



4050 SERIES

**GRAPHIC COMPUTING
SYSTEM**

OPERATOR'S MANUAL

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PRODUCT 4051, 4052, 4054 Graphic Computing Systems

This manual supports the following versions of this product: B010100 and up

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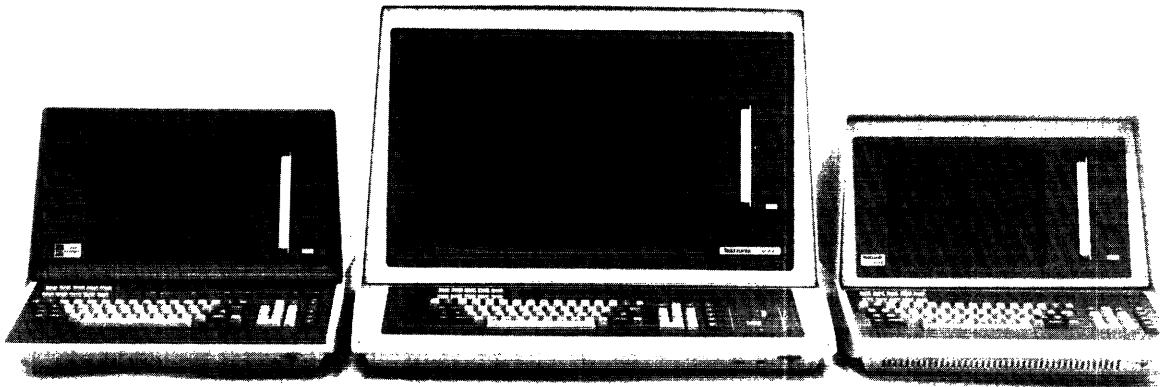
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Figure 1-1. 4050 Series Graphic Computing Systems.

Section 1

INTRODUCTION

OVERVIEW

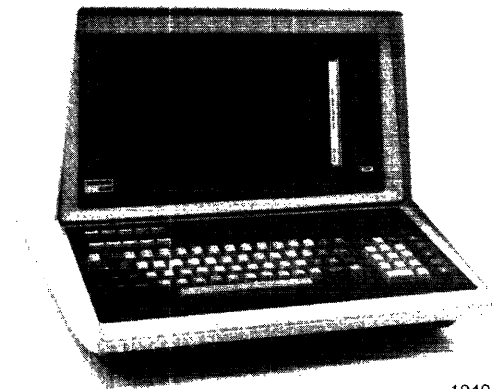
It's called the 4050 Series Graphic Computing System. It looks like this . . .



1940-201

Figure 1-2. 4051 Graphic Computing System.

Or like this . . .

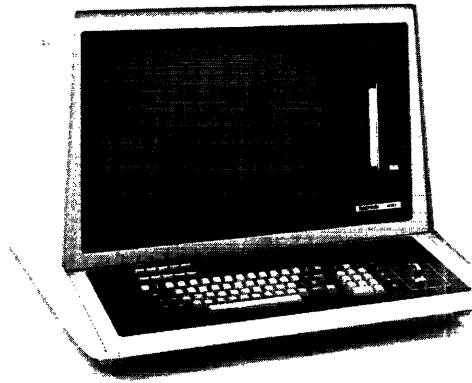


1940-202

Figure 1-3. 4052 Graphic Computing System.

INTRODUCTION

Or like this . . .



1940 208

Figure 1-4. 4054 Graphic Computing System.

When you first see one of these, you may get the uneasy feeling that something is missing. Where's the rest of the equipment? After all, when someone refers to a system, you expect to see several black boxes and a web of interconnecting cable. Not this time! A 4050 Series Graphic Computing System is a system by itself, and a powerful one; but the system is compactly placed in one chassis.

Before we begin talking in detail about your 4050 Series Graphic Computing System, let's take a few moments to summarize what the System is and how it operates. Then we'll look at the documentation package and find out how the supporting manuals and preprogrammed tapes are organized. Finally, we'll point out different learning routes you can take to tailor the documentation package to your requirements.

SYSTEM OPERATION

Your 4050 Series Graphic Computing System (or simply Graphic System) receives, stores, solves, displays, and transmits logic problems that you create from a combination of symbols, letters, numbers, and graphics. The System accepts data from its keyboard, from magnetic tapes, and from other instruments. It displays data on its screen and transmits the data to another instrument, to magnetic tape, or to both simultaneously.

How can you use the Graphic System? All sorts of ways! You can use it as a super desk-sized calculator. You can consider it a graphics machine, too. It can generate graphs you create from scratch or with the help of the PLOT 50 System Software Tape. If you attach an optional hard copy unit, you can make paper copies of anything you display on the System screen. If you already have a printer that meets certain industry standards, you can make printed copies of Graphic System data. Another option allows you to use the Graphic System as a computer terminal; that is, the option permits the Graphic System and a computer to exchange data. This could be accomplished locally by a direct wire hookup, or commercial telephone lines could be used to connect the Graphic System to a remotely located computer.

There are three memories in each 4050 Series Graphic Computing System. There is a permanent Read Only Memory (ROM) that contains the System's intelligence, a large temporary Random Access Memory (RAM) that stores data you want to process, and a small temporary memory (line buffer) that allows you to write something on the display screen and edit it before releasing the data to RAM.

If this kind of equipment is new to you, don't be intimidated by the screen and those keys and buttons. When you study the keyboard, you can see familiar key arrangements. One group of keys looks like a typewriter keyboard; next to it is a numeric pad that resembles a calculator keyboard. These key configurations have about the same functions as their familiar counterparts.

The direct view storage tube (DVST) displays information. The information may be entered into the System from the keyboard, from outside instruments, and from magnetic tape. The vertical rectangular opening on the front panel is where you insert a magnetic tape cartridge.

When the Graphic System is plugged into the proper power source and turned on, you can sit down at the keyboard and press letter, number, and symbol keys. Instead of the images appearing on a piece of paper--as they would if you were operating a typewriter—they are displayed on the screen.

THE BASIC LANGUAGE

If you're going to let the Graphic System help you solve complex problems, you must have a way of communicating with it. You can't type keyboard commands to the System just any old way. You can't write, "Hey, machine, I want you to remember that Y equals 2 when and only when Y is preceded by X." Of course, the System is capable of responding to an easy statement like that faster than you can wink, but it won't do it until you write your statement in a special format—in a computer language.

In the Graphic System, the permanent Read Only Memory (ROM) has been programmed to respond to BASIC (Beginner's All-purpose Symbolic Instruction Code), a computer language developed at Dartmouth College. BASIC has gained great popularity as a general-purpose computer language in the last few years because it's easy to learn, easy to remember, and easy to apply. There are two levels of BASIC: basic BASIC that forms the "hard-core" vocabulary used in all applications; and extended BASIC, which is basic BASIC supplemented with special commands created for a specific application. For the Graphic System, Tektronix has augmented basic BASIC with commands that expand the language to fit the Graphic System's capabilities. We call it the Graphic System BASIC language, a rich, versatile, and powerful extension of Dartmouth's BASIC.

THE DOCUMENTATION PACKAGE

The Graphic System documentation package consists of four manuals, a reference card, and two preprogrammed magnetic tapes. The manuals and tapes form a learning package that is structured to allow you to bypass irrelevant material and study subjects that complement your experience in BASIC programming. The reference card provides a brief summary for those already familiar with a 4050 Series Graphic Computing System.

Because the Graphic System is so versatile, users from a variety of vocations are attracted to the System. They possess a broad spectrum of experience and skills. The documentation package is designed to help the beginner, the experienced, and the expert programmer learn how to use the Graphic System quickly and effectively.

To satisfy such vastly different teaching requirements, the documentation package is divided into subject building blocks that start out with simple concepts and progress to complex system applications. For you to get optimum results from this package, you must understand what the building blocks are and where they are located. Only then will you be able to choose learning routes that will help you meet your system operation objectives.

First, we'll identify the learning blocks and then we'll stack the blocks into different learning configurations (learning maps) that may coincide with your requirements. At least we'll make you familiar with the blocks so that you can build your own learning structure.

THE LEARNING BLOCKS

Let's begin by examining the learning blocks in the documentation package: two PLOT 50 System Software Tapes and four manuals.

The PLOT 50 System Software Tapes

The PLOT 50 System Software Tapes are duplicates. Put one of them in a safe place; it exists to minimize downtime in case the tape you are using is accidentally erased. Each tape contains the following programs:

- System Verification
- Tutorial
- Y Only Data Plot
- X vs Y Data Plot
- Histogram Plot
- Function Plot
- Special 4054 Features

The System Verification Programs check for proper System operation when the Graphic System is installed and at any later time when System performance is in doubt.

The Tutorial Program presents an overview of the Graphic System on the display screen. It discusses keyboard operations, gives a demonstration of graphic software, presents a programming primer, and talks about graphic commands unique to the Graphic System.

The Y Only Data Plot, X vs Y Data Plot, Histogram Plot, and Function Plot Programs are separate software programs, each designed to help you create a specific type of graph with minimum effort.

The Special 4054 Features Program familiarizes the 4054 Graphic System operator with unique features of the 4054.

The Manuals

The 4050 Series Graphic System Operator's Manual documents the following:

- Graphic Computing System Introduction
- PLOT 50 System Software Programs
 - General Information
 - Tutorial
 - Y Only Data Plot
 - X vs Y Data Plot
 - Histogram Plot
 - Function Plot
 - System Verification
- Keys, Buttons, and Switches
- Maintenance
- Error Messages
- Specifications
- Installation
- Accessories and Peripherals
- Glossary
- Index

The PLOT 50 System Software Programs sections provide text instruction for the tape counterparts. The General Information section offers an overview of the programs and provides important data common to the software programs.

Keys, Buttons, and Switches gives an in-depth view of the keyboard and Graphic System operation. It is a natural follow-up to the Keyboard Operations Module of the Tutorial Program.

The Appendices include:

Error Messages—a numerical list and description of Graphic System procedure errors.

Specifications—an outline of physical, environmental, power, and mechanical specifications of the 4050 Series Graphic Computing Systems.

Installation—procedures for installation and first-time operation.

Accessories and Peripherals—a list of Tektronix equipment and software that you can use with your Graphic System.

Glossary—an alphabetical list and description of Graphic System terminology.

The Index provides an alphabetical subject locator.

The PLOT 50 Introduction to Programming in BASIC manual is written for nonprogrammers. It teaches programming in an operational format and confines itself to programming as it applies to the Graphic System as a stand-alone system.

The PLOT 50 Introduction to Graphic Programming in BASIC manual is a sequel to the Introduction to Programming in BASIC manual. It is a text for programmers at all experience levels who want to create graphics without software-program assistance.

The 4050 Series Graphic System Reference Manual is written for the experienced programmer. It presents an in-depth description of the Graphic System BASIC language.

LEARNING MAPS

Now that you know what the learning blocks are and where they are located, let's arrange them in logical groups.

The Installation Group:

Specifications—4050 Series Graphic System Operator's Manual

Installation—4050 Series Graphic System Operator's Manual

System Verification—4050 Series Graphic System Operator's Manual and PLOT 50 System Software Tape

PLOT 50 System Software General Information—4050 Series Graphic System Operator's Manual

The Installation and Specification Appendices must be read prior to System operation. This is especially important because the System has power settings that must be selected to match local power input. A power mismatch may seriously damage the Graphic System. After the System is installed, the System Verification Programs should be implemented before operating the Graphic System for other purposes.

INTRODUCTION

The Reference Group:

Keys, Buttons, and Switches—4050 Series Graphic System Operator's Manual

Maintenance—4050 Series Graphic System Operator's Manual

Glossary—4050 Series Graphic System Operator's Manual/4050 Series Graphic System Reference Manual

Index—4050 Series Graphic System Operator's Manual/4050 Series Graphic System Reference Manual

Error Messages—4050 Series Graphic System Operator's Manual/4050 Series Graphic System Reference Manual

This group's use is self-explanatory. It should be a supplement to all learning maps.

Beginner's Software Graphics Map

PLOT 50 System Software General Information—4050 Series Graphic System Operator's Manual

Graphic System Tutorial—4050 Series Graphic System Operator's Manual

Tutorial Keyboard Operations—PLOT 50 System Software Tape

Tutorial Demonstration of Graphic Software—PLOT 50 System Software Tape

Choice of:

Y Only Data Plot—4050 Series Graphic System Operator's Manual & PLOT 50 System Software Tape

X vs Y Data Plot—4050 Series Graphic System Operator's Manual & PLOT 50 System Software Tape

Histogram Plot—4050 Series Graphic System Operator's Manual & PLOT 50 System Software Tape

Function Plot—4050 Series Graphic System Operator's Manual & PLOT 50 System Software Tape

This is the recommended list and sequence for you to follow if you want to use the software graphics programs first. Later, you can follow the outline in the Beginner's General System Operation Map (leaving out duplicate material) to complete your Graphic System studies.

Beginner's General System Operation Map

PLOT 50 System Software General Information—4050 Series Graphic System Operator's Manual

Graphic System Tutorial—4050 Series Graphic System Operator's Manual

Tutorial Keyboard Operations—PLOT 50 System Software Tape

Keys, Buttons, and Switches—4050 Series Graphic System Operator's Manual

Tutorial Programming Primer—PLOT 50 System Software Tape

PLOT 50 Introduction to Programming in BASIC—entire manual except Graphics section

4050 Series Graphic System Reference Manual—topics as needed

This list in this sequence is intended for the beginner who has no interest in graphics at the moment.

Beginner's Graphics Map

Beginner's General System Operation Map plus . . .

PLOT 50 Introduction to Programming in BASIC—Graphics section only

PLOT 50 Introduction to Graphic Programming in BASIC—complete manual

There is some overlap of graphics material in the manuals in this map. We think this is healthy repetition, since you will be reading fundamental material from two distinct viewpoints.

Experienced Programmer's Map

PLOT 50 System Software General Information—4050 Series Graphic System Operator's Manual

Graphic System Tutorial—4050 Series Graphic System Operator's Manual

Graphic System Tutorial—PLOT 50 System Software Tape

Keys, Buttons, and Switches—4050 Series Graphic System Operator's Manual

PLOT 50 Introduction to Graphic Programming in BASIC—optional

4050 Series Graphic System Reference Manual—topics as needed

Error Messages—4050 Series Graphic System Operator's Manual/4050 Series Graphic System Reference Manual

Although the Graphic System Tutorial is written for the beginner, it also provides an excellent overview for the experienced programmer.

Experienced Programmer's System Software Map

Choose from these pairs:

Y Only Data Plot Operation Summary—4050 Series Graphic System Operator's Manual

Y Only Data Plot—PLOT 50 System Software Tape

X vs Y Data Plot Operation Summary—4050 Series Graphic System Operator's Manual

X vs Y Data Plot—PLOT 50 System Software Tape

Histogram Plot Operation Summary—4050 Series Graphic System Operator's Manual

Histogram Plot—PLOT 50 System Software Tape

Function Plot Operation Summary—4050 Series Graphic System Operator's Manual

Function Plot—PLOT 50 System Software Tape

If you're interested in software graphics, it is suggested that you place this map in the Experienced Programmer's Map following Keys, Buttons, and Switches.

These learning maps will fit most people, but they may not be just right for you. If you would feel more comfortable designing your own, go back to The Learning Blocks in this section; everything is listed there. Rearrange the blocks until you find the combination that suits your requirements exactly.

Section 2

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Section 2

PLOT 50 SYSTEM SOFTWARE GENERAL INFORMATION

OVERVIEW

The PLOT 50 System Software tape allows you to:

1. Verify that the Graphic System is working properly.
2. Use tutorial programs to overview the Graphic System's capabilities on the System display screen.
3. Create four kinds of graphs with minimum effort.

The System Software Tape and supporting text in this manual are designed for busy people like you, people who want to achieve optimum results from a minimum investment in time. The Graphic System Tutorial Program is in modular format and begins with simple concepts. You are not expected to have any special knowledge about computers, programming, graphs, mathematics, or the Graphic System. But if you do have expertise in one or more of these areas, you can bypass material you already know and move to pertinent material by using the System software's building-block construction.

The System Software Tape is composed of four modules: Verification, Tutorial, Graphics, and 4054 Features. Let's examine these areas.

The Verification Module contains two programs for checking the proper operation of the Graphic System. The Software Verification Program checks out system internal components: the keyboard, the Graphic System display, and data transfer to and from the internal magnetic tape unit. The Firmware Verification Program checks out System memory.

The Tutorial Module provides an overview of how to use the Graphic System. The Tutorial Program displays frames of text and graphics arranged in four major subject areas: keyboard operations, graphic software, programming, and graphic commands.

The Graphic Software Module helps you create four kinds of graphs on the System display screen with minimum time and effort. In these programs, most graph parameters are established for you; this permits you to create intricate graphs with little more than the raw data or the function you want plotted. If you wish to "customize" your graphs, you specify different parameters. It's very easy to do.

The 4054 Features Module introduces you to special features available in the 4054 Graphic System only.

THE PLOT 50 SYSTEM SOFTWARE TAPE

Two preprogrammed PLOT 50 System Software Tapes arrive with your Graphic System. They provide the Graphic System with instructions that direct it to perform specific operations. The tapes are duplicates. You should put one of the tapes in a safe location; it is your insurance policy against the inconvenience of having the tape you are using accidentally erased.

We call a tape “programmed” when it has instructions recorded on it. When a programmed tape is inserted into the Graphic System tape slot, a program is transferred from the tape to the Graphic System memory in response to specific keyboard entries. The transfer of instructions from the tape to memory can be repeated as often as you like. A magnetic tape with software instructions on it is a convenience; it transfers long, complex programs to the Graphic System memory in seconds.

The PLOT 50 System Software Tape is recorded in software program segments; each program is designed to perform a specific series of tasks. At the beginning of the tape, there is a program table of contents called the Master Menu. It lists programs and gives them item numbers. When the Master Menu is displayed on the screen, you find a specific program on the tape by entering the appropriate item number into the Graphic System from the keyboard.

The PLOT 50 System Software Tape contains the following programs:

| | | |
|-----------------------|---|-------------------------|
| Y Only Data Plot | } | Graphic Software Module |
| X vs Y Data Plot | | |
| Function Plot | | |
| Histogram Plot | | |
| Tutorial | | Tutorial Module |
| Software Verification | } | Verification Module |
| Firmware Verification | | |
| 4054 Special Features | | 4054 Features Module |

The construction of the tape (as it applies to the location and sequence of programs) is unimportant since the Master Menu gives you immediate access to any program. The menu concept is used at all program levels. Menus are used in programs that contain a choice of routines. Like the Master Menu, each program menu lists alternate routines and assigns each routine an item number to permit immediate access. Some of the routines have alternate subroutines, too; so these routines have menus to give you a choice of the subroutines. The tape’s menu format allows you to choose programs, routines, and subroutines with ease.

Only one program is transferred (loaded) from the tape to memory at a time. This makes it necessary for you to make an intermediate stop at the Master Menu when you want to go from one tape program to another. There is no direct route from the Y Only Data Plot Program to the Histogram Plot Program, for example. You must use a program selection in the plot programs called "STOP" or press the AUTO LOAD key on the System keyboard to go to the Master Menu. At the Master Menu, you press the proper program item number to reach the Histogram Plot Program. It is important to remember that when you leave a program and return to the Master Menu, all input data (values you put into the program to be graphed) is erased (lost).

THE PLOT 50 SYSTEM SOFTWARE TEXT

Text in this manual explains how to use the PLOT 50 System Software Tape. The text is organized like the software; it is divided into program segments.

The text for each plot program contains a basic step-by-step description of the program and explains how it can be used to meet a variety of graphing requirements. The written sections each feature an operation summary that is designed for the experienced programmer or for beginners who have read the basic text and want to use the summary for a reference. Technical terms are avoided as much as possible, and each plot program is written as a separate entity. It is not necessary to study the plot programs in any particular sequence, since each plot program is structured to tell you what you need to know to use that specific program.

PHOTOGRAPHIC REPRESENTATION AND DIRECTIONAL REFERENCES

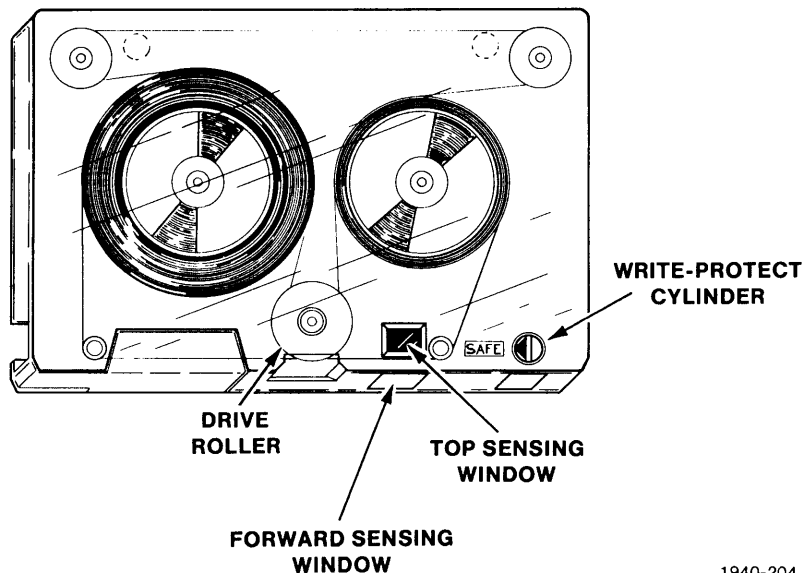
Since many external aspects of the 4050 Series Graphic Systems are similar, photographic representation of one of the Systems is often representative of the others also. Where differences are important, you will see your specific System.

In this text, when we use directional terms like up, down, right, and left, the terms relate to the operator's point of view, facing the Graphic System keyboard.

TAPE CARTRIDGE CARE

Performance of the internal magnetic tape unit and prevention of data errors are partially dependent on the handling of the tape cartridge. The cartridge contains a small plastic door over the tape access area to protect the tape. The door is automatically opened when the tape cartridge is inserted in the tape unit and closed when the cartridge is removed. The following precautions will help prolong the life of a tape cartridge and prevent data errors.

- Do not touch the brown-colored tape in the cartridge.
- Do not expose cartridges to direct heat or strong sunlight. (Note the environmental specifications in the Specifications Appendix.)
- Acclimate a tape to operating temperature for several hours if it has been stored in a warmer or colder environment.
- Use caution with cigarettes, cigars, and pipes around cartridges. Heat and contamination from a carelessly dropped ash can damage a tape.
- Keep tape cartridges in a clean, dust-free area.
- Do not allow the light sensing windows (Figure 2-1) to become dirty or smudged, as this may cause the tape to run off its spools. Under no circumstances should the windows be covered.



1940-204

Figure 2-1. Tape Cartridge Components.

- Do not drop or throw a tape cartridge. Physical stress might bend the metal base plate or cause tape misalignment, resulting in data errors.
- Keep cartridges away from magnetic fields and ferromagnetic materials that might become magnetized. Strong magnetic fields can damage the magnetically recorded data on a tape.
- Do not leave a tape cartridge inserted in the tape unit for an extended period when the unit is not in use (such as overnight). This results in a temporary flat spot on the drive roller (Figure 2-1), causing the unit to be excessively noisy during the next few minutes of operation. It may also cause occasional tape slippage.

Write-Protecting a Tape Cartridge

Write-protecting a tape cartridge prevents writing on the tape or erasing information that is recorded on the tape. To write-protect a tape cartridge, insert a coin or a screwdriver into the cylinder with an arrow painted on it, the write-protect cylinder (Figure 2-1). Turn the cylinder until the arrow points to the position marked SAFE and locks there. To remove the write-protection, turn the cylinder until the arrow points to the position opposite SAFE and locks there.

Cycling a Tape Cartridge

It is wise to cycle (wind and rewind) a tape periodically to keep tension evenly adjusted and to prevent irregular stacking. This is especially important if only a portion of the tape is used repeatedly. Cycling a tape is very easy with the 4052 and 4054 Graphic Systems: simply enter CALL "MTPACK" and press RETURN.

To cycle a tape with the 4051 Graphic System, remove the write-protection and proceed as follows. This procedure does not destroy data that is already on the tape.

| | |
|---------------|--|
| FIND n | (n is the LAST file on the tape) |
| MARK 1,400000 | (large enough to reach the end of the tape without room for a LAST file) |

The 4051 Graphic System will reach the end of the tape, rewind it, and display an error message. Restore the LAST File before write-protecting your tape:

| | |
|----------|---------------------------------|
| FIND n | (n is the NEW file just marked) |
| MARK 1,1 | (establishes a LAST file) |

Cycling a tape is also valuable when the tape has been dropped or has undergone a significant temperature change.

INSERTING THE TAPE CARTRIDGE INTO THE GRAPHIC SYSTEM

Pick up the PLOT 50 System Software Tape between the thumb and fingers of the right hand so that the metal side of the tape cartridge is resting against your fingers. The tape label is visible, and your thumb is resting against the clear plastic side of the cartridge. Insert the cartridge about two inches into the tape slot in the right side of the Graphic System front panel (Figure 2-2A).

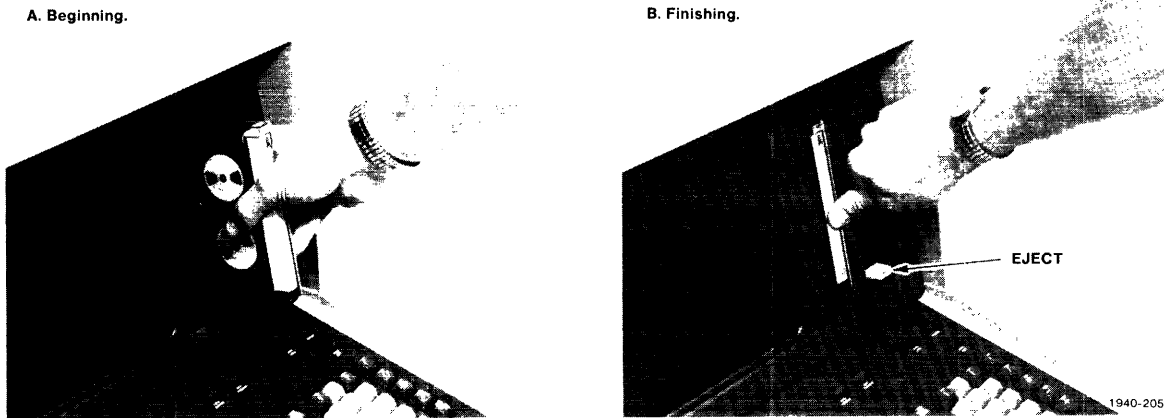


Figure 2-2. Tape Cartridge Insertion.

Release the cartridge; place your thumb against the label end and push the cartridge into the slot slowly. You won't notice much mechanical resistance until the cartridge's label end projects only 3/4 of an inch beyond the System front panel. At that time, notice that the EJECT button is flush with the front panel. Now press slowly against the cartridge until the last 3/4 of an inch goes into the tape slot (Figure 2-2B).

When the cartridge is properly seated in the tape slot, you won't be able to push it in any further, the label end of the cartridge will be flush with the front panel, and the EJECT button will be fully extended beyond the front panel.

ERROR RECOVERY

Studying error recovery techniques is like studying first aid procedures; you feel obligated to study them, but you hope you never have to use them. You probably won't make an error while studying the System Software Programs, but it is reassuring to know what to do if you should make one. That's what this topic is all about — the kind of errors you might make, and the recovery techniques you must use to get the Graphic System back into a normal operating mode.

You can make two kinds of errors: fatal and nonfatal. A fatal error is not as lethal as it sounds; if you make a fatal error while you're running a System software program, the System will go out of program control and give you control at the keyboard until the error is corrected. A nonfatal error needs correction too, but control is still maintained by the program. Fatal errors and some nonfatal errors require action on your part before you can resume normal System operation. We call your remedial action a recovery technique.

If you make a mistake that violates Graphic System procedures or violates the BASIC structure of a statement, the System will notify you of the error by printing an error message on the display screen. If your ego can take it, being notified that you made an error is a convenience because it saves you time. But the System is not always that accommodating. If you make a typographical error while entering data to be graphed, for example, the System will not notify you of your mistake; in fact, it will not be aware that a mistake has been made.

There are more than 80 types of fatal errors that can be made on the Graphic System. When you commit a fatal error, the screen displays a message similar to one of these:

```
MAG TAPE ERROR IN LINE 1310 — MESSAGE NUMBER 55  
INVALID FUNCTION ARGUMENT IN LINE 390 — MESSAGE NUMBER 21
```

As soon as a fatal error message is displayed, a small blinking rectangle (cursor) appears at the left margin of the display. The appearance of the cursor signifies that the keyboard has control of the System.

Right now, it's premature in your study of the Graphic System for us to define mag tape errors, invalid function arguments, or any of the other fatal errors. The important point at this time is for you to know what a fatal error message looks like on the display screen and how to recover from the error.

SYSTEM SOFTWARE GENERAL INFORMATION

In the System Software Programs, you are guided carefully from one operation to another. If you follow directions, you won't make fatal errors. But if you should make one, it's probably because you misunderstood the directions or pressed the wrong key. After you have performed the proper recovery technique and returned the Graphic System to the operating mode, go back several sentences in the text and read the directions carefully before you try to implement the trouble area again.

Pressing User Definable Key Number 1 (Figure 2-3) is the recovery technique for a fatal error in the Y Only Data Plot, X vs Y Data Plot, Histogram Plot, and Function Plot Programs only. This causes the System to erase the screen and reprint the appropriate program menu. This recovery does not destroy input data, destroy a function entered before the error occurred, or reset default values.

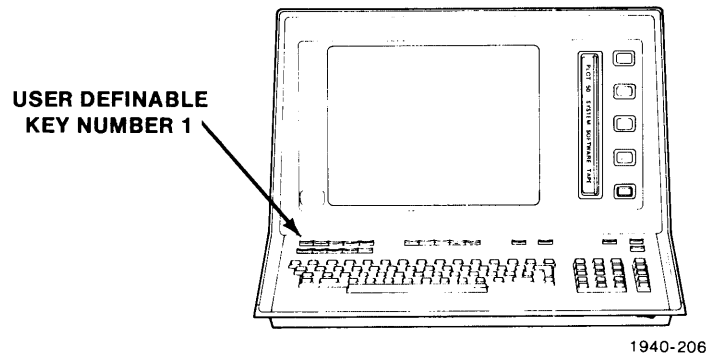


Figure 2-3. User Definable Key Number 1.

When a fatal error occurs in the System Verification Programs or the Graphic System Tutorial Program, the recovery technique is:

Press BREAK
Press BREAK

Screen: PROGRAM ABORTED IN LINE 560 (line number will vary with error)

Press AUTO LOAD

The screen displays the Master Menu.

This recovery technique (BREAK/BREAK/AUTO LOAD) will work in the plotting programs, too; but when it is used, functions and input data are lost and default values are reset. You also have the inconvenience of returning to the Master Menu.

Nonfatal errors are syntax errors or errors you make when entering a function or other graph values. A syntax error is a mistake in the BASIC sentence structure of a statement. It could be a misspelled keyword, an omission, etc. A keyword is an alphabetical code that tells the Graphic System what function to perform. For example, RUN is a keyword; if you spell it RIN, you create a syntax error.

After a syntax error is made and you press the RETURN key to dump the contents of the line buffer into the System memory, your incorrect line is reprinted on the display. Above it, are the words SYNTAX ERROR with an arrow pointing to the general vicinity of the error. Your attempt to unload data from the line buffer was ignored; the System refused to put an incorrect statement into memory.

There are two recovery techniques for a syntax error. You can use the editing keys (Figure 2-4) to correct the error or press the CLEAR (editing) key (to erase the line buffer data) and start the line over.

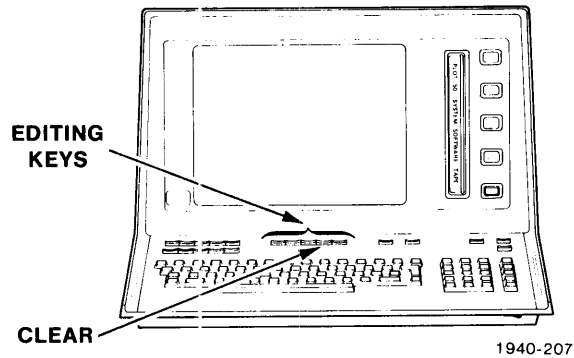


Figure 2-4. The Editing Keys.

You create a second category of nonfatal error when you make typographical mistakes entering data, entering a function, changing graph axes locations, etc. Since the System doesn't know your intentions, it accepts your data as correct as long as you do not violate Graphic System procedures. You can correct this type of error by using the editing keys if the RETURN key has not been pressed. If the RETURN key has been pressed, ignore the error and complete your entries. In each plot program, there are menu selections that allow you to add, change, or delete input data; use these selections to correct input data errors. When you make function entry errors, rewrite the function. If you make other entry errors, choose the appropriate menu item a second time and rewrite the input correctly.

MARKING A TAPE FILE

Marking a tape file is a subject you should not explore until you have studied at least one of the PLOT 50 System Software Programs and wish to record input data on magnetic tape for later use. If it is premature for you to read this topic now, you may want to move to the Graphic System Tutorial.

In three of the PLOT 50 System Software Programs, there are instructions on how to store data on a magnetic tape for later retrieval. The procedure given in these programs begins after you mark a file on a magnetic tape. Here, we discuss how to mark a file on a new tape and on a tape that has other data recorded on it.

The magnetic tapes used with the Graphic System are packaged in plastic-and-metal constructed digital tape cartridges. The reusable magnetic tape in each cartridge has space for about 2,400,000 pieces of information. We call these information pieces “bits.” They are grouped, like you group letters into words; however, in this case, the groups are always the same size — eight bits per group. These bit groups are called “bytes.” There is room for approximately 300,000 bytes of data on a tape.

You mark files to accomplish two things: to give the file a reference number so you can return to it later and to reserve tape space for data. When you mark files, they are automatically numbered sequentially, beginning with 1. You can mark one or several files at a time. When you mark a file, you reserve tape space by specifying a number of bytes. The System marks off sufficient room on the tape to record the number of bytes you specify.

By now, you’re probably thinking, “How do I equate byte space to data space; how do I know how many bytes to reserve for my data?” In the PLOT 50 System Software Programs, input data is stored on an auxiliary tape in binary-data format. It takes 10 bytes of binary data to store each data item regardless of the data item’s numerical size. For example, the number 2 and the number 100,000,000,000 each use 10 bytes of tape space (actually, only 8 bytes are used for data and 2 bytes form an “identifier” or “header”). If you add 1 to the number of data items you want to store on tape, and multiply by 10, you get the correct byte-space number you need to mark a file for your data.

A data tape is made up of segments called physical records. Each physical record occupies tape space that holds 256 bytes of data. The minimum tape space that the Graphic System assigns to any file is three physical records long (768 bytes). When you mark a file for 1010 bytes, the System assigns as many physical records as it takes to at least equal that number; the System does not split the last record to give you space exactly equal to your request. When you mark a file for 1010 bytes, you get 1024 byte spaces reserved for your data (the equivalent of four records).

This is how you mark a file on a new tape. Turn the Graphic System on. Insert the new magnetic tape cartridge into the tape slot on the front panel of the Graphic System as described in Inserting the Tape Cartridge into the Graphic System.

Type FIND ()
Press RETURN

This positions the System tape head at the beginning of the tape. Let's assume you want to mark one file for 50 pieces of data.

Type MARK 1, 510
Press RETURN

Here is what you have accomplished with these entries: you have marked one file that reserves space on the tape large enough to hold 510 bytes of data. That file will actually be 768 bytes long — the System minimum file length (three physical records).

If you want to create two files at the beginning of a tape with each file containing 2010 bytes of data, your entry looks like this:

Type MARK 2, 2010
Press RETURN

There is a procedure for listing a directory of tape files on the screen. Type the keyword TLIST and follow that entry by pressing the RETURN key. This asks the Graphic System to list a file directory of the magnetic tape currently in the tape slot. The System tape head starts at the beginning of the tape and searches its entire length for the beginning of each file. When it encounters a file, information about that file is displayed on the screen. In the last paragraph, we marked two files on a new tape. We reserved 2010 bytes of tape space for each file. Here is what would be displayed on the System screen after a TLIST of that tape.

| | | |
|---|------|------|
| 1 | NEW | 2048 |
| 2 | NEW | 2048 |
| 3 | LAST | 768 |

As you can see, each screen line lists one file. The list contains the file number (assigned automatically by the System), the contents of the file, and the length of the file in data bytes. Notice that we marked only two files, yet we got three. Why?

Whenever you mark one or more files, the System establishes that number of files for you and always establishes a dummy file as the last file. The dummy file is a marked portion of the tape where the next new file will begin; it's just a convenient way of addressing the next available tape space.

SYSTEM SOFTWARE GENERAL INFORMATION

Let's discuss storing data on a tape that is partially filled. Suppose we have a data tape in the System that we want to use; however, we have no idea what the tape contains. We have to make a TLIST to see if there is any room available for one file of 75 data items.

Type TLIST
Press RETURN

The display screen shows the following:

| | | |
|---|-------------|------|
| 1 | BINARY DATA | 2048 |
| 2 | ASCII DATA | 3072 |
| 3 | BINARY DATA | 3072 |
| 4 | BINARY DATA | 1024 |
| 5 | LAST | 768 |

The screen listing reveals that the dummy file is number 5. By inspection, we can see that there is a lot of recording space left on the tape. Position the System tape head at the beginning of the dummy file and mark a file for 75 data items:

Type FIND 5
Press RETURN
Type MARK 1, 760
Press RETURN

That's really all you have to do; but let's make another TLIST of the tape and see what the file directory looks like after your entries.

Type TLIST
Press RETURN

The screen displays the following:

| | | |
|---|-------------|------|
| 1 | BINARY DATA | 2048 |
| 2 | ASCII DATA | 3072 |
| 3 | BINARY DATA | 3072 |
| 4 | BINARY DATA | 1024 |
| 5 | NEW | 768 |
| 6 | LAST | 768 |

Notice that the System labeled your file as NEW, and created file 6 as a dummy file (LAST) to allow access to the next available tape space.

If you have a magnetic tape filled with obsolete data, you can go to the first file (FIND 1) and mark the file to your specifications. Marking this tape space also creates dummy file 2 and erases all data previously in these spaces. In fact, **all** data previously on the rest of your tape is now inaccessible and for all practical purposes is lost data.

If you have a tape that has one file you want to save, but is otherwise filled with obsolete material, reuse the tape following the valuable file. Assume file 5 is valuable. If you mark the tape starting at file 1, you lose the data in file 5. If you mark the tape beginning with file 6, file 5 remains.

There's another technique you can use when you want to record data on a tape that has some obsolete material. Find a useless file (4, for example) marked to a tape area large enough for your data. Erase the contents of that file only, and recategorize that file as a NEW file by entering a KILL statement from the keyboard. You do it this way:

```
Type FIND 4
Press RETURN
Type KILL 4
Press RETURN
```

Because the Histogram Plot and the Y Only Data Plot Programs have a limitation of 100 input data items, reserving 1010 bytes of tape space is an adequate maximum for either program. The X vs Y Data Plot Program is different; it has an input data limitation of 100 sets of data. Each set equals one X axis data item and one Y axis data item. If we unravel the sets, we have a total of 200 data items. Add 1 and multiply by 10 for a total of 2010. If you mark a 2010 byte space on the data tape, that space will store all input data allowed for the X vs Y Data Plot Program.

You can be super-conservative and always reserve 1010 bytes of tape space when you mark a file for the Histogram Plot or for the Y Only Data Plot Program, and reserve a 2010 byte data-tape space when you mark a file for the X vs Y Data Plot Program. If you do this, you'll be wasting a little space on your data tape when you store less than maximum quantities, but you'll never have a file marked too small when using these programs.

You commit a fatal error if you don't leave sufficient room to store your data. When such an error occurs, the display screen shows a fatal error message that might look like this:

```
EOF ON UNIT 0 IN LINE 560 — MESSAGE NUMBER 48
```

SYSTEM SOFTWARE GENERAL INFORMATION

You still have the data in the System memory but your file is worthless. Some of the data is in the file; some of the data isn't. What should you do? If this is the last file on the tape, you can go back and mark it again, establishing sufficient room for the data. If it is not the last file, you can abandon that file and mark the next available one. Regardless, you must store the data again if you want to save it.

Let's assume you're in the Y Only Data Plot program trying to store 100 data points (the program maximum) in file 7, which was marked for 768 bytes of tape space. File 7 is the last data file on the tape. You have the data tape in the tape slot, and the screen shows the EOF fatal error message. Remark the file:

```
Type FIND 7
Press RETURN
Type MARK 1, 1010
Press RETURN
Press USER DEFINABLE KEY 1
```

The screen displays the program menu. Select menu item 15 — STORE DATA.

```
Enter 15
Press RETURN
```

Screen: INSERT DATA TAPE AND ENTER FILE NUMBER ?

```
Enter 7
Press RETURN
```

Screen: DATA STORED
 INSERT SYSTEM TAPE AND PRESS RETURN ?

You have remarked file 7 and stored your data in it. See the PLOT 50 Introduction to Programming in BASIC manual or the 4050 Series Graphic System Reference Manual for additional information about marking files.

Section 3

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| Implementing the Tutorial Program | 3-2 |
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Section 3

GRAPHIC SYSTEM TUTORIAL

INTRODUCTION

The Graphic System Tutorial Program provides an overview of how to use the Graphic System. Text and illustrations are presented on the Graphic System display screen in a sequenced format that encourages you to be a participant in the learning process. The Tutorial is like a book; from any program location, you have the freedom to go back as many frames as you like for review, or go forward several frames when you want to skip familiar material. At appropriate places in the program, you are given the opportunity to work independently, experimenting with material that has just been presented. This coupling of teaching techniques—presenting new subject material, then presenting the opportunity to “try it out on your own” --helps dramatize important topics.

The learning process is enhanced because you are learning on the System you are studying. For example, in the Keyboard Operations Module you are given information about the editing keys; then you are asked to use those keys. You immediately see the effect editing keys have on display screen text.

The Tutorial Program's value is not restricted to the initial learning activity. The Tutorial is also a valuable review tool. An index permits you to select any single topic for immediate viewing.

THE TUTORIAL'S ROLE IN THE DOCUMENTATION PACKAGE

The Tutorial Program is not a text alternative; it is instead an integral part of the Graphic System documentation package. The Tutorial Program and the accompanying manuals fit together to form a comprehensive learning library for the Graphic System.

The Tutorial is composed of four modules, a master menu, and an index. The modules are as follows:

1. **KEYBOARD OPERATIONS.** This module discusses operation of the keyboard. The Keys, Buttons, and Switches section of this manual discusses keyboard operations in detail.

- 2. **DEMONSTRATION OF GRAPHIC SOFTWARE.** This module demonstrates the four types of graphs that can be created using the PLOT 50 System Software Programs. Software applications for these plots are contained in the Y Only Data Plot, X vs Y Data Plot, Histogram Plot, and Function Plot sections of this manual.
- 3. **PROGRAMMING PRIMER.** This module presents an overview of fundamental BASIC statements. A detailed discussion of Graphic System BASIC is covered in the PLOT 50 Introduction to Programming in BASIC manual. The 4050 Series Graphic System Reference Manual offers in-depth BASIC language information.
- 4. **GRAPHIC COMMANDS.** This module discusses graphic commands unique to the 4050 Series Graphic System. The PLOT 50 Introduction to Graphic Programming in BASIC manual provides a comprehensive discussion of graphing techniques. The 4050 Series Graphic System Reference Manual provides detailed information on each graphic statement.

IMPLEMENTING THE TUTORIAL PROGRAM

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage settings of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 3-1). The four green indicator lights on the front panel (Figure 3-1) will turn on, but only the POWER light remains on. It stays on as long as power is applied to the System.

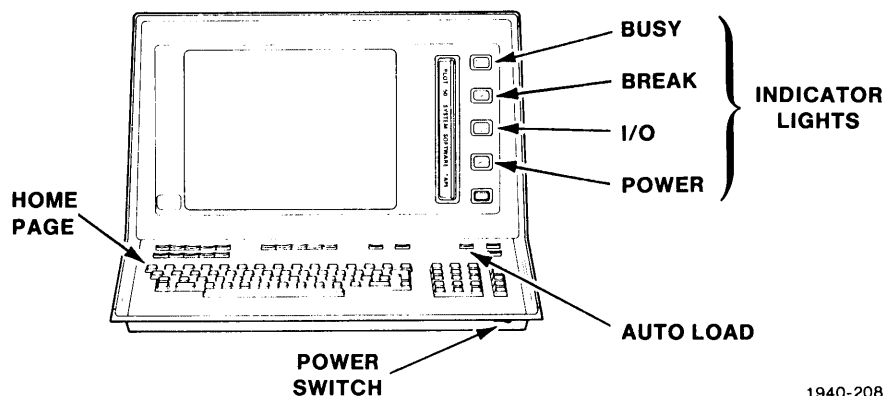


Figure 3-1. Power Switch, Indicator Lights, HOME/PAGE Key, and AUTO LOAD Key.

Press the HOME/PAGE key. Now the screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen.

Insert the PLOT 50 System Software Tape into the Graphic System. Refer to the PLOT 50 System Software General Information section of this manual for specific instructions. Press the AUTO LOAD key (Figure 3-1.) This rewinds the magnetic tape, locates the first ASCII program on the tape, loads the program into the Graphic System memory, and begins execution—in this case, by displaying a program directory (menu). When you press the AUTO LOAD key, the BUSY and I/O (Input/Output) indicator lights (Figure 3-1) turn on. The System makes a series of sounds that normally occur whenever there is tape movement in the System. Figure 3-2 shows the PLOT 50 System Software Master Menu that appears after the tape stops:

```

** PLOT 50: SYSTEM SOFTWARE **

PROGRAM          TITLE
                GRAPHIC SUPPORT PROGRAMS
1                Y Only Data Plot
2                X vs Y Data Plot
3                Function Plot
4                Histogram Plot

5                GRAPHIC SYSTEM TUTORIAL
6                SOFTWARE VERIFICATION PROGRAM
7                FIRMWARE VERIFICATION PROGRAM (4051 only)
8                SPECIAL 4054 FEATURES (4054 only)

ENTER THE PROGRAM NUMBER YOU WANT: 1940-209

```

Figure 3-2. PLOT 50 System Software Master Menu.

The Master Menu is an eight-item program directory. Notice that the Graphic System Tutorial is listed as item number 5. Press the 5 key. Press the RETURN key. You have just completed your Graphic System Tutorial selection. In a moment, the screen will erase the Master Menu and display the first frame of the Tutorial Program.

USING THE TUTORIAL PROGRAM

The Graphic System has a repeat-key feature. If any key on the keyboard is pressed and held down, it is equivalent to pressing that key several times. The Tutorial Program often asks you to press the RETURN key to progress from frame to frame. If you hold the RETURN key down too long, the system receives several RETURN signals and remembers them. As a result, the frames will pass by more rapidly than intended until the System has used all the stored RETURN signals. Also, do not press the RETURN key until asked to do so.

Figure 3-3 shows the second frame of the Tutorial; this frame displays the menu for all the programs in the Tutorial:

```

This Tutorial program is designed to familiarize you with the 4050
SERIES GRAPHIC SYSTEM.

Some of the sections are timed to present information at a speed which
should be easy to read. Other sections require you to respond with an
answer or choose an alternative.

There are also sections that allow you to use the machine without the
Tutorial program operating. In these cases, to resume the Tutorial type
RUN and press RETURN.

NOTE**The display will dim after 90 seconds of inactivity
      to save energy. Press SHIFT to restore the view.

The menu below allows you to select alternatives.

1 THE WHOLE TUTORIAL ---Includes items 2,3,4 & 5
2 KEYBOARD OPERATIONS ---Introduction to the keyboard
3 DEMONSTRATION OF GRAPHIC SOFTWARE ---Graphic support software
4 PROGRAMMING PRIMER ---Fundamental BASIC statements & item 5
5 GRAPHICS COMMANDS ---Graphic statements, unique to the Graphic System
6 INDEX ---Pick and choose individually from all the topics

Please enter menu item and press RETURN
1940-210
    
```

Figure 3-3. Tutorial Menu.

You can view the entire Tutorial Program or you can view single modules. To view the complete Tutorial, press the 1 key and then press the RETURN key. To view a single module, press the appropriate number key and then press the RETURN key. The System will display all the frames in that module before taking you back to the Tutorial Menu.

Regardless of whether you choose to see the entire Tutorial or a specific program module, the first display will be the general information frame shown in Figure 3-4.

If you or the machine make an error at any time and the cursor (a rectangular blinking indicator) appears, then type RUN and press RETURN to resume the Tutorial. If this fails, press AUTO LOAD.

Any time you are asked a question with a (YES,NO) answer or have the opportunity to "press RETURN to go on," you may:

- A. Answer appropriately (YES,NO,RETURN)
- B. Return to the MENU (Type MENU and press RETURN)
- C. Turn FORWARD n pages (Type FORWARD n and press RETURN)
- D. Turn BACK n pages (Type BACK n and press RETURN)
- E. Leave the Tutorial altogether (Type GOOD BYE and press RETURN)
- F. Review the present page (Type REVIEW and press RETURN)
- G. Find the INDEX (Type INDEX and press RETURN)

In the above n is the number of pages to be "turned."

Press RETURN to go on

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Figure 3-4. Tutorial Program General Information Frame.

Notice the frame's top statement. It tells you what to do if you should make a mistake. The rest of the frame gives you instructions on program movement. Table 3-1 provides an alphabetical summary of commands that control program movement for the Tutorial. You may enter them from the keyboard anytime you are asked to give a YES, NO response or "press RETURN to go on." You may not enter them when a numeric response is expected or before leaving the general information frame (Figure 3-4). Remember to press the RETURN key after typing any of these commands.

Table 3-1

TUTORIAL COMMANDS

| Command | Program Movement |
|------------|--|
| BACKWARD n | Moves backward n frames |
| FORWARD n | Moves forward n frames |
| GOOD BYE | Moves to Master Menu |
| INDEX | Moves to Index |
| MENU | Moves to Tutorial Menu |
| REVIEW | Repeats current page |
| RUN | Attempts error recovery/Returns System to program control. |
| YES/NO | Moves to next appropriate frame |

If you decide to view the entire Tutorial and you want to quit in the middle of the program, wait until the complete frame is displayed and you are requested to press the RETURN key. At that point, type GOOD BYE. Then press the RETURN key. The System will return you to the PLOT 50 Master Menu. If you're through using the System for the day, the easiest way to terminate the program is to turn the System OFF with the System power switch.

If you wish to review a single topic, go to the Index and select the appropriate topic. Enter the topic's number into the System by pressing the appropriate number key(s) and then pressing the RETURN key. After your review, press the RETURN key to return to the Index. To return to the Master Menu, select topic 20 (GOOD BYE) and press RETURN.

If you are uncertain what you should study after you've completed a module or the entire Tutorial, you may find it advantageous to return to the learning maps in the Introduction of this manual.

Section 4

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Section 4

Y ONLY DATA PLOT

INTRODUCTION

If you are an experienced programmer, you have several options after reading this Introduction: read the Operation Summary, scan the text following the Operation Summary, or combine the two. If you're relatively new at this graphing business, read this Introduction, skip the Operation Summary for now, and begin studying the text that starts with "What Is a Y Only Data Plot?" Later you may want to use the Operation Summary as a reference.

In the Y Only Data Plot text, we use one set of data for all demonstrations. Once that data is entered into the Graphic System and the program displays the Y Only Data Plot Menu, you have reached a STOP/START point. These labeled STOP/START points are convenient places for you to stop studying and turn off the System, aware that you can reenter the test's running commentary at that location with the proper settings on the Graphic System for future demonstrations. We'll provide you with detailed instructions on how to use this study technique when we reach the first text STOP/START point.

OPERATION SUMMARY

To initialize the Graphic System: (text: Initializing the Graphic System)

1. Refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.
2. Connect the power cord to the Graphic System and then to your power source.
3. Turn ON the power switch located beneath the right-front corner of the unit.

To begin the PLOT 50 System Software Programs: (text: Initializing the PLOT 50 System Software Tape)

1. Insert the PLOT 50 System Software Tape.
2. Press the AUTO LOAD key.
3. The screen displays the PLOT 50 System Software Master Menu

Y ONLY DATA PLOT

The Y Only Data Plot Menu will be used as a reference base for this Operation Summary. Menu selections will be listed following their menu item numbers. Text references are provided to guide you to a detailed explanation.

1. **ENTER DATA** (text: Creating a Graph Using All Default Values)
The data values are entered in sequence. The process of entering data is terminated by entering M as an input data value.
2. **DISPLAY DATA** (text: Creating a Graph Using All Default Values)
This menu item graphs input data. The Graphic System must have data, beginning X, and X increment values before a graph can be constructed. The System will query you about these X parameters before you attempt to graph data if these values have not been entered into the System from menu item 5.
3. **LIST DATA** (text: Creating a Graph Using All Default Values)
This menu selection presents a columnar list of input Y data.
4. **LIST PARAMETERS** (text: Listing Parameters)
This menu section presents a columnar list of selected or default condition graph values. They are . . .

NUMBER OF

POINTS: shows number of input data items.

LINE CODE: displays the selected Plot Mode.

SYMBOL

CODE: gives symbol selection.

SCREEN

MINIMUM: displays X and Y axes screen starting points in graphic display units (GDUs).

SCREEN

RANGE: displays X and Y axes GDU lengths.

DATA

MINIMUM: shows X and Y axes minimum data values.

DATA

RANGE: displays X and Y axes data ranges.

5. **SET X PARAMETERS** (text: Creating a Graph Using All Default Values)
This menu item asks you to determine . . .
 1. Beginning X: the value of the first plot point.
 2. X Increment: the value of plot-point intervals.

The menu item has no defaults. If X parameters are not established, and you attempt to graph data, the two X parameter questions are asked automatically.
6. **SET X SCREEN POSITION** (text: Changing the Graph's Screen Position)
This menu item sets the X axis horizontal length and position in GDUs on the 130 GDU horizontal screen surface. The default condition begins the axis at 30 GDUs and ends it at 110 GDUs, establishing an axis that is 80 GDUs long.
7. **SET Y SCREEN POSITION** (text: Changing the Graph's Screen Position)
This menu selection sets the Y axis vertical length and position in GDUs on the 100 GDU vertical display screen surface. The default condition begins the axis at 10 GDUs and terminates it at 90 GDUs. This creates a Y axis that is 80 GDUs high.
8. **SET X DATA RANGE** (text: Changing the Data Ranges)
This menu item establishes minimum and maximum X axis data values. The default condition is a result of autoscaled X axis input data values.
9. **SET Y RANGE** (text: Changing the Data Ranges)
This menu item establishes minimum and maximum Y axis data values. The default condition is a result of autoscaled Y axis input data values.
10. **SELECT PLOT MODE** (text: Selecting Plot Modes)
Two modes are available: a default line plot and an optional point plot.
11. **SELECT SYMBOL** (text: Selecting Plot Symbols)
Here you are offered a choice of five plot symbols: point, triangle, plus sign, square, and diamond. The point symbol is the default condition.
12. **INSERT DATA** (text: Inserting Data)
This menu item permits insertion of data into a Y data string already entered into the System's memory. Enter M as a data entry to terminate the insert-data routine.

Y ONLY DATA PLOT

13. **DELETE DATA** (text: Deleting Data Inside the Data String)
(text: Deleting Data at the End of a Data String)
From this menu selection, you can delete data from a Y data string that has been entered into the System's memory. Enter M as a data item to terminate the delete-data routine.
14. **CHANGE DATA** (text: Changing Data)
This menu selection allows you to change one or more data values in a string of Y data previously entered into the System. An M is entered as a data value to terminate the data-change routine.
15. **STORE DATA** (text: Storing Data on a Magnetic Tape)
Data that has already been entered into the System's memory can be stored on a separate magnetic tape for later data reentry. This menu selection is made after a data file has been marked on a separate magnetic tape (optional accessory).
16. **STOP** (text: Stop)
Menu Item 16 is enabled from the Y Only Data Plot Menu or from any entry statement that permits an M entry. STOP takes you to the PLOT 50 System Software Master Menu. All defaults are enabled. All Y input data is lost.

In addition to the menu items above, the following topics in the text are brought to your attention.

ADD DATA (text: Adding Data)

To add Y data to the end of a previously entered data string, select menu item 1, ENTER DATA. Enter the data in response to display screen queries. Terminate the add-data routine by entering M as a data value.

CORRECTING ERRORS (text: PLOT 50 System Software Information)
(text: Creating a Graph Using All Default Values)

DEFINITION OF A Y ONLY DATA PLOT (text: What is a Y Only Data Plot?)

INPUT DATA LIMITS (text: Input Data Limits)
A maximum of 100 Y data values may be entered into the system in this program.

PLACEMENT OF AXES TOO CLOSE TO SCREEN EDGE (text: Changing the Graph's Screen Position)

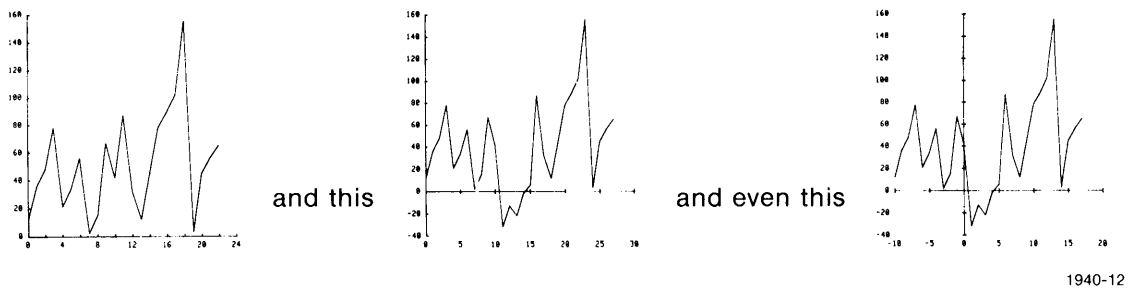
STOP/START POINTS (text: Introduction — this section)
(text: Creating a Graph Using All Default Values)

AUTOSCALE (text: Autoscaling)

WHAT IS A Y ONLY DATA PLOT?

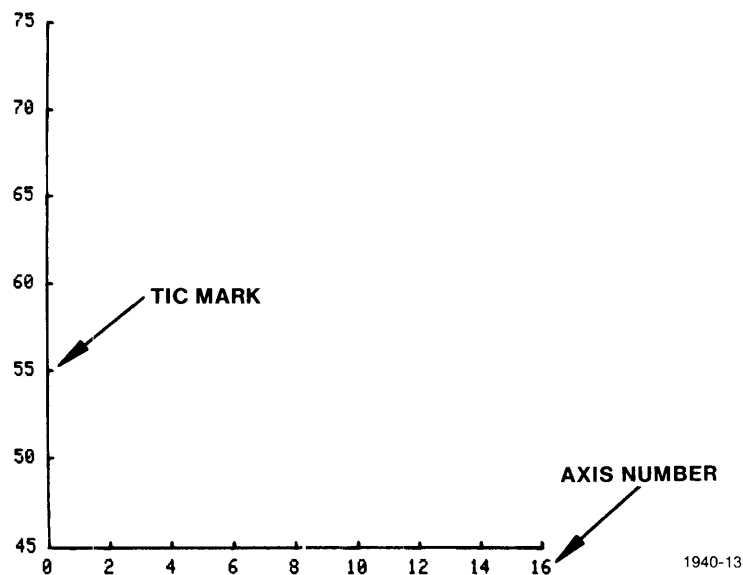
Y Only Data Plot is only one name for a type of graph you've been exposed to all your life. It has several names. Some people call it an Arithmetic Line Chart. Others refer to it as a Rectilinear Chart or a Cartesian Coordinate Chart. Whatever its called, the Y Only Data Plot is probably the most extensively used type of graph in magazines, newspapers and other media designed for the general public.

Graphs that show something changing against time, for example, are Y Only Data Plots. Population changes plotted by years, a company's gross sales figures plotted by months, or temperature readings plotted by hours or days are all applications of this type of graph. A Y Only Data Plot looks like this . . .



1940-12

A Y only Data Plot is positioned against two reference lines: a Y axis vertical line, and an X axis horizontal like. X and Y axes are divided into segments by smaller lines called "tic marks." A number that labels a specific tic mark is called an "axis number." See Figure 4- 1.



1940-13

Figure 4-1. Tic Marks and Axis Numbers.

Y ONLY DATA PLOT

The quantities, or variables, associated with a graph can be either “discrete” or “continuous.” Discrete variables can have only a certain number of values. The number of members of your family, for example, is a discrete quantity. The “average” family may have 2.7 children but your family may have 0, 1, 2, 3, or some other whole number of children. The amount of money you carry is another discrete quantity. You may have \$7.61, but not \$7.61392. On the other hand, continuous variables can have any value at all, within specified limits. Your thermometer may measure any temperature between -40 and 140 F, at least in principle. As another example, when you drive to work each morning, your distance from home varies continuously as you drive.

When we plotted daily temperature readings at 11 a.m. at the Portland International Airport, it looked like Figure 4-2.

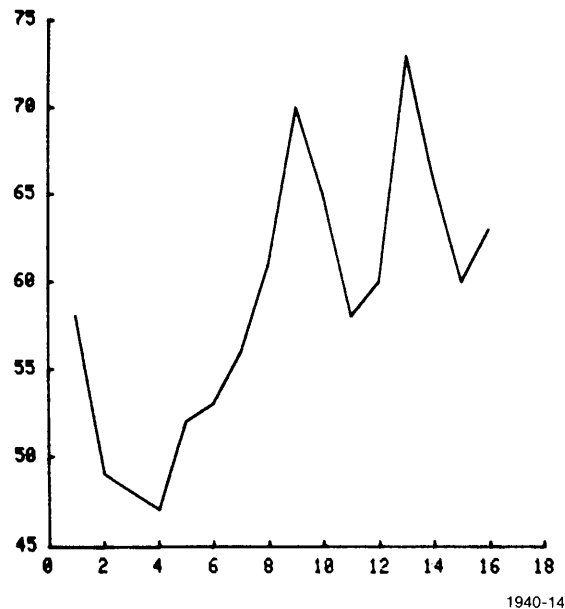


Figure 4-2. Y Only Data Plot of Continuous Data

That's a Y Only Data Plot, It's a graph that plots either continuous or discrete variables on the Y axis against discrete variables on the X axis.

Creating a Y Only Data Plot on the Graphic System from scratch isn't hard, but it does require some programming expertise and a Graphic System operating agility that many users don't want to take the time to acquire — at least not at first.

Using BASIC programs already stored on a magnetic tape to create Y Only Data Plots offers two major advantages:

1. It saves time.
2. It permits the beginning programmer or the casual user to create graphs with a minimum of study.

The PLOT 50 System Software Tape programs the Graphic System to calculate most graph parameters automatically. You are required to input only:

1. The data to be plotted.
2. The beginning plot in the X axis.
3. The frequency of plot points (plot increment).

That's all it takes to create professional quality Y Only Data Plots on the Graphic System display screen. And it can be done quickly, because the System automatically determines most graph parameters for you. We call these parameters "default conditions" or "default values."

Although the defaults serve a variety of graphic situations, it is often advantageous to alter or "override" one or more default conditions to put a plot in a more appropriate setting.

By overriding default conditions, you can:

1. Move the X axis horizontally on the display screen and make it longer or shorter.
2. Move the Y axis vertically on the display screen and make it longer or shorter.
3. Change the X axis data range.
4. Change the Y axis data range.
5. Choose either a line or a point plot.
6. Choose from five plot symbols.

Don't be alarmed if some of the terms don't make sense yet. This is an overview; later we'll discuss each item thoroughly.

Y ONLY DATA PLOT

Now, it's time to create a graph on your Graphic System display screen. We'll go through the procedure together step-by-step, and we'll let the System do most of the work. After you've created your Y Only Data Plot using all possible default conditions, we'll examine those conditions and explore why you might want to override some of them from time to time. Finally, we'll take your graph, and by nullifying defaults, treat it like baker's dough. We'll squeeze it together, stretch it out, and knead it to change its appearance. This will emphasize how versatile the Graphic System software package is.

During these demonstrations, you'll be entering data into the Graphic System from the keyboard. At the conclusion of the Y Only Data Plot discussion, we'll explore the procedure used when you wish to store system data on an auxiliary magnetic tape for later retrieval.

INITIALIZING THE GRAPHIC SYSTEM

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 4-3). The four green indicator lights on the front panel (Figure 4-3) will turn on, but only the power light remains on. It stays on as long as power is applied to the System.

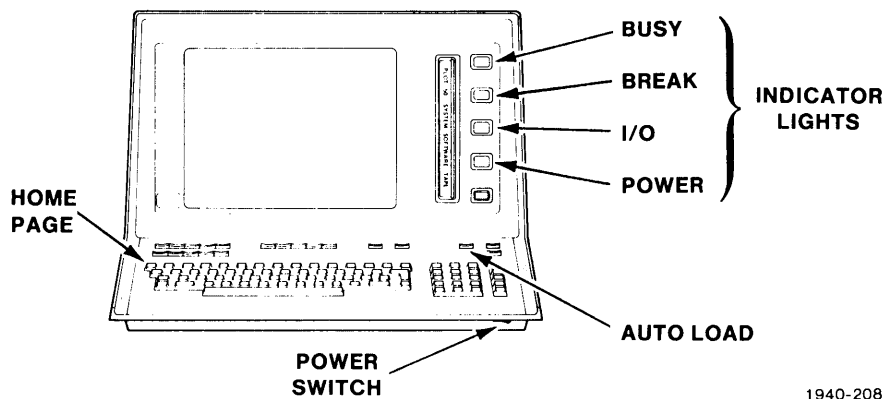


Figure 4-3. Power Switch, Indicator Lights, HOME/PAGE Key, and AUTO LOAD Key.

Press the HOME/PAGE key. The screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen.

INITIALIZING THE PLOT 50 SYSTEM SOFTWARE TAPE

Insert the PLOT 50 System Software Tape. Refer to the PLOT 50 System Software General Information section for specific instructions. Press the AUTO LOAD key (Figure 4-3). This rewinds the magnetic tape, locates the first program on the tape, loads the program into the Graphic System memory, and begins the first program — in this case, a program directory (menu).

When you press the AUTO LOAD key, the BUSY and I/O (input/output) indicator lights (Figure 4-3) turn on. The System makes a series of sounds that normally occur whenever there is tape movement in the System. Figure 4-4 shows the PLOT 50 System Software Master Menu that appears after the tape stops.

```

** PLOT 50: SYSTEM SOFTWARE **

PROGRAM      TITLE
            GRAPHIC SUPPORT PROGRAMS
1           Y Only Data Plot
2           X vs Y Data Plot
3           Function Plot
4           Histogram Plot

5           GRAPHIC SYSTEM TUTORIAL
6           SOFTWARE VERIFICATION PROGRAM
7           FIRMWARE VERIFICATION PROGRAM (4051 only)
8           SPECIAL 4054 FEATURES (4054 only)

```

ENTER THE PROGRAM NUMBER YOU WANT: 1940-209
 Figure 4-4. PLOT 50 System Software Master Menu.

CREATING A GRAPH USING ALL DEFAULT VALUES

The Master Menu is a seven-item program directory. Notice that the Y Only Data Plot — the program module we're looking for -- is listed as item number 1.

At the bottom of the menu is a single sentence we call an "entry statement." It is followed by a blinking question mark. When a blinking question mark appears, it indicates that the Graphic System is waiting for you to make a keyboard entry.

To get to the Y Only Data Plot, press the 1 key on the numeric pad. From now on in this manual when you are expected to press a number on the keyboard, the expression, "Enter" will appear, followed by the appropriate number.

Enter 1

Y ONLY DATA PLOT

When you press the 1 key, the 1 appears on the screen and is entered into the line buffer, a small temporary memory. Notice that the blinking question mark now appears to the right of the displayed 1. The System is waiting for you to continue your entry or complete your entry by pressing the RETURN key. Whenever you are expected to press any key other than a number key, the expression will be "Press" followed by the name of the key. You're expected to use the RETURN key now, so we say . . .

Press RETURN

You can type data repeatedly on the keyboard, but until you press the RETURN key, the System will not act on your entries. When the RETURN key is pressed, the number 1 is sent from the line buffer to the System memory.

Now the line buffer is empty. It will begin filling up as you enter additional data. It will hold 72 characters before it refuses to accept any more. While data is in the line buffer, you can change it over and over again if you like. Once you press that RETURN key, you're committed!

In effect, by pressing the 1 key and the RETURN key you say to the System, "Locate the Y Only Data Plot Program on the System Software Tape and display the Y Only Data Plot menu." After the tape-movement noises stop, the Master Menu is erased from the screen, and the Y Only Data Plot Menu shown in Figure 4-5 appears.

```
Y ONLY DATA PLOT  
1 ENTER Y DATA  
2 DISPLAY DATA  
3 LIST DATA  
4 LIST PARAMETERS  
5 SET X PARAMETERS  
6 SET X SCREEN POSITION  
7 SET Y SCREEN POSITION  
8 SET X DATA RANGE  
9 SET Y DATA RANGE  
10 SELECT PLOT MODE  
11 SELECT SYMBOL  
12 INSERT DATA  
13 DELETE DATA  
14 CHANGE DATA  
15 STORE DATA  
16 STOP
```

ENTER MENU ITEM NUMBER OR M FOR NEW MENU

1940-18

Figure 4-5. Y Only Data Plot Menu.

Notice the wording of the entry statement at the bottom of the menu. While you are using the Y Only Data Plot Program and this entry statement appears on the display screen, you can return to the Y Only Data Plot Menu by pressing the M key, followed by pressing the RETURN key. It also means that you can bypass the menu and go from one menu selection to another provided you know the appropriate menu selection number to enter. The menu is just a table of contents put in the program for your convenience. Use it when you need it; bypass it when you don't need it.

Examine the Y Only Data Plot Menu for the proper selection. We want to enter data, so menu item 1 is our selection.

Enter 1
Press RETURN

a question appears on the screen. . .

DO YOU WANT TO USE THE KEYBOARD (Y OR N) ?

You do, so...

Press Y
Press RETURN

The screen is erased, and the following appears:

ENTER M TO DISCONTINUE DATA ENTRY
1 ?

Earlier we showed you a graph of temperature readings. We'll be using that graphed data throughout this section to illustrate various program steps. Incidentally, the data is Fahrenheit temperature readings taken at the Portland International Airport at 11 a.m. Standard Time for the first 16 days in May, 1975. The data was collected by the National Weather Service. The data in degrees Fahrenheit is:

| | | | |
|----|----|-----|----|
| 1. | 58 | 9. | 70 |
| 2. | 49 | 10. | 65 |
| 3. | 48 | 11. | 58 |
| 4. | 47 | 12. | 60 |
| 5. | 52 | 13. | 73 |
| 6. | 53 | 14. | 66 |
| 7. | 56 | 15. | 60 |
| 8. | 61 | 16. | 63 |

Y ONLY DATA PLOT

Enter the first temperature reading.

Enter 58
Press RETURN

The display responds to the entry and looks like this:

```
ENTER M TO DISCONTINUE DATA ENTRY
1 ..... 58
2 ..... ?
```

The screen is asking for the second data entry.

Enter 49
Press RETURN

The screen displays your second entry and asked for a third. Continue in the same manner until you enter the 16 temperature values. If you make a mistake, but haven't hit the RETURN key, corrections are easy. The data is still in the line buffer and subject to editing. You can backspace, delete, add, or whatever. If you make a mistake and don't realize it until after you have pressed the RETURN key, remember the mistake and its location but continue your data entries. After you have completed all data entries and return to the Y Only Data Plot Menu, you can select another menu item that allows you to change data. We'll study that procedure later.

When you have entered all the data, the screen will look like this:

```
DATA LIST
NUMBER      VALUE
1           58
2           49
3           48
4           47
5           52
6           53
7           56
8           61
9           70
10          65
11          58
12          60
13          73
14          66
15          60
16          63
END OF LIST

ENTER MENU ITEM NUMBER OR M FOR NEW MENU
```

1140 211

Whenever you're working with data (entering it, adding to it, changing it, deleting it, or making insertions in it) the Graphic System has no way of knowing how many data items you're working with. It will continue asking you for data until you tell it to stop. You do that by entering an M. This terminates the data routine and returns the program to the Y Only Data Plot Menu. It is appropriate to do that now.

Press M
Press RETURN

This is a STOP/START point.

The screen reflects the M entry, erases, and displays the Y Only Data Plot Menu.

We just passed the first STOP/START point. Let's discuss how to resume using the text and continue with the demonstrations if you terminate your studies at one of these STOP/START points. We assume you turned off the Graphic System at the STOP/START point. Here's how to reenter:

1. Initialize the Graphic System.
2. Initialize the PLOT 50 System Software Tape. This displays the PLOT 50 System Software Master Menu.
3. Select menu item 1. This displays the Y Only Data Plot Menu.
4. Select menu item 1 — ENTER DATA — and enter the 16 temperature readings.
5. Select menu item 5 and enter 1 for both the "beginning X" and "X increment" queries.
6. Return to the Y Only Data Plot Menu.
7. Resume your studies.

Now, back to the creation of our graph. Choose menu item 2 — DISPLAY DATA.

Enter 2
Press RETURN

Y ONLY DATA PLOT

The 2 appears on the screen following the entry statement at the bottom of the menu. Another entry statement is displayed.

ENTER BEGINNING X ?

You are plotting daily temperature readings from the first of May. Begin your X axis plot with a 1. If you were beginning your plots on the 16th of May, you would want to start your beginning X axis plot point at 16.

Enter 1
Press RETURN

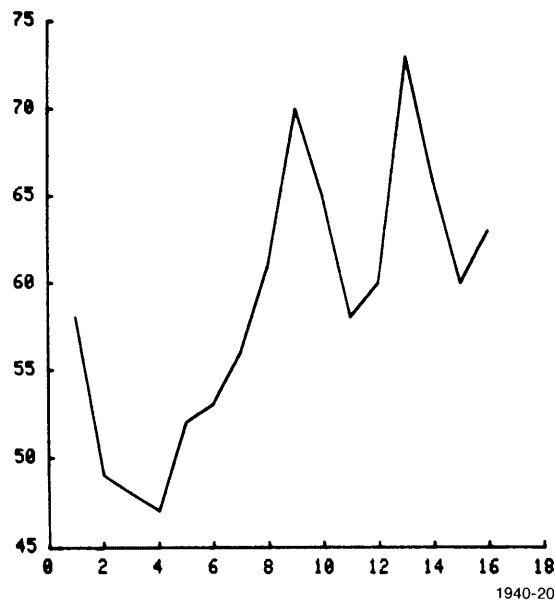
The screen displays the 1. Another entry statement appears.

ENTER X INCREMENT ?

The System wants to know how frequently to plot the data values against the X axis. Since these were daily temperature readings, you'll want to plot them in increments of 1 (every other day would be 2; twice a day would be .5 increments).

Enter 1
Press RETURN

The display screen shows the 1, erases, and your graph is created!



Congratulations! Now, return to the Y Only Data Plot Menu.

Press M
Press RETURN

This is a STOP/START point.

Remember, you can't plot a Y Only Data Plot without giving the System at least three things:

1. Y data.
2. Beginning X.
3. X increment.

ALTERNATE METHOD OF DEFAULT GRAPHING

We used only two menu selections to create our graph: 1 and 2. There is another menu selection routine that you can use to create the same graph: 1, 5, and 2. Here's how it works . . .

Menu selection 1 is ENTER DATA. We've already done that, so we'll bypass the first menu item and go to selection 5 — SET X PARAMETERS.

Enter 5
Press RETURN

The display screen shows:

ENTER BEGINNING X ?

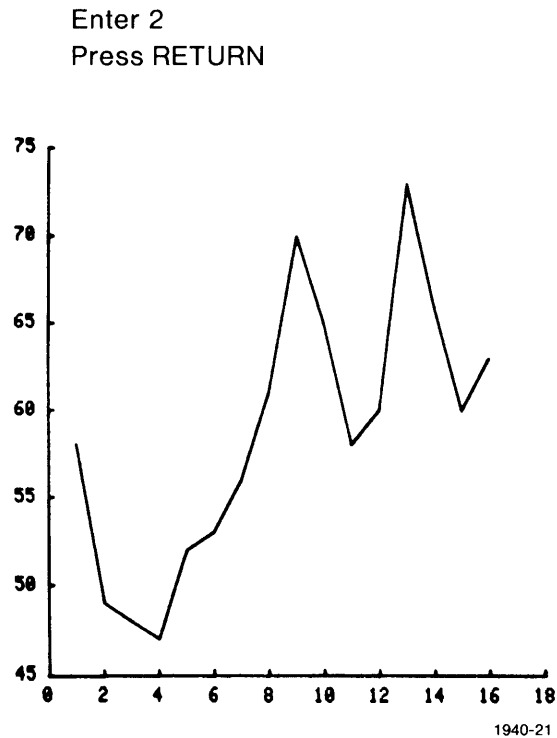
Enter 1
Press RETURN

Screen: ENTER X INCREMENT ?

Enter 1
Press RETURN

Y ONLY DATA PLOT

Now we have all the data entered into the System that is necessary to create a graph. Let's do it!



You've just created the same graph using the alternate method. Go back to the menu.

Press M
Press RETURN

This is a STOP/START point.

INPUT DATA LIMITS

You cannot enter more than 100 Y axis data values. When you enter the 100th data item, the screen displays the following:

MAXIMUM NUMBER OF VALUES IS 100
ENTER NEW MENU ITEM NUMBER OR M FOR NEW MENU?

CHANGING DATA

Sometimes you may want to change data because you make a mistake entering data values and don't realize it until after you pressed the RETURN key. Or maybe you're working on a project where one or two data points change while the others remain fixed. Retaining the old data and changing to the one or two new data values is more expedient than reentering the entire data string.

Or maybe you're the sales manager of a company, and you want to project the effect different courses of action will have on gross national sales for the next several months. By changing data, you can project alternatives without having to reenter a complicated total data input.

Now that we've indicated a few applications for this feature, let's find out how to do it.

Notice that menu item 3 is a data list. This selection is a valuable reference that you'll use frequently.

Enter 3
Press RETURN

The screen displays the data list. Notice that both the data and the item numbers are listed. When inserting, deleting, or changing data, the data item number is used to refer to the appropriate data value.

Look at data item 4, which is 47°. Assume you've got incorrect data for the fourth day, and you just found out that the temperature reading was really 70°. Here's how to make the change.

Press M
Press RETURN

The screen displays the Y Only Data Plot Menu. Observe that item 14 is CHANGE DATA.

Enter 14
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

Enter 4
Press RETURN

Y ONLY DATA PLOT

Screen: CURRENT VALUE OF ITEM 4 IS 47
CHANGE TO ?

Enter 70
Press RETURN

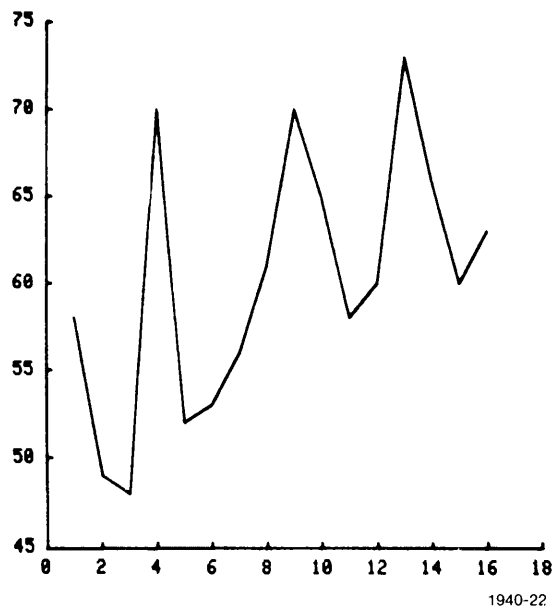
Screen: ENTER ITEM TO BE CHANGED ?

The Graphic System has to be ready to accept more than one data change. You terminate the data-change routine by entering M as a data value.

Press M
Press RETURN

The screen displays the Y Only Data Plot Menu. Draw your graph:

Enter 2
Press RETURN



Notice that the display screen did not ask for beginning X or X increment values. Once the initial graph is created, the System assumes that these values remain constant. Of course, if you want to change these parameters, you select menu item 5.

We want to preserve the original temperature data, so let's change data item 4 back to its original value. Here's the procedure . . .

Enter 14
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

Enter 4
Press RETURN

Screen: CURRENT VALUE OF ITEM 4 IS 70
CHANGE TO ?

Enter 47
Press RETURN

Screen: ENTER ITEM TO BE CHANGED ?

Press M
Press Return

The screen displays the menu. Let's verify the change by going to the data list.

Enter 3
Press RETJRN

The screen displays the temperature data list. Item 4 is now 47.

This is a STOP/START point.

INSERTING DATA

If you wish to insert data in a data string already in System memory, the procedure is as simple as it was for changing data. Assume that between data items 8 and 9, you inadvertently left out a reading of -44° (our apologies to the Portland Chamber of Commerce for even imagining such a temperature). You discover the error and want to insert the data value and regraph. Notice in our data list that data item 8 is listed at 61° and that data item 9 is listed at 70° . Go to the Y Only Data Plot Menu and find the appropriate item for inserting data.

Press M
Press RETURN

The screen displays the menu. Item 12 is our selection — INSERT DATA.

Enter 12
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

We want our “left out” temperature reading to slip between items 8 and 9, so we want to precede 9.

Enter 9
Press RETURN

Screen: ENTER NEW VALUE ?

Enter -44
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

We terminate the insert routine by entering M as a data value.

Press M
Press RETURN

The screen displays the menu. Let's verify the change with a data list, then graph the temperature so we can observe the parameters of our first negative-number Y Only Data Plot.

Enter 3
Press RETURN

The screen shows the data list. Notice that former data items 9 through 16 have been reassigned data item numbers 10 through 17, one sequential item number higher to allow -44° to be inserted as data item 9. Figure 4-6 shows the graph of this data.

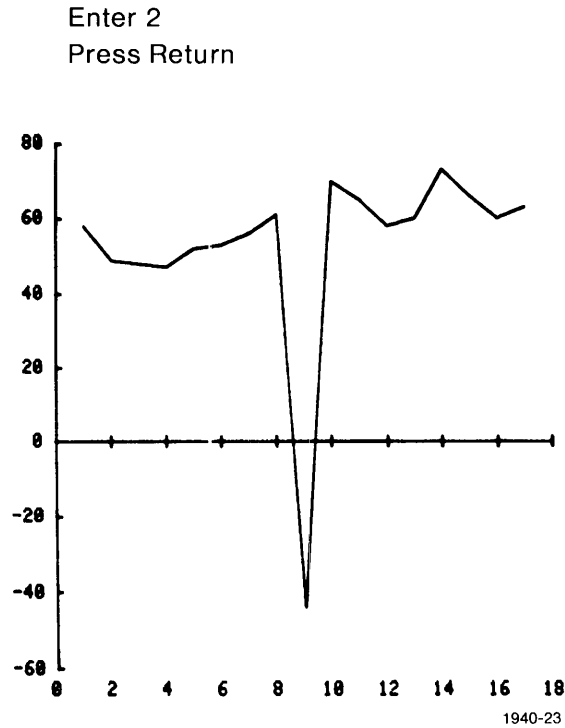


Figure 4-6. Y Only Data Plot with Negative Data.

DELETING DATA INSIDE THE DATA STRING

Deleting data is simple, too. Since we want to return to our original data anyway, let's demonstrate the delete procedure by taking the -44° out of the data string. Return to the data list to find out what the item number is of the -44° data item is.

Press M
Press RETURN

We go to the menu to find the data-list item number.

Enter 3
Press RETURN

Y ONLY DATA PLOT

Verify that the item number for -44° is 9. Go to the menu and find the proper menu selection for deleting data.

Press M
Press RETURN

The screen displays the menu. Notice that selection 13 is DELETE DATA.

Enter 13
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 9
Press RETURN

Screen: VALUE DELETED -44
ENTER ITEM NUMBER TO BE DELETED ?

Enter M as a data item to terminate the delete routine.

Press M
Press RETURN

The screen displays the menu. Go to the data list.

Enter 3
Press RETURN

The screen displays the data list. Notice that when data is deleted, all data following the deletion is assigned a lower data item number to compensate for the deletion gap. In this instance, the temperature readings for the 9th day and beyond have been reassigned to their original data item numbers.

Thus far, we've been discussing deletions from the middle of a data string. The procedure for deleting data from the end of a data string is different. We'll defer studying this technique for a few moments while we discuss how to add data to the end of a data string. After we cover that topic, a demonstration of how to delete data from the end of a data string will be a natural follow-up.

This is a STOP/START point.

ADDING DATA

You can add to data already entered in memory at any time. The Graphic System accommodates you by displaying the next available data item number.

Enter 1
Press RETURN

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y OR N) ?

PRESS Y
PRESS RETURN

Screen: ENTER M TO DISCONTINUE DATA ENTRY ?
17.....?

Let's add four additional values: -5, 7, 32, and 66.

Enter -5
Press RETURN

Screen: 17..... -5 ?
18..... ?

Enter the last three items (7, 32, and 66) in the same manner. Now, we'll discontinue data entries by entering M as a data value, verify by observing a data list, and follow up with a graph.

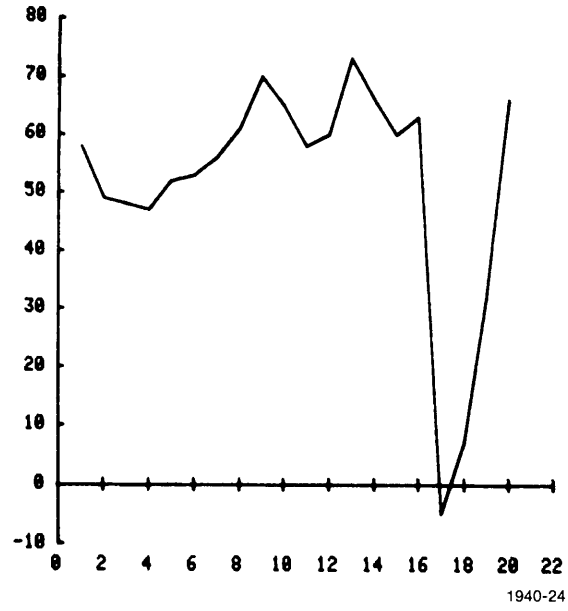
Press M
Press RETURN

The screen displays the menu.

Enter 3
Press RETURN

Y ONLY DATA PLOT

The screen displays the data list with the additional items.



DELETING DATA AT THE END OF A DATA STRING

We want to return to our original data, so we will delete the four data items we just put on the end of our data string.

Delete the lowest unwanted data item number as many times as there are numbers to be deleted. In this case, 17 is the lowest data item to be deleted. We want to eliminate four numbers; delete 17 four times.

Press M
Press RETURN

The screen displays the Y Only Data Plot Menu. Item 13 is DELETE DATA.

Enter 13
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 17
Press RETURN

Screen: VALUE DELETED -5
ENTER ITEM NUMBER TO BE DELETED ?

Enter 17
Press RETURN

Screen: VALUE DELETED 7
ENTER ITEM NUMBER TO BE DELETED ?

Enter 17
Press RETURN

Screen: VALUE DELETED 32
ENTER ITEM NUMBER TO BE DELETED ?

Enter 17
Press RETURN

Screen: VALUE DELETED 66
ENTER ITEM NUMBER TO BE DELETED ?

Y ONLY DATA PLOT

To terminate the delete data routine, it is necessary to enter M as a data value.

Press M
Press RETURN

This is a STOP/START point.

SELECTING PLOT SYMBOLS

The Y Only Data Plot Program offers you a choice of five plot symbols. Let's take a look at them. Select menu item 11 — SELECT SYMBOL.

Enter 11
Press RETURN

Screen: 1. POINT
 2. TRIANGLE
 3. PLUS SIGN
 4. SQUARE
 5. DIAMOND
 SELECT NUMBER AND PRESS RETURN ?

The point, item 1 on this menu, is the default value; it is the symbol we've been plotting with thus far. Let's create a graph with the triangle plot symbol, and follow that with a graph using square plot symbols.

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Figure 4-7 shows a graph using triangles.

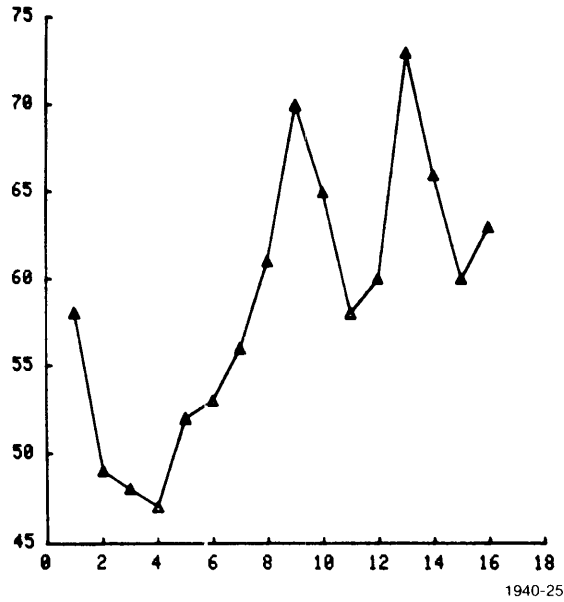


Figure 4-7. Y Only Data Plot with Triangle Plot Symbols.

Notice that a triangle represents each graph point (temperature reading). Go through the procedure again for square plot symbols.

Enter 11
Press RETURN

The screen displays the Symbol Menu. Selection 4 displays square symbols.

Enter 4
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Y ONLY DATA PLOT

Figure 4-8 shows the same graph, but the plot symbols are squares.

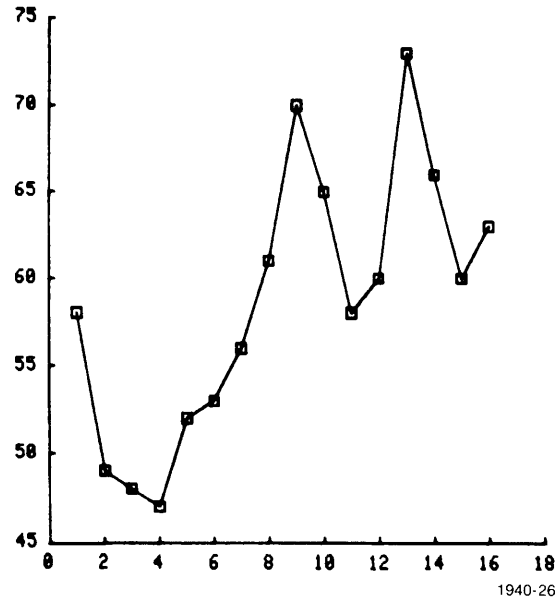


Figure 4-8. Y Only Data Plot with Square Plot Symbols.

What symbol should you use? It depends on your aesthetic tastes and the type of graph you want to present.

Let's return to the Y Only Data Plot Menu and study another subject.

Press M
Press RETURN

SELECTING PLOT MODES

SELECT PLOT MODE, menu selection 10, gives you a choice of plotting with points only or with points connected by lines.

Enter 10
Press RETURN

Screen: 1. LINE PLOT MODE
 2. POINT PLOT MODE

SELECT NUMBER AND PRESS RETURN ?

Here we have a real mini-menu, only two items. The Line Plot Mode is the default condition we've been using. We're still in the Square Symbol Mode from menu item 11. Let's stay with the square symbols and combine them with the Point Plot Mode (Figure 4-9).

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

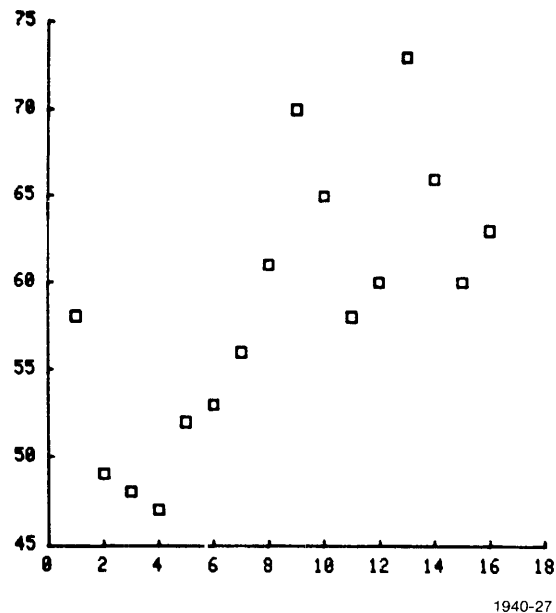


Figure 4-9. Y Only Data Plot in Point Plot Mode with Square Plot Symbols.

Y ONLY DATA PLOT

Now, let's stay in the Point Plot Mode, but change to plus sign symbols.

Enter 11
Press RETURN

The screen shows the Symbol Menu. We want item 3 — PLUS SIGN.

Enter 3
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Figure 4-9 shows the same graph, but the plot symbols are plus signs.

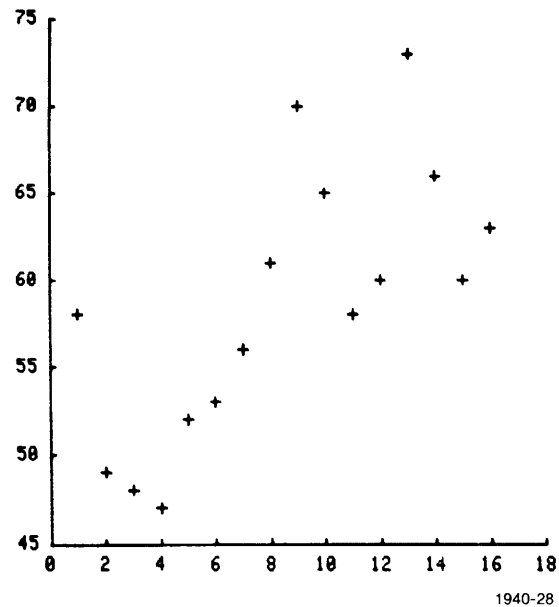


Figure 4-10. Y Only Data Plot in Point Plot Mode with Plus Sign Plot Symbols.

Since we are ready to study another subject, we want to go back to the default conditions we started with: Line Plot Mode and Point Symbol Mode.

Enter 11
Press RETURN

The screen displays the Symbol Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 10
Press RETURN

The screen displays the Plot Mode Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

An easy way to verify that you are back to your default conditions is to create a graph (Figure 4-11).

Enter 2
Press RETURN

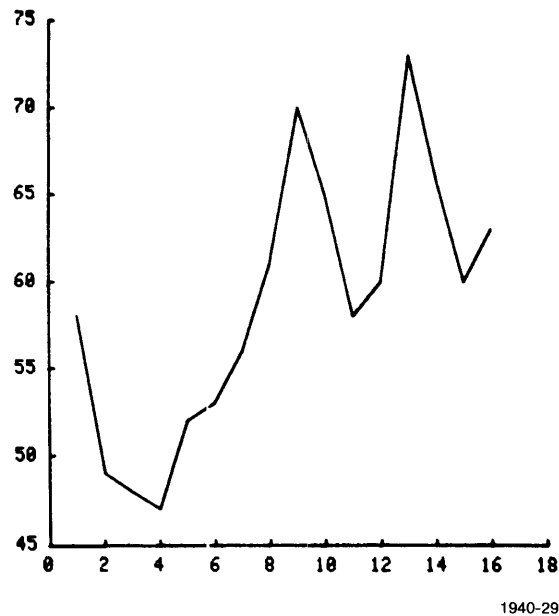


Figure 4-11. Y Only Data Plot in Default Modes.

Y ONLY DATA PLOT

Looks familiar, doesn't it?

Press M
Press RETURN

This is a STOP/START point.

AUTOSCALING

When you put Y data into the Graphic System without specifying specific X and Y axes data ranges at the time you request a graph, the System establishes X and Y axes data ranges that include all input data. We call that automatic range determination "autoscaling." When we talk about data ranges for an X axis, for example, we're referring to the minimum to maximum data values that are plotted against the X axis. The X axis index numbers (the numbers that label the X axis tic marks) reflect those data range values. This range format applies to the Y axis also.

If you put data into the Graphic System and immediately ask for a Y Only Data Plot by selecting menu item 2, the System searches its memory to see if you gave it data range instructions. If not, the System autoscales the data. Remember, the System does not autoscale until just before the graph is created.

LISTING PARAMETERS

We divide the System display screen into 100 vertical and 130 horizontal units called Graphic Display Units (GDUs). We'll be working with these units to relocate the graph on the display screen.

When you select item 4 — LIST PARAMETERS — on the Y Only Data Plot Menu, you have picked out a handy reference chart that will assist you in many plotting situations. Let's take a few moments to talk about these parameter entries.

Enter 4
Press Return

```
Screen:  PARAMETER LIST
          NUMBER OF POINTS          16
          LINE CODE   1
          SYMBOL     1
          SCREEN MINIMUM          30      10
          SCREEN RANGE           80      80
          DATA MINIMUM           0       45
          DATA RANGE            18      30
```

ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Here is an explanation of the Parameter List headings:

NUMBER OF

POINTS: This refers to the number of data items you enter.

LINE CODE: It's another name for Plot Mode. The default value is Line Plot Mode (plot menu item 1).

SYMBOL CODE:

This refers to menu item 11. The default value is Point Symbol Mode (symbol menu item 1).

SCREEN

MINIMUM: This indicates the Graphic Display Unit (GDU) at the beginning of the X axis. When in a default condition, the X axis begins 30 GDUs horizontally from the left side of the screen, and the Y axis begins 10 GDUs vertically from the bottom of the screen. These default conditions provide a screen graphing location suitable for most situations.

SCREEN

RANGE: These entries indicate the length of the X and Y axes in GDUs. If you add this value to an axis screen minimum, you obtain the axis termination point expressed in GDUs (screen maximum).

DATA

MINIMUM: The data minimum is the X and Y axes data minimums established by you, or it is the autoscaled data minimums selected by the System.

DATA

RANGE: These numbers show the total data range for each axis. Add the data range number to the data minimum, and the result is the data maximum value.

We'll reinforce these definitions with specific examples in the next few paragraphs. Don't feel uneasy if they are not yet clear to you.

If you entered the text at the last STOP/START point, the data range and data minimum values on your Parameter List will be zeros instead of the numbers shown in the text example. The System does not autoscale until a graph is created. Since the entry point occurred subsequent to the last graphing demonstration, since you haven't established data ranges, and since the System hasn't been forced to autoscale, there just aren't any data ranges yet.

CHANGING THE GRAPH'S SCREEN POSITION

Shortening and lengthening the X and Y axes emphasizes or de-emphasizes the impact of the graphed data. If we stretch the X axis and compress the Y axis, we "flatten out" the graphed data and de-emphasize differences in the data. Conversely, if we lengthen the Y axis and shorten the X axis, we make minor data differences appear huge.

Let's take our familiar temperature graph and observe how it seems to tell a different story when we push the X and Y axes around. We'll use extreme examples to dramatize the differences. We'll begin by shortening the X axis to emphasize data differences.

You should still be displaying the Parameter List. Notice that the X screen minimum is 30 and the X screen range is 80 GDUs. If the X axis starts at 30 GDUs and is 80 GDUs long, then the X axis maximum point is at 110 GDUs. Remember, the total horizontal length of the screen is 130 GDUs.

Notice also that the X data minimum is 0 and the X data range is 18. Add them together and you obtain the maximum X value: 18. The Y data minimum is 45 and the Y data range is 30. So, we know our Y axis data range begins at 45 and is 30 units long. Add the two values together ($45 + 30$) and you have a Y maximum data value of 75. Create a graph (Figure 4-12) and verify these data ranges.

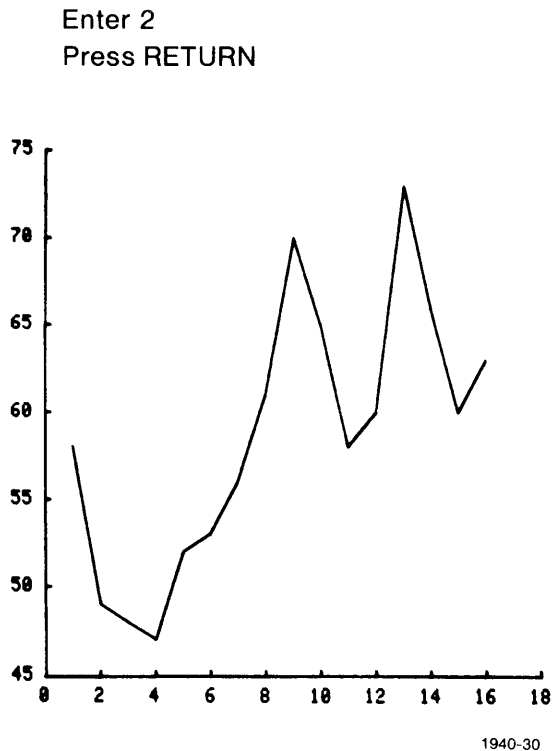


Figure 4-12. Y Only Data Plot with Normal Axes.

Return to the menu.

Press M
Press RETURN

This is a STOP/START point.

The screen displays the menu. We want to select SET X SCREEN POSITION. Selection 6 is our choice.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Since we're compressing this axis, we may as well leave the minimum axis point alone and push in the other end. We enter the same minimum value we had before.

Enter 30
Press RETURN

Screen: MAXIMUM ?

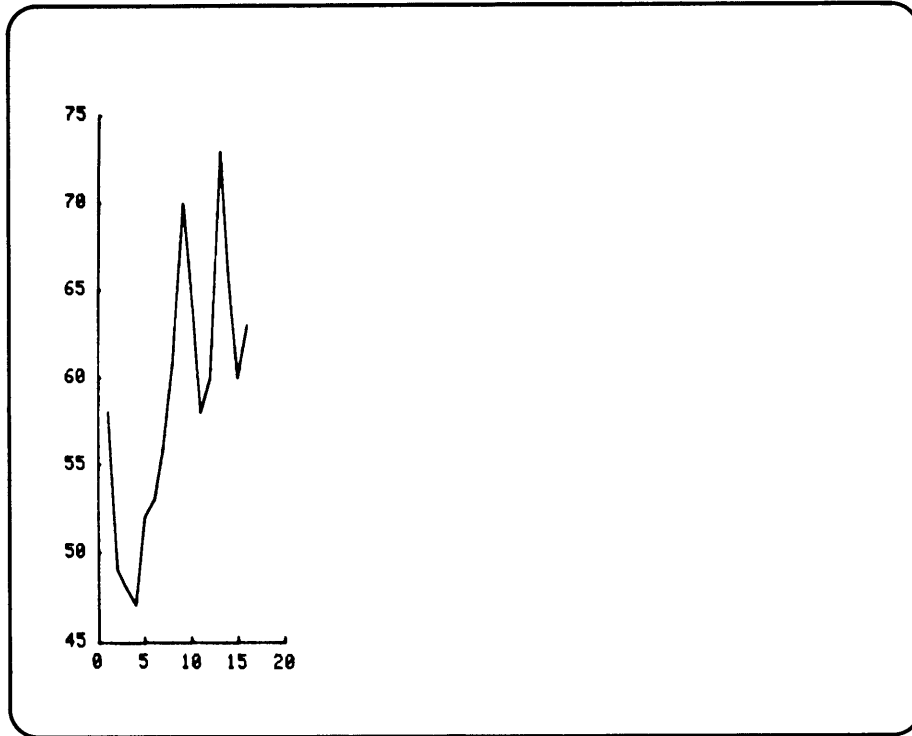
Enter 60
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Y ONLY DATA PLOT

Figure 4-13 shows what we've done.

Enter 2
Press RETURN



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Figure 4-13. Y Only Data Plot with Compressed X Axis.

No question about it, even though the data and the axis numbers remain the same, this graph gives you the impression that the data changes are large. Go back to the Parameter List and notice the difference this modification made to list statistics.

Enter 4
Press RETURN

The screen displays the Parameter List. Notice the changes in the X axis listings. The screen minimum is 30 and the screen range is 30. Add them to get the screen maximum: 60. The data minimum is 0, and the data range is 20. When the graph changed size, the System automatically changed tic intervals.

Let's move the graph to the right side of the screen. We'll make the X axis minimum 90 GDUs and the X axis maximum 120 GDUs. This still gives us a 30 GDU X axis length.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 90
Press RETURN

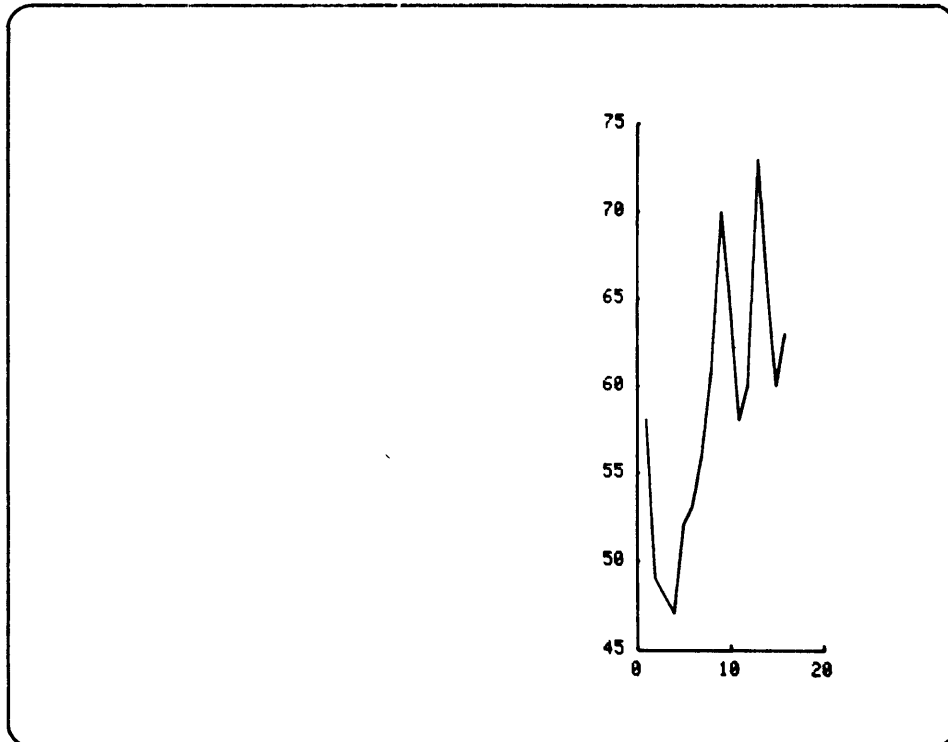
Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Figure 4-14 shows the graph which appears on the display screen.



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Figure 4-14. Y Only Data Plot with Compressed X Axis Shifted Right.

Y ONLY DATA PLOT

Suppose we go the other way now and make the data changes appear a insignificant as possible. To do this, we'll lengthen the X axis and shorten the Y axis. First the X axis . . .

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM OR M FOR NEW MENU ?

Press M
Press RETURN

The screen displays the menu. We've now completed stretching the X axis; compressing the Y axis is next. The menu reveals that menu item 7 is what we're looking for. Check the Parameter List and see what the Y axis configuration is.

Enter 4
Press RETURN

The screen displays the Parameter List. Notice that our Y axis Screen Minimum is 10 and that our Y axis Screen Range is 80 — these are the default parameters. Let's compress the Y axis down to 10 and 30; that gives us a 40 unit Y axis that significantly de-emphasizes the change in data.

Enter 7
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN

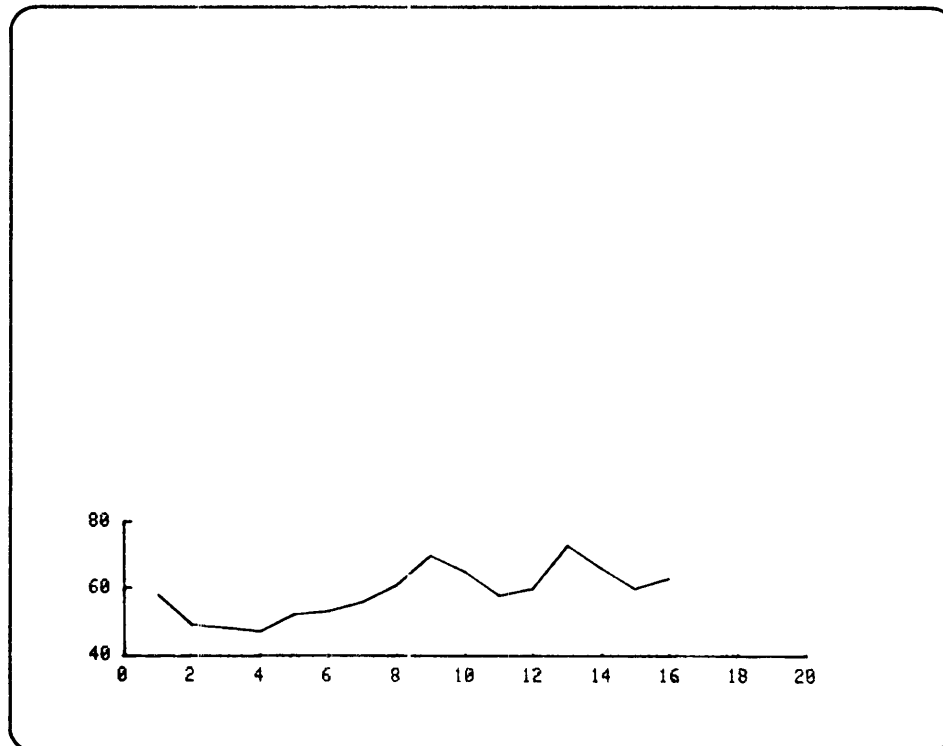
Screen: MAXIMUM ?

Enter 30
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Figure 4-15 shows the contrast to our earlier example (Figure 4-13).



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Figure 4-15. Y Only Data Plot with Compressed Y Axis.

If you extend the X axis too close to the left or right screen border, or if you move the Y axis too close to the bottom or top of the display screen, you can get some graph aberrations. You may discover your graph data chopped off or the axis index numbers misplaced. The default configuration for the X and Y axes is adequate for most graphing requirements. If you do customize the location of your graph on the screen, remember to allow sufficient room horizontally and vertically for the display of axis index numbers.

Y ONLY DATA PLOT

Return the X and Y screen locations to their starting values. In GDUs they were: X axis 30 and 110; Y axis 10 and 90.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 30
Press RETURN

Screen: MAXIMUM ?

Enter 110
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 7
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Now that we've returned the X and the Y axes to their former location, are we back to our original graph? Nope! When we compressed the Y axis during the demonstrations, the System autoscaled the X axis from the original data range of 0 to 18 to a new range of 0 to 20. The Y axis went through a configuration change, too. Originally, the Y axis data range went from 45 to 75. Now it starts at 40 and ends at 80. Let's graph the data and look at the data ranges (Figure 4-16). Then we'll go to the Parameter List and observe data range parameters.

Enter 2
Press RETURN

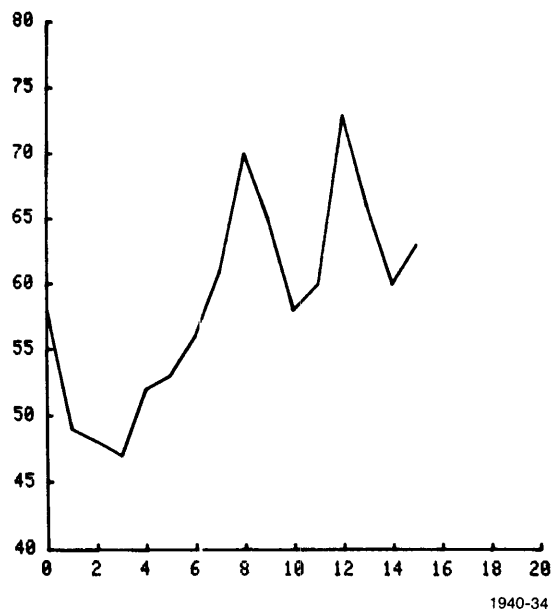


Figure 4-16. Original Y Only Data Plot with Changed Data Range Parameters.

Enter 4
Press RETURN

The screen displays the Parameter List.

To achieve X and Y data minimum and data range values like our original graph, we "zero out" the minimum and maximum data values with menu selections 8 and 9 — SET X DATA RANGE and SET Y DATA RANGE. This causes the Graphic System to autoscale again to restore the graph to its original configuration.

Enter 8
Press RETURN

Y ONLY DATA PLOT

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 0
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 0
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Now, graph the data again.

Enter 2
Press RETURN

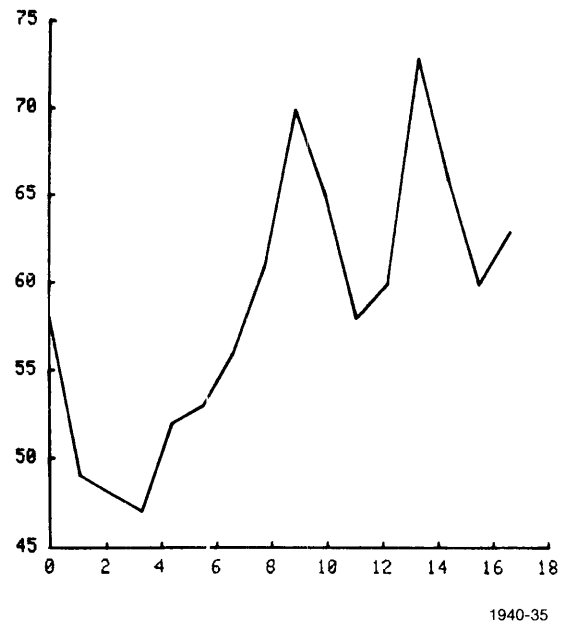


Figure 4-17. Original Y Only Data Plot.

Figure 4-17 is our original graph. Go to the Parameter List and verify the data range and data range statistics.

Enter 4
Press RETURN

The screen displays the Parameter List.

Press M
Press RETURN

This is a STOP/START point.

CHANGING THE DATA RANGES

X and Y data range parameters permit you to change the relationship of the axes to the plotted data. Menu items 8 and 9 are selected for these activities. We can do one of two things: dwarf the plotted data by making the axes data range much larger than the input data range, or “clip off” part of the data when we make the axes data range smaller than the input data range.

Look at the menu and observe that item 8 is SET X DATA RANGE.

Enter 8
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 200
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

The screen displays the menu. Notice that item 9 is SET Y DATA RANGE.

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 100
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

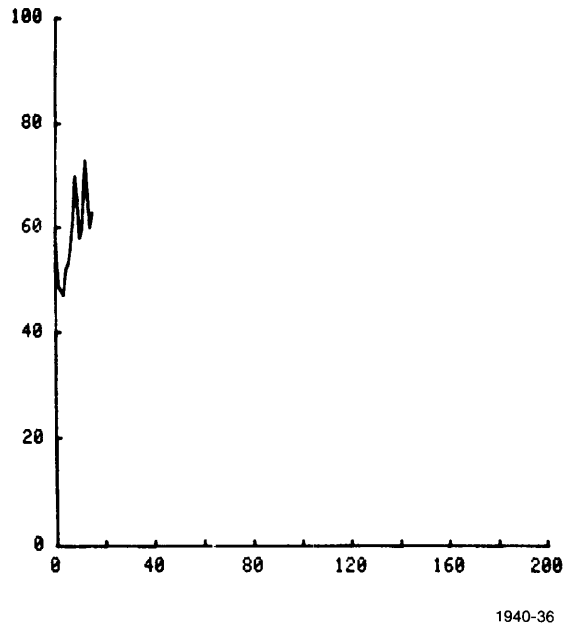


Figure 4-18. Y Only Data Plot with Extreme Data Ranges.

Figure 4-18 shows this example, which is extreme, but in-between values may apply to a situation you have.

Return the graph to original default parameters by entering zeros at all four data range minimum and maximum points.

Enter 8
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 0
Press RETURN

Y ONLY DATA PLOT

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 0
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

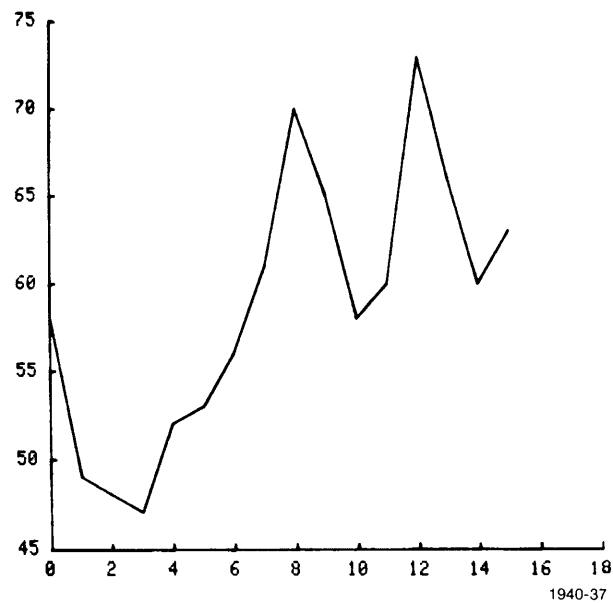


Figure 4-19. Original Y Only Data Plot.

We have our familiar temperature graph back again (Figure 4-19). Could you have returned to these data range values by entering the original data range values instead of zeros? Certainly! This is just the easier way — no need to remember numbers.

If the axes are assigned a smaller data range than that of our data input, data out of the established range is not displayed. We'll chop off the Y data peaks and valleys by entering a new data range of 50 to 67. We'll demonstrate the same technique on the X axis by entering a new data range of 2 to 14. Look at the graph and see how much data will be eliminated by the cuts. We'll begin by going to menu item 8 and changing the X axis data range.

Enter 8
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 2
Press RETURN

Screen: MAXIMUM ?

Enter 14
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 50
Press RETURN

Screen: MAXIMUM ?

Enter 67
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Y ONLY DATA PLOT

Figure 4-20 shows the resulting graph.

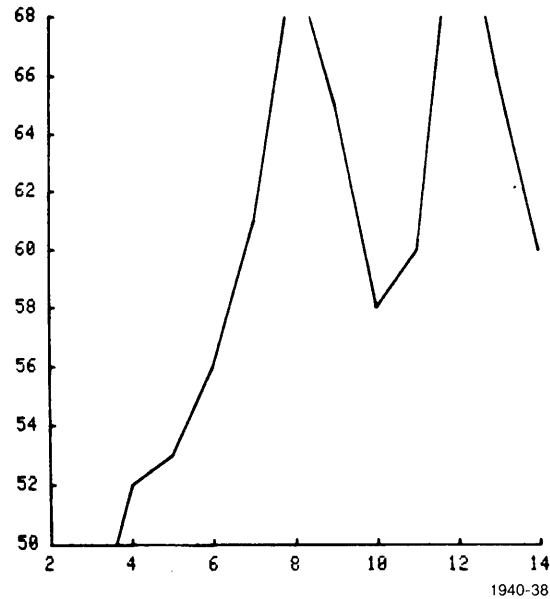


Figure 4-20. Y Only Data Plot with Clipped Data.

Now, on your own, put the original temperature graph back on the display screen by doing the following:

1. Go to menu item 8, SET X DATA RANGE, and enter zeros for the minimum and maximum data ranges.
2. Go to menu item 9, SET Y DATA RANGE, and enter zeros for the minimum and maximum data ranges.
3. Go to menu item 2, DISPLAY DATA, and observe our basic graph and verify the changes.
4. Return to the Y Only Data Plot Menu by pressing the M key followed by pressing the RETURN key.

STOP

The Y Only Data Plot Menu item 16 — STOP — terminates the program and returns you to the PLOT 50 System Software Master Menu. STOP is executed from the Y Only Data Plot Menu or other program locations where an "M" is a part of an entry statement. STOP takes you back to the Master Menu, all default conditions are reset, and Y input data is lost.

Except for information and step-by-step instructions on how to store and retrieve data from an auxiliary data tape, you have completed the Y Only Data Plot instruction. Select item 16 from the Y Only Data Plot Menu to leave the Y Only Data Plot Program.

Enter 16
Press RETURN

STORING DATA ON A MAGNETIC TAPE

Using a magnetic tape to store PLOT 50 System Software program data is a time saver in some situations. It is advantageous to record data on an auxiliary magnetic tape when you have a sizable block of data that you intend to add to later, or when you have data that you plan to use as a base for "what if" projections. When you need the original data again, insert the data tape into the Graphic System and effortlessly place the recorded data into System memory.

The next several paragraphs give a description of how to use an auxiliary data tape with the program. The procedure begins from a Graphic System initialized condition (System operational, but PLOT 50 System Software not enabled). Do not attempt to duplicate this step-by-step procedure until you have a data tape available.

1. Before you insert the PLOT 50 System Software Tape into the System, select an auxiliary data tape that has sufficient room for your data. Ensure that the "write protector" arrow on the cartridge is turned opposite the SAFE mark (180° from SAFE). Insert the data tape into the System's magnetic tape slot. If it's an old tape, make a TLIST of the tape's contents (described in the PLOT 50 System Software General Information section) and locate the next available file. If it's a new tape, press the REWIND key to position the tape at its beginning. Find and mark a file (discussed in the PLOT 50 System Software General Information section), providing sufficient tape space to accommodate the data you intend to record.
2. Remove the data tape from the tape slot and set the tape aside.
3. Insert the PLOT 50 System Software Tape into the tape slot and progress to the Y Only Data Plot Menu.

Y ONLY DATA PLOT

4. Select menu item number 1, and enter your data from the keyboard.
5. Return to the Y Only Data Plot Menu.

We continue with a step-by-step procedure . . .

Enter 15
Press RETURN

Screen: INSERT DATA TAPE AND ENTER FILE NUMBER ?

Press the EJECT button and remove the PLOT 50 System Software Tape from the System.
Insert the appropriate data tape into the tape slot.

Enter (your marked file number)
Press RETURN

Screen: DATA STORED
 INSERT SYSTEM TAPE AND PRESS RETURN ?

Press the EJECT button and take the data tape out of the tape slot. You now have the data stored on your selected file. Put the PLOT 50 System Software Tape back into the System.

Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Continue with your graphing activities. At a later time, when you wish to use the recorded data, start from the Y Only Data Plot Menu and do the following:

Enter 1
Press RETURN

If you already entered data into the memory, the System will ask:

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y or N) ?

Press N
Press RETURN

Now, the routine is the same for everyone.

Screen: DO YOU WISH TO USE THE KEYBOARD (Y or N) ?

Press N
Press RETURN

Screen: TAPE PROCESSING (Y or N) ?

Press Y
Press RETURN

Screen: INSERT DATA TAPE AND ENTER TAPE FILE # ?

Press the EJECT button, take the PLOT 50 System Software Tape out of the System and insert the data tape into the tape slot.

Enter (your file number)
Press RETURN

The System finds the file and loads the data into the System memory.

Screen: INSERT SYSTEM TAPE AND RETURN ?

Push the EJECT button, remove the data tape, and insert the PLOT 50 System Software Tape into the system.

Press RETURN

Verify the data entries by referring to the data list.

Enter 3
Press RETURN

That completes the procedure. Continue your graphing activities.

Section 5

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Section 5

X VS Y DATA PLOT

INTRODUCTION

If you are an experienced programmer, you have several options after reading this Introduction: read the Operation Summary, scan the text following the Operation Summary, or combine the two. If you're relatively new at this graphing business, read this Introduction, skip the Operation Summary for now, and begin studying the text that starts with "What is an X vs Y Data Plot?" Later you may want to use the Operation Summary as a reference.

In the X vs Y Data Plot text, we use one set of data for all demonstrations. Once that data is entered into the Graphic System and the program displays the X vs Y Data Plot Menu, you have reached a STOP/START point. These labeled STOP/START points are convenient places for you to stop studying and turn off the System, aware that you can reenter the text's running commentary at that location with the proper settings on the Graphic System for future demonstrations. We'll provide you with detailed instructions on how to use this study technique when we reach the first STOP/START point.

OPERATION SUMMARY

To initialize the Graphic System: (text: Initializing the Graphic System)

1. Refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.
2. Connect the power cord to the Graphic System and then to your power source.
3. Turn ON the power switch located beneath the right-front corner of the unit.

To begin the PLOT 50 System Software Programs: (text: Initializing the PLOT 50 System Software Tape)

1. Insert the PLOT 50 System Software Tape into the Graphic System.
2. Press the AUTO LOAD key.
3. The screen displays the PLOT 50 Master Menu.

X VS Y DATA PLOT

The X vs Y Data Plot Menu is used as a reference for this Operation Summary. Menu selections are listed following their menu item numbers. Text references are provided to guide you to a detailed explanation.

1. ENTER DATA (text: Creating a Graph Using All Default Parameters)

Data values are entered as X-Y pairs. The process of entering data is terminated by entering M as a data value.

2. DISPLAY DATA (text: Creating a Graph Using All Default Parameters)

This selection graphs the input data. The X-Y data is the only input required to create a graph. All other graph parameters can be established by the Graphic System.

3. LIST DATA (text: Listing Data)

A columnar list of input X-Y data with their corresponding data item numbers as displayed on the screen when this menu item is selected.

4. LIST PARAMETERS (text: Listing Parameters)

This menu selection presents a columnar list of selected or default condition graph values. They are . . .

NUMBER OF

POINTS: shows number of input data items.

LINE CODE: displays the selected Plot Mode.

SYMBOL

CODE: gives the symbol selection.

SCREEN

MINIMUM: displays X and Y axes screen starting points in Graphic Display Units (GDUs).

SCREEN

RANGE: displays X and Y axes GDU lengths.

DATA

MINIMUM: shows X and Y axes minimum data values.

DATA

RANGE: displays X and Y axes data ranges.

5. SET AUTOSCALE (text: Autoscaling)

This menu item selects appropriate X and Y data ranges based on input data values. The System makes autoscale determinations simultaneously to a Display Data function (menu item 2). When the Set Autoscale menu item is selected, it returns your arbitrary data range selections to values that coincide with original default conditions, providing a Display Data menu selection follows the Set Autoscale menu entry.

6. SET X SCREEN POSITION (text: Changing the Graph's Screen Position)

This menu item sets the X axis horizontal length and position in GDUs on the 130 GDU horizontal display screen surface. The default condition begins the axis at 30 GDUs and ends it at 110 GDUs, establishing an axis that is 80 GDUs long.

7. SET Y SCREEN POSITION (text: Changing the Graph's Screen Position)

This menu selection sets the Y axis vertical length and position in GDUs on the 100 GDU vertical display screen surface. The default condition begins the axis at 10 GDUs and terminates it at 90 GDUs. This creates a Y axis 80 GDUs high.

8. SET X DATA RANGE (text: Changing the Graph's Data Range)

This menu item establishes minimum and maximum X axis data points. The default condition is a result of autoscaled X axis input data values.

9. SET Y DATA RANGE (text: Changing the Graph's Data Range)

This menu item establishes minimum and maximum Y axis data values. The default condition is a result of autoscaled Y axis input data values.

10. SELECT PLOT MODE (text: Selecting Plot Modes)

Two modes are available: an optional line plot and a default point plot.

11. SELECT SYMBOL (text: Selecting Plot Symbols)

Here, you are offered a choice of five plot symbols: point, triangle, plus sign, square, and diamond. The point symbol is the default condition.

X VS Y DATA PLOT

12. **INSERT DATA** (text: Inserting Data)

This menu item permits insertion of data into an X-Y data string already entered in the System's memory. Enter M as a data value to terminate the insert data routine.

13. **DELETE DATA** (text: Deleting Data Inside the Data String) (text: Deleting Data at the end of a Data String)

From this menu selection, you can delete data from an X-Y data string that has been entered into System memory. Enter M as a data value to terminate the delete-data routine.

14. **CHANGE DATA** (text: Changing Data)

This menu selection allows you to change one or more data values in a string of X-Y data previously entered into the System. An M is entered as a data value to terminate the data change routine.

15. **STORE DATA** (text: Storing Data on a Magnetic Tape)

Data that has already been entered into the System's memory can be stored on a separate magnetic tape for later data reentry. This selection is made after a data file has been marked on a separate magnetic tape (optional accessory).

16. **STOP** (text: Stop)

This selection takes you back to the PLOT 50 System Software Master Menu. X-Y input data is lost when this menu item is selected, and all default conditions are enabled.

In addition to the menu items above, the following topics in the text are brought to your attention.

ADD DATA (text: Adding Data)

To add X-Y data to the end of a previously entered data string, select menu item 1, ENTER DATA. Enter the data in response to the System's display screen queries. Terminate the add data routine by entering M as a data value.

CORRECTING ERRORS (text: Plot 50 System Software General Information) (text: Creating a Graph Using ALL Default Parameters)

DEFINITION OF AN X-Y DATA PLOT (text: What is an X vs Y Data Plot?)

GRAPHING NEGATIVE DATA (text: Graphing Negative Data)

PLACEMENT OF X OR Y AXIS TOO CLOSE TO SCREEN EDGE (text: Changing the Graph's Screen Position)

STOP/START POINTS (text: Introduction—this section)
(text: Creating a Graph Using All Default Parameters)

WHAT IS AN X VS Y DATA PLOT?

An X vs Y Data Plot is positioned against two reference lines: an X axis horizontal line and a Y axis vertical line.

X and Y axes are divided into segments by small lines called "tic marks." Numbers that label these tic marks are called "axis numbers." Figure 5-1 shows how they relate to a graph.

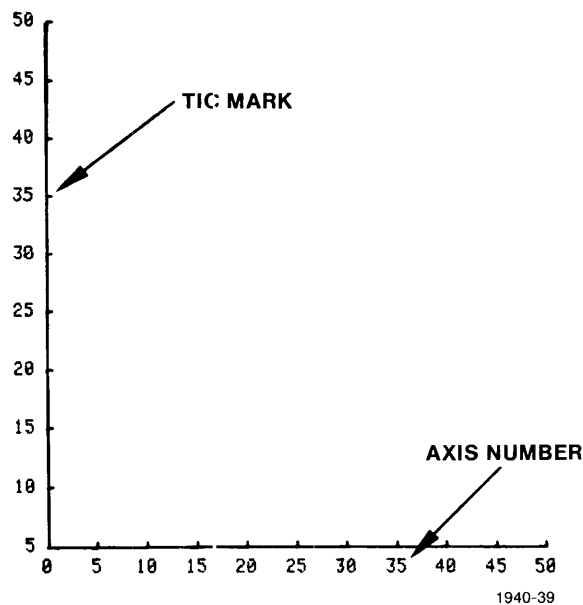
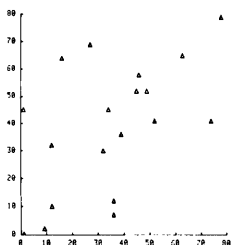


Figure 5-1. Tic Marks and Axis Numbers.

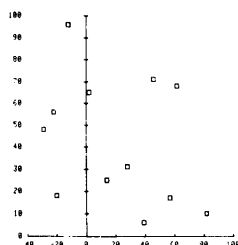
X VS Y DATA PLOT

An X-Y Data Plot graphs the correlation between two sets of data. The data on either axis can be either “discrete” or “continuous.” Discrete variables can have only a certain number of values. The number of members of your family, for example, is a discrete quantity. The “average” family may have 2.7 children, but your family 0, 1, 2, 3, or some other whole number of children. The amount of money you carry is another discrete quantity. You may have \$7.61, but not \$7.61392. On the other hand, continuous variables can have any value at all, within specified limits. Your thermometer may measure any temperature between -40°F and $+140^{\circ}\text{F}$, at least in principle. As another example, when you drive to work each morning, your distance from home varies continuously as you drive.

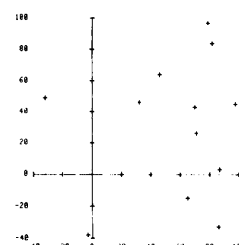
An X vs Y Data Plot looks like this . . .



and this



and even this



1940-40

THE PLOT 50 SYSTEM SOFTWARE TAPE

Creating an X vs Y Data Plot on the Graphic System from scratch isn't hard, but it does require some programming expertise and a Graphic System operating agility that many users don't want to take the time to acquire—at least not at first.

Using BASIC programs already stored on a magnetic tape to create X vs Y Data Plots offers two major advantages:

1. It saves time.
2. It assists the beginning programmer or the casual user and permits them to create graphs with a minimum of study.

The PLOT 50 System Software Tape programs the Graphic System to calculate most graph parameters automatically. In fact, you can create a professional looking X vs Y graph by doing nothing more than entering the raw data into the Graphic System.

The parameters that the Graphic System automatically establishes for you are called "default values." These are system settings that are used unless you specify otherwise. Although the default values serve a variety of graphic situations, it is often advantageous to alter or "override" one or more of the default parameters to put a plot in a more appropriate setting. This can be done quickly and easily. By overriding default conditions, you can:

1. Move the X axis horizontally on the Graphic System display screen and make the axis length shorter or longer.
2. Move the Y axis vertically on the display screen and make the axis length shorter or longer.
3. Change the X axis data range.
4. Change the Y axis data range.
5. Choose either a line or a point plot.
6. Choose from five plot symbols.

Don't feel uneasy if some of the terms we just used don't mean anything to you yet. This is an overview of topics that we'll be discussing thoroughly a little later.

Now, let's create a graph on your Graphic System display screen. We'll go through the procedure together step-by-step, and we'll let the System do most of the work. After you've created your X vs Y Data Plot using all possible default values, we'll move the input data values around until you feel at ease making data changes. We'll add data to the end of your input, insert numbers in the middle of the data string, and delete some data values. Then we'll examine the default parameters and explore why you might want to override some of them from time to time. We'll take your graph and, by nullifying default values, change its appearance and move the graph to different screen locations. All this manipulation emphasizes how versatile the Graphic System software package is, and how easy it is for you to use the program to complete your graphing requirements.

During the text demonstrations, you'll be entering data into the Graphic System from the keyboard. At the conclusion of the X vs Y Data Plot discussion we'll explore the procedure used when you wish to store system data on magnetic tape for later retrieval.

INITIALIZING THE GRAPHIC SYSTEM

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 5-2). The four green indicator lights on the front panel (Figure 4-3) will turn on, but only the power light remains on. It stays on as long as power is applied to the System.

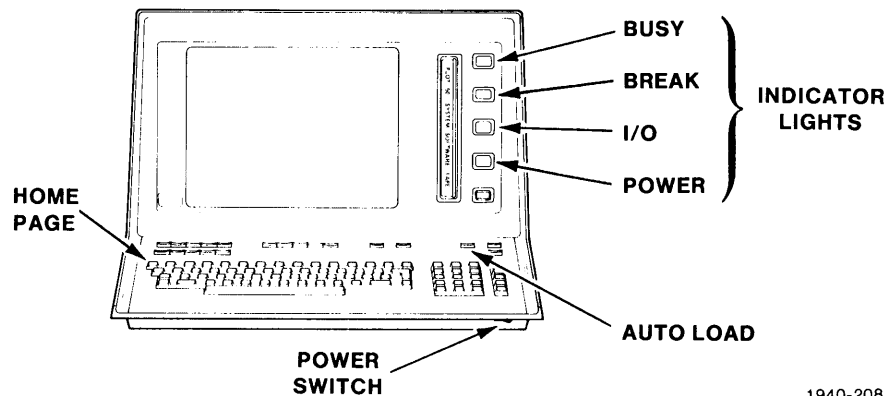


Figure 5-2. Power Switch, Indicator Lights, HOME/PAGE Key, and AUTO LOAD Key.

Press the HOME/PAGE key. The screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen.

INITIALIZING THE PLOT 50 SYSTEM SOFTWARE TAPE

Insert the PLOT 50 System Software Tape. Refer to the PLOT 50 System Software General Information section for specific instructions. Press the AUTO LOAD key (Figure 5-2). This rewinds the magnetic tape, locates the first program on the tape, loads the program into the Graphic System memory, and begins the first program—in this case, a program directory (menu).

When you press the AUTO LOAD key, the BUSY and I/O (Input/Output) indicator lights turn on (Figure 5-2). The System makes a series of sounds that normally occur whenever there is a tape movement in the system. Figure 5-3 shows the PLOT 50 System Software Master Menu that appears after the tape stops.

```

** PLOT 50: SYSTEM SOFTWARE **

PROGRAM      TITLE
          GRAPHIC SUPPORT PROGRAMS
1          Y Only Data Plot
2          X vs Y Data Plot
3          Function Plot
4          Histogram Plot

5          GRAPHIC SYSTEM TUTORIAL
6          SOFTWARE VERIFICATION PROGRAM
7          FIRMWARE VERIFICATION PROGRAM (4051 only)
8          SPECIAL 4054 FEATURES (4054 only)

ENTER THE PROGRAM NUMBER YOU WANT:

```

Figure 5-3. PLOT 50 System Software Master Menu.

CREATING A GRAPH USING ALL DEFAULT VALUES

The Master Menu is a seven-item list of the programs stored on the PLOT 50 System Software Tape. Notice that the X vs Y Data Plot—the program module we’re looking for—is listed as item number 2.

At the bottom of the menu is a single sentence we call an “entry statement.” It is followed by a blinking question mark. When a blinking question mark appears, it means that the Graphic System is waiting for you to make a keyboard entry.

To get to the X vs Y Data Plot Program, make your selection by pressing the 2 key on the numeric pad.

In this manual, when you are expected to press a number key on the keyboard, the expression “Enter” will be printed, followed by an appropriate number or numbers and their separators. The direction will appear like this:

Enter 2

Go ahead and press the 2 key. The 2 appears on the screen and is entered into the line buffer, a small temporary memory. Notice that the blinking question mark now appears to the right of the displayed 2. The System is waiting for you to continue your entry or complete your entry by pressing the RETURN key. Whenever you are expected to press any key other than a number key, the expression will be “Press” followed by the name of the key. You’re expected to press the RETURN key now, so we say . . .

Press RETURN

X VS Y DATA PLOT

You can type data repeatedly on the keyboard, but until you press the RETURN key, the System will not act on your entry. When the RETURN key is pressed, the number 2 is sent from the line buffer to the System.

Now the line buffer is empty again; it will begin filling up as you enter additional data. It will hold 72 characters before it refuses to accept any more. While data is in the line buffer, you can change it over and over again if you like. That's what it's there for—to give you an editing capability. But once you press that RETURN key, you're committed.

In effect, by pressing the 2 key and the RETURN key, you have just said to the the System, "Locate the X vs Y Data Plot Program on the System Software Tape and display the X vs Y Data Plot Menu." After the tape-movement noises stop the Master Menu is erased from the screen, and the X vs Y Data Plot Menu shown in Figure 5-4 appears:

```

                                X vs Y DATA PLOT
1  ENTER DATA
2  DISPLAY DATA
3  LIST DATA
4  LIST PARAMETERS
5  SET AUTOSCALE
6  SET X SCREEN POSITION
7  SET Y SCREEN POSITION
8  SET X DATA RANGE
9  SET Y DATA RANGE
10 SELECT PLOT MODE
11 SELECT SYMBOL
12 INSERT DATA
13 DELETE DATA
14 CHANGE DATA
15 STORE DATA
16 STOP

ENTER MENU ITEM NUMBER OR M FOR NEW MENU
                                1940-44
```

Figure 5-4. X vs Y Data Plot Menu.

Notice the wording of the entry statement at the bottom of the menu. This means that while you are using the X vs Y Data Plot Program and this entry statement appears on the display screen, you can return to the X vs Y Data Plot Menu by pressing the M key followed by pressing the RETURN key. It also means that you can bypass the menu and go from one menu selection to another provided you know the appropriate menu selection number to enter. The menu is just a table of contents that's put in the program for your convenience. Use it when you need it; bypass it when you don't need it.

Examine the X vs Y Data Plot Menu for the proper selection. We want to enter data, so menu item 1 is our selection.

```
Enter 1
Press RETURN
```

A question appears on the screen:

DO YOU WANT TO USE THE KEYBOARD (Y or N) ?

You do, so . . .

Press Y
Press RETURN

The screen erases, and the following appears:

ENTER M TO DISCONTINUE DATA ENTRY
X(1) ?

The Graphic System is ready to receive the first X axis value from the keyboard. To get data for these demonstrations, we queried a few people about their age and how many hours of television they watched each week. The fourteen people we included in the "survey" formed too small a sampling to reveal any significant information about TV viewing. Here's the data.

| AGE | HOURS IN VIEWING TIME |
|------------|----------------------------------|
| 48..... | 21 |
| 28..... | 10 |
| 26..... | 5 |
| 21..... | 13 |
| 27..... | 17 |
| 36..... | 27 |
| 24..... | 25 |
| 31..... | 14 |
| 20..... | 5 |
| 35..... | 11 |
| 34..... | 12 |
| 33..... | 20 |
| 24..... | 16 |
| 25..... | 15 |

X VS Y DATA PLOT

The System is still waiting for us to enter the first data item. The procedure is to enter the X axis data value, press RETURN, enter the Y data value, press RETURN, and so forth. The System keeps everything in order by indicating the data item number for the next data entry and whether it is to be an X axis or a Y axis value. Let's look at the screen again:

```
ENTER M TO DISCONTINUE DATA ENTRY
X(1) ?
```

The display is saying, "Enter your first item of X axis data." We want to plot age on the X axis, so our first entry is 48.

```
Enter 48
Press RETURN
```

Screen: ENTER M TO DISCONTINUE DATA ENTRY

```
                 X(1) 48
                 Y(1) ?
```

The display screen retains the first entry and now asks for Y axis data.

```
Enter 21
Press RETURN
```

The screen displays the latest entry and asks for the second X axis data value. Enter the appropriate value (28) and continue entering data until you have entered all the survey information. If you should make a mistake but haven't pressed the RETURN key, corrections are easy. The data is still in the line buffer and subject to edit. You can backspace, delete, add, or whatever. If you make a mistake and don't see it until after you have pressed the RETURN key, remember the mistake and its location (data item number), but continue your data entries. After you have completed all data entries and returned to the X vs Y Data Plot Menu, you can select another menu item that allows you to change data. We'll be studying that procedure later.

When you have entered all the data, the last screen line will be . . .

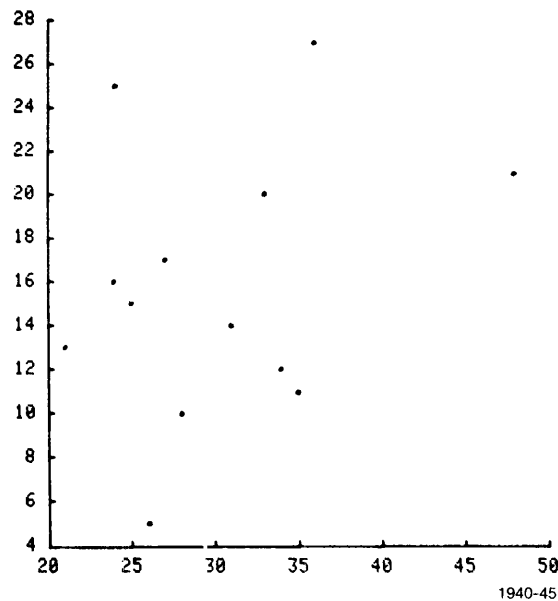
```
X(15) ?
```

Whenever you're working with data (entering it, adding to it, changing it, or making insertions in it), the Graphic System has no way of knowing how many data items you're working with. It continues asking you for data until you tell it to stop. You do that by entering an M. This entry terminates the data routine and returns the program to the X vs Y Data Plot Menu. It is appropriate to do that now.

Press M
Press RETURN

This is a STOP/START point.

The screen reflects the M entry, erases, and displays the X vs Y Data Plot Menu. Believe it or not, you've done everything you need to do to create a graph! Select menu item 2, DISPLAY DATA, and see for yourself.



We just passed the first STOP/START point. Let's discuss how to resume using the text and continue with the demonstrations if you terminate your studies at one of these STOP/START points. We assume you turned off the Graphic System at the STOP/START point. Here's how to reenter:

1. Initialize the Graphic System.
2. Initialize the PLOT 50 System Software Tape. This displays the PLOT 50 System Software Master Menu.
3. Select menu item 1. This displays the X vs Y Data Plot Menu.

X VS Y DATA PLOT

4. Select menu item 1—ENTER DATA—and enter the 14 sets of X-Y survey data.
5. Return to the X vs Y Data Plot Menu.
6. Resume your studies.

DATA LIMITATIONS

The standard 4051 Graphic System has an 8K byte Random Access Memory (RAM). Optional add-on RAM in 8K increments is available. If you have a standard 4051 Graphic System (8K RAM), you can enter a maximum of 50 data pairs into this X vs Y data Plot Program. When the 4051 Graphic System is provided with options that give you more than 8K RAM, or when you are using a 4052 Graphic System or a 4054 Graphic System, you can enter 100 sets of X-Y data pairs for this program. In either case, when you enter the maximum data set, the screen displays the following:

MAXIMUM NUMBER OF VALUES IS 100 (or 50 if that's appropriate)
ENTER NEW MENU ITEM NUMBER OR M FOR NEW MENU ?

The graph you've just created is using a point to mark the X vs Y plot values you entered into the System. This is the default condition; unless you specify otherwise, this is the graph symbol that will display your data. The points aren't suitable for all applications, so several other plot symbols are available. Let's go back to the menu and find the proper menu selection.

Press M
Press RETURN

This is a STOP/START point.

SELECTING PLOT SYMBOLS

The screen displays the Symbol Menu. Notice that item 11, SELECT SYMBOL, is the proper entry.

Enter 11
Press RETURN

Screen: 1 POINT
2 TRIANGLE
3 PLUS SIGN
4 SQUARE
5 DIAMOND
SELECT NUMBER AND PRESS RETURN ?

Let's experiment with the triangle symbol and see what it looks like on a graph.

Enter 2

Press RET JRN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M

Press RETURN

We return to the Symbol Menu and find the proper menu selection to draw the graph shown in Figure 5-5.

Enter 2

Press RETURN

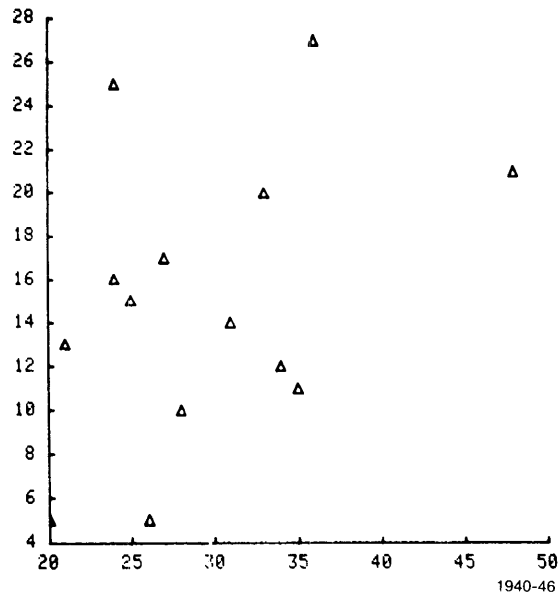


Figure 5-5. X vs Y Data Plot with Triangle Plot Symbols.

X VS Y DATA PLOT

There, that's easier to see! We'll ignore the other symbol possibilities for now, but we'll incorporate them in subsequent graphs. Let's return to our default symbol (point) and go back to the X vs Y Data Plot Menu.

Enter 11
Press RETURN

The screen displays the Symbol Menu. The point symbol is 1.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

This is a STOP/START point.

CHANGING DATA

You may want to change some of the input data you entered into the system for any of several reasons. Perhaps you made an error.

Perhaps you're working on a project where only one or two data points change while other graph points remain fixed; changing a few data values will be simpler than reentering the entire data string.

Perhaps you want to visualize the impact of alternate sets of data into a statistical picture. These forecasting alternates are often entered into the System by changing part of the original data.

You change data by selecting item 14 on the X vs Y Data Plot Menu.

Enter 14
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

Let's pretend for a moment that the correct data for item 5 was an X of 38 and a Y of 2 instead of the 27 and 17 data values now in memory. Here's how to make the change.

Enter 5
Press RETURN

Screen: CURRENT VALUE OF ITEM 5 is X 27 Y 17
 ENTER NEW X AND Y VALUES ?

 Enter 38, 2
 Press RETURN

Or as an alternate entry:

 Enter 38
 Press RETURN
 Enter 2
 Press RETURN

Either routine does it!

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

The graphic System assumes you have more data to be changed. You haven't; so it's necessary to notify the System by entering an M as a data value.

 Press M
 Press RETURN

The screen displays the X vs Y Data Plot Menu.

LISTING DATA

Let's verify the data change by looking at a very helpful reference—a listing of the data, menu item 3.

 Enter 3
 Press RETURN

X VS Y DATA PLOT

| NUMBER | DATA LIST | |
|-------------|-----------|----|
| | X | Y |
| 1 | 48 | 21 |
| 2 | 28 | 10 |
| 3 | 26 | 5 |
| 4 | 21 | 13 |
| 5 | 38 | 2 |
| 6 | 36 | 27 |
| 7 | 24 | 25 |
| 8 | 31 | 14 |
| 9 | 20 | 5 |
| 10 | 35 | 11 |
| 11 | 34 | 12 |
| 12 | 33 | 20 |
| 13 | 24 | 16 |
| 14 | 25 | 15 |
| END OF LIST | | |

ENTER MENU ITEM NUMBER OR M FOR NEW MENU

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Figure 5-6. Data List.

Figure 5-6 shows that data item 5 reflects the change just entered into the System. Let's return the original values to the data string before we begin another topic. The menu selection is 14.

Enter 14
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

Enter 5
Press RETURN

Screen: CURRENT VALUE OF ITEM 5 is X 32 Y 2
ENTER NEW X AND Y VALUES ?

Enter 27
Press RETURN
Enter 12
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

We must now terminate the data-change routine.

Press M
Press RETURN

ADDING DATA

It's easy to add data to the values you've entered into the Graphic System. Suppose we survey four more people and add this additional data into our survey results (this add-on data is fictitious):

| AGE | HOURS IN VIEWING TIME |
|------------|----------------------------------|
| 5 | 1 |
| 72 | 36 |
| 12 | 19 |
| 87 | 8 |

Enter 1
Press RETURN

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y or N) ?

You do, so . . .

Press Y
Press RETURN

The screen erases and displays the following:

ENTER M TO DISCONTINUE DATA ENTRY
X (15) ?

The System automatically gives you the next available data item number to complete. Enter the new values in the conventional manner and terminate the add-on data string by entering M as a data value.

Press M
Press RETURN

The screen displays the X vs Y Data Plot Menu. Verify your new entries by listing the data as selected by menu item 3.

Enter 3
Press RETURN

X VS Y DATA PLOT

The screen displays the data list containing 18 data sets of X-Y data. This new input alters our graph data parameters because we've added new minimum and maximum data values. Let's regraph the data (Figure 5-7) and use plus signs for point symbols.

Press M
Press RETURN

The menu is displayed. The SELECT SYMBOL menu item is 11.

Press 11
Press RETURN

The screen displays the Symbol Menu.

Enter 3
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

You probably recall that the DISPLAY DATA selection is menu item 2.

Enter 2
Press RETURN

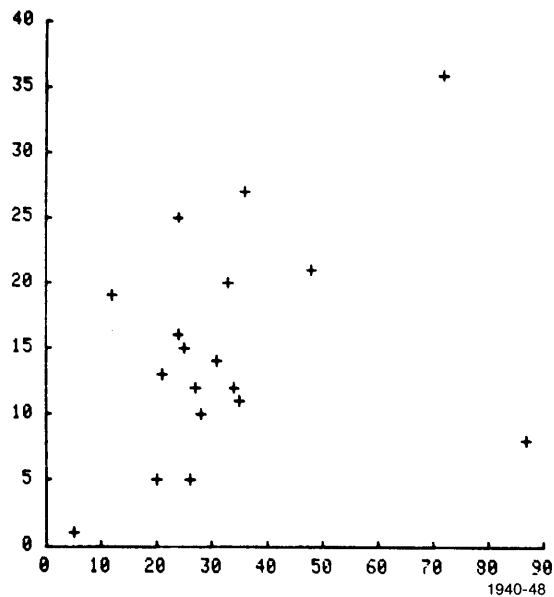


Figure 5-7. X vs Y Data Plot with Plus Sign Plot Symbols.

Notice that our Y axis has been rescaled from previous 4 to 28 values to an expanded scale of 0 to 40. Likewise, the X axis changes from the range of 20 to 50 to new range values of 0 to 90. These changes are necessary to accommodate the new data—and it's done automatically!

We want to go back to our original data and the original graph parameters. To do this, we'll have to get rid of those four additional data items. And that brings us to our next topic.

DELETING DATA

You delete data by referring to data item numbers; you terminate the deletion routine by entering an M as a data value. When you delete data from within the data string, the data string “reforms itself” following the deletion. Right now, if you delete item 7 from our data string, all higher numbered items “shift down” one lower sequential number to fill the gap left by the deleted seventh item. Item 8 becomes item 7, item 9 becomes item 8, and so on. The “reformed” data string has 17 sets of data values without a data-item gap.

When you want to delete data from either end of the data string, you delete the lowest unwanted data item number as many times as there are numbers to be deleted. In this situation, you eliminate item 15 four times.

The deletion selection on the menu is item 13. Let's delete our four unwanted numbers and go back to our original survey data.

Enter 13
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 15
Press RET JRN

Screen: VALUE DELETED X 5 Y 1
ENTER ITEM NUMBER TO BE DELETED ?

Enter 15
Press RETURN

X VS Y DATA PLOT

Screen: VALUE DELETED X 72 Y 36
ENTER THE NUMBER TO BE DELETED ?

Enter 15
Press RETURN

Screen: VALUE DELETED: X 12 Y 19
ENTER ITEM NUMBER TO BE DELETED ?

Enter 15
Press RETURN

Screen: VALUE DELETED: X 87 Y 8
ENTER ITEM NUMBER TO BE DELETED ?

Press M
Press RETURN

The M entry is necessary to discontinue the delete-data routine. The screen displays the menu. To return to our original graph configuration, we must select the point symbol.

Enter 11
Press RETURN

The screen displays the 5-item Symbol Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

This is a STOP/START point.

INSERTING DATA

Inserting data into a data string already entered in the Graphic System is easy to do. Assume that you inadvertently left out one survey sample (data regarding one individual), and you want to insert that data between data items 5 and 6. Let's go to our data list.

Enter 3
Press RETURN

The screen displays the data list. Notice that data item 5 has values of X 27 and Y 17. Data item 6 has values of X 36 and Y 27. Our insertion is for a 103 year old man who watches 63 hours of television a week. We must first go back to the X vs Y Data Plot Menu to find the proper selection.

Press M
Press RETURN

Notice that selection 12 is the proper entry.

Enter 12
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

We want to slip a data set between data items 5 and 6, so our input data will precede item 6.

Enter 6
Press RETURN

Screen: ENTER NEW X VALUE ?

Enter 103
Press RETURN

Screen: ENTER NEW Y VALUE ?

Enter 63
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

X VS Y DATA PLOT

To terminate the delete data routine, an M must be entered as a data value.

Press M
Press RETURN

The screen displays the X vs Y Data Plot Menu. Let's do four things; look at the data list to verify our insertion, return to the menu, select the diamond symbol, and plot a graph with the inserted data.

Enter 3
Press RETURN

The screen shows the data list. Our insertion is data item 6. The data item that was previously item 6 is now moved up to item 7. It and all higher numbered data have been moved up one sequential number to make room for the insertion.

Press M
Press RETURN

The screen displays the X vs Y Data Plot menu. Make the SELECT SYMBOL entry.

Enter 11
Press RETURN

The screen shows the five-item Symbol Menu. We want to use diamonds this time (Figure 5-8).

Enter 5
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

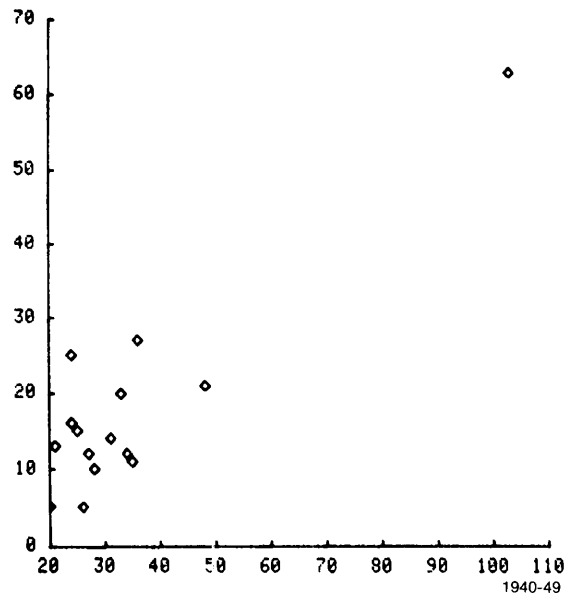


Figure 5-8. X vs Y Data Plot with Diamond Plot Symbols.

Notice that our graph has new parameters because our 103 year old man extended our data range. Return to the standard survey data by deleting the insert. The deletion selection is number 13.

Enter 13
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 6
Press RETURN

Screen: VALUE DELETED: X 103 Y 63
ENTER ITEM NUMBER TO BE DELETED ?

Press M
Press RETURN

Returning to the X vs Y Data Plot Menu discontinues the delete routine. Now, let's change back to the point symbol.

Enter 11
Press RETURN

X VS Y DATA PLOT

The screen displays the Symbol Menu. We want item 1.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press Return

This is a STOP/START point.

SELECTING PLOT MODES

You've probably noticed that we haven't been drawing lines between our plotted X vs Y data points. Unless the data has been previously sorted, or unless the data happens to be accumulated in a manner that has data on one axis moving in a sequential fashion, connecting lines between data points is a superfluous and confusing technique. Let's check it out. Observe that SELECT PLOT MODE is menu item 10.

Enter 10
Press RETURN

Screen: 1 LINE PLOT MODE
2 POINT PLOT MODE
SELECT NUMBER AND PRESS RETURN

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Let's select item 2 and plot the graph shown in Figure 5-9.

Enter 2
Press RETURN

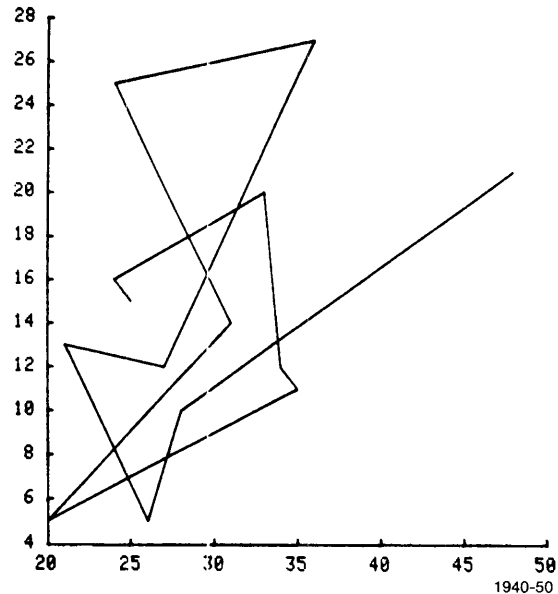


Figure 5-9. X vs Y Data Plot in Line Plot Mode.

It looks more like a sketch than it does a graph. We are only using 14 data items; imagine the confusion if we had 45! But as we stated, when the data on one axis is in sequential order, you can use Line Plot Mode advantageously. Point Plot Mode is the default setting. Let's return to it.

Enter 10
Press RETURN

The screen displays the Plot Mode Menu.

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

This is a STOP/START point.

AUTOSCALING

When you put data into the Graphic System without specifying specific X and Y axes data ranges at the time you request a graph, the System established X and Y axes data ranges that include all input data. We call that automatic range determination “autoscaling.”

When we talk about data ranges for an X axis, for example, we’re referring to the minimum to maximum data values that are plotted against the X axis. The X axis index numbers (the numbers that label the X axis tic marks) reflect those data range values. This range format applies to the Y axis also.

If you put data into the Graphic System and immediately ask for an X vs Y data plot by selecting menu item 2, the System searches its memory to see if you gave it data-range instructions. If not, the System autoscales the data; that is, it scans the data and established minimum and maximum data ranges that include all data values. Remember, the System does not autoscale until just before the graph is created.

So far, we have not specified any specific axis data ranges; so, all our graphs have been autoscaled. Later on in the text, when we manipulate data ranges, we may want to return the data ranges to values we presently have. To do that, we will select menu item 5 — SET AUTOSCALE. We will review autoscale information at that time.

GRAPHIC DISPLAY UNITS

The Graphic System display screen is internally divided into 100 vertical and 130 horizontal units called Graphic Display Units (GDUs). We’ll be working with these units to relocate the position of the graph on the screen.

LISTING PARAMETERS

When you select item 4 — LIST PARAMETERS — on the X vs Y Data Plot Menu, you have picked a handy reference chart that will assist you in many plotting situations. Let’s take a few moments to describe the parameter list headings as they appear on the screen (Figure 5-10).

```

PARAMETER LIST
NUMBER OF POINTS      14
LINE CODE             2
SYMBOL CODE          1

          -----X-----      -----Y-----
SCREEN MINIMUM        30          10
SCREEN RANGE          80          80
DATA MINIMUM         20          4
DATA RANGE           30          24

ENTER MENU ITEM NUMBER OR M FOR NEW MENU

```

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Figure 5-10. Parameter List Headings.

Here is an explanation of the Parameter List headings:

NUMBER OF

POINTS: This is the number of data item sets you enter.

LINE CODE: The same as Plot Mode. The default value is Point Plot Mode (plot menu item 2).

SYMBOL

CODE: This refers to X vs Y Data Plot Menu item 11. The default value is Point Symbol Mode (symbol menu item 1).

SCREEN

MINIMUM: This indicates the Graphic Display Unit (GDU) point where the X axis begins. When in a default condition, the X axis begins 30 GDUs horizontally from the left side of the screen, and the Y axis begins 10 GDUs vertically from the bottom of the screen. These default conditions provide a screen graphing location suitable for most applications.

SCREEN

RANGE: These entries indicate the length of the X and Y axes in GDUs. If you add this value to the screen minimum, you obtain the axis termination point expressed in GDUs (screen maximum).

DATA

MINIMUM: The data minimum is the X and Y axes data minimums established by you, or it is the autoscaled data minimums selected by the Graphic System.

DATA

RANGE: This figure shows the total range value on each axis. Add this figure to the data minimum and the result is the maximum data range value.

X VS Y DATA PLOT

If you have reached this text point by reentering the text from the last STOP/START point, the Data Range and Data Minimum columns on your Parameter List will contain zeroes instead of the numbers shown in the parameter illustration. The Graphic System does not autoscale until a graph is created. Since the last STOP/START point occurred subsequent to the last graphing demonstration, since you haven't been told to establish data ranges, and since the system hasn't been forced to autoscale, there just aren't any data ranges yet.

CHANGING THE SHAPE OF THE GRAPH

Shortening or lengthening the X and Y axes changes the impact of your graph. If we stretch the X axis and compress the Y axis, we tend to "flatten out" the graph and de-emphasize differences in the data. Conversely, if we lengthen the Y axis and shorten the X axis, we make minor differences in the data appear more pronounced.

Since a point plot is the more common configuration in X vs Y data plots, that is the mode we'll use for these examples.

Your Graphic System should be displaying menu item 4 — LIST PARAMETERS. Notice that the X screen minimum is 30 and the X screen range is 80. The horizontal display screen is 130 GDUs long. If the X axis starts at 30 GDUs and is 80 GDUs long, then the X axis terminates at 110 GDUs.

Notice also that the X data minimum is 20 and the X data range is 30. This means that the data starts with a value of 20 and has 30 units of data on the X axis. Add these values together ($20 + 30$) and you obtain the maximum data range for the X axis: 50.

We analyze Y axis data the same way. The Y data minimum is 4, and the data range is 24. So we know our minimum Y axis data is 4 and that there are 24 units of data on the Y axis. When we add the two value together, we compute the maximum Y axis data value of 28 ($24 + 4$).

Let's take our familiar survey graph, add the square symbol for plotting point emphasis, and see how the graph seems to tell a different story when we push the X and Y axes around. We'll use extreme examples to dramatize the differences.

Press M
Press RETURN

This is a STOP/START point.

We'll begin by shortening the X axis to emphasize data differences.

Let's get our square symbol first.

Enter 11
Press RETURN

The screen displays the Symbol Menu.

Enter 4
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

The menu item for changing the X axis screen position is number 6.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Since we're compressing this axis, we'll leave the minimum X axis point (30) alone and push in the other end; so, we enter the same minimum value we presently have.

Enter 30
Press RETURN

Screen: MAXIMUM ?

Here's where we make the change!

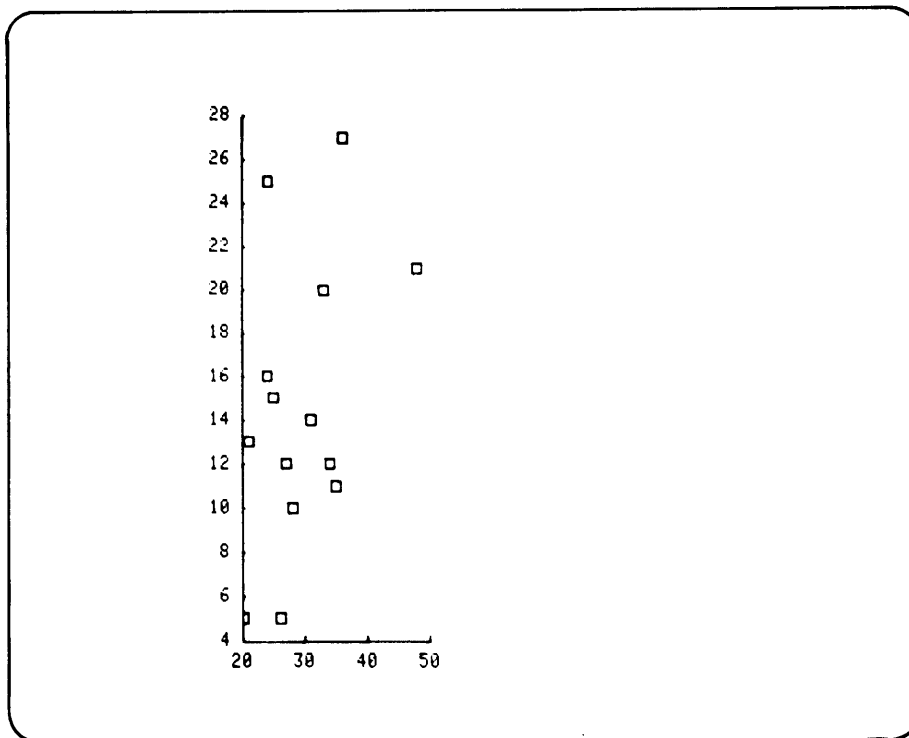
Enter 60
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

X VS Y DATA PLOT

Figure 5-11 shows what the graph looks like.



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Figure 5-11. X vs Y Data Plot with Compressed X Axis.

No question about it, even though the data and the axis numbers remain the same, this graph leaves you with the impression that the Y data changes are large compared to the X data changes. Go back to the Parameter List and notice the difference this X axis modification makes.

Enter 4
Press RETURN

The Parameter List shows that the X axis screen minimum is 30 (where it was before) and the screen range is 30. Add these two values together to get the screen maximum (30 + 30), which is the value we entered: 60. Other values on the list are unchanged.

Let's move the graph to the right side of the screen. We'll make the X axis minimum 90 GDUs and the X axis maximum 120 GDUs — this still gives us our present 30 GDU X axis length.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

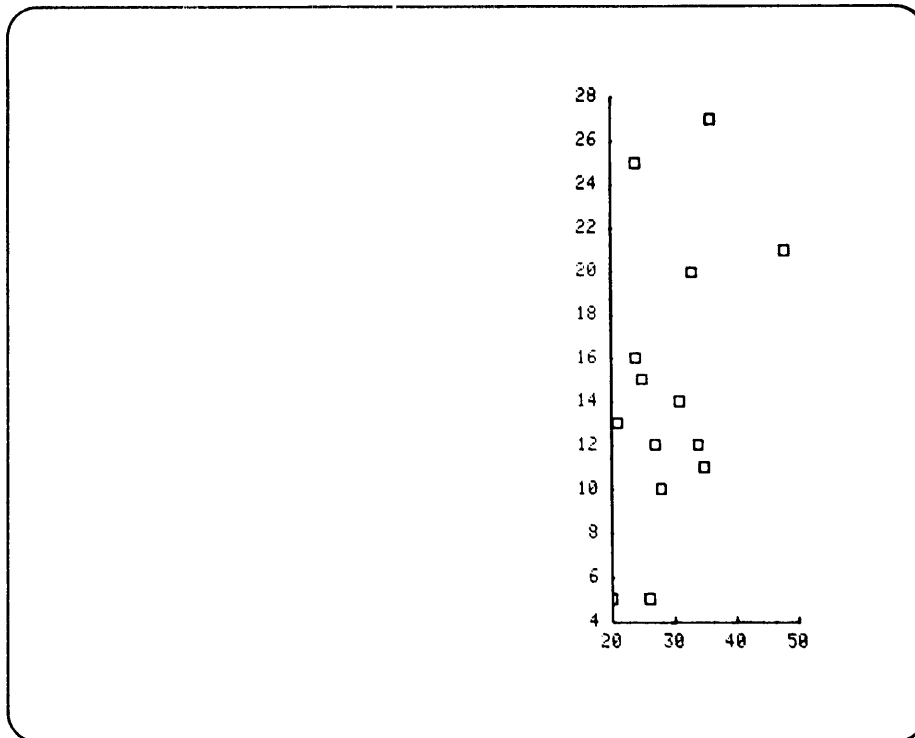
Enter 90
Press RETURN

Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN



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Figure 5-12. X vs Y Data Plot with Compressed X Axis Shifted Right.

X VS Y DATA PLOT

And there you are!

Go to the Parameter List and observe the X axis entries for screen minimum and screen range.

Enter 4
Press RETURN

The entries should be self-explanatory.

Suppose we go the other way now and the data changes appear as insignificant as possible. One way to do this is to lengthen the X axis and shorten the Y axis. First, the X axis . . .

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

The screen displays the X vs Y Data Plot Menu. We've just completed stretching an X axis line of 110 GDUs from a 10 GDU starting point on the screen to a terminating point at 120 GDUs. Okay? Compressing the Y axis is next. The menu reveals that item 7 is what we're looking for.

Now, let's return to the Parameter List to verify Y axis default values.

Enter 4
Press RETURN

The screen displays the Parameter List. Notice that our Y axis screen minimum is 10 and our Y axis screen range is 80. These are default conditions. Let's shorten the Y axis and give it values of 10 and 30; that gives us a Y axis length of only 40 GDUs, a configuration that ought to de-emphasize the graph's data changes significantly.

Enter 7
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

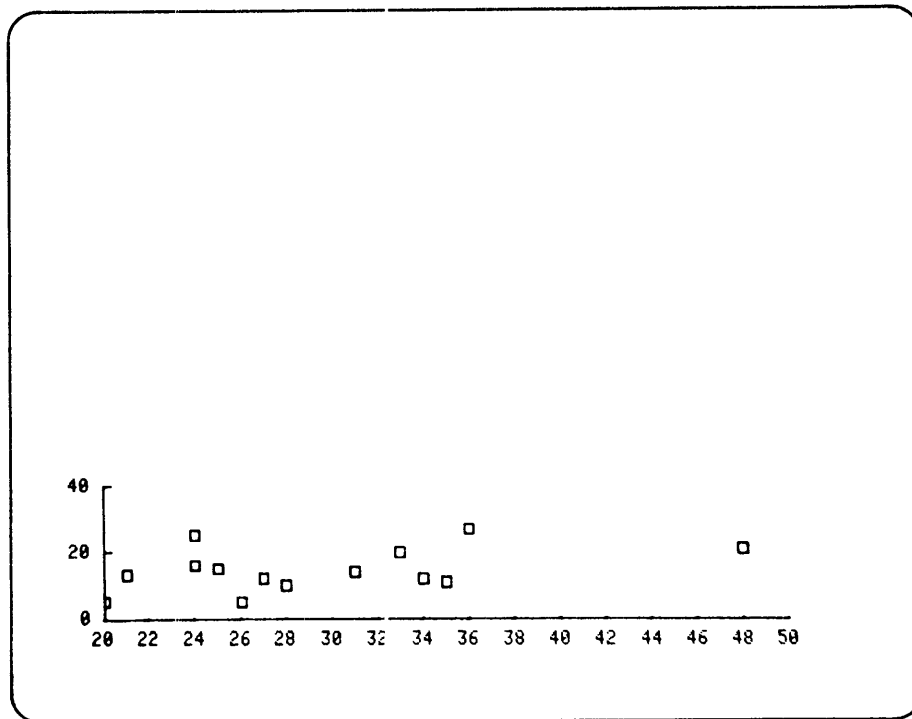
Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 30
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN



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Figure 5-13. X vs Y Data Plot with Compressed Y Axis.

X VS Y DATA PLOT

Figure 5-13 shows the contrast to our earlier example.

If you put the X axis too close to the left or the right screen border, or if you establish the Y axis too close to the bottom or top of the display screen, you get graph aberrations. You'll find your graph data chopped off, the axis index numbers misplaced, or that the System goes into a "page full" condition repeatedly before completing the graph.

The default condition for the location of the X and Y axes is adequate for most graphing requirements. If you do customize the screen location of your graph, remember to allow sufficient room horizontally and vertically for axes index numbers.

Before we begin another topic, let's take time to return our graph to its original condition. The original X and Y screen locations in GDUs were X axis 30 and 110; Y axis 10 and 90.

Enter 6
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 30
Press RETURN

Screen: MAXIMUM ?

Enter 110
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 7
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 11
Press RETURN

The screen displays the Symbol Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

We've returned the X and Y axes to their former configuration, and we've returned to the point symbol. Are we back to our original graph? No! When we compressed the Y axis during one of the demonstrations, the System autoscaled that axis to a new data minimum of 0 and a data range maximum of 40 (the original values were 4 and 28). Let's go to the Parameter List and verify the present settings of 0 and 40.

Enter 4
Press RETURN

The screen displays the Parameter List.

To obtain the Y axis data range values that we had on our original graph, we select menu item 5 — SET AUTOSCALE.

Enter 5
Press RETURN

Screen: AUTOSCALED
ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Now, let's see what the Parameter List shows:

Enter 4
Press RETURN

X VS Y DATA PLOT

The screen displays the Parameter List. Notice that the X and Y axes data ranges are zero. Recall that autoscaling does not occur until the graphing function is requested.

Enter 2
Press RETURN

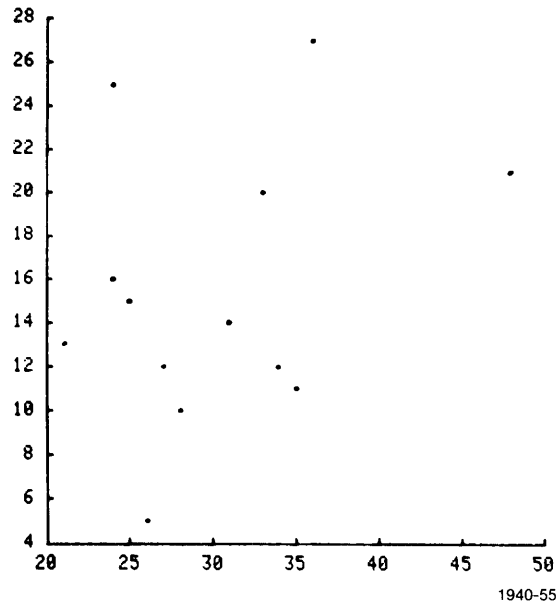


Figure 5-14. Original X vs Y Data Plot.

Figure 5-14 shows our old friend, the original graph. Notice the proper index numbers. Now, let's go back to the Parameter List and see the results of the autoscaling.

Enter 4
Press RETURN

The Parameter List verifies that we have indeed returned to the original graph configuration.

Press M
Press RETURN

This is a STOP/START point.

CHANGING THE DATA RANGES

X vs Y Data Plot Menu items 8 and 9 permit you to change the minimum to maximum data range of the X and Y axes. In autoscaling, the axes data ranges are set to just include all input data values. By customizing the axes data ranges, you can do one of two things: dwarf the plotted data by giving data ranges to the axes that significantly exceed the range of the input data, or "clip-off" part of the input data by making the axes data range smaller than the input data range. Let's begin by increasing the X axis and the Y axis data ranges and observe the effect. Set X DATA RANGE is item 8.

Enter 8
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 200
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Menu item 9 is SET Y DATA RANGE.

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 0
Press RETURN

Screen: MAXIMUM ?

Enter 200
Press RETURN

X VS Y DATA PLOT

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Let's graph with a triangle symbol. The menu item for SELECT SYMBOL is 11.

Enter 11
Press RETURN

The screen displays the Symbol Menu.

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

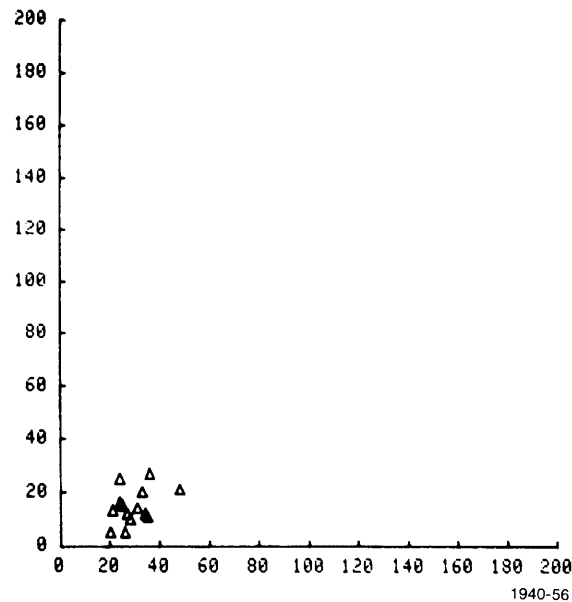


Figure 5-15. X vs Y Data Plot with Extreme Data Ranges.

Figure 5-15 shows this example, which is extreme, but in-between values may apply to an application you have.

If the axes are established with a data range that has a smaller set of values than our input data, data values that fall out of the established range are not displayed. To demonstrate this, we'll begin with X axis, make data range changes, go to the Y axis, make data range changes; then display a graph. We'll stay with the triangle symbols to emphasize the plot points. Menu item 8 is SET X DATA RANGE.

Enter 8
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter 22
Press RETURN

Screen: MAXIMUM ?

Enter 45
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Now, we want menu item 9, SET Y DATA RANGE.

Enter 9
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter 6
Press RETURN

Screen: MAXIMUM ?

Enter 24
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Let's see what we've got!

Enter 2
Press RETURN

X VS Y DATA PLOT

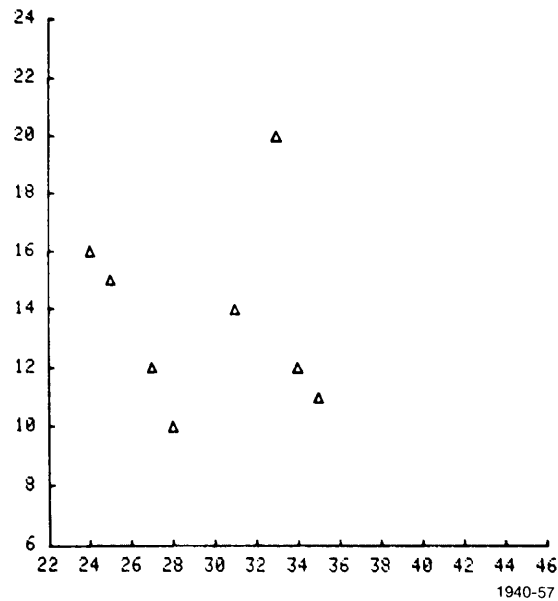


Figure 5-16. X vs Y Data Plot with Clipped Data.

Compare Figure 5-16 with Figure 5-17. The graph in Figure 5-16 does not show all of the input values shown in Figure 5-17. By reducing X and Y data ranges, we have eliminated input data at both axes minimum and maximum data ranges, and we have changed index numbering along the axes.

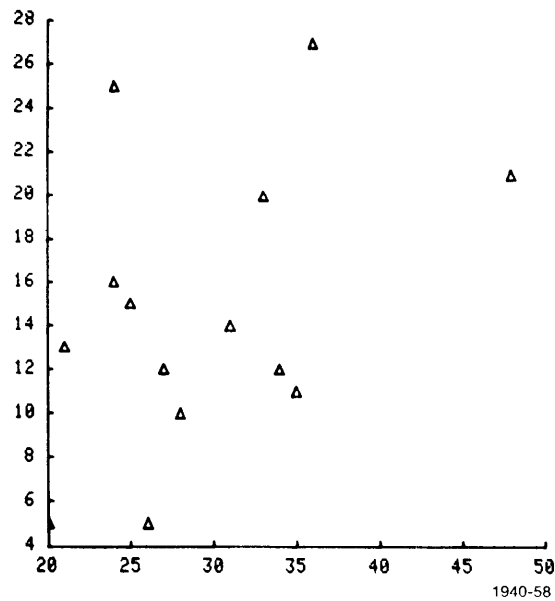


Figure 5-17. Original X vs Y Data Plot with Triangle Plot Symbols.

We do not have to go through a laborious routine to restore the graph to its original configuration; all we have to do is autscale and change symbols.

Enter 11
Press RETURN

The screen displays the Symbol Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

The SET AUTOSCALE menu selection is number 5.

Enter 5
Press RETURN

Screen: AUTOSCALED
ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press Return

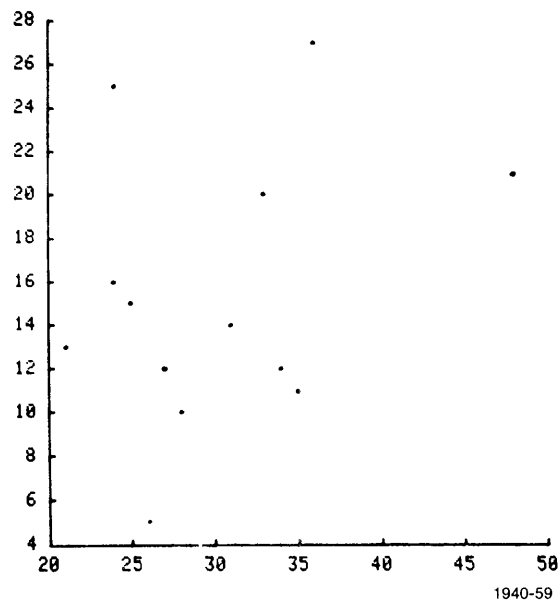


Figure 5-18. Original X vs Y Data Plot.

X VS Y DATA PLOT

Look familiar?

Press M
Press RETURN

This is a STOP/START point.

GRAPHING NEGATIVE DATA

Unfortunately, our famous TV Viewing-Time Survey does not lend itself to negative data. Let's insert an arbitrary negative number into X and Y axes survey data so you can observe the graph configuration.

Enter 12
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

Enter 9
Press RETURN

Screen: ENTER NEW X VALUE ?

Enter -33
Press RETURN

Screen: ENTER NEW Y VALUE ?

Enter -14
Press RETURN

Screen: ENTER ITEM TO BE PRECEDED ?

Press M
Press RETURN

The X vs Y Data Plot Menu was selected to terminate the insert data routine. Let's add diamond symbols to this graph.

Enter 11
Press RETURN

The screen displays the Symbol Menu

Enter 6
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

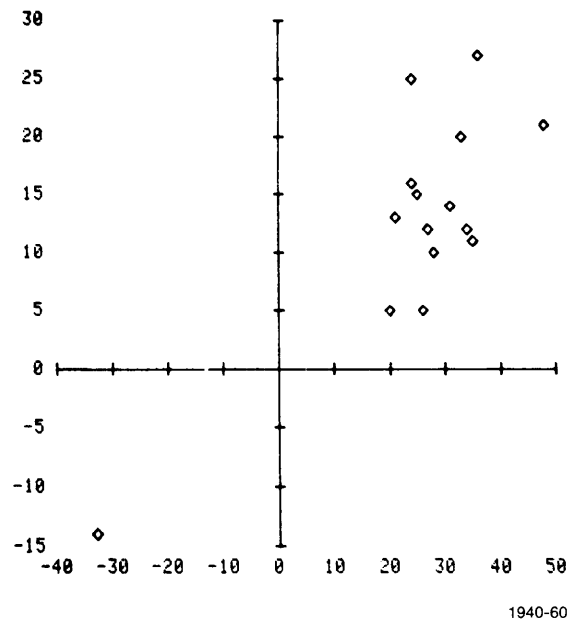


Figure 5-19. X vs. Y Data Plot with Negative Data.

STOP

X vs Y Data Plot Menu item 16 — STOP — terminates the program and returns you to the PLOT 50 System Software Master Menu. STOP is executed from the X vs Y Data Plot Menu. It takes you back to the Master Menu, all default parameters are reset, and X axis and Y axis input data is lost.

You have completed the X vs Y Data Plot instruction except for information and step-by-step instructions on how to store and retrieve data from an auxiliary tape. Go to the next paragraph and begin that instruction now, or implement the STOP menu selection that follows and leave the program.

Enter 16
Press RETURN

STORING DATA ON A MAGNETIC TAPE

Using a magnetic tape to store PLOT 50 System Software program data is a time saver in some situations. It is advantageous to record data on an auxiliary magnetic tape when you have a large block of data that you intend to add to later, or when you have data that you plan to use as a base for "what if" projections. When you need the original data again, insert the data tape into the Graphic System and place the recorded data into System memory.

The next several paragraphs give a description of how to use an auxiliary data tape with the program. The procedure begins from a Graphic System initialized condition (system operational, but PLOT 50 System Software not enabled). Do not attempt to duplicate this step-by-step procedure until you have a data tape available.

1. Before you insert the PLOT 50 System Software Tape into the System, select an auxiliary data tape that has sufficient room for your data. Ensure that the "write protector" arrow on the cartridge is turned opposite the SAFE mark (180° from SAFE). Insert the data tape into the system's magnetic tape slot. If it's an old tape, make a TLIST of the tape's contents (described in the PLOT 50 System Software General Information section) and locate the next available file. If it's a new tape, press the REWIND key to position the tape at its beginning. Find and mark a file (discussed in the PLOT 50 System Software General Information section), providing sufficient tape space to accommodate the data you intend to record.
2. Remove the data tape from the tape slot and set the tape aside.
3. Insert the PLOT 50 System Software Tape into the tape slot and progress to the X vs Y Data Plot Menu.
4. Select menu item number 1, and enter your data from the keyboard.
5. Return to the X vs Y Data Plot Menu.

We continue with a step-by-step procedure . . .

Enter 15
Press RETURN

Screen: INSERT DATA TAPE AND ENTER FILE NUMBER ?

Press the EJECT button and remove the PLOT 50 System Software Tape from the System. Insert the appropriate data tape into the tape slot.

Enter (your marked file number)
Press RETURN

Screen: DATA STORED
INSERT SYSTEM TAPE AND PRESS RETURN ?

Press the EJECT button and take the data tape out at the tape slot. You now have the data stored on your selected file. Put the PLOT 50 System Software Tape back into the System.

Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Continue with your graphing activities. At a later time, when you wish to use the recorded data, start from the X vs Y Data Plot Menu and do the following:

Enter 1
Press RETURN

If you already entered data into the memory, the System will ask:

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y or N) ?

Press N
Press RETURN

Now, the routine is the same for everyone.

Screen: DO YOU WISH TO USE THE KEYBOARD (Y or N) ?

Press N
Press RETURN

Screen: TAPE PROCESSING (Y or N) ?

Press Y
Press RETURN

Screen: INSERT DATA TAPE AND ENTER TAPE FILE # ?

X VS Y DATA PLOT

Press the EJECT button, take the PLOT 50 System Software Tape out of the System, and insert the data tape into the tape slot.

Enter (your file number)
Press RETURN

The System finds the file and loads the data into the System memory.

Screen: INSERT SYSTEM TAPE AND RETURN ?

Push the EJECT button, remove the data tape, and insert the PLOT 50 System Software Tape into the System.

Press RETURN

Verify the data entries by referring to the data list.

Enter 3
Press RETURN

That completes the procedure. Continue your graphing activities.

Section 6

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Section 6

HISTOGRAM PLOT

INTRODUCTION

If you are an experienced programmer, you have several options after reading this Introduction: read the Operation Summary, scan the text following the Operation Summary, or combine the two. If you're relatively new at this graphing business, read this Introduction, skip the Operation Summary for now, and begin studying the text that starts with "What Is a Histogram ?" Later you may want to use the Operation Summary as a reference.

In the Histogram text, we use one set of data for all demonstrations. Once that data is entered into the Graphic System and the program displays the Histogram Menu, you have reached a STOP/START point. These labeled STOP/START points are convenient places for you to stop studying and turn off the System, aware that you can reenter the text's running commentary at that location with the proper settings on the Graphic System for future demonstrations. We'll provide you with detailed instructions on how to use this study technique when we reach the first STOP/START point.

OPERATION SUMMARY

To initialize the Graphic System: (text: Initializing the Graphic System)

1. Refer to the Installation Index to verify that your power source is compatible with the line voltage of the Graphic System.
2. Connect the power cord to the Graphic System and then to your power source.
3. Turn ON the power switch located beneath the right-front corner of the unit.

To begin the PLOT 50 System Software Programs: (text: Initializing the PLOT 50 System Software Tape)

1. Insert the PLOT 50 System Software Tape.
2. Press the AUTO LOAD key.
3. The screen displays the PLOT 50 System Software Master Menu.

This Histogram Plot Menu is used as a reference for this Operation Summary. Menu selections are listed following their menu item numbers. Text references are provided to guide you to a detailed explanation.

1. **ENTER DATA** (text: Creating a Histogram Plot Using All Default Values)
The data values are entered in sequence if sorted, or in any random fashion otherwise. The input data string is terminated by entering M as an input data value.
2. **DISPLAY HISTOGRAM** (text: Creating a Histogram Plot Using All Default Values)
This menu item graphs the input data in a percentage or a frequency distribution histogram. In this selection routine, you are queried regarding the graph's offset, cell width, and type of histogram to be created. Offset is the X axis data minimum. Cell width is the data grouping. The Graphic System PLOT 50 System Software limits you to a maximum of 30 cells between the offset and the data maximum. It is computed as: data maximum minus offset divided by cell width. The result must not exceed 30. The System notifies you if you go over the cell limit. (If your System is a standard 4051 Graphic System (8K RAM) with Option 1, Data Communications Interface, your histogram cannot have more than 10 cells.)
3. **LIST DATA** (text: Creating a Histogram Plot Using All Default Values)
This menu selection presents a columnar list of the input data with sequential data item numbers.

4. LIST PARAMETERS (text: Listing Parameters)

This menu selection presents a columnar list of selection or default condition graph values. They are . . .

NUMBER

OF POINTS: shows number of input data items.

SCREEN

MINIMUM: displays X and Y axes screen starting points in Graphic Display Units (GDUs).

SCREEN

RANGE: displays X and Y axes GDU lengths.

DATA

MINIMUM: shows X and Y axes minimum data values.

DATA

RANGE: displays X and Y axes data ranges.

5. SET X SCREEN POSITION (text: Changing the Graph's Screen Location)

This menu item sets the X axis horizontal length and position in GDUs on the 130 GDU horizontal screen surface. The default condition begins the axis at 30 GDUs and ends it at 110 GDUs, establishing an axis that is 80 GDUs long.

6. SET Y SCREEN POSITION (text: Changing the Graph's Screen Location)

This menu selection sets the Y axis vertical length and position in GDUs on the 100 GDU vertical display screen surface. The default condition begins the axis at 10 GDUs and terminates it at 90 GDUs. This creates a Y axis that is 80 GDUs high.

7. INSERT DATA (text: Inserting Data)

This menu item permits insertion of data into a sorted input data string that is already in the System's memory. Enter M as a data entry to terminate the insert data routine.

8. DELETE DATA (text: Deleting Data Inside the Data String)

(text: Deleting Data at the End of a Data String)

From this menu selection, you can delete data from a data string that has been entered into the System's memory. At the end of a data string, delete the lowest unwanted item number as many times as you have unwanted data values.

HISTOGRAM PLOT

9. CHANGE DATA (text: Changing Data)

This menu selection allows you to change one or more data values in a string of data previously entered into the System. An M is entered as a data value to terminate the data change routine.

10. STORE DATA (text: Storing Data on a Magnetic Tape)

Data that has already been entered into the System's memory can be stored on a separate magnetic tape for later data reentry. This menu selection is made after a data file has been marked on a separate magnetic tape (optional accessory).

11. STOP (text: Stop)

Menu item 11 is enabled from the Histogram Plot Menu. STOP takes you back to the PLOT 50 System Software Master Menu. All parameters are reset to their default values. All input data is lost.

In addition to the preceding menu items, the following topics in the text are brought to your attention.

ADDING DATA (text: Adding Data)

To add data to the end of a previously entered data string, select menu item 1, ENTER DATA. Enter the data in response to display screen queries. Terminate the add data routine by entering M as a data value.

CORRECTING ERRORS (text: PLOT 50 System Software General Information)
(text: Creating A Histogram Plot Using All Default Values)

DEFINITION OF A HISTOGRAM PLOT (text: What Is a Histogram?)

HISTOGRAM PLOT LIMITATIONS (text: Histogram Plot Limitations)

PLACEMENT OF X OR Y AXES TOO CLOSE TO SCREEN EDGE

(text: Changing the Graph's Screen Position)

STOP/START POINTS (text: Introduction — this section)

(text: Creating a Histogram Plot Using All Default Values)

WHAT IS A HISTOGRAM ?

A Histogram or Column Frequency Diagram is a bar graph that shows the number of times data values are grouped into arbitrary data ranges. Histograms show the frequency distribution or percentage distribution of data. They are a popular statistical tool with a variety of applications in business, education, and science. One educational application familiar to all of us is when a histogram is used as an analytical tool for grading students.

If a number of students are given a test where the possible score covers a 0 to 100 point range, the number of students achieving a score within the 60 to 70 grade range becomes the frequency of that 10-point data range. The data range — sometimes called a class interval or cell — is an arbitrary boundary. A graphed columnar presentation of student test scores arranged in data-range cells is a histogram. It might look like Figure 6-1.

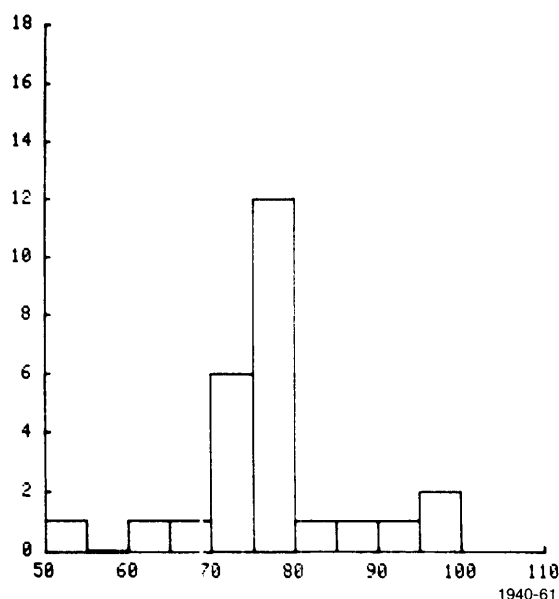


Figure 6-1. A Histogram.

Histograms are constructed by erecting vertical lines at the limits of the class intervals. When you close off the top of the class lines, a rectangle or cell is formed. The area of each rectangle represents that cell's frequency. If all cells are of equal width, the height of a rectangle is proportional to the rectangle's area. When that's true, you can forget about the areas of the rectangles and just use cell height for evaluation.

All that sounds complicated — much more complicated than it really is. All the histograms we create will have equal cell widths; so we evaluate them by their height. We will create a small histogram now, so you can see how everything fits together.

HISTOGRAM PLOT

Let's construct a simple histogram from the following data:

There are six students in a history class. They achieve the following scores in a weekly quiz that has a scoring range of 0 to 100: 62, 71, 74, 78, 83, and 97.

First, we plot the scores on a horizontal baseline called the X axis. For the purpose of this histogram, we could label the line or axis from 0 to 100, but since our data doesn't start until we reach a test score of 62, we begin our axis with a score of 60. We call that starting point the "offset." Although we've arbitrarily put the offset at 60, we could just as easily have established the offset at 50 or even 40.

At five-number intervals along the X axis, we draw a small vertical line through the axis. These small indicators are called "tic marks," and the numbers that identify their values are "axis numbers." From the beginning of the horizontal X axis (the 60 offset point), we draw a vertical line called the Y axis. This axis will be set off with tic marks, too. We label the Y axis tics with Y axis numbers ranging from 0 through 3. Figure 6-2 shows what it looks like so far.

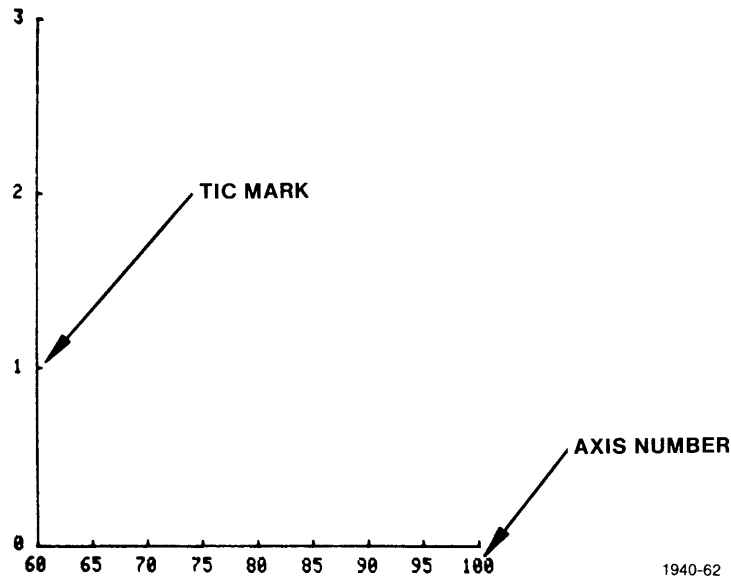


Figure 6-2. Tic Marks and Axis Numbers.

Suppose we group student scores in cells that are five test scores wide. The first cell includes student scores from 60 through 64.99. The height of that cell is plotted against the Y axis. There is one student with a test score that falls within that data range, so the cell would have a height of 1 on the Y axis. The other cells would be formed in the same manner, and the final result would be a histogram that looks like Figure 6-3.

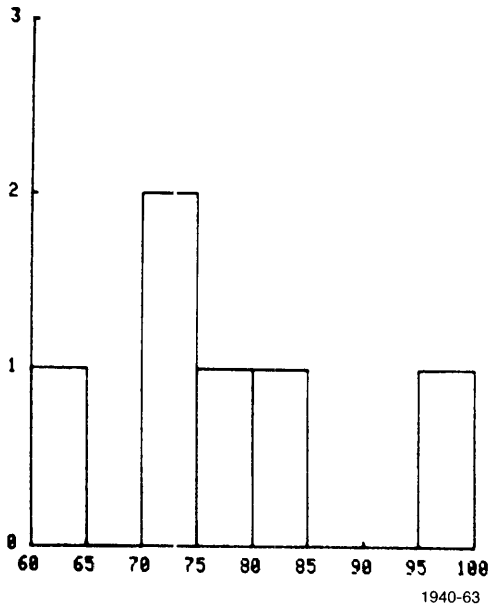


Figure 6-3. Histogram of Test Scores with Cell Width = 5.

If we decide that the data is more meaningful plotted in cell widths that are 10 score points wide, we end up with the histogram configuration shown in Figure 6-4.

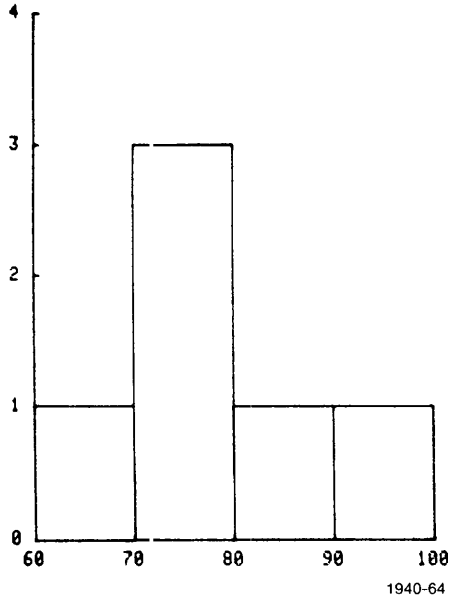


Figure 6-4. Histogram of Test Scores with Cell Width = 10.

HISTOGRAM PLOT

Which one of these two graphs is the right one? They both are. The choice of cell widths is based on the distribution of the data and what divisions of that data (cell widths) are meaningful to you.

As you can see, a histogram is a graph that provides you with additional information about data, and it can help you interpret that data more intelligently.

Creating a histogram on paper is time consuming and requires artistic talent. Creating a histogram on the Graphic System display screen from scratch isn't hard, doesn't take any artistic talent, is relatively fast, and provides great graphing flexibility. But it does require some programming expertise and a Graphic System operating agility that many users don't want to take the time to acquire — at least not at first.

Using BASIC programs already stored on a magnetic tape to create a histogram offers two major advantages:

1. It saves time.
2. It permits the beginning programmer or the casual user to create histograms with a minimum of study.

The PLOT 50 System Software Tape programs the Graphic System to calculate most graph parameters automatically. You are required to input only:

1. The data to be plotted.
2. The offset.
3. The cell width.
4. A choice between a percentage histogram and a frequency distribution histogram.

That's all it takes to create professional quality histograms on the display screen. And it can be done quickly, because the Graphic System automatically determines most graph parameters for you. We call these parameters "default conditions" or "default values."

Although the defaults serve a variety of graphic situations, it is often advantageous to alter or "override" one or more default conditions to put a plot in a more appropriate setting.

Now, it's time for you to create a histogram on the Graphic System display screen. We'll go through the procedure together step-by-step, and we'll let the machine do most of the work. After you've created your histogram using all possible default conditions, we'll examine those conditions and explore why you might want to override some of them from time to time.

First, we want to move the input data around until you feel at ease making data changes. We'll add data to the end of your input, insert numbers in the middle of the data string, and delete numbers. Then, we'll take your graph and, by nullifying default values, change its appearance. All this manipulation will emphasize how versatile the Graphic System software package is and how easy it will be for you to use the Histogram Plot Program to complete your graphing requirements.

During the text demonstrations, you'll be entering data into the Graphic System from the keyboard. At the conclusion of the histogram discussion, we'll explore the procedure used when you wish to store data on magnetic tape for later retrieval.

INITIALIZING THE GRAPHIC SYSTEM

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 6-5). The four green indicator lights on the front panel (Figure 6-5) will turn on, but only the POWER light remains on. It stays on as long as power is applied to the System.

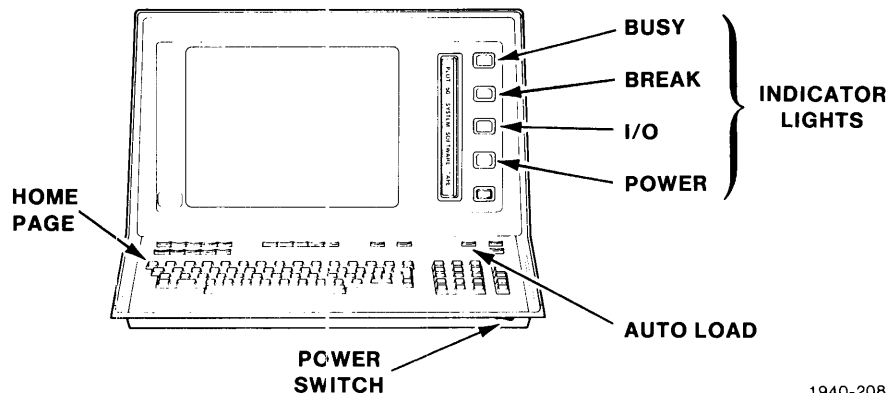


Figure 6-5. Power Switch, Indicator Lights, HOME/PAGE Key, and AUTO LOAD Key.

Press the HOME/PAGE key. The screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen.

INITIALIZING THE PLOT 50 SYSTEM SOFTWARE TAPE

Insert the PLOT 50 System Software Tape. Refer to the PLOT 50 System Software General Information section for specific instructions. Press the AUTO LOAD key (Figure 6-5). This rewinds the magnetic tape, locates the first ASCII program on the tape, loads the program into the Graphic System Random Access Memory (RAM), and begins execution — in this case, by displaying a program directory (menu).

When you press the AUTO LOAD key, the BUSY and I/O (Input/Output) indicator lights (Figure 6-5) turn on. The System makes a series of sounds that normally occur whenever there is tape movement in the System. Figure 6-6 shows the PLOT 50 System Software Master Menu that appears after the tape stops:

```

** PLOT 50: SYSTEM SOFTWARE **

PROGRAM          TITLE
                GRAPHIC SUPPORT PROGRAMS
1                Y Only Data Plot
2                X vs Y Data Plot
3                Function Plot
4                Histogram Plot

5                GRAPHIC SYSTEM TUTORIAL
6                SOFTWARE VERIFICATION PROGRAM
7                FIRMWARE VERIFICATION PROGRAM (4051 only)
8                SPECIAL 4054 FEATURES (4054 only)

ENTER THE PROGRAM NUMBER YOU WANT: 1940-209

```

Figure 6-6. PLOT 50 System Software Master Menu.

CREATING A HISTOGRAM PLOT USING ALL DEFAULT VALUES

The Master Menu is a seven-item program directory. Notice that the Histogram Plot — the program module we’re looking for — is listed as item number 4.

At the bottom of the menu is a single sentence we call an “entry statement.” It is followed by a blinking question mark. When a blinking question mark appears, it means that the Graphic System is waiting for you to make a keyboard entry.

To get to the Histogram Plot Program, press the 4 key on the numeric pad. From now on in this manual, when you are expected to press a number on the keyboard, the expression “Enter” appears, followed by the appropriate number, like this . . .

Enter 4

When you enter 4, it appears on the display screen and is entered into the line buffer, a small temporary memory. Notice that the blinking question mark now appears to the right of the display 4. The System is waiting for you to continue your entry or complete your entry by pressing the RETURN key. When you are expected to press any key other than a number key, the expression will be "Press" followed by the name of the key. You're expected to use the RETURN key now, so we say . . .

Press RETURN

Even though you enter data on the keyboard, the System does not act on your entries until you press the RETURN key. When you pressed the RETURN key just now, the number 4 was sent from the line buffer into the System memory. Now, the line buffer is empty. It will begin filling up as you enter additional data. It will hold 72 characters before it's full and refuses to accept any more. While data is in the line buffer, you can change it over and over again if you like. But once you press the RETURN key, you're committed!

In effect, by pressing the 4 key and the RETURN key, you have just said to the System, "Locate the Histogram Plot Program on the System Software Tape and display the Histogram Plot menu." After the tape-movement noises stop, the Master Menu is erased from the screen, and the Histogram Plot Menu shown in Figure 6-7 appears:

```

                                HISTOGRAM PLOT
1  ENTER DATA
2  DISPLAY HISTOGRAM
3  LIST DATA
4  LIST PARAMETERS
5  SET X SCREEN POSITION
6  SET Y SCREEN POSITION
7  INSERT DATA
8  DELETE DATA
9  CHANGE DATA
10 STORE DATA
11 STOP

ENTER MENU ITEM NUMBER OR M FOR NEW MENU

```

1940-68

Figure 6-7. Histogram Plot Menu.

Notice the wording of the entry statement at the bottom of the menu. It means that once you leave the Histogram Plot and go to any menu selection, whenever you see this entry statement on the display screen, you can return to the Histogram Plot Menu by pressing the M key followed by pressing the RETURN key. It also means that you can bypass the menu and go from one menu selection to another provided you know the appropriate menu selection number to enter. The menu is just a table of contents that's put in the program for your convenience. Use it when you need it; bypass it when you don't.

HISTOGRAM PLOT

Examine the Histogram Plot Menu for the proper selection. We want to enter data, so menu item 1 is our selection.

Enter 1
Press RETURN

A question appears on the screen . . .

DO YOU WANT TO USE THE KEYBOARD (Y or N) ?

You do, so . . .

Press Y
Press RETURN

The screen erases and the following appears:

ENTER M TO DISCONTINUE DATA ENTRY
1 ?

Since almost everyone can relate to a school classroom environment, we will use student test scores for our demonstration data. A community college was the source for the following 26 student scores on a test that had a possible scoring range of 0 through 100 points:

| | | |
|--------|--------|--------|
| 1. 76 | 11. 74 | 21. 79 |
| 2. 96 | 12. 73 | 22. 70 |
| 3. 73 | 13. 62 | 23. 77 |
| 4. 76 | 14. 87 | 24. 92 |
| 5. 98 | 15. 68 | 25. 72 |
| 6. 78 | 16. 77 | 26. 75 |
| 7. 79 | 17. 84 | |
| 8. 51 | 18. 76 | |
| 9. 75 | 19. 75 | |
| 10. 75 | 20. 72 | |

Enter the first test score.

Enter 76
Press RETURN

The System responds to the entry and the screen looks like this:

```
ENTER M TO DISCONTINUE DATA ENTRY
1 ..... 76
2 ..... ?
```

The System is asking for the second data entry.

```
Enter 96
Press RETURN
```

The screen displays your second entry and asks for a third. Continue in the same manner until you have entered the 26 scores. If you should make a mistake but haven't pressed the RETURN key, corrections are easy. The data is still in the line buffer and subject to edit. You can backspace, delete, add, or whatever. If you make a mistake and don't realize it until after you have pressed the RETURN key, remember the mistake and its location, but continue your data entries. After you have completed all data entries and returned to the Histogram Plot Menu, you can select another menu item that will allow you to change data. We'll study that procedure later.

When you have entered all the data, the screen's last two entries will look like this:

```
26 ..... 75
27 ..... ?
```

Whenever you're working with data (entering it, adding to it, changing it, deleting it, or making insertions in it) the Graphic System has no way of knowing how many data items you're working with. It continues asking you for data until you tell it to stop. You do that by entering an M as the next data item. This terminates the data routine and returns the program to the Histogram Plot Menu. It is appropriate to do that now.

```
Press M
Press RETURN
```

The screen reflects the M entry, erases, and displays the Histogram Plot Menu.

This is a STOP/START point.

HISTOGRAM PLOT

We have just passed the first STOP/START point. Let's discuss how you reenter the text and continue with the demonstrations if you terminate your studies at one of these STOP/START locations. We assume your text exit included turning off the Graphic System. Here's how to reenter:

1. Initialize the Graphic System
2. Initialize the PLOT 50 System Software Tape. This displays the PLOT 50 System Software Master Menu.
3. Select menu item 4. This displays the Histogram Plot Menu.
4. Select item 1 and enter the 26 scores.
5. Return to the Histogram Plot Menu.
6. Resume your studies at the appropriate text point.

Now, back to the creation of our graph. Choose menu item 2 — DISPLAY HISTOGRAM.

Enter 2
Press RETURN

The 2 appears on the screen following the entry statement at the bottom of the menu. In addition, the minimum and maximum data ranges are displayed with a request for offset and cell-width inputs as follows:

Screen: DATA MINIMUM 51
 DATA MAXIMUM 98
 ENTER (OFFSET, CELL WIDTH) ?

The System has studied our input data and displays minimum and maximum data values. As you recall from our earlier discussion of a simple six-item histogram, an offset is the minimum value we plot on the X axis. The cell width is the size (data range) of the data categories or cells. Since we have a minimum value of 51, let's make our offset 50, and arbitrarily pick 5 for our cell width. Make the entry this way . . .

Enter 50,5
Press RETURN

An alternate way of making this entry is . . .

Enter 50
Press RETURN
Enter 5
Press RETURN

Although either entry technique will work, we'll utilize the first format throughout this text.

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
 DISTRIBUTION ?

Let's look at the frequency distribution first (Figure 6-8).

ENTER 2
Press RETURN

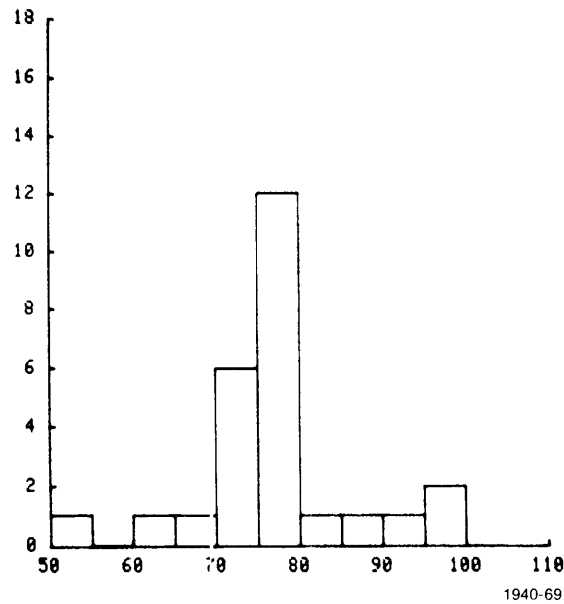


Figure 6-8. Frequency Distribution Histogram.

HISTOGRAM PLOT

Congratulations! That wasn't so hard, was it? Notice that scores are graphed in increments starting from the offset value of 50. This means that the first cell includes all scores from 50 through 54.99. When read against the Y axis index numbers, the height of the cells indicates how many students got a test score in the cell's data range. Would you like to see the same data on a percentage basis?

Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 1
Press RETURN

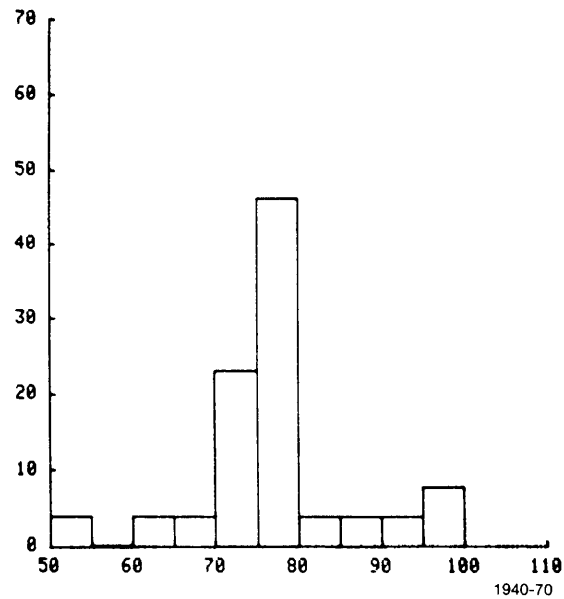


Figure 6-9. Percentage Histogram with Cell Width = 5.

The histogram still has the test scores divided into cell widths of 5; but this time, the height of the cells represents the percentage of the total test scores the cells represent. That lonely cell on the left side that represents the test scores between 50 and 55 has one score in it. If you evaluate the cell's height against the Y axis index numbers, you can see that its height is slightly under 4% (actually 3.846%).

About now you probably want to know when to use the percentage histogram and when to use the frequency distribution histogram. It depends on the type of data you're dealing with; it depends on what you want the histogram to say; it depends on whether the people interpreting the histogram tend to think in numbers or in percentages.

Of course, a percentage histogram can be misleading unless you know how many data samples are involved. You could say, "Twenty-five percent of the class failed the test." This could be a very accurate statement about the test results of a class of 4 people. That statement may have an entirely different impact than, "One person failed the test."

A histogram is a graphing device to help you clarify data. Use the histogram you think is most appropriate for the data and for the circumstances.

To simplify this series of histogram demonstrations, we will focus on a display of frequency distribution histograms. Our selection does not mean to imply that percentage histograms might not be an equally appropriate way of interpreting various test situations. We will ask you — on your own — to replot some test frequency distribution histograms as percentage histograms. That way you can make your own comparisons about the effectiveness of one histogram against the other.

So far, we've been using a cell width of 5 score points. Let's see what the same data looks like in 10-point cells.

Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 10
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN

HISTOGRAM PLOT

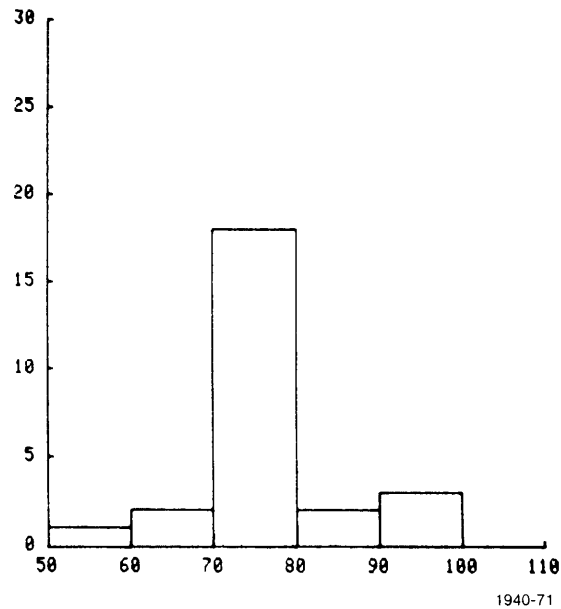


Figure 6-10. Percentage Histogram with Cell Width = 10.

Figure 6-10 looks different, doesn't it? Notice that the wider cells close up the "data gap" that existed in the 5-point cell width. Now, using the same offset of 50, and the same cell width of 10, create a percentage histogram.

After you've made your percentage histogram, let's go back to the Histogram Plot Menu.

Press M
Press RETURN

This is a STOP/START point.

HISTOGRAM PLOT LIMITATIONS

There are two Histogram Plot Program limitations. First, you cannot enter more than 100 data values. When you enter the 100th data item, the screen automatically displays the following:

MAXIMUM NUMBER OF VALUES IS 100
ENTER NEW MENU ITEM NUMBER OR M FOR NEW MENU ?

The second Histogram Plot Program limitation is a more subtle one. You cannot create a histogram with more than 30 cells.¹ It's computed this way:

$\frac{\text{MAXIMUM DATA VALUE minus OFFSET}}{\text{divided by CELL WIDTH}}$ must not equal more than 30

Let's attempt to create a histogram with more than 30 cells.

Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

If we attempt to create a histogram with an offset of 50 (the offset we've been using) and a cell width of 1, would this histogram have more than 30 cells? Let's compute it.

$\frac{\text{MAXIMUM DATE VALUE (98) minus OFFSET (50)}{\text{divided by CELL WIDTH (1)}} \text{ equals } 48$

This histogram would indeed have more than 30 cells, and it cannot be created on the Graphic System. Let's attempt to do it anyway!

Enter 50, 1
Press RETURN

Screen: TOO MANY CELLS CREATED
DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

¹ If your System is a standard 4051 Graphic System (8K RAM) with Option 1 (Data Communications Interface), your histogram cannot have more than 10 cells.

HISTOGRAM PLOT

So you see, you don't really need to use the formula if you don't want to. The Graphic System always tells you if you're trying to make a histogram with too many cells; then it gives you another opportunity to change the graph's configuration.

The formula makes it obvious that the placement of the offset is a critical factor in the design of your histogram. If you place the offset at 0 and try to make a histogram with a cell width of 2, the System will not take it. It is apparent then that the closer the offset is to the minimum data value, the more histogram design freedom you have.

Let's see what our data looks like in cell widths of 7.5. Will that histogram configuration be over our 30 cell limitation? Let's find out (Figure 6-11).

Enter 50, 7.5.
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN

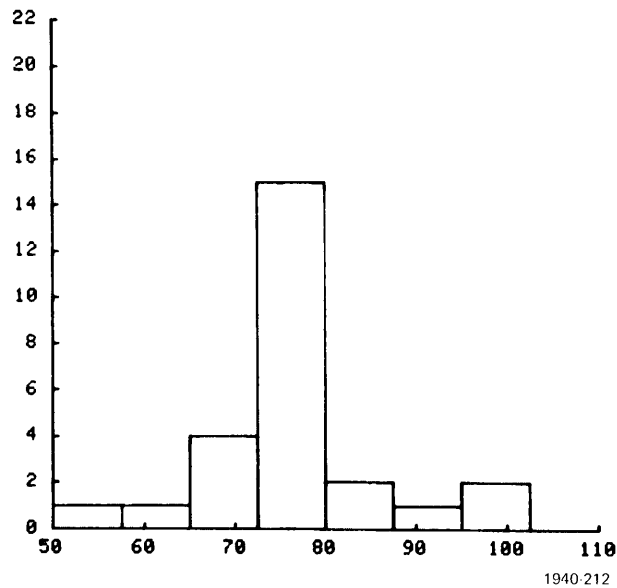


Figure 6-11. Frequency Distribution Histogram with Cell Width = 7.5.

After you've made your own percentage histogram plot of the data, using the same cell width, return to the Histogram Plot Menu.

Press M
Press RETURN

This is a STOP/START point.

CHANGING DATA

Sometimes you may want to change data because you make a mistake entering data values and don't realize it until after you press the RETURN key.

Or maybe you're working on a project where one or two data points change while others remain fixed. Retaining the old data and changing one or two new data values is more expedient than reentering the entire data string.

Or maybe you are forecasting or playing "what if" games with statistics. By changing data, you can project alternatives without having to reenter a complicated total data input.

Now that we've indicated a few possible applications for this feature, let's find out how to use it. Notice that CHANGE DATA is menu item 9, and that LIST DATA is menu item 3. Let's look at the data first and decide what we want to change.

Enter 3
Press RETURN

Data item 10 is 75. Suppose we change that to a score of 33.

Enter 9
Press RETURN

We bypassed the menu because we knew the selection we wanted.

Screen: ENTER ITEM NUMBER TO BE CHANGED?

Enter 10
Press RETURN

HISTOGRAM PLOT

Screen: CURRENT VALUE OF ITEM 10 IS 75
 CHANGE TO ?

Enter 33
Press RETURN

The screen indicates your selection. Then on a separate line it asks:

ENTER ITEM NUMBER TO BE CHANGED?

The Graphic System has to be ready to accept more than one data change. You must enter an M as a data value to stop the change data routine.

Press M
Press RETURN

Let's make a Histogram Plot of the data with the changed value. Because we added a value below the smallest number on our data string, it is necessary to lower the offset value.

Enter 2
Press RETURN

Screen: DATA MINIMUM 33
 DATA MAXIMUM 98
 ENTER (OFFSET, CELL WIDTH) ?

Enter 30, 10
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
 DISTRIBUTION ?

Enter 2
Press RETURN

Figure 6-12 shows the frequency distribution histogram of this changed data. Using the same cell width and offset, make a percentage histogram of the data.

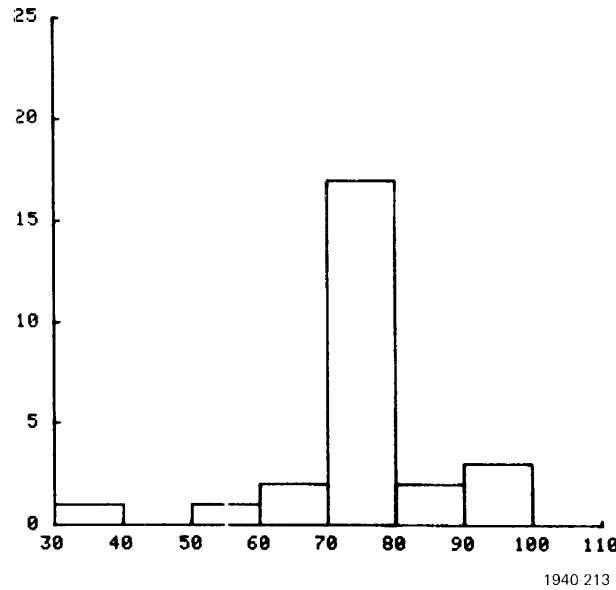


Figure 6-12. Frequency Distribution Histogram with Changed Data.

Now, let's return the original score of 75. We want to use CHANGE DATA, menu item 9.

Enter 9
Press RETURN

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

Enter 10
Press RETURN

Screen: CURRENT VALUE OF ITEM 10 IS 33
CHANGE TO ?

Enter 75
Press RETURN

HISTOGRAM PLOT

Screen: ENTER ITEM NUMBER TO BE CHANGED ?

To stop the change data routine, we must enter M as a data value.

Press M
Press RETURN

The screen displays the Histogram Plot Menu.

This is a STOP/START point.

INSERTING DATA

If the input data in the System's memory is not sorted, additional data may be put in the data string at any location because data positioning is not important. It is usually convenient to put add-on data at the end of the data string. The procedure for doing this is discussed in the Adding Data section.

If you wish to insert data into a sorted data string that is already in the Graphic System memory, the procedure is easy. Assume that between data items 9 and 10 we inadvertently left out a test score of 55. You discover the error and want to insert the data value. First, let's look at the data list.

Enter 3
Press RETURN

Notice that data item numbers 9 and 10 both have a value of 75. We are going to put a value of 55 between those two numbers. That means that the 55 will be listed as data item 10, and all numbers that follow will be redesignated one sequential number higher than they were before. Let's try it out.

Press M
Press RETURN

The Histogram Plot Menu is displayed. Notice that INSERT DATA is menu item 7.

Enter 7
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

Enter 10
Press RETURN

Screen: ENTER NEW VALUE ?

Enter 55
Press RETURN

Screen: ENTER ITEM NUMBER TO BE PRECEDED ?

We terminate the insert data routine by entering an M as a data value.

Press M
Press RETURN

The screen displays the Histogram Plot Menu. Let's verify our insert and see what happened to the rest of the data by examining the data list.

Enter 3
Press RETURN

The screen displays the data list. Notice that the 55 is sandwiched between the two 75 data values. Notice also that data values after 55 on the listing have shifted to a data item position that is one higher than before.

Okay, we have it in there; how are we going to get the 55 out? It's simple, and it takes us to our next topic.

DELETING DATA INSIDE THE DATA STRING

We'll demonstrate the delete procedure by taking the 55 out of the data string. We know that the unwanted number is data item 10. Let's go to the Histogram Plot Menu and find the delete selection.

Press M
Press RETURN

The screen displays the menu. Menu item 8 is DELETE DATA.

Enter 8
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 10
Press RETURN

HISTOGRAM PLOT

Screen: VALUE DELETED 55
ENTER ITEM NUMBER TO BE DELETED ?

Again, the Graphic System must anticipate that more than one value is to be deleted. We must enter an M as a data value to terminate the delete routine.

Press M
Press RETURN

The screen displays the menu. Go to the data list and observe what occurred after a deletion.

Enter 3
Press RETURN

The screen displays the data listing.

When a deletion occurs inside a data string, data values with a higher data index number than the deleted value shift down one lower index number to fill the gap left by the deletion.

Thus far, we've been discussing deletions from the middle of the data string. We'll defer studying the procedure for deleting data from the end of the data string for a few moments while we discuss how to add data to the end of a data string. After we cover that topic, a demonstration of how to delete data from the end of a data string will be a natural follow-up.

ADDING DATA

You can add to data you've already entered into the System memory at any time. The Graphic System accommodates you by displaying the next available data item number.

For the purposes of this demonstration, we'll assume that our test has a possible high score of 160, and that we have just received the scores of the four top students. The scores are: 115, 137, 143, and 149. We want to add these results to our other data.

Press M
Press RETURN

The screen displays the Histogram Plot Menu. Notice that there is no ADD DATA selection. You add data by using ENTER DATA, menu item 1.

Enter 1
Press RETURN

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y or N) ?

Press Y
Press RETURN

Screen: ENTER M TO DISCONTINUE DATA ENTRY
27 ?

Enter 115
Press RETURN

Screen: 27 115
28 ?

Unless your System is a standard 4051 Graphic System (8K RAM) with Option 1 (Data Communications Interface), enter the last three scores yourself, using the same procedure. If you have a standard 4051 with Option 1, continue without entering the additional three scores.

Now, we'll discontinue data entries by entering an M as a data value; we'll verify the addition of the data by looking at the data list; and finally, we'll construct a histogram for the total data.

Press M
Press RETURN

The screen displays the menu.

Enter 3
Press RETURN

The screen displays the data list. Observe the additional values.

Enter 2
Press RETURN

If nothing happens when you press the RETURN key, you may have a "page full" condition. When this occurs the System remembers what you enter, but it is not displayed because there is no room on the screen. If the screen is full, there will be a blinking F in the upper left-hand corner of the display screen. If that's true, press the PAGE key and continue.

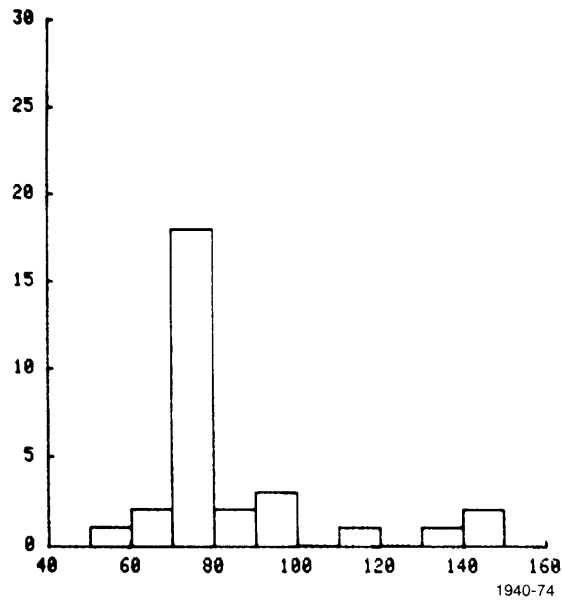
Screen: DATA MINIMUM 51
DATA MAXIMUM 149
ENTER (OFFSET, CELL WIDTH) ?

HISTOGRAM PLOT

Enter 50, 10
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE, (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN



A frequency distribution histogram of your data appears on the screen. Now, why don't you create a percentage histogram of the data by yourself using the same offset and cell width?

Let's return to the menu.

Press M
Press RETURN

The screen displays the Histogram Plot Menu.

This is a STOP/START point.

DELETING DATA AT THE END OF A DATA STRING

Since we want to return to our original data, we will delete the data we just put on the end of our data string.

Delete the lowest unwanted data item number as many times as there are numbers to be deleted. In this instance, 27 is the lowest data item number to be deleted. To eliminate 27, 28, 29, and 30, delete 27 four times. When deleting unwanted data values from the low end of the data string, delete item number 1 as many times as you have unwanted values.

There are other deletion methods, but they are more complicated and a little bit tricky, too. Let's settle for the foolproof method described above and eliminate our four items of unwanted data.

Enter 8
Press RETURN

Screen: ENTER ITEM NUMBER TO BE DELETED ?

Enter 27
Press RETURN

Screen: VALUE DELETED 115
ENTER ITEM NUMBER TO BE DELETED ?

Enter 27
Press RETURN

Screen: VALUE DELETED 137
ENTER ITEM NUMBER TO BE DELETED ?

Enter 27
Press RETURN

Screen: VALUE DELETED 143
ENTER ITEM NUMBER TO BE DELETED ?

Enter 27
Press RETURN

Screen: VALUE DELETED 149
ENTER ITEM NUMBER TO BE DELETED ?

HISTOGRAM PLOT

It is necessary to enter an M at this time to terminate the delete data routine.

Press M
Press RETURN

The screen displays the Histogram Plot Menu.

Now, on your own, make a frequency distribution histogram using an offset of 50 and a cell width of 5. Return to the Histogram Plot Menu.

This is a STOP/START point.

LISTING PARAMETERS

We divide the Graphic System display screen into 100 vertical and 130 horizontal units called Graphic Display Units (GDUs). We'll be working with these units when we relocate the graph on the display screen.

When you select menu item 4 — LIST PARAMETERS — you have picked out a valuable reference chart that will assist you in many plotting situations. Let's take a few moments to describe the parameter listings as they appear on the screen (Figure 6-13).

```

                                PARAMETER LIST
NUMBER OF POINTS                26
                                ----X----
SCREEN MINIMUM                   30          10
SCREEN RANGE                      80          80
DATA MINIMUM                      40           0
DATA RANGE                       120         30
                                ----Y-----

ENTER MENU ITEM NUMBER OR M FOR NEW MENU
```

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Figure 6-13. Parameter List Headings.

Here is an explanation of the Parameter List headings:

NUMBER OF
POINTS: This refers to the number of data items you enter.

SCREEN

MINIMUM: This indicates the Graphic Display Unit where the X axis begins. When the X axis screen minimum is in a default condition, the X axis begins 30 GDUs horizontally from the left side of the screen. In a default condition, the Y axis begins 10 GDUs vertically from the bottom of the screen. These default conditions provide a screen graphing location suitable for most situations.

SCREEN

RANGE: These entries indicate the length of the X and Y axes in GDUs. If you add this value to the screen minimum, you obtain the end of the axis line expressed in GDUs.

DATA

MINIMUM: On the X axis, the data minimum is the location of the offset. On the Y axis, the data minimum is established by the Graphic System; it is normally zero.

DATA

RANGE: This is the total data value of the axis. If you add this figure to the data minimum, the result is the maximum data value.

We'll reinforce these definitions with specific examples in the next few paragraphs. So don't feel uneasy if they are not yet clear to you.

CHANGING THE GRAPH'S SCREEN LOCATION

Shortening and lengthening the X and Y axes changes the impact of your histogram. If we stretch the X axis and compress the Y axis, we tend to "flatten out" the graph and de-emphasize differences in the data. Conversely, if we lengthen the Y axis and shorten the X axis, we make minor differences in the data appear more pronounced.

Because of their bar-graph configuration, histograms do not lend themselves to this type of dramatization as much as Y Only Data Plots do, for example, but it can be done. In conjunction with this demonstration of axes compression and expansion, we'll move the histogram to different screen sectors. We will show extreme configuration changes for emphasis.

The Histogram Plot Program's X and Y axes default screen locations will probably fulfill 95% of your histogram graphing requirements. These histogram screen placement techniques give you the added operational versatility needed to cope with the other 5%.

HISTOGRAM PLOT

Before we begin moving the graph around, let's establish where it is now. Looking at the Screen Minimum on the Parameter List, we see that the X axis begins at 30 GDUs. The X axis screen range is 80; that is, it is 80 GDUs long. Add the 30 and the 80 and you have 110 GDUs. This is the screen maximum — the GDU point where the X axis ends. The data minimum is 50, where we arbitrarily put the offset. The Data Range is 60. If we add the 60 to our data minimum, we get a data Maximum of 110, which is the highest index number on the X axis.

Notice that the Y axis screen minimum is 10 and the Y axis screen range is 80. When added together they equal 90, which is the termination point of the axis in GDUs. The Y Data Minimum is 0 and Y Data Range is 18. Both of those values were chosen by the System in response to your data input.

Now, we know where we are! Let's move the histogram to the right side of the screen, and at the same time, let's compress the X axis. Figure 6-14 shows how this graphs the data.

Press M
Press RETURN

This is a STOP/START point.

Notice that menu item 5 sets the X screen position, and that menu item 6 performs a similar function for the Y axis. We will make our X axis 30 GDUs long and position it from the 90 to the 120 GDU screen unit.

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 90
Press RETURN

Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

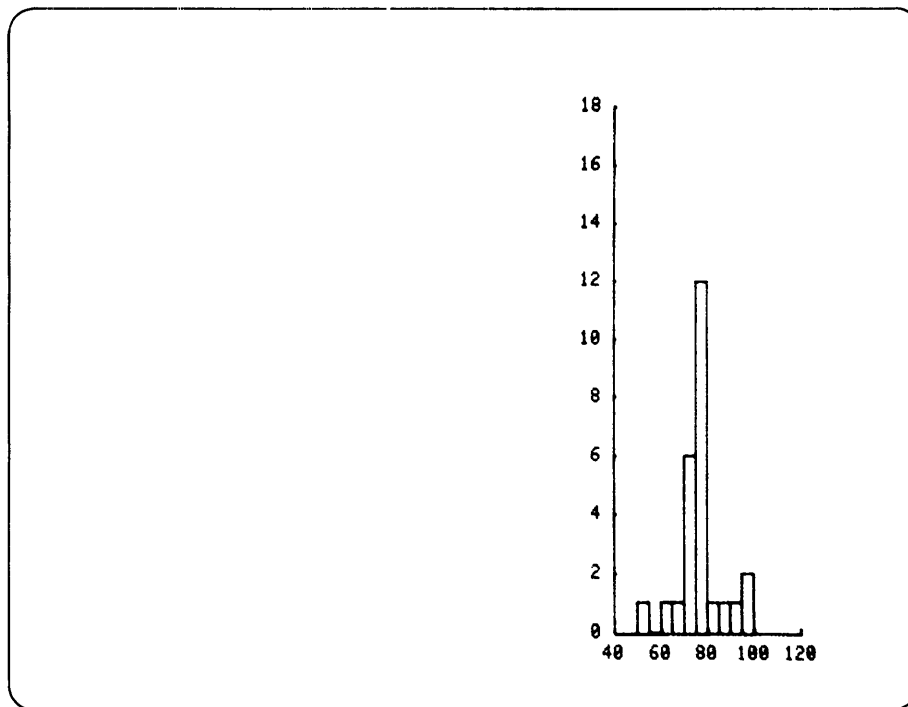
Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RET JRN



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Figure 6-14. Histogram with Compressed X Axis Shifted Right.

HISTOGRAM PLOT

To put the histogram in the upper-right corner (Figure 6-15), reduce the Y axis to a 30 GDU line; that is, have it begin at 65 and end at 95 GDUs. Remember, the menu selection for Y axis screen positioning is 6.

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 65
Press RETURN

Screen: MAXIMUM ?

Enter 95
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

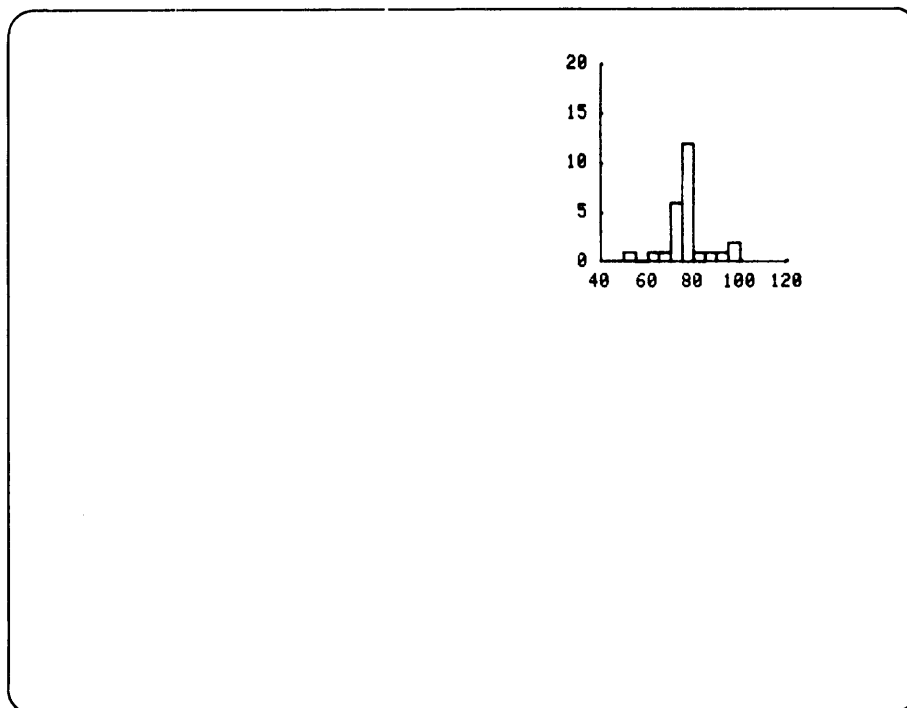
Enter 2
Press RETURN

Now, we'll go to the left side of the screen, and return to a normal Y axis.

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN



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Figure 6-15. Histogram with Compressed X and Y Axes.

Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

HISTOGRAM PLOT

Enter 30
Press RETURN

We have both axes changed to our new location and configuration. Let's graph it.

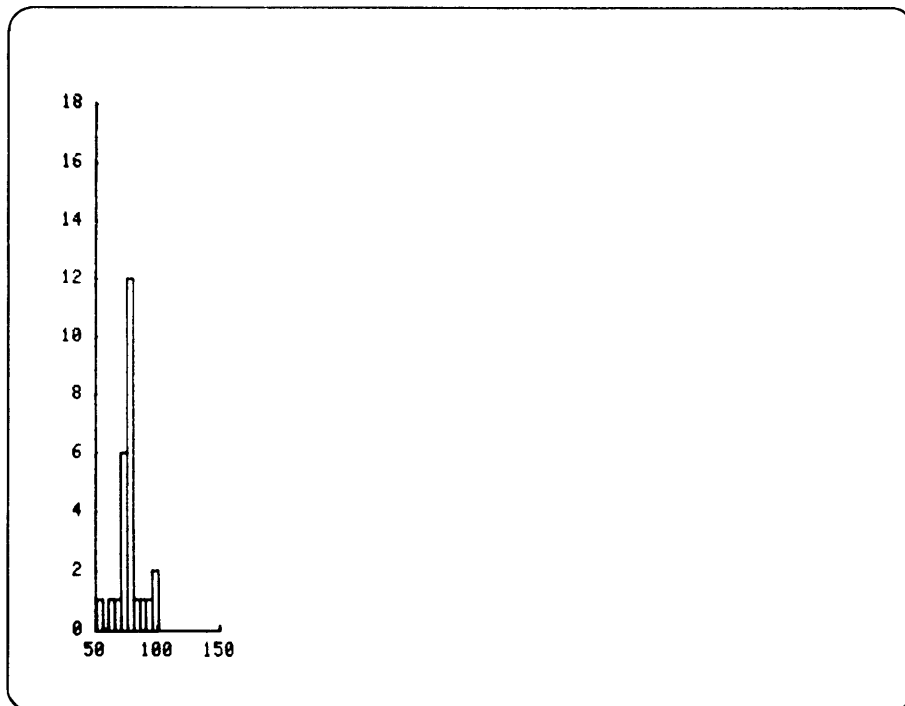
Enter 2
Press RETURN

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN



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Now let's go to menu item 4 and look at the parameter listing. Compare the listing to the graph and see how the numbers verify graph parameters.

We'll do one last manipulation of histogram size and screen location. This time we'll expand the X axis across the screen while compressing the Y axis. This tends to de-emphasize data differences. We'll run the X axis from 10 to 120 GDUs, and we'll compress the Y axis into a 20 GDU data range established by going to a 10 to 30 Y axis screen location.

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 120
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 30
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

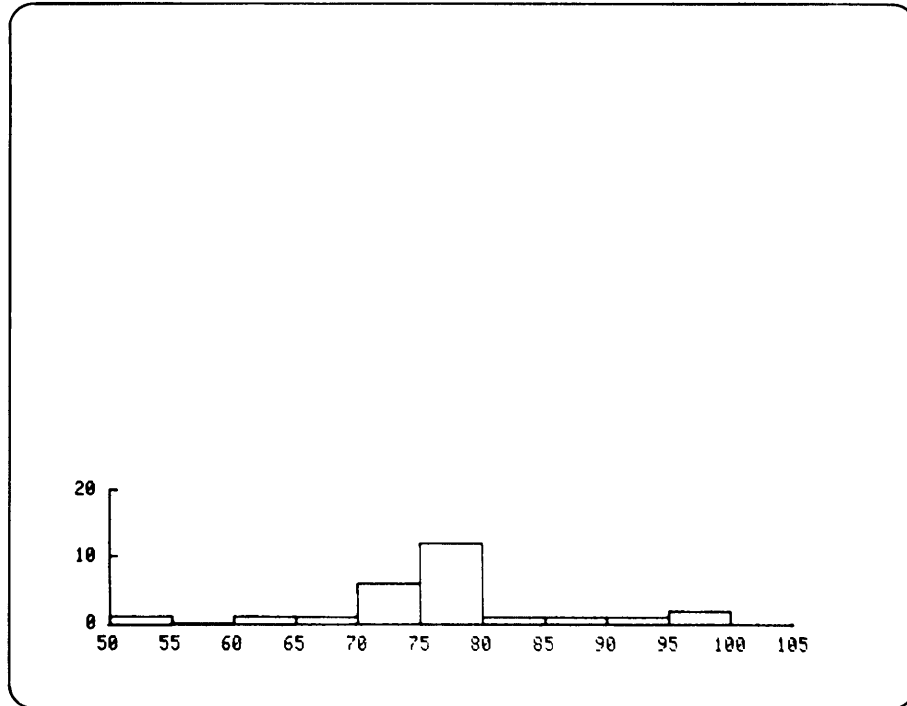
HISTOGRAM PLOT

Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAPH (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN



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Figure 6-16. Histogram with Expanded X Axis and Compressed Y Axis.

Figure 6-16 shows an exaggerated example, to be sure, but some in-between parameters may fit a requirement of yours someday.

Let's return to our standard graph. Our preset parameters are: Y axis 10 to 90 GDUs, and X axis 30 to 110 GDUs.

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Enter 10
Press RETURN

Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 30
Press RETURN

Screen: MAXIMUM ?

Enter 110
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 2
Press RETURN

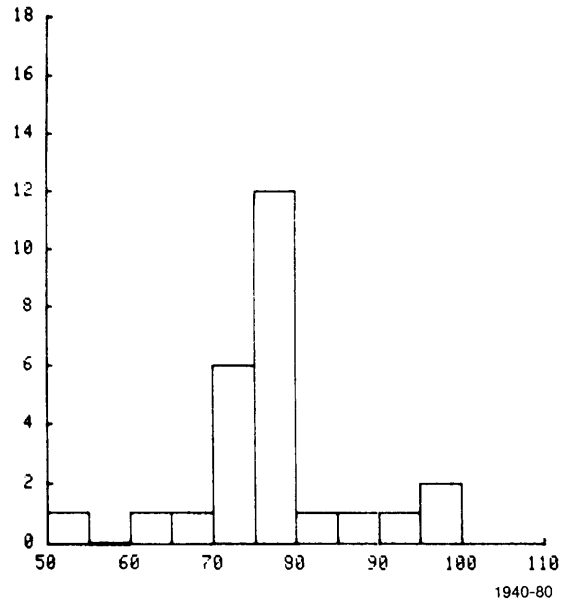
Screen: DATA MINIMUM 51
DATA MAXIMUM 98
ENTER (OFFSET, CELL WIDTH) ?

Enter 50, 5
Press RETURN

Screen: SELECT TYPE OF HISTOGRAM (1) PERCENTAGE (2) FREQUENCY
DISTRIBUTION ?

Enter 2
Press RETURN

HISTOGRAM PLOT



Here we are, back to our standard graph. Now, go to the LIST PARAMETERS selection on the menu — item 4 — and observe that our numbers have returned to where they were before we started moving things around.

Enter 4
Press RETURN

The screen displays the Parameter List.

If you extend the X axis too close to the left or right screen border, or if you move the Y axis too close to the bottom or top of the display screen, you can get some graph aberrations. Your graphed data may be “chopped off” or the axis index numbers may be misplaced. Remember to allow sufficient room both horizontally and vertically for the display of the axes index numbers, and you won’t have these problems. Let’s go back to the Histogram Plot Menu.

Press M
Press RETURN

This is a STOP/START POINT.

STOP

The Histogram Plot Menu item 11 — STOP — terminates the program and returns you to the PLOT 50 System Software Master Menu. STOP is executed from the Histogram Plot Menu. STOP resets all default conditions, and X and Y input data is lost.

You have completed the Histogram Plot instruction except for information and step-by-step instructions on how to store and retrieve data from an auxiliary magnetic tape. Go to the next paragraph and begin that instruction now, or implement the STOP menu selection that follows and leave the program.

Enter 11
Press RETURN

STORING DATA ON A MAGNETIC TAPE

Using a magnetic tape to store PLOT 50 System Software program data is a time saver in some situations. It is advantageous to record data on an auxiliary magnetic tape when you have a sizable block of data that you intend to add to later, or when you have data that you plan to use as a base for "what if" projections. When you need the original data again, insert the data tape into the Graphic System and effortlessly place recorded data into System memory.

The next several paragraphs give a description of how to use a data tape with the program. The procedure begins from a Graphic System initialized condition (System operational, but PLOT 50 System Software not loaded). Do not attempt to duplicate this step-by-step procedure until you have a data tape available.

1. Before you insert the PLOT 50 System Software Tape into the System, select an auxiliary data tape that has sufficient room for your data. Ensure that the "write protector" arrow on the cartridge is turned opposite the SAFE mark (180° from SAFE). Insert the data tape into the System's magnetic tape slot. If it's an old tape, make a TLIST of the tape's contents (described in the PLOT 50 System Software General Information section), and locate the next available file. If it's a new tape, press the REWIND key to position the tape at its beginning. Find and mark a file (discussed in the PLOT 50 System Software General Information section), providing sufficient tape space to accommodate the data you intend to record.
2. Remove the data tape from the tape slot and set the tape aside.

HISTOGRAM PLOT

3. Insert the PLOT 50 System Software Tape into the tape slot and progress to the Histogram Plot Menu.
4. Select menu item number 1, and enter your data from the keyboard.
5. Return to the Histogram Plot Menu.

We continue with a step-by-step procedure . . .

Enter 10
Press RETURN

Screen: INSERT DATA TAPE AND ENTER FILE NUMBER ?

Press the EJECT button and remove the PLOT 50 System Software Tape from the System. Insert the appropriate data tape into the tape slot.

Enter (your marked file number)
Press RETURN

Screen: DATA STORED
 INSERT SYSTEM TAPE AND PRESS RETURN ?

Press the EJECT button and take the tape out of the tape slot. You now have the data stored on your selected file. Put the PLOT 50 System Software Tape back into the tape slot.

Press RETURN

Continue with your graphing activities. At a later time, when you wish to use the recorded data, start from the Histogram Plot Menu and do the following:

Enter 1
Press RETURN

If you have already entered data into the memory, the System will ask:

Screen: DO YOU WISH TO ADD TO PREVIOUS DATA (Y or N) ?

Press N
Press RETURN

Now, the routine is the same for everyone.

Screen: DO YOU WISH TO USE THE KEYBOARD (Y or N) ?

Press N
Press RETURN

Screen: TAPE PROCESSING (Y or N) ?

Press Y
Press RETURN

Screen: INSERT DATA TAPE AND ENTER TAPE FILE ?

Press the EJECT button, take the PLOT 50 System Software tape out of the System, and insert the data tape into the tape slot.

Enter (your file number)
Press RETURN

The System finds the file and loads the data into the System memory.

Screen: INSERT SYSTEM TAPE AND RETURN ?

Push the EJECT button, remove the data tape, and insert the PLOT 50 System Software Tape into the System.

Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Verify the data entries by referring to the data list.

Enter 3
Press RETURN

That completes the procedure. Continue your graphing activities.

Section 7

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Section 7

FUNCTION PLOT

INTRODUCTION

If you're an experienced programmer well versed in display graphics techniques, you have several options after reading this Introduction: read the Operation Summary, scan the text following the Operation Summary, or combine the two.

If you know Function Plots and their applications, but have little background in display graphics, read this Introduction, skip the Operation Summary for now, and begin studying the text that starts with "The PLOT 50 System Software Tape." Later you may want to use the Operation Summary as a reference.

When you graph mathematical functions, you create a Function Plot. In this section, we'll focus on how to display data points from both single-variable and double-variable mathematical functions quickly and easily by using the PLOT 50 System Software.

We have labeled several locations in the text as STOP/START points. These STOP/START points are convenient places for you to stop studying and turn off the Graphic System, aware that you can reenter the text at that location with the proper settings on the Graphic System for future demonstrations. You will receive instructions on how to use this study convenience when you reach the first STOP/START point.

OPERATION SUMMARY

To initialize the Graphic System: (text: Initializing the Graphic System)

1. Refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.
2. Connect the power cord to the Graphic System and then to your power source.
3. Turn ON the power switch located beneath the right-front corner of the unit.

FUNCTION PLOT

To begin the PLOT 50 System Software Programs: (text: Initializing the Plot 50 System Software Tape)

1. Insert the PLOT 50 System Software Tape.
2. Press the AUTO LOAD key.
3. The screen displays the PLOT 50 System Software Master Menu.

To initialize the Function Plot Program: (text: Graphing the First Single-Variable Function)

1. Select item 3 on the Master Menu.
2. The screen displays the Function Plot subroutine instructions.

The Function Plot Menu is used as a reference for this Operation Summary. Menu selections are listed following their menu item number. Text references are provided to guide you to a detailed explanation.

1. **DISPLAY FUNCTION.** (text: Graphing the First Single-Variable Function)

This menu selection graphs the function. If you have not yet established the parameters in menu selection 3, SET PARAMETERS, you will be questioned about them here.

2. **LIST PARAMETERS.** (text: Listing Parameters)

This menu selection presents a columnar list of graph values. They are . . .

LINE CODE: displays the selected Plot Mode.

SYMBOL
CODE: gives the symbol selection.

BEGINNING
VARIABLE: beginning of plot.

VARIABLE
INCREMENT: number of plot points.

ENDING
VARIABLE: end of plot.

SCREEN
 MINIMUM: displays X and Y axes screen starting points in Graphic Display Units (GDUs).

SCREEN
 RANGE: displays X and Y axes GDU lengths.

DATA
 MINIMUM: shows X and Y axes minimum range values.

DATA
 RANGE: displays X and Y axes total range units.

3. SET PARAMETERS (text: Graphing the First Single-Variable Function)

This menu item queries you on three parameters that must be established before a graph can be created: the beginning variable, the ending variable, and the increment. These represent the first plot point, the last plot point, and the distance between plot points. If this menu item is not selected before menu item 1, DISPLAY FUNCTION is chosen, the appropriate queries are made automatically.

4. SET AUTOSCALE. (text: Autoscaling)

This menu item selects appropriate X and Y range values based on the function. When the SET AUTOSCALE menu item is selected, it returns your arbitrary axis range selections to values that coincide with original default conditions, providing a DISPLAY FUNCTION menu selection follows the SET AUTOSCALE menu entry.

5. SET X SCREEN POSITION. (text: Changing the Shape of the Graph)

This menu item sets the X axis horizontal length and position in GDUs on the 130 GDU horizontal screen surface. The default condition begins the axis at 30 GDUs and ends it at 110 GDUs; this establishes an axis that is 80 GDUs long.

6. SET Y SCREEN POSITION. (text: Changing the Shape of the Graph)

This menu selection sets the Y axis vertical length and position in GDUs on the 100 GDU vertical display screen surface. The default condition begins the axis at 10 GDUs and terminates it at 90 GDUs. This creates a Y axis that is 80 GDUs high.

FUNCTION PLOT

7. **SET X DATA RANGE.** (text: Changing the Graph's Range Values)

This menu item establishes minimum and maximum X axis range values. The default condition is a result of autoscaling.

8. **SET Y DATA RANGE.** (text: Changing the Graph's Range Values)

This menu item establishes minimum and maximum Y axis range values. The default condition is a result of autoscaling.

9. **SELECT PLOT MODE** (text: Selecting Plot Modes)

Two modes are available from this menu selection: the default line plot, and the optional point plot.

10. **SELECT SYMBOL.** (text: Selecting Plot Symbols)

Here, you are offered a choice of five plot symbols: point, triangle, plus sign, square, and diamond. The point symbol is the default condition.

11. **STOP.** (text: Stop)

This selection takes you back to the PLOT 50 System Software Master Menu. The function is deleted from the subroutine and all default conditions are established when STOP is selected.

In addition to the menu items, the following topics in the text are brought to your attention.

CORRECTING ERRORS. (text: Graphing the First Single-Variable Function)
(text: PLOT 50 System Software General Information)

GRAPHIC DISPLAY UNITS. (text: Graphic Display Units)

PLACEMENT OF AXIS TOO CLOSE TO SCREEN BORDER.
(text: Changing the Shape of the Graph)

START/STOP POINTS. (text: Introduction — this section)
(text: Graphing the First Single-Variable Function)

SUBROUTINE FOR SINGLE-VARIABLE FUNCTION.
(text: Graphing the First Single- Variable Function)

Use the following: 100 (function entry)
110 RETURN
RUN

SUBROUTINE FOR DOUBLE-VARIABLE FUNCTION.

(text: Graphing the First Double- Variable Function)

Use the following: 100 (function entry)
 110 (function entry)
 120 RETURN
 RUN

TEXT SUMMARY. (text: Operation Summary)**THE PLOT 50 SYSTEM SOFTWARE TAPE**

Creating a Function Plot on the Graphic System from scratch isn't hard, but it does require some programming expertise and a Graphic System operating agility that many users don't want to take the time to acquire — at least not at first.

Using BASIC programs already stored on magnetic tape to create function plots offers two major advantages:

1. It saves time.
2. It permits the beginning programmer or the casual user to create graphs with a minimum of study.

The PLOT 50 System Software Tape programs the Graphic System to calculate most graph parameters automatically. The parameters the System establishes for you are called "default values." These System settings are made unless you specify otherwise. Although default values serve a variety of graphic situations, it may be advantageous sometimes to alter or "override" one or more of the default parameters to put a plot in a more appropriate setting. This can be done quickly and easily. By overriding default conditions, you can . . .

1. Move the X axis horizontally on the Graphic System display screen and make the axis length shorter or longer.
2. Move the Y axis vertically on the display screen and make the axis length shorter or longer.
3. Change the X axis data range.
4. Change the Y axis data range.
5. Choose either a line or a point plot.
6. Choose from five plot symbols.

We'll explain these alternatives in detail later in this section.

FUNCTION PLOT TEXT SUMMARY

Now, let's start creating Function Plots on your Graphic System display screen. We'll go through the procedure together step-by-step, and we'll let the System do most of the work. After you've created Function Plots using default values, we'll examine default parameters and explore why you might want to override some of them from time to time. We'll take a plot, and by overriding default values, change its appearance, and move it to different screen locations. This manipulation emphasizes the versatility of the Graphic System software package and shows you how easy it is to use the program to complete a variety of graphing requirements.

During these demonstrations, we'll plot three single-variable functions and graph the functions of two double-variable functions.

INITIALIZING THE GRAPHIC SYSTEM

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 7-1). The four green indicator lights on the front panel (Figure 7-1) will turn on, but only the power light remains on. It stays on as long as power is applied to the System.

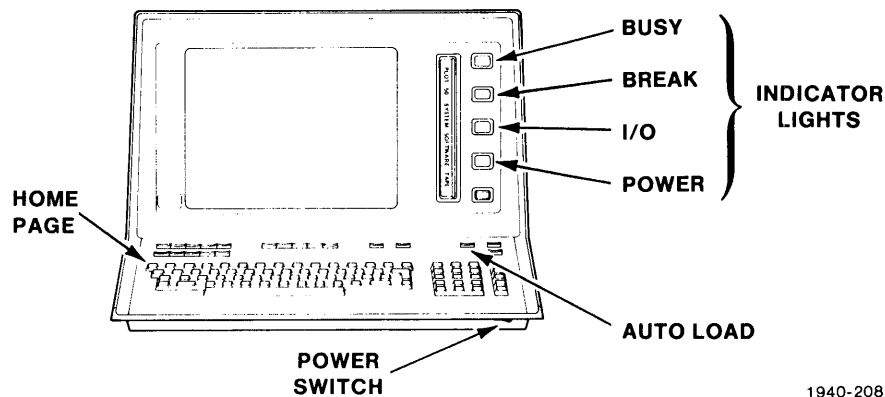


Figure 7-1. Power Switch, Indicator Lights, HOME/PAGE Key, and AUTO LOAD Key.

Press the HOME/PAGE key. The screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen.

INITIALIZING THE PLOT 50 SYSTEM SOFTWARE TAPE

Insert the PLOT 50 System Software Tape. Refer to the PLOT 50 System Software section for specific instructions. Press the AUTO LOAD key (Figure 7-1). This rewinds the magnetic tape, locates the first ASCII program on the tape, loads the program into the Graphic System memory, and begins execution — in this case, by displaying a program directory (menu).

When you press the AUTO LOAD key, the BUSY and I/O (Input/Output) indicator lights (Figure 7-1) turn on. The System makes a series of sounds that normally occur whenever there is tape movement in the System. Figure 7-2 shows the PLOT 50 System Software Master Menu that appears after the tape stops.

```

** PLOT 50: SYSTEM SOFTWARE **

PROGRAM      TITLE
            GRAPHIC SUPPORT PROGRAMS
1           Y Only Data Plot
2           X vs Y Data Plot
3           Function Plot
4           Histogram Plot

5           GRAPHIC SYSTEM TUTORIAL
6           SOFTWARE VERIFICATION PROGRAM
7           FIRMWARE VERIFICATION PROGRAM (4051 only)
8           SPECIAL 4054 FEATURES (4054 only)

ENTER THE PROGRAM NUMBER YOU WANT: 1940-209

```

Figure 7-2. PLOT 50 System Software Master Menu.

GRAPHING THE FIRST SINGLE VARIABLE FUNCTION

The Master Menu is a list of the programs stored on the PLOT 50 System Software Tape. Notice that the Function Plot Program -- the program we're looking for -- is listed as item 3.

At the bottom of the menu is a single sentence we call an "entry statement." It is followed by a blinking question mark. When a blinking question mark appears, it means that the Graphic System is waiting for you to make a keyboard entry.

To get to the Function Plot Program, make your selection by pressing the 3 key on the numeric pad. Throughout this manual, when you are expected to press a number key on the keyboard, the expression "Enter" will be printed, followed by an appropriate number or numbers and their separators. The direction will appear like this:

Enter 3

FUNCTION PLOT

Go ahead and press the 3 key. The 3 appears on the screen and is entered into the line buffer, a small temporary memory used for editing.

Notice that the blinking question mark now appears to the right of the displayed 3. The System is waiting for you to continue your entry, or complete your entry by pressing the RETURN key. Whenever you are expected to press any single key other than a number key, the expression will be "Press" followed by the name of the key. You're expected to press the RETURN key now, so we say . . .

Press RETURN

You can type data repeatedly on the keyboard, but until you press the RETURN key, the System does not act on your entry. When the RETURN key is pressed, the number 3 is sent from the line buffer to the Random Access Memory (RAM).

Now the line buffer is empty again; it begins filling up as you press additional keys. It will hold 72 characters before it fills up. While data is in the line buffer, you can change it over and over again if you like. That's what it's there for — to give you an editing capability. But once you press that RETURN key, you're committed.

In effect, by pressing the 3 key and the RETURN key, you have just said to the System, "Locate the Function Plot Program on the System Software Tape and display the Function Plot Menu." After the tape-movement noises stop, the Master Menu is erased from the screen, and the Function Plot subroutine instructions shown in Figure 7-3 appear:

```
TO ENTER FUNCTION:
BEGIN AT LINE 100 INCREMENTING BY 10
FOR SINGLE VARIABLE USE Y=FUNCTION(X)
FOR DOUBLE VARIABLE USE X=FUNCTION(T1)
                        Y=FUNCTION(T1)
FOLLOW THE FUNCTION WITH RETURN
THEN TYPE RUN
```

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Figure 7-3. Function Subroutine Instructions.

When you are expected to enter a combination of numbers, letters, and symbols into the memory, these items will be preceded by the word "Type." An instruction of this kind might look like this (just look at it; don't enter it!):

Type $Y = \text{SIN}(X)/X$

To create a Function Plot on the Graphic System display screen using defaults, it is necessary to enter four items into System memory:

1. The function entered in subroutine format.
2. The beginning independent variable.
3. The ending independent variable.
4. The increment.

Let's use the function $Y = \text{SIN}(X)/X$ MIN .5 for our first demonstration. The subroutine instructions tell us to type the number 100 on the keyboard and then type in the function. Press the RETURN key. On the second subroutine line, type 110, type the word RETURN, and press the RETURN key again. On the third line, type RUN; press the RETURN key. To ask you to enter the same data, we would format our directions this way.

```
Type 100 Y:=SIN(X)/X MIN .5
Press RETURN
Type 110 RETURN
Press RETURN
```

Now, enter the subroutine by following those directions. When you're through, the display screen will look like Figure 7-4.

```
TO ENTER FUNCTION:
BEGIN AT LINE 100 INCREMENTING BY 10
FOR SINGLE VARIABLE USE Y=FUNCTION(X)
FOR DOUBLE VARIABLE USE X=FUNCTION(T1)
                                Y=FUNCTION(T1)
FOLLOW THE FUNCTION WITH RETURN
THEN TYPE RUN
100 Y=SIN(X)/X MIN .5
110 RETURN
```

1940-83

Figure 7-4. Entering a Function Subroutine.

If you make a mistake before pressing the RETURN key at the conclusion of a program line entry, corrections are easy. The data is still in the line buffer and subject to edit. You can backspace, delete, add, or whatever. If you make a mistake and don't see it until after you have pressed the RETURN key, simply rewrite the program line. The new entry will nullify the old one.

```
Type RUN
Press RETURN
```

FUNCTION PLOT

The screen erases and displays the Function Plot Menu shown in Figure 7-5.

```
                FUNCTION PLOT
1  DISPLAY FUNCTION
2  LIST PARAMETERS
3  SET PARAMETERS
4  SET AUTOSCALE
5  SET X SCREEN POSITION
6  SET Y SCREEN POSITION
7  SET X DATA RANGE
8  SET Y DATA RANGE
9  SELECT PLOT MODE
10 SELECT SYMBOL
11 STOP

ENTER MENU ITEM NUMBER OR M FOR NEW MENU
1940-84
```

Figure 7-5. Function Plot Menu.

Notice the wording of the entry statement at the bottom of the menu. Once you leave the Function Plot Menu and go to any menu selection, when this entry statement appears on the display screen, you can return to the Function Plot Menu by pressing the M key, then pressing the RETURN key. You can also bypass the menu and go from one menu selection to another provided you know the appropriate menu selection to enter. The menu is a table of contents for your convenience. Use it when you need it; bypass it when you don't need it.

Examine the Function Plot Menu and notice the selections that are available. In the next few pages, we'll discuss all the selections and how they apply to function plotting. Right now, let's select menu item 1, DISPLAY FUNCTION.

```
Enter 1
Press RETURN
```

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

The System is asking you to enter the X axis beginning range value. Let's use -20.

```
Enter -20
Press RETURN
```

Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Now, you are asked to enter the X axis ending range value. We'll use +20.

Enter 20
Press RETURN

Screen: ENTER INCREMENT ?

The System is asking for the last entry needed to plot the function. The increment is the distance between plot points. Let's make a "rough" plot by using an increment of 1.

Enter 1
Press RETURN

The screen displays the function shown in Figure 7-6.

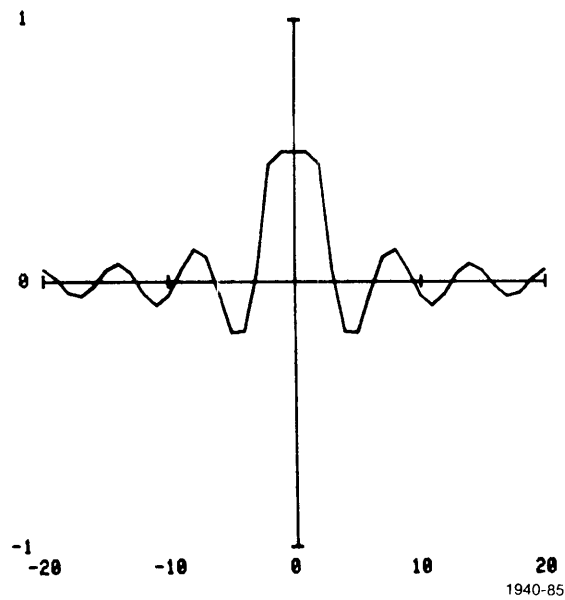


Figure 7-6. Function Plot with Increment of 1.

Notice that the X axis range duplicates your recent independent variable entries. Notice also that an increment of 1 gives you a "rough" plot. Let's go back to the Function Plot Menu.

Press M
Press RETURN

FUNCTION PLOT

The screen displays the Function Plot Menu. Notice that item 3 is SET PARAMETERS. Make that selection now.

Enter 3
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

When you first plot a function, the questions in this menu item are obtained automatically by selecting menu item 1 — DISPLAY FUNCTION. This was demonstrated when you created the graph earlier. When you create a plot and later want to change the parameters, you must address menu item 3 to do it. We now want to refine the plot increment. We'll leave the independent variables the same and use .1 for the increment.

Enter -20
Press RETURN

Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 20
Press RETURN

Screen: ENTER INCREMENT ?

Enter .1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Let's graph the function and see how much smoother the plot becomes (Figure 7-7).

Enter 1
Press RETURN

The BUSY light on the front panel shows you that the System is performing the necessary calculations; the smaller you make the increment, the longer it takes.

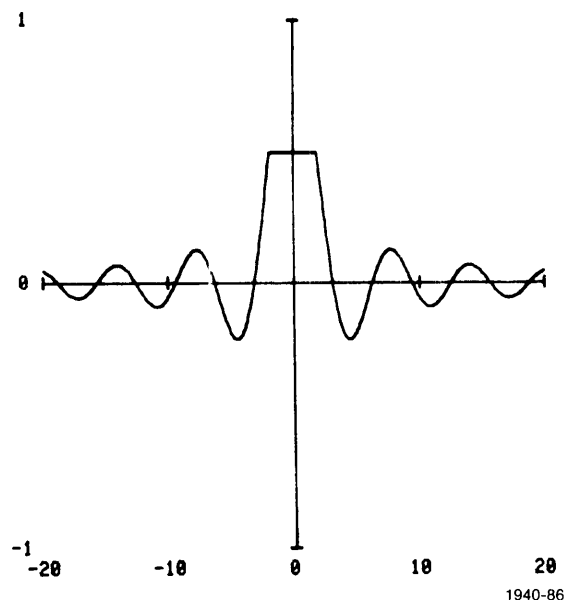


Figure 7-7. Function Plot with Increment of .1.

That's a smoother plot, and worth waiting for!

Press M
Press RETURN

The screen displays the Function Plot Menu.

STOP

Observe menu item 11 — STOP. You must return to the PLOT 50 System Software Master Menu if you wish to go to another program on the PLOT 50 System Software Tape. You must also return to the Master Menu if you want to enter another function. STOP takes you to the Master Menu and resets all default parameters. We will execute it now.

Enter 11
Press RETURN

The screen displays the Plot 50 System Software Master Menu.

Enter 3
Press RETURN

The screen displays the Function Plot subroutine instructions.

FUNCTION PLOT

This is a STOP/START point.

We just passed the first STOP/START point. Let's digress long enough to discuss how to reenter the text and continue the demonstrations if you terminate your studies at one of these points. We assume your text edit includes turning off the Graphic System. Here's how to reenter:

1. Initialize the Graphic System.
2. Initialize the PLOT 50 System Software Tape. This displays the PLOT 50 Master Menu.
3. Select menu item 3. This displays the Function Plot subroutine instructions.
4. Resume your text studies.

GRAPHING THE SECOND SINGLE-VARIABLE FUNCTION

You will be graphing the function: $Y = \text{EXP}(-.01 * X^2) * \text{SIN}(X * 2)$.

```
Type 100 Y=EXP(-.01*X^2)*SIN(X*2)
Press RETURN
Type 110 RETURN
```

At this point in the subroutine, your screen should display this:

```
TO ENTER FUNCTION:
BEGIN AT LINE 100 INCREMENTING BY 10
FOR SINGLE VARIABLE USE Y=FUNCTION(X)
FOR DOUBLE VARIABLE USE X=FUNCTION(T1)
                        Y=FUNCTION(T1)
FOLLOW THE FUNCTION WITH RETURN
THEN TYPE RUN
100 Y=EXP(-.01*X^2)*SIN(X*2)
110 RETURN
```

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Now, finish the subroutine.

```
Type RUN
Press RETURN
```

The screen erases and displays the Function Plot Menu. We can select the SET PARAMETERS menu item and establish our other parameters before we select item 1 — DISPLAY FUNCTION, or we can go directly to menu item 1 and have the System query us on the parameters anyway. Let's save a step and go directly to the DISPLAY FUNCTION selection.

Enter 1
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

This time, we'll go from a -20 to a +20 on the X axis and use .5 for the increment.

Enter -20
Press RETURN

Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 20
Press RETURN

Screen: ENTER INCREMENT ?

Enter .5
Press RETURN

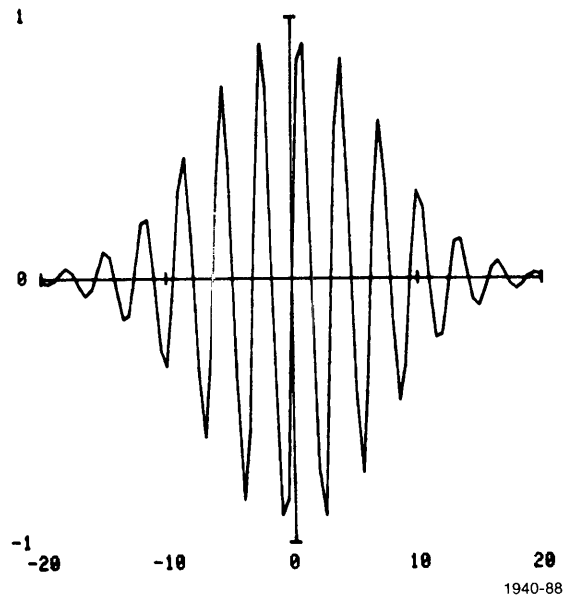


Figure 7-8. Function Plot with Increment of .5.

FUNCTION PLOT

Previously, you plotted a function with an increment of 1 and .1; this time we used .5 as an increment. You might find it interesting to compare the three plots and see how the increment changes the smoothness of the graph.

Press M
Press RETURN

The screen displays the Function Plot Menu. We are ready to start another function, so we must return to the Master Menu.

Enter 11
Press RETURN

The screen displays the PLOT 50 System Software Master Menu.

This is a STOP/START point.

GRAPHING THE THIRD SINGLE-VARIABLE FUNCTION

To return to the Function Plot subroutine instructions:

Enter 3
Press RETURN

Let's plot the function: $Y = 2 * X^2 + 3 * X + 25$.

Type 100 $Y = 2 * X^2 + 3 * X + 25$
Press RETURN
Type 110 RETURN
Press RETURN

Your display screen should look like this:

```
TO ENTER FUNCTION:
BEGIN AT LINE 100 INCREMENTING BY 10
FOR SINGLE VARIABLE USE Y=FUNCTION(X)
FOR DOUBLE VARIABLE USE X=FUNCTION(T1)
                                Y=FUNCTION(T1)
FOLLOW THE FUNCTION WITH RETURN
THEN TYPE RUN
100 Y=2*X^2+3*X+25
110 RETURN
```

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Now complete the subroutine:

Type RUN
Press RETURN

The screen erases and displays the Function Plot Menu.

Enter 1
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

ENTER -10
Press RETURN

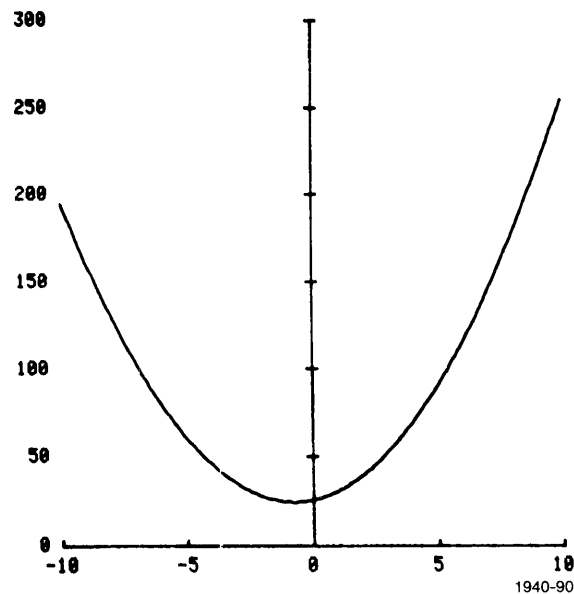
Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 10
Press RETURN

Screen: ENTER INCREMENT ?

Enter 1
Press RETURN

The BUSY light on the front panel assures you that the System is preparing your plot; then this function plot is displayed:



FUNCTION PLOT

SELECTING PLOT MODES

Menu selection 9 is called SELECT PLOT MODE. It gives you the choice of a line or a point plot. Let's go there, choose the point plot, and regraph the function.

Enter 9
Press RETURN

Screen: 1 LINE PLOT MODE
2 POINT PLOT MODE
SELECT NUMBER AND PRESS RETURN ?

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

Figure 7-9 shows the function regraphed in Point Plot Mode.

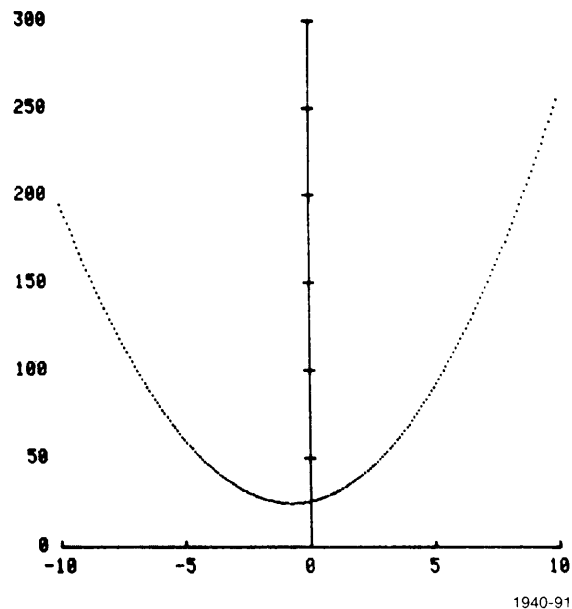


Figure 7-9. Function Plot in Point Plot Mode.

SELECTING PLOT SYMBOLS

There are other plotting symbols besides points that we can use. Menu item 10, SELECT SYMBOL, gives us several choices.

Enter 10
Press RETURN

Screen: 1 POINT
 2 TRIANGLE
 3 PLUS SIGN
 4 SQUARE
 5 DIAMOND

Let's see what the function looks like plotted with triangles.

Enter 2
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

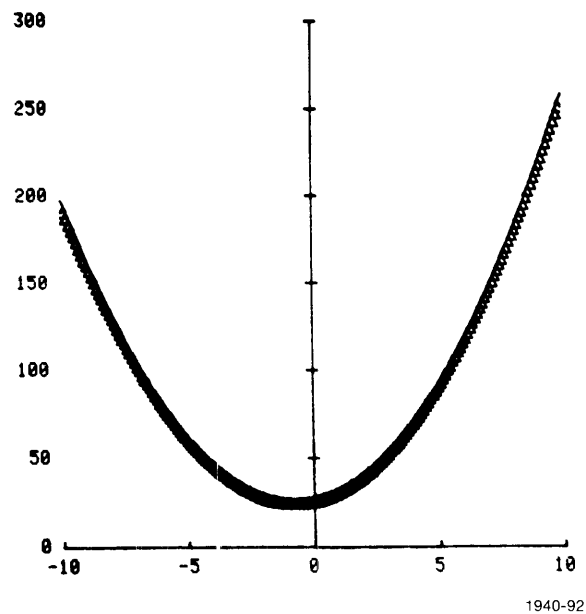


Figure 7-10. Function Plot in Point Plot Mode with Triangle Plot Symbols and Increment of .1.

FUNCTION PLOT

As Figure 7-10 shows, it's sort of like trying to write a business letter with a paint brush! If you have a special application for these symbols, use a large plotting increment. Let's change to an increment of 1 and replot.

Enter 3
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

We won't change the variables, just the increment.

Enter -10
Press RETURN

Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 10
Press RETURN

Screen: ENTER VARIABLE ?

Enter 1
Press Return

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

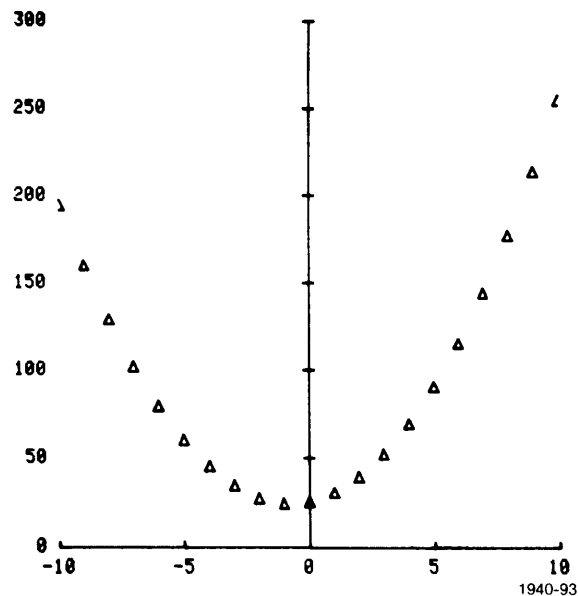


Figure 7-11. Function Plot in Point Plot Mode with Triangle Plot Symbols and Increment of 1.

Figure 7-11 shows the improvement! The first Symbol Menu selection gives us “dots.” which we’ve already displayed. Why don’t you plot the function using other symbol selections? When you’re through, return to the Function Plot Menu. To do this: Enter 10, Press RETURN; Enter the Symbol Menu number of the symbol you choose, Press RETURN; Enter 1, Press RETURN. When you have plotted all the symbols, you will want to . . .

Press M
Press RETURN

Let’s return to Line Plot Mode and the point symbol:

Enter 9
Press RETURN

The screen displays the Plot Mode Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 10
Press RETURN

The screen displays the Symbol Menu.

Enter 1
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Press M
Press RETURN

The screen displays the Function Plot Menu.

AUTOSCALING

When you plot a function on the Graphic System without indicating specific X and Y axes data ranges, the System establishes ranges that display the function plot appropriately. We call this automatic range determination "autoscaling." When we talk about data ranges for the X axis, for example, we're referring to the minimum to maximum values plotted against the X axis. The X axis index numbers (the numbers that label the X axis tic marks) reflect those data range values. The same data range format applies to the Y axis.

If you enter a function into the Graphic System and immediately ask for a Function Plot by selecting menu item 1, the System searches its memory to see if you gave it data range instructions. If not, the System autoscales; that is, it tests the function with each selected independent variable and establishes minimum and maximum data ranges on both axes that include all point values. The System does not autoscale until just before the graph is created. So far, we have not specified any specific axes data ranges, so all our graphs have been autoscaled.

GRAPHIC DISPLAY UNITS

The Graphic System display screen is internally divided into 100 vertical and 130 horizontal units called "Graphic Display Units" (GDUs). We'll be working with these units to relocate the position of the graph on the screen.

LISTING PARAMETERS

When you select menu item 2, LIST PARAMETERS, you have picked a handy reference chart that will assist you in many plotting situations. Let's take a few moments to examine these parameter entries (Figure 7-12).

```

PARAMETER LIST

LINE CODE          1
SYMBOL CODE        1
BEGINNING VARIABLE -10
VARIABLE INCREMENT 1
ENDING VARIABLE    10

          -----X-----Y-----
SCREEN MINIMUM      30                10
SCREEN RANGE        80                30
DATA MINIMUM        -10               0
DATA RANGE          20                300

ENTER MENU ITEM NUMBER OR M FOR NEW MENU

```

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Figure 7-12. Parameter List Headings.

Here is an explanation of the Parameter List headings:

Line Code: This heading shows the Plot Mode Menu selection. The default value is Line Plot Mode.

Symbol Code: This heading shows the Symbol menu selection. The default value is Point Symbol Mode.

Beginning Variable: This heading reflects the beginning independent variable you specify.

Variable Increment: This heading shows the plotting increment you determine.

Ending Variable: This heading indicates the ending variable you specify.

Screen Minimum: This parameter entry indicates the Graphic Display Unit (GDU) point where the X and Y axis begin. When in a default condition, the X axis begins 30 GDUs horizontally from the left side of the screen, and the Y axis begins 10 GDUs vertically from the bottom of the screen. These default conditions provide a screen graphing location suitable for most function plots.

Screen Range: These entries indicate the length of the X and Y axes in GDUs. If you add this value to the screen minimum, you obtain the axis termination point expressed in GDUs (screen maximum).

Data Minimum: The data minimum is the X and Y axes data minimums established by you, or it is the autoscaled data minimums selected by the Graphic System.

Data Range: These figures show total values on each axes. Add the data range to the data minimum to get a maximum value on each axis.

We'll reinforce these comments with specific examples in the next few paragraphs; don't feel uneasy if some terms are not yet clear to you.

CHANGING THE SHAPE OF THE GRAPH

Shortening and lengthening the X and Y axes changes the impact of your graph. If we stretch the X axis and compress the Y axis, we tend to “flatten out” the graph and de-emphasize differences in the plot points. Conversely, if we lengthen the Y axis and shorten the X axis, we make minor differences in plot points appear more pronounced.

Another reason for changing the size and shape of the plot is to meet size requirements. If you need to make a copy of a screen plot smaller than the original and suitable reduction facilities are not available, make the screen plot smaller and take a picture of the screen with an optional hard copy unit.

Your Graphic System should still be displaying the Parameter List. Before we start moving the plot around, let's make sure we know where it is now. We're using a screen that is 130 GDUs wide. Notice that the X screen minimum is 30 and the X screen range is 80. If the X axis starts at 30 GDUs and is 80 GDUs long, the X axis terminates at 110 GDUs.

The X data minimum is -10 and the X data range is 20. This means that the axis minimum range starts with a value of -10 and continues for 20 units to a maximum range of 10.

We analyze Y axis parameter listings the same way. There are 100 vertical GDU points on the screen. The Y screen minimum is 10 and the Y screen range is 80. Add the 80 and the 10 and we have the Y axis ending at the 90 GDU screen point.

The Y data minimum is 0 and the Y data range is 300; the Y axis has a range of 300 units ($0 + 300$) that starts at 0 and ends at 300.

Now, let's take our function plot and change its shape. We'll use extreme examples to dramatize the differences. We'll begin by shortening the X axis.

Press M
Press RETURN

The screen displays the Function Plot Menu. Notice that menu items 5 and 6 are the selections for X and Y axes screen positions.

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

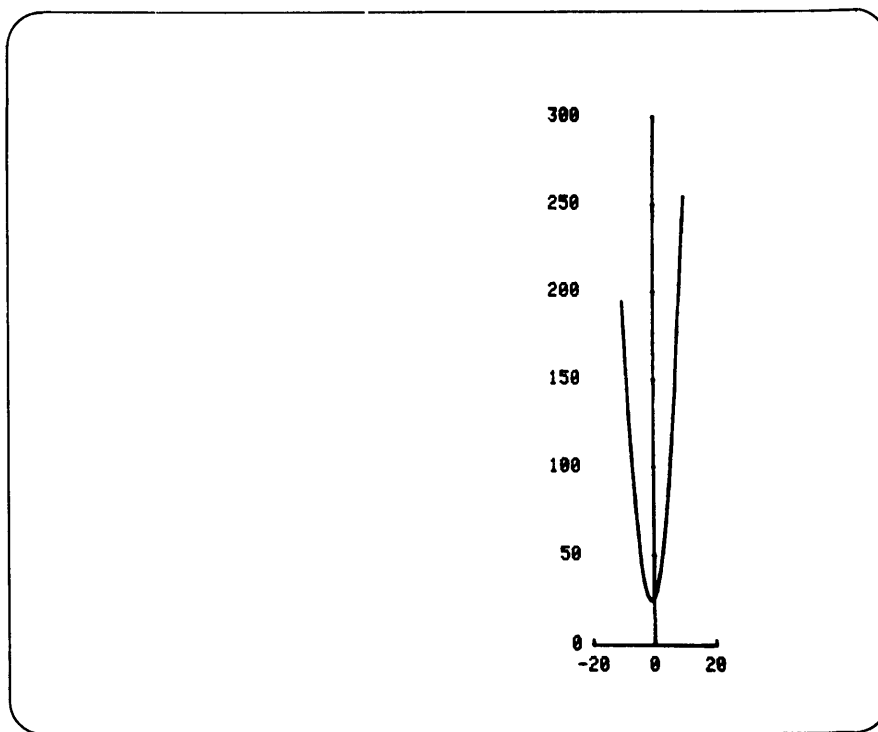
Enter 90
Press RETURN

Screen: MAXIMUM ?

Enter 110
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN



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Figure 7-13. Function Plot with Compressed X Axis.

Observe the emphasis this format gives to differences in plot points (Figure 7-13). Notice that the System has changed the X axis data range to 40 units (-20 to +20) to accommodate the new format.

FUNCTION PLOT

Now, we'll reduce the Y axis, and at the same time place the function plot in the upper-right corner of the display screen (Figure 7-14).

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

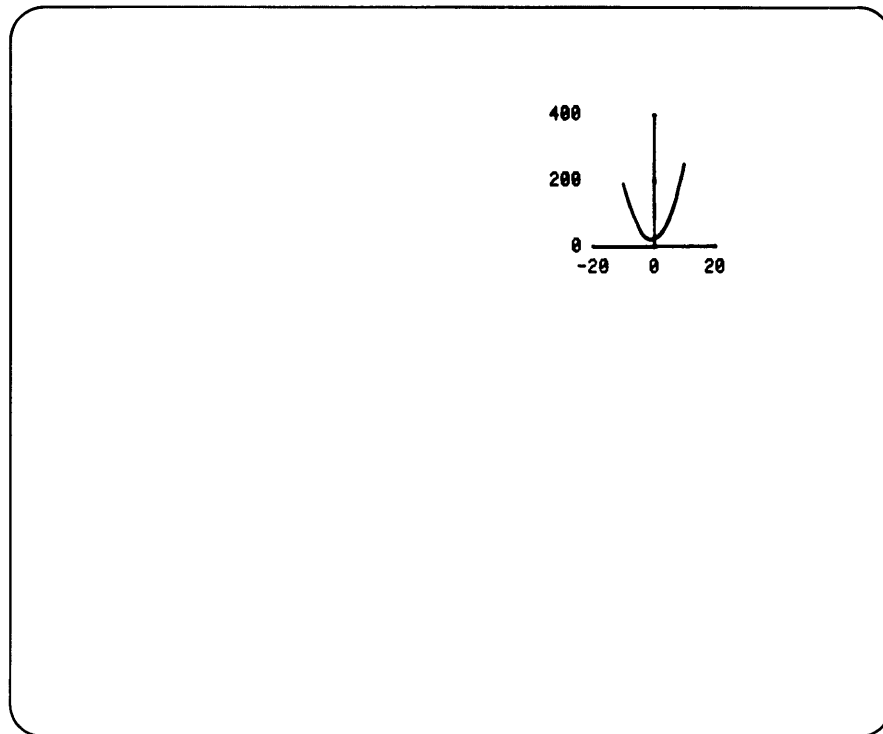
Enter 70
Press RETURN

Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN



1940-96

Figure 7-14. Function Plot with Compressed X and Y Axes.

Notice that the System has changed the Y data range to accommodate the reduced format. Now, we'll de-emphasize differences in plot points by extending the X axis and compressing the Y axis. We'll start with the X axis.

Enter 5
Press RETURN

Screen: PLEASE ENTER X SCREEN MINIMUM ?

Enter 15
Press RETURN

Screen: MAXIMUM ?

Enter 115
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

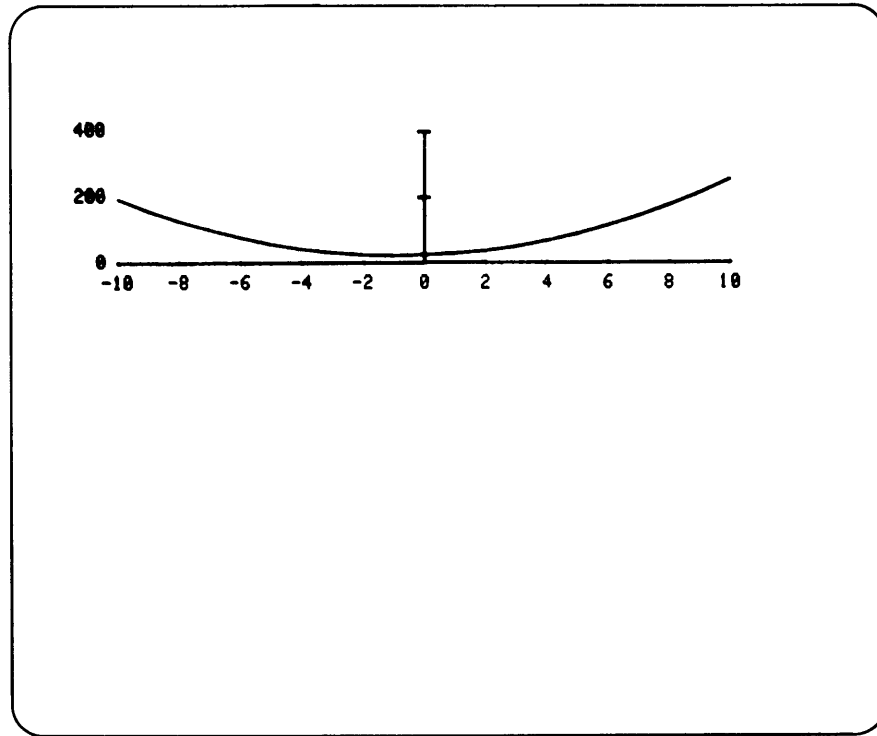
If we were to graph this plot now, we would retain the -20 to $+20$ X axis data range. We want to get back to the original range of -10 to $+10$ and we can accomplish this easily by using the menu selection SET AUTOSCALE.

Enter 4
Press RETURN

Screen: AUTOSCALED
ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

FUNCTION PLOT



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Figure 7-15. Function Plot with Extended X Axis and Compressed Y Axis.

Observe how this format de-emphasizes differences in plot points. Let's go back to our original format before we start on another topic. If you recall, our X axis parameters were: screen position from 30 to 110 GDUs; the data range from -10 to $+10$. Y axis parameters were: screen position from 10 to 90 GDUs; the data range from 0 to 300.

To return to our original format . . .

Enter 5
Press RETURN

Screen: ENTER X SCREEN MINIMUM ?

Enter 30
Press RETURN

Screen: MAXIMUM ?

Enter 110
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 6
Press RETURN

Screen: PLEASE ENTER Y SCREEN MINIMUM ?

Press 10
Press RETURN

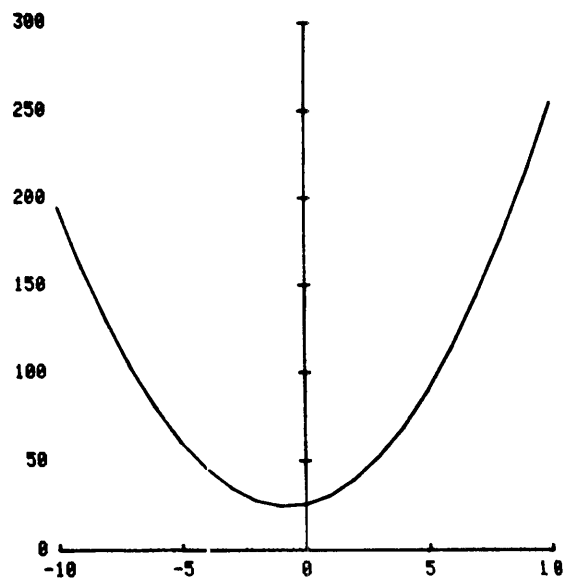
Screen: MAXIMUM ?

Enter 90
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

And there's the graph we started with!



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FUNCTION PLOT

If you put the X axis too close to the left or the right screen border, or if you establish the Y axis too close to the bottom or top of the display screen, you can get graph aberrations. When your graph is too close to the screen boundaries, you may find your graph data chopped off, the axis index numbers compressed at one end of an axis, or the screen displaying only part of a plot and stopped in a "page full" condition.

The default parameters for the X and Y axes are adequate for most graphing requirements. If you decide to customize the graph's screen location, remember to allow sufficient room horizontally and vertically for axis index numbers.

Now, let's go to the subroutine instructions and create a different function plot.

Press M
Press RETURN

The screen displays the Function Plot Menu.

Enter 11
Press RETURN

The screen displays the PLOT 50 System Software Master Menu.

Enter 3
Press RETURN

The screen displays the Function Plot subroutine instructions.

This is a STOP/START point.

GRAPHING THE FIRST DOUBLE-VARIABLE FUNCTION

Plotting a double-variable function is easy when you use the Function Plot Program. In the double-variable function format, we put either the X or the Y function on program line 100, the other function on program line 110, and the RETURN instruction on program line 120. Let's try one.

Type 100 X=COS(T1)*25
Press RETURN
Type 110 Y=SIN(T1)*25
Press RETURN
Type 120 RETURN
Press RETURN

The screen looks like this:

```

TO ENTER FUNCTION:
BEGIN AT LINE 100 INCREMENTING BY 10
FOR SINGLE VARIABLE USE Y=FUNCTION(X)
FOR DOUBLE VARIABLE USE X=FUNCTION(T1)
                                Y=FUNCTION(T1)
FOLLOW THE FUNCTION WITH RETURN
THEN TYPE RUN
100 X=COS(T1)*25
110 Y=SIN(T1)*25
120 RETURN

```

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Type RUN
Press RETURN

The screen erases and displays the Function Plot Menu.

Enter 1
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

We'll start at 0 and use 2 PI to obtain a circle.

Enter 0
Press RETURN

Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 6.28
Press RETURN

Screen: ENTER INCREMENT ?

Enter .04
Press RETURN

FUNCTION PLOT

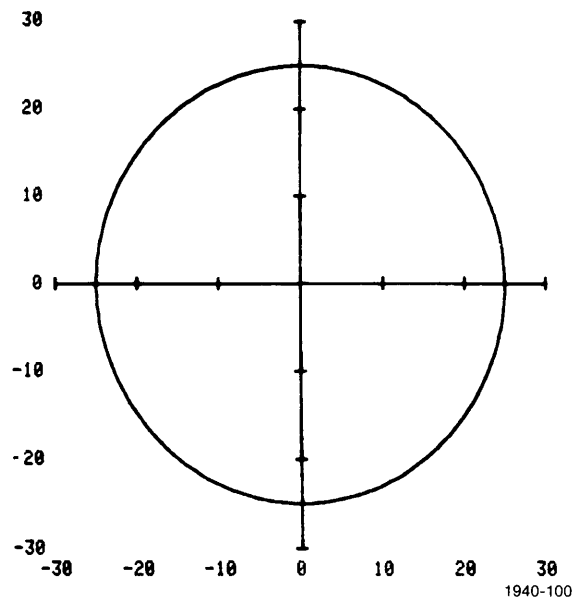


Figure 7-16. Double-Variable Function Plot.

Figure 7-16 shows the resulting function plot.

Let's try another one. As you recall, we must return to the PLOT 50 System Software Master Menu to reach the subroutine instructions. STOP is menu item 11.

Enter 11
Press RETURN

The screen displays the Master Menu.

Enter 3
Press RETURN

The screen displays the Function Plot subroutine instructions.

GRAPHING THE SECOND DOUBLE-VARIABLE FUNCTION

Type 100 $X:=\text{SIN}(T1)+T1$
Press RETURN
Type 110 $Y:=\text{SIN}(T1)-T1$
Press RETURN
Type 120 RETURN
Press RETURN
Type RUN
Press RETURN

The screen displays the Function Plot Menu.

Enter 1
Press RETURN

Screen: ENTER BEGINNING INDEPENDENT VARIABLE ?

Enter -3
Press RETURN

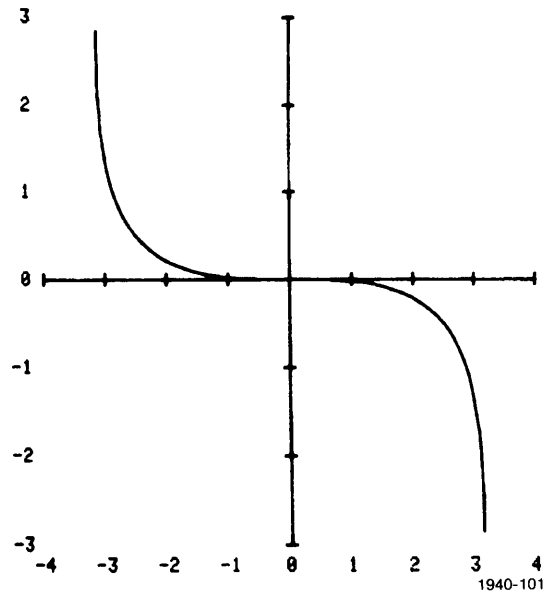
Screen: ENTER ENDING INDEPENDENT VARIABLE ?

Enter 3
Press RETURN

Screen: ENTER INCREMENT ?

Enter .1
Press RETURN

FUNCTION PLOT



CHANGING THE GRAPH'S RANGE VALUES

Function Plot Menu items 7 and 8 permit you to change the minimum to maximum range values of the X and Y axes. In autoscaling, the axes have range values set to include the dependent values generated by the function. These variables determine the plotting points; you can increase the range values of the X and Y axes as much as you like, but it will not affect the plot. On the other hand, if you decrease the axes ranges to values less than the values given to the independent variables, you “chop off” segments of the plot. Let's go to the Function Plot Menu first and identify these two menu selections. Then we'll modify the graph we currently have in System memory and see how all these things fit together.

Press M
Press RETURN

The screen displays the menu. Observe selections 7 and 8. Also, refresh your memory about the item number for the SET AUTOSCALE selection. First, we'll make the graph bigger than the plot by extending both the X and the Y axes.

Enter 7
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter -20
Press RETURN

Screen: MAXIMUM ?

Enter 20
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 8
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter -20
Press RETURN

Screen: MAXIMUM ?

Enter 20
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

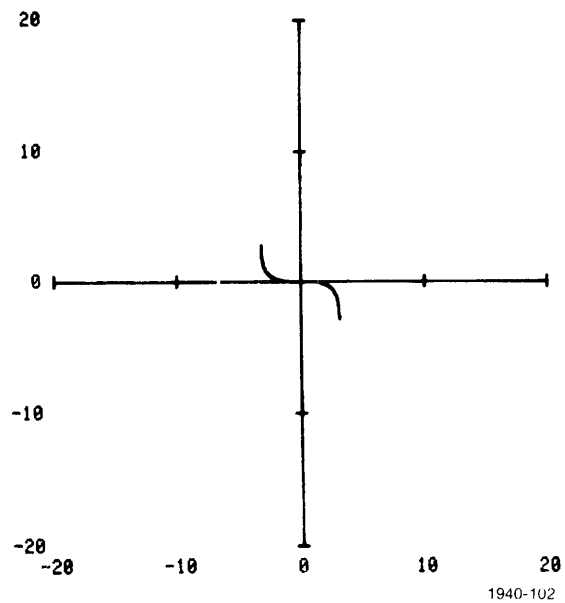


Figure 7-17. Function Plot with Extreme Data Ranges.

FUNCTION PLOT

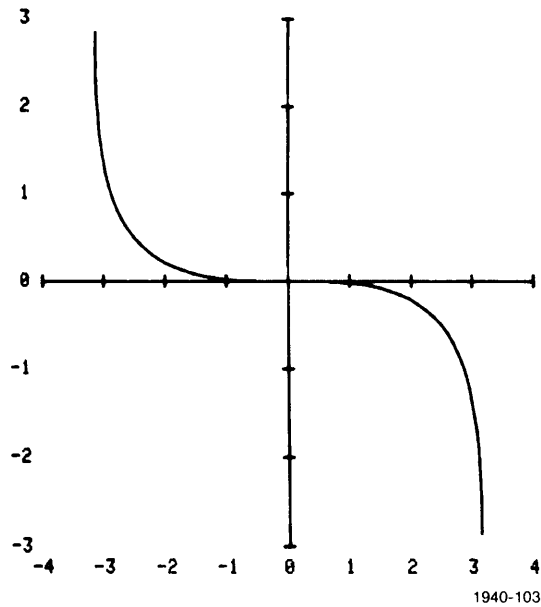
Figure 7-17 shows this exaggerated example of how a graph can dwarf a plot! To return to the original graph, we don't have to go back and do everything in reverse; all we have to do is autoscale. Like this . . .

Enter 4
Press RETURN

Screen: AUTOSCALED
 ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Let's make a graph and see if it really works!

Enter 1
Press RETURN



Notice that we have returned to the range values we had originally. We will now "chop off" segments of the plot by reducing the X and Y range values. Figure 7-18 shows what these range values are going to do to the present plot.

Enter 7
Press RETURN

Screen: PLEASE ENTER X DATA MINIMUM ?

Enter -2.5
Press RETURN

Screen: MAXIMUM ?

Enter 2.5
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 8
Press RETURN

Screen: PLEASE ENTER Y DATA MINIMUM ?

Enter -2.5
Press RETURN

Screen: MAXIMUM ?

Enter 2.5
Press RETURN

Screen: ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN

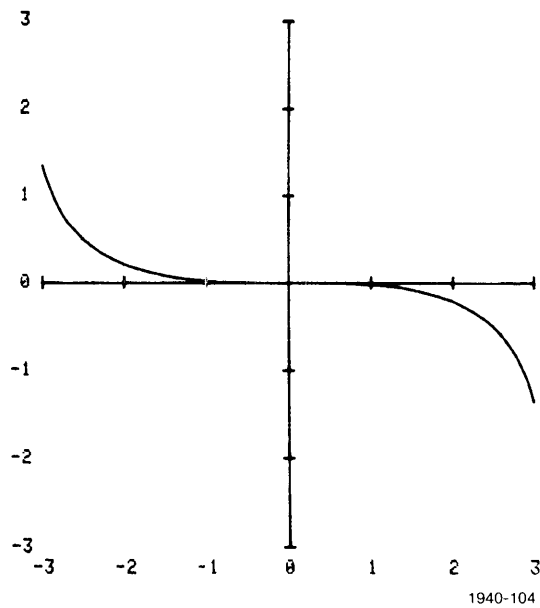


Figure 7-18. Function Plot with Clipped Segments.

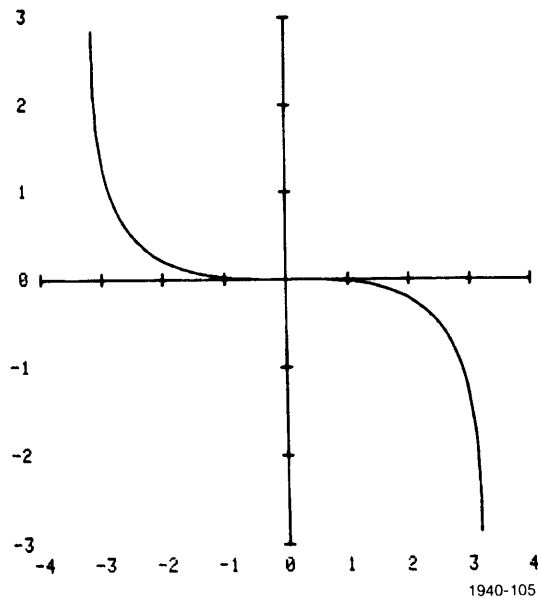
FUNCTION PLOT

Notice that the plot is "chopped off" from the top and bottom on the Y axis and from both sides on the X axis. If we autoscale, the plot returns to original range values.

Enter 4
Press RETURN

Screen: AUTOSCALED
ENTER MENU ITEM NUMBER OR M FOR NEW MENU ?

Enter 1
Press RETURN



You have just completed the Function Plot study program. You may turn the System off; or you may implement the STOP menu selection that follows, leave the Function Plot Program, and return to the PLOT 50 System Software Master Menu.

Enter 11
Press RETURN

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Section 8

SYSTEM VERIFICATION

INTRODUCTION

Since you're expecting the Graphic System to help solve some important problems, you're anxious to get the System into operation as soon as possible. Before the System is used, you want assurance that the memory and associated internal components are performing properly.

Careful production procedures and vigilant quality control at the Tektronix factory make us confident of the Graphic System's accuracy when it leaves the factor loading dock. However, a Graphic System may be subjected to a variety of shocks and vibrations en route to your location; in spite of our protective packaging, some subtle damage could occur.

We want you to be confident that your new Graphic System is in perfect working order. The System Verification Programs were created to verify proper System performance when the Graphic System is received, and at any later time if System performance is in doubt.

The nice part about the System Verification Programs is that they form a do-it-yourself verification kit. You don't lose operating time waiting for someone to come and check out the System for you.

You can run the System Verification Programs in less than 10 minutes. When the System checks out, it can be used immediately with confidence. In those rare instances when something is wrong, the program tells you about it, and you call a Tektronix representative for assistance.

There are two verification programs: a software program and a firmware program.

The Software Verification Program checks out System internal components: the keyboard, the Graphic System display, and data transfer to and from the internal magnetic tape unit. You and the Graphic System act as a team in this checkout. You press keys in response to System requests, and the System responds with various statements and test patterns.

The Firmware Verification Program checks out the System memory. The System does all the work in this program in about 1 minute.

SYSTEM VERIFICATION

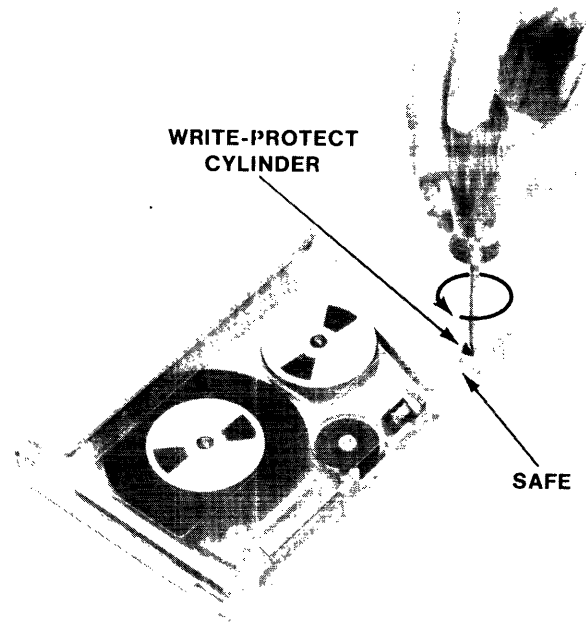
If you have a 4051 Graphic System, you should run both verification programs during the initial checkout. You should also run the Software Verification Program after cleaning the tape head, and whenever you wish to check internal tape drive operation.

If you have a 4052/4054 Graphic System, you should run the Software Verification Program during the initial checkout, after cleaning the tape head, and whenever you wish to check internal tape drive operation. Because of their internal configurations, it is never necessary to run the Firmware Verification Program on the 4052/4054 Graphic Systems.

IMPLEMENTATION

Okay, you've got a Graphic System. It's been unpacked, the installation instructions have been read and followed, and the System has been turned on. Now, you want to know if it is operating properly—you want the System Verification Programs to check out the System. How is that done?

Figure 8-1 shows how to write-protect a tape cartridge. This prevents writing on the tape or erasing information that is recorded on the tape. To write-protect a tape cartridge, insert a coin or a screwdriver into the cylinder with an arrow painted on it, the write-protect cylinder. Turn the cylinder until the arrow points to the position marked SAFE and locks there. To remove the write-protection, turn the cylinder until the arrow points to the position opposite SAFE and locks there.



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Figure 8-1. Write-Protecting a Tape Cartridge.

Remove the write-protection from the PLOT 50 System Software Tape before running the System Verification Programs. This allows the Software Verification Program to test data transfer to a magnetic tape.

CAUTION

When the System Verification Programs are completed, return the write-protect arrow to SAFE to protect the tape from inadvertent erasure.

Insert the PLOT 50 System Software Tape into the System. Detailed instruction on loading a magnetic tape cartridge is provided in the PLOT 50 System Software General Information section. Press the AUTO LOAD key. When tape movement stops, the PLOT 50 System Software Master Menu appears on the display screen. Notice that menu selection 6 is the Software Verification Program. Press the 6 key; then press the RETURN key. This will take you to the Software Verification Program.

SYSTEM VERIFICATION

When the Software Verification Program is completed, the System automatically returns to the Master Menu. Notice that the 7th selection on the menu is the Firmware Verification Program. If you have a 4051 Graphic System, press the 7 key; then press the RETURN key.

After completion of the Verification Program(s), turn off the Graphic System or press the AUTO LOAD key to return to the Master Menu.

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Section 9

KEYS, BUTTONS, AND SWITCHES

INTRODUCTION

The first part of this section discusses the BASIC programming language, explaining why you must understand the “basics” of BASIC to use the 4050 Series Graphic System. The next part presents a simplified block diagram of the Graphic System hardware. It also presents general descriptions of its major hardware components: the keyboard, the Processor, the Random Access Memory (RAM), the magnetic tape unit, and the display. The block diagram and descriptions are provided to help you understand the basic hardware of the Graphic System. The last part of this section discusses System operation and operator control.

THE BASIC PROGRAMMING LANGUAGE

To communicate with the Graphic System, you must communicate in a language the System understands. Your 4050 Series Graphic System understands a language called BASIC (Beginner's All-purpose Symbolic Instruction Code).

BASIC is a high-level programming language that uses English-like and math-like notation. The BASIC programming language is similar to a written language. A written language is composed of sentences, whereas BASIC is composed of statements. Sentences are formed from fundamental elements, such as nouns, verbs, and adjectives; statements in BASIC are formed from fundamental elements, such as constants, variables, and expressions. The set of rules which governs sentence structure in a written language and statement structure in BASIC is called the syntax of the language. The Graphic System cannot process a statement that does not conform to proper syntax. If you enter a statement with incorrect syntax, a syntax error message appears on the screen. (Refer to the 4050 Series Graphic System Reference Manual for detailed syntax information.)

The Graphic System BASIC language, which is an extended form of the original BASIC programming language, is especially adapted for graphics. The Graphic System BASIC language differs from other BASIC languages in that most keywords and their parameters can be evaluated by the System independently from program control; they are executed immediately by the System if the statement is entered without a line number. For example, to draw a single vector (line) on the display, simply type DRAW followed by the position coordinates that identify where the line is to be drawn. Pressing the RETURN key causes the statement to be executed immediately. This is one characteristic that makes the Graphic System BASIC language unique.

KEYS, BUTTONS, AND SWITCHES

To prevent immediate statement execution, you precede a statement with a line number. The line number alerts the System that the statement following the line number is part of a program. BASIC programs are stored in the Random Access Memory (RAM) and are executed sequentially when the program execute statement (RUN) is entered from the keyboard and the RETURN key is pressed.

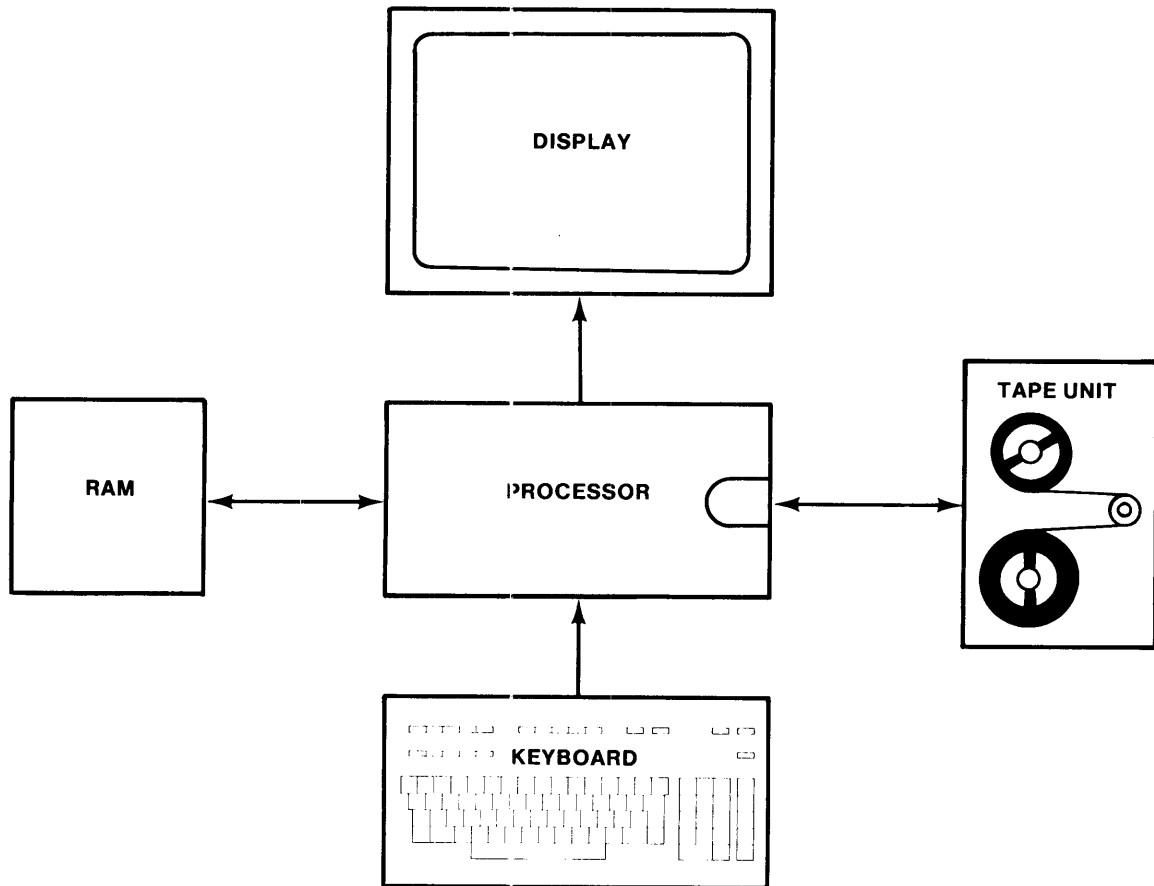
The primary reason for mentioning BASIC here is to emphasize that you cannot get the System to do anything for you unless your entries conform to proper syntax. Of course, entering a simple BASIC statement is one thing; putting the statements together to make a program is another. Let's leave the details on syntax and programming to the 4050 Series Graphic Reference Manual and the PLOT 50 Introduction to Programming in BASIC and the PLOT 50 Introduction to Graphic Programming in BASIC manuals.

THE 4050 SERIES GRAPHIC SYSTEM HARDWARE

Overview

Figure 9-1 presents a simplified block drawing of the 4050 Series Graphic System hardware: the keyboard, the Processor, the Random Access Memory (RAM), the internal magnetic tape unit, and the display.

As a Graphic System user, your primary interest lies in entering BASIC statements that tell the System how to perform a task. You may want to perform a simple mathematical calculation, or you may want to enter a program and then have the System process it. For any task within the capabilities of the System, the necessary processing power is provided by the Processor. The Processor provides the intelligence for the Graphic System and controls all routing of data within the System. The keyboard and magnetic tape unit are your means for sending information to the Processor. Entries from the keyboard are routed to the display. There you can check your entry to make sure the syntax is correct before commanding the Processor to execute the statement. If a statement is written with proper syntax and is not preceded by a line number, the Processor executes the statement immediately after the RETURN key is pressed. If a statement preceded by a line number is syntactically correct, the Processor directs the statement to the Random Access Memory (RAM) and awaits further instructions.



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Figure 9-1. The 4050 Series Graphic System Hardware.

The Keyboard

The keyboard is the primary input device for the System. Each time a key is pressed, the Processor places a representation for that key in a RAM location called the line buffer. It also displays that representation on the screen. The line buffer, which holds up to 72 keyboard characters, is discussed in detail later in this section. When the RETURN key is pressed, the line buffer contents are processed by the Processor if the input conforms to proper syntax. If the input does not conform to proper syntax, the Processor sends it back to the line buffer to be displayed and edited. A syntax error notation also appears on the screen.

The Processor

The Processor is the routing and computing device for the Graphic System. All other modules are considered support devices. In other words, in relation to the Processor, the keyboard is an input device, the display is an output device, and RAM and the magnetic tape unit can be either input or output devices, depending on the function being performed. Optional devices can be added to the System externally to enhance either the input or output capabilities. The Processor directs all System operations, decodes BASIC instructions, and performs arithmetic and logic operations. It is guided by a set of instructions called firmware that enables it to interpret the BASIC programming language. These instructions are permanently fixed in the System and cannot be changed. Because the firmware is an integral part of the Processor, it is not destroyed when the power is turned off. It is always available when the System is turned on. Firmware may be supplemented externally by ROM Packs (each up to 16K bytes of specialized firmware programs). 4052 Graphic System ROM Packs and 4054 Graphic System ROM Packs are compatible, but neither are compatible with the 4051 Graphic System. Neither are 4051 ROM Packs compatible with the 4052 or the 4054.

Random Access Memory (RAM)

The Random Access Memory (RAM) functions like a scratchpad for the Processor; it provides temporary storage locations for keyboard entries, BASIC program instructions, and intermediate processing results. Data flowing into and out of RAM is controlled by the Processor. The contents of RAM are not destroyed unless overwritten by new information, or unless power is removed from the System.

The Magnetic Tape Unit

Like RAM, the magnetic tape unit also provides data storage capability for the System. However, the magnetic tape unit provides permanent data storage capability, rather than the temporary storage provided by RAM. The information stored on tape may be a program or it may be data to be processed by a program.

Data is not passed directly between RAM and the tape unit; the Processor acts as a go-between. Information traveling to the magnetic tape unit from RAM passes through the Processor first; likewise, data traveling from the magnetic tape unit to RAM passes through the Processor first.

The Display

The display is the device that enables you to view your keyboard entries and that gives the Processor a means to "talk" to you. The Processor may respond to your entry with a blinking question mark (?), which is an indication that you are to make another entry; it may respond by drawing a graph, a picture, a function plot, etc.; or it may respond with a syntax error message, which is its way of telling you that it does not understand your entry.

The Graphic System display is a storage crt device. "Storage" refers to the ability of the display to retain an image when the image is written only once. The display screen retains the written image for operator viewing and hard copy purposes. (An optional hard copy unit can obtain a permanent paper copy of the screen contents.)

SYSTEM OPERATION

Introduction

This material explains Graphic System operation and operator control. It is not intended to cover every detail of Graphic System operation nor to teach programming concepts and techniques. However, because the Graphic System is unique, flexible, and extremely powerful, care is taken to describe items of operation not obvious to the new user, (especially those items unique to display graphics). If you are new to the Graphic System, read the preceding information in this section if you have not already done so. It will enable you to understand the following information more thoroughly.

System Initialization

If this is the first time the Graphic System is turned on in your area, refer to the Installation Appendix to verify that your power source is compatible with the line voltage setting of the Graphic System.

Turn ON the System by pressing the right side of the power switch located under the right-front corner of the unit (Figure 9-2).

NOTE

If several devices are connected to the GPIB, one more than 50% of the devices must be turned on (regardless of whether they are used) before you turn on the Graphic System. Otherwise, the bus may be loaded down, causing an error message or causing the System not to respond properly.

KEYS, BUTTONS, AND SWITCHES

The four green indicator lights on the front panel (Figure 9-2) will turn on, but only the POWER light remains on. It stays on as long as power is applied to the System.

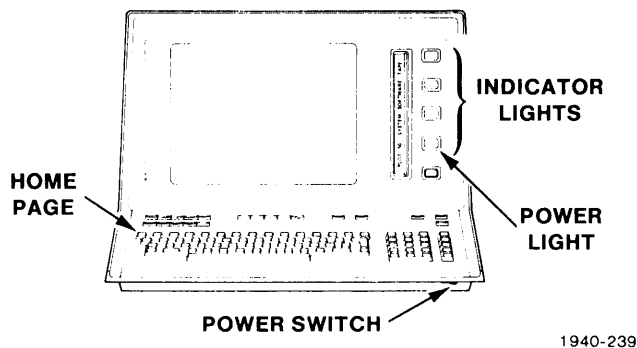


Figure 9-2. Power Switch, Indicator Lights, and HOME/PAGE Key.

When the System powers up, it is immediately ready to go to work for you; its firmware contains operating instructions that enable it to interpret the language with which you'll communicate — Graphic System BASIC.

The Graphic System Display

The Graphic System display is the device that enables you to monitor the communications that occur between you and the Graphic System. It has been especially adapted to the graphic processing capabilities of the System and enables the Processor to communicate to you in either alphanumerics or graphics.

At power-up, you may notice the screen "writing up" around the page borders. This is normal. Simply press the HOME/PAGE key (Figure 9-2) and the screen will be blank except for a small blinking rectangle (cursor) in the upper-left corner of the screen. This position is called the "home" position.

The home position is the first character position of the first usable line of the display screen.

Cursors

The cursor is moved about the display screen during System operation to show the current position of the writing beam. It indicates the position where the next keyboard character is to be printed. There are four 4050 Series Graphic System cursors: the blinking rectangle, the blinking question mark, the blinking arrow, and the full screen crosshair.

The blinking rectangle appears at power-up and is displayed when the System is not under program control. It is present when you are doing things such as entering BASIC statements and editing programs.

The blinking question mark is displayed when the System is under program control and is waiting for input from the keyboard.

The blinking arrow, a graphic cursor, is displayed only on the 4051 and 4052 Graphic Systems. It appears following execution of a POINTER statement and is under operator control only with an optional Joystick.

The full screen crosshair cursor is the graphic cursor displayed only on the 4054 Graphic System. It appears following execution of a POINTER statement and is controlled with the thumbwheels at the right side of the keyboard or by an optional Joystick. See the POINTER statement explanation in the 4050 Series Graphic System Reference Manual for additional information.

The Line Buffer

You may think that entries from the keyboard go directly to the display, but that isn't what happens. The display, like every other System device, is controlled by the Processor and does not receive input directly from any other device. A keyboard entry goes first to the Processor. The Processor loads the character into a line buffer and displays the character on the screen if it is a displayable character.

The line buffer is a 72-character portion of RAM that allows you to edit your entry before it is sent to the BASIC interpreter for syntax checking. Statements in the line buffer are sent to the interpreter by pressing the RETURN key. If a statement does not conform to proper syntax, it is sent back to the line buffer and displayed for further editing. A syntax error notation accompanies the rejected statement. A statement conforming to proper syntax and not preceded by a line number is executed immediately by the Processor. A syntactically correct statement that is preceded by a line number is stored in memory to be executed when a RUN statement is received.

KEYS, BUTTONS, AND SWITCHES

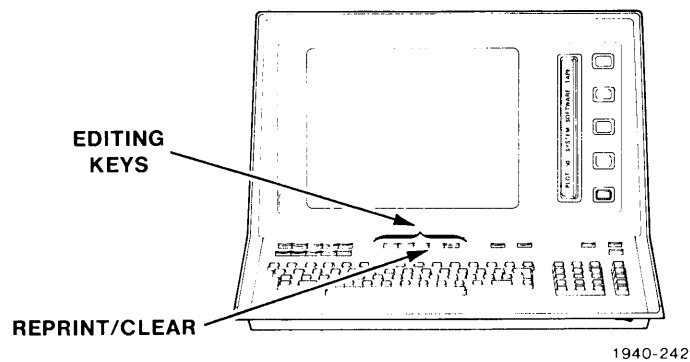
If the line buffer becomes full, the cursor stops moving to the right. Attempting to enter additional characters causes only the contents of the last buffer position to change. If you begin an entry in the middle of a display line and fill the display line before filling the line buffer, the System continues to display line buffer entries by “wrapping around” to the next line until the 72 line buffer positions are filled. See Figure 9-3.

If you fill the display line before the line buffer, wrap around occurs.

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Figure 9-3. Wrapping Around to Display Remainder of Line Buffer Contents.

To edit a wrapped-around line, hold down the SHIFT key and press the REPRINT/CLEAR key (Figure 9-4); this displays the wrapped-around line as one line. The editing keys are discussed in detail later in this section.



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Figure 9-4. The REPRINT/CLEAR Key.

The Page Full Condition

The page full condition occurs when attempting to enter data past the bottom line of the display. The page full condition is indicated by the following:

1. Additional keyboard entries are not displayed.
2. The cursor disappears.
3. A blinking "F" appears in the upper-left corner of the screen, above the home position.

Clear the page full condition by pressing the HOME/PAGE key. The screen is erased and the blinking cursor appears at the home position. Refer to the Environmental Control section of the 4050 Series Graphic System Reference Manual for information on program control alternatives when the page full condition occurs.

The Type Ahead Feature

The type ahead feature enables you to enter a maximum of 28 entries when a page full condition has occurred or when the System is operating under program control and is not waiting for keyboard input. Its main purpose is to save the few characters you may inadvertently enter before you realize the page full condition exists. Pressing the HOME/PAGE key erases the screen and displays the typed-ahead characters.

The type ahead feature allows you to enter keyboard entries while waiting for the System to finish an operation (no cursor present). If you know that a keyboard response will be expected of you, you can save time by entering it into the line buffer before the System is ready to process it. When the System finishes its programmed operation, it will send the contents of the line buffer to the Processor and also display the line buffer contents on the screen.

Type-ahead entries are limited to 28 characters or filling the line buffer, whichever occurs first. If you attempt to enter a 29th type-ahead character, the bell rings. If the line buffer is filled before the bell rings, the characters entered after it became full are lost, and the character occupying the 72nd line buffer position may not be what you expect it to be. Since type-ahead entries are not displayed immediately, it's a good idea to limit them to just a few characters. Also, when the Graphic System executes any of the following, it is possible that some or all of the characters in the line buffer will be lost: MARK, FIND TLIST, BREAK.

KEYS, BUTTONS, AND SWITCHES

Intensity

The display operates in either View Mode (normal intensity level) or Hold Mode (reduced intensity level). In View Mode, displayed data is easily visible on the screen. If no display activity occurs for about 110 seconds, the display goes into Hold Mode. In Hold Mode, data remains stored, but it becomes almost invisible and the cursor disappears. View Mode is re-established by any display storage activity or by pressing the SHIFT key.

Automatic Paging (Erasing)

Information remains on the screen in Hold Mode for approximately 30 minutes. If there is no System activity (4051/4052) or display activity (4054) within that time, the screen is paged (erased) automatically and View Mode is re-established. If no display activity occurs within about 110 seconds of that, Hold Mode recurs. The cycle repeats until further System activity (4051/4052) or display activity (4054) occurs or until System power is turned off.

Character Size

The 4051/4052 Graphic Systems display only one character size. Display input and output are limited to 72 characters per line (the length of the line buffer) and 35 lines per page. The 4054 Graphic System can display four character sizes. The power-up default character size is 4, the largest size. To change the power-up default character size, contact your local Tektronix representative.

Although the 4054 Graphic System can display four character sizes, display *input* is limited to 72 characters per line. Display *output* capabilities are shown in Table 9-1.

Table 9-1

4054 GRAPHIC SYSTEM DISPLAY OUTPUT CAPABILITIES

| Character Size | Characters Per Line | Lines Per Page | Characters Per Page |
|----------------|---------------------|----------------|---------------------|
| 4 (default) | 72 | 35 | 2520 |
| 3 | 79 | 38 | 3002 |
| 2 | 119 | 58 | 6902 |
| 1 | 132 | 64 | 8448 |

The CHARSIZE statement, CHARSIZE n (where n = 1, 2, 3, or 4), specifies character size for the 4054 Graphic System screen only. It does not alter character size for some optional peripherals such as a plotter. (Character size can be altered for a Tektronix 4660 Series plotter with the Graphic System BASIC statement ALPHASCALE. Refer to the 4050 Series Graphic Reference Manual for additional information.)

Vectors

The MOVE, RMOVE, DRAW and RDRAW commands draw vectors on the display screen. Vectors are displayed as solid lines on the 4051/4052 Graphic System screens. On the 4054 Graphic System screen they are displayed as solid lines unless altered by the DASH statement. The DASH statement specifies which of 36 dash patterns is selected. See the Graphics section of the 4050 Series Reference Manual for details of these and other statements used in graphics. For additional programming information, refer to the programming manuals: PLOT 50 Introduction to Programming in BASIC and PLOT 50 Introduction to Graphic Programming in BASIC.

Addressable Units and Display Resolution

Points on the screen to which the writing beam can be moved are addressable in two types of units: Graphic Display Units (GDUs) and user data units. A GDU is an internal unit of measurement that represents 1/130 of the X axis and 1/100 of the Y axis. User data units are units specified by the user in a WINDOW statement. These may be anything you choose, such as days, weeks, months, years, dollar amounts, items sold, etc. User data units depend on the specific user application.

The writing beam addresses user data units unless none are specified. If none are specified, the writing beam addresses GDUs or their fractional parts.

Although the 4051/4052 Graphic Systems can address approximately 120 points per inch and the 4054 Graphic System can address approximately 292 points per inch, the display resolution (ability to distinguish one written point or line from another) is approximately 40 points or lines per inch on each System.

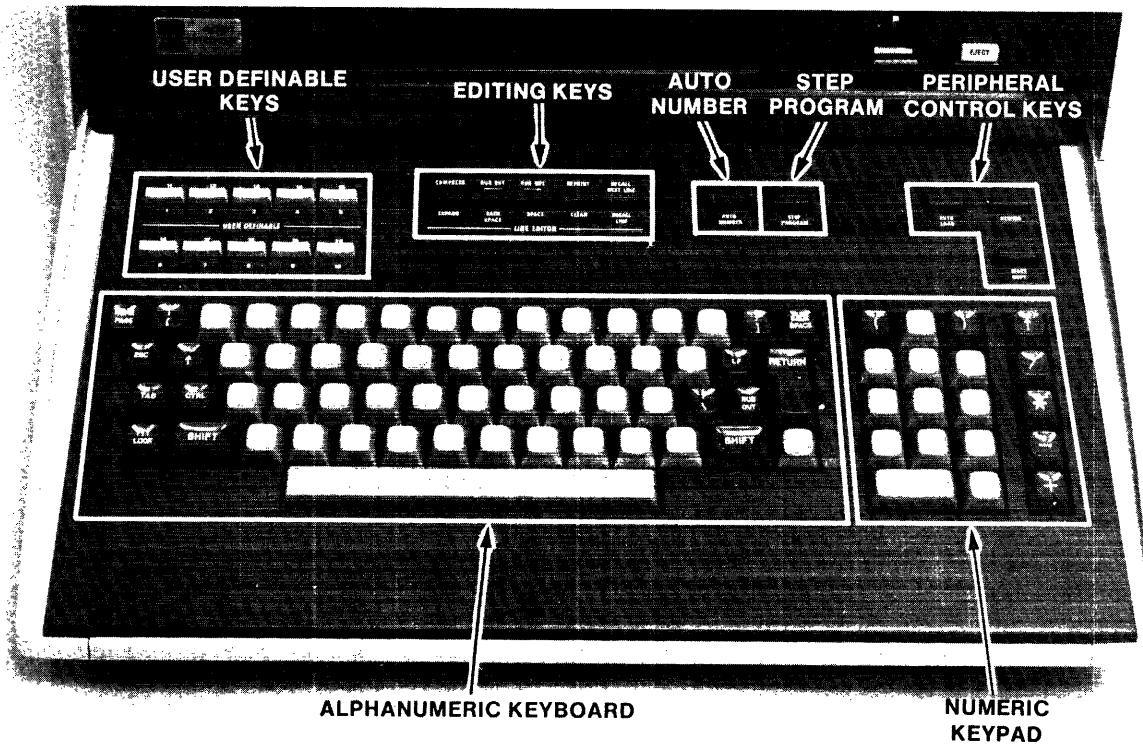
Control Descriptions**Introduction**

The Graphic System keyboard controls and front panel indicators allow you to enter input from the keyboard, to control a program that is in progress, and to stay informed of the System's activity. The keyboard's primary function is as a source of information for the Processor; the indicator lights are a source of information for the user.

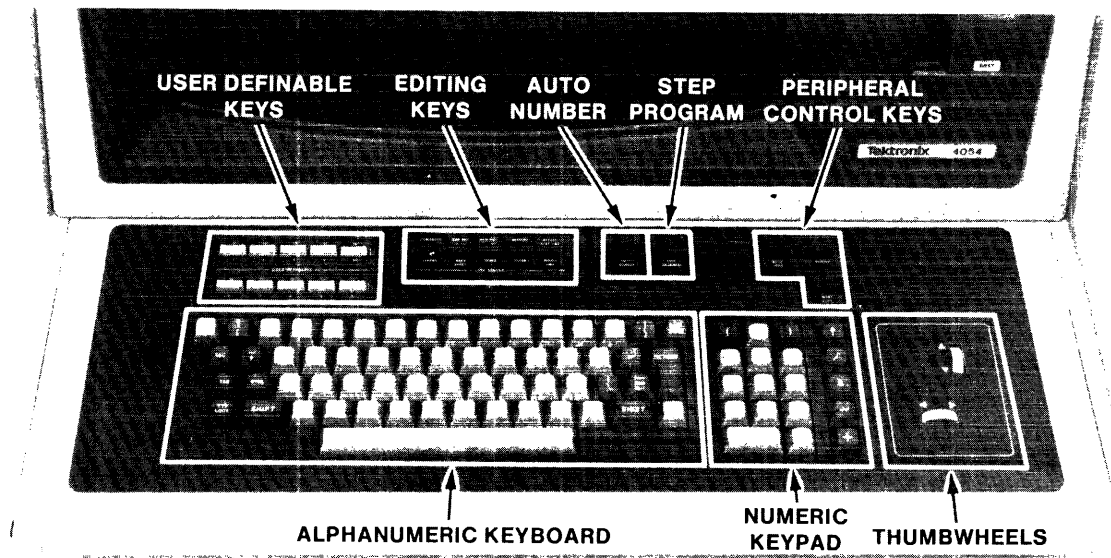
The following information familiarizes you with the functions of these controls and indicators. The repeat-key feature repeats the function of a control if the key is pressed and held down; for example, holding down the X key prints X repeatedly across the screen.

Figure 9-5 divides the keyboard controls into operational groups: the alphanumeric keyboard, the numeric keypad, the editing keys, the user definable keys, the AUTO NUMBER and STEP PROGRAM keys, the peripheral control keys, and the thumbwheels.

KEYS, BUTTONS, AND SWITCHES



A. 4051/4052



B. 4054

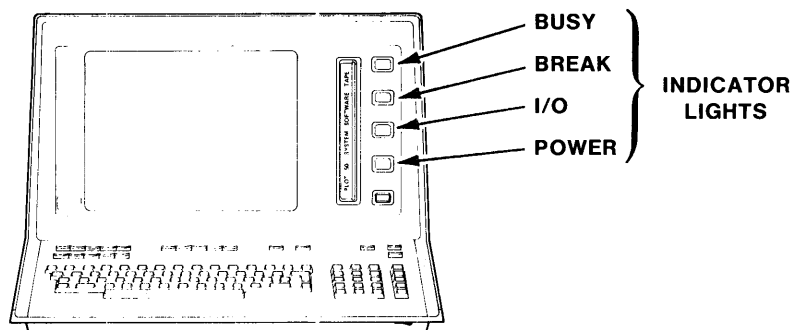
Figure 9-5. Keyboard Controls.

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Front Panel Indicators

The four green indicator lights on the front panel (Figure 9-6) indicate the following status conditions when they are on.

| | |
|-------|---|
| BUSY | The System is busy transferring or processing data. |
| I/O | An I/O (Input/Output) operation is in progress. |
| BREAK | A break in an operating program is pending. (The light goes out when the break occurs.) |
| POWER | Power is supplied to the Graphic System. |



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Figure 9-6. Front Panel Indicators.

The Alphanumeric Keyboard

THE ALPHANUMERIC KEYS The alphanumeric keys (letters, numbers, and symbols) are used to enter data and BASIC statements and to generate control characters. (Keys 0-9 can be used to enter numeric data.) If your 4050 Series Graphic System includes Option 1, Data Communications Interface, the alphanumeric keys can be used to communicate with a host computer.

THE SPACE BAR When the SPACE bar is pressed, the cursor moves one horizontal space to the right. No character is printed, although the ASCII Space character is placed in the line buffer. If the cursor is in the 72nd line buffer position, no operation is performed.

SHIFT This key is similar to the SHIFT key on a typewriter keyboard. It determines which of two characters is printed when an alphanumeric key is pressed, or which of two functions is performed when an editing or user definable key is pressed.

Pressing the SHIFT key by itself returns the display to View Mode from Hold Mode.

KEYS, BUTTONS, AND SWITCHES

TTY LOCK Pressing the TTY LOCK key causes all lower case ASCII alpha characters to be transmitted and displayed as upper case characters, regardless of the condition of the SHIFT key. The TTY LOCK key must be pressed again to release it from the lock condition.

TAB When the TAB key is pressed, the keyboard issues the ASCII control character Tab. The tab function is executed only as part of a PRINT statement (for example, by executing a PRINT "T" statement). The cursor moves to the right and stops at the next tab position. If there are no more tab positions on the current display line, the System tabs to character position 1 on the next line.

The Tab character prints on the display as an underlined I, I. Tab positions are provided every 18 spaces. The 4051/4052 Graphic System tab positions are at character positions 1, 19, 37, and 55. Table 9-2 shows the tab positions for the 4054 Graphic System.

**Table 9-2
4054 GRAPHIC SYSTEM TAB POSITIONS**

| Character Size | Tab Positions | | | | | | | | |
|----------------|---------------|----|----|----|----|----|-----|-----|--|
| 4 (default) | 1 | 19 | 37 | 55 | | | | | |
| 3 | 1 | 19 | 37 | 55 | 73 | | | | |
| 2 | 1 | 19 | 37 | 55 | 73 | 91 | 109 | | |
| 1 | 1 | 19 | 37 | 55 | 73 | 91 | 109 | 127 | |

CTRL To send a control character, hold down the CTRL key while pressing an alpha key or one of the following: [, \,], ↑, or RUB OUT. When a control character is entered from the keyboard, the keyboard issues the corresponding ASCII control character. It is displayed as an underlined letter (except CTRL M which issues the Carriage Return character and displays no character on the screen, and CTRL RUB OUT which issues the Carriage Return/Linefeed character and displays only an underline, _, on the screen). All 32 ASCII control characters can be generated by the keyboard. At statement execution time, some control characters have an effect on display functions. These are shown in Table 9-3.

Table 9-3

EFFECT OF CONTROL CHARACTERS ON THE DISPLAY^a

| Control Character | Keyboard Input | Displayed Character | Function Performed |
|----------------------------------|----------------|----------------------------|---|
| BEL (Bell) | CTRL G | <u>G</u> | Rings bell. |
| BS (Backspace) | CTRL H | <u>H</u> | Backspaces the cursor. |
| HT (Horizontal Tab) | CTRL I | <u>I</u> | Tabs the cursor to the next tab stop. |
| LF (Linefeed) | CTRL J | <u>J</u> | Moves the cursor down one line. |
| VT (Vertical Tab) | CTRL K | <u>K</u> | Moves the cursor up one line. |
| FF (Form Feed) | CTRL L | <u>L</u> | Erases the screen and moves the cursor to the home position. |
| CR (Carriage Return) | CTRL M | Does not display character | Moves the cursor to the left margin and down one vertical space. Sends the line buffer contents to the Processor. (Performs the same function as the RETURN key.) |
| RS (Record Separator) | CTRL ↑ | <u>↑</u> | Returns the cursor to the home position. |
| CR/LF (Carriage Return/Linefeed) | CTRL RUB OUT | — | Moves the cursor to the left margin and down one vertical space. |

^aThese control character functions (except carriage return) cannot be executed unless they are part of a PRINT statement. Refer to the PRINT statement in the 4050 Series Graphic System Reference Manual for details.

KEYS, BUTTONS, AND SWITCHES

| | |
|------------|---|
| ESC | <p>Pressing the ESC key places the ASCII control character Esc in the line buffer. The Esc character prints on the Graphic System display as [.</p> |
| HOME/PAGE | <p>Pressing the HOME/PAGE key by itself erases the display and returns the blinking rectangle or blinking question mark cursor to the home position. Pressing the HOME/PAGE key has no effect on the contents of the line buffer.</p> <p>Holding the SHIFT key down while pressing the HOME/PAGE key returns the blinking rectangle or blinking question mark cursor to the home position without erasing the display.</p> |
| BACK SPACE | <p>Pressing the BACK SPACE key moves the cursor one character position to the left.</p> |
| RETURN | <p>Pressing the RETURN key issues the ASCII control character CR, causing everything that is in the line buffer to be sent to the Processor. The cursor returns to the left margin of the next line. The Processor evaluates the statement received from the line buffer. If the statement is syntactically correct and contains a line number, the statement is sent to memory (RAM) as part of a program. It is not executed until a RUN statement is entered. If the statement does not contain a line number and is syntactically correct, it is executed immediately.</p> <p>The RETURN key function can be duplicated by simultaneously pressing the CTRL and M keys.</p> |
| LF | <p>Pressing the LF key causes no immediate display function other than printing the LF control character symbol, <u>J</u>, as an indication that a LF control character has been entered. The LF control character cannot be executed unless it is part of a PRINT statement.</p> |

RUB OUT

Pressing the RUB OUT key causes the character beneath the cursor to be replaced with the Space character. If no character is displayed beneath the cursor, the cursor backspaces one character position and then performs its function if a character is displayed in that position.

On the 4051/4052 Graphic System screen, the cursor writes a full 5 X 8 dot matrix over any characters replaced by the Space character during the rub out operation. On the 4054 Graphic System screen, a cursor-size rectangle writes over the replaced character. Reprinting the line causes a space to appear instead of a 5 X 8 matrix or a rectangle.

BREAK

The BREAK key is used to interrupt a program. Two levels of interrupt are provided: a program interrupt and a program abort. For a program interrupt, press the BREAK key once. This causes the BREAK indicator on the front panel to light up. Program execution stops after the current BASIC line, an interrupt message appears on the screen, and the BREAK light goes out. To restart the program at the point of interruption, enter RUN followed by the line number that is printed in the message and press RETURN.

For a program abort, press the BREAK key twice in quick succession or press it once while the BREAK light is on. Program execution is aborted immediately.

NOTE

Pressing the BREAK key as described does not perform an immediate interrupt if the program is executing a statement which involves tape movement. The interrupt occurs when the System finishes executing that statement.

To restart the program at the beginning, enter RUN and press RETURN. Attempting to restart the program at the point of interruption may give you questionable results, depending on the operation in progress when the interrupt occurred.

KEYS, BUTTONS, AND SWITCHES

Character Font Selection

The 4051 Graphic System displays six character fonts, and the 4052/4054 Graphic Systems each display eight character fonts. Each 4050 Graphic System powers up with the ASCII font. To change the character font on the 4051 Graphic System, use the PRINT statement:

PRINT @ 32,18:n

where n = the font code

Table 9-4 shows the 4051 Graphic System character fonts, the font codes, and the special characters that can be displayed in each font. It also shows the key(s) to press to select these characters and the ASCII Decimal Equivalent (ADE) for each character. (The CHR, Character, function requires an ADE value. Refer to the 4050 Series Graphic System Reference Manual for more information about the CHR function.)

Table 9-4
4051 GRAPHIC SYSTEM CHARACTER FONTS

| ASCII DECIMAL EQUIVALENT | | 91 | 123 | 93 | 125 | 35 | 36 | 92 | 124 | 64 |
|--------------------------|------------------|----|-----|----|-----|----|----|----|-----|----|
| CODE | FONT | | | | | | | | | |
| 0 | ASCII | E | ← | J | → | # | \$ | \ | | @ |
| 1 | Scandinavian | ä | Ä | å | Å | é | ø | ö | ë | ÿ |
| 2 | German | ä | Ä | ü | Ü | é | ø | ö | ë | ÿ |
| 3 | General European | E | ← | J | → | é | ø | \ | | @ |
| 4 | Spanish | í | ← | ç | → | é | ø | ñ | | @ |
| 5 | Graphic | E | ← | J | → | ■ | \$ | \ | █ | ÿ |

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To change the character font on the 4052/4054 Graphic System, use the PRINT statement as explained for the 4051 Graphic System or use the FONT statement:

FONT n

where n = the font code

Table 9-5 shows the 4052/4054 Graphic System character fonts, the font codes, the special characters that can be displayed in each font, and the key(s) to press to select these characters.

Table 9-5
KEY SELECTIONS FOR 4052/4054 GRAPHIC
SYSTEM CHARACTER FONTS

| CODE | FONT | SHIFT | | | | | | SHIFT | SHIFT | SHIFT |
|------|----------|----------------|---|---|---|---|---|-------|-------|-------|
| | | #3 | Ø | @ | £ | ¥ | ¦ | £ | ¥ | ¦ |
| 0 | ASCII | # | Ø | @ | £ | ¥ | ¦ | £ | ¥ | ¦ |
| 1 | Swedish | # | Ø | @ | ä | ö | å | Ä | Ö | Å |
| 2 | German | ä | Ø | @ | ä | ö | ü | Ä | Ö | Ü |
| 3 | British | ä | Ø | @ | £ | ¥ | ¦ | £ | ¥ | ¦ |
| 4 | Spanish | # | Ø | @ | ¡ | ñ | ¿ | £ | ¥ | ¦ |
| 5 | Graphic | # | Ø | @ | £ | ¥ | ¦ | £ | ¥ | ¦ |
| 6 | Reserved | Same as FONT 0 | | | | | | | | |
| 7 | Reserved | Same as FONT 0 | | | | | | | | |
| 8 | Business | ä | Ø | @ | £ | ¥ | ¦ | £ | ¥ | ¦ |
| 9 | Danish | # | Ø | @ | ø | ö | å | Æ | Ø | Å |

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NOTE

The TTY LOCK key affects the $\{$, $\}$, and \backslash keys in fonts 1, 2, and 9 on the 4052/4054 Graphic Systems. When the TTY LOCK key is pressed, an uppercase letter will print when you press one of these keys, regardless of whether the SHIFT key is pressed.

KEYS, BUTTONS, AND SWITCHES

Table 9-6 shows the 4052/4054 Graphic System character fonts, the font codes, the special characters that can be displayed in each font, and the ASCII Decimal Equivalent (ADE) for each of these characters. (The CHR, Character, function requires an ADE value. Refer to the 4050 Series Graphic Reference Manual for more information about the CHR function.)

Table 9-6

**ASCII DECIMAL EQUIVALENTS FOR
4052/4054 GRAPHIC SYSTEM CHARACTER FONTS**

| CODE | ASCII DECIMAL EQUIVALENT | 35 | 48 | 64 | 91 | 92 | 93 | 123 | 124 | 125 |
|------|--------------------------|----------------|----|----|----|----|----|-----|-----|-----|
| 0 | ASCII | # | 0 | @ | E | \ |] | [| | } |
| 1 | Swedish | # | 0 | @ | Å | Ö | Ä | ä | ö | å |
| 2 | German | £ | 0 | @ | Ä | Ö | U | ä | ö | ü |
| 3 | British | £ | 0 | @ | E | \ |] | [| | } |
| 4 | Spanish | # | 0 | @ | í | ñ | ¿ | [| | } |
| 5 | Graphic | # | 0 | S | E | \ |] | + | ⊗ | ⊕ |
| 6 | Reserved | Same as FONT 0 | | | | | | | | |
| 7 | Reserved | Same as FONT 0 | | | | | | | | |
| 8 | Business | £ | 0 | @ | E | \ |] | [| | } |
| 9 | Danish | # | 0 | @ | Æ | Ø | Å | æ | ø | å |

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The power-up default font (font 0, the ASCII font) can be changed on the 4054 Graphic System only. To change the power-up default font, contact your local Tektronix representative.

The Numeric Keypad

The numeric keypad is located to the right of the alphanumeric keyboard. It is used to enter numeric data and perform mathematical operations: exponentiation, division, multiplication, subtraction and addition. When the numeric keypad is used as a calculator, without a BASIC program, pressing the RETURN key causes the calculated result to print on the screen.

Although math operations can be generated from the alphanumeric keyboard, the numeric keypad is provided as an operator convenience. It provides the following: 10 numeric keys, five math operator keys, a decimal point, parentheses, and ENTER EXP (for scientific notation).

The last part of this section contains a few instructions on performing general math functions. You can refer to this for general information, or you can refer to the Math Operations section in the 4050 Series Graphic System Reference Manual for details on math operations.

The Editing Keys

The group of keys at the top center of the keyboard (Figure 9-7) are the editing keys. These keys allow convenient editing of data entry and BASIC statements. All operations are performed on the current contents of the line buffer: a keyboard entry or a program statement recalled from the program currently in RAM. (The contents of RAM are not changed until the RETURN key is pressed to send the edited line to RAM.)

The five editing keys provide control for ten different editing functions. The function shown below each key is performed by simply pressing the key. The function shown above each key is performed by pressing the editing key while holding down the SHIFT key.

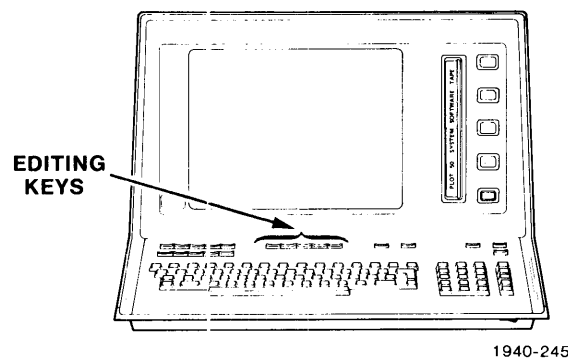
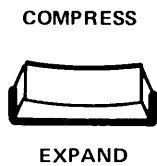


Figure 9-7. The Editing Keys.

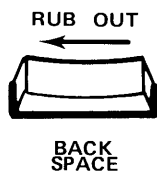
KEYS, BUTTONS, AND SWITCHES

Following are explanations of the functions of the editing keys. Notice that the rub out, backspace, and space functions can also be performed with keys on the alphanumeric keyboard.



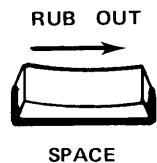
COMPRESS. Pressing this key while holding down the SHIFT key removes any spaces between the cursor position and the next non-space character in the line buffer. The portion of the line to the right of the screen is shifted to the current position of the cursor. After pressing SHIFT-COMPRESS, press RETURN to enter the line into memory if all editing functions are completed.

EXPAND. Pressing this key by itself causes the character beneath the cursor and all characters to the right of the cursor to move to the extreme right of the line buffer. On the screen, the line appears to split into left and right portions separated by a gap. The cursor remains at the extreme left of the gap. Characters may now be inserted.



RUB OUT. Pressing this key while holding down the SHIFT key is equivalent to pressing the RUB OUT key on the alphanumeric keyboard. If a character is displayed beneath the cursor, it is replaced with the Space character. If a character is not displayed beneath the cursor, the cursor backspaces one character position and then performs its function if a character is displayed in that location. See the explanation of the RUB OUT key in the description of the alphanumeric keyboard.

Pressing this key by itself duplicates the function of the BACK SPACE key on the alphanumeric keyboard; the cursor moves one character position to the left.



RUB OUT. Pressing this key while holding down the SHIFT key is equivalent to pressing the RUB OUT editing key except that the cursor moves to the right instead of the left. If a character is displayed beneath the cursor, it is replaced with a space character. If a character is not displayed beneath the cursor, the cursor moves one character position to the right and then performs its function if a character is displayed in that position.

SPACE. Pressing this key by itself is equivalent to pressing the SPACE bar on the alphanumeric keyboard. The cursor moves one character space to the right. If the cursor is in the 72nd line buffer position, no operation is performed.

REPRINT



CLEAR

REPRINT. Pressing this key while holding down the SHIFT key displays the current contents of the line buffer on the next display line. The cursor also moves down one line while retaining its position in the line.

This provides a good tool to use when a line has type-overs, rubouts, etc. Pressing SHIFT-REPRINT provides a “clean” line to check before pressing the RETURN key.

CLEAR. Pressing this key by itself clears (erases) the contents of the line buffer. This is a good tool to use when it’s easier to rewrite a statement than to edit it.

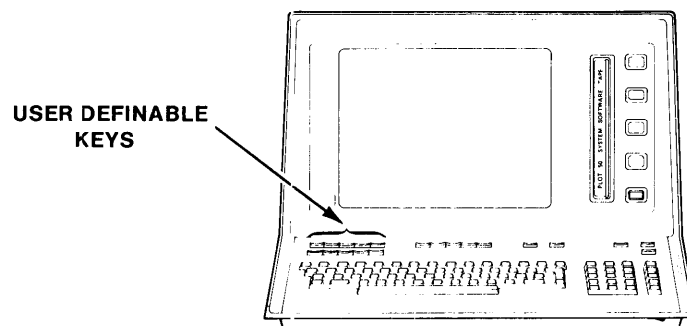
RECALL
NEXT LINERECALL
LINE

RECALL NEXT LINE. Entering a line number and then pressing this key while holding down the SHIFT key recalls a specific program line stored in RAM and places a copy of it into the line buffer. The line recalled is the statement numerically following the number you entered (the statement with the next ascending line number). The cursor is positioned at the end of the recalled line.

RECALL LINE. Entering a line number and then pressing this key alone recalls that program line from RAM and places a copy of it into the line buffer. The cursor is positioned at the end of the recalled line. You can perform your editing functions and then press RETURN to replace the initial line with the edited line.

User Definable Keys

The 10 user definable keys on the upper-left of the keyboard (Figure 9-8) allow the user to branch to any of 20 specific BASIC program locations. Ten locations are available by pressing each of the 10 user definable keys alone; ten more are available by holding down the SHIFT key while pressing each user definable key.



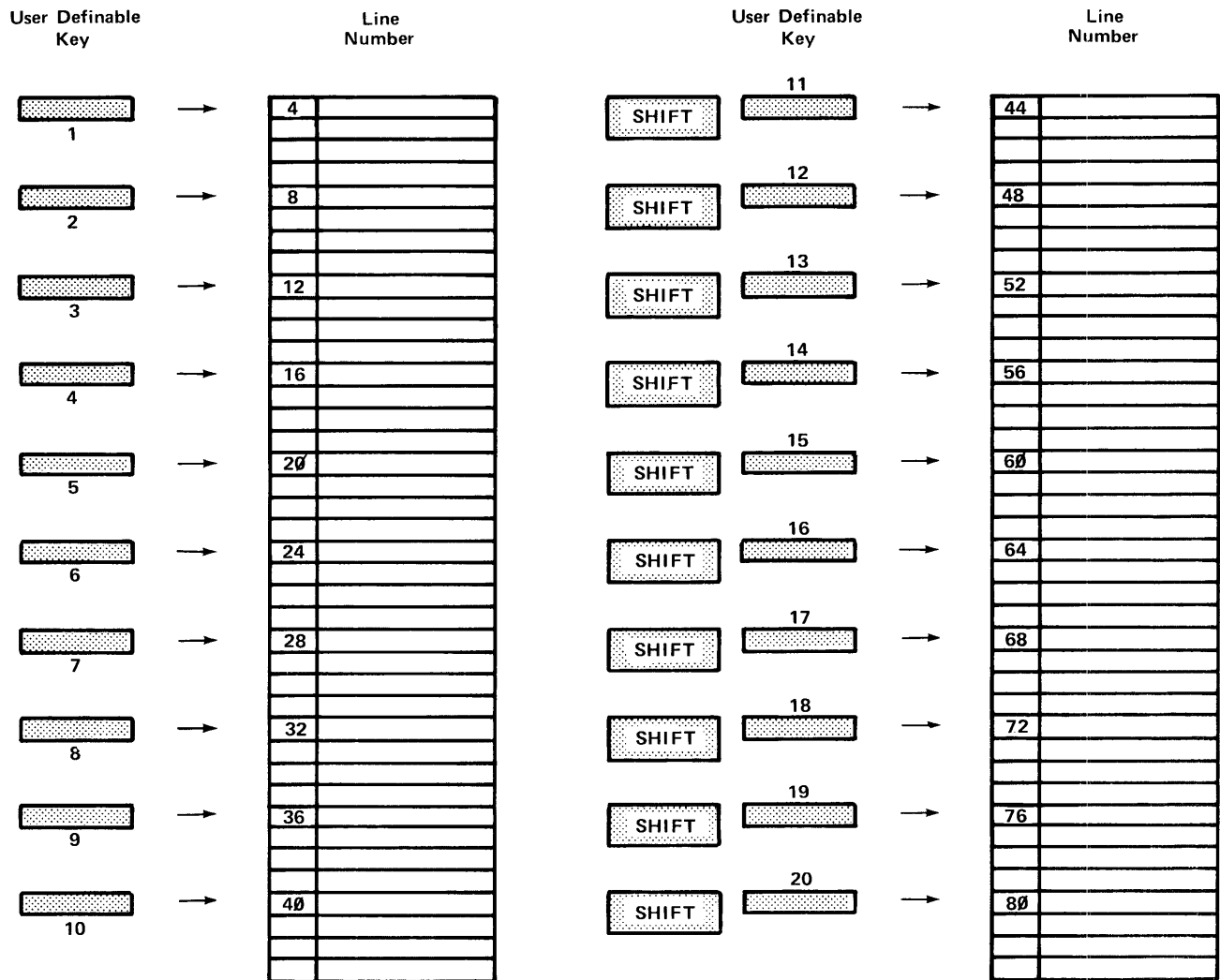
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Figure 9-8. User Definable Keys.

KEYS, BUTTONS, AND SWITCHES

The user definable keys provide a convenient means of interrupting the main program to perform a subroutine already placed in memory by the user. (The System finishes executing the current BASIC line before performing the subroutine.)

To write a program that uses the user definable keys, begin with line number 100. One of the early program statements must be the SET KEY statement to allow the System to respond to the user definable keys while the program is executing. Pressing one of the user definable keys is the same as executing a GOSUB statement: the main program is interrupted and program control is transferred to the program line number that is four times the number of the user definable key pressed. These numbers are fixed and cannot be changed. Figure 9-9 shows the line number to which program control is transferred when each user definable key is pressed (in a program with SET KEY established).



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Figure 9-9. User Definable Key Program Control Transfer.

The subroutine begins with the statement to which control is transferred and continues to execute statements in sequential order until an END, STOP, or RETURN statement is found or until the BREAK key is pressed. If none of these occur before line number 100 is reached, the System continues into the main program (which begins at line number 100). When a user defined function ends with a RETURN statement, program control is transferred back to the interrupt point in the main program.

Control can be passed from one subroutine line to another subroutine (for example, to a larger one) with a GOSUB statement. Figure 9-10 shows how this looks.

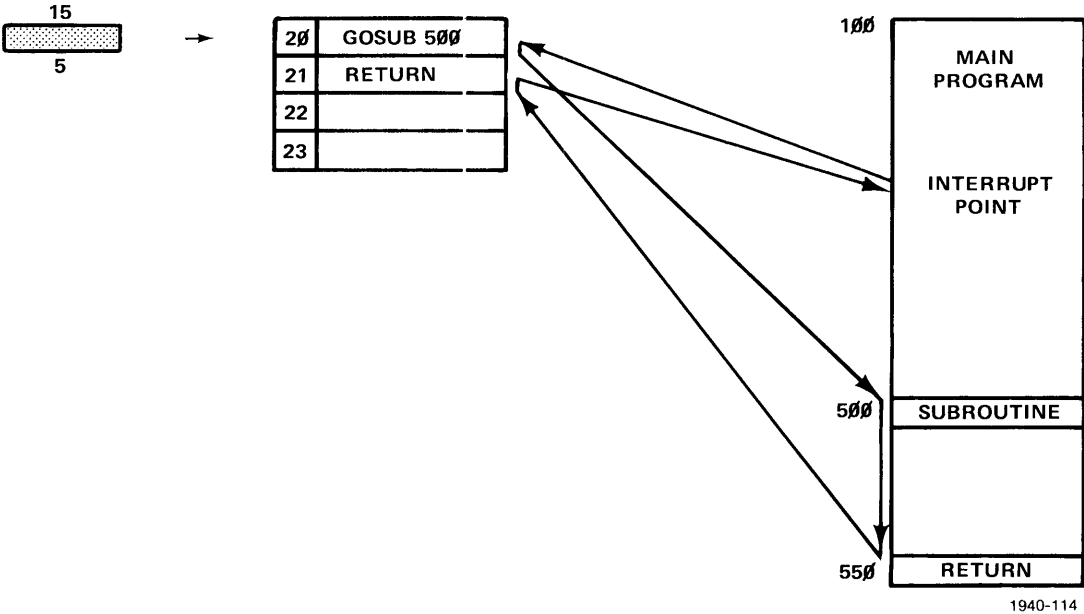


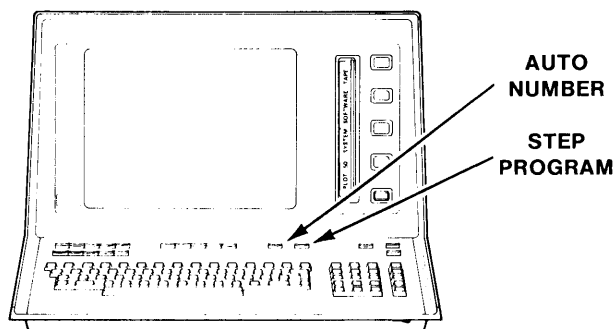
Figure 9-10. Transferring Control Between Subroutines.

User Definable Key Number 5 transfers program control to line number 20, a GOSUB 500 instruction. Line 20 then transfers control to line 500, the beginning of a large subroutine. When the larger subroutine is finished executing, a RETURN statement transfers program control back to line 21, which is also a RETURN statement. Line 21 then transfers program control back to the interruption point in the main program.

AUTO NUMBER and STEP PROGRAM

AUTO NUMBER

The AUTO NUMBER key (Figure 9-11) provides an operator convenience when entering BASIC program statements. Pressing the key once instructs the System to provide line numbers automatically for each BASIC statement entry from the keyboard. The first time the key is pressed, line number 100 is placed in the line buffer and appears on the display. After you enter a BASIC statement and press the RETURN key, the System then places line number 110 in the line buffer for the next statement entry. The line number increment is automatically set at 10. When you no longer want automatic line numbering, press the AUTO NUMBER key again.



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Figure 9-11. The AUTO NUMBER Key and the STEP PROGRAM Key.

To start the auto numbering sequence with a line number other than 100, enter the desired line number and press the AUTO NUMBER key. The System then provides line numbers starting with that number and incrementing by 10.

To specify increments other than the default increment of 10, follow the beginning line number with the desired increment number. For example, typing 150,5 and then pressing the AUTO NUMBER key provides automatic line numbering beginning with line number 150 and incrementing by 5.

STEP PROGRAM

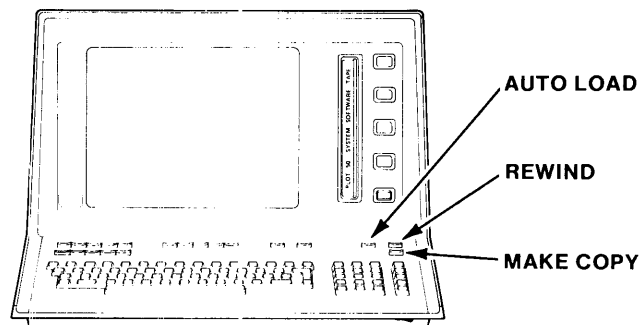
Pressing the STEP PROGRAM key (Figure 9-11) allows the operator to monitor execution of the BASIC program in RAM during debugging operations. Instead of using the RUN command, press the STEP PROGRAM key. Each time the key is pressed, one line in the program is executed.

To begin execution other than at the beginning of a program, enter a GO TO statement and specify the line number of the statement with which execution is to begin. For example, entering GO TO 500 and pressing the RETURN key causes the System to execute the program from line number 500. The program executes one step at a time as the STEP PROGRAM key is pressed repeatedly.

Refer to the 4050 Series Graphic Reference Manual for a description of the SET TRACE command, which is especially useful with the STEP PROGRAM key.

Peripheral Control Keys

Figure 9-12 shows the peripheral control keys.



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Figure 9-12. The Peripheral Control Keys.

KEYS, BUTTONS, AND SWITCHES

| | |
|-----------|--|
| AUTO LOAD | Pressing the AUTO LOAD key rewinds the internal magnetic tape, locates the first ASCII program on the tape, loads the program into the Graphic System memory (RAM), and begins executing the program. (The program doesn't have to be located in the first tape file.) Refer to the Input/Output Operations section in the 4050 Series Graphic System Reference Manual for more information on magnetic tape operations. |
| REWIND | Pressing the REWIND key causes the System to rewind the tape cartridge in the magnetic tape unit. Pressing this key is the same as executing the BASIC statement FIND 0. |
| MAKE COPY | Pressing the MAKE COPY key causes an attached hard copy unit (an optional peripheral) to make a paper copy of the information on the display. Pressing this key is the same as executing the BASIC statement COPY. |

The Thumbwheels (4054 Only)

The thumbwheels, located at the right of the 4054 keyboard (Figure 9-5B), control the movement of the full screen crosshair graphic cursor. To place the graphic cursor on the screen, enter the POINTER statement as follows and press RETURN:

```
POINTER A,B,C$
```

This displays the crosshair cursor with the intersection of the crosshairs indicating the present position of the graphic point. (The graphic point is normally used as a reference for drawing vectors.)

Moving the thumbwheels as indicated by the arrows on the keyboard moves the graphic cursor left, right, up, and down. Refer to the 4050 Series Graphic System Reference Manual for detailed POINTER statement information.

Math Operations

Introduction

This section introduces you to the mathematical capabilities of the 4050 Series Graphic System. Refer to the 4050 Series Graphic System Reference Manual and the Introduction to Programming in BASIC Manual for detailed information about mathematical operations.

The typical math operations are provided by the \uparrow (exponentiation), $/$ (division), $*$ (multiplication), $-$ (subtraction), and $+$ (addition) keys. There are also nine standard math functions, six trigonometric functions, and twenty-six user-definable math functions (not to be confused with the user definable keys) available. In addition, the 4051 Graphic System provides one matrix function, and the 4052/4054 Graphic Systems each provide six matrix functions.

First, let's define the fundamental numerical terms associated with the Graphic System: real numbers (integers, standard notation, and scientific notation), numeric constants, and numeric variables.

Real Numbers. The Graphic System treats every number as a real decimal number; that is, as a number that can be negative or positive and may or may not have a fractional part to the right of the decimal point. The numbers 5, 9.86, $-.043$, and 65000 are examples of real numbers.

INTEGERS Integers are real numbers that have no fractional parts. The numbers 1, -2 , 3, and 4 are integers.

STANDARD NOTATION Numbers written in standard notation are written with all digits displayed; for example, 3280000.00 is a number written in standard notation. No embedded spaces are allowed.

SCIENTIFIC NOTATION (E FORMAT) When a number is too big or too small to manage conveniently with standard notation, it is converted to scientific notation. Numbers written in scientific notation have a fractional part called the mantissa and a power of ten part called the exponent. For example, $3.28E+6$ is a number written in scientific notation; 3.28 is the mantissa, and $E+6$ is the exponent. The number $3.28E+6$ is the same as 3.28×10^6 , which is the same as 3280000.00. The number range of the Graphic System extends from approximately $-1.0E+308$ to approximately $1.0E+308$. The mantissa must be less than 15 characters. No embedded spaces are allowed with the exception of one space following the E. This space implies the presence of a plus (+) sign; the plus sign entry is optional, and a minus ($-$) sign may be entered as necessary.

KEYS, BUTTONS, AND SWITCHES

Numeric Constants. A numeric constant is any real number entered as numeric data. Numeric constants can be written in standard notation or scientific notation. The plus (+) or minus (–) sign associated with the number is considered part of the number.

Numeric Variables. Numeric variables are symbols that represent numeric constants. For example, assume the numeric constant 5 is assigned to the numeric variable X and the BASIC interpreter evaluates a BASIC statement containing the variable X. The BASIC interpreter replaces the X with its assigned value (5) before the statement is evaluated. Specifically, if $X=5$ and the BASIC interpreter evaluates the equation $Y=X^2$, the variable X is replaced with 5, and the result (25) is assigned to the numeric variable Y. If X does not have an assigned value when the equation $Y=X^2$ is evaluated, an undefined variable error occurs.

There are 286 possible symbols which can represent numeric constants. All twenty-six upper case letters (A-Z) are valid symbols. Also, an upper case letter followed by a digit from 0-9 is valid. For example, A, A0, A1, A2, A3, A4, A5, A6, A7, A8 and A9 are all valid symbols. Eleven possibilities exist for each letter of the alphabet, as just shown with the letter A, for a total of 286 possible symbols. If a lower case letter is entered as a numeric variable, the BASIC interpreter automatically converts it to upper case.

Numeric constants are assigned (by the operator or under program control) to numeric variables with the LET statement, the INPUT statement, and the READ statement. For a discussion of these statements refer to the 4050 Series Graphic System Reference Manual.

Numeric functions and numeric expressions can also be assigned to numeric variables as long as the function or expression can be reduced to a numeric constant. In addition, a numeric variable can assume a succession of values over a period of time, but it can represent only one value at a given time.

Numeric Range. For all practical purposes, the limits of the Graphic System are -8.98×10^{307} and $+8.98 \times 10^{307}$. It is difficult to imagine any practical problem that yields these numbers; however, it is possible to place the System in an over-range condition. In such cases, an appropriate error message will be displayed. Refer to the Error Message Appendix for explanations of error messages generated by the System.

Arithmetic Operations

The most commonly used mathematical operations are provided by the + (addition), – (subtraction), * (multiplication), / (division), and \uparrow (exponentiation) keys. If the mathematical operation is in a statement not preceded by a line number, the results are immediately displayed when the RETURN key is pressed. If the operation is part of a BASIC program (the statement is preceded by a line number), the results are not calculated until the program is executed.

Before doing the following examples, empty the line buffer by pressing the CLEAR key. Begin with simple addition:

ENTER 5+4
PRESS RETURN

The display returns the answer, 9. Now subtract:

ENTER 5-4
PRESS RETURN

The answer, 1, is displayed on the screen. Try multiplying:

ENTER 5*4
PRESS RETURN

The display shows the answer, 20. Now divide:

ENTER 20/4
PRESS RETURN

Note the answer, 5, on the display. Now do an exponentiation function:

ENTER 5²
PRESS RETURN

The screen displays 25.

As you can see, the Graphic System is designed to accept arithmetic instructions in a conventional manner. However, there are some other things you need to keep in mind when performing arithmetic operations, namely, hierarchy and the translating of algebraic expressions into BASIC.

Hierarchy. The Graphic System is designed to recognize priority, or hierarchy, for arithmetic operators. Multiplying and dividing are higher order operators than adding and subtracting. The System recognizes this. As far as you are concerned, this means that mathematical statements can be entered and executed according to the conventions of mathematics. Consider the equation $Y = A + B \times C$. When verbally expressing the relationships between A, B, and C, care must be taken to avoid misinterpretations. For example, does the expression mean "A plus the quantity B times C," or does it mean "C times the quantity A plus B"? These expressions are different and only one is correct. The Graphic System interprets relationships of this kind without misinterpretations by using the hierarchy of arithmetic operators long established as part of everyday mathematics.

Table 9-7 shows the five arithmetic operators. The Relative Hierarchy column refers to the priority of the arithmetic operators.

Table 9-7

HIERARCHY OF ARITHMETIC OPERATORS

| Operator | Operation | Relative Hierarchy |
|----------|----------------|--------------------|
| ↑ | Exponentiation | 1 |
| * | Multiplication | 2 |
| / | Division | 2 |
| + | Addition | 3 |
| − | Subtraction | 3 |

When an arithmetic expression is evaluated, exponentiation is performed first, then multiplication and division, then addition and subtraction. Equal priority operators are evaluated left-to-right. In writing arithmetic expressions, you must be aware of the hierarchy of the operators you are using.

Translating Algebraic Expressions into BASIC. Care must be exercised in translating algebraic expressions into BASIC. Table 9-8 translates several algebraic statements into BASIC.

Table 9-8

TRANSLATING ALGEBRAIC STATEMENTS INTO BASIC

| Algebraic | BASIC |
|-----------------------|-----------------|
| $4B - 3C$ | $4*B - 3*C$ |
| $X^2 + 3Y^4$ | $X^2 + 3*Y^4$ |
| $6X - \frac{1.2Y}{Z}$ | $6*X - 1.2*Y/Z$ |

Note that arithmetic expressions are represented in BASIC by a single line of numbers and symbols. This can present some difficulties in translating an expression like the following:

$$\frac{4X + 7}{2X - 3}$$

A first attempt to convert this expression into an arithmetic expression in BASIC might yield this:

$$4*X + 7/2*X - 3$$

This comes out to be interpreted as:

$$4X + \frac{7X}{2} - 3$$

The problem can be resolved through the use of parentheses:

$$(4*X + 7)/(2*X - 3)$$

Parentheses are used in BASIC as they are used in conventional algebraic notation. Table 9-9 provides some examples.

Table 9-9

PARENTHESES IN BASIC ALGEBRAIC EXPRESSIONS

| Algebraic | BASIC |
|--------------------------|------------------------|
| $\frac{Y - 3}{4Q}$ | $(Y - 3)/(4*Q)$ |
| $\frac{P - 14}{5R} + 3P$ | $(P - 14)/(5*R) + 3*P$ |
| $\frac{(5X - 3Y)^2}{2X}$ | $(5*X - 3*Y)^2/(2*X)$ |
| $\sqrt{A^2 + B^2}$ | $SQR (A^2 + B^2)$ |

KEYS, BUTTONS, AND SWITCHES

Parentheses clarify execution order. For example, in the expression

$$2X^{y+1}$$

you might be tempted to write:

$$2 * X \uparrow Y + 1$$

This is equivalent to:

$$2X^y + 1$$

Using parentheses to write this, we have:

$$2 * X \uparrow (Y + 1)$$

A frequent error in writing arithmetic expressions is that the number of left parentheses does not equal the number of right parentheses, as in the following:

$$((A + B)/(A - B)) \uparrow 2$$

which should be:

$$((A + B)/(A - B)) \uparrow 2$$

Math Functions

Table 9-10 presents the standard math functions provided by a 4050 Series Graphic System.

Table 9-10**MATH FUNCTIONS**

| Function | Purpose |
|-------------------------|--|
| ABS (Absolute Value) | Returns the absolute value of the specified numeric expression. |
| EXP (Exponent) | Returns the value of e (the natural logarithm base) raised to the power specified by the numeric expression. |
| INT (Integer) | Returns the largest integer possible without exceeding the value of the specified numeric expression. |
| LGT (Logarithm Base 10) | Returns the logarithm of the specified numeric expression to the base 10. |
| LOG (Logarithm Base e) | Returns the logarithm of the specified numeric expression to the base e (the natural logarithm base). |
| PI (π) | Returns the value 3.14159265359. |
| RND (Random Number) | Returns a random number between 0 and 1. |
| SGN (Signum or Sign) | Returns +1 if the specified numeric expression is positive, 0 if the specified numeric expression is zero, and -1 if the specified numeric expression is negative. |
| SQR (Square Root) | Returns the square root of the specified numeric expression. |

The Math Operations section of the 4050 Series Graphic System Reference Manual explains the math functions in detail and provides examples.

Trigonometric Functions

Trigonometry provides a method of finding the values of the remaining angles and sides of a right triangle when only a few angles and sides are known. Table 9-11 explains the six trigonometric functions available for use in math operations.

Table 9-11

TRIGONOMETRIC FUNCTIONS

| Function | Purpose |
|-------------------|--|
| SIN (Sine) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as an angle, and returns the sine of the angle expressed in the current trigonometric units for the System. |
| COS (Cosine) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as an angle, and returns the cosine of the angle expressed in the current trigonometric units for the System. |
| TAN (Tangent) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as an angle, and returns the tangent of the angle expressed in the current trigonometric units for the System. |
| ASN (Arc Sine) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as the sine of an angle, and returns the angle expressed in the current trigonometric units for the System. |
| ACS (Arc Cosine) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as the cosine of an angle, and returns the angle expressed in the current trigonometric units for the System. |
| ATN (Arc Tangent) | This function reduces the specified numeric expression to a numeric constant, interprets the numeric constant as the tangent of an angle, and returns the angle expressed in the current trigonometric unit for the System. |

The Math Operations section of the 4050 Series Graphic System Reference Manual explains each of these trigonometric functions in detail and provides examples.

Matrix Functions

Table 9-12 shows the matrix functions provided by the 4052 Graphic System and the 4054 Graphic System. The only matrix function available in the 4051 graphic system is the SUM function. The SUM function algebraically adds the elements of the specified array and returns their sum to a numeric expression or to the Graphic System display.

Table 9-12

4052/4054 GRAPHIC SYSTEM MATRIX FUNCTIONS

| Function | Purpose |
|--------------------------------|--|
| DET (Determinant) | This function returns the value of the determinant. |
| IDN (Identity) | This routine creates a matrix whose elements are 1's along the diagonal and 0's elsewhere. |
| INV (Inverse) | This function performs matrix inversion and solves systems of linear equations. |
| MPY (Matrix Multiplication) | This function returns the matrix product of two arrays. |
| SUM | This function returns the algebraic sum of the elements in the specified array. |
| TRN (Transpose) | This function returns the transpose of a matrix. |

The Math Operations section of the 4050 Series Graphic System Reference Manual explains each of the matrix functions and provides examples.

User-Definable Math Functions

The 4050 Series Graphic System allows you to define a maximum of 26 numeric expressions as numeric functions. Defining a numeric expression as a function is convenient when the expression must be specified repeatedly throughout a BASIC program. The DEF FN (Define Function) statement is explained in detail in the Math Operations section of the 4050 Series Graphic System Reference Manual.

Section 10

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Section 10

MAINTENANCE

GENERAL

Beyond the need for occasional cleaning, there is little need for routine maintenance of your 4050 Series Graphic Computing System. However, this section provides a recommended routine maintenance schedule and maintenance procedures. It also provides procedures you may occasionally need for fuse replacement, tape cartridge respooling, and hard copy intensity adjustment.

ROUTINE MAINTENANCE

Table 10-1 provides a routine maintenance schedule and lists the only routine maintenance required.

Table 10-1

ROUTINE MAINTENANCE SCHEDULE

| Item | Interval |
|-----------------------------|--|
| Tape head | Every three months (more frequently if needed) |
| Dust filter (4051/4054 fan) | As needed |
| Verification Program(s) | Monthly |
| Exterior surfaces | As needed |

Cleaning the Tape Head

The surface of the internal magnetic tape unit head (Figure 10-1) must be kept clean to preserve the life of the tape head and to prevent data errors. Oxide deposits, dust, and other foreign particles may be deposited on the tape head during tape operation and act as abrasives. Frequency of cleaning depends on the amount of tape use and the cleanliness of the area in which the Graphic System is used. The following procedure describes how to inspect and clean the tape head.

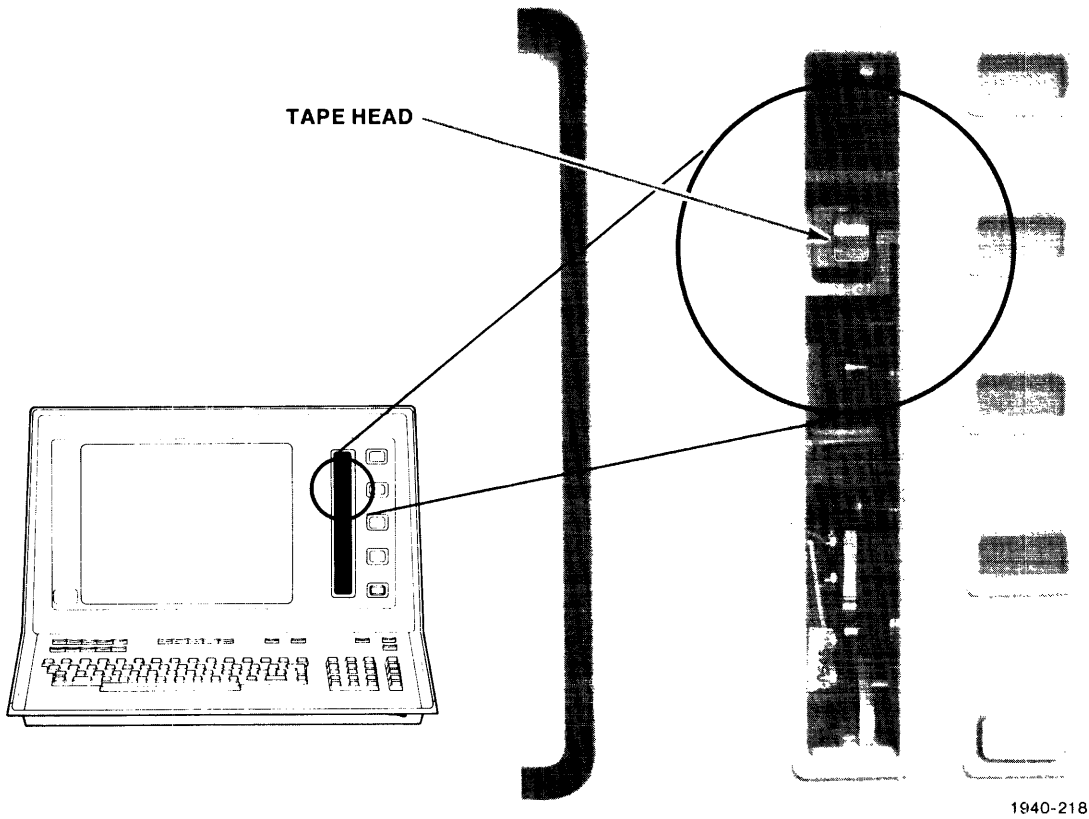


Figure 10-1. Tape Head Location.

CAUTION

Do not use magnetic devices near the tape head. Do not touch the head with metal or other hard objects. Doing so may damage the head, resulting in damage to tape cartridges and causing loss of data.

1. Turn OFF the Graphic System power switch.
2. Unplug the System power cord from the power source.
3. Inspect the tape head by shining a light, such as a penlight, at an angle across the surface of the head. This reveals accumulations of foreign material or damage to the head.
4. If the head is dirty, continue with this procedure. However, if the head is scratched, scored, or excessively worn (Figure 10-2), it should be replaced by a Tektronix Field Service Specialist.

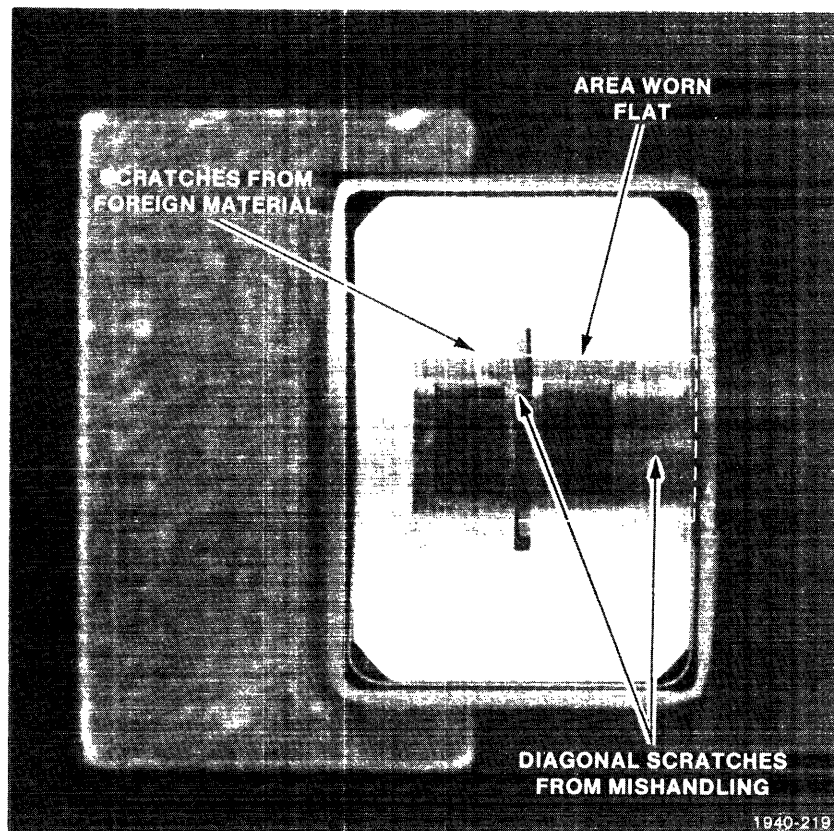
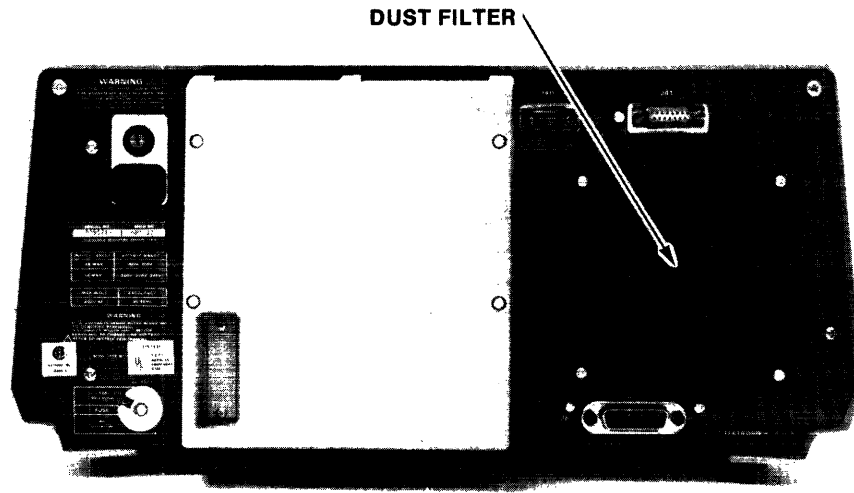


Figure 10-2. Tape Head Damage.

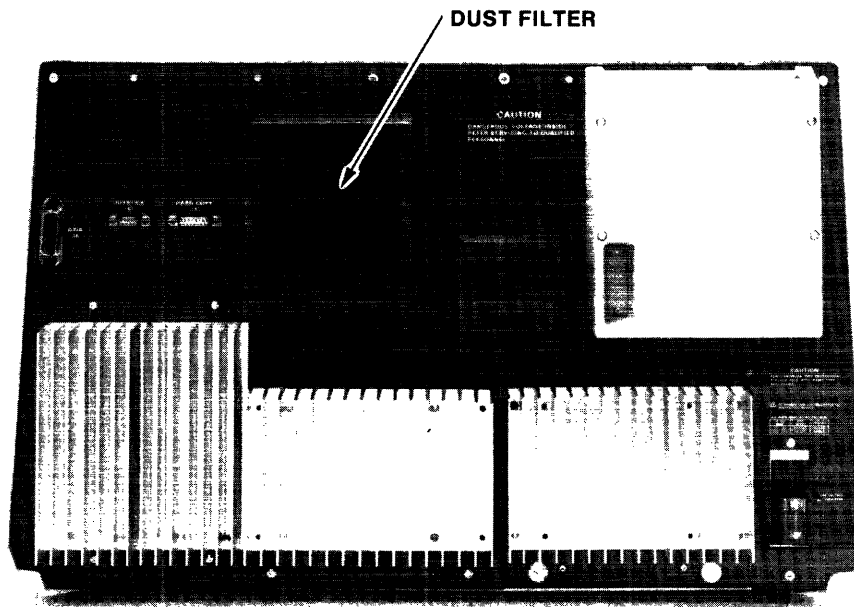
5. To rub off accumulated matter, use a cotton swab moistened with isopropyl alcohol or a special cleaning pad (available through a Tektronix representative.) Light accumulations of oxide are usually readily removable. Heavy or long-term accumulations may require more cleaning with alcohol and clean swabs. Use extreme care when cleaning the head to prevent scratching or damaging the head surface.
6. After removing all accumulated matter, use a clean, dry cotton swab to polish the head and remove alcohol residue.
7. Plug the Graphic System power cord into your power source.
8. Turn ON the System power switch and run the Software Verification Program to check magnetic tape unit operation. (See the System Verification section.)

MAINTENANCE

Cleaning the Dust Filter (4051/4054 Fan Only)



A. 4051



B. 4054

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Figure 10-3. Dust Filter.

Figure 10-3 shows the dust filter on the rear panel. This filter should be checked periodically and cleaned as needed to ensure optimum air flow through the System. The cleaning procedure follows.

1. Turn OFF the Graphic System power switch.
2. Unplug the System power cord from your power source.
3. Remove the dust filter by pulling it through the opening in the filter bracket.
4. Shake loose as much dust as possible (or vacuum the filter).
5. Clean the filter in a mild detergent and water solution, rinse, and dry.



Do not clean the filter with any other spray or solution. Be sure the filter is thoroughly dry before replacing it into the Graphic System.

6. Replace the filter.
7. Plug the Graphic System power cord into your power source and turn ON the System power switch.

Running the Verification Software

Running the System Verification Program(s) checks out the System internal components and the System memory. They run in less than 10 minutes and should be run monthly, after cleaning the internal magnetic tape unit head, and anytime System performance is in doubt. See the System Verification section for detailed instructions.

Cleaning Exterior Surfaces



Avoid the use of chemical cleaning agents that might damage the plastics, paint, or metal in this instrument. Avoid chemicals that contain benzene, toluene, xylene, acetone, or similar solvents.

The keyboard and other exterior surfaces of the Graphic System can be cleaned with a mild detergent and water solution. Dampen a soft cloth with the solution and wring it out thoroughly before wiping the surface. The display screen can also be cleaned with a glass cleaner: spray the cleaner onto a soft cloth, wring the cloth thoroughly, then wipe the display. Touch-up paint for extensive scratches and finish damage may be ordered through a Tektronix representative.

Cycling a Tape Cartridge

It is wise to cycle (wind and rewind) a tape periodically to keep tension evenly adjusted and to prevent irregular stacking. This is especially important if only a portion of the tape is used repeatedly. Cycling a tape is very easy with the 4052 and 4054 Graphic Systems: simply enter CALL "MTPACK" and press RETURN.

To cycle a tape with the 4051 Graphic System, remove the write-protection and proceed as follows. This procedure does not destroy data that is already on the tape.

FIND n (n is the LAST file on the tape)

MARK 1, 400000 (large enough to reach the end of the tape without room for a
LAST file)

The 4051 Graphic System will reach the end of the tape, rewind it, and display an error message. Restore the LAST file before write-protecting your tape:

FIND n (n is the NEW file just marked)

MARK 1,1 (establishes a LAST file)

Cycling a tape cartridge is also valuable if the tape has been dropped or has undergone a significant temperature change.

SPECIAL MAINTENANCE

Fuse Replacement

If nothing happens when you turn on the power switch, turn off the power switch and check the following: (1) that your System is connected to the proper power source, (2) that the rear-panel fuse (Figure 10-4) is the correct value, and (3) that the rear panel fuse is not blown.

If all of the following normal power-up events do not occur when you turn on the power switch, note those that do not occur; especially note and record the activity of the front-panel indicator lights. Report all power-up failure information to your Tektronix Field Office.

The normal power-up events include:

- The four green indicator lights on the front panel (BUSY, BREAK, I/O, and POWER) turn on.
- The BUSY, BREAK, and I/O lights turn off.
- The POWER light remains on.
- If a tape is in the tape unit, the tape rewinds to the beginning.
- A blinking cursor appears in the upper-left corner of the screen. (It may be necessary to press the HOME/PAGE key to view the cursor.)

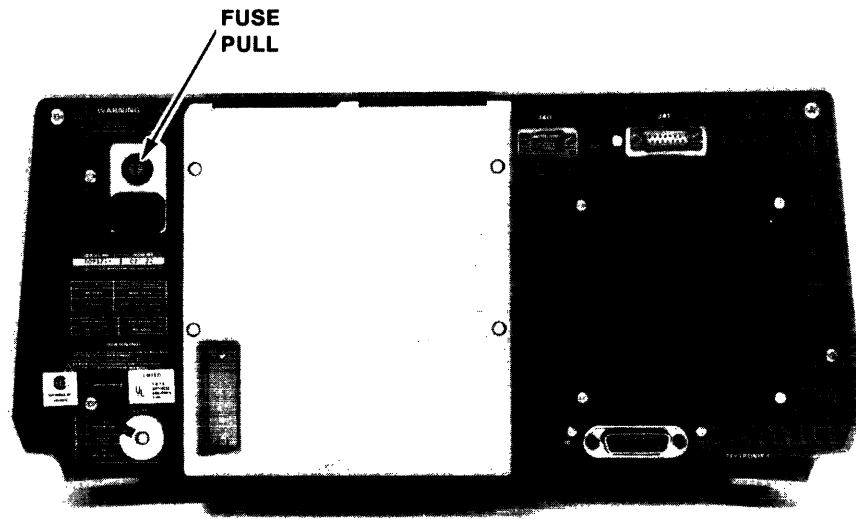
Table 10-2 lists the values for correct fuse protection, and Figure 10-4 shows the rear-panel fuse location for your System.

Table 10-2

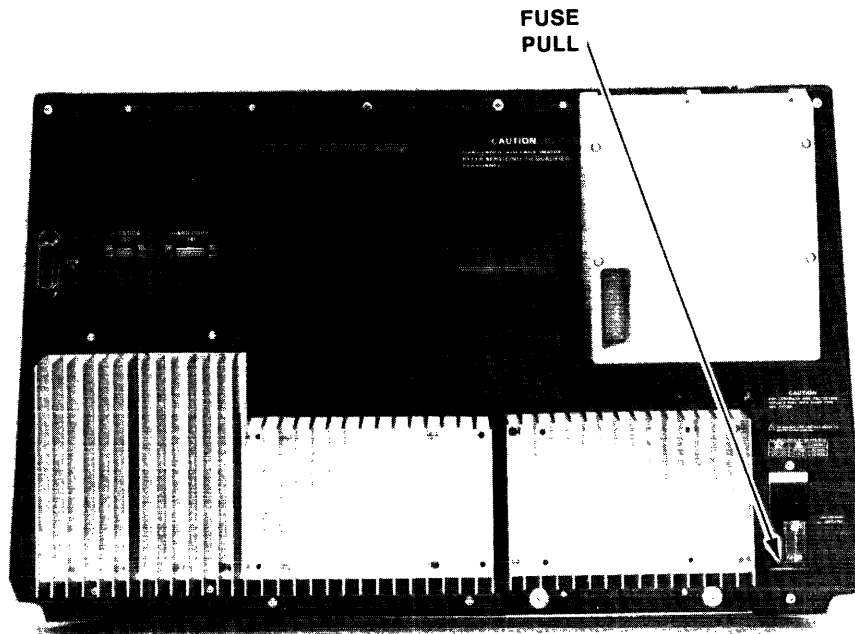
FUSE PROTECTION

| | 4051 | 4052 | 4054 |
|---------|-------------------|---------------|---------------|
| 115 Vac | 1.6 A medium blow | 3 A fast blow | 5 A fast blow |
| 230 Vac | .8 A medium blow | 3 A fast blow | 3 A slow blow |

MAINTENANCE



A. 4051/4052



B. 4054

1940-221

Figure 10-4. Rear-Panel Fuse Location.

If a fuse blows repeatedly, do not continue to operate the System; call your Tektronix Field Office.

The following procedure describes how to replace the 4051/4052 rear-panel fuse.

1. Turn OFF the Graphic System power switch.
2. Unplug the System power cord from your power source.
3. Use a screwdriver to turn the fuse holder 1/8 turn counterclockwise.
4. Pull the fuse holder straight out.
5. Remove the old fuse and place the new fuse in the fuse holder (inserting either end).
6. Replace the fuse holder and gently turn it clockwise until it slips into a groove.
7. Push the fuse holder straight in (against spring loading).
8. Use a screwdriver to turn the fuse holder 1/8 turn clockwise.
9. Plug the Graphic System power cord into your power source.
10. Turn ON the System power switch.

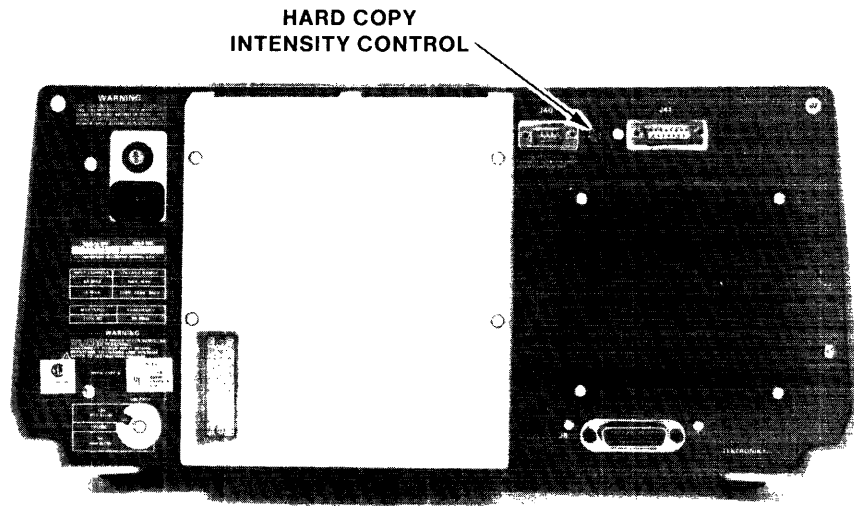
The following procedure describes how to replace the 4054 rear-panel fuse.

1. Turn OFF the Graphic System power switch.
2. Unplug the power cord from the 4054.
3. Slide up the plastic door below the power connector.
4. Slide the FUSE PULL upward as far as possible.
5. Remove the fuse.
6. Slide the FUSE PULL downward as far as possible.
7. Insert the new fuse (either end up).
8. Slide the plastic door downward.
9. Attach the power cord to the 4054.
10. Turn ON the Graphic System power switch.

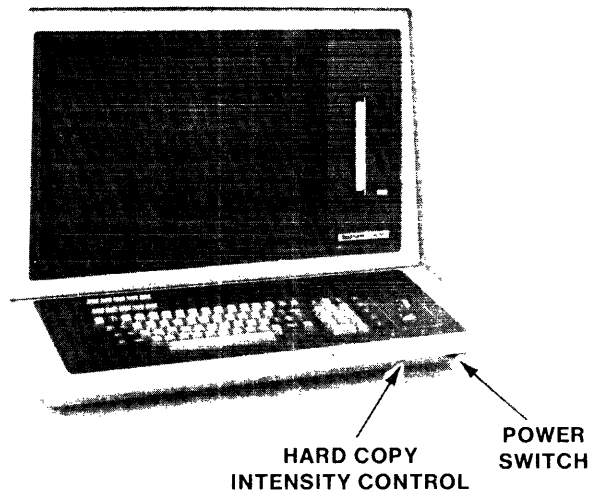
MAINTENANCE

Hard Copy Intensity Adjustment

Figure 10-5 shows the location of the hard copy intensity control. This adjusts the contrast of a hard copy if an optional hard copy unit is part of your Graphic System configuration. An optimal setting produces a hard copy without dark edges, without filling in of characters, and without storage on the screen from the hard copy scanning bar. Adjusting the hard copy intensity control eliminates these effects, but turning it too far produces a copy that is incomplete and without detail.



A. 4051/4052



B. 4054

1940-240

Figure 10-5. Hard Copy Intensity Control.

Tape Cartridge Respooling

The tape cartridge used in the Graphic System is open-ended; that is, the tape ends are not secured to either of the spools. The magnetic tape unit relies on light-sensing of small holes at either end of the tape to stop tape motion before the physical end of the tape is reached. Under certain conditions, such as a possible circuit failure, a burned-out lamp, or an obstruction (such as a soiled cartridge or lamp-detector assembly) in the light path (Figure 10-6), the tape may fail to stop in time. This results in a tape end coming off one of the spools. If you suspect the cause is a circuit failure or a burned out lamp, contact the Tektronix Field Office. In any event, you will want to wind the tape back onto the empty spool. Use the following procedure.

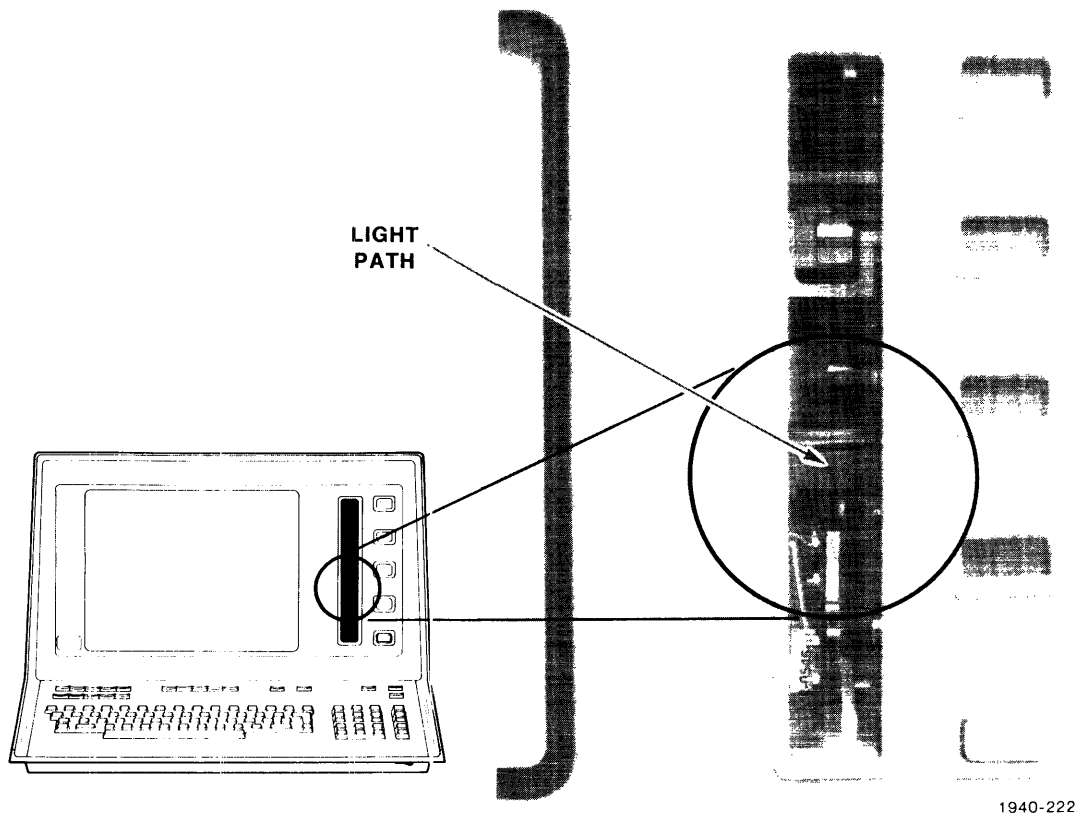


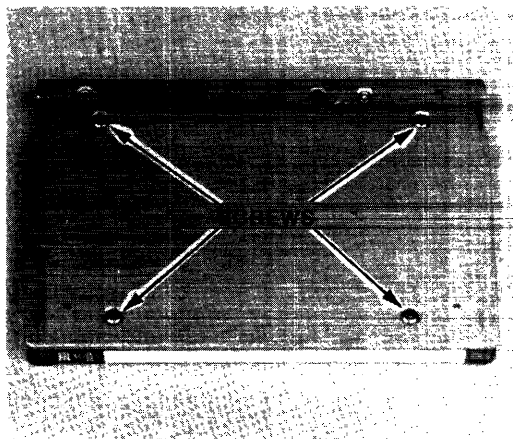
Figure 10-6. Light Path Location.

MAINTENANCE

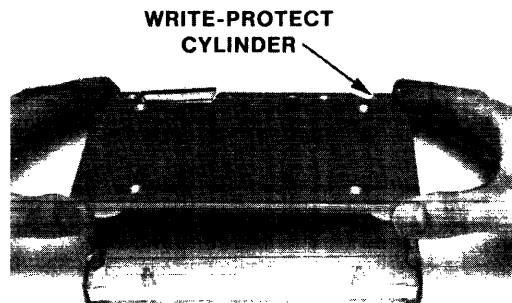


Do not use a magnetic screwdriver when working on or around a tape cartridge.

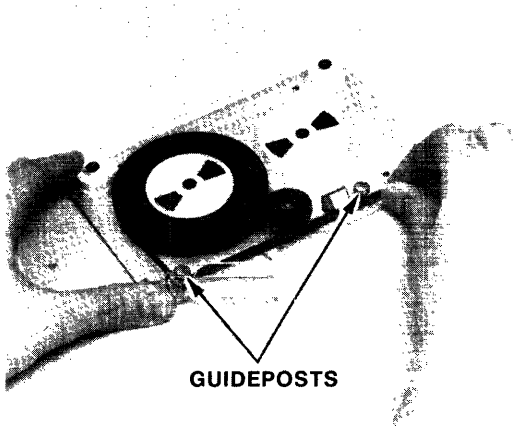
1. Position the tape cartridge with the metal side up and remove the four screws that attach the metal base to the plastic cover (Figure 10-7A).
2. Carefully remove the metal base from the plastic case (Figure 10-7B). Be careful not to lose the plastic write-protect cylinder or the small metal spring washer between the cylinder and the metal base.
3. Turn the base over and place the loose end of the tape across the front of the cartridge, threading it in front of the two guideposts (Figure 10-7C).
4. Keeping light tension on the tape, place the loose end of the tape around the outside edge of the take-up spool to the point where the spool meets the white tension band (Figure 10-7D).
5. Rotate the drive roller (Figure 10-7E) clockwise, causing the tape to pass around the take-up spool with the loose end passing between the tension band and the spool.
6. Hold the loose end of the tape against the spool and continue rotating the drive roller until the loose end passes under the continuing length of tape. Continue to rotate the spool by turning the drive roller until three sets of double holes have passed both guideposts. Make certain that these first windings are centered between the spool edges.
7. Be sure that the write-protect cylinder is in position, with the spring washer between the cylinder and the metal cartridge base. Position the metal base over the plastic case (Figure 10-7F) and be sure to fit the write-protect cylinder through the opening in the metal base. Be careful not to catch or wrinkle the tape with the plastic case. Replace the four screws and tighten them evenly.
8. Check the light path (Figure 10-6) and remove any obstructions (lint, dust, etc.). Insert the tape cartridge in the tape unit and cycle the tape as described in the Routine Maintenance section. If the problem reoccurs and you have removed any obstructions from the light path, contact your Tektronix Field Office before loading another tape.



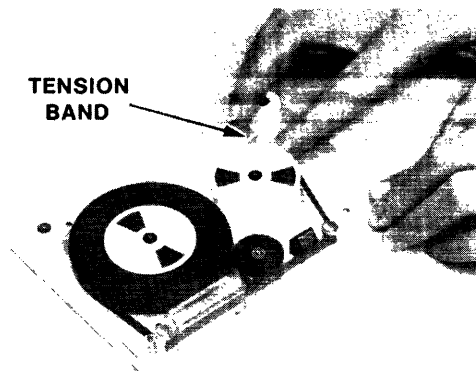
A. Positioning the Tape Cartridge.



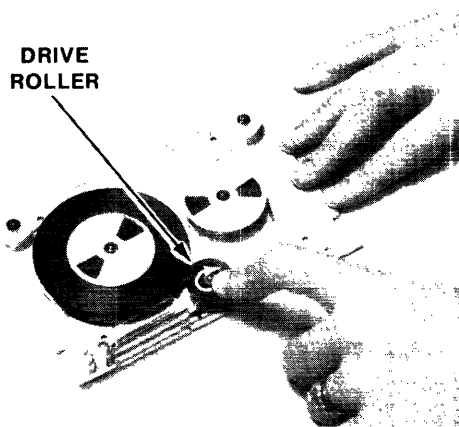
B. Dissassembling the Tape Cartridge.



C. Positioning the Tape Within the Cartridge

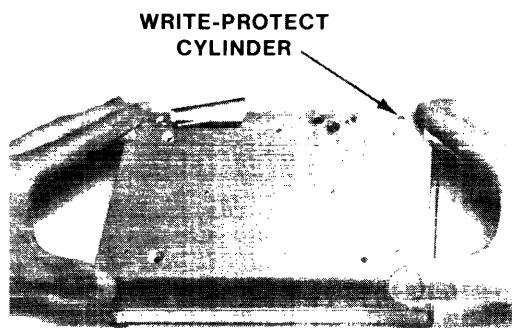


D. Beginning the Tape Winding.



E. Winding the Tape.

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F. Assembling the Tape Cartridge.

Figure 10-7. Tape Cartridge Respooling Procedure.

Appendix A

Appendix A

ERROR MESSAGES

| Message Number | Error Message |
|----------------|---|
| 0 | <p>A firmware failure has occurred. Turn OFF the power switch and wait five seconds before turning it ON again.</p> <p>Example:</p> <p> Loading into the 4051 a program which contains commands available only in the 4052/4054 Graphic Systems.</p> |
| 1 ^a | <p>An arithmetic operation has resulted in an out of range number.</p> <p>Example:</p> <p> 1/1.0E--308</p> |
| 2 ^a | <p>A divide by zero operation has resulted in an out of range number.</p> <p>Example:</p> <p> 4/0</p> |
| 3 ^a | <p>An exponentiation operation has resulted in an out of range number.</p> <p>Example:</p> <p> 511.0E+300</p> |
| 4 ^a | <p>An exponentiation operation involving the base e has resulted in an out of range number.</p> <p>Example:</p> <p> EXP (1.0E+234)</p> |
| 5 ^a | <p>The parameter of a trigonometric function is too large; that is, the variable N in the statement A=SIN(N*2*PI) is greater than 65536.</p> <p>Example:</p> <p> A=SIN(4.2E+5) when the trigonometric units are set to RADIANS.</p> |
| 6 ^a | <p>An attempt has been made to take the square root of a negative number. The positive square root is returned by default.</p> <p>Example:</p> <p> SQR (-4)</p> |

^a This error is caused by a math operation which produces a predefined out of range number. This error condition can be handled by the BASIC program without terminating program execution. Refer to the ON ... THEN ... statement in the 4050 Series Graphic System Reference Manual for details.

| Message Number | Error Message |
|----------------|---|
| 16 | There is an invalid parameter in the FUZZ statement. Example: FUZZ -10 |
| 17 | There is an invalid parameter in a RENUMBER operation due to one of the following: <ol style="list-style-type: none"> <li>1. The first or third parameter is not a line number within the range 1 through 65535. <li>2. The increment (second parameter) is not within the range 1 through 65535 or is so large that out of range line numbers are generated during the RENUMBER operation. <li>3. Statement replacement or statement interlacing will occur if the RENUMBER operation is attempted. <p>This error may occur during an APPEND operation.</p> |
| 18 | Not used. |
| 19 | There is an invalid parameter in a GO TO, FOR, or NEXT statement. Example: 500 FOR I=1 to 20 where I has been previously defined as an array variable. |
| 20 | The logical unit number specified in the statement is not within the range 0 through 9. 100 ON EOF (10) THEN 500 |
| 21 | The assignment statement is invalid because of one of the following: <ol style="list-style-type: none"> <li>1. An attempt has been made to assign an array to a numeric variable. <li>2. Two arrays in the statement are not conformable (not of the same dimension and/or do not have the same number of elements). <li>3. An attempt has been made to assign a character string to a string variable and the character string is larger than the dimensioned size of the variable. |
| 22 | There is an error in an exponentiation operation because the base is less than 0 and the exponent is not an integer less than 256. Example: -10 ^{1257.5} |

ERROR MESSAGES

| Message Number | Error Message |
|-----------------|--|
| 23 | An attempt has been made to take the LOG or LGT of a number which is equal to or less than 0. Example: LOG (-1) |
| 24 | The parameter of the ASN function or the ACS function is not within the range -1 to +1. Example: ASN (2) |
| 25 | The parameter of the CHR function is not within the range 0 through 127. Example: A\$=CHR(128) |
| 26 | Not used. |
| 27 | The parameter is out of the domain of the function. Example: A\$=STR(X) where X has been previously defined as an array variable. |
| 28 | A REP function parameter is invalid. |
| 29 | The parameter in the VAL function is not a character string containing a valid number. Example: A=VAL("Hi") |
| 30 | The matrix multiplication operation failed because the arrays are not conformable. |
| 31 ^a | The matrix inversion failed because the determinant was 0. This error is treated as a SIZE error. |
| 32 | The routine name specified in the CALL statement can not be found. Example: CALL "FIX IT" where the routine "FIX IT" resides in a ROM pack which is not plugged into the System. |
| 33 | Not used. |

^a This error is caused by a math operation which produces a predefined out of range number. This error condition can be handled by the BASIC program without terminating program execution. Refer to the ON ... THEN ... statement in the 4050 Series Graphic System Reference Manual for details.

| Message Number | Error Message |
|----------------|--|
| 34 | <p>The DATA statement is invalid because of one of the following:</p> <ol style="list-style-type: none"> 1. There isn't a DATA statement in the current BASIC program. 2. There is not enough data in the DATA statement from the present position of the pointer to the end of the statement. 3. An attempt has been made to RESTORE the data statement pointer to a nonexistent DATA statement. |
| 35 | <p>The statements DEF FN, FOR, and ON . . . THEN . . . can not be entered without a line number.</p> |
| 36 | <p>There is an undefined variable in the specified line. A numeric variable has not been assigned a value or an array element has not been assigned a value.</p> <p>Example:</p> <pre> INIT DIM A(2,2) A(1,2) = 4 PRINT A </pre> |
| 37 | <p>An extended function ROM (Read Only Memory) is required to perform this operation.</p> |
| 38 | <p>This output operation cannot be executed because the current BASIC program is marked SECRET.</p> |
| 39 | <p>This operation can not be executed because the Random Access Memory is full. Some program lines or variables must be deleted.</p> |
| 40 | <p>Not used.</p> |
| 41 | <p>A SIZE interrupt condition has occurred and an ON SIZE THEN statement has not been executed in the current BASIC program.</p> |
| 42 | <p>A PAGE FULL interrupt condition has occurred.</p> |
| 43 | <p>A peripheral device on the General Purpose Interface Bus is requesting service and an ON SRQ THEN . . . statement has not been executed in the current BASIC program.</p> |
| 44 | <p>The EOI signal line on the General Purpose Interface Bus has been activated and an ON EOI THEN . . . statement has not been activated in the current BASIC program.</p> |

ERROR MESSAGES

| Message Number | Error Message |
|----------------|--|
| 45 | A ROM pack is requesting service and the ON UNIT for external interrupt number 1 has not been activated in the current BASIC program. |
| 46 | A ROM pack is requesting service and the ON UNIT for external interrupt number 2 has not been activated in the current BASIC program. |
| 47 | A ROM pack is requesting service and the ON UNIT for external interrupt number 3 has not been activated in the current BASIC program. |
| 48 | The end of the current file has been reached on an I/O device and an ON EOF THEN . . . statement has not been executed in the current BASIC program. |
| 49 | The statement in the specified line is too long. This error situation occurs if an attempt is made to LIST or SAVE a BASIC program which contains a line with more than 72 characters. Sometimes a RENUMBER operation can make a line longer than 72 characters. |
| 50 | The incoming BASIC program contains a line with more than 72 characters. |
| 51 | The line number specified in this statement cannot be found or is invalid. Example: GO TO 500 where the line 500 doesn't exist or PRINT USING 100: where line 100 isn't an IMAGE statement. |
| 52 | Either the specified magnetic tape file doesn't exist or an attempt has just been made to KILL the LAST (dummy) file. |
| 53 | After 10 attempts, the internal magnetic tape unit has been unable to read a portion of the current magnetic tape. The tape head has been positioned after the bad portion in the file to allow the rest of the file to be read. |
| 54 | The end of the magnetic tape medium has been detected. Marking a file longer than the remaining portion of the tape can cause this error. |
| 55 | An attempt has been made to incorrectly access a magnetic tape file. Example: Executing an OLD statement when the tape head is positioned in the middle of a file. |

| Message Number | Error Message |
|-----------------------|---|
| 56 | An attempt has been made to send information to a write-protected tape. Remove the tape cartridge, rotate the write-protect cylinder until the black arrow points away from SAFE, insert the tape cartridge, and try the operation again. |
| 57 | An attempt has been made to read to or write to a nonexistent tape cartridge. Insert a tape cartridge into the tape slot and try the operation again. |
| 58 | An attempt has been made to read data which is stored in an invalid magnetic tape format. The tape format must be compatible with the Graphic System. |
| 59 | A program was not found when the OLD statement was executed. |
| 60 | Not used. |
| 61 | An attempt has been made to execute an invalid operation on an open magnetic tape file. Example: Executing a MARK statement with the tape head positioned in the middle of an open data file. |
| 62 | There is a disc file system parameter error. |
| 63 | There is an error in a binary data header, most likely caused by a machine malfunction. |
| 64 | The character string is too long to output in binary format. The length is limited to 8192 characters. |
| 65 | A parity error has occurred in the 4052 or 4054 RAM memory. Although the error is nonfatal (and the message will not be repeated), further operations are unreliable until power has been turned off and back on. In the 4051 this error is not used. |
| 66 | The primary address in the specified line is not within the range 1 through 255. |

ERROR MESSAGES

| Message Number | Error Message |
|----------------|---|
| 67 | An attempt has been made to execute an illegal I/O operation on an internal peripheral device. Example: DRAW @ 33:50,50 |
| 68 | The diagnostic loader failed. |
| 69 | An input error or an output error has occurred on the General Purpose Interface Bus. Both the NDAC and NRFD signal lines are inactive high, which is an illegal GPIB state. This usually means that there are no peripheral devices connected to the GPIB. |
| 70 | There is an incomplete literal string specification in the format string. Example: 100 IMAGE 6D,5("MARK |
| 71 | A format string is not specified for the PRINT USING operation. |
| 72 | A format string is too short or not enough matching data is specified. Example: 100 IMAGE 6D 110 PRINT USING 100: 23,24,25 Line 100 should be: 100 IMAGE 3(6D) |
| 73 | There is an invalid character in the format string specified in the PRINT USING statement. |
| 74 | An n modifier in the format string is out of range or is incorrectly used. When used with the E field operator, n modifiers must be positive integers within the range 1 through 11; they must be within the range 1 through 255 when used with the A,D,L,P,T,X, " , (, and / field operators. |
| 75 | The format string specified in the PRINT USING statement is too long (that is, there are too many data specifiers for the PRINT statement). Example: 100 IMAGE 3(6D) 110 PRINT USING 100:A,B Line 100 should be: 100 IMAGE 2(6D) |
| 76 | Parentheses are incorrectly used in the format string which is specified in the PRINT USING statement. Example: 100 IMAGE 2(6D 110 PRINT USING 100:A,B Line 100 should be: 100 IMAGE 2(6D) |

| Message Number | Error Message |
|----------------|--|
| 77 | <p>There is an invalid modifier to a field operator in the format string which is specified in the PRINT USING statement.</p> <p>Example:</p> <pre>100 IMAGE 2(6D),2S 110 PRINT USING 100:A,B</pre> <p>Line 100 should be: 100 IMAGE 2(6D),S An n modifier is not allowed.</p> |
| 78 | <p>An S modifier is incorrectly positioned in the format string which is specified in the PRINT USING statement. The S modifier must always be positioned at the end of the format string.</p> <p>Example:</p> <pre>100 IMAGE 4D,S,8A</pre> <p>Line 100 should be: 100 IMAGE 4D,8A,S</p> |
| 79 | <p>A comma is incorrectly used in the format string which is specified in the PRINT USING statement.</p> <p>Example:</p> <pre>100 IMAGE 6,D,S</pre> <p>Line 100 should be: 100 IMAGE 6D,S</p> |
| 80 | <p>A decimal point is incorrectly used in the format string which is specified in the PRINT USING statement.</p> <p>Example:</p> <pre>100 IMAGE .3D 110 PRINT USING 100:812.345</pre> <p>Line 100 should be: 100 IMAGE FD.3D</p> |
| 81 | <p>A data type mismatch has occurred in the PRINT USING statement.</p> <p>Example:</p> <pre>100 IMAGE 6D,6A 110 PRINT USING 100: "MARY",26</pre> <p>Line 100 should be : 100 IMAGE 6A,6D</p> |
| 82 | <p>A tabbing error has occurred in the format string which is specified in the PRINT USING statement.</p> <p>Example:</p> <pre>100 IMAGE 10A,2T,FD 110 PRINT USING 100: "ENTER DATA",D</pre> <p>The absolute tab to positon 2 specified by 2T in line 100 cannot occur because the cursor has already advanced beyond position 2. The tab specification must be at least 11T in this case.</p> |

ERROR MESSAGES

| Message Number | Error Message |
|----------------|--|
| 83 | <p>A number specified in the PRINT USING statement contains an exponent outside the range ± 127.</p> <p>Example:</p> <pre>100 IMAGE FD.3D 110 PRINT USING 100:8.5E+200</pre> |
| 84 | <p>The IMAGE format string was deleted during the PAGE FULL interrupt routine.</p> |
| 85 | <p>A portion of the IMAGE format string was deleted or altered during the PAGE FULL interrupt routine.</p> |
| 86 | <p>A portion of the data specified in the PRINT statement was deleted during the PAGE FULL interrupt routine.</p> |
| 87 | <p>A data item specified in the PRINT USING statement is too large to fit into the print field specified in the format string.</p> <p>Example:</p> <pre>100 IMAGE 5A 110 PRINT USING 100: "HORSE FEATHERS"</pre> <p>In this example, the string constant "HORSE FEATHERS" is too large to fit into the 5 character field which is specified in line 100.</p> |
| 88 | <p>Not used.</p> |
| 89 | <p>A ROM pack has issued an error message.</p> |
| 90 | <p>Not used.</p> |
| 91 | <p>Not used.</p> |
| 92 | <p>Not used.</p> |
| 93 | <p>Not used.</p> |
| 94 | <p>Not used.</p> |
| 95 | <p>An internal conversion error has occurred because a parameter in the specified statement is negative.</p> |
| 96 | <p>An internal conversion error has occurred because a parameter in the specified statement is greater than 65535.</p> |

Appendix B

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Appendix B

SPECIFICATIONS

PROCESSOR

| | |
|------------------------|--|
| Programming Language | BASIC: includes all the standard BASIC language elements plus graphics and other extensions. |
| Workspace Size 4051 | 8K bytes of RAM (Random Access Memory) standard; expandable to 32K bytes in 8K increments. |
| 4052/4054 | 32K bytes of RAM standard; 56K bytes optional. |

KEYBOARD

| | |
|---------------------------|--|
| Alphanumeric Keys | Complete upper and lower case alphanumerics with auto-repeating keys. Full ASCII 128 characters. |
| User Definable Keys | 10 user definable keys with SHIFT control for up to 20 separate function calls. |
| Editing Keys | Five editing keys with SHIFT control for 10 different editing functions to edit a BASIC statement before processing. |
| Numeric Keypad | 10 numeric keys, five math operator keys, decimal point, parentheses, and ENTER EXP (for scientific notation). |
| Other Keys AUTO NUMBER | Generates program line numbers automatically. |
| STEP | Executes program steps one at a time. |
| AUTO LOAD | Automatically loads and runs the first ASCII program on a magnetic tape cartridge. |

SPECIFICATIONS

| | |
|-------------------------|--|
| REWIND | Rewinds the magnetic tape cartridge. |
| MAKE COPY | Activates an optional hard copy unit. |
| Thumbwheels (4054 only) | Position the full screen crosshair cursor for graphic input. |

MAGNETIC TAPE CARTRIDGE

| | |
|------------------|--|
| Characteristics | A file-structured device for storing programs and data. BASIC statements executed under program control or entered from the keyboard are used to transfer information to and from the magnetic tape cartridge. |
| Type | 3M DC300A |
| Storage Capacity | 300K bytes maximum (dependent on number of files) |
| Record Length | 256 characters (128 characters selectable) |
| Operating Life | 5000 passes minimum |

DISPLAY CHARACTERISTICS

General

| | |
|-----------------------------------|--|
| Quality Display Area 4051/4052 | An 11" DVST provides a 7.48 in x 5.51 in (19.00 cm x 14.00 cm) rectangle with its center within 0.25 inches of crt faceplate center. |
| 4054 | A 19" DVST provides a 14.00 in x 10.50 in (35.56 cm x 26.67 cm) rectangle, approximately centered on the crt. |
| Erase Time 4051/4052 | Less than 1 s. |
| 4054 | Less than 1.5 s. |

Hold Mode (Reduced display intensity) If there is no display activity (except the cursor) for approximately 110 seconds, the System goes into Hold Mode (reduced display intensity). View Mode (normal intensity) is reset by any display storage activity or by pressing the SHIFT key.

Usable Storage Time Up to 15 minutes in View Mode or up to 1 hour in Hold Mode without permanent damage to storage target. If a residual image remains after the screen is erased, it can usually be removed by erasing the screen several times.

Automatic Paging
4051/4052 If there is no System activity for approximately 30 minutes, the screen is paged (erased) automatically.

4054 If there is no display activity (except the cursor) for approximately 30 minutes, the screen is paged (erased) automatically.

Hard Copy Time Refer to the documentation for your hard copy unit (optional peripheral) for specific times.

Alphanumeric Display Format

Characters Displayed 96 ASCII characters (upper and lower case)

Character Type
4051/4052 5 x 8 dot matrix

4054 Stroke character

Character Size
4051/4052 5 x 8 dot matrix approximately 87 x 106 mils

4054 Four character sizes; see Table B-1.

Characters Per Line
4051/4052 72 (74 with Option 1, Data Communications Interface)

4054 See Table B-1.

SPECIFICATIONS

| | |
|-------------------------------------|--|
| Characters Per Display 4051/4052 | 2520 (2590 with Option 1, Data Communications Interface) |
| 4054 | See Table B-1. |
| Lines Per Page 4051/4052 | 35 |
| 4054 | See Table B-1. |

Table B-1

4054 ALPHANUMERIC CHARACTER DISPLAY

| Character Size | Characters Per Line | Lines Per Page | Characters Per Page |
|-----------------------|----------------------------|-----------------------|----------------------------|
| 4 (default) | 72 (74 with Option 1) | 35 | 2520 (2590 with Option 1) |
| 3 | 79 (81 with Option 1) | 38 | 3002 (3078 with Option 1) |
| 2 | 119 (121 with Option 1) | 58 | 6902 (7018 with Option 1) |
| 1 | 132 (133 with Option 1) | 64 | 8448 (8512 with Option 1) |

| | |
|--------------------------|--|
| Cursor Type 4051/4052 | Pulsating 5 x 8 dot matrix |
| 4054 | Pulsating stroke character rectangle |
| Linefeed | Occurs automatically upon activation of Carriage Return. |
| Carriage Return/Linefeed | Automatic when attempting to print a character past the right margin position under program control. |

Graphic Display Format

| | |
|--|--|
| Drawing Area | Within quality display area |
| Addressable Points Graphic Display Unit (GDU) | 130 horizontal graphic display units are addressable and viewable; 130 vertical graphic display units are addressable, with 100 points viewable. |
| User Data Unit | The WINDOW (WIN) statement permits units of addressability (weeks, years, dollars, etc.) other than GDUs. The System automatically translates predefined user data units into their GDU equivalent for beam positioning. |
| Graphic Input | |
| 4051 (with optional Joystick) | Blinking arrow |
| 4052 (with optional Joystick) | Blinking arrow |
| 4054 | Full screen crosshair cursor with keyboard thumbwheel control standard; Joystick optional. |
| Address Resolution | |
| 4051/4052 | Maximal resolution obtainable by addressing fractional GDUs or using the WINDOW statement to establish the viewable portion of a 1024 x 1024 grid (WINDOW 0,1024,0,788). |
| 4054 | Maximal resolution obtainable by addressing fractional GDUs or by using the WINDOW statement to establish the viewable portion of a 4096 x 4096 grid (WINDOW 0,4096,0,3152). |
| Vector Type | |
| 4051/4052 | Solid |
| 4054 | Solid and dash pattern |

SPECIFICATIONS

GENERAL PURPOSE INTERFACE BUS

| | |
|----------------|--|
| Purpose | Allows peripheral devices to be attached to the System. |
| Specifications | Conforms to IEEE Standard 488-1975. Transfer mode is byte-serial, bit-parallel. For complete specifications refer to IEEE Standard 488-1975. |
| Control | External devices are serviced via interrupt procedures available in the BASIC operating system. Enable/disable, polling, and data transfer commands are available under program control. Refer to the 4050 Series Graphic System Reference Manual. |

PHYSICAL CHARACTERISTICS

Table B-2 shows the physical characteristics of the 4050 Series Graphic Computing Systems.

Table B-2

PHYSICAL CHARACTERISTICS

| Characteristic | 4051 | 4052 | 4054 |
|------------------------------------|---------------------|---------------------|---------------------|
| Width | 18.30 in (46.48 cm) | 18.30 in (46.48 cm) | 26.30 in (66.80 cm) |
| Depth | 32.05 in (81.41 cm) | 32.05 in (81.41 cm) | 32.75 in (83.18 cm) |
| Height | 14.25 in (36.20 cm) | 14.25 in (36.20 cm) | 20.50 in (52.07 cm) |
| Weight | 67 lb (30.45 kg) | 70 lb (31.82 kg) | 145 lb (65.91 kg) |
| Shipping Weight (with accessories) | 90 lb (40.91 kg) | 100 lb (45.45 kg) | 215 lb (97.73 kg) |

POWER REQUIREMENTS

The 4050 Series Graphic Computing System is intended to be operated from a single-phase, alternating current power source that has one of its current-carrying conductors (neutral) at ground (earth) potential. Table B-3 shows additional power supply requirements.

Table B-3

POWER REQUIREMENTS

| Requirements | 4051 | 4052 | 4054 |
|-----------------------|----------------------------|----------------------------|----------------------------|
| Line Voltage Ranges | | | |
| Nominal 115 Vac | 90 Vac—132 Vac | 90 Vac—132 Vac | 90 Vac—132 Vac |
| Nominal 230 Vac | 180 Vac—250 Vac | 198 Vac—250 Vac | 198 Vac—250 Vac |
| Line Frequency Range | 48—66 Hz | 48—66 Hz | 48—66 Hz |
| Maximum Voltage Input | | | |
| Nominal 115 Vac Range | 132 Vac | 132 Vac | 132 Vac |
| Nominal 230 Vac Range | 250 Vac | 250 Vac | 250 Vac |
| Power Consumption | 200 watts (approximate) | 230 watts (approximate) | 360 watts (approximate) |
| Fuse Protection | | | |
| Nominal 115 Vac Range | 1.6 A medium blow | 3 A fast blow | 5 A fast blow |
| Nominal 230 Vac Range | .8 A medium blow | 3 A fast blow | 3 A slow blow |

ENVIRONMENTAL SPECIFICATIONS

Your 4050 Series Graphic Computing System is intended for operation in a stationary, indoor environment. It is not intended for use outdoors, in vehicles, or on a moving platform. Tables B-4 and B-5 present environmental specifications for each 4050 Series Graphic System.

SPECIFICATIONS

Table B-4

ENVIRONMENTAL SPECIFICATIONS
(Note exceptions in Table B-5)

| Characteristic | 4051 | 4052 | 4054 |
|--------------------------------|--|--|--|
| Temperature Range Operating | +10° C (+50° F) to +40° C (+104° F) | +10° C (+50° F) to +40° C (+104° F) | +10° C (+50° F) to +40° C (+104° F) |
| Nonoperating | -40° C (-40° F) to +65° C (+149° F) | -40° C (-40° F) to +65° C (+149° F) | -40° C (-40° F) to +65° C (+149° F) |
| Humidity Range Operating | 0%—80% noncondensing | 0%—80% noncondensing | 0%—80% noncondensing |
| Nonoperating | 0%—95% noncondensing | 0%—95% noncondensing | 0%—95% noncondensing |
| Altitude Operating | to 15,000 ft (4,572 m) | to 15,000 ft (4,572 m) | to 15,000 ft (4,572 m) |
| Nonoperating | to 50,000 ft (15,240 m) | to 50,000 ft (15,240 m) | to 50,000 ft (15,240 m) |
| Shock (Nonoperating) | ½ sine, 11 ms duration, 30 g's | ½ sine, 11 ms duration, 30 g's | ½ sine, 11 ms duration, 30 g's |
| Vibration (Nonoperating) | 0.015" (0.038 cm) DA—10—40—10 Hz | 0.015" (0.038 cm) DA—10—40—10 Hz | 0.010" (0.025 cm) DA—10—40—10 Hz |
| Heat Dissipation | 682 BTU/hr (approximate) | 780 BTU/hr (approximate) | 1230 BTU/hr (approximate) |

Table B-5

TAPE CARTRIDGE ENVIRONMENTAL SPECIFICATIONS

| Characteristic | Specification |
|--------------------------------|---|
| Temperature Range Operating | +5° C (+41° F) to +45° C (+113° F) |
| Nonoperating | −40° C (− 40° F) to +45° C (+113° F) |
| Humidity Range | 20%—80% noncondensing |
| Conditioning | Acclimate tape to operating temperature for several hours if it has been stored in a colder or warmer environment. See the PLOT 50 System Software General Information section, Tape Cartridge Care, for information about tape tension adjustment. |

Appendix C

| | Page |
|---|-------------|
| General | C-1 |
| Unpacking | C-1 |
| Power Source and Operating Voltage | C-3 |
| Connectors and Optional Peripherals | C-6 |
| First-Time Operation | C-8 |
| Repackaging | C-8 |
| Line Voltage Selection and Fuse Replacement | C-10 |
| General | C-10 |
| The 4051 Graphic System | C-10 |
| The 4052 Graphic System | C-13 |
| The 4054 Graphic System | C-17 |

Appendix C

INSTALLATION

GENERAL

Installation consists of unpacking the Graphic System from the shipping carton, ensuring line voltage and fuse compatibility with the site power source, and connecting the power cord between the Graphic System and the power source.

UNPACKING

You may wish to save the carton and packing materials in which the Graphic System was shipped in case the System needs to be shipped to a Tektronix Service Center for service or repair. Repackaging instructions are included later in this appendix.

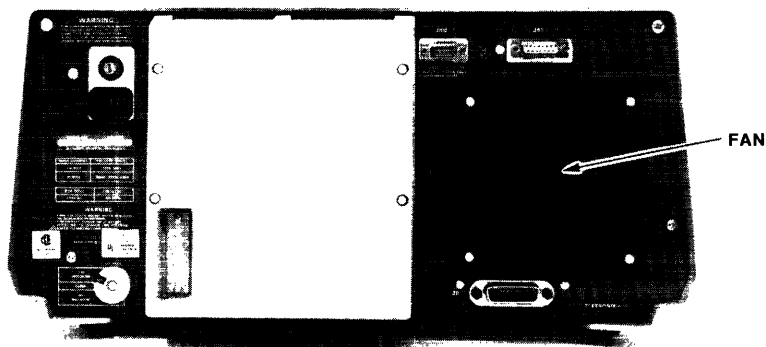
Table C-1

STANDARD 4050 SERIES GRAPHIC SYSTEM DIMENSIONS

| Characteristic | 4051 | 4052 | 4054 |
|---------------------------------------|---------------------|---------------------|---------------------|
| Width | 18.30 in (46.48 cm) | 18.30 in (46.48 cm) | 26.30 in (66.80 cm) |
| Depth | 32.05 in (81.41 cm) | 32.05 in (81.41 cm) | 32.75 in (83.18 cm) |
| Height | 14.25 in (36.20 cm) | 14.25 in (36.20 cm) | 20.50 in (52.07 cm) |
| Weight | 67 lb (30.45 kg) | 70 lb (31.82 kg) | 145 lb (65.91 kg) |
| Shipping Weight (with accessories) | 90 lb (40.91 kg) | 100 lb (45.45 kg) | 215 lb (97.73 kg) |

Table C-1 shows the dimensions for each standard 4050 Series Graphic Computing System. After removing the System from the shipping carton, place it on a table or other work surface that safely supports it. Note the air vents and fans shown in Figure C-1. Make certain they are always free from obstructions (walls, papers, clothing, etc.) to permit airflow through the unit.

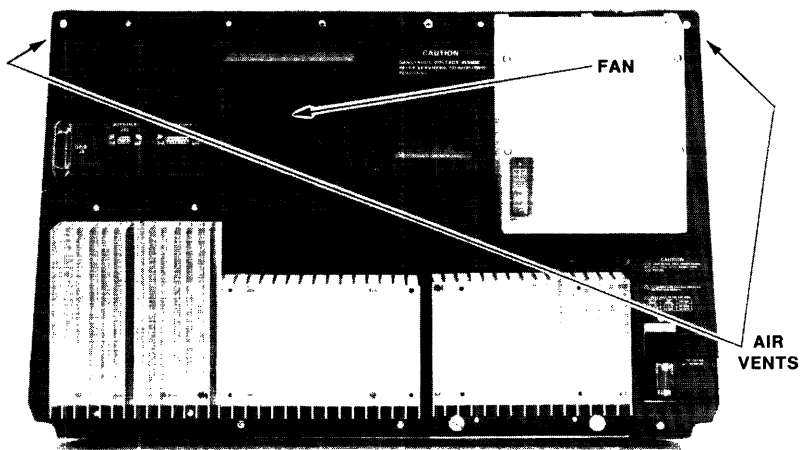
INSTALLATION



A. 4051/4052 Fan



B. 4052 Air Vents



C. 4054 Fan and Air Vents

1940-224

Figure C-1. Fan and Air Vent Locations.

CAUTION

Allow at least four inches of clearance behind a 4054 Graphic System and approximately three inches on each side.

Take inventory of the standard accessories shipped with your unit. Compare them with the standard accessories listed in the Accessories and Peripherals Appendix. If any differences exist or if there is damage to either the System or the accessories, contact your Tektronix representative. If you have received optional accessories with your System (a plotter, a hard copy unit, a Joystick, etc.), refer to their accompanying manuals for installation information.

POWER SOURCE AND OPERATING VOLTAGE**CAUTION**

The Graphic System is intended to be operated from a single-phase power source that has one of its current-carrying conductors (neutral) at ground (earth) potential. Operating from other power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a multiphase system, or across the legs of a 110-220 volt single-phase, three-wire system) is not recommended, since only the line conductor has over-current (fuse) protection within the unit.

On the rear panel of the Graphic System is a three-wire polarized power connector with one lead connected directly to the instrument frame to provide electric shock protection. Connect this to only a three-wire outlet which has a safety ground. Contact a qualified service technician to verify that the outlet is properly grounded. Figure C-2 shows power cord configuration and color coding.

CAUTION

The Graphic System must have the correct power cord and line voltage setting to avoid damage to the System power supply.

INSTALLATION

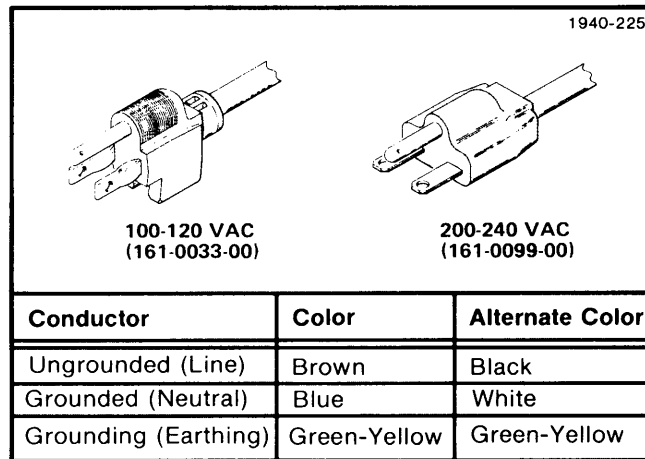


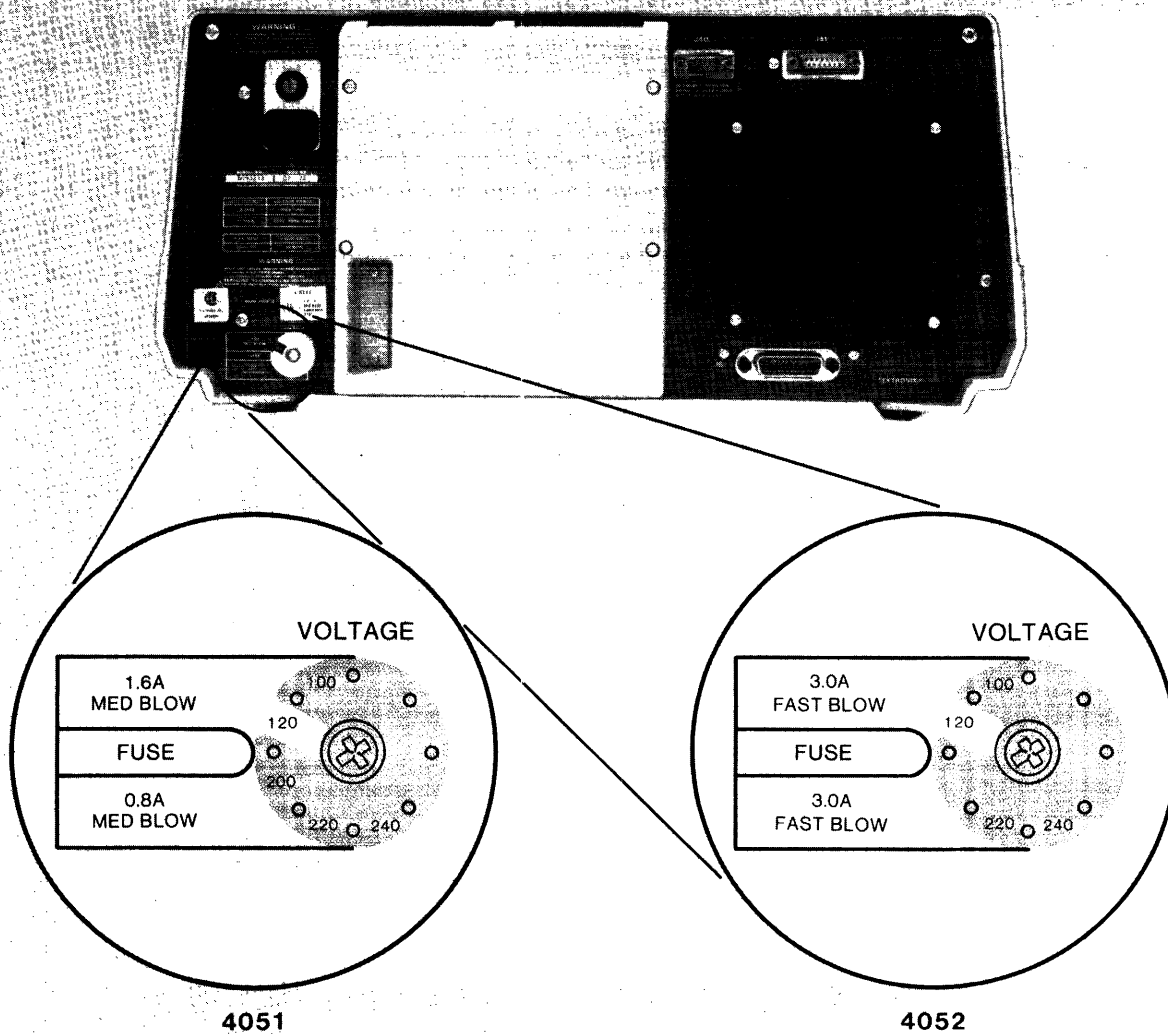
Figure C-2. Power Cord Conductor Identification.

The Graphic System is designed to operate from a 110-220 volt nominal line voltage that has a frequency between 48-66 Hz. Before connecting the power cord, verify that the voltage of your power source is the same as the line voltage of your Graphic System.

Figure C-3 shows the yellow voltage indicator below the power connector on the rear panel of the 4051/4052. This indicates the voltage to which the unit was set before leaving the factory. If the voltage of your power source differs from the voltage indicator reading, refer to the Line Voltage Selection and Fuse Replacement material at the end of this appendix.



Changing the yellow voltage indicator does not change the line voltage.

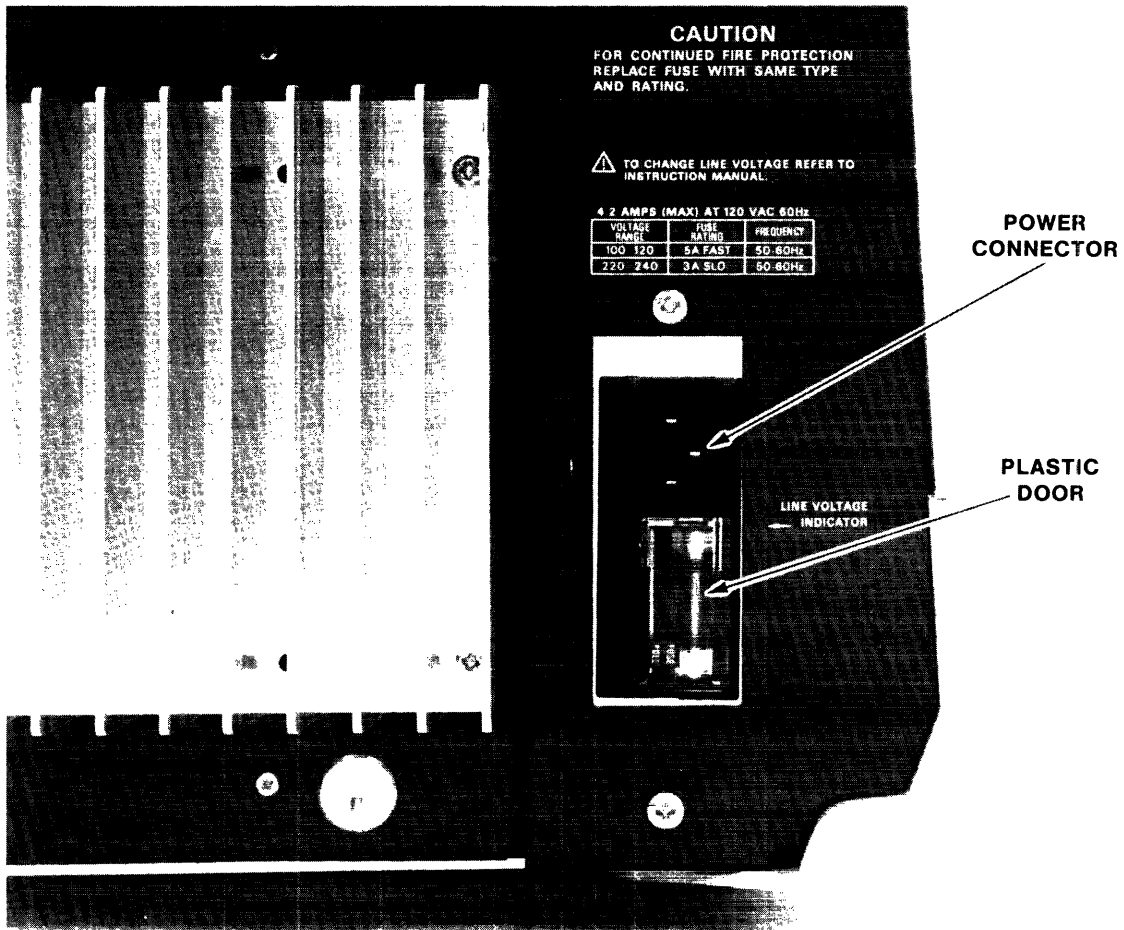


1940-226

Figure C-3. 4051/4052 Line Voltage Indicator.

INSTALLATION

Figure C-4 shows the line voltage indicator below the power connector on the rear panel of the 4054. If the voltage of your power source differs from the number visible on the circuit card behind the plastic door, refer to the Line Voltage Selection and Fuse Replacement material at the end of this appendix.

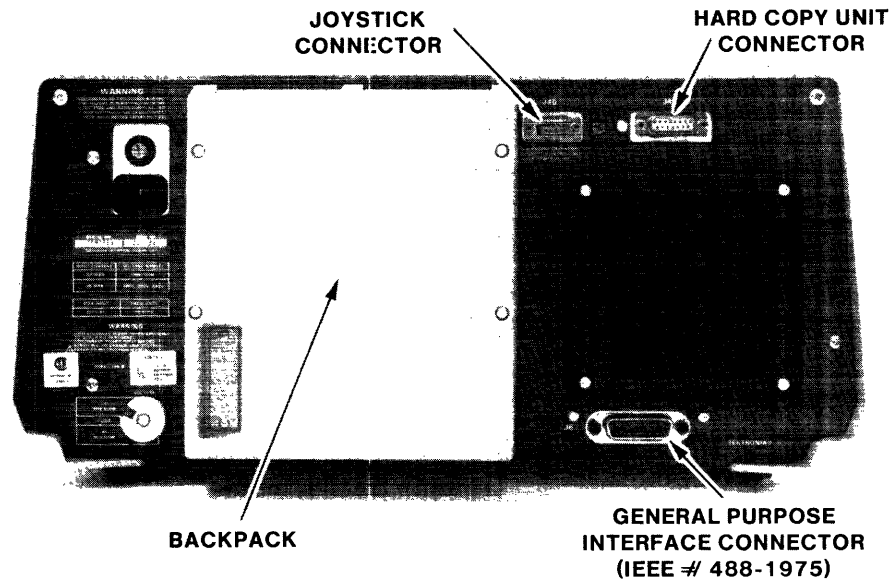


1940-227

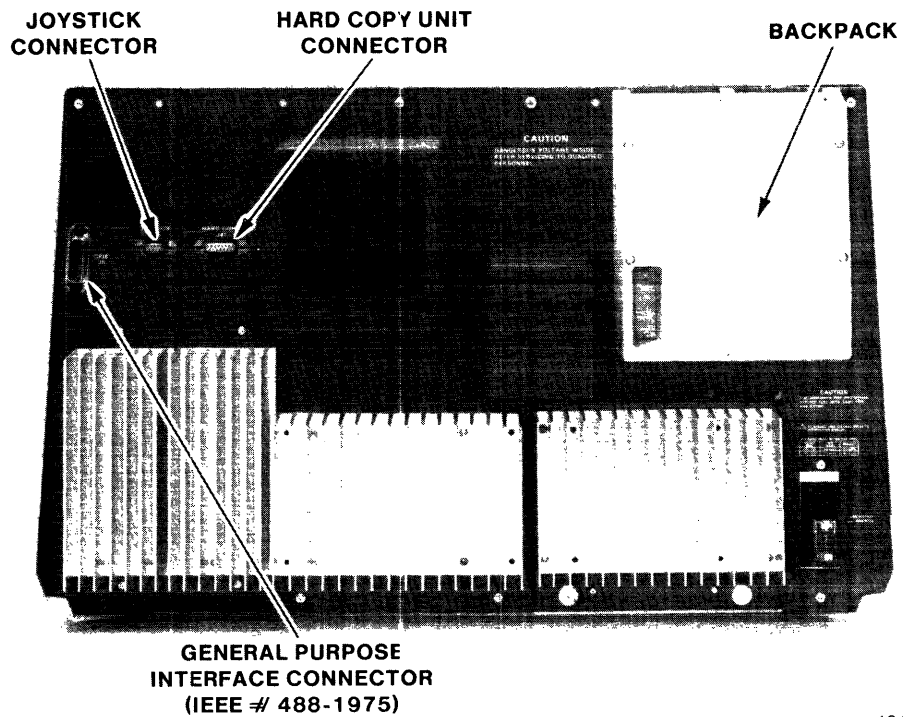
Figure C-4. 4054 Line Voltage Indicator.

CONNECTORS AND OPTIONAL PERIPHERALS

The rear panel provides three connectors for System peripherals. One connector is reserved for the Joystick, and another is reserved for an optional hard copy unit. The third is the IEEE Standard #488-1975 compatible connector, the GPIB (General Purpose Interface Bus). This connector is for peripherals such as a plotter, an additional magnetic tape unit, or a disc unit. Figure C-5 shows these connectors and the backpack.



A. 4051/4052



B. 4054

1940-228

Figure C-5. Rear-Panel Connectors and Backpack.

INSTALLATION

The backpack is used for optional ROM Packs, an optional printer interface, and the Option 1 Data Communications Interface. Connectors for a printer and/or a modem are provided as part of an option, if needed. For detailed peripheral installation information, refer to the appropriate peripheral manual.

FIRST-TIME OPERATION

After ensuring line voltage and fuse compatibility with your power source, connect the power cord to your System and then to your power source.

NOTE

If several devices are connected to the GPIB, one more than 50% of the devices must be turned on (regardless of whether they are used) before you turn on the Graphic System. Otherwise, the bus may be loaded down, causing an error message or causing the System not to respond properly.

Power up the Graphic System by pressing the right side of the power switch located beneath the right-front corner of the unit. If nothing happens when you turn on the power switch, turn off the power switch and check the following: (1) that your System is connected to the proper power source, (2) that the rear-panel fuse (Figure 10-4) is the correct value, and (3) that the rear panel fuse is not blown.

If all of the following normal power-up events do not occur when you turn on the power switch, note those that do not occur; especially note and record the activity of the front-panel indicator lights. Report all power-up failure information to your Tektronix Field Office.

The normal power-up events include:

- The four green indicator lights on the front panel (BUSY, BREAK, I/O, and POWER) turn on.
- The BUSY, BREAK, and I/O lights turn off.
- The POWER light remains on.
- If a tape is in the tape unit, the tape rewinds to the beginning.
- A blinking cursor appears in the upper-left corner of the screen. (It may be necessary to press the HOME/PAGE key to view the cursor.)

First-time operation consists of running the System Verification Program(s) as described in System Verification (Section 8). After that, you may select your own course. You can start with the introductory material in Sections 1 and 2, run the Graphic System Tutorial (Section 3), draw graphs with the Plot Programs (Sections 4-7), read Keys, Buttons, and Switches (Section 9), or get right into programming the System to fit your application needs.

REPACKAGING

If the Graphic System is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address), name of an individual at your firm who can be contacted, complete serial number, and a description of the service required. If the original packaging is unfit for use or not available, repackage the System as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions of at least six inches more than the instrument dimensions in each direction; this allows for cushioning. Refer to Table C-2 for carton strength requirements.
2. Surround the System with polyethylene sheeting to protect the finish.
3. Cushion the System on all sides by tightly packing dunnage or urethane foam between the carton and the sides of the system.
4. Seal with shipping tape or use an industrial stapler.

Table C-2

SHIPPING CARTON TEST STRENGTH

| Gross Weight | | Carton Test Strength | |
|---------------------|------------------|-----------------------------|------------------|
| Pounds | Kilograms | Pounds | Kilograms |
| 0-10 | 0-3.73 | 200 | 74.6 |
| 10-30 | 3.73-11.19 | 275 | 102.5 |
| 30-120 | 11.19-44.76 | 375 | 140.0 |
| 120-140 | 44.76-52.22 | 500 | 186.5 |
| 140-160 | 52.22-59.63 | 600 | 223.8 |

INSTALLATION

LINE VOLTAGE SELECTION AND FUSE REPLACEMENT

General

WARNING

Dangerous voltages exist inside the Graphic System. Always turn the System OFF and disconnect it from the power source before removing the top cover. Only qualified technical personnel should attempt to change the line voltage of a 4051 or a 4052. Unfamiliarity with electronic equipment and safety procedures can result in personal injury.

The 4051 Graphic System

Line voltage for the 4051 is selected by positioning wire jumpers on the power supply transformer. The transformer is located inside the unit in the right-rear corner.

If the voltage of your power source differs from the voltage setting of your 4051, use the following procedure to select proper line voltage and to ensure fuse compatibility.

1. Be certain the System power cord is disconnected from your power source.
2. Turn the unit on its side (being sure it is adequately supported).
3. Loosen the two 5/16" hex bolts shown in Figure C-6.

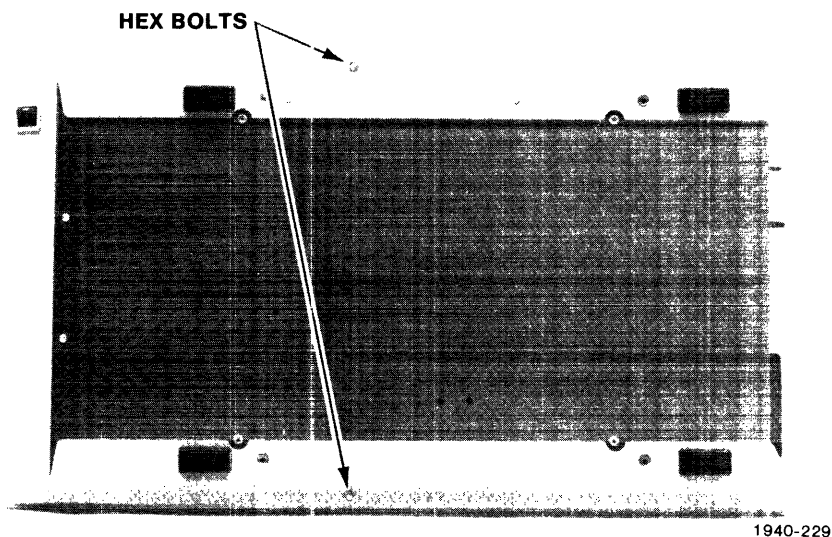
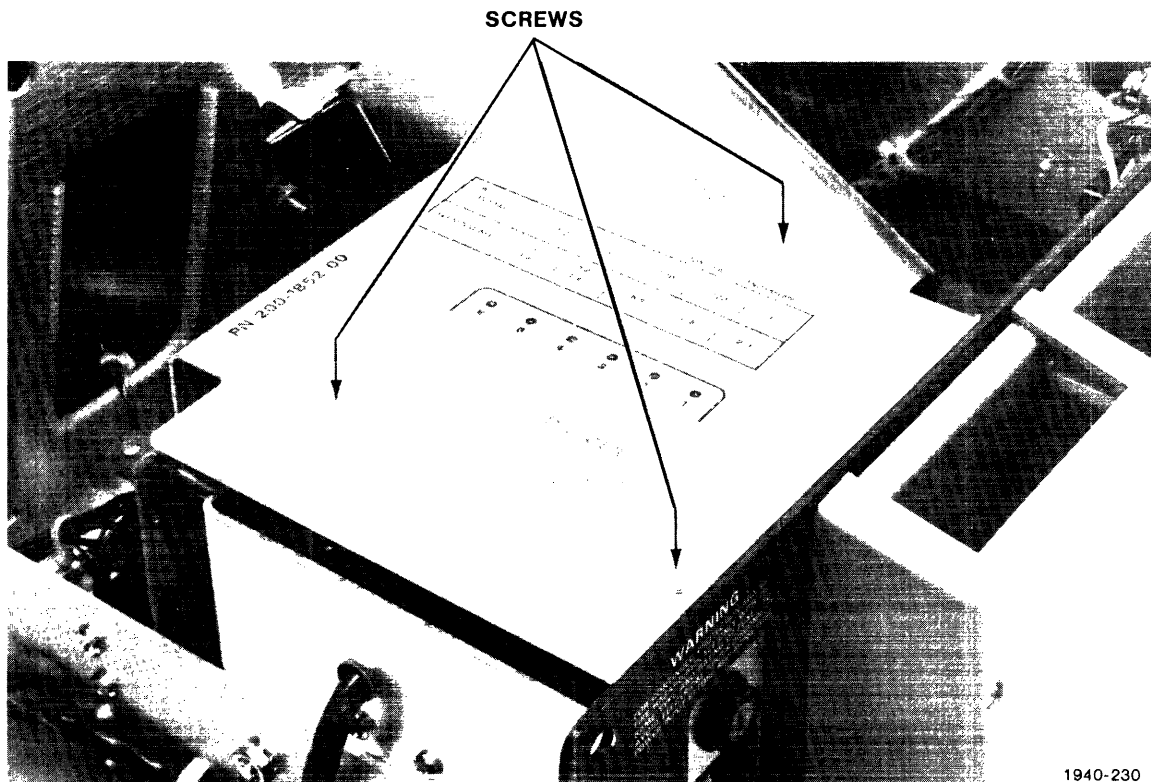


Figure C-6. Hex Bolts on Bottom of 4051.

INSTALLATION

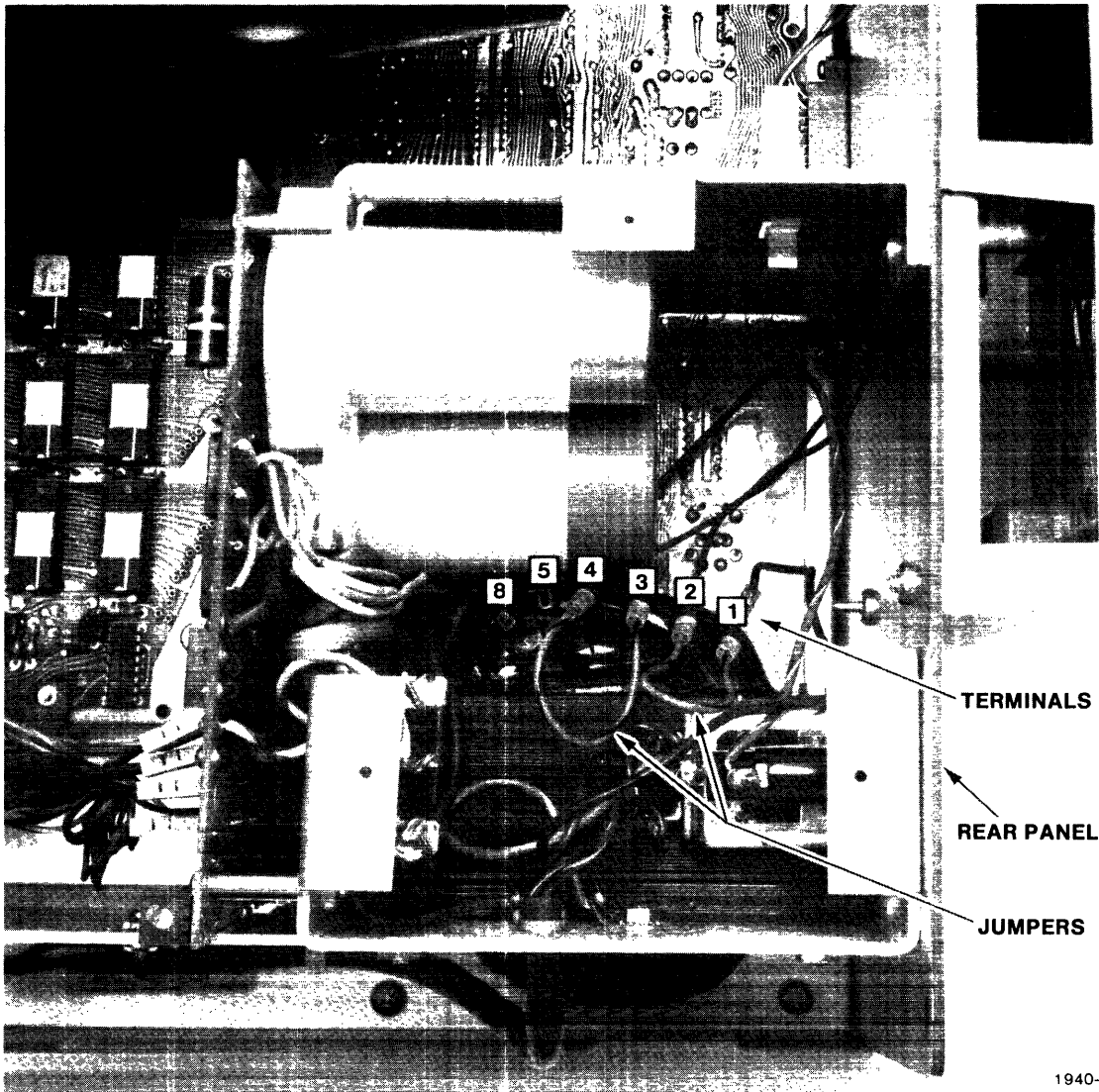
4. Position the unit upright and remove the screws from the upper corners of the rear panel.
5. Carefully remove the cover by lifting it straight up without hitting circuit components.
6. Remove the metal safety shield that is over the transformer by removing the three screws shown in Figure C-7.



1940-230

Figure C-7. 4051 Power Supply Transformer Safety Shield.

7. Figure C-8 shows the numbering of the six terminals to which two jumpers are attached. Positioning these jumpers as shown on the transformer safety shield selects the line voltage.



1940-231

Figure C-8. 4051 Power Supply Transformer Terminal and Jumpers.

CAUTION

If improper line voltage is selected, the power supply may be damaged.

INSTALLATION

8. Loosen the yellow voltage indicator screw on the rear panel of the 4051. Turn the indicator to show the proper voltage in the window. Tighten the screw.

NOTE

The voltage indicator only provides information; it does not select line voltage.

9. Replace the transformer safety shield.
10. Remove the fuse as explained in the Maintenance Section and compare it with the fuse requirements (on the rear panel); change the fuse if necessary. Place the fuse in the fuse holder (inserting either end), and replace the fuse holder.
11. Carefully replace the System cover and the two rear-panel screws.
12. Tighten the two hex bolts.

The 4052 Graphic System

Line voltage for the 4052 is selected by setting three switches. These are under the cover of the power supply transformer in the right-rear corner of the unit.

If the voltage of your power source differs from the voltage setting of your 4052, use the following procedure to select proper line voltage.

1. Be sure the System power cord is disconnected from your power source.
2. Turn the unit on its side (being sure it is adequately supported).
3. Loosen the two 5/16" hex bolts shown in Figure C-9.

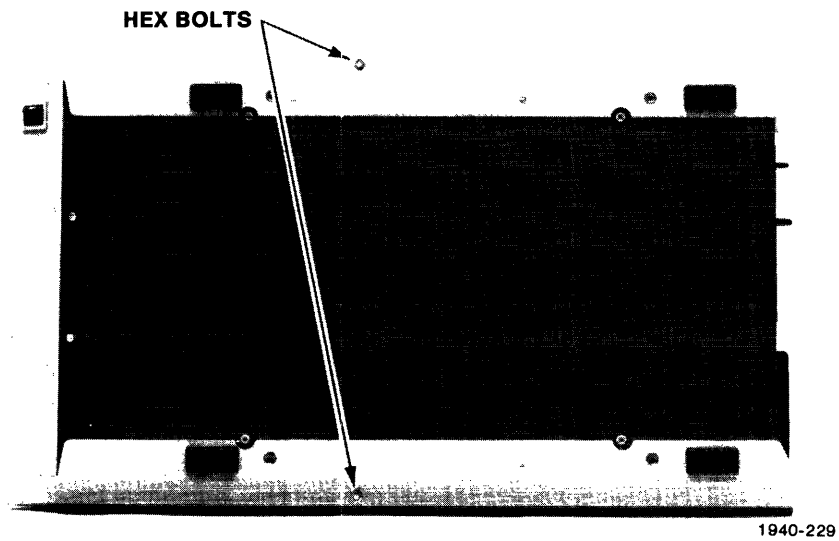
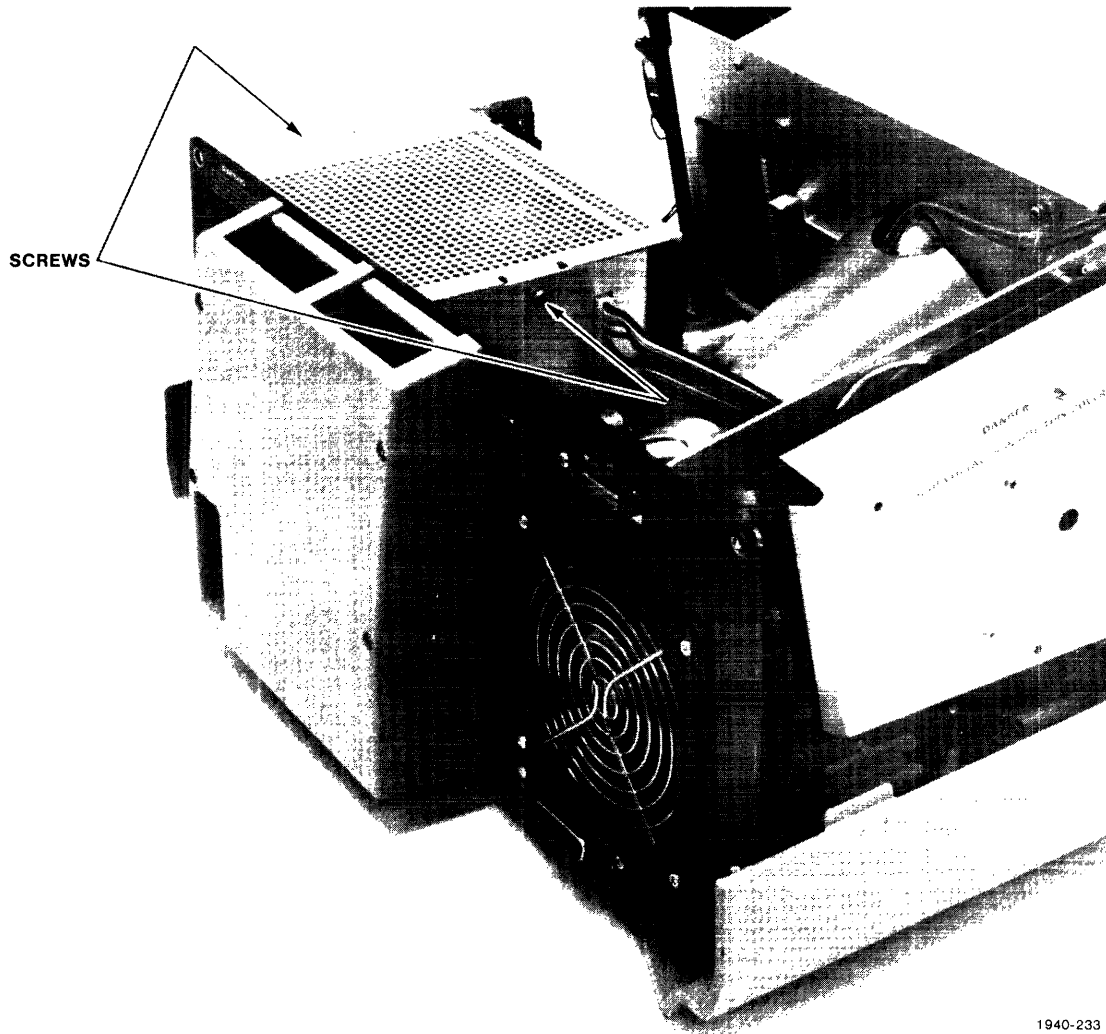


Figure C-9. Hex Bolts on Bottom of 4052.

4. Position the unit upright and remove the screws from the upper corners of the rear panel.
5. Carefully remove the cover by lifting it straight up without hitting circuit components.
6. Remove the power supply cover by removing the two screws shown in Figure C-10.

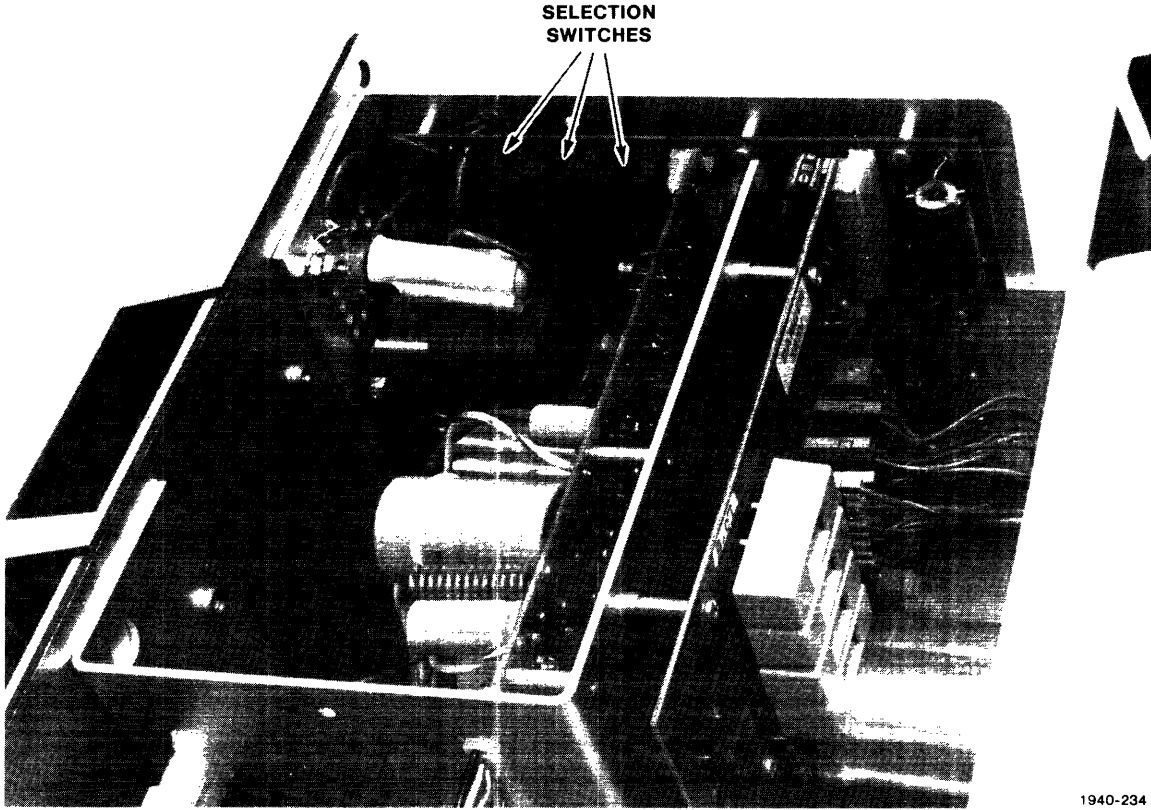
INSTALLATION



1940-233

Figure C-10. 4052 Power Supply Shield.

7. Locate the three line voltage selection switches (Figure C-11) and compare their positions with Figure C-12. Set the combination that is appropriate for your power source.



1940-234

Figure C-11. 4052 Line Voltage Selection Switches.

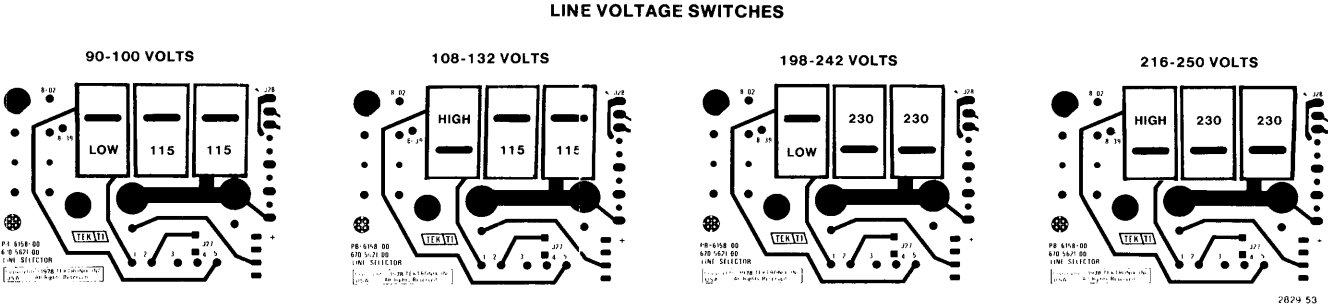


Figure C-12. 4052 Line Voltage Switch Settings.

CAUTION

If improper line voltage is selected, the power supply may be damaged.

INSTALLATION

8. Loosen the yellow voltage indicator screw on the rear panel of the 4052. Turn the indicator to show the proper voltage in the window. Tighten the screw.

NOTE

The voltage indicator only provides information; it does not select line voltage.

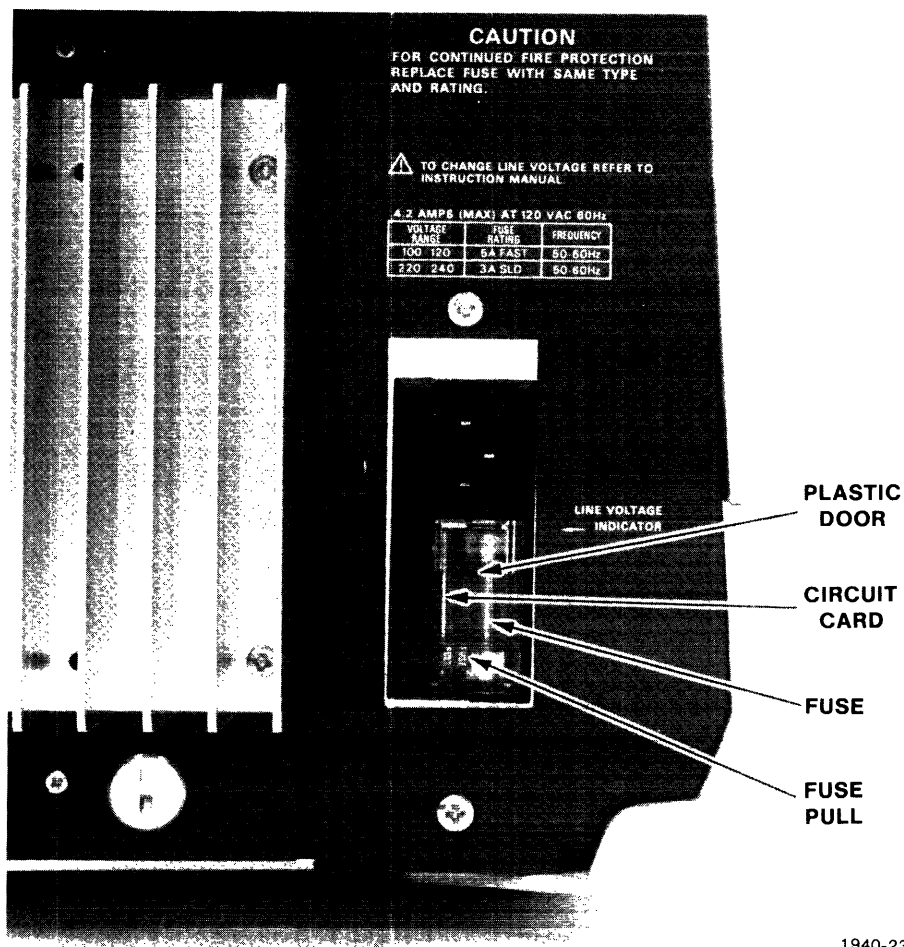
9. Replace the power supply cover.
10. Carefully replace the System cover and the two rear-panel screws.
11. Tighten the two hex bolts.

The 4052 fuse does not need to be changed.

The 4054 Graphic System

If the voltage of your power source differs from the voltage setting of your 4054, use the following procedure to select proper line voltage and to ensure fuse compatibility.

1. Be sure the System power cord is disconnected from your power source.
2. Locate the plastic door below the power connector on the rear panel of the 4054. This covers the circuit card and the line voltage fuse. See Figure C-13.



1940-235

Figure C-13. 4054 Line Voltage Fuse and Circuit Card.

3. Slide the door upward.
4. Slide the FUSE PULL upward as far as possible and remove the fuse.
5. Use a pair of serrated needle-nose pliers or a similar tool to remove the circuit card. Grasp the card near the center of the nearest edge (where there is a hole) and pull firmly (Figure C-14). Note the vertical position of the card.

NOTE

Line voltage is selected by the position of the circuit card. One side of the card designates 120 Vac or 240 Vac; the other designates 100 Vac or 220 Vac.

INSTALLATION



1940-236

Figure C-14. Removing the Circuit Card.

6. Reinsert the circuit card with the proper voltage designation in the upper position on the side of the card nearest the FUSE PULL (Figure C-15).



1940-237

Figure C-15. Inserting the Circuit Card for 120 Vac Selection.

CAUTION

If improper line voltage is selected, the power supply may be damaged.

INSTALLATION

7. Slide the FUSE PULL downward. If the circuit card has been inserted properly, the only number now visible on the card is the number corresponding to the voltage of your power source.
8. Check fuse size requirements (on the rear panel). Change the fuse if necessary.
9. Insert the fuse (either end up).
10. Slide the plastic door downward.

Appendix D

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| Standard Accessories | D-1 |
| Optional Accessories | D-1 |
| Systems | D-2 |
| 4051 Graphic Computing System | D-2 |
| 4052 Graphic Computing System | D-2 |
| 4054 Graphic Computing System | D-2 |
| Graphic Input | D-2 |
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| Peripheral Manuals | D-5 |

Appendix D

ACCESSORIES AND PERIPHERALS

This appendix provides a list of standard and optional accessories for your 4050 Series Graphic Computing System. If you did not receive all of the standard accessories with your System, contact your Tektronix representative.

This appendix also includes a summary of Tektronix products that are compatible with 4050 Series Graphic Computing Systems. Your local Tektronix Field Office has up-to-date information on new products.

STANDARD ACCESSORIES

| | Part Number |
|---|--------------------------|
| PLOT 50 System Software Tape | 020-0160-02 |
| PLOT 50 System Software Backup Tape | 020-0161-02 |
| 4050 Series Graphic System Operator's Manual | 070-1940-XX ^a |
| 4050 Series Graphic System Reference Manual | 070-2056-XX |
| 4050 Series BASIC Reference Guide | 070-2142-XX |
| PLOT 50 Introduction to Programming in BASIC Manual | 070-2058-XX |
| PLOT 50 Introduction to Graphic Programming in BASIC Manual | 070-2059-XX |
| Binder (2 inch) | 016-0367-00 |
| Binder (2 inch) with Tape Pockets and Divider | |
| Package of 10 Blank Overlays | 334-2630-02 |
| Power Cord | 161-0066-00 |

OPTIONAL ACCESSORIES

| | Part Number |
|--|--------------------|
| Visor for CRT | 016-0346-00 |
| Pedestal Kit | 016-0364-00 |
| Protective Dust Cover | 016-0376-00 |
| GPIB Interconnect Cable (two meters long) | 012-0630-03 |
| GPIB Interconnect Cable (four meters long) | 012-0630-04 |
| Package of 5 Blank Tape Cartridges | 119-0680-01 |
| (Also see list of manuals) | |

^aXX represents two-digit code of most recent revision.

SYSTEMS

4051 Graphic Computing System

4051 Option 1 Data Communications Interface
4051 Option 10 Printer Interface
4051 Option 20 16K Bytes Total Memory
4051 Option 21 24K Bytes Total Memory
4051 Option 22 32K Bytes Total Memory
4051 Option 48 220V, 50 Hz

4052 Graphic Computing System

4052 Option 1 Data Communications Interface
4052 Option 2 Four Slot ROM Backpack
4052 Option 3 Data Communications Interface, Four Slot
4052 Option 10 Printer Interface
4052 Option 24 56K Bytes Total Memory
4052 Option 48 220V, 50 Hz

4054 Graphic Computing System

4054 Option 1 Data Communications Interface
4054 Option 2 Four Slot ROM Backpack
4054 Option 3 Data Communications Interface, Four Slot
4054 Option 10 Printer Interface
4054 Option 24 56K Bytes Total Memory
4054 Option 48 220V, 50 Hz

GRAPHIC INPUT

4952 Option 2 Joystick
4956 Graphics Tablet (20" X 20" Surface)
Option 33 36" X 36" Surface

GRAPHIC OR ALPHANUMERIC OUTPUT

4631 Hard Copy Unit
4662 or 4663 Interactive Digital Plotter
4641 or 4642 Character Printer

STORAGE DEVICES

4924 Digital Cartridge Tape Drive
4907 File Management System
Option 30 Total Two Disc Drives
Option 31 Total Three Disc Drives
Option 40 File Manager (for the 4052 and 4054)

INTERFACES

4051 Option 1 Data Communications Interface
4052 Option 1 Data Communications Interface
4054 Option 1 Data Communications Interface
4052 Option 3 Data Communications Interface, Four Slot
4054 Option 3 Data Communications Interface, Four Slot
4051C01 Synchronous Communications Interface (for the 4051 only)
4051 Option 10 Printer Interface
4052 Option 10 Printer Interface (for the 4052 and 4054)
4931 Modem (Modulator/Demodulator)

ROM PACKS AND ROM PACK ACCESSORIES

4051R01 Matrix Functions ROM Pack
4051R05 Binary Program Loader ROM Pack
4051R06 Editor ROM Pack
4052R06 Editor ROM Pack (for the 4052 and 4054)
4051R07 Signal Processing ROM Pack #1
4052R07 Signal Processing ROM Pack #1 (for the 4052 and 4054)
4051E01 ROM Expander (for the 4051 only)
4052 Option 2 Four Slot ROM Backpack
4054 Option 2 Four Slot ROM Backpack

SOFTWARE

4050A01 PLOT 50 Statistics, Vol. 1
 4050A02 PLOT 50 Statistics, Vol. 2
 4050A03 PLOT 50 Statistics, Vol. 3
 4050A04 PLOT 50 Mathematics, Vol. 1
 4050A05 PLOT 50 Mathematics, Vol. 2
 4050A06 PLOT 50 Electrical Engineering, Vol. 1
 4050A07 PLOT 50 Graph Plot
 4050A08 PLOT 50 General Utilities, Vol. 1
 4050A09 PLOT 50 Business Planning and Analysis, Vol. 1
 4050A10 PLOT 50 Statistics, Vol. 4
 4050A11 PLOT 50 Business Planning and Analysis, Vol. 2
 4050A12 PLOT 50 Business Planning and Analysis, Vol. 2 (Flexible Disc)
 4050A13 PLOT 50 Statistics Library
 4050A14 PLOT 50 Mathematics Library
 4050A15 PLOT 50 Scientific Library
 4050B01 Modeling and Reporting Software
 Option 5 Flexible Disc

GRAPHIC COMPUTING SYSTEM MANUALS

| | Part Number |
|--|--------------------------|
| PLOT 50 Introduction to Programming in BASIC Manual | 070-2058-XX ^a |
| PLOT 50 Introduction to Graphic Programming in BASIC Manual | 070-2059-XX |
| 4050 Series Graphic System Operator's Manual | 070-1940-XX |
| 4050 Series Graphics System Reference Manual | 070-2056-XX |
| 4050 Series BASIC Reference Guide | 070-2142-XX |
| 4051 Service Manual, Vol. 1 | 070-2065-XX |
| 4051 Service Manual, Vol. 2 | 070-2286-XX |
| System Test Fixture Instruction Manual | 070-2304-XX |
| GPIB Application Support Manual | 070-2307-XX |
| GPIB Hardware Support Manual | 070-2270-XX |
| 4052 Parts and Schematics Service Manual | |
| Option 1 Data Communications Interface Operator's Manual | 070-2066-XX |
| Option 10 Printer Interface Instruction Manual | 070-2119-XX |
| 4051C01 Synchronous Communications Interface Instruction Manual (4051 only) | 070-2436-XX |
| 4051E01 ROM Expander Instruction Manual (4051 only) | 070-2215-XX |
| 4051R01 Matrix Functions ROM Pack Operator's Manual (4051 only) | 070-2127-XX |
| 4051R05 Binary Program Loader ROM Pack Operator's Manual (4051 only) | 070-2171-XX |

^aXX represents two-digit code of most recent revision.

ACCESSORIES AND PERIPHERALS

| | |
|---|-------------|
| 4050 Series R06 Editor Operator's Manual | 070-2170-XX |
| 4050 Series R07 Signal Processing ROM Pack #1 Instruction Manual | 070-2557-XX |
| 4931 Modem Instruction Manual | 070-2180-XX |

PERIPHERAL MANUALS

| | |
|--|-------------|
| 4631 Hard Copy Unit User's Manual | 070-1830-XX |
| 4631 Hard Copy Unit Service Manual | 070-1831-XX |
| 4641/4641-1 Character Printer Operator's Manual | 070-2110-XX |
| 4641/4641-1 Printer Service Manual | 070-2111-XX |
| 4642/4642-1 Printer Operator's Manual | 070-2486-XX |
| 4642/4642-1 Printer Service Manual | 070-2489-XX |
| 4662 Interactive Digital Plotter User's Manual | 070-1932-XX |
| 4662 Interactive Digital Plotter Service Manual | 070-1933-XX |
| 4662 Test Tape (067-0829-00) Operator's Manual | 070-2366-XX |
| 4662 Interactive Digital Plotter User's Reference Card | 070-2556-XX |
| 4907 File Manager Operator's Manual | 070-2380-XX |
| 4907 File Manager Operator's Pocket Reference | 070-2381-XX |
| 4907 Installation Guide | 070-2493-XX |
| 4907 Service Manual | 070-2405-XX |
| 119-0977-00 Flexible Disc Drive Instruction Manual | 070-2504-XX |
| 4924 Digital Cartridge Tape Drive Operator's Manual | 070-2128-XX |
| 4924 Digital Cartridge Tape Drive Service Manual | 070-2131-XX |
| 4924 Reference Guide | 070-2302-XX |
| 4952 Joystick Option 2 Operator's Manual | 070-2098-XX |
| 4956 Graphic Tablet Operator's Manual | 070-2210-XX |
| 4956 Graphic Tablet Service Manual | 070-2211-XX |

Appendix E

Appendix E

GLOSSARY

| Term | Definition |
|----------------------|---|
| Accumulator | A temporary storage area used for storing a number, summing it with another number, and replacing the first number with the sum. |
| Algorithm | A step-by-step method for solving a given problem. |
| Argument | A value operated on by a function or a keyword. Also called a parameter. |
| Arithmetic Operator | Operators which describe arithmetic operations, such as +, -, *, /, †. |
| Array | A collection of data items arranged in a meaningful pattern. In the Graphic System, arrays may be one or two dimensional; that is, they may be organized into rows, or rows and columns. |
| Array Variable | A name corresponding to a (usually) multi-element collection of data items. Array variables may be named with the characters A through Z and A0 through Z9. |
| ASCII Code | A standardized code of alphanumeric characters, symbols, and special "control" characters. ASCII is an acronym for American Standard Code for Information Interchange. |
| Assignment Statement | A statement which is used to assign, or give, a value to a variable. |
| BASIC | An acronym derived from Beginner's All-purpose Symbolic Instruction Code. BASIC is a "high level" programming language because it uses English-like instructions. |
| BASIC Interpreter | The BASIC interpreter is a set of machine language instructions which gives the System the ability to understand and execute BASIC statements. The BASIC interpreter resides in the Read Only Memory and is part of the operating system. |

GLOSSARY

| | |
|------------------|---|
| Binary String | A connected sequence of 1's and 0's. |
| Bit | A binary digit. A unit of data in the binary numbering system; a 1 or 0. |
| Byte | A group of consecutive binary digits operated upon as a unit. One ASCII character, for example, is represented by one binary byte. |
| Character String | A connected sequence of ASCII characters, sometimes referred to simply as a "string." |
| Clipping | Removing vectors or portions of vectors which lie outside the defined window. |
| Coding | The process of preparing a list of successive computer instructions for solving a specific problem. Coding is usually done from a flowchart or algorithm. |
| Concatenate | To join together two character strings with the concatenation operator (&) to form a larger character string. |
| Constant | A number that appears in its actual numerical form. In the following expression, 4 is a constant: $X = 4 * P$ |
| crt | An abbreviation for cathode ray tube. In the Graphic System, the crt is a "storage" display, as opposed to a "refreshed" or tv-like display. |
| Cursor | The blinking rectangle, blinking question mark, blinking arrow, or full screen crosshair that indicates the position of the writing beam. It shows where the next character is to be printed. |
| Debug | The process of locating and correcting errors in a program; also, the process of testing a program to ensure that it operates properly. |
| Default | The property of a computer that enables it to examine a statement requiring parameters to see if those parameters are present and to assign substitute values for those parameters when none were present. Default actions provide a powerful means for saving memory space and time when loading program statements into memory. |

| | |
|----------------------------|---|
| Delimiter | A character that fixes the limits, or bounds, of a string of characters. |
| Dyadic | Refers to an operator having two operands. |
| Execute | To perform the operations indicated by a statement or group of statements. |
| Expression | Refers to either numeric expressions or string expressions. A collection of variables, constants, and functions connected by operators in such a way that the expression as a whole can be reduced to a constant. |
| Fatal Error | An error which causes program execution to terminate. |
| Flowchart | A programming tool that provides a graphic representation of a routine to solve a specific problem. |
| Function | A special purpose operation referring to a set of calculations within an expression, as in the sine function, square root function, etc. |
| Graphic Display Unit (GDU) | An internal unit of measurement representing 1/100 of the vertical axis on the graphic drawing surface and 1/130 of the horizontal axis. |
| Graphic Point | The tip of the writing tool on a graphic device, for example, the tip of the pen on a plotter or the writing beam on the Graphic System display. |
| Graphics | Computer output that is composed of lines rather than letters, numbers, and symbols. |
| Hardware | The physical devices and components of a computer. |
| Index | A number used to identify the position of a specific quantity in an array or string of quantities. For example, in the array A, the elements are represented by the variables A(1), A(2), . . . A(50). the indices are 1,2, . . . 50. |
| Input | Data that is transferred to the Graphic System memory from an external source. |

GLOSSARY

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|--------------------|---|
| Instruction | A line number plus a statement. (A line number plus a keyword plus any associated parameters.) |
| Integer | A whole number; a number without a decimal part. |
| Interrupt | To cause an operation to be halted in such a fashion that it can be resumed at a later time. |
| Iterate | To repeatedly execute a series of instructions in a loop until a condition is satisfied. |
| Justify | To align a set of characters to the right or left of a reference point. |
| Keyboard | The device that encodes data when keys are pressed. |
| Keyword | An alphanumeric code that the Graphics System recognizes as a function to be performed. |
| Line Number | An integer establishing the sequence of execution of lines in a program. In the Graphic System, line numbers must be in the range of 1 through 65,535. |
| Logic | In the Graphic System, the principle of truth tables; also, the interconnection of on-off, true-false elements, etc. for computational purposes. |
| Logical Expression | A numeric expression using the logical operators: AND, OR, NOT. The numeric expression is arranged in such a way that the numeric result is a logical 1 or a logical 0. A logical expression may be part of a larger numeric expression involving relational operators and/or arithmetic operators. |
| Logical Operator | Operators which return logical 1's and 0's; specifically, the AND, OR, and NOT operators. True operations return 1; false operations return 0. |
| Loop | Repeatedly executing a series of statements for a specified number of times. Also, a programming technique that causes a group of statements to be repeatedly executed. |

| | |
|--------------------|--|
| Mantissa | In scientific notation, that part of the number which precedes the exponent. For example, the mantissa in the number $1.234E+200$ is 1.234. |
| Matrix | A rectangular array of numbers subject to special mathematical operations. Also, something having a rectangular arrangement of rows and columns. |
| Memory | This generally refers to the Read/Write Random Access Memory that contains BASIC programs and data, as opposed to the Read Only Memory which contains the BASIC interpreter. |
| Monadic | Refers to an operator that has only one operand. |
| Numeric Constant | Any real number that is entered as numeric data; also, the contents of a numeric variable. |
| Numeric Expression | Any combination of numeric constants, numeric variables, array variables, subscripted array variables, numeric functions, or string relational comparisons enclosed in parentheses joined together by one or more arithmetic, logical, or relational operators in such a way that the expression, as a whole, can be reduced to a numeric constant when evaluated. |
| Numeric Function | Special purpose mathematical operations which reduce their associated parameters (or arguments) to a numeric constant |
| Numeric Variable | A variable that can contain a single numeric value. Numeric variables can be named with the characters A through Z and A0 through Z9, and can be used in numeric expressions. |
| Operand | Any one of the quantities involved in an operation. Operands may be numeric expressions or constants. In the numeric expression $A = B + 4 * C$, the numeric variables B and C and the numeric constant 4 are operands. |
| Operator | A symbol indicating the operation to be performed on two operands. In the expression $Z + Y$, the plus sign (+) is the operator. |

GLOSSARY

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|---------------------|---|
| Output | The results obtained from the Graphic System; also, information transferred to a peripheral device. |
| Parameter | A quantity that may be specified as different values; usually used in conjunction with BASIC statements. For example, in the statement WINDOW -50, 50, -100, 100, the parameters are -50, 50, -100, and 100. |
| Peripheral Device | Various devices (hard copy unit, plotter, magnetic tape drive, etc.) that are used in the Graphic System to input data, output data, and store data. |
| Program | A sequence of instructions for the automatic solution of a problem, resulting from a planned approach. |
| Programming | The process of preparing programs from planning the process (from input to output) to entering the code into memory. |
| RAM | The Random Access Memory; that portion of the System memory which provides temporary storage locations for keyboard entries, BASIC program instructions, and intermediate processing results. |
| Relational Operator | An operator that causes a comparison of two operands and returns a logical result. Comparisons that are true return 1; comparisons that are false return 0. The relational operators in the Graphic System are =, <>, <, >, >=, and <=. |
| ROM | The Read Only Memory; that portion of the System memory which cannot be changed. The information in ROM can only be read. In the Graphic System, the BASIC operating system resides in ROM. |
| Scalar | A single numeric value. |
| Scientific Notation | A format representing a number as a fractional part, or mantissa, and a power of 10; for example, in 3.28E6, 3.28 is the mantissa and E6 is the power of 10. |
| Scissoring | Removing vectors which attempt to move the graphic point off the graphic surface. |

| | |
|----------------------------|---|
| Software | Prepared programs that simplify computer operations, such as mathematics and statistics software. Software must be reloaded into memory each time the System power is turned on. |
| Statement | A keyword plus any associated parameters. |
| String | A connected sequence of alphanumeric characters. Often called a character string. |
| String Constant | A character string of fixed length enclosed in quotation marks; also, the contents of a string variable. |
| String Function | A special purpose function that manipulates character strings and produces string constants. |
| String Variable | A variable that contains only alphanumeric characters, or "strings." String variables can be represented by the symbols A\$ through Z\$. They have a default length of 72; that is, they can contain up to 72 characters without being dimensioned in a DIM statement. |
| Subroutine | A part of a larger "main" routine, arranged in such a way that control is passed from the main routine to the subroutine. At the conclusion of the subroutine, control returns to the main routine. Control is usually passed to the subroutine from more than one place in the main routine. |
| Subscripted Array Variable | An array variable followed by one or two subscripts, as in A(9), B3(1,2), and Z(N). A subscript refers to a specific element within an array. |
| Substring | A portion of a larger string; "BC," for example, is a substring within the string "ABCD." |
| System | A purposeful collection of interacting components (hardware and software) forming an organized whole and performing a function beyond the capability of any one component. |
| Target Variable | Any variable which is specified as a target to receive incoming data or the results of an operation. |

GLOSSARY

| | |
|-----------------|---|
| Truncate | To reduce the number of least significant digits present in a number, in contrast to rounding off. For example, the number 5 is the result of truncating the decimal part of the number 5.382. |
| User Data Units | The units of measurement the programmer elects to work with for a particular graphing application. These units are established in the WINDOW statement as a numeric range for each axis. For example, the vertical axis range can be set starting at 0 dollars and ending at 100 dollars; the horizontal range can be set starting at the year 1962 and ending at the year 1975. All coordinate values for graphic statements (except VIEWPORT) are specified in user data units. |
| Variable | A symbol, corresponding to a location in memory, whose value may change as a program executes. |
| Variable Name | A name selected by the programmer that represents a specific variable. Numeric variables and array variables may be named with the characters A through Z and A0 through Z9. String variables may be named with the characters A\$ through Z\$. |
| Vector | A line drawn between two points on a graphic surface. |
| Viewport | The area of the Graphic System's display, measured in Graphic Display Units (GDUs), in which graphics can be displayed. The default viewport is full size, that is, 130 by 100 GDUs. |
| Window | The minimum and maximum coordinates in both the X and Y directions to be applied to the area of the screen defined as the viewport. (Also see User Data Units.) |

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