
R = RETURN TO SYSTEM MENU

The information on this page is entered in the units represented on the graph. The solicited information includes the intersection point of the axes, the distance between hash marks on the axes and the numbering of the axes. The axes are normally subdivided by short perpendicular hash marks. The user has the option of extending these hash marks the full width of the graph horizontally and/or vertically to create a full-grid effect. Numbering of the axis hash marks is also provided as an option. Hash marks can be numbered at each hash mark interval or at multiples of that interval. The system numbers hash marks along the left side of the Y-axis and below the X-axis.

Numbering of the axes is done in hardware - provided characters on the Models 2212, 2272 and 2282 plotters to utilize their greater speed. The other plotters use software routines for axis numbering.

X-ORIGIN, Y-ORIGIN

The X-ORIGIN is the point on the X-axis where the Y-axis crosses it. The value of the point must not be less than X-MIN or greater than X-MAX.

The Y-ORIGIN is the point on the Y-axis where the X-axis crosses it. The value may not be less than Y-MIN or greater than Y-MAX.

The user specifies the axis intersection to suit his particular plot. Depending on the selection of X-ORIGIN and Y-ORIGIN, axis numbering at the intersection will conform to the patterns shown in Table 4-1.

Table 4-1. Axis Numbering at the Intersection of X-ORIGIN and Y-ORIGIN

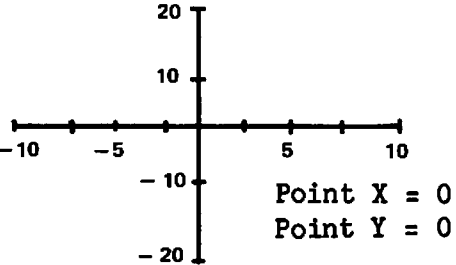
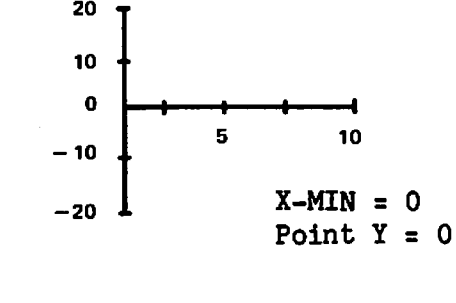
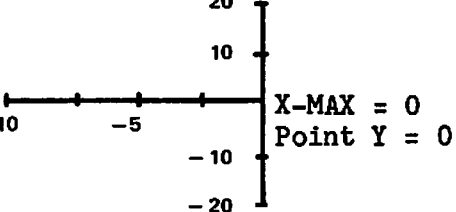
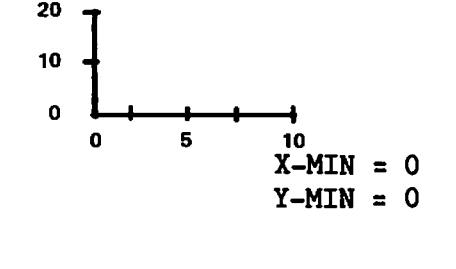
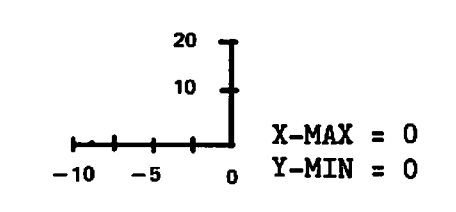
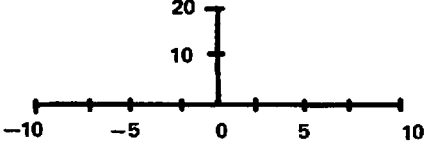
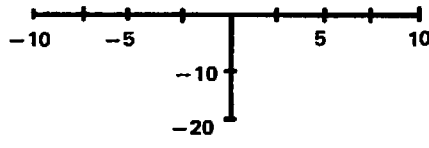
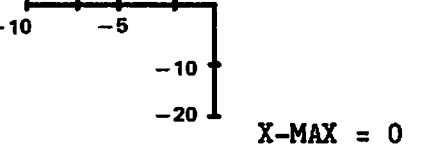
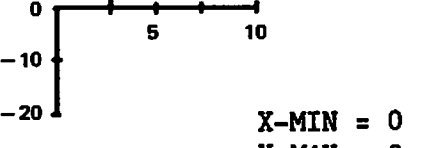
Axis Intersection	Axis Numbering at the Intersection	Example
<p>X-ORIGIN = Point X Y-ORIGIN = Point Y</p>	<p>none</p>	 <p>Point X = 0 Point Y = 0</p>
<p>X-ORIGIN = X-MIN Y-ORIGIN = Point Y</p> <p>Note: X-MARGIN > 0</p>	<p>Point Y</p>	 <p>X-MIN = 0 Point Y = 0</p>
<p>X-ORIGIN = X-MAX Y-ORIGIN = Point Y</p>	<p>none</p>	 <p>X-MAX = 0 Point Y = 0</p>
<p>X-ORIGIN = X-MIN Y-ORIGIN = Y-MIN</p> <p>Note: X-MARGIN > 0 Y-MARGIN > 0</p>	<p>X-MIN Y-MIN</p>	 <p>X-MIN = 0 Y-MIN = 0</p>
<p>X-ORIGIN = X-MAX Y-ORIGIN = Y-MIN</p> <p>Note: Y-MARGIN > 0</p>	<p>X-MAX</p>	 <p>X-MAX = 0 Y-MIN = 0</p>

TABLE 4-1 (continued)

Axis Intersection	Axis Numbering at the Intersection	Example
<p>X-ORIGIN = Point X Y-ORIGIN = Y-MIN</p> <p>Note: Y-MARGIN > 0</p>	<p>Point X</p>	 <p>Point X = 0 Y-MIN = 0</p>
<p>X-ORIGIN = Point X Y-ORIGIN = Y-MAX</p>	<p>none</p>	 <p>Point X = 0 Y-MAX = 0</p>
<p>X-ORIGIN = X-MAX Y-ORIGIN = Y-MAX</p>	<p>none</p>	 <p>X-MAX = 0 Y-MAX = 0</p>
<p>X-ORIGIN = X-MIN Y-ORIGIN = Y-MAX</p> <p>Note: X-MARGIN > 0</p>	<p>Y-MAX</p>	 <p>X-MIN = 0 Y-MAX = 0</p>

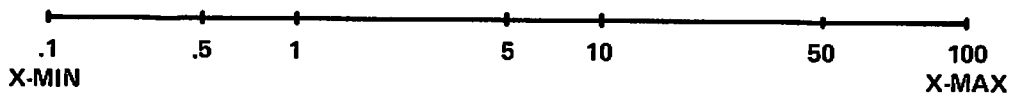
DELTA X

DELTA X is the increment between hash marks on the X-axis. The value specified must be greater than zero.

For a linear X-axis, if hash marks are not required (e.g., on the X-axis of a bar graph), the value of DELTA X should be set greater than the extent of the axis. As an example, if the full extent of the X-axis is 100 graph units, setting DELTA X=110 will suppress hash marks.

For a Log X-axis, the value for DELTA X will be that used within the first cycle of the Log scale. The program multiplies this value by 10 for each subsequent cycle.

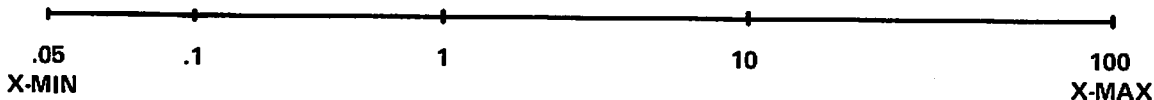
Example 1:



Specifying a DELTA X = 0.5 gives hash marks at 0.5, 1, 5, 10, 50, and 100.

If marking only between cycles is required, the DELTA X value entered is that of the end of the first complete cycle in the axis. For the example above, a DELTA X = 1 gives hash marks at 0.1, 1, 10 and 100.

Example 2:



Specifying a DELTA X = 1 gives hash marks at 0.1, 1, 10 and 100 since the "first" complete cycle on the axis is 0.1 to 1.

If no hash marks are required on the log X-axis, any DELTA X value greater than the end of the first complete cycle may be entered. In the examples above a DELTA X = 1.2 could be used to suppress hash marks.

DELTA Y

DELTA Y is the increment between hash marks on the Y-axis. The value must be greater than zero.

For a linear Y-axis if hash marks are not required, DELTA Y should be set greater than the extent of the axis. As an example, if the full extent of the Y-axis is 50 graph units, then a DELTA value of 60 will suppress hash marks.

For defining hash marks on a Log Y-axis, the user should follow the discussion under DELTA X.

HORIZONTAL LINES, VERTICAL LINES

The combination of Horizontal and Vertical lines is used to draw a graph paper type grid.

If the option for horizontal lines is exercised, the hash marks on the Y-axis are extended to cover the entire horizontal extent of the graph area, i.e., active plot area minus margins.

If vertical lines are selected, the hash marks on the X-axis are extended to cover the entire vertical extent of the graph area.

NUMBER THE AXES

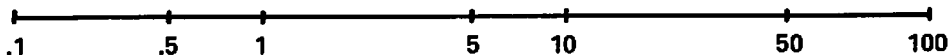
If this option is exercised, the system automatically generates numbers on the X and Y axes at intervals specified in items 8 and 9 of the menu. Item 8 (X INCREMENTS) and item 9 (Y INCREMENTS) are only displayed if the axis numbering option is taken.

X INCREMENT

The value of X INCREMENT is the increment between numbered hash marks on the X-axis. Only those hash marks specified by the ratio of X INCREMENT to DELTA X are numbered. Thus, for a linear X-axis, if DELTA X is 10 and the X INCREMENT is 50, hash marks will appear at intervals of 10, and every fifth one will be numbered. X INCREMENT must be positive and an integer multiple of the DELTA X value.

If numbered hash marks are not required on the X-axis (but are required in the Y-axis), the value of X INCREMENT should be set greater than the full extent of the axis.

For a Log scale X-axis, the X INCREMENT value is that used within the first cycle. The program multiplies this value by 10 for each subsequent cycle. For example, if 0.1 and 100 are the X-MIN and the X-MAX, an X INCREMENT = 0.5 will provide numbering at 0.5, 1, 5, 10, 50 and 100.



If numbering only between cycles is desired, the X INCREMENT value entered must be the value at the end of the first complete cycle. For the example above, an X INCREMENT = 1 gives numbered hash marks at 0.1, 1, 10 and 100.



Likewise, if the scale is from 0.5 to 100, X INCREMENT = 1 would also give numbered hash marks at 0.1, 1, 10 and 100 since the first "full" cycle is still 0.1 to 1.

If no numbering is desired, any value greater than the end of the first full cycle may be entered. For the examples above, X INCREMENT = 1.1 could be used to suppress numbering.

NOTE:

For a linear scale, the user may wish to select X-MAX, X-MIN, DELTA X and X INCREMENT such that X-MIN and X-MAX are both integer multiples of both DELTA X and X INCREMENT. This ensures that the hash marks at X-MAX and X-MIN will be numbered. For example:

X-MIN = -100
X-MAX = 100
DELTA X = 10
X INCREMENT = 20

Y INCREMENT

For a linear Y-axis, Y INCREMENT is the increment between numbered hash marks on the Y-axis. Only those hash marks specified by the ratio of Y INCREMENT to DELTA Y are numbered. Y INCREMENT must be an integer multiple of the DELTA Y. If numbered hash marks are not required on the Y-axis (but are required on the X-axis), the value of Y INCREMENT should be set greater than the full extent of the axis.

For defining numbered hash marks on a log Y-axis, the user should follow the previous discussion under X INCREMENT.

NOTE:

For a linear scale, the user may wish to select Y-MAX, Y-MIN, DELTA Y and Y INCREMENT such that Y-MIN and Y-MAX are both integer multiples of both DELTA Y and Y INCREMENT. This ensures that the hash marks at Y-MAX and Y-MIN will be numbered. For example:

Y-MIN = -400
Y-MAX = 600
DELTA Y = 20
Y INCREMENT = 40

4.6 PAGE 2 - APPEARANCE OF PLOT (3-D PLOTTING)

In 3-Dimensional plotting there are two kinds of information needed to specify the general appearance of the image of the function on the plotter surface:

- 1 - The nature and "fineness" of the "stretchable net".
- 2 - The position of the viewer in relation to the object.

The parameters needed to describe these features are entered in PAGE 2 - APPEARANCE OF PLOT.

ENTER AN ITEM NUMBER OR A FUNCTION
LETTER

?--

PARAMETER FILE = (NONE)

PAGE 2 - APPEARANCE OF PLOT

1...LINE OPTION TO PLOT

3...INTERVALS PER LINE = 0

2...INTERVALS BETWEEN LINES = 0

4...HIDDEN POINT

ACCURACY = 0

DIRECTION OF VIEW:

5...X = 1.4142

6...Y = 1.4142

7...Z = 1.6329

VERTICAL VECTOR:

8...X = 0

9...Y = 0

10...Z = 1

C = CHANGE ALL ANSWERS

S = SAVE PARAMETERS

N = NEXT PAGE

P = PREVIOUS PAGE

A = ADVANCE TO LABELS MODULE

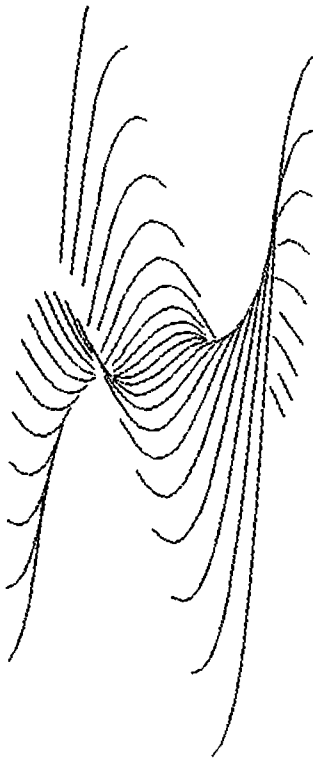
R = RETURN TO SYSTEM MENU

D = STANDARD DIRECTION

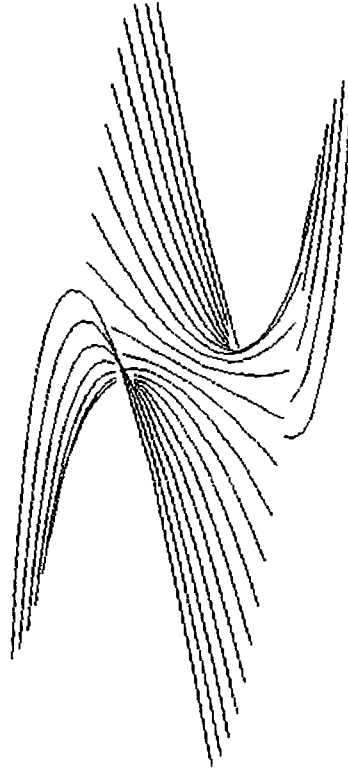
Line Option to Plot

The "stretchable net" representation of the image of the function consists of two sets of related lines which cross each other. For a simple case of rectangular coordinates with $x = X$ and $y = Y$, each line in the first set of lines, an "x-line", is one which runs in the general direction of the X axis. Similarly the other set consists of "y-lines" which generally are seen to be along the Y axis. To be more precise, an x line is formed by plotting between points of the function for which the values of the independent variable y are held constant while different values of the independent variable x are utilized. In the same manner, a y line is plotted between points having a constant x value and varying y values.

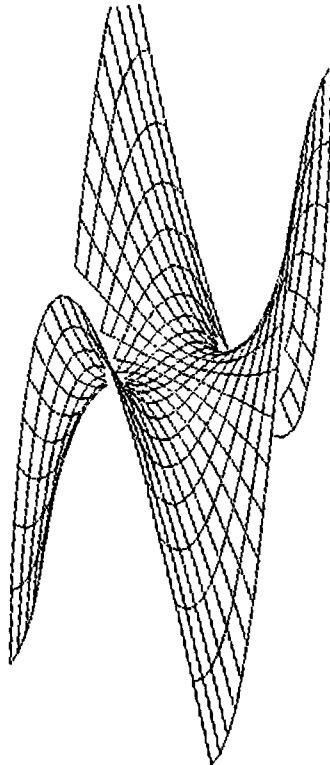
In defining the general appearance of the "stretchable net", the user must specify either x lines, y lines, or both x and y lines. Figure 4-3 shows a representation of the function by "x-lines" only, "y-lines" only, and then by both sets of lines.



OPTION 1: X-LINES ONLY



OPTION 2: Y-LINES ONLY



OPTION 3: X-LINES AND Y-LINES

Figure 4-3. Relation between X-lines and Y-lines in the "stretchable net" representation on the plotter surface.

Intervals Between Lines

As is shown in Figure 4-3, the "stretchable net" on the plotted surface is represented by a set of lines drawn in either of two directions or by sets of lines in both directions. In order to determine the line spacing or "fineness" of the "stretchable net", the user must specify the number of intervals between each set of lines. For lines in both directions the number of lines (one greater than the number of intervals) is the same in each direction (See Figure 4-4.)

From the specified number of intervals, the program computes line spacing so that the surface is exactly covered by the number of equally spaced lines between the first and last points used to scale the computed function which defines the surface. The first points are the values of X-MIN and Y-MIN on Page 3 - 3-D Scaling. The last points are the values of X-MAX and Y-MAX on Page 3 - 3-D Scaling (see Section 4.7). If a zero value is specified, only a single line will be plotted to represent the function.

The Interval Between Lines can also be specified as a negative number. The absolute value of this negative number represents the size of the interval between two adjacent lines.

Example: The computed function representing the surface is to be evaluated over the domain

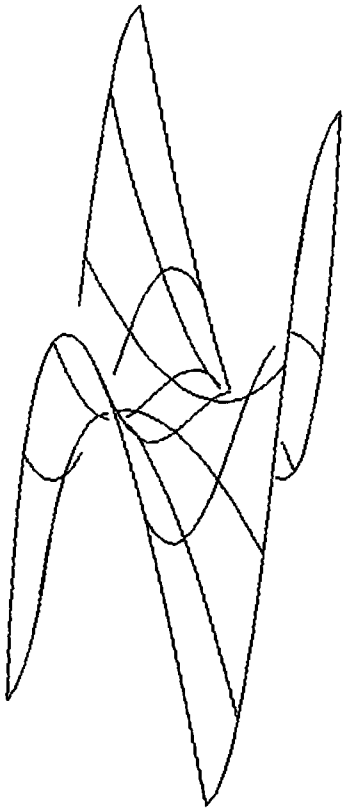
X-MAX = 180 , X-MIN = 0
and
Y-MAX = 180 , Y-MIN = 0

If the Interval Between Lines = -30 then $\frac{180 - 0}{-30} = -6$

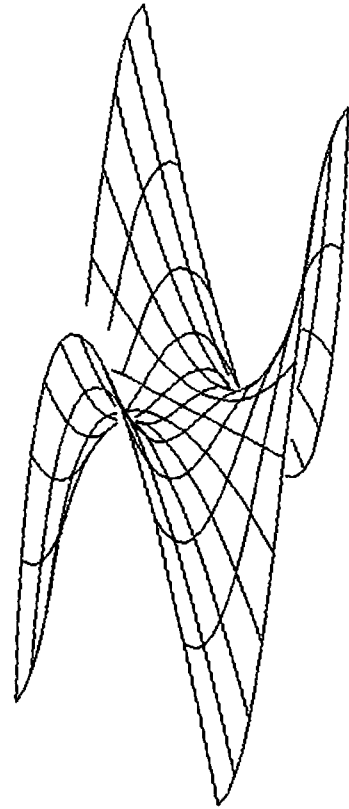
The system uses the value of 6 as the number of intervals between Lines.

NOTE:

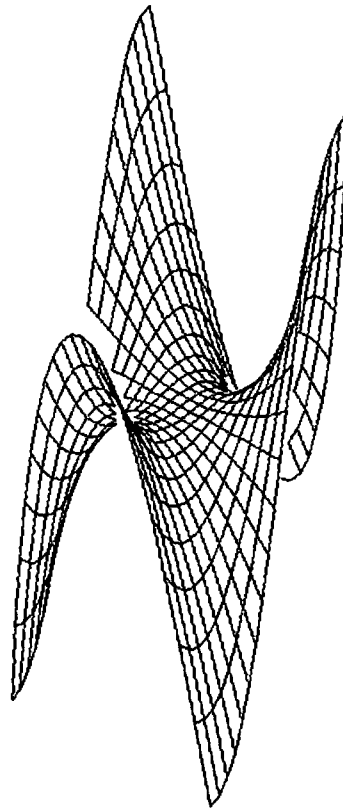
If the Interval Between Lines specified as a negative number does not produce an integer when divided into the difference between the maximum and minimum values, the system may not draw the last line intended by the user. If this occurs, the user may select a slightly smaller value for the increment to insure that the last line desired falls just within the maximum value rather than just beyond. As an example, for X-MIN = 0 and X-MAX = 4, an Interval Between Lines value of -.66 will produce better results than -.67.



OF INTERVALS BETWEEN LINES = 5



OF INTERVALS BETWEEN LINES = 10



OF INTERVALS BETWEEN LINES = 20

Figure 4-4. Surface Representations using Interval Between Lines Values

Intervals Per Line

It must be understood that in most computer graphics applications, the lines displayed on the plotter are not continuous curves. On a line plotter (such as the Models 2212, 2232, 2272 and Tektronix) a curved line is represented by a series of short, straight line segments drawn between a chosen number of points which lie on the curve. On a point plotter, such as the Model 2202, a curved line is constructed by a series of closely positioned points which lie on the curve. In the system, the closeness with which these lines follow the three-dimensional surface is determined by the number of points on each line. As with the Interval Between Lines, the "fineness" of a line is specified as the number of intervals between points on the line. The "fineness" of the line structure is directly proportional to the number of intervals per line. For lines in both directions, the number of points per line (one greater than the number of intervals) is the same in each direction. Figure 4-5 illustrates the relation of line structure with the number of intervals per line.

The value for Intervals per Line can also be specified as a negative number. The absolute value of this negative number represents the size of the interval between the first and last points used to scale the computed function representing the surface.

Example: The computed function representing the surface is to be evaluated over the domain

X-MAX = 360 , X-MIN = 0
and
Y-MAX = 360 , Y-MIN = 0

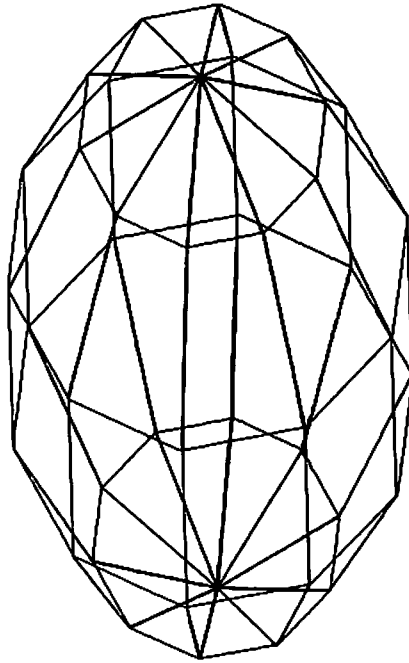
If the Interval Between Points = -60 then $\frac{360 - 0}{-60} = -6$

The system uses the value of 6 as the number of intervals per line.

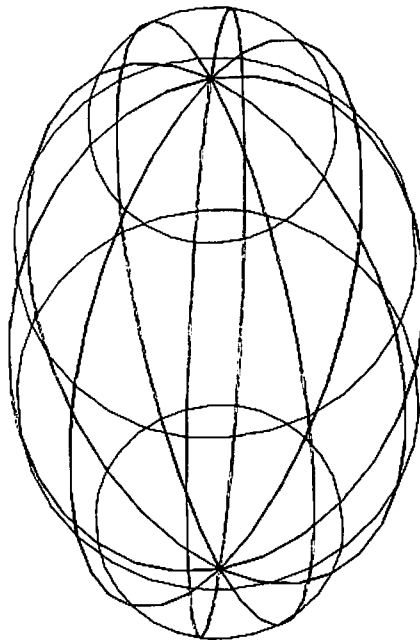
NOTE:

If the Intervals per Line specified as a negative number does not produce an integer when divided into the difference between the maximum and minimum values, the system may not complete each line to the specified maximum.

If a zero value is specified, only a single point will be presented on the line. Both Intervals between Lines and Intervals per Line may not be zero.



INTERVALS PER LINE = 10



INTERVALS PER LINE = 30

Figure 4-5. Line Structure versus Intervals per Line

Cross-over Points for Lines in Both Directions (Line Plotters)

On line plotters for lines in both directions, if the user wants the two sets of lines to cross at points that correspond to actual points on the surface, he must specify that the "# of Intervals per Line" be an integer multiple of "# of Intervals Between Lines". (This is essentially the rationale for specifying values as "# of intervals" rather than # of lines or # of points.) Figure 4-6 illustrates this point for line plotters.

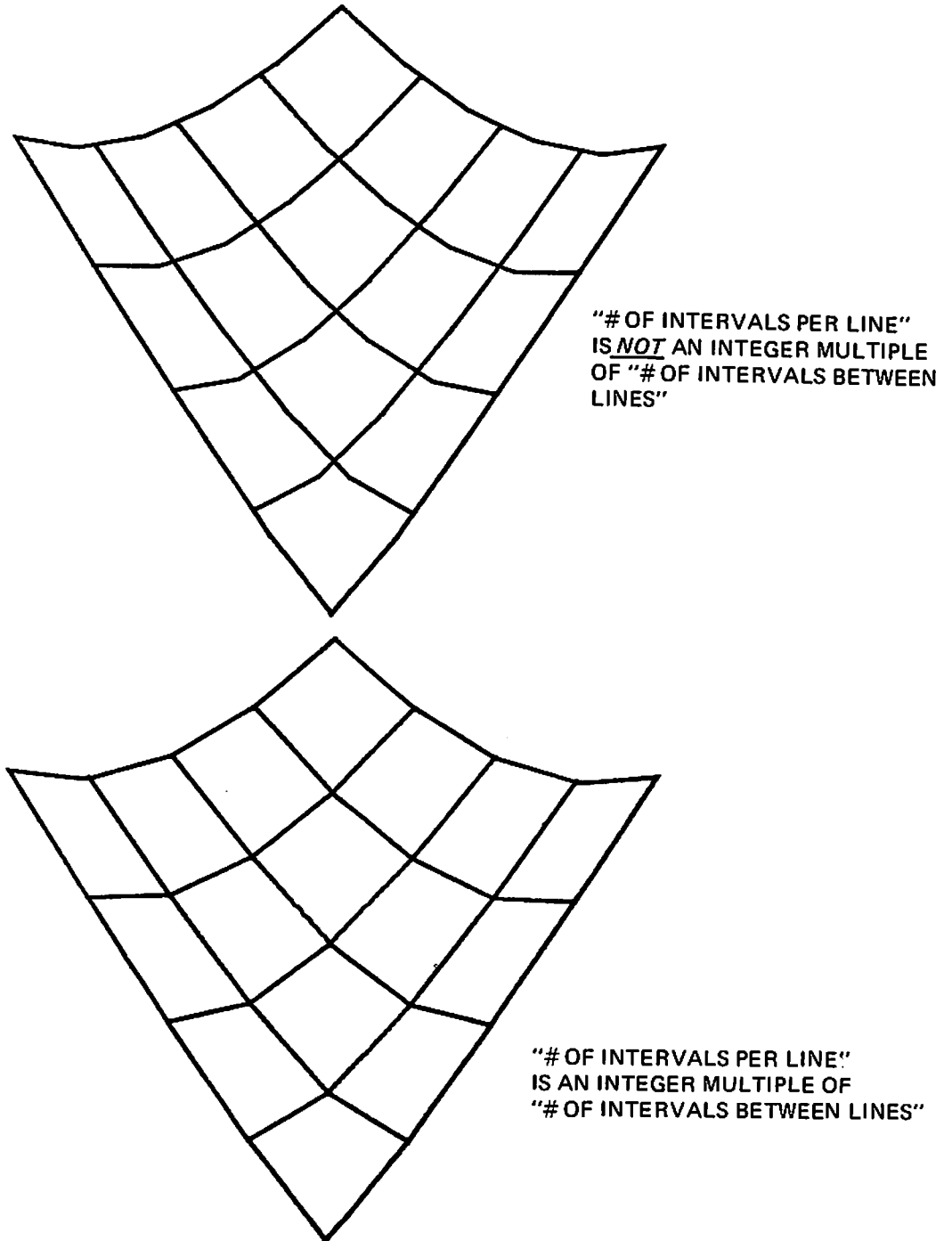
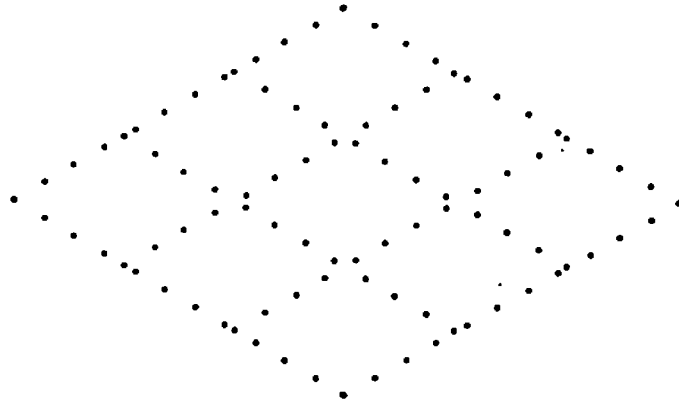


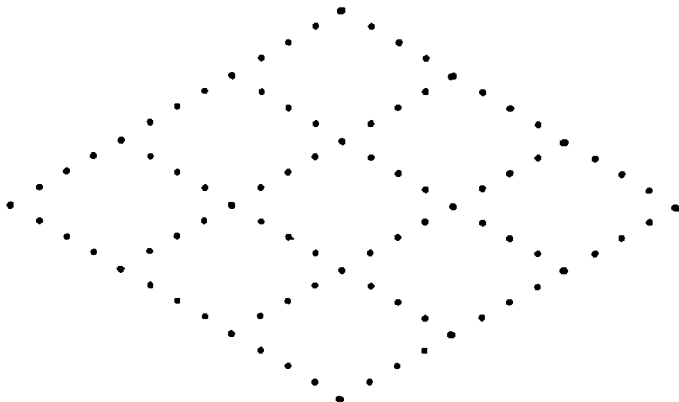
Figure 4-6. Crossover Points for Line Plotters

Cross-over Points for Lines in Both Directions (Point Plotters)

On point plotters for lines in both directions, if the user wants the two sets of dotted lines to share points in common at intersections, he must specify that the "# of Intervals per Line" be an integer multiple of "# of Intervals Between Lines". Figure 4-7 illustrates this feature for the point plotter.



"# OF INTERVALS PER LINE" IS NOT
AN INTEGER MULTIPLE OF
"# OF INTERVALS BETWEEN LINES"



"# OF INTERVALS PER LINE" IS AN
INTEGER MULTIPLE OF "# OF
INTERVALS BETWEEN LINES"

Figure 4-7. Cross over Points for Point Plotters

Hidden Point Accuracy

The hidden point feature in 3-D plotting allows the user to suppress line segments which represent portions of the surface which lie behind or are hidden by other portions of the surface. The hidden point option is only available when a rectangular coordinate system is being used and the independent variables x and y are used as the point coordinates X and Y of the point (X, Y, Z) on the surface. In GUS, the hidden points option is activated when the hidden point accuracy value is specified as a positive integer. In the hidden point process (described below), the positive integer value represents the maximum number of points that will be examined for each point that is to be plotted. If the value for hidden point accuracy is zero, the program does not attempt to hide points.

The factors to be considered in selecting a positive integer for hidden point accuracy value are:

1. A larger number produces a clearer line between hidden and exposed surfaces.
2. Steeply sloped surfaces will require a larger number for this value.
3. A larger number substantially increases plotting time.
4. The user must make a trade-off between (1) and (3).

To decide if a point shall be hidden, the program checks to see if any part of the surface is in front of the point in question. The program examines points on a line from the point in question in the direction from which the graph is being viewed. The program examines points along this line until the surface crosses the line, in which case the point is hidden and not plotted. The distance between two successive points on the line being examined is called the increment and is computed using the value entered for Hidden Point Accuracy. Figure 4-8 shows a surface plotted with and without the hidden point feature.

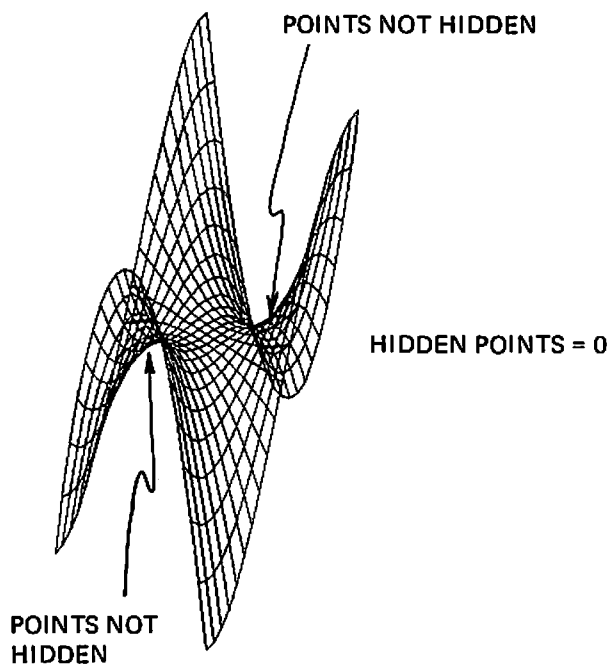
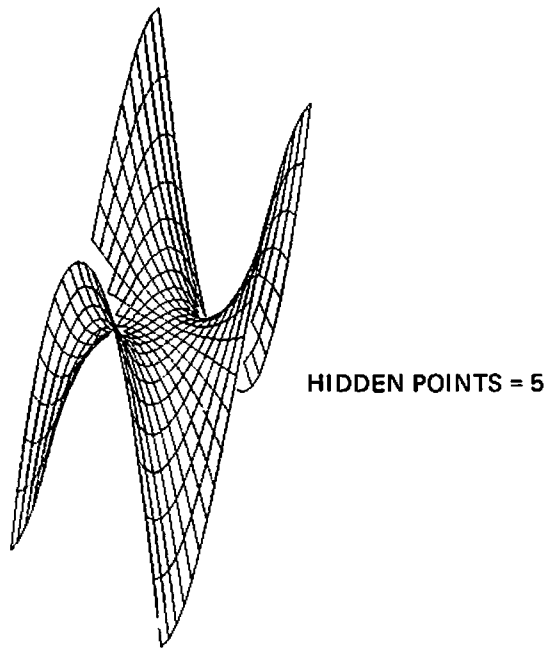


Figure 4-8. Hidden Points in Rectangular Coordinate System.

Direction of View

The Direction of View parameter allows the plotted function of a surface to be viewed from any direction specified by the user. This direction is entered as a vector from the origin toward the viewer. The three coordinates of the vector are specified in the "object" coordinate system (X,Y,Z) as the X Coordinate, Y Coordinate and Z Coordinate of Direction of View respectively.

From this direction of view, a plane is constructed which is perpendicular to the vector. This plane represents the two-dimensional surface onto which the image of the three-dimensional object or surface is being projected. Figure 4-9 illustrates this concept.

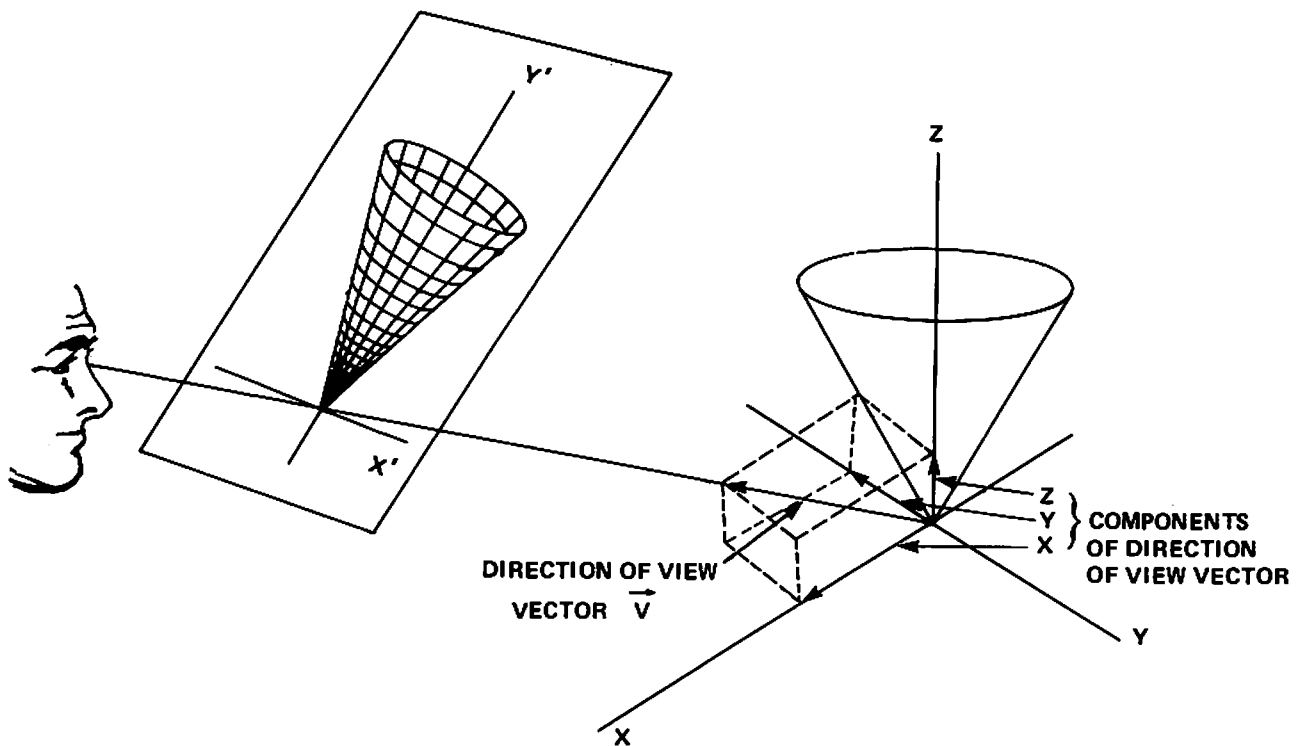


Figure 4-9. Direction of View

In many applications, particularly in descriptive geometry and engineering drafting, a standard direction of view is used resulting in an isometric projection. This direction of view produces a projection in which all three axes are equally dimensioned when projected. In other words, unit length lines which lie parallel to any of the three original axes in the "object" coordinate system are of equivalent length in the two-dimensional projection.

The system considers the isometric projection with direction vector ($\sqrt{2}$, $\sqrt{2}$, $2\cos 35$) to be the "standard view" and displays these numbers as the default values in items 5, 6, and 7 of the table when a new parameter file is entered from the keyboard. As with any parameter, they may be altered by the user.

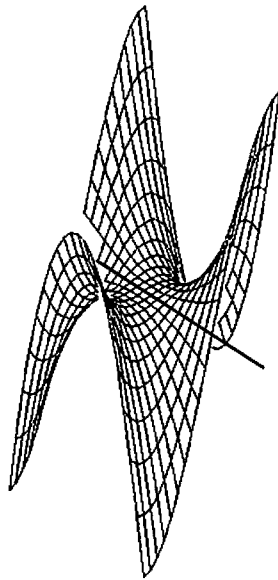
Vertical Vector

To orient the projection on the plane which is perpendicular to the direction of view, the coordinates of the vertical vector of the projection must be specified. This vector specifies a direction in the object space which will be projected from the origin to the top of the paper (or screen) in the image space. The vertical direction of the projection is expressed in the original coordinates of the object coordinate system and is entered as the X Coordinate, Y Coordinate, and Z Coordinate of the vertical vector (items 8, 9, and 10).

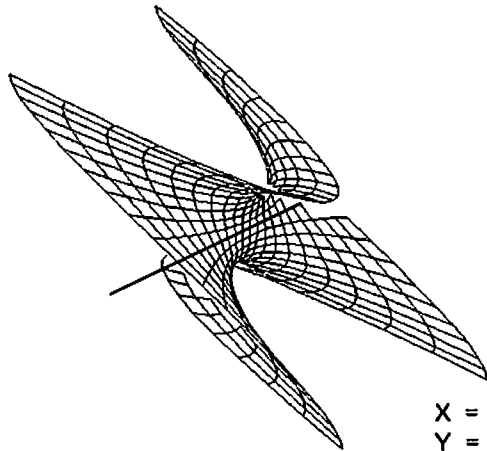
In most instances, it is desirable to show the positive Z axis of the object coordinate system along the vertical or Y' axis of the projection. This insures that what is "up" on the object will remain "up" on the image. The system therefore provides the vector (0, 0, 1) as the default values for the vertical vector.

The standard default values may be changed as required. For example, if the original surface (or function) is greater in one direction than another, it may be desirable to rotate the projection so that the greatest dimension of the object is plotted in the direction of the longest side of the available plotting area. Figure 4-10 illustrates a surface plotted with three different values for the vertical vector.

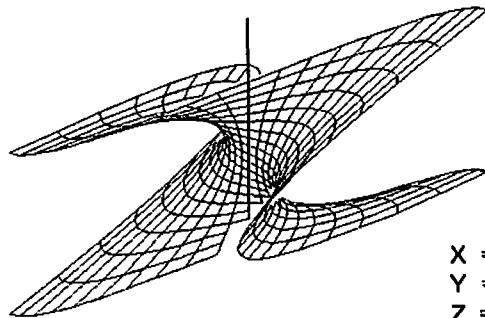
The function letter D (STANDARD DIRECTION) is used to restore the X, Y, Z components of the vertical vector to the standard default values (0, 0, 1), as required.



X = 0
Y = 0
Z = 1



X = 1
Y = 0
Z = 0



X = 0
Y = 1
Z = 0

Figure 4-10. Illustration of Vertical Vector Concept

4.7 PAGE 3 - 3-D SCALING (3-D PLOTTING)

ENTER A LINE NUMBER OR A FUNCTION LETTER
?--
_

PARAMETER FILE = (NONE)
PAGE 3 3-D SCALING

1...LINE OPTION TO SCALE = 0 3...INTERVALS PER LINE = 0
2...INTERVALS BETWEEN LINES = 0 4...SCALE FACTOR = 0
5...X-MIN = 0 8...Y-MAX = 0
6...X-MAX = 0 9...Z-MIN = 0
7...Y-MIN = 0 10...Z-MAX = 0

C = CHANGE ALL ANSWERS S = SAVE PARAMETERS
N = NEXT PAGE R = RETURN TO SYSTEM MENU
P = PREVIOUS PAGE A = ADVANCE TO LABELS MODULE
V = VALUES OF Z & SCALE L = LOAD A FUNCTION FILE

Line Option, Intervals for Lines and Points, Scale Factor

In GUS the size of the object surface and the size of its image are independent of each other. In fact, the system is designed to execute a plot with the same graphic input on six different plotter models with vastly different plotting area characteristics. It is through the Scale Factor that the relationship between object and image is expressed.

Before plotting can begin a scale factor must be established. To perform the necessary scaling calculations, it is necessary for the program to evaluate the function at various points and keep track of their range of values. To produce a plot with the appearance of a smooth surface may require a large number of points (entered as items 2 and 3 on Page 2) to be checked especially if the nature of the function is unknown, unpredictable or contains sharp peaks. Note that the same values entered as items 1, 2, and 3 on Page 2 are automatically entered as items 1, 2, and 3 on Page 3.

If, on the other hand, the computed function contains no sharp peaks and is predictable, it may be feasible to examine the function for scaling purposes at fewer points than are desired for plotting. Therefore, items 2 and 3 may be changed to smaller values in order to reduce computer time. Furthermore, the predictable nature of the function may make it possible to scan along lines in only one direction for scaling even though both directions are specified for plotting purposes. In this situation item 1 Line Option to Scale may be changed.

As the user gains more experience with the system he may be able to select and enter an appropriate value for the scale factor in lieu of the one computed by the system.

X MINIMUM AND MAXIMUM/Y MINIMUM AND MAXIMUM

A three-dimensional plot is represented by sets of short straight line segments drawn between points on the surface. Previously (in items 1, 2, and 3 on Page 2), the number of points in each set was specified. Now the domain over which these points are distributed must be entered in the system. The values entered are the maximum and minimum values of the independent variables x and y to be used as inputs to the computed function. In the menu these values are entered as X-MIN, X-MAX and Y-MIN, Y-MAX.

In the simplest application the x 's and y 's provided are used as the X and Y in a rectangular coordinate system. In a cylindrical coordinate system the x 's and y 's provided may be equated to X and Y in the computed function when these letter variables are taken to be r and θ respectively, and $z = f(r, \theta)$. Likewise in a spherical coordinate system, the x 's and y 's may be equated to X and Y in the computed function where the x and y are taken to be r and θ and ϕ is computed by the function. (See Appendix B).

In more sophisticated applications, the x 's and y 's are arbitrary parameters from which all three coordinates (X, Y, Z or r, θ, z , r, θ, ϕ) are computed. (See Appendix B, example 4).

Values of Z and Scale Factor - Function Letters L and V

The function letter L allows the operator to enter the name of a program file containing the computed function routine. After the program file is entered from the data disk, automatic scaling of the computed function is initiated with Function Letter V.

At the completion of the scaling processes the following features are noted on the CRT:

1. The largest and smallest values of the third value produced by the computed function is displayed as Z MINIMUM and Z MAXIMUM (items 9 and 10 of Page 3). In the simplest case, the values of Z MINIMUM and Z MAXIMUM are a function of x and y in rectangular coordinates system of the object.
2. The largest and smallest values of X' and Y' , the coordinates of the image of each point, are displayed temporarily on the third line of the CRT screen. If a hardcopy output is to be produced, these values are shown as item 13 and 14 on the printed copy. The values X' and Y' are important in the creation of a label file (see Section 6.2 Menu Items (X Coordinate, Y Coordinate)).

3. A value is assigned to the SCALE FACTOR (item 4). The calculation of a SCALE FACTOR is dependent upon the range of values for X' and Y'. The SCALE FACTOR cannot be computed if the range is zero, that is if all the values are equal to each other for either X' or Y'. This is the case if all the points examined are projected onto the same horizontal or vertical line. In such a case, an error message, SCALING ERROR is displayed. This condition is always true if the interval between lines and the interval between points on a line are both zero. (See Appendix C for more Scale Factor information.)

It should be noted that the 3-D image will be positioned at the center of the plotting area. Unless the SCALE FACTOR is manually changed, the plot is scaled to extend from one margin to the other either horizontally or vertically but may not completely fill the graph area in both directions. Hence, the actual plot may be narrower or shorter than the specified graph area. (See Appendix E).

CHAPTER 5 ENTER DATA POINTS MODULE

5.1 INTRODUCTION

The Enter Data Points module is only used in two-dimensional plotting. This module allows the user to create and maintain "standard data files" of data points in the form of X-Y coordinate pairs. The module can be called from the System menu or advanced from the Enter Parameters module. In either case, the menu asks:

ENTER THE NAME OF THE INPUT FILE, IF ANY.

If a name is entered, the contents of the named file are read from the data disk and the X-Y values of the first five data points are displayed on the CRT. The data points in the named file can be modified as required. If no name is specified, all values must be keyed in manually from the keyboard to create a new data points file. Data points are entered as numeric pairs of values corresponding to X and Y coordinates (or r and θ if polar coordinates). Coordinates are accepted in normal as well as exponential format with up to five significant digits. The data is entered in the units to be represented on the graph.

5.2 DEFAULT VALUES OF X

If data points are uniformly spaced along the x-axis of a 2-D plot, the user can elect to have the X values provided automatically during data entry. For instance, a graph of a company's revenue versus time might have the time(X) axis go from 1955 to 1975 in five year intervals. The system displays

DO YOU WISH TO USE DEFAULT VALUES FOR X?

If the user responds in the affirmative, the system continues with

FIRST X

In the example above, the FIRST X value is 1955. The next item displayed is:

INCREMENT BETWEEN X VALUES

In the example above, INCREMENT BETWEEN X VALUES is 5. When the automatic X default option is selected, a null response must be entered each time the system asks for the X Coordinate of the first data point. The system responds by automatically displaying the value specified for "FIRST X". Y values are not defaulted and must be entered when requested each time. When the system requests the X value for the second data point, the user must again enter a null response. The system automatically increments the value of the first data point (point number 001) by the entry specified in INCREMENT BETWEEN X VALUES.

The operator can override the default X procedure by entering a non-blank value for X when the system asks for an X coordinate. This may be done for one data point or a sequence of data points. The system reverts back to the default X procedure when a null response is again entered for the value of X.

5.3 MENU ITEMS

Items in the Data Points menu are displayed and entered in X-Y coordinate pairs. The X-coordinate is entered first and the Y-coordinate is entered second. Five data point pairs are shown on the CRT at any one time ranging from 1 to 5, or 6 to 10, or 11 to 15, etc. For example, when the first five data point pairs are entered, the next page of points 6 to 10 is automatically displayed on the CRT. The data points displayed are updated only after both X and Y coordinates of a point are entered. If data points being entered are in polar coordinates, the radius in graph units is entered first (in response to the X-coordinate prompt), and the angle in degrees is entered second (as the Y-coordinate).

5.4 LETTER OPTIONS

In addition to function letters S, A, and R, the following function letters are used in the Data Points Module:

CX = CHANGE ITEM # X

This function letter can be used to change a consecutive sequence of previously entered data points. In addition, it is used to add any number of points onto the end of the data point file. For example, if ten Data Point Pairs are in the file, entering a "C11" will initiate adding new points to the file. With the CX function the system will ask for the next sequential X,Y coordinate pair until Special Function Key '15 is depressed.

IX = INSERT #X

The function letter IX allows new data points to be inserted between existing data points. The module creates a space at the point X for the insertion of a new point. For example, to insert a data point between points 1 and 2, enter I2. The system creates a hole at the SEQ# 2 for the insertion of a new data point. Upon entering the data for data point 2 the system creates a hole for data point 3. The user may continue to enter data points or may terminate data, entry with the Special Function Key 15. After the Special Function Key '15 is depressed, the space created for the data point is deleted.

DX = DELETE ITEM #X

The DX function letter deletes data points starting at number X. For example, to delete data point 2 enter D2. A prompt to enter the number of the last data point to be deleted must be answered. To delete only data point 2, enter 2. If data points 2 through 5 are to be deleted, enter 5.

After a data point is deleted the space created by the deletion is automatically filled and subsequent data points are advanced. The deletion of data points is canceled without deleting any points if Special Function Key '15 is keyed instead of a number in response to the prompt for the last data point to be deleted.

N = NEXT PAGE / P = PREVIOUS PAGE

In the Data Points module the function letters N and P are normally used to examine respectively the next and previous pages of a completed data file. For this purpose the five consecutive data points displayed as a screen load are considered to be a page.

CHAPTER 6 ENTER LABELS MODULE

6.1 INTRODUCTION

The Enter Labels module is advanced (via the function letter A) from the Data Points module when a standard data file is used or from the Enter Parameters module when a non-standard data file or computed function is used. The Enter Labels module can also be called from the System Menu. In all cases the menu asks:

ENTER THE NAME OF THE INPUT FILE, IF ANY

If a name is entered, the contents of the named file are read from the data disk and the information concerning the first label is displayed on the CRT. If no name is specified, all values must be keyed in manually from the keyboard to create a new labels file.

The module continues with:

CHARACTER TYPE (S = SOFTWARE, H = HARDWARE)

This question is asked only for the Model 2212, 2272 and 2282 plotters which have built-in (hardware) lettering capabilities. For these plotters the default for this question is HARDWARE unless the input file (read from the data disk) was set up to be SOFTWARE. For the other plotters, the system automatically assumes SOFTWARE lettering and bypasses this question.

IF software characters are specified the module displays:

ENTER THE NAME OF THE CHARACTER ARRAY

A standard character array (called CHARF010) is supplied with the system on the program disk. It can be used to define the software character set. Alternately, the user may enter the name of his own character array.* The default for this question is the array specified when the input file was created.

* Consult the 2200 Plotter Utilities Manual (700-3838) for creating special characters.

6.2 MENU ITEMS

TEXT

The label text may contain up to 35 uppercase characters or symbols.

SIZE OF LETTER

For hardware lettering, the size can vary from 1 to 15. In software lettering the size variation is 1 to 999. After a label text and size have been entered the length of the label (as it will be plotted) is displayed on the CRT in the physical units (inches, centimeters, etc.) selected in the Initialize System module. In hardware lettering the length will be modified if a non-zero value is specified for ROTATION (item 4). The user may judge the length and modify the text or size of letters as required. The expressions for determining length are related to the plotter type (See Tables 6-1 and 6-2).

Table 6-1. Software Characters
Factor Table

Plotter	Inches	Cm.
2202	.08	.20513
2212	.08	.20513
2232 ENGLISH	.02	.051
2232 METRIC	.0157	.04
2272 ENGLISH	.04	.1013
2272 METRIC	.0315	.08
2281P	.133	.333
2282	.1143	.2895
TEKTRONIX	.1143	.2895

LENGTH = (size) (no of characters in text) (factor)
including spaces

Table 6-2. Hardware Characters
Factor Table

Plotter	Inches	Cm.
2212	.13	.333
2272 ENGLISH	.13	.3291
2272 METRIC	.102	.26
2282	.146	.371

LENGTH = (size) (no. of characters in text) (factor)
including spaces

SLANT

This feature is only available for software lettering. SLANT distorts the orientation of the text characters as shown in Table 6-3 below. SLANT must be specified in degrees as a value between -90 and 90 degrees. It should be noted that SLANT and the actual angular distortion of characters from the vertical position are generally not equivalent.

Table 6-3. Character Orientation Versus Slant Angle

<u>Slant Angle-degrees</u>	<u>Actual Angular Distortion from the Vertical</u>	<u>Distortion of Sample Character</u>
90	45	<i>A</i>
40	30	<i>A</i>
15	15	<i>A</i>
0	0	A
-15	-15	<i>A</i>
-40	-30	<i>A</i>
-90	-45	<i>A</i>

ROTATION

If software lettering is selected, the Angle of Rotation causes the text label to be rotated around the plotter X-axis as shown in Figure 6-1. By selecting different combinations of SLANT and ROTATION values various labelling effects as shown in Figure 6-2 are possible.

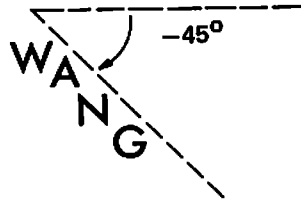
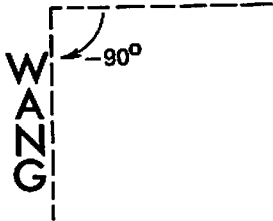
If hardware lettering is selected, each character of the label will be plotted vertically with the Angle of Rotation used to determine the direction to move to plot a subsequent character in the label. (See Table 6-4 below.)

ROTATION must be specified in degrees and must be between -360 and 360.

NOTE:

Although it is possible to change a label file from software to hardware, the system does not automatically modify the size specified. Therefore, the factors of Table 6-2 will apply. Slant is ignored and Rotation is interpreted differently. At plot time a label with a size greater than 15 will not be plotted and an error message will be displayed.

Table 6-4. Text Orientation Versus Rotation Angle
(Hardware Characters)

<u>Rotation Angle-degrees</u>	<u>Sample Plot</u>
0	WANG
-45	
-90	

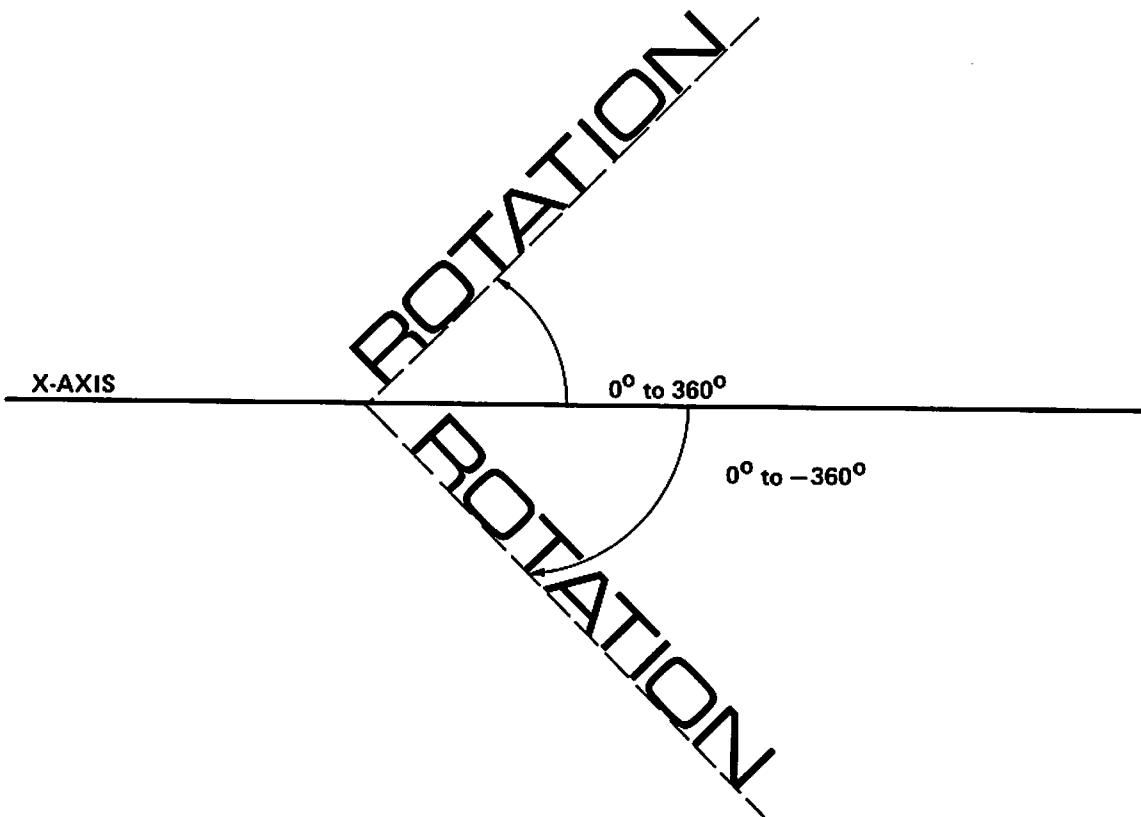


Figure 6-1. Sample Rotation of Text (Software Lettering)

THE QUICK BROWN FOX (SLANT=90)
THE QUICK BROWN FOX (SLANT=40)
THE QUICK BROWN FOX (SLANT=15)
THE QUICK BROWN FOX (SLANT=0)
THE QUICK BROWN FOX (SLANT=-15)
THE QUICK BROWN FOX (SLANT=-40)
THE QUICK BROWN FOX (SLANT=-90)

a) Slant only

SLANT=90 & ROTATION=45

SLANT=-90 & ROTATION=-45

(b) Slant and Rotation

Figure 6-2. Sample Slant and Rotation Orientations of Text (Software Lettering)

POSITION OPTION

The Position Option specifies how the label text is to be plotted with respect to a reference coordinate point. The user designates the reference coordinate point as the start, center, or end point of the text label. (See Table 6.5). The reference point is specified by the X and Y coordinates in items 6 and 7 of the menu.

Table 6-5. Orientation of Text Versus Position Option

<u>Position Option</u>	<u>Text Position</u>
1 START AT REFERENCE POINT	TEXT LABEL (X,Y)
2 CENTER AT REFERENCE POINT	TEXT LABEL (X,Y)
3 END AT REFERENCE POINT	TEXT LABEL (X,Y)

X COORDINATE, Y COORDINATE

The reference point of a label is entered in rectangular coordinates. The X COORDINATE is the X position of the reference point specified in terms of the lower-left corner of a character. The Y COORDINATE is the Y position of the reference point relative to the lower-left corner of a character. Reference point coordinates are entered in graph units.

Note on 3-D Plotting:

For 3-D plotting, the X COORDINATE and Y COORDINATE values are entered in the "image" coordinate system X' and Y' as graph units and not physical units. To facilitate this, PAGE 3 3-D SCALING of Enter Parameters makes available to the user the maximum and minimum values of X' and Y' at the completion of scaling. The maximum and minimum values of X' and Y' are also shown in the last two lines of the hardcopy output of the parameter file. As in the case for 2-D Plotting, X COORDINATE and Y COORDINATE must be specified within the active plot area (See Appendix E.)

6.3 LETTER OPTIONS

In addition to the function letters S, R, or A for saving a label file the following letter options are available:

D = DELETE THIS LABEL

This function letter is used when a particular label is no longer needed in the label file. After the D function is executed, the label currently on display is deleted and all other entries in items 2 through 7 are set to zero. The space left in the label file is not closed up until all the labels are saved on the data disk.

E = ENTER A NEW LABEL

System control moves to the end of the current set of labels and allows the user to add a new label at the next sequential position. There is no "insert label" feature in this module; labels are always added to the end in sequence. Following the entry of "E" all item numbers are sequentially prompted.

N = NEXT LABEL

The next label in the current file of labels is displayed.

P = PREVIOUS LABEL

The previous label in the current file of labels is displayed:

FX = FIND LABEL #X

The system locates the label by number (#X) and displays it.

L = PLOT THIS LABEL


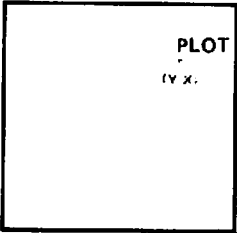
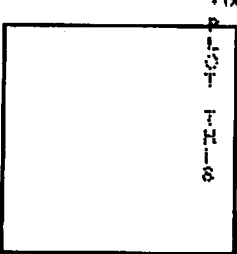
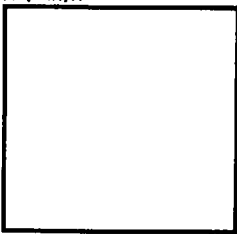
The label currently on display is plotted. The first time function L is selected for a particular label file, the program asks for the name of a previously created parameter file containing the necessary scaling information. This file and the character file named on entry to the module are read before plotting the label. The default parameter file is the last one activated by the system.

Before plotting a label the X and Y coordinates of the reference point are checked to see if they are within the active plotting area. If the X and Y coordinates of the reference point do not fall within the active plotting area defined in the parameter file, the label may not be plotted (see conditions in Table 6-6).

NOTE TO MODEL 2282 USERS ONLY

In addition to L, an LC function is available. The LC clears the Model 2282 Graphic CRT before the label is displayed on the screen.

Table 6-6. Plotting Labels and the Active Plotting Area

<p style="text-align: center;">Case 1</p> <p>The X and Y coordinates and the entire label are accommodated in the active plot area. This is the normally expected condition and plotting will occur correctly.</p>	<p style="text-align: center;">Example 1</p> 
<p style="text-align: center;">Case 2</p> <p>The X and Y coordinate is inside the active plot area but a portion of the label is outside. That portion of the label which is inside the area will be plotted. If hardware lettering is being used the remainder of the text may also be plotted if within the limits of the plotter boundaries. However, detectable irregularities may be produced during plotting.</p>	<p style="text-align: center;">Example 2</p> 
<p style="text-align: center;">Case 3</p> <p>The X or Y coordinate is outside the active area and some of the label is inside the area. None of the label will be plotted and an error message will be displayed on the CRT.</p>	<p style="text-align: center;">Example 3</p> 
<p style="text-align: center;">Case 4</p> <p>The X and Y coordinate and all the label is outside the active area. None of the label will be plotted and an error message will be displayed on the CRT.</p>	<p style="text-align: center;">Example 4</p> 

CHAPTER 7 START PLOT MODULE

7.1 INTRODUCTION

The Start Plot module has two menus or pages for both two-dimensional and three-dimensional plotting. The first page PAGE 1 - FILE NAMES ETC asks for the name of a Parameter file, whether the axes, labels, and graph are to be drawn and if needed the names of label, data, and computed function files. The second page of the Start Plot module is strictly optional. It contains a set of plotting changes and enhancements that the user may exercise if he so desires. Plotting can proceed from Page 1 without going to Page 2. In two-dimensional plotting, PAGE 2-OPTIONS asks for the point symbol to be used in plotting line graphs, symbol size, and whether to plot a regression line in addition to the graph. In three-dimensional plotting, PAGE 2-3D GRAPH OPTIONS asks for the location of the axes in the plotting area and the option to suppress lettering the axes.

When the appropriate parameter, data generating information, and label files have been created, and stored on the data disk, execution of the Start Plot module may proceed. On any given execution of the plotting module, any combination of (1) parameter file, (2) data set or computed function, and (3) label file may be selected. When the specified plotting has been completed, the program returns to the beginning of the Page 1 menu to allow further selections to be made for execution on the same page or a new page.

No information entered into the Start Plot menu is saved on disk.

7.2 PAGE 1 - FILENAMES ETC.

In order to simplify data entry into the menu, only those items that require answering are displayed. Thus there may be apparent gaps in the item numbers depending on the responses.

START PLOT USING PARAMETER FILE

The name of the parameter file to be used for the graph must be specified in item 1 no matter what choices are made for options and items 2 through 4. The parameter file must be specified before item 4 can be selected. Upon execution the parameter file is read immediately from the data disk and the name is displayed in item 1.

DRAW AXES

A Y/N option. If the response is yes, the axes will be drawn as specified in the parameter file named in item 1.

NOTE FOR 2-D PLOTTING:

In two-dimensional plotting, axes numbering may or may not occur depending on the "number the axes" option selected during the creation of a parameter file.

LABEL GRAPH

A Y/N option. If Y, the name of a label file must be specified in item 5-LABEL FILE. The label file prompt only appears if labels are to be drawn. If a label file was previously activated by the system, its name is displayed in item 5 as the default entry.

DRAW GRAPH

DRAW GRAPH is a Y/N option which allows the user to produce the actual lines, points, or "stretchable net" of a line graph, point graph or 3-D plot, respectively, as distinct from the Axis and label options above. If Y, the name of a standard data file, computed function program file, or non-standard data program file must be specified. Item 6 PROGRAM FILE is displayed only if the data source is a computed function or a non-standard file. If a program file was previously activated, its name is displayed in item 6. Item 7, DATA FILE is displayed only if the data source is a standard data file. If a data file was previously activated, its name is displayed in item 7 as the default entry.

NOTE:

Before going on to plot (via function letter G (see Section 7.5)) or proceeding to the Page 2 - START PLOT OPTIONS menu, values must be filled in for all items displayed on Page 1. Also the system does not accept an input of "N" (NEXT PAGE) on Page 1 unless DRAW GRAPH has been set to yes (Y).

7.3 PAGE 2 - START PLOT OPTIONS (Two-Dimensional Plotting)

In two-dimensional plotting three different versions of Page 2 are displayed according to the selection made for GRAPH TYPE in the parameters file entered in Page 1. (GRAPH TYPE can be Line Graph, Point Graph, or Bar Graph.)

Menu Items (Line Graph)

Line Type

Five types are available: DASH, DOT, DASH/DOT, SOLID and NONE. If "NONE" is selected, the graph becomes a point graph. The default choice shown on the screen is SOLID.

Interval Length

This item is asked only for line types with dots and/or dashes. The available lengths are SMALL, MEDIUM, and LARGE for which the letters S, M, and L respectively are to be entered.

NOTE:

The Graph Utility System can provide graphs from the smallest legible size up to 31 by 40 inches. To adequately provide for this range, the system determines whether a graph is small, medium or large size. This decision is used to set the length of hash marks, the size of the numbers used for axes numbering and to provide a default size for the options described here. For this purpose the length of the shorter axis is calculated and adjusted for the particular plotter model selected. If the graph is less than 8 inches on an English plotter or 16 cm. on a Metric plotter, the graph is considered SMALL. If the graph is 8 or more inches (or 16 or more cm.) but less than 16 inches (or 32 cm.), it is considered MEDIUM. Graphs larger than 16 inches (32 cm) are considered LARGE. (This calculation is completely independent of the physical unit of measure which is entered in Initialize System.)

Point Symbol

An alphanumeric character or symbol is selected to be plotted at each data point. Different symbols may be employed to distinguish one graph from another when several data sets are plotted on the same area. If the graph type is LINE, it is possible to select options for both a point symbol at data points and a line type between data points. The default choice for Point Symbol is a space, i.e., NONE.

Symbol Size

After the point symbol is selected a default value SYMBOL SIZE is displayed (see previous note). Available sizes are SMALL, MEDIUM and LARGE (S, M or L respectively).

NOTE:

Symbol size is not displayed if the point symbol is a space, i.e., NONE.

Regression Line

A Y/N option, which, if exercised, causes a regression line to be plotted over the data points. In the regression calculation, all points in the data set are used even those that fall outside the graph area. (Note: points with a non-positive coordinate on a log scale are not used). The default value for Regression Line is N.

Menu Items (Bar Graph)

The only option available for a bar graph is the Regression Line.

Menu Items (Point Graph)

The only options on Page 2 available for a point graph are POINT SYMBOL, SYMBOL SIZE, and REGRESSION LINE, which are explained under Menu Items (Line Graph) above. The default for the point symbol of a point graph is ".".

7.4 PAGE 2 - 3-D GRAPH OPTIONS

The only options available for 3-D plotting are the Location of Axes on the Plotting Area and the Lettering of the Axes.

Location of Axes on Plotting Area

The "standard" display of the axes is a small representation (10% of graph size) of the object coordinate system showing the positive half of each axis labeled with X, Y, and Z. The axis is plotted in the lower left hand corner of the plot area if Draw Axes (item 2 of Page 1) is set to yes.

NOTE:

The system does not accept an input of N-Next Page unless DRAW AXES (item 2 in PAGE 1) is set to yes.

Several choices of location of the axes with relation to the plot area are available to the user (see below). Four choices allow placement in any of the four corners. In each case, a small representation of the positive axes is plotted. (See Figure 7-1).

1. LOCATION OF AXES ON PLOTTING AREA

?-----
?

- | | | |
|-------------|-------------|---------|
| 1. UPPER-LT | 2. UPPER-RT | |
| 3. ORIGIN | | |
| 4. LOWER-LT | 5. LOWER-RT | 6. NONE |

An additional choice is to position the axes so that the origin coincides with the origin of the actual plot. In this case, the axes extend from one margin to another and represent both the positive and negative ends of the axes.

NOTE:

The system does not allow this choice if the origin of the plot is not within the 2-D plotting area (image) on the plotter.

The choice "NONE" essentially allows the user to reverse his previous decision and not plot any axes at all.

Letter the Axes

The choice for lettering the axis is a Yes or No. Depending on the circumstances the user may not want the axes to be lettered X, Y, and Z in the standard manner. If lettering is selected, letters are plotted only at the positive end of the axis. In all cases software characters are used from the available character array (the default array CHARF010 or a user-provided array).

NOTE:

LETTER THE AXES is erased from the screen if "NONE" is selected as the response to LOCATION ON PLOT, item 1.

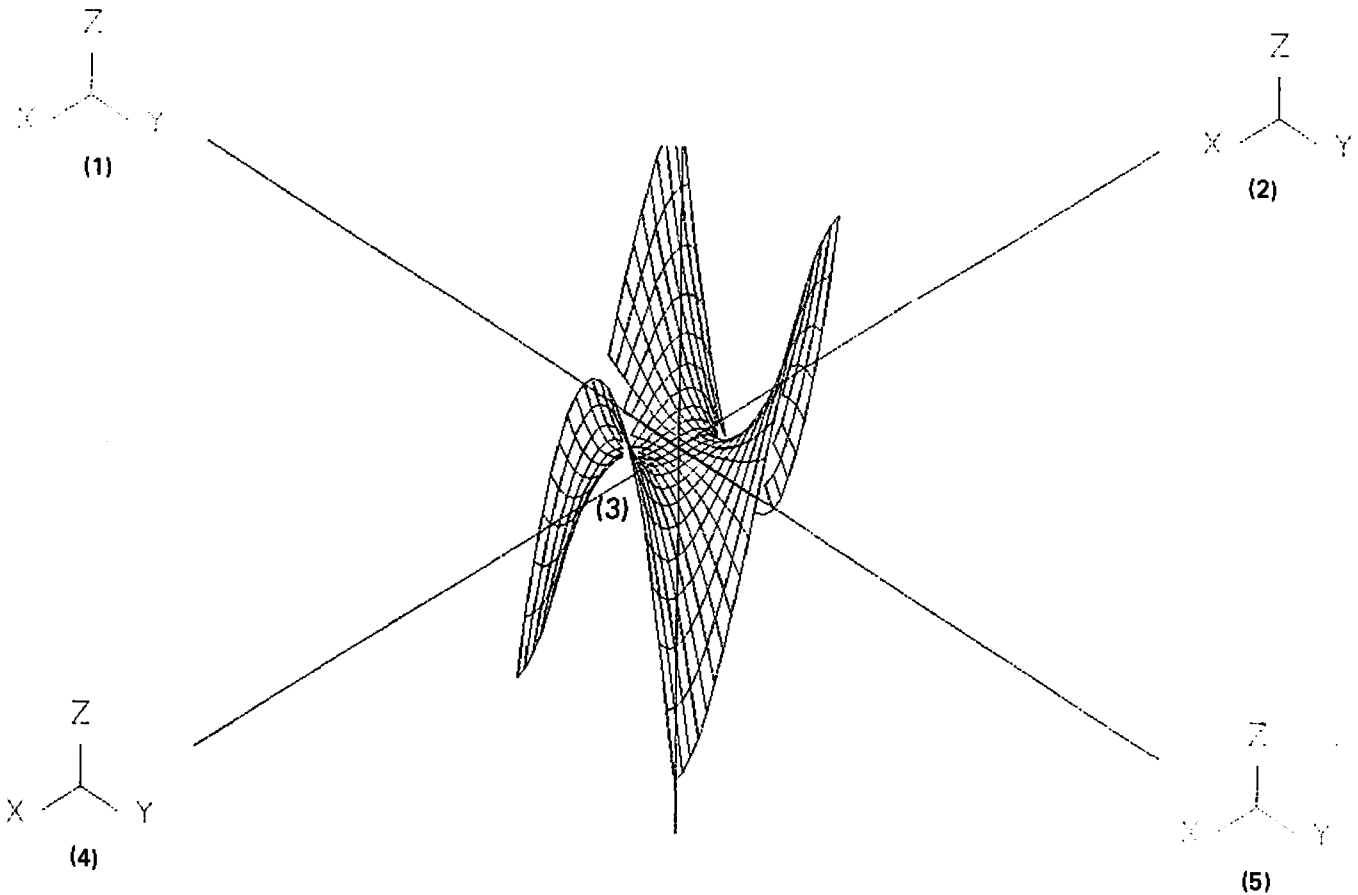


Figure 7-1. Examples of Axes Selection in a 3-D Plot.

7.5 LETTER OPTIONS

C = CHANGE ALL ANSWERS

This function is available on both two- and three- dimensional versions of the Start Plot Module.

Y = CHANGE ITEMS 2 THRU 4 TO YES

This function is available on Page 1 and conveniently activates all graph features.

N = NEXT PAGE

This function need not be entered unless altering certain standard features of the graph is desired. These features are described in Sections 7.3 and 7.4.

R = RETURN TO SYSTEM MENU

Items entered in Start Plot are not saved on the data disk but are intended for immediate execution. Subsequently when R is entered, control returns to the system menu and most information entered into the Start Plot menu is erased. Filenames, however, are retained as defaults.

G = PLOT GRAPH

PLOT GRAPH allows the user to produce the entire plot as specified by items 2 through 4 (on PAGE 1) which may or may not include a yes response to DRAW GRAPH. Function letter G initiates the plotting operations. When function letter G is keyed, the execution of the graph, given the appropriate file names and options if any, proceeds without further user intervention. If errors or inconsistencies in the information are detected, error messages will be displayed on the CRT. Plotting will proceed, nevertheless, to the extent possible. At the conclusion of plotting, all generated error messages are displayed to allow the operator to take note of them. If more than a full screen load of errors are detected, some will be lost when the screen is rolled. RETURN (EXEC) must be keyed to continue. Thereafter, or if no errors occurred, Page 1 of Start Plot is displayed with the previously selected parameter file and items 2 through 4 reset to N. Items on Page 2 are reset to default values.

NOTE TO MODEL 2282 USERS ONLY

When GUS is initialized for the Model 2282, options GC and H are available in addition to G. The function GC clears the Model 2282 screen before plotting begins. The function H transfers the image on the Model 2282 CRT to the Model 2231W-3 printer when the printer is connected to the Model 2282. While the printer is copying the CRT the user is permitted to modify plot selection information or even go to other modules. However, initiating another plot on the Model 2282 must await the completion of the hardcopy on the printer.

Plotting Interruption

Plotting can be interrupted before normal completion by keying Halt/Step and S.F. Key '15. Control is returned to Page 1. Since it may be desirable to redo the same graph if, for example, a pen runs dry, the values on Page 1 are displayed unchanged. The options on Page 2 are reset to the default values as with the completion of a plot.

APPENDIX A

COMPUTED FUNCTION & NON-STD FILE READ ROUTINES FOR 2-D PLOTTING

This appendix describes the procedure for creating Computed Function and Non-Std file read routines. When Data Source on Page 1 of the parameter file is specified as a Computed Function or a Non-Std file, the user must supply a routine to generate data points.

For use as a Computed Function file, this routine must exist in a program file on the disk specified as the data disk. If, however, the DATA SOURCE is a Non-standard Data File, the program which reads it must be on the platter specified as the program disk. The program must occupy lines 6500 to 6999 and only the set of variables starting with X, Y, and Z, I and N (as specified) can be used. Control is passed to the routine at line 6500 where an initialization code should reside. At the end of initialization, control must be given back to the system by executing a GOSUB'99. Following the GOSUB'99 the user supplies a DEFFN'50(Z), followed by code to set up X and Y values. The parameter Z corresponds to the value T displayed on the menu.

Whenever control is passed to DEFFN'50 the system is selected to degrees. If the user wishes, radians or gradians may be selected for computational purposes. It is not necessary to reselect degrees before exiting as the main program automatically reselects degrees.

Example 1, Computed Function:

```
6500 GOSUB'99
6510 DEFFN'50 (Z)
6520 Y = X * Z
6530 X = Z
6540 RETURN
```

Example 2, Computed Function with polar coordinates:

If polar coordinates are selected for scale type in the parameter file, it is assumed that the value returned as X is the radius, r and the Y value is the angle, theta. The program will convert these values to rectangular coordinates before using them for scaling or to plot points.

```
6500 X1 = 4
6510 GOSUB'99
6520 DEFFN'50 (Z)
6530 X = 1 - COS (X1 *Z)
6540 Y = Z
6550 RETURN
```

This plots a four-leaf clover for T=0 to 360.

Example 3, Non-std File:

```
6500 DIM Z(8,3)
6510 DATA LOAD DCT#2, N
```

In this routine the system has already done a DC OPEN on the data file. The routine should set the variable N to the number of points to be plotted, if known. Line 6510 assumes there is a header record to the data file containing the number of points. If N is not set, the system uses the number 9999 as a maximum.

```
6520 GOSUB'99
6530 DEFFN'50 (Z)           Z is the sequence number of the
                           point to be fetched.

6450 IF (Z-1)/8 <> INT ((Z-1)/8) THEN 6550
6545 DATA LOAD DCT #2, Z()
6550 X = Z (Z-8*INT((Z-1)/8),1)
6560 Y = Z (Z-8*INT((Z-1)/8),2)
6570 RETURN
```

This routine presumes that datapoints are stored with 8 points to a sector. It is also assumed that for each point there is an X and Y coordinate and a weighting factor which will not be used. If the value N was not set during initialization, then when the routine recognizes that no more points exist, it should execute the following before the final RETURN:

```
I = N           (Note: This is the only allowable use of the variable I
                 and N in the Computed Function routine.)
```


APPENDIX B

CONSTRUCTION OF COMPUTED FUNCTION FILE FOR 3-D PLOTTING

For all three-dimensional plotting the user supplies a routine to generate a point each time it is called by the main program. This routine must occupy lines 6500 to 6999 and be in a program file on the data disk at the address specified. Control is passed to the routine at line 6500 to execute any desired initialization code. At the end of this code, control is passed back to the system by executing a GOSUB'99. The routine proceeds with a DEFFN'50 (x,y) followed by code to calculate coordinates for the point. Only variables in the X, Y, and Z range should be used. A variable I when set to 1 may be used to tell the main program to ignore a point and proceed to the next one (see Example 3). The routine concludes with a RETURN instruction.

As with the two-Dimensional Computed Function, whenever control is passed to DEFFN'50 the system is selected in degrees. Radians or gradians may also be selected for computational purposes. Degrees are automatically reselected before exiting to the main program.

In the simplest cases the two parameters for the independent variables x and y will be identical with the first and second coordinates of the point for which a third coordinate is to be computed. In these cases, DEFFN'50 (X,Y) insures that X=x and Y=y will be available as two of the required output variables.

EXAMPLE 1

Given independent variables x and y as input to a computed function, calculate X, Y, and Z as the coordinates of a point on the surface.

```
X = x
Y = y
Z = SQR (x+2 + y+2)/10
```

This example presumes rectangular coordinates have been specified.

```
6500 GOSUB '99
6510 DEFFN '50 (X, Y)
6520 Z = SQR(X+2 + Y+2)/10
6530 RETURN
```

EXAMPLE 2

Given independent variables x and y (as radius r and angle θ respectively) as input to a computed function, compute z as a function of these:

```
X = x
Y = y
Z = 2*x
```

This example presumes cylindrical coordinates have been specified.

```
6500 GOSUB '99
6510 DEFFN '50 (X, Y)
6520 Z = 2 * X
6530 RETURN
```

EXAMPLE 3

The variable "I" is always set to zero when control is passed to the computed function routine. If the user wishes to indicate that a point is to be ignored and not plotted, "I" should be set to 1. In the routine below this has been done so that points with a Z coordinate greater than 10 will not be plotted.

```
6500 GOSUB '99
6510 DEFFN '50 (X, Y)
6520 Z = SQR(X+2 + Y+2)/10
6530 IF Z = 10 THEN 6550
6540 I = 1
6550 RETURN
```

EXAMPLE 4

The variables x and y need not be the same as the output variables. The routine described below produces a family of eight spiral curves around a sphere. The spirals can be thought of as starting at the North pole and ending at the South pole.

```
6500 GOSUB '99
6510 DEFFN '50 (X1, Y)
6520 X = 10
6530 Z = 4*Y + X1 * 360/8
6540 RETURN
```

Here the first independent variable x is used to represent the spiral line number. It will be presumed that its value will be from $x - \text{MIN} = 0$ to $x - \text{MAX} = 7$ (with 8 increments between lines plotted for y lines only). Since it corresponds to none of the spherical coordinates r, θ or ϕ passed to the system as X, Y, or Z, the DEFFN '50 establishes it as X1 for use in the calculation of Z.

The 2nd independent variable y is used as the angle θ between the two poles of the sphere. Therefore, the DEFFN '50 establishes it a Y which is used to pass the variable θ for spherical coordinates.

Line 6520 insures a consistent radius of 10 is passed in variable X.

Line 6530 calculates a value of ϕ to be passed in variable Z. It is calculated so the angle around the pole ϕ causes two complete rotations around the N - S pole as the spiral line moves from pole to pole (0 to 180 or half of a revolution). This amount is augmented by 1/8 of a revolution times the spiral line number so each line will be offset from the previous one by 45.

APPENDIX C

3-D SCALING FEATURES

This appendix describes the operations performed during the scaling of a 3-D plot. The majority of the information concerns the internal functioning of the program and need not concern the user except possibly in the implementation of some sophisticated applications. The starred paragraphs describe portions of the scaling process which are displayed or output for the user.

1. The direction of view and vertical vector inputs are used to construct a 3×2 transformation matrix to convert from three-dimensional object space to two-dimensional image space.
2. The computed function is evaluated at the specified number of points along each line for which scaling is desired. If both x and y lines are specified, the evaluation is made first for each x line for which y is held constant (as x is stepped by the point increment between the minimum and maximum values of x). Likewise the evaluation is made for each y line (for which x is held constant and y is stepped).

* During the evaluation, the top line of the CRT displays the value of the line presently being processed.

For each point, the following occurs:

- a. The evaluation of the function at a point (x, y) produces the three values for either (X, Y, Z) , (r, θ, z) or (r, θ, ϕ) depending upon the chosen coordinate system.
 - b. For each point generated, the value returned by the computed function as the third variable $(Z, z, \text{ or } \phi)$ is compared to previous values so that a maximum and minimum value for the variable will be accumulated.
 - c. The output from the computed function is converted to rectangular coordinates (if not already in a rectangular system) using the mathematical relationships shown in Appendix D.
 - d. Using the transformation matrix, the X' and Y' coordinates for each point in the image coordinate system are computed. The coordinates of each point are compared to the image coordinates of previously computed points and the minimum and maximum values for each variable (X', Y') are accumulated.
3. A Scale Factor (multiplier) is computed to relate the size of the image surface in the units of X' and Y' onto the size of the plotting area in physical units specified on Page 1 of Enter Parameters. In the computation, the X size of the plotting area minus the margins is compared to the difference between maximum and minimum values of X' .

Similarly, the Y size of the plotting area minus the margins is compared to the difference between the maximum and minimum values of Y'.

An integer value for the Scale Factor is selected so that the resulting plot will, as nearly as possible, fill one direction of the plotting area. The other measurement of the plot may not completely fill the specified space. See Figure E-1, Appendix E.

- *4. The table of values for Page 3 - Enter Parameters is redisplayed on the screen showing the computed values for the Scale Factor, Z minimum and Z maximum (items 4, 9 and 10). It should be noted that in the most common cases, the values of the two independent variables x and y (items 5 through 8) will be the values of the first two dependent variables X and Y. Then these four values and the values for the third dependent variable Z (items 9 and 10) will all be in the coordinate system selected (rectangular, cylindrical or spherical). However, this need not always be true, in which case the two values displayed will not be compatible with the x's and y's of the same screen. The system nevertheless maintains the compatibility of appropriate variables and no difficulty will be encountered. In fact, the Z-MAX and Z-MIN values are utilized only in the Hidden Points routine which is only applicable in the simple rectangular coordinate case.
- *5. The values for the minimum and maximum for each of the image variables X' and Y' are displayed on the third line of the screen. The top line identifies the order in which the four numbers are shown. The system then awaits possible notation of these values by the user before continuing.
6. The user may replace any of the values on Page 3 Enter Parameters with another value. In particular, changing the Scale Factor to a smaller value will reduce the plot size of the function, while leaving the length of the axes unchanged. Increasing the size of the margin reduces both the size of the plot and the axes.
- *7. When a hardcopy of a parameter file is obtained, it will show the values for Scale Factor, (line 9), Z min and Z max (line 11 and 12), X' and Y' minimums (line 13) and X' and Y' maximums (line 14) as well as all values entered by the user. In addition, if scaling is used the computed function filename is displayed in the heading.

APPENDIX D

3-D COORDINATE CONVERSION FORMULAS

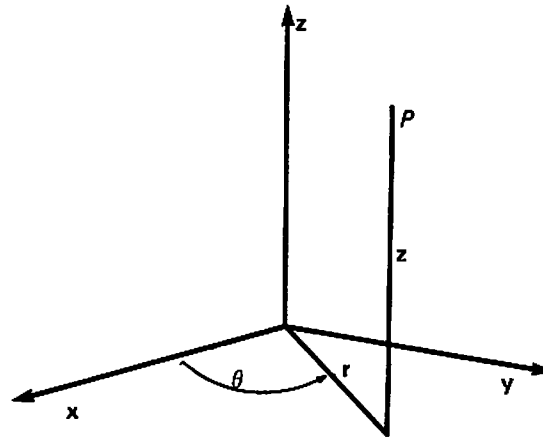
Cylindrical Coordinates

If (r, θ, z) are the cylindrical coordinates and (X, Y, Z) the rectangular coordinates of a point P, then:

$$x = r \cos \theta, \quad r = \sqrt{x^2 + y^2},$$

$$y = r \sin \theta, \quad \theta = \arctan \frac{y}{x},$$

$$z = z, \quad z = z.$$



Spherical Coordinates

If (r, θ, ϕ) are the spherical coordinates and (X, Y, Z) the rectangular coordinates of a point P, then:

$$x = r \sin \theta \cos \phi,$$

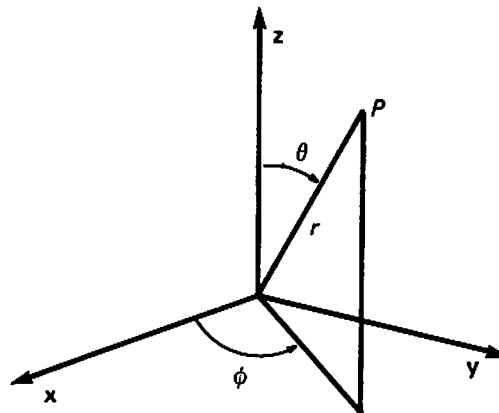
$$y = r \sin \theta \sin \phi,$$

$$z = r \cos \theta,$$

$$r = \sqrt{x^2 + y^2 + z^2},$$

$$\theta = \arccos \frac{z}{\sqrt{x^2 + y^2 + z^2}}$$

$$\phi = \arctan \frac{y}{x}$$



APPENDIX E

"IMAGE" PLOT AREA RELATIONS (3-D PLOTTING)

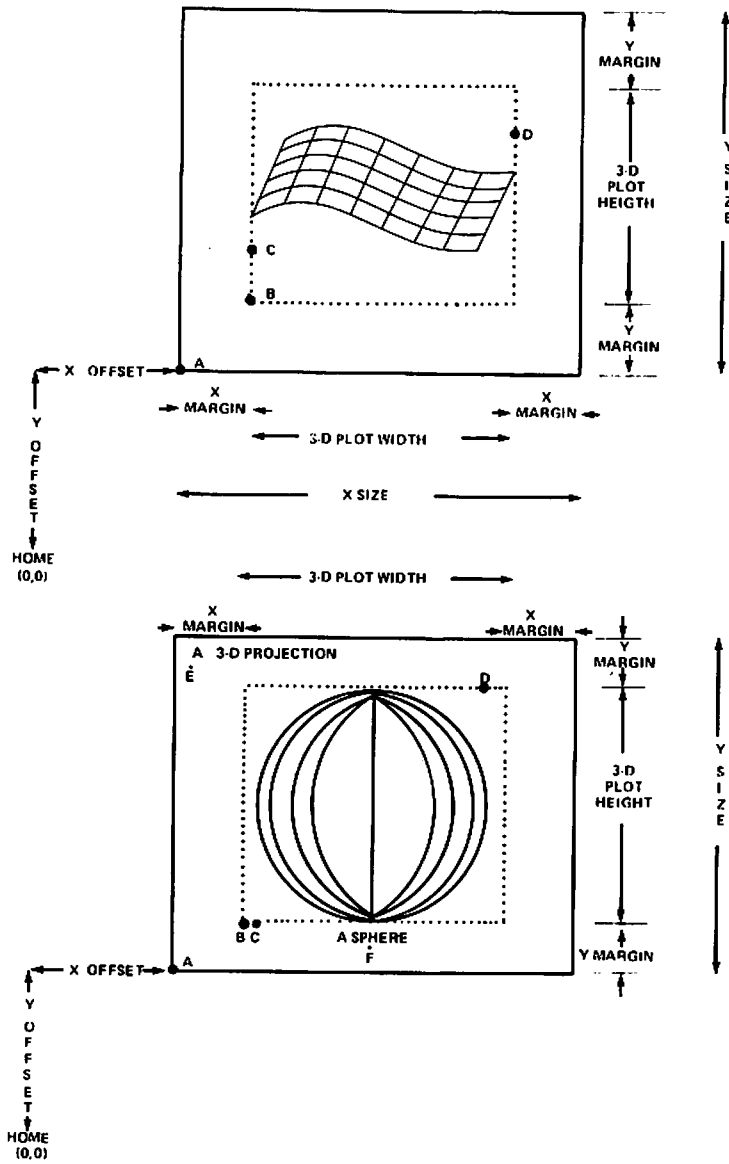


Figure E-1. "Image" Plot Area Relations

The following parameters of the plotter's surface are in physical units.

- (1) X & Y size
- (2) X & Y offset
- (3) X & Y margin

Therefore, points A and B in Figure E-1 are in physical units.

The following parameters of the plotting surface are in the graph units of the image.

- (4) X' & Y' minimum = coordinates of point C
- (5) X' & Y' maximum = coordinates of point D
- (6) X & Y coordinate of label 1 = coordinates of point E
- (7) X & Y coordinate of label 2 = coordinates of point F

Therefore, points C and D are in the units of X' and Y' and are the result of the scaling routine.

The common shared units which are used internally by the system are plotter units.

To convert (1), (2) or (3) to plotter units, the parameter is multiplied by the number of plotter units per physical unit entered during INITIALIZE SYSTEM as item 3.

To convert (4) and (5) to plotter units, the parameter is multiplied by the SCALE FACTOR on line 9 of the hardcopy or item 4 of PAGE 3 of ENTER PARAMETERS. Unless the user has changed the size of the SCALE FACTOR to greater than that computed, the following is true:

$$(\text{SIZE} - 2 * \text{MARGIN}) * \text{plotter units per physical unit} = \\ (\text{IMAGE MAX} - \text{IMAGE MIN}) * \text{SCALE FACTOR}$$

As with 2-D plots, the coordinates of labels are given in graph (image) units. They may, however, specify any point in the plotting area and hence may have values less than the image minimum or greater than the image maximum (e.g., the range of X' and Y').

As an example, the labels shown around the spherical plot are entered in the graph units of the image as follows:

- Label E has
- (1) a Position Option of 1.
 - (2) an X-coordinate considerably less than the X'min which is the X-coordinate of point C.
 - (3) a Y-coordinate slightly more than Y'max which is the Y-coordinate of point D.
- Label F has
- (1) a Position Option of 2.
 - (2) an X-coordinate = $(X'max - X'min)/2$, which is halfway across the 3-D image.
 - (3) a Y-coordinate slightly less than Y'min which is the Y-coordinate of point C.

APPENDIX F

SUMMARY OF VARIABLE USAGE (3-D PLOTTING)

<u>Usage of Coordinates</u> (1)	<u>Designation</u> (2)	<u>Information</u> (3)	<u>Occurrence in Prompts</u> (4)
A. Boundaries of Computed Function Parameters: domain of independent parameters to computed function	x, y	Passed in GOSUB'99 subroutine and stored in variables specified in DEFFN'50. (All variables starting with X, Y, and Z are available).	Enter Parameters Page 3 items 5, 6, 7, and 8
B. Selection of Points at which to Evaluate Function For x lines: intervals or increments between lines intervals or increments between points in a line For y lines: intervals or increments between lines intervals or increments between points on a line	y x x y	Intervals or increments for lines or points which the user specifies. Must be interpreted in relation to the difference between two values of a <u>variable</u> (defined above as X or Y) which is thereby subdivided. The <u>variable</u> being used in each case is shown here in column 2.	Enter Parameters For plotting: Page 2 items 2 and 3 For scaling: Page 3 items 2 and 3

APPENDIX F (Cont.)

<u>Usage of Coordinates</u> (1)	<u>Designation</u> (2)	<u>Information</u> (3)	<u>Occurrence in Prompts</u> (4)
<p>C. Coordinate of a Point on the object or surface in the selected coordinate system (rectangular, cylindrical, or spherical). Dependent variables output from the computed function to specify surface.</p>	<p>For rectangular coordinates: X, Y, Z</p> <p>For cylindrical coordinates: r, θ, z</p> <p>For spherical coordinates: r, θ, ϕ (see Appendix D)</p>	<p>Computed by the user in DEFFN' 50 and: passed to the system by user in X,Y,Z</p> <p>passed by user with r in location X θ in location Y z in location Z</p> <p>passed by user with r in location X θ in location Y ϕ in location Z</p>	<p>Enter Parameters</p> <p>Page 3 item 9=Z-Min, item 10=Z-Max</p> <p>Page 3 item 9=Z-Min, item 10=Z-Max</p> <p>Page 3 item 9=ϕ-Min, item 10=ϕ-Max</p>
<p>D. Direction of View and Vertical Vector: Specified in Cartesian coordinate system corresponding to coordinate system of surface (rectangular, cylindrical, or spherical.)</p>	<p>X, Y, Z</p>	<p>Related to variable in particular coordinate system by formulas specified in Appendix D</p> <p>(The system determines a matrix of transformation from these variables to project from the <u>object system</u> to the <u>image system</u>.)</p>	<p>Enter Parameters</p> <p>Page 2 items 5 through 10.</p>

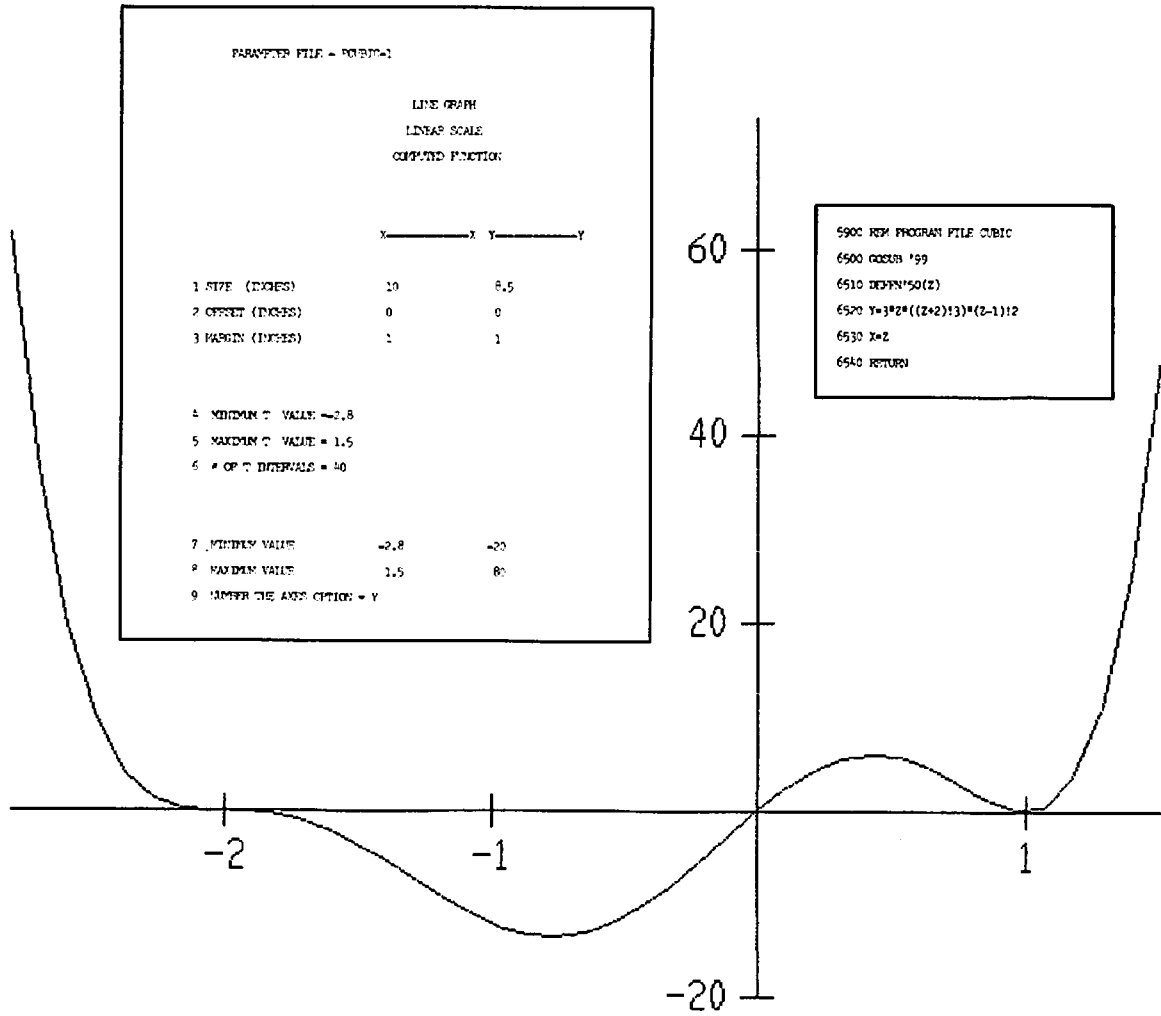
APPENDIX F (Cont.)

<u>Usage of Coordinates</u> (1)	<u>Designation</u> (2)	<u>Information</u> (3)	<u>Occurrence in Prompts</u> (4)
<p>E. Coordinates a Point in a 2-Dimensional Space (coordinate system of the image.)</p>	<p>X', Y'</p>	<p>Displayed on the screen after Scaling completed on Page 3- 3-D Scaling. Optionally printed as lines 13 and 14 of hardcopy of parameter file.</p>	<p>Enter Labels items 6 and 7</p>
<p>F. Physical Dimension of Plot Area (size, offset, margins.)</p> <p>The units for Physical Dimension are specified in Initialize System, items 2 and 3.</p> <p>Note: Although they are designated throughout the system in this manner, these are not the same units as the variables X,Y in section C & D of this table.</p>	<p>X, Y (see Note)</p>	<p>Related to X', and Y' variables by the Scale Factor computed as item 4 on Page 3.</p>	<p>Enter Parameters Page 1 items 4 through 9</p>

APPENDIX G

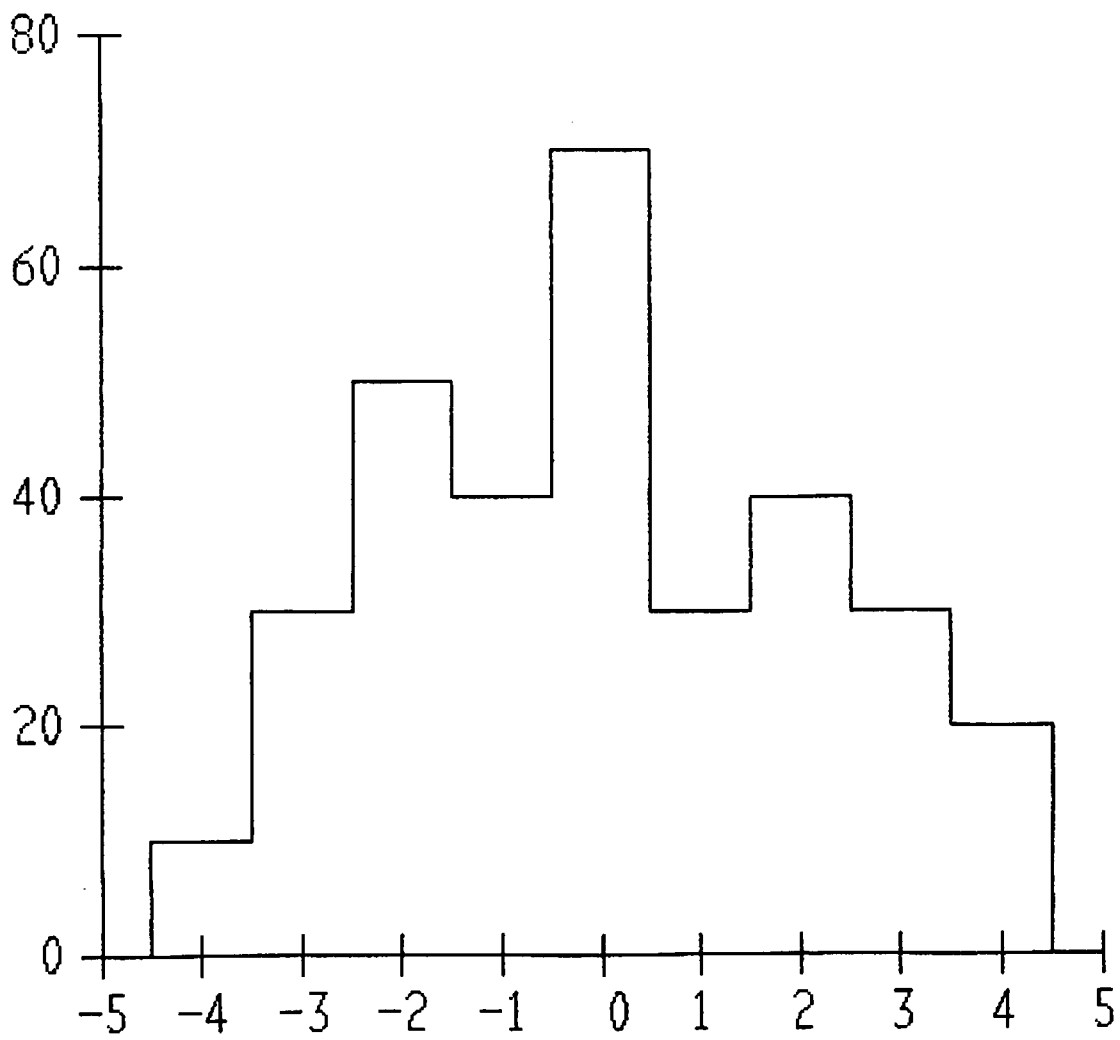
SAMPLE PLOTS AND FILES

EXAMPLE 1



EXAMPLE 2

PLOTTING A STEP FUNCTION FROM DATA



EXAMPLE 2 (Cont.)

PARAMETER FILE - P11-2-77

LINE GRAPH
LINEAR SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	7.5	7
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	1	1
4 MINIMUM VALUE	-5	0
5 MAXIMUM VALUE	5	80
6 NUMBER THE AXES OPTION =	Y	

DATA POINT FILE - D11-2-77

X-----X Y-----Y

SER #	X	Y
1	-4.5	0
2	-4.5	10
3	-3.5	10
4	-3.5	30
5	-2.5	30
6	-2.5	50
7	-1.5	50
8	-1.5	40
9	-.5	40
10	-.5	70
11	.5	70
12	.5	30
13	1.5	30
14	1.5	40
15	2.5	40
16	2.5	30
17	3.5	30
18	3.5	20
19	4.5	20
20	4.5	0

LABEL FILE - L11-2-77

HARDWARE LETTERING
SPACE AVAILABLE FOR 16 LABELS

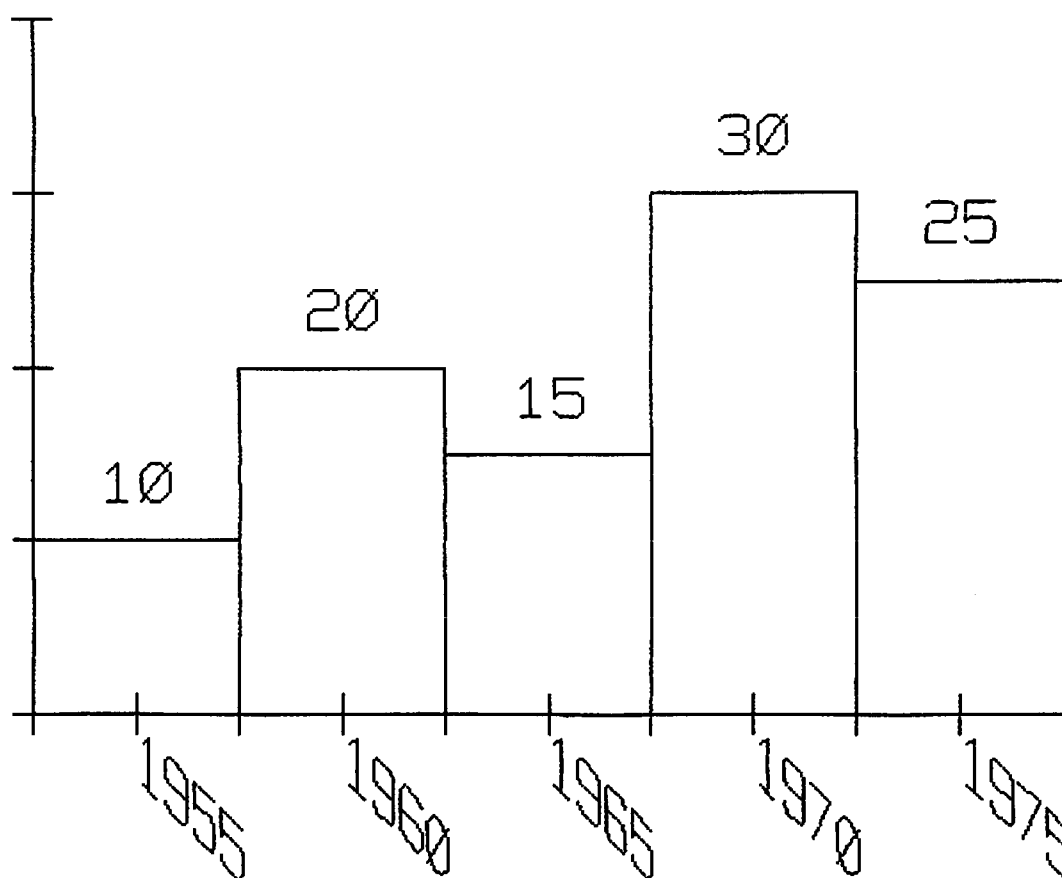
TEXT

SIZE SLANT ROTATION POS. X-----X Y-----Y

1	PLOTTING A STEP FUNCTION FROM DATA								
	.	1	0	0	2	0	90		

EXAMPLE 3

HOG POPULATION IN U.S.A
(BILLIONS)



EXAMPLE 3 (Cont.)

PARAMETER FILE - P-BAR

BAR GRAPH
LINEAR SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	10	8
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	2	2
4 MINIMUM VALUE	0	0
5 MAXIMUM VALUE	10	40
6 BAR WIDTH	2	
7 INTERSECTION OF AXES	0	0
8 HASH MARK INTERVAL	1	10
9 HORIZONTAL LINES OPTION = N		
10 VERTICAL LINES OPTION = N		
11 NUMBER THE AXES OPTION = N		

DATA POINT FILE - D-BAR

SEQ # X-----X Y-----Y

1	1	10
2	3	20
3	5	15
4	7	30
5	9	25

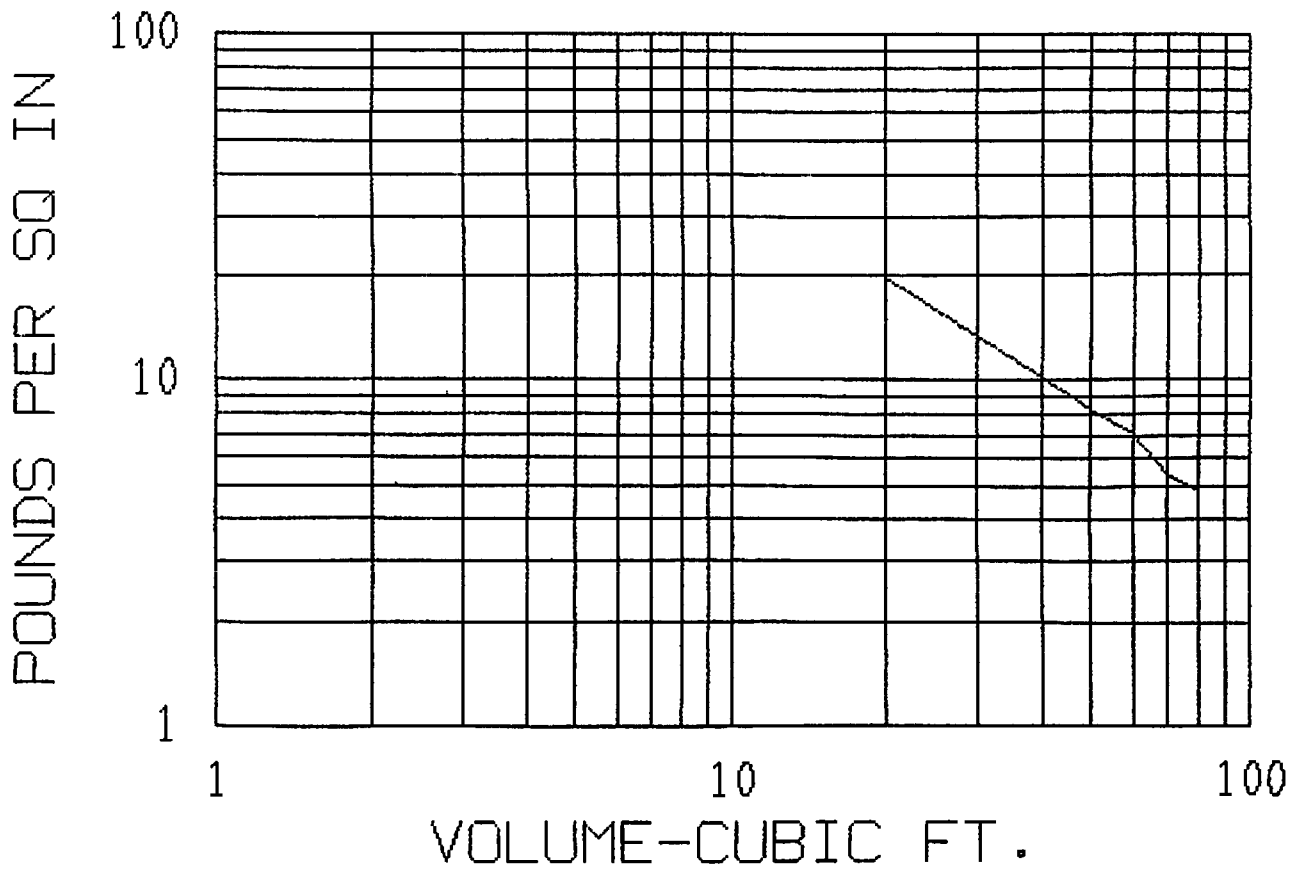
LABEL FILE - L-BAR

SOFTWARE LETTERING USING CHARACTER ARRAY - CHARF01C
SPACE AVAILABLE FOR 16 LABELS

TEXT SIZE SLANT ROTATION POS. X-----X Y-----Y

1	1955	2	-90	-45	1	1	-4
2	1960	2	-90	-45	1	3	-4
3	1965	2	-90	-45	1	5	-4
4	1970	2	-90	-45	1	7	-4
5	1975	2	-90	-45	1	9	-4
6	10	2	0	0	2	1	12
7	20	2	0	0	2	3	22
8	15	2	0	0	2	5	17
9	30	2	0	0	2	7	32
10	25	2	0	0	2	9	27
11	HOG POPULATION IN U.S.A	2	0	0	2	5	45
12	(BILLIONS)	1	90	0	2	5	42

EXAMPLE 4



EXAMPLE 4 (Cont.)

PARAMETER FILE - FLOGLOG

LINE GRAPH
LOG/LOG SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	10	8	
2 OFFSET (INCHES)	1	0	
3 MARGIN (INCHES)	2	2	
-			
4 MINIMUM VALUE	1	1	
5 MAXIMUM VALUE	100	100	
6 NUMBER THE AXES OPTION = Y			

LABEL FILE - LLOGLOG

SOFTWARE LETTERING USING CHARACTER ARRAY - CHARF010
SPACE AVAILABLE FOR 16 LABELS

TEXT

SIZE SLANT ROTATION POS. X-----X Y-----Y

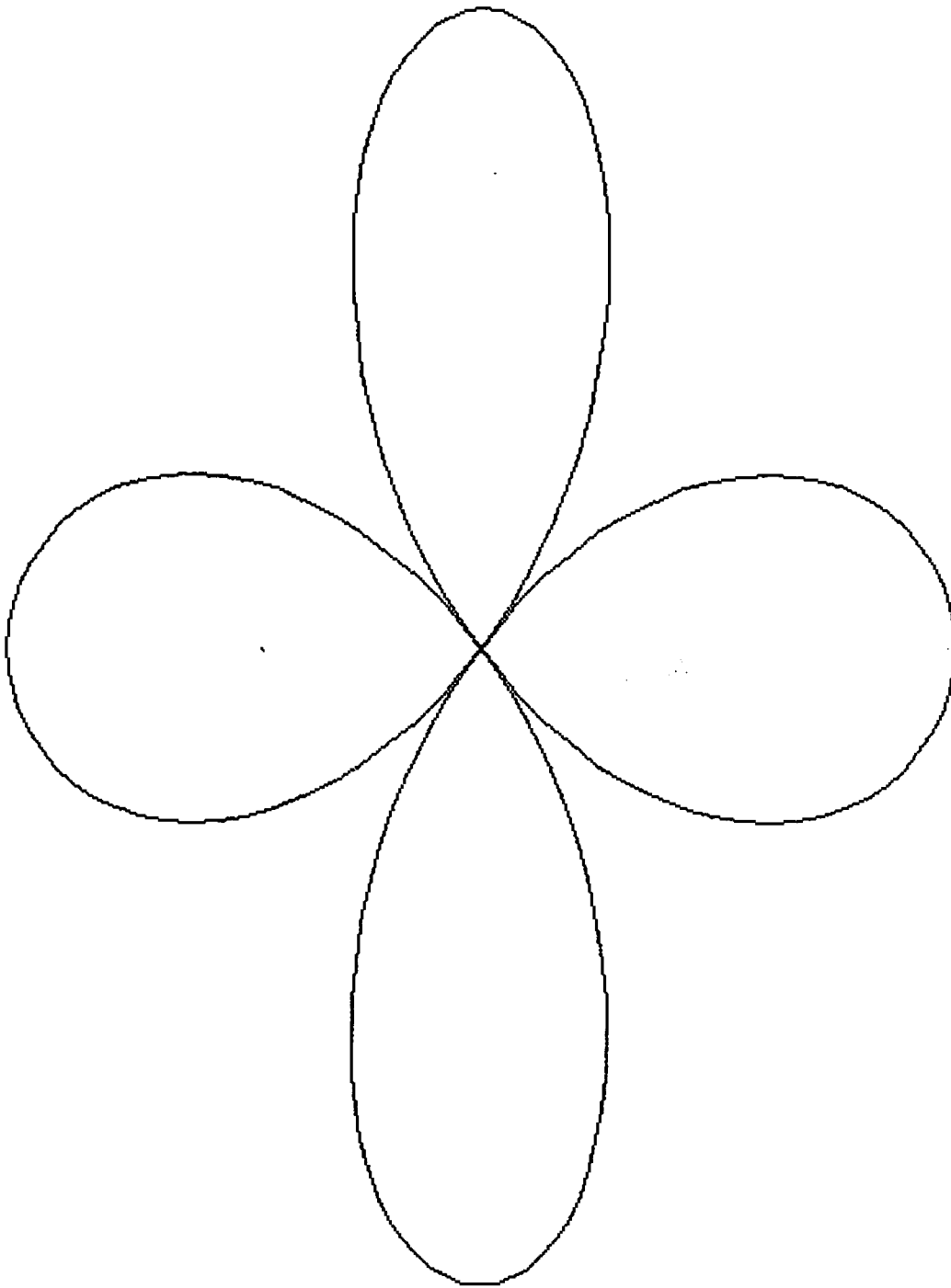
1 VOLUME-CUBIC FT.							
	2	0	0	2	10		.4
2 POUNDS PER SQ IN							
	2	0	90	2	.5		10

DATA POINT FILE - DLOGLOG

SEQ # X-----X Y-----Y

1	20		19.8
2	30		13.5
3	40		10.3
4	50		8.35
5	60		7.04
6	70		5.37
7	80		4.81

EXAMPLE 5



EXAMPLE 5 (Cont.)

PARAMETER FILE - PCLOVER1

LINE GRAPH
POLAR SCALE
COMPUTED FUNCTION

X-----X Y-----Y

1 SIZE (INCHES)	10	8
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	1	1

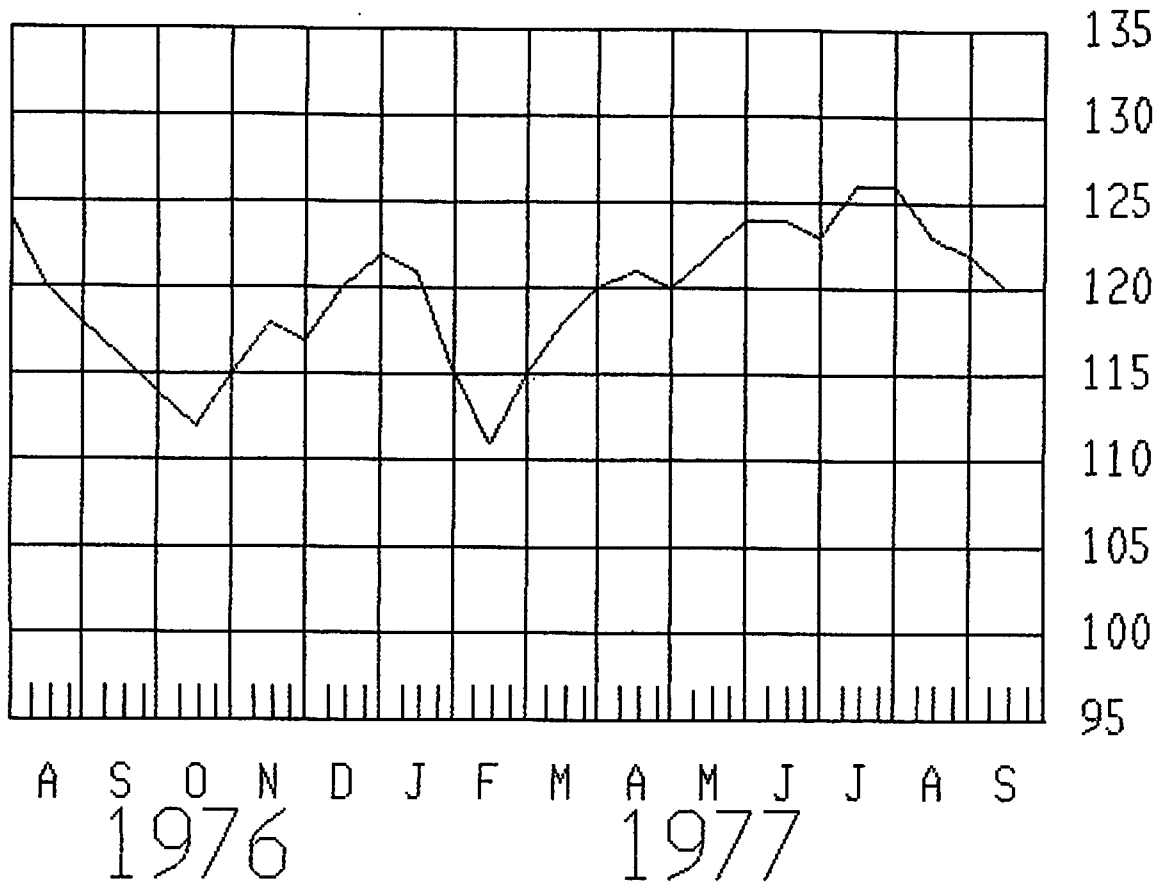
4 MINIMUM T VALUE = 0
5 MAXIMUM T VALUE = 360
6 # OF T INTERVALS = 180

7 MINIMUM VALUE	-4	-4
8 MAXIMUM VALUE	4	4
9 NUMBER THE AXES OPTION = 11		

```
5900 REM PROGRAM FILE CLOVER
6500 GOSUB '99
6510 DEF FN'50(Z)
6520 X=4*COS(2*Z)
6530 Y=Z
6540 RETURN
```

EXAMPLE 6

INDEX OF BUSINESS ACTIVITY



EXAMPLE 6 (Cont.)

PARAMETER FILE - P-200005

LINE GRAPH
LINEAR SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	10	9
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	2	2
4 MINIMUM VALUE	0	95
5 MAXIMUM VALUE	14	135
6 NUMBER OF AXES OPTION = N		

(PARTIAL LISTING)

TABLE FILE - L-200005

MARKING LISTING
SPACE AVAILABLE FOR 80 LABELS

TEXT

SIZE SLANT ROTATION POC. Y-----X Y-----Y

1 A	1	0	0	2	1.5	90
2 B	1	0	0	2	1.5	90
3 C	1	0	0	2	2.5	90
4 H	1	0	0	2	3.5	90
14 S	1	0	0	2	13.5	90
15 1976	2	0	0	2	2.5	85
16 1977	2	0	0	2	9.5	85
17 95	1	0	0	1	14.5	94
65 L	1	0	0	1	13.25	94.7
66 L	1	0	0	1	13.5	94.7
67 L	1	0	0	1	13.75	94.7
68 INDEX OF FISHERIES ACTIVITY	2	0	0	2	6.5	177

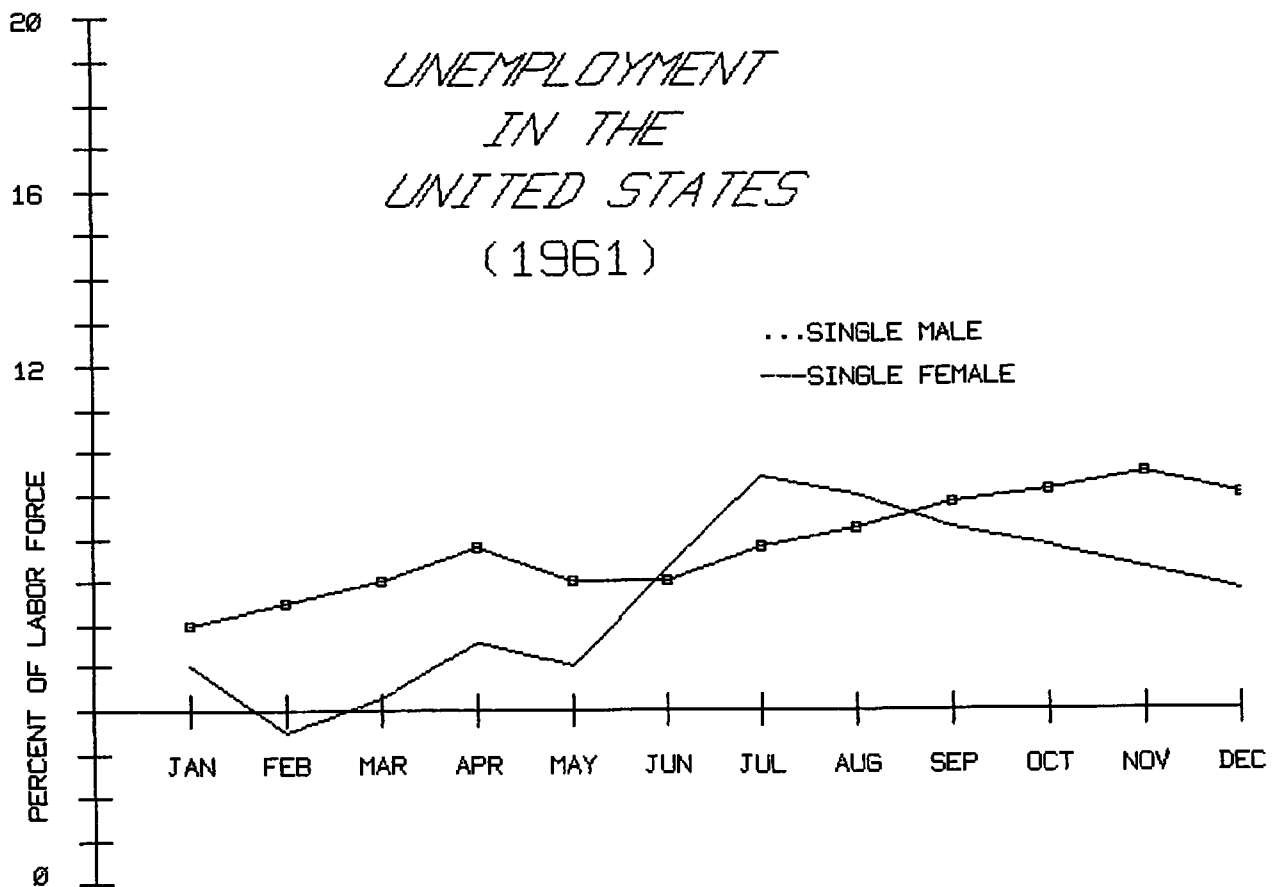
(PARTIAL LISTING)

DATA POINT FILE - D-200005

SEQ # X-----X Y-----Y

1	0	128
2	.5	120
3	1	118
4	1.5	126
5	2	124
6	2.5	122
7	3	115
8	3.5	118
9	4	127
10	4.5	129
11	5	122
12	5.5	121
13	6	115
14	6.5	111
15	7	115
16	7.5	118
17	8	120
18	8.5	121
19	9	120
20	9.5	122
21	10	124
22	10.5	124
23	11	123
24	11.5	126

EXAMPLE 7



EXAMPLE 7 (Cont.)

PARAMETER FILE - DEPLOY

LINE GRAPH
LINEAR SCALE
STANDARD FILE

X—————X Y—————Y

1 SIZE (INCHES)	10	8	
2 OFFSET (INCHES)	0	0	
3 MARGIN (INCHES)	1	1	
4 MINIMUM VALUE	0	0	
5 MAXIMUM VALUE	12	20	
6 NUMBER THE AXES OPTION = N			

DATA POINT FILE - DEPLOY

SEQ # X—————X Y—————Y

1	1		5
2	2		3.5
3	3		4.3
4	4		5.6
5	5		5
6	6		7.3
7	7		9.4
8	8		9
9	9		8.2
10	10		7.9
11	11		7.3
12	12		6.8

DATA POINT FILE - DEPLOY

SEQ # X—————X Y—————Y

1	1		6
2	2		6.5
3	3		7
4	4		7.8
5	5		7
6	6		7
7	7		7.8
8	8		8.2
9	9		8.8
10	10		9.1
11	11		9.5
12	12		9

EXAMPLE 7 (Cont.)

(CONTINUED)

LABEL FILE - M37010

SOFTWARE UTILIZING USING CHARACTER ARRAY - CHAR010

SPACE AVAILABLE FOR 24 LABELS

#	TEXT	SIZE	SLANT	NOTATION	POS.	X	Y	
1	UNEMPLOYMENT	2	45	0	2	3		18.4
2	IN THE	2	45	0	1	4		17
3	UNITED STATES	2	45	0	1	3		15.6
4	...SINGLE MALE	1	0	0	1	7		12.5
5	...SINGLE FEMALE	1	0	0	1	7		11.5
6	(1961)	2	0	0	1	4		14
7	PERCENT OF LABOR FORCE	1	0	90	1	-5		1.5

8	JAN	1	0	0	2	1		2.5
9	FEB	1	0	0	2	2		2.5
10	MAR	1	0	0	2	3		2.5
11	APR	1	0	0	2	4		2.5
12	MAY	1	0	0	2	5		2.5
13	JUN	1	0	0	2	6		2.5
14	JUL	1	0	0	2	7		2.5
15	AUG	1	0	0	2	8		2.5
16	SEP	1	0	0	2	9		2.5
17	OCT	1	0	0	2	10		2.5
18	NOV	1	0	0	2	11		2.5
19	DEC	1	0	0	2	12		2.5
20	0	1	0	0	3	-5		0
21	20	1	0	0	3	-5		19.75
22	12	1	0	0	3	-5		11.75
23	16	1	0	0	3	-5		15.75

EXAMPLE 8

WANG

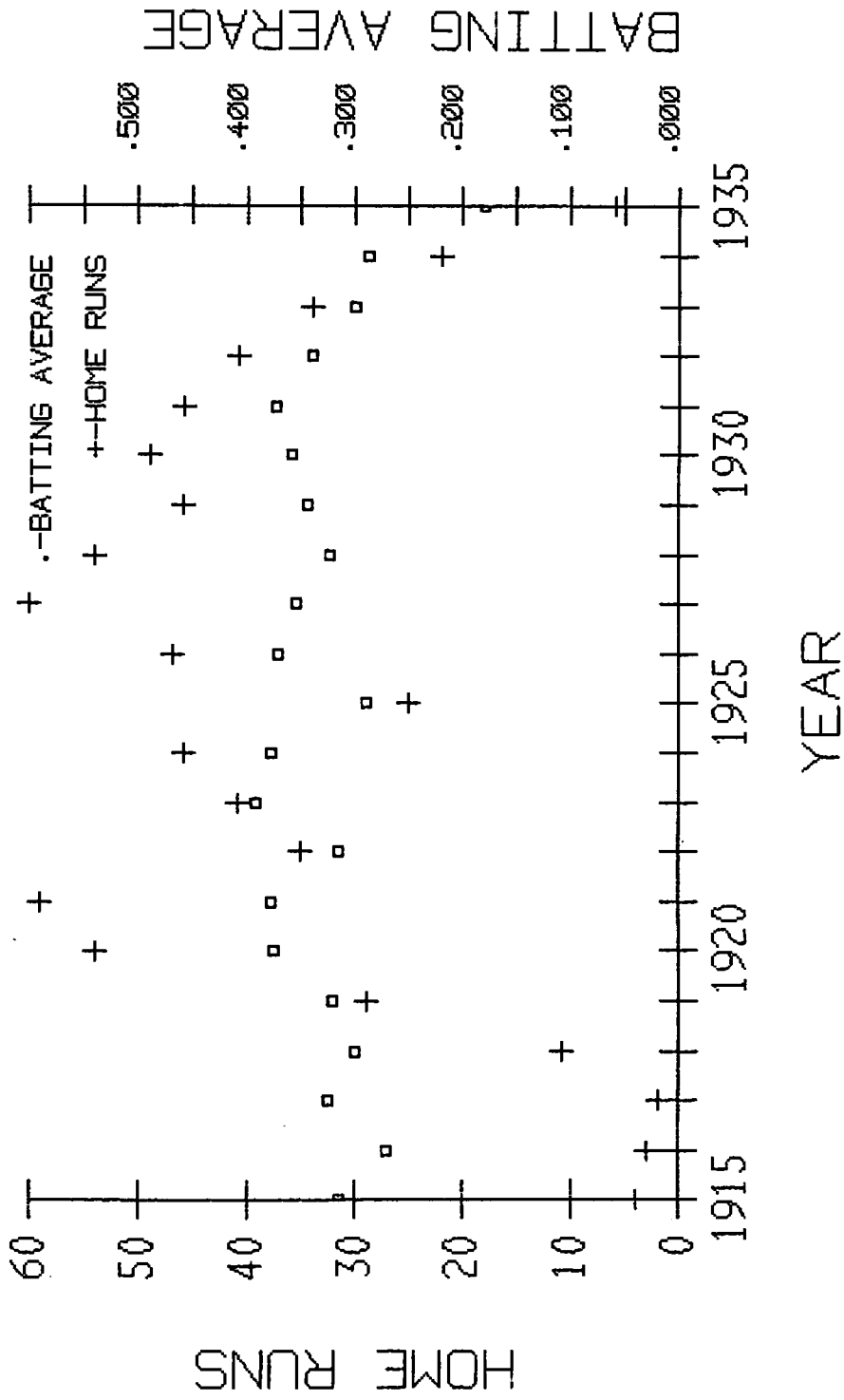
W
A
N
G

W
A
N
G

PARAMETER FILE - P-QUADS			LABEL FILE - L-WANG		
	LINE GRAPH LINEAR SCALE STANDARD FILE			HARDWARE LETTERING SPACE AVAILABLE FOR 16 LABELS	
	X	Y	#	TEXT	
	X	Y		SIZE SLANT ROTATION POS.	X Y
1	SIZE (INCHES)	10 8	1	WANG	7
2	OFFSET (INCHES)	0 0	2	WANG	4
3	MARGIN (INCHES)	0 0	3	WANG	6
4	MINIMUM VALUE	-10 -10			
5	MAXIMUM VALUE	10 10			
6	NUMBER THE AXES OPTION = N				

BABE RUTH STATISTICS

EXAMPLE 9



EXAMPLE 9 (Cont.)

PARAMETER FILE - PRUTH-HR

POINT GRAPH
LINEAR SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	10	8
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	2	2
4 MINIMUM VALUE	1915	0
5 MAXIMUM VALUE	1935	60
6 NUMBER THE AXES OPTION = Y		

DATA POINT FILE - DRUTH-HR

SEQ #	X-----X	Y-----Y
1	1915	4
2	1916	3
3	1917	2
4	1918	11
5	1919	29
6	1920	54
7	1921	59
8	1922	35
9	1923	41
10	1924	46
11	1925	25
12	1926	47
13	1927	60
14	1928	54
15	1929	46
16	1930	49
17	1931	46
18	1932	41
19	1933	34
20	1934	22
21	1935	6

LABEL FILE - LRUTH-1

SOFTWARE LETTERING USING CHARACTER ARRAY - CHARF010
SPACE AVAILABLE FOR 16 LABELS

TEXT

SIZE SLANT ROTATION POS. X-----X Y-----Y

1	YEAR	2	C	0	2	1925	-15
2	HOME RUNS	2	0	90	2	1912	30
3	←HOME RUNS	1	0	0	3	1934	53
4	←BATTING AVERAGE	1	0	0	3	1924	58
5	BASE RUTH STATISTICS	3	0	0	2	1925	65

EXAMPLE 9 (Cont.)

PARAMETER FILE - PRUTH-BA

POINT GRAPH
LINEAR SCALE
STANDARD FILE

X-----X Y-----Y

1 SIZE (INCHES)	10	8
2 OFFSET (INCHES)	1	0
3 MARGIN (INCHES)	2	2
4 MINIMUM VALUE	1915	0
5 MAXIMUM VALUE	1935	.6
6 NUMBER THE AXES OPTION = N		

DATA POINT FILE - DRUTH-BA

SEQ #	X-----X	Y-----Y
1	1915	.315
2	1916	.272
3	1917	.325
4	1918	.3
5	1919	.322
6	1920	.376
7	1921	.378
8	1922	.315
9	1923	.393
10	1924	.378
11	1925	.29
12	1926	.372
13	1927	.356
14	1928	.323
15	1929	.345
16	1930	.359
17	1931	.373
18	1932	.341
19	1933	.301
20	1934	.288
21	1935	.181

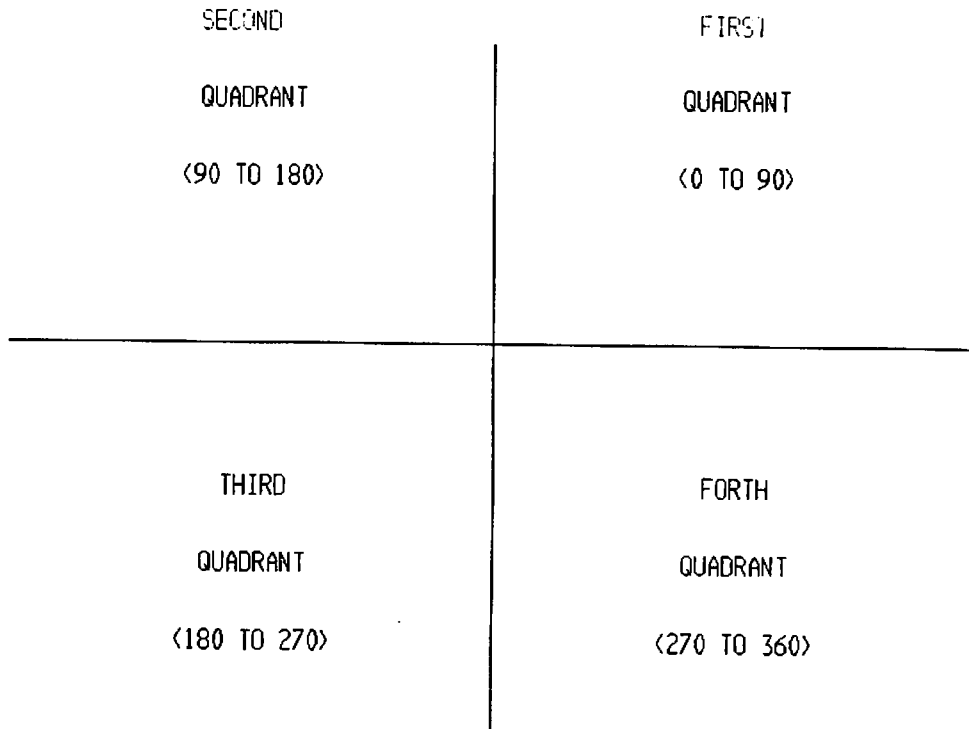
LABEL FILE - LRUTH-2

SOFTWARE LETTERING USING CHARACTER ARRAY - CHARFOLD
SPACE AVAILABLE PCP 16 LABELS

TEXT
SIZE SLANT ROTATION POS. X-----X Y-----Y

1	.000	1	0	0	1	1935	0
2	.100	1	0	0	1	1936	.1
3	.200	1	0	0	1	1936	.2
4	.300	1	0	0	1	1936	.3
5	.400	1	0	0	1	1936	.4
6	RATTINY AVERAGE	2	0	90	2	1939	.25
7	.500	1	0	0	1	1936	.5

EXAMPLE 10



NOTE: Parameter file is the same as Example 8.

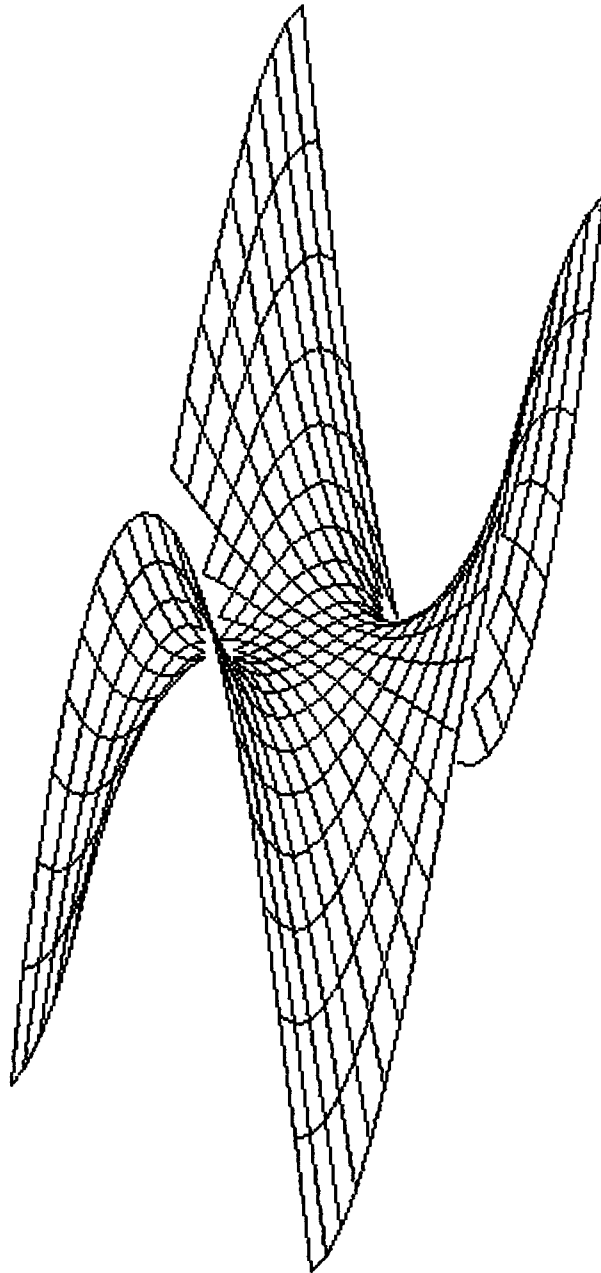
LABEL FILE - L-QUADS

HARDWARE LETTERING
SPACE AVAILABLE FOR 24 LABELS

#	TEXT	SIZE	SLANT	ROTATION	POS. X	Y
					X	Y
1	FIRST	1	0	0	2	5
2	QUADRANT	1	0	0	2	5
3	<0 TO 90>	1	0	0	2	5
4	SECOND	1	0	0	2	-5
5	QUADRANT	1	0	0	2	-5

6	<90 TO 180>	1	0	0	2	-5
7	THIRD	1	0	0	2	-5
8	QUADRANT	1	0	0	2	-5
9	<180 TO 270>	1	0	0	2	-5
10	FORTH	1	0	0	2	5
11	QUADRANT	1	0	0	2	5
12	<270 TO 360>	1	0	0	2	5

EXAMPLE 11



EXAMPLE 11 (Cont.)

PARAMETER FILE - P9-14-77

3-D PLOT
RECTANGULAR COORD
COMPUTED FUNCTION

X-----X Y-----Y

1 SIZE (INCHES)	10	8
2 OFFSET (INCHES)	0	0
3 MARGIN (INCHES)	0	0

4 X LINE OPTION = Y	
5 Y LINE OPTION = Y	
6 INTERVAL BETWEEN LINES	20
7 INTERVAL PER LINE	20
8 HIDDEN POINT ACCURACY	10
9 SCALE FACTOR	42

X-----X Y-----Y Z-----Z

9 DIRECTION OF VIEW	1.4142	1.4142	1.6329
10 VERTICAL VECTOR	0	0	1

INDEPENDENT VARIABLES/INPUT &
DEPENDENT VARIABLE/OUTPUT
FOR COMPUTED FUNCTION

11 MINIMUM VALUES	-2	-2	-5.3333333333334
12 MAXIMUM VALUES	2	2	5.3333333333334

RANGE OF VARIABLES TRANSFORMED
FOR PROJECTED FUNCTION

X-----X Y-----Y

13 MINIMUM VALUES	-2.828427124746	-5.920064103916
14 MAXIMUM VALUES	2.828427124746	5.920064103916

```

5900 REM PROGRAM FILE FIG13.37
6500 GOSUB '99
6510 DEFFN'50(X,Y)
6520 Z=(1/3)*X3-X*Y2
6530 RETURN
    
```

APPENDIX H

MINIDISKETTE VERSION OF GUS

In the minidiskette version of GUS, the modules are contained on two minidiskettes. The Enter Parameters, Enter Data Points, Enter Labels, Initialize System, and Change Applications are located on minidiskette #1. Minidiskette #2 contains the Start Plot, Enter Labels, Initialize System, and Change Applications modules. It should be noted that Enter Labels, Initialize System, and Change Applications are resident on both minidiskettes in order to minimize the changing of minidiskettes in the course of processing.

The Graph Utility System can be "started" from either of the two minidiskettes and any of the modules contained in the mounted minidiskettes can be called from the System Menu shown below.

GRAPH UTILITY SYTEM - 4.0

SF KEY	DESCRIPTION	SF KEY	DESCRIPTION
00	- ENTER PARAMETER	03	- START PLOT
01	- ENTER DATA POINTS	04	- INITIALIZE SYSTEM
02	- ENTER LABELS	15	- CHANGE APPLICATIONS

However, when an attempt is made to call a module not contained in the mounted minidiskette, the system displays a prompt to mount the minidiskette where the particular module resides. For example, if an attempt is made to call Start Plot from the System Menu while minidiskette #1 is mounted in the drive, the system responds by displaying the prompt "MOUNT DISKETTE #2: KEY RETURN(EXEC) WHEN READY". Likewise, the system responds with the prompt "MOUNT DISKETTE #1: KEY RETURN(EXEC) WHEN READY" if an attempt is made to load either ENTER PARAMETERS or ENTER DATA POINTS from minidiskette #2. Normal processing will continue when the prompt is obeyed.

The prompt to mount another minidiskette can be overridden by depressing SF KEY '15. When this is done the System Menu is displayed and the user may choose another module from the menu. Similarly, if the system is initialized via the Initialize System module in minidiskette #2 and the letter option "A" (ADVANCE TO PARAMETER MODULE) is chosen, the prompt "MOUNT DISKETTE #1: KEY RETURN(EXEC) WHEN READY" is displayed. Again this prompt can be obeyed, and the Enter Parameter module is loaded, or SF KEY '15 can be depressed to override the prompt and display the System Menu.

Finally, if the letter option "A" (ADVANCE TO START PLOT) is chosen in the Enter Labels module on minidiskette #1, the prompt "MOUNT DISKETTE #2: KEY RETURN(EXEC) WHEN READY" is displayed after the user has answered the requests for "OUTPUT FILE NAME" and "DO YOU WANT A HARDCOPY?"

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