WANG

2262 DIGITIZER UTILITIES REFERENCE MANUAL

SYSTEM 2200

2262

DIGITIZER UTILITIES

REFERENCE MANUAL

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HOW TO USE THIS MANUAL

The Digitizer Utilities manual provides operating instructions for each of the 14 digitizer utility programs. Also provided is a detailed discussion of the theory and purpose behind each program. Where applicable, subroutine calling sequences and definitions of variables are given, to enable the programmer to incorporate the routines readily into his own system. The manual assumes that the reader has a working knowledge of the System 2200 as well as the Model 2262 X-Y Digitizer. Information on the programming and operation of the digitizer is included in a separate manual, the Model 2262 Digitizer Reference Manual.

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INTRODUCTION TO THE DIGITIZER UTILITIES

1.1 INTRODUCTION

The Model 2262 X-Y Digitizer Utility Package consists of ten utility programs designed to serve a twofold purpose:

1. To provide stand-alone routines which support a number of typical digitizer applications (such as scaling, area and distance calculations, etc.).

2. To serve as extended programming examples for users who wish to write their own software for the digitizer.

Given the versatility of the digitizer, and the wide range of applications in which it may find use, it is not anticipated that the utility routines will be sufficient to answer all the needs of every user. In cases where a user must develop his own software, however, it is hoped that the utility programs may be instructive in illustrating various methods of receiving, storing, and processing digitizer input.

1.2 THE UTILITY PROGRAMS

A total of ten stand-alone programs are included in the Digitizer Utility Package. Individual programs are accessed via Special Function keys from the Program Menu, which is contained in the start-up module. When the start-up module is loaded and run, the Program Menu displays the name and Special Function key of each utility program:

FN KEY	PROGRAM NAME	FN KEY	PROGRAM NAME
00	MENU DEFINITION	06	IMAGE PLOTTING
01	AREA UTILITY	07	DIRECTION & DIST.
02	IMAGE STORING	08	INQUIRY LIST
03	EQUAL SCALING	09	REGRESSION
04	UNEQUAL SCALING	10	INTERPOLATION
05	CO-ORD TRANSLATION	11*	BACK-UP

*The BACK-UP utility is used in disk-based systems only, and does not appear in the Program Menu for tape-based systems.

1.3 DIFFERENCES BETWEEN THE DISK AND TAPE UTILITIES

The Digitizer Utility Package is available in both disk and tape-based versions. For the majority of programs, differences between the two systems are negligible. In those programs which require mass storage (such as Image Storing and Menu Definition), however, there are significant differences between the disk and tape versions. A single set of operating instructions is provided for

each utility program; where discrepancies arise between the disk and tape versions of a program, these differences are clearly noted in the operating instructions.

Part numbers for the disk and tape versions of the Digitizer Utility Package are listed below:

Tape -	195-0012-1
Flexible Disk -	195-0012-2
Diskette -	195-0012-3

1.4 REQUIRED CONFIGURATIONS

The minimum configuration required to run the Digitizer Utility programs includes the following equipment:

- System 2200B-3 or 2200C-3 (12K of memory), WCS/20 (with one additional memory block), or WCS/30.
- Single flexible disk or diskette drive (disk-based systems) or tape cassette drive (tape-based systems).
- Model 2262 X-Y Digitizer.

Additionally, a Model 2212 or 2232A plotter is required for the "Image Plotting" program. For plotted output from the "Regression" program, a Model 2202 or 2212 plotter must be used. In order to run the Back-Up program for disk systems, a single tape cassette drive must be available.

1.5 THE CURSOR FLAG BUTTONS

Throughout the utility programs, the flag pushbuttons on the digitizer cursor are used to signal certain special conditions to the system. The meanings of the individual flags are defined within each program, for the purposes of that program. The operator must therefore be familiar with the locations of the four flag buttons.

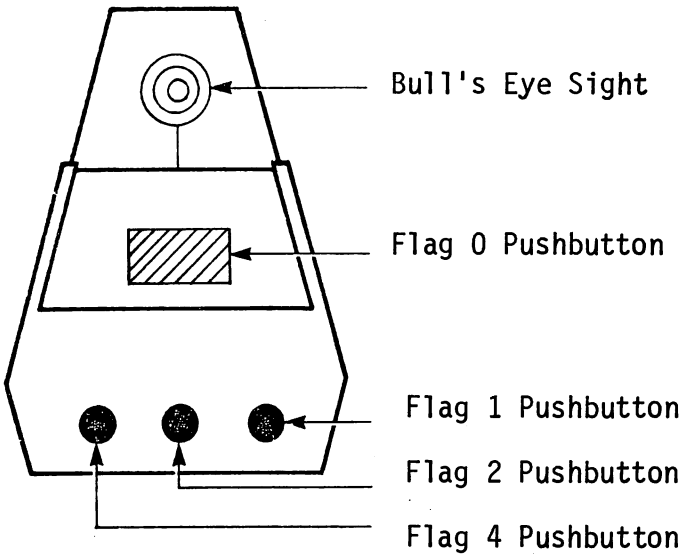


Figure 1-1
The Four-Button Cursor, Showing the Flag Associated with Each Button

1.6 SYSTEM START-UP PROCEDURES

Before any utility program can be accessed, it is necessary to load and run the starter program in order to display the Program Menu. The procedure is as follows:

1. Mount the Digitizer Utilities program disk or tape in the appropriate drive. The program disk must be mounted in the 'F' disk drive, address 310. The program tape must be mounted in the console tape drive, address 10A.

2. Enter LOAD, key RETURN (EXEC).

> NOTE:
>
> Throughout all of the following operating instructions, the RETURN(EXEC) key is referred to simply as the (EXEC) key.

3. For tape systems, enter

   LOAD "START", key (EXEC)

   For disk systems, enter

   LOAD DC F "START", key (EXEC)

4. Key RUN, (EXEC)

5. The Program Menu is now displayed.

The starter program need be loaded only once, since it is automatically reloaded, and the Program Menu displayed, at the conclusion of each utility program. In the operating instructions for the utility programs which follow, it is always assumed at the outset that the starter program has been loaded, and that the Program Menu is displayed.

CHAPTER 2

MENU DEFINITION

2.1 INTRODUCTION

The Menu Definition program enables a user to define or recall a menu. A "menu" is a coordinate grid like that in Figure 2-3, each of whose squares or "cells" has a unique identifying name. Each cell name is further associated with a particular operation or routine in the main program, so that digitizing a particular cell produces a specific response in the program. Note that the Menu Definition program enables the user to define and label a menu, without concern for the interpretation which is placed upon the menu by the main program. This latter task is left entirely to the individual programmer, since it is entirely application dependent.

In order to define a menu, the user must enter a menu name, along with certain information necessary to determine the dimensions of the menu, and the number of cells in it. It is recommended, therefore, that the menu be drawn up and labelled prior to running the program. Once the physical layout is defined, the operator is asked to enter the name of each cell in the menu. This information is stored in a data file on disk or tape (the menu name is used as the file name) for subsequent use.

2.2 THEORY OF OPERATION

Three points are used to define a rectangular menu with respect to the digitizer tablet's coordinate grid. The points used are the lower left corner (point A in Figure 2-1 below), the lower right corner (point B), and the upper right corner (point C).

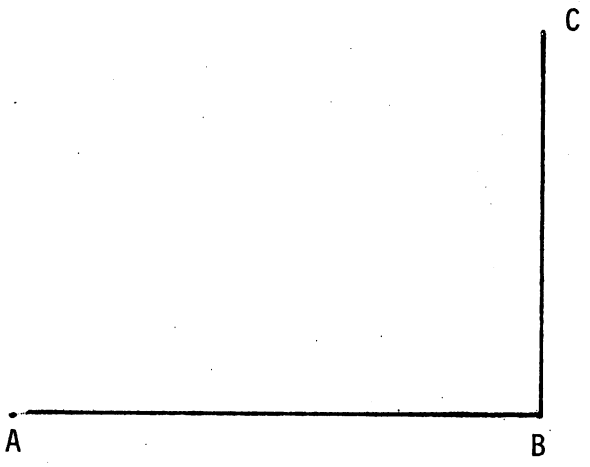


Figure 2-1
Three Points Used to Define a Menu

From the three points A, B, and C, it is possible to complete the rectangle:

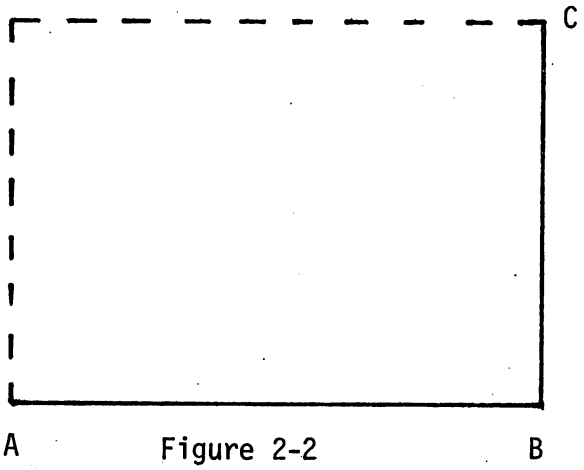


Figure 2-2

By requesting the number of cells along the X axis (the horizontal axis) and the number of cells along the Y axis (the vertical axis), the program can define a grid (see Figure 2-3).

Line AB is divided into x equal sections (where x is the number of cells along the X axis), while line CB is divided into y equal sections (where y is the number of cells along the Y axis). The result is a grid, as shown in Figure 2-3.

(1,1)	(1,2)	(1,3)
(2,1)	(2,2)	(2,3)
(3,1)	(3,2)	(3,3)

where x = 3
y = 3

Figure 2-3
Defined Grid for Menu

The grid is made up of x*y cells. (In Figure 2-3 above, 3*3 = 9 total cells.)

Each cell in the grid is defined as its row, column. Since cell numbering begins in the upper left-hand corner, that cell is identified as row 1, column 1, or simply (1,1). (See Figure 2-3 above.) This scheme makes it convenient to regard the menu as an array, in which each cell corresponds to a particular array element.

The row, column identification scheme also makes it relatively easy to calculate cell coordinates. For example, cell (1,1) is made up of all points in the range $1 \leq X < 2$ and $1 \leq Y < 2$ where X and Y are the real X and Y coordinates. When a point within cell (1,1) is digitized, the coordinates are first scaled. Next, the integer function is used to truncate the real X and Y coordinates. Since the decimal portion is truncated, the result is always an integer value for each coordinate - in this case, it is (1,1). Finally, the truncated coordinates are used as subscripts of the corresponding element in the menu array. (For example, if the menu array is A$(), then cell (1,1) corresponds to A$(1,1).)

2.3 OPERATING INSTRUCTIONS - MENU DEFINITION

	Display	Comments
1.	(The Program Menu is displayed).	1. Touch Special Function key 00 to load and run Menu Definition.
2.	SYSTEM NOW LOADING MENU DEFINITION	
3.	MOUNT MENU DATA DISK IN FIXED or MOUNT MENU DATA TAPE IN 10A KEY RETURN(EXEC) TO RESUME	3. Remove the program disk or tape, and insert a data disk or tape in its place. The data disk/ tape may be blank, or it may already contain one or more menu files.

NOTE:

For disk-based systems, it is recommended that all data disks also contain all of the utility programs. In systems with more than one disk drive, this can be done by copying or moving all program files to a data disk prior to defining the menu. In systems with only a single disk drive, the Back-Up routine must be used to copy the programs from disk to tape, and then to copy them back from tape to a data disk. A data disk which does not contain the utility programs cannot be backed up with the Back-Up program.

4. ENTER D - DEFINE A MENU, R - RECALL A MENU, OR E - END	4. Enter the appropriate letter, key (EXEC). If you enter D or R, proceed to Step 5. If you enter E, skip to Step 15. A response other than D, R, or E is illegal.
5. ENTER MENU NAME (8 CHARACTERS) ?_	5. Enter the name of the menu, key (EXEC). If recalling an existing menu ('R' at Step 4), skip to Step 8.

NOTE:

The following Steps 6 and 7 apply only to the tape version of this program. Disk system operators skip to Step 8.

6. DOES DATA TAPE HAVE EXISTING MENU DATA FILES? (Y OR N) ?_	6. If one or more menu files are stored on the data tape, key Y, (EXEC). If the tape is blank, key N, (EXEC).
7. ENTER 1 - 75 FT. TAPE OR 2 - 150 FT. TAPE ?_	7. Enter the appropriate number to indicate the length of your data tape. Key (EXEC).
8. DIGITIZE LOWER LEFT HAND CORNER ?_	8. Set the digitizer to Single Point mode, and digitize the lower left-hand corner of the menu.
9. DIGITIZE LOWER RIGHT HAND CORNER ?_	9. Digitize the lower right-hand corner of the menu.

10. DIGITIZE UPPER RIGHT HAND CORNER ?_	10. Digitize the upper right-hand corner of the menu. If re-calling an existing menu ('R' at Step 4), skip to Step 14.
11. ENTER THE NO. OF DIVISIONS ALONG X-AXIS ?_	11. The number of divisions along the X-axis (horizontal axis) is the number of columns in the menu. Enter the number, key (EXEC).
12. ENTER THE NO. OF DIVISIONS ALONG Y-AXIS ?_	12. The number of divisions on the Y-axis (vertical axis) is the number of rows in the menu. Enter the number, key (EXEC).
13. READING LEFT TO RIGHT, TOP TO BOTTOM ENTER THE NAME OF CELL	13. Enter the name of each cell in the menu. Cell identification begins with the cell in the upper left-hand corner (1,1) and proceeds row by row. To leave a cell name blank, simply key (EXEC).
14. DIGITIZE POINT ?_	14. When all cell names have been entered, the menu definition is complete. If you now digitize a point anywhere within the menu, the name of the cell containing the digitized point is displayed. Use the Flag 0 or Flag 1 button for normal points.

NOTE:

The Flag 2 or Flag 4 buttons are used to signal termination of the digitizing routine, and return the program to Step 4.

```
**************************************************
*                                                *
*                 END OF PROGRAM                 *
*                                                *
* If you enter 'E' at Step 4 (signalling end of  *
* program), the program skips to Step 15 below.  *
*                                                *
**************************************************
```

15. REMOVE DATA DISK AND
INSERT PROGRAM DISK
or
REMOVE DATA TAPE AND INSERT
PROGRAM TAPE

KEY RETURN(EXEC) TO RESUME

15. Remove the data disk/tape, and replace it with the program disk/tape. When you key (EXEC), the menu program is cleared, the starter program is automatically loaded, and the Program Menu is displayed.

> Note:
>
> In disk systems, if the data disk contains all utility programs, it is not necessary to remove it and insert the program disk.

CHAPTER 3

AREA UTILITY

3.1 INTRODUCTION

The Area Utility computes and displays the area of any polygonal or curvilinear plane figure in scaled units. (The scale may be entered by the operator or calculated by the program.) For polygonal figures, the digitizer may be set to Single Point mode, and only the vertices of the figure digitized. For curvilinear figures, the digitizer must be set to Switch Stream mode, and the entire perimeter of the figure carefully traced. (The degree of accuracy with which the perimeter is traced will, of course, have a direct bearing upon the accuracy of the area calculation.)

A special flag button (Flag 4) is used to signal the last point on the figure. When the last point is signalled, the system automatically closes the figure by drawing a straight line from the last point to the first point, and computes the area of the enclosed figure. A second flag button, Flag 1, is used to signal operator intervention. This flag enables the operator to temporarily halt digitizing at a given point, and switch the digitizer to a different operating mode - a capability which may be important, for example, in working with a figure composed of both straight and curved lines.

3.2 THEORY OF OPERATION

The coordinate method of area calculation is used by the Area Utility program. Initially, the coordinates of the first point are stored for later reference when the figure is closed. As the operator digitizes, the area is calculated continuously with the following formula:

$$A = A + (X1 * Y2 - X2 * Y1)/2$$

where: X1 = last X coordinate
X2 = current X coordinate
Y1 = last Y coordinate
Y2 = current Y coordinate

Because the area is computed continuously, the operator may obtain the area already computed (the "temporary area") at any point.

When the figure is closed, and a final area computed, the absolute units are scaled according to the scale factor entered or calculated earlier in the program, and the final area is displayed in real units.

3.3 OPERATING INSTRUCTIONS - AREA UTILITY

Display	Comments
1. IS THE SCALE ALREADY KNOWN? (Y/N)	1. Key Y or N, (EXEC). If the scale is not known, skip to Step 3.
2. ENTER THE KNOWN SCALE IN UNITS PER INCH ?_	2. If the scale is known, enter it and key (EXEC). Skip to Step 7.
3. SET DIGITIZER TO POINT MODE KEY RETURN(EXEC) TO RESUME ?_	3. If the scale is not known, set the digitizer to Single Point mode, key (EXEC). Follow Steps 4-6.
4. ENTER THE LENGTH OF ANY KNOWN DIMENSION ?_	4. If the scale is not known, the length of at least one line in the figure must be known. The length is assumed to be in the user's units.
5. DIGITIZE END POINTS OF KNOWN DIMENSION - 1ST PASS POINT NUMBER 1 ? POINT NUMBER 2 ?_	5. Define the line whose length has just been entered by digitizing its end points.

NOTE:

The end points of the reference line are digitized in two passes, and the calculated length of the line is averaged, to allow for operator inaccuracy.

6. DIGITIZE END POINTS OF KNOWN DIMENSION - 2ND PASS POINT NUMBER 1 ? POINT NUMBER 2 ?_	6. Digitize the end points again, in the same order as on the first pass. The scale (calculated or known) is displayed.
7. SET DIGITIZER TO DESIRED MODE KEY RETURN(EXEC) TO RESUME ?_	7. For computing the area of polygonal figure (i.e., one composed of straight lines), leave the digitizer in Single Point mode. For curvilinear figures set the unit to Switch Stream mode.

8. DIGITIZE INITIAL POINT
?_

FLAG 0 - NORMAL POINT
FLAG 1 - OPERATOR INTERVENTION
FLAG 2 - NORMAL POINT

FLAG 4 = LAST POINT

8. Digitize the initial point on the figure's perimeter. Use the Flag 0 or Flag 2 button. The initial point is arbitrarily chosen by the user.

9. DIGITIZE POINT
?_

9. Continue digitizing points on the perimeter. When the perimeter has been defined, indicate this fact by signalling "Last Point" with Flag 4.

```
**********************************************************************
*                        LAST POINT (FLAG 4)                         *
*                                                                    *
*  When the Last Point is signalled with the Flag 4 button, the      *
*  program automatically closes the figure by drawing a straight     *
*  line between the last point and the initial point.  The area      *
*  is then displayed in scaled units, and the operator is asked      *
*  whether he wishes to rerun the program.                           *
*                                                                    *
**********************************************************************
```

10. DO YOU WANT TO CALCULATE ANOTHER AREA? (Y OR N)
?_

10. If you enter Y, (EXEC), proceed to Step 11. If you enter N, (EXEC), the screen is cleared, and the Program Menu is reloaded and displayed.

11. DO YOU WANT TO KEEP THE SAME SCALE? (Y OR N)
?_

11. If you enter Y, (EXEC), return to Step 8.
If you enter N, (EXEC), return to Step 1.

```
**********************************************************************
*                  OPERATOR INTERVENTION (FLAG 1)                    *
*                                                                    *
*  Flag 1 is the Operator Intervention button.  If it is             *
*  depressed at any point during the digitizing process, the         *
*  program halts and displays the area computed to that              *
*  point.  It also enables the user to switch modes of               *
*  operation, i.e., if digitizing a combination of straight          *
*  and curved lines, he would want to switch from POINT MODE         *
*  to SWITCH STREAM MODE.  The operator then has the option to:      *
*  (a) continue program execution at the last digitized point,       *
*  or (b) rerun the program.                                         *
*                                                                    *
**********************************************************************
```

12. ENTER EXECUTE TO RESUME OR
1 TO START NEW AREA
?_

12. If you key RETURN(EXEC), return to Step 9, and continue digitizing at the last digitized point. If you key 1, RETURN(EXEC), proceed to Step 13.

13. DO YOU WISH TO KEEP THE
SAME SCALE? (Y OR N)
?_

13. If you key Y, (EXEC), return to Step 8 and begin digitizing. If you key N, (EXEC), return to Step 1 to enter or compute a new scale.

CHAPTER 4

INTRODUCTION TO SCALING

4.1 THE THREE SCALING UTILITIES

The Utility Package provides three separate scaling utilities:

Equal Scaling	(Chapter 5)
Unequal Scaling	(Chapter 6)
Coordinate Transformation	(Chapter 7)

Although all three utilities are referred to as "scaling" routines, only two of them (Equal and Unequal Scaling) actually perform a scaling operation properly so-called. The third, Coordinate Transformation, does not compute a scale factor. All three routines can be used, however, to convert the digitizer's ("absolute") coordinates into the user's ("real") coordinate system.

4.2 THEORY OF OPERATION

A detailed geometric explanation of each program's operation is provided in the chapter devoted to that program. In general, all three scaling programs utilize the same variables for the scale, rotation, and displacement factors (the variables are listed at the end of each chapter), thus making it possible to use the same formula for converting from digitizer coordinates to real coordinates in all three programs. (Scale and translation factors are computed differently in each program.) The X and Y absolute-to-real conversion formulae used in all three programs are shown below:

```
X = U5+U*(X7*U3-Y7*U4)
Y = U6+U1*(Y7*U3+X7*U4)
```

where:

```
U5 = Translation factor of X
U  = X scale factor in units per .01 inch
U6 = Translation factor of Y
U1 = Y scale factor in units per .01 inch
X7 = Absolute X coordinate
Y7 = Absolute Y coordinate
U3 = Sine  of minus rotation of real X-axis above absolute
U4 = Cosine of minus rotation of real X-axis above absolute
```

4.3 THE HOLD AND TRANSLATE ROUTINE

Each of the three scaling utilities, Equal Scaling, Unequal Scaling, and Coordinate Transformation provides a Hold and Translate routine which enables the operator to reposition a document on the digitizer tablet without having to rescale. Because the same routine is common to all three programs, its theory of operation is described in this chapter.

In order to reposition a document with Hold and Translate, the operator must begin by digitizing two reference points which will remain on the digitizing surface when the document is repositioned. When the document has been moved, the same pair of reference points are redigitized, to reorient the new section of document on the tablet surface. The program then computes new rotation and displacement factors; the scale factor is not changed, however.

The geometrical explanation of Hold and Translate may be most clearly presented with reference to Figure 4-1 below. In Figure 4-1, points A and B correspond to the reference points #1 and #2 digitized before the document is moved, and points A and C lie on a line parallel to the line containing the same two points #1 and #2 digitized after the document is moved. Given that lines AB and AC are of equal length, it is necessary to find the angle formed by the intersection of the two lines. This angle CAB represents the change in the rotation angle of the coordinate system, and must be added to the previous rotation angle to produce a new rotation angle for the repositioned document. The procedure for determining the value of angle CAB is described below:

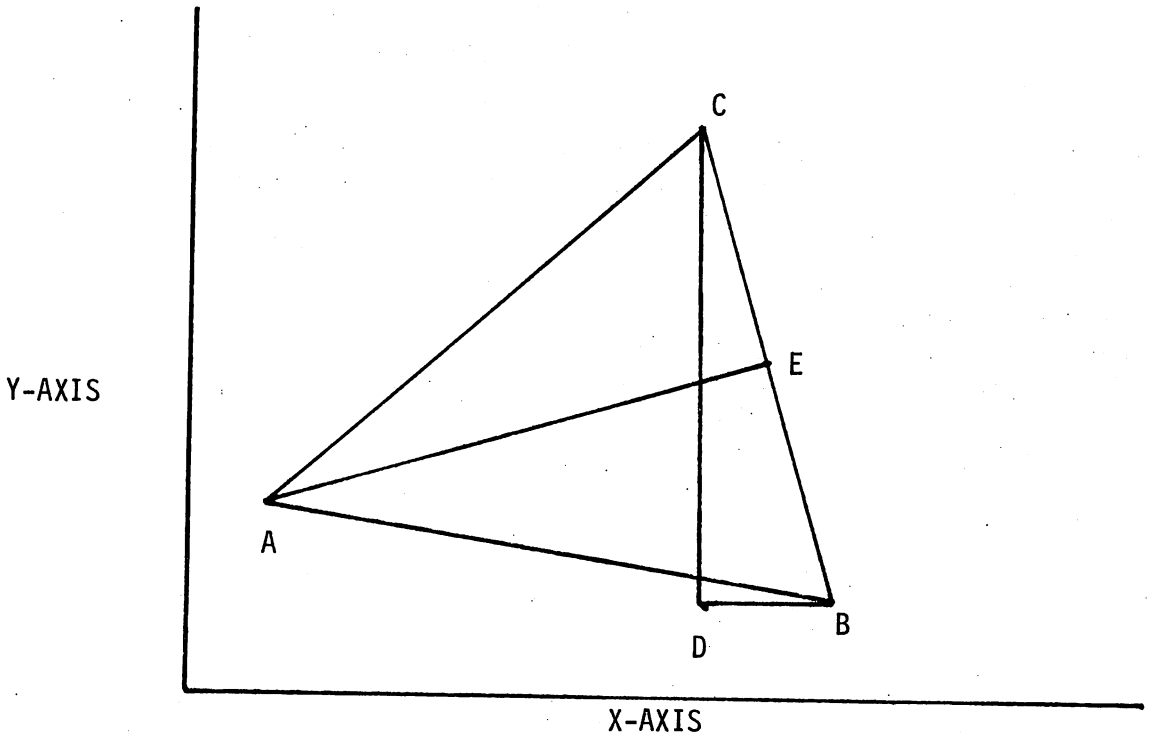


Figure 4-1

1. Since lines AB and AC are of equal length, the triangle CAB is isosceles, with base angles ABC and ACB. One method of finding angle CAB is to determine the midpoint of line BC (point E), and connect points E and A. The line AE then bisects angle CAB, and angle CAE is one-half angle CAB. Thus, angle CAB can be found by discovering the value of angle CAE and multiplying by two. This method is fruitful because triangle CAE is a right triangle; thus to find the measure of angle CAE all that is needed are the lengths of any two sides of triangle CAE.

2. To find the length of line CE, the length of line CB must be known, since CE is one-half of CB. The length of CB can be computed if the lengths of lines CD and DB are known. The length of line DB is equal to the change in X for points A and C minus the change in X for points A and B. The length of line CD is equal to the change in Y for points A and C minus the change in Y for points A and B. From this the length of line CB is computed by using the Pythagorean theorem. The length of line CE is then computed by dividing CB by two.

3. Since the length of lines AC and EC are known, the length of line AE is easily computed with the Pythagorean theorem. The measure of angle CAE is then computed as the ARCCOS of AC/AE, and angle CAB is computed as twice CAE.

Angle CAB represents the change in the rotation angle from the previous document section to the new section, and is added to the previous rotation angle to produce the rotation angle for the new section. With the new rotation angle, the routine can compute the new displacement factors. Point C is used as the known point, and displacement factors are computed with respect to that point.

NOTE:

The "rotation angle" is the angle formed by the real X axis and the absolute X axis. The "displacement factors" are the X and Y from the absolute origin point (in the lower left-hand corner of the digitizer tablet) to the real origin point.

4.4 THE 'HOLD AND TRANSLATE' SUBROUTINE

In each of the three scaling utilities, 'Hold and Transfer' operations are performed in a single marked subroutine, DEFFN'0. This subroutine may be accessed directly from a user program. The subroutine calling sequence and meanings of the arguments passed are shown below:

```
GOSUB'0 (V1,V2,V3,V4,V5,V6,V7,V8,V9,V0)
```

where:

```
V1 = Absolute X Coordinate Point #1 (before moving)
V2 = Abs. Y Coordinate Point #1 (before moving)
V3 = Abs. X Coord. Point #2 (before moving)
V4 = Abs. Y Coord. Point #2 (before moving)
V5 = Abs. X Coord. Point #1 (after moving)
V6 = Abs. Y Coord. Point #1 (after moving)
V7 = Abs. X Coord. Point #2 (after moving)
V8 = Abs. Y Coord. Point #2 (after moving)
V9 = Real X Coord. Point #2 (before moving)
V0 = Real Y Coord. Point #2 (before moving)
```

Working Variables

None

Return Variables

See Return Variables listing for each scaling routine.

CHAPTER 5

EQUAL SCALING

5.1 INTRODUCTION

The Equal Scaling program computes rotation and displacement factors necessary to convert the digitizer's absolute coordinates into the user's real coordinate system. Additionally, a scale factor is computed for the X and Y axes. Note that the same scale factor is used for both axes. If different scale factors are needed for each axis, the Unequal Scaling program (Chapter 6) must be used.

Required input for this program consists of the real and absolute coordinates of two reference points. The operator must enter the real X and Y coordinates of the chosen points, then digitize the points to generate their absolute coordinates.

From the input information, the following output is generated:

1. The X and Y scale factor in units per inch.

2. The minimum distance which can be measured along each axis, in scaled units (called the "Minimum Measure").

3. The rotation of the real X axis above or below the digitizer X axis, in decimal degrees.

4. The real X and Y coordinates of each digitized point.

5.2 THEORY OF OPERATION

In the explanation which follows, all references are to Figure 5-1.

1. The first item to be computed is the scale factors. In this case, the same scale factor is used for both X and Y axes. The scale factor is computed as the length of line AB in real units divided by the length of the same line in digitizer units (hundredths of an inch).

2. Next, the rotation angle and X and Y rotation factors must be calculated. The rotation angle (angle 3 in Figure 5-1) is found by first determining the measure of the angle formed by the intersection of line AB with the digitizer X axis (angle 1 in the figure). Angle 1 is computed as the arccosine of delta Y in digitizer units divided by the length of line AB in digitizer units. Following this, the measure of the angle formed by the intersection of line AB with the real X axis is found (angle 2 in the figure). This angle is computed as the arccosine of delta Y in real units divided by the length of line AB in real units. Finally, the rotation angle is computed as angle 1 minus angle 2.

3. Once the rotation angle is found, the X and Y rotation factors are computed. The X rotation factor is the cosine of the negative rotation angle, and the Y rotation factor is the sine of the negative rotation angle.

4. Finally, the displacement factors are computed.

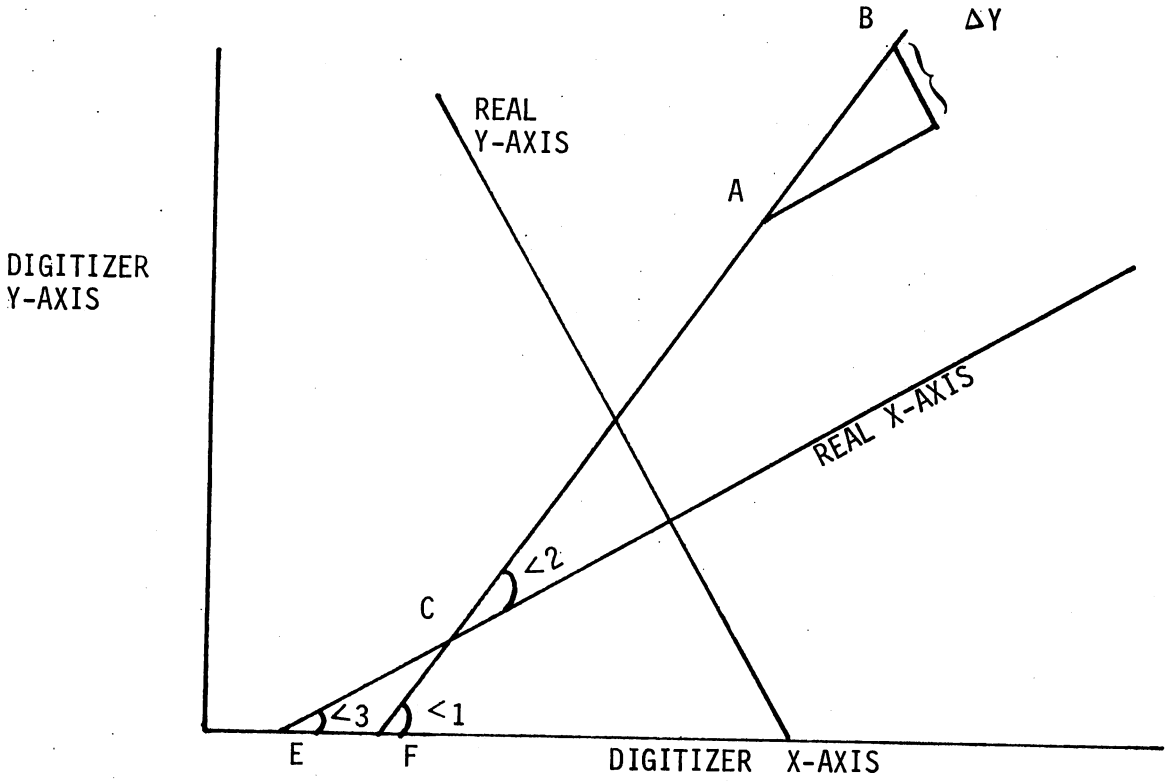


Figure 5-1

5.3 OPERATING INSTRUCTIONS - EQUAL SCALING

	Display		Comments
1.	ENTER THE X COORDINATE OF POINT #1 ?_	1.	Enter the real X coordinate of the first reference point, key (EXEC).
2.	ENTER THE Y COORDINATE OF POINT #1 ?_	2.	Enter the real Y coordinate of the first reference point, key (EXEC).
3.	ENTER THE X COORDINATE OF POINT #2 ?_	3.	Enter the real X coordinate of the second reference point, key (EXEC).
4.	ENTER THE Y COORDINATE OF POINT #2 ?_	4.	Enter the real Y coordinate of the second reference point, key (EXEC).

NOTE:

The coordinates of any two known points on the user's document may be used for reference points.

5.	DIGITIZE POINT #1 _	5.	Center the cursor bull's eye sight on point #1, and digitize by depressing the 0 Flag button (the large white cursor push button).
6.	DIGITIZE POINT #2 _	6.	Digitize Point #2 in the same way.

NOTE:

The program now computes from the real coordinates of the two reference points and the digitizer coordinates of those same points the displacement and rotation factors which will be used to convert all absolute coordinates into the real coordinate system defined for this document. The scale factor is also computed. The following information is then displayed:

7. KEY RETURN(EXEC) TO RESUME OR 1 RETURN(EXEC) TO RESTART
?_

	POINT #1		POINT #2	
	X	Y	X	Y
INPUT	----	----	----	----
DIGITIZED	----	-.--	----	----

X SCALE = ---- UNITS/INCH MIN MEASURE = ---- UNITS

Y SCALE = ---- UNITS/INCH MIN MEASURE = ---- UNITS

POSITIVE X-AXIS ROTATED ---- DEGREES ABOVE HORIZONTAL

The INPUT coordinates of points #1 and #2 are those entered by the operator. When the points #1 and #2 are digitized, the program computes the conversion factor, then independently recalculates the real coordinates of the points. The newly calculated coordinates are the DIGITIZED values, and are displayed beneath the INPUT values to verify that the conversion is accurate. The DIGITIZED coordinates may vary from the INPUT coordinates by as much as +.005 inch. This discrepancy is well within the accepted margin for error, however.

The X and Y scales indicate the number of real units per inch along each axis. A MINIMUM MEASURE in each case is the smallest portion of a unit which can be accurately measured by the digitizer. The digitizer is accurate to less than .01 inch. Thus, if the scale were one unit per inch, the minimum measure would be .01 unit.

Once the conversion and scaling factors have been computed, the digitizer coordinates for each point digitized are automatically converted to real coordinates in the newly defined coordinate system, and displayed in that form.

8. FLAG 1 = HOLD AND TRANSLATE,
FLAG 4 = END

DIGITIZE POINT #1
POINT # X Y
_

8. Use the 0-Flag or 2-Flag push-buttons to digitize normal points.

Digitize any points on the document and their real coordinates are displayed.

To end the program, digitize a point with the Flag 4 button. The Equal Scale program is halted, and a message asks whether you wish to rerun the program.

9. DO YOU WANT TO RUN THIS PROGRAM AGAIN? (N/Y)
?_

9. If you enter Y, the program restarts. If you enter N, the program is cleared, and the Program Menu is reloaded and displayed.

```
**********************************************************************
*                                                                    *
*              HOLD AND TRANSLATE ROUTINE (FLAG 1)                   *
*                                                                    *
*  Flag-1 initiates the hold and translate routine.  This special    *
*  routine is used when digitizing documents which are too large     *
*  for the digitizer tablet.  In such a case, the document must      *
*  be digitized in sections.  The system retains the same            *
*  scaling factor for each successive section, and automatically     *
*  recalculates a new conversion factor for each new section of      *
*  the document.  Each new section can thus be digitized without     *
*  rescaling or reentry  of known coordinates.                       *
*                                                                    *
**********************************************************************
```

10. FLAG 1 = HOLD AND TRANSLATE
FLAG 4 = END

DIGITIZE POINT

POINT # X Y
?_

10. To hold and translate the scaling factor to a new section of the same document, use the Flag 1 button to digitize the last point on the present section of the document.

11. HOLD AND TRANSLATE
DIGITIZE POINT #1

DIGITIZE POINT #2

_

11. It is now necessary to digitize two reference points which will enable the system to convert from the present coordinate system to the new coordinate system on the next section. Choose any pair of points near on the present section, and digitize them (the Flag 0 or Flag 2 button may be used). These points must be kept on the tablet surface when the document is repositioned.

12. REPOSITION THE DOCUMENT
KEY RETURN(EXEC) TO RESUME

12. Reposition the document, shifting the next section to be digitized onto the tablet. Be sure that the portion of the previous section containing the two reference points #1 and #2 overlaps onto the tablet surface. Tape the new section down. When the document has

been repositioned, key RETURN (EXEC) to continue program execution.

13. RE-DIGITIZE POINTS
    DIGITIZE POINT #1
    —
    DIGITIZE POINT #2

13. The reference points #1 and #2 which were digitized on the previous section must now be re-digitized to establish points of reference on the new section. A new conversion factor is computed by the program. The scaling factor is retained from the previous section.

14. DIGITIZE POINT #

    POINT # X Y
    ?

14. You can now resume digitizing points on the document. The next point digitized follows the last point digitized on the previous section (e.g., if point #100 was the last point digitized on the previous section, the program now instructs you to digitize Point #101.)

5.4 THE EQUAL SCALING SUBROUTINE

The scaling and coordinate translation operations performed by the Equal Scaling program are grouped in a single marked subroutine, DEFFN' 2. The subroutine may be called directly from a user's program, bypassing the input and output routines also contained in the Equal Scaling program. The subroutine calling sequence, and the meanings of the variables passed, are shown below.

```
GOSUB' 2 (V1, V2, V3, V4, V5, V6, V7, V8)
```

Where:

```
V1 = Real X Coordinate of Point #1
V2 = Real Y Coordinate of Point #1
V3 = Real X Coordinate of Point #2
V4 = Real Y Coordinate of Point #2
V5 = Absolute X Coordinate of Point #1
V6 = Abs. Y Coord. of Point #1
V7 = Abs. X Coord. of Point #2
V8 = Abs. Y Coord. of Point #2
```

Working Variables:

```
V0 = Scratch
```

Return Variables

U = X Scale Factor (.01 inch)
U1 = Y Scale Factor (" ")
U2 = Rotation of Real X Axis above Absolute (Degrees)
U3 = Cosine (-U2) [Rotation Factor]
U4 = Sine (-U2) [Rotation Factor]
U5 = X Displacement
U6 = Y Displacement

CHAPTER 6

UNEQUAL SCALING

6.1 INTRODUCTION

The Unequal Scaling program computes rotation and displacement factors necessary to convert the digitizer's absolute coordinates into the user's real coordinate system. Additionally, separate scale factors are computed for the X and Y axes.

Required input for this program includes the following information:

1. The real and absolute coordinates of two reference points on the document. (The operator must enter the real X and Y coordinates of each point, then digitize the two points to generate their absolute coordinates.)

2. The absolute coordinates of two points on the real X axis. (The operator must "define" the real X axis by digitizing any two points lying on it.)

From the input information, the following output is generated:

1. The X and Y scale factors in units per inch.

2. The minimum distance which can be measured on each axis, in scaled units (called the "Minimum Measure").

3. The rotation of the real X axis above or below the digitizer X axis, in decimal degrees.

4. The real X and Y coordinates of each digitized point.

6.2 THEORY OF OPERATION

In the explanation which follows, all references are to Figure 6-1.

1. First, the rotation angle must be found. The rotation angle is formed by the intersection of the real X axis with the digitizer X axis, and is labelled "angle 1" in the figure. Points A and B on the real X axis are the two reference points digitized by the operator during the program's input phase. Angle 1 (the rotation angle) is computed as the arccosine of delta Y of points A and B (see figure) divided by the length of segment AB.

2. Once the rotation angle is known, the X and Y rotation factors are computed. The X rotation factor is the cosine of the negative rotation angle, and the Y rotation factor is the sine of the negative rotation angle.

3. Next, the X and Y scale factors are computed. In this program, a separate scale factor is produced for each axis. The X scale factor is computed by dividing the delta X of the real coordinates of points C and D (the user-defined points) by the delta X of the absolute coordinates of those same two points. Similarly, the Y scale is computed as delta Y of the real coordinates of C and D divided by delta Y of the absolute coordinates of those points. (In each case the delta X and delta Y of the digitizer coordinates are adjusted to reflect the rotation angle of the real X axis.)

4. Finally, the displacement factors are computed to translate the axis system so that point C has the desired coordinates.

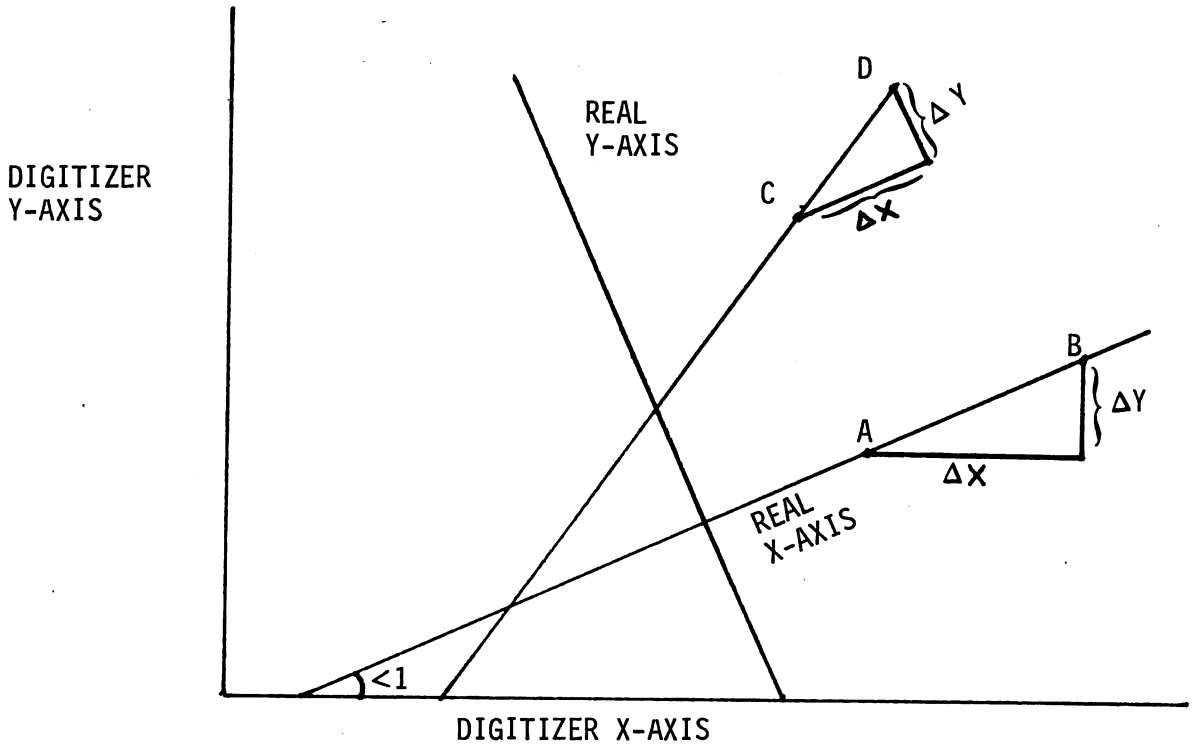


Figure 6-1

6.3 OPERATING INSTRUCTIONS - UNEQUAL SCALING

Display	Comments
1. ENTER THE X COORDINATE OF ?_	1. Enter the X coordinate of the first reference point, key (EXEC).
2. ENTER THE Y COORDINATE OF POINT #1 ?_	2. Enter the Y coordinate of the first reference point, key (EXEC).
3. ENTER THE X COORDINATE OF POINT #2 ?_	3. Enter the X coordinate of the second reference point, (EXEC).
4. ENTER THE Y COORDINATE OF POINT #2 ?_	4. Enter the Y coordinate of the second reference point, (EXEC).

NOTE:

The coordinates of any two known points on the user's document can be used as reference points, so long as they do not lie on a line parallel to either axis.

When the real coordinates of the two reference points have been entered, the operator is required to define the real X axis. This is done simply by digitizing a pair of points, identified as points #One and #Two, which lie on the X axis, or any line parallel to the X axis. The sole restriction here is that point #One must be smaller than point #Two.

5. DEFINE THE X-AXIS DIGITIZE POINT #ONE _	5. Note that point #One is not the same as point #1, whose coordinates were entered above. Point #One is any point lying on the X axis or on a line parallel to the X axis. Its real coordinates need not be known. Use the Flag 0 button to digitize this point.
6. DEFINE THE X-AXIS DIGITIZE POINT #TWO _	6. Note that point #Two should not be confused with point #2, whose coordinates were entered above. Point #Two is a second point lying on the line which contains point #One. Point #Two must have a greater X coordinate than Point #One, but its exact coordinates need not be known. Digitize point #Two with the Flag 0 button.

7. DEFINE POINTS #1 and #2
DIGITIZE POINT #1
_

7. The two reference points #1 and #2, whose real coordinates were entered at Steps 1-4 above, are now digitized to determine their absolute coordinates. Use the Flag 0 button to digitize point #1.

8. DIGITIZE POINT #2
_

8. Use the Flag 0 button to digitize point #2.

The real coordinates of the reference points #1 and #2 (entered by the operator) and the absolute coordinates of those same two points (generated by digitizing points #1 and #2) are used to compute displacement and rotation factors which enable the system to orient the coordinate system of the user's document on the tablet's coordinate grid. Subsequently, the absolute coordinates of each digitized point are automatically converted to real coordinates in the document's coordinate system. The system also computes and displays the following items:

The input coordinates of points #1 and #2.
The real digitized coordinates of points #1 and #2.
The real scale factor in units per inch.
The minimum measure in real units.
The rotation angle of the real X axis above or below the digitizer X axis.

The user is then asked to verify this information:

9. KEY RETURN(EXEC) TO RESUME,
OR 1 RETURN(EXEC) TO RESTART

9. If the information displayed is acceptable, key (EXEC) and proceed to Step 10. If not, enter 1, key (EXEC), and return to Step 1.

Note that two sets of X and Y coordinates are displayed for points #1 and #2. The INPUT coordinates are the real coordinates of points #1 and #2 entered by the operator during the program's initial phase of Steps 1-4. The DIGITIZED coordinates are the real coordinates of the same two points computed by the program from their absolute coordinates after the points were digitized at Steps 7 and 8. The DIGITIZED values are displayed beneath the INPUT values to verify the accuracy of the conversion procedure. The DIGITIZED coordinates may show a slight variance from the INPUT coordinates (for example, 7.9999 instead of 8.0000). This discrepancy is well within the acceptable margin for error, however ($\pm$ .005 inch).

Once the conversion and scaling factors have been computed, the absolute coordinates of each digitized point are converted by the program into real coordinates in the document's coordinate system, and displayed in that form.

10. FLAG 1 = HOLD AND TRANSLATE
FLAG 4 = END

DIGITIZE POINT #1

POINT # X Y

10. Use the Flag 0 or Flag 2 push buttons to digitize normal points. Digitize any points on the figure, and their real coordinates are displayed.

```
**********************************************************************
*                  PROGRAM TERMINATION (FLAG 4)                      *
*                                                                    *
* Flag 4 (END) is the program termination button.  When you          *
* depress the Flag 4 button, program execution is halted, the        *
* screen is cleared, and the program asks if you wish to rerun       *
* the Unequal Scaling program.                                       *
**********************************************************************
```

11. DO YOU WANT TO RUN THIS PROGRAM AGAIN? (Y/N)
?_

11. If you key Y, (EXEC) the Unequal Scaling program is rerun starting at Step 1. If you key N, (EXEC), the program is cleared, and the program Menu is loaded and displayed.

```
**********************************************************************
*                                                                    *
*              HOLD AND TRANSLATE ROUTINE (FLAG 1)                   *
*                                                                    *
*  Flag-1 initiates the hold and translate routine.  This special    *
*  routine is used when digitizing documents which are too large     *
*  for the digitizer tablet.  In such a case, a portion of the       *
*  document is digitized, and the next portion is then moved         *
*  onto the tablet.  The system retains the same scaling factor,     *
*  and automatically recalculates a new conversion factor for        *
*  each new section of the document.  The new section can thus be    *
*  digitized without rescaling or reentry of known coordinates.      *
*                                                                    *
**********************************************************************
```

12. FLAG 1 = HOLD AND TRANSLATE

DIGITIZE POINT

POINT # X Y

_

12. To hold and translate the scaling factor to a new section of the same document use the Flag 1 button to digitize the last point on the present section of the document.

13. HOLD AND TRANSLATE
DIGITIZE POINT #1

DIGITIZE POINT #2

_

13. It is now necessary to digitize two reference points which will enable the system to convert from the present coordinate system to the new coordinate system on the next section. Choose any pair of points on the present section, and

digitize them (the Flag 0 or Flag 2 button may be used). These points must be kept on the tablet surface on the new section when the document is repositioned.

14. REPOSITION THE DOCUMENT
KEY RETURN(EXEC) TO RESUME

14. Reposition the document, shifting the next section to be digitized onto the tablet. Be sure that the portion of the previous section containing the two reference points #1 and #2 overlaps onto the tablet surface. Tape the new section down. When the document has been repositioned, key RETURN(EXEC) to continue program execution.

15. RE-DIGITIZE POINTS
DIGITIZE POINT #1
_
DIGITIZE POINT #2

15. The reference points #1 and #2 which were digitized on the previous section must now be redigitized to establish points of reference on the new section. A new conversion factor is computed by the program. The scaling factor is retained from the previous section.

16. DIGITIZE POINT #
POINT # X Y
_

16. You can now resume digitizing points on the document. The next point digitized follows the last point digitized on the previous section (e.g., if point #100 was the last point digitized on the previous section, the program now instructs you to digitize Point #101.)

6.4 THE UNEQUAL SCALING SUBROUTINE

The scaling and coordinate translation operations performed in the Unequal Scaling program are grouped in a single marked subroutine, DEFFN'3, which may be called directly from a user's program. The input and output routines in the Unequal Scaling program may be completely bypassed in this way, if the programmer wishes to integrate the Unequal Scaling subroutine into his own program. The subroutine calling sequence, and the meanings of the arguments passed, are shown below.

```
GOSUB'3 (V1, V2, V3, V4, V5, V6, V7, V8, V9, V0)
```

Where:

V1 - Real X Coordinate of Point #1
V2 = Real Y Coord. of Point #1
V3 = Real X Coord. of Point #2
V4 = Real Y Coord. of Point #2
V5 = Abs. X Coord. of Point #1

V6 = Abs. Y Coord. of Point #1
V7 = Abs. X Coord. of Point #2
V8 = Abs. Y Coord. of Point #2
V9 = X (Abs. X Coord. of Pt. Two - Abs. X Coord. of Pt. One)
V0 = X (Abs. Y Coord. of Pt. Two - Abs. Y Coord. of Pt. One)

Working Variables:

V = Scratch
Q6$ = Error Code ("E" if Error, Blank otherwise)

Return Variables:

U = X Scale Factor (.01 inch)
U1 = Y Scale Factor (" ")
U2 = Rotation of Real X Axis Above Absolute (Degrees)
U3 = Cosine (-U2) [Rotation Factor]
U4 = Sine (-U2) [Rotation Factor]
U5 = X Displacement
U6 = Y Displacement

CHAPTER 7

COORDINATE TRANSFORMATION

7.1 INTRODUCTION

The Coordinate Transformation program computes rotation and displacement factors necessary to convert the digitizer's absolute coordinates into the user's real coordinate system. Coordinate Transformation does not, however, compute a scale factor. The scale factor may be entered by the user (it must be the same for both axes), or it may be computed by the Equal Scaling routine (Bhapter 5), and passed to Coordinate Transformation.

Required input for this program includes the following information:

1. The real and absolute coordinates of one reference point on the user's document. (The real X and Y coordinates are entered by the operator; the absolute coordinates are generated by digitizing the reference point.) The absolute coordinates of a second point are entered by digitizing the second point; the real coordinates of this point need not be known.

2. The angle formed between the line containing the two reference points and the real X axis. (The angle may be entered in degrees, minutes, seconds, or in decimal degrees.)

3. The X and Y scale factor. Equal scale factors are required. The scale factor may be entered by the user, or computed by Equal Scaling prior to running this program.

From the input information described above, the following output is produced:

1. The minimum distance which can be measured along the X and Y axes, in scaled units (referred to as the "Minimum Measure").

2. The rotation of the real X axis above or below the digitizer X axis, in decimal degrees.

3. The real coordinates of each digitized point.

NOTE:

If other routines have been run before Coordinate Transformation and a scale factor is not entered by the operator for this program, unequal scale factors may be passed to Coordinate Transformation from the previous program. In such a case, the program will not proceed beyond Step 8; instead, it will check for unequal scale factors, which are illegal in Coordinate Transformation, and continuously loop back to Step 1. This problem arises because scale factors are stored in common variables so they may be passed automatically to subsequent routines which

require a scale factor. Unless the scale factors already computed are equal, therefore, the operator must enter 'Y' in response to Step 5, and enter his own scale factor.

7.2 THEORY OF OPERATION

In the explanation which follows, all references are to Figure 7-1.

1. The first item to be found is the rotation angle. The rotation angle is formed by the intersection of the real X axis with the digitizer X axis, and is labelled "angle 1" in the figure. This is done by first computing the measure of angle ADF as the arccosine of the length of line AH divided by the length of line AB (where the real and absolute coordinates of point A were input by the operator, as well as the absolute coordinates of point B). The measure of angle 1 (angle GEF) is now computed as angle ADF minus angle ACG (where angle ACG is the reference angle whose value was input by the operator.

2. The X and Y rotation factors are computed next. The X rotation factor is the cosine of the negative rotation angle, while the Y rotation is the sine of the negative rotation angle.

3. Finally, the displacement factors are calculated so that point A has the desired coordinates.

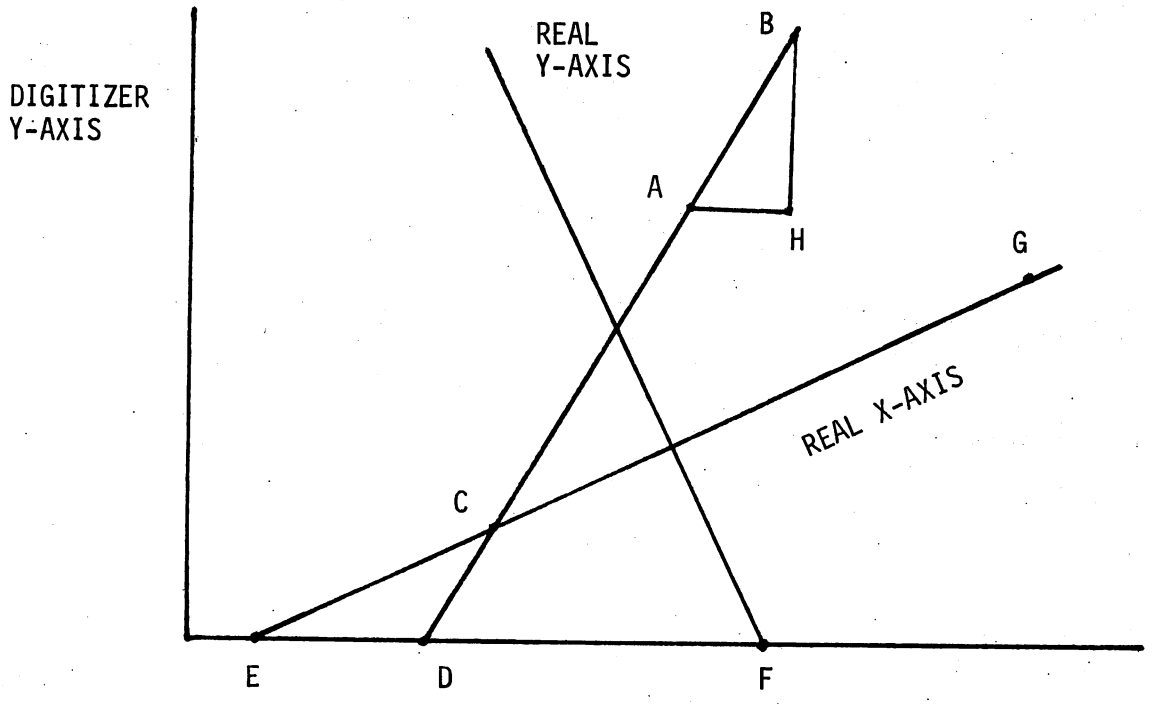


Figure 7-1

7.3 OPERATING INSTRUCTIONS - COORDINATE TRANSFORMATION

Display	Comments
1. ENTER THE X COORDINATE OF POINT #1 ?_	1. Enter the real X coordinate of the known reference point.
2. ENTER THE Y COORDINATE OF POINT #1 ?_	2. Enter the real Y coordinate of the known reference point.
3. ENTER THE ANGLE FROM THE POSITIVE X-AXIS DEGREES MINUTES SECONDS (DDDMMSS) OR DECIMAL DEGREES (DDD.DDDD) ?-_------	3. Enter the angle formed by the line containing points #1 and #2 and the real X axis. This angle may be entered in degrees, minutes, seconds (e.g., 400210 for 40 degrees, 2 minutes, 10 seconds) or in decimal degrees (e.g., 10.2010 for 10.2010 degrees). Key (EXEC).

NOTE:

The reference point whose coordinates are entered in Steps 1 and 2 may be the origin point (0,0). In this case, the reference angle entered at Step 3 is also zero.

4. IS THE ANGLE CORRECT? (Y/N) ?_	4. The angle just entered is displayed. If it is correct, enter Y, key (EXEC). If not, enter N, key (EXEC), and reenter.
5. DO YOU WISH TO ENTER A SCALE? (Y/N) ?_	5. You must enter a scale, unless a scale has previously been computed with another routine (such as Equal Scaling). The scale must be equal for both axes. If no scale is entered, the program automatically utilizes the last computed scale (which remains stored in common variables), and loops back to Step 1 if this scale is not equal.
6. ENTER THE SCALE ?_	6. The scale is always assumed to be in units per inch. Enter the scale, key (EXEC).
7. DIGITIZE POINT #1 _	7. Use the Flag 0 or Flag 2 push button on the cursor to digitize Point #1, the reference point whose coordinates you entered above.

8. DIGITIZE POINT #2

_

8. The coordinates of Point #2 have not been entered, and do not need to be entered. Point #2 is used to define the line upon which point #1 lies, and may be any point on that line.

The program now computes the rotation and displacement of the coordinate system on the user's document relative to the absolute coordinate system on the digitizer tablet. Subsequently, the absolute coordinates of all points digitized on the subject document are converted to the real coordinate system and displayed. To demonstrate that the conversion is accurate, the real coordinates of Point #1 are computed using the conversion factors, and displayed beneath the real coordinates entered for Point #1 by the operator. The variance between the input coordinates and the digitized coordinates will not be greater than ± .005 inch.

POINT #1 X Y

INPUT ---- ----

DIGITIZED ---- ----

SCALE = --- UNITS/INCH MIN. MEASURE = --- UNITS

POSITIVE X-AXIS ROTATED ---- DEGREES ABOVE HORIZONTAL

9. FLAG 1 = HOLD AND TRANSLATE
FLAG 4 = END
DIGITIZE POINT #1

POINT # X Y

9. You can now begin digitizing points on your document. The real coordinates of each point are automatically computed and displayed. Use the Flag 0 or Flag 2 push button for normal points.

```
**************************************************************
*                                                            *
*                  PROGRAM TERMINATION (FLAG 4)              *
*                                                            *
*  Flag 4 (END) is the program termination button.  When you *
*  depress the Flag 4 button, program execution is haltered, *
*  the screen is cleared, and you are asked if you wish to   *
*  rerun the program.                                        *
*                                                            *
**************************************************************
```

10. DO YOU WANT TO RUN THIS PROGRAM AGAIN? (Y/N)
?_

10. If you key Y, (EXEC), the program restart at Step 1. If you key N, (EXEC), the program is cleared, and the Program Menu is reloaded and displayed.

```
**********************************************************************
*                                                                    *
*              HOLD AND TRANSLATE ROUTINE (FLAG 1)                   *
*                                                                    *
*  Flag-1 initiates the hold and translate routine.  This special    *
*  routine is used when digitizing documents which are too large     *
*  for the digitizer tablet.  In such a case, a portion of the       *
*  document is digitized, and the next portion is then moved onto    *
*  the tablet.  The system retains the same scaling factor, and      *
*  automatically recalculates a new conversion factor for each       *
*  new section of the document.  The new section can thus be         *
*  digitized without rescaling or reentry of known coordinates.      *
*                                                                    *
**********************************************************************
```

11. FLAG 1 = HOLD AND TRANSLATE
DIGITIZE POINT
POINT # X Y
_

11. To hold and translate the scaling factor to a new section of the same document, use the Flag 1 button to digitize the last point on the present section of the document.

12. HOLD AND TRANSLATE
DIGITIZE POINT #1
_
DIGITIZE POINT #2
_

12. It is now necessary to digitize two reference points which will enable the system to convert from the present coordinate system to the new coordinate system on the next section. Choose any pair of points near the bottom of the present section, and digitize them (the Flag 0 or Flag 2 button may be used). These points must be kept on the tablet surface at the top of the new section, when the document is repositioned.

13. REPOSITION THE DOCUMENT
KEY RETURN(EXEC) TO RESUME

13. Reposition the document, shifting the next section to be digitized onto the tablet. Be sure that the portion of the previous section containing the two reference points #1 and #2 overlaps onto the tablet surface. Tape the new section down. When the document has been repositioned, key RETURN(EXEC) to continue program execution.

14. RE-DIGITIZE POINTS
    DIGITIZE POINT #1
    —
    DIGITIZE POINT #2

14. The reference points #1 and #2 which were digitized on the previous section must now be redigitized to establish points of reference on the new section. A new conversion factor is computed by the program. The scaling factor is retained from the previous section.

15. DIGITIZE POINT #
    POINT # X Y
    —

15. You can now resume digitizing points on the document. The next point digitized follows the last point digitized on the previous section (e.g., if point #100 was the last point digitized on the previous section, the program now instructs you to digitize Point #101.)

7.4 THE COORDINATE TRANSFORMATION SUBROUTINE

The coordinate translation routine performed in the Coordinate Transformation program is contained in a single marked subroutine, DEFFN'1, which can be called directly from a user's program. For the programmer who wishes to bypass the input and output routines in the Coordinate Transformation program, and integrate the Coordinate Transformation subroutine into his own program, the subroutine calling sequence, and the meanings of the arguments passed, are shown below.

```
GOSUB'1 (V1, V2, V3, V4, V5, V6, U2)
```

Where:

```
V1 = Real X Coordinate of Point #1
V2 = Real Y Coord. of Point #1
V3 = Absolute X Coord. of Point #1
V4 = Abs. Y Coord. of Point #1
V5 = Abs. X Coord. of Point #2
V6 = Abs. Y Coord. of Point #2
U2 = Rotation of Real X Axis Above Absolute (Degrees or Radians)
```

Working Variables

```
V7 }
   } scratch
V8 }
Q6$ = Error Code ("E" if error, blank otherwise)
V0  = Degree/Radian Flag
```

NOTE:

The X-axis rotation angle may be entered in either degrees or radians. If radians are used, the routine automatically converts to degrees for its computations, and converts back to radians upon completion. V0 is used as a flag to indicate whether degrees of radians were entered.

Return Variables

U3 = Cosine (-U2) [Rotation Factor]
U4 = Sine (-U2) [Rotation Factor]
U5 = X Displacement
U6 = Y Displacement

NOTE:

Scale factors are not calculated by Coordinate Transformation, and must be available to the routine in the following variables:

U = X Scale Factor
U1 = Y Scale Factor

CHAPTER 8

IMAGE STORING

8.1 INTRODUCTION

The digitizer's unique ability to "capture" a graphic image in a series of coordinate pairs which can be stored off, analyzed, or replotted, is important in many types of graphic analysis. The "Image Storing" program enables an operator to digitize a plane figure, and store the coordinates in one or more data files on disk or tape. Subsequently, the digitized "image" can be recalled for plotting (with the Image Plotting program discussed in Chapter 9) or analysis.

Image Storing sets up one or more data files into which coordinate pairs generated by the digitizer are stored. The image to be digitized can be divided into several user-defined sections, each of which is assigned a unique section identification code. Coordinates for each section are stored in a separate data file on disk or tape. Subsequently, individual sections can be recalled for analysis or plotting. In the disk-based system, it is also possible to delete and replace individual sections. In the tape version, deletion and replacement capabilities are not supported, due to the extensive file maintenance problems involved.

8.2 THEORY OF OPERATION - TAPE VERSION

When a fresh data tape is created, the program writes a "dummy" data file containing control information (including counters which specify the number of blocks on tape and the number of blocks used) at the beginning of the tape. The first data file saved on tape writes over the dummy control file, and the dummy file is rewritten immediately following the data file. This process is repeated for each new file saved, with the result that the dummy file is always the last file on tape. Following the addition of each new data file, the "blocks used" counter is updated; this counter is always checked by the program prior to storing a new file to determine how much space is available on the tape. When the tape is exhausted, a prompt is displayed directing the operator to mount a new cassette.

For each file on the tape, the program writes a hardware header record with the file name "SCRATCH". This name is used in the hardware header records for all image files. Next, a software header record is written containing the name of new data file. (The data file name consists of a six-character image name concatenated with a two-character section I.D.)

Once the file on tape is opened and named, the system is prepared to accept points from the digitizer. Points are accepted and packed into an array whose maximum capacity is 40 points. When the array is full, its entire contents are dumped onto the tape. This process continues until the operator signals the end of the section with a 4 flag. At that point, the tape file is closed. Due to the relative slowness of the tape storage operation, it is recommended that the image be digitized exclusively in Single Point Mode. A significant number of points will be lost in Stream Mode.

8.3 THEORY OF OPERATION - DISK VERSION

The disk version of Image Storing performs three operations: create new data files; delete existing data files, and replace existing data files. A "data file" is a disk file containing all points for a particular section of a digitized image. The data file name is created by concatenating the six-character image file name with a two-character section I.D. code. Each data file is created with the following disk statements:

1. DATASAVE DC OPEN T #1, X, "DATA FILE NAME"

2. DATASAVE DC #1, Identification Record

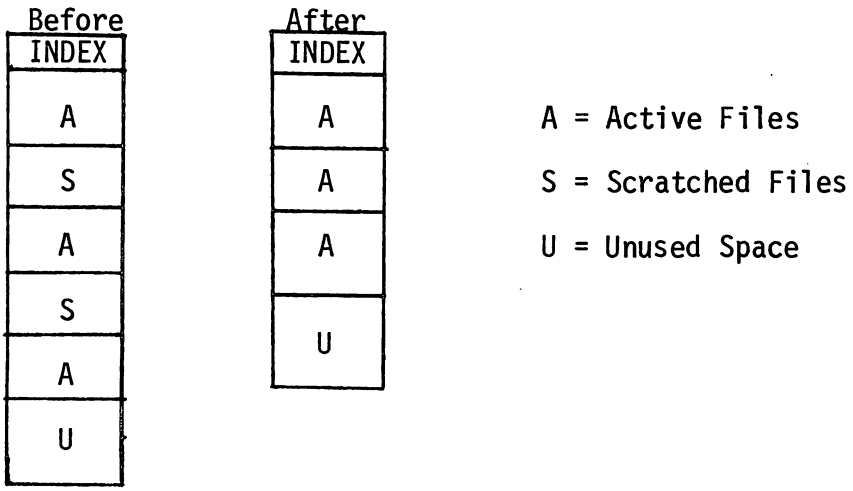
3. DATASAVE DC #1, Array

4. DATASAVE DC #1, END

In the first statement, 'X' is the number of sectors reserved for the new data file. This number actually represents the total number of sectors remaining in the Catalog Area. After all points have been stored for this section, the operator signals end of section with a 4 flag, and the data file is ended with the third statement above. At this point, the remaining sectors not used by the new file are returned to free status by adjustments to certain control information in the Catalog Index. These sectors are then available for the next file.

Once the file is opened and the Identification Record written (see Section 8.4 below), the program is ready to accept points from the digitizer. Points are packed into a 40-element array. When the array is filled, it is dumped out on disk. This process continues until the operator signals end-of-section with a Flag 4.

Existing data files (or sections) are deleted by first scratching the file(s) and then compressing the platter to squeeze out the scratched file(s). A special program, named CONDENSE, searches the Catalog Index, storing information on all active files. The Index is then cleared and reconstructed, one file at a time. Finally, the files themselves are rewritten in the Catalog Area to eliminate any scratched files among the active files. For example:



In order to replace a section, the data file for that section is deleted, the disk is condensed, and a new file (having the same name) is opened. The entire section must then be redigitized.

8.4 THE IMAGE FILE IDENTIFICATION RECORD

An Identification record is written at the beginning of each image data file. The Identification record consists of eight fields, containing the two 50-byte Identification lines entered for the corresponding section, along with scaling and rotation factors for that section. Note that the scaling and rotation factors are not computed by Image Storing, but must have been computed previously by one of the scaling routines (Equal, Unequal, or Coordinate Transformation).

The information contained in the Identification record can be obtained by loading the record into memory. On tape, the Identification record is the third record in a file, following the hardware and software headers:

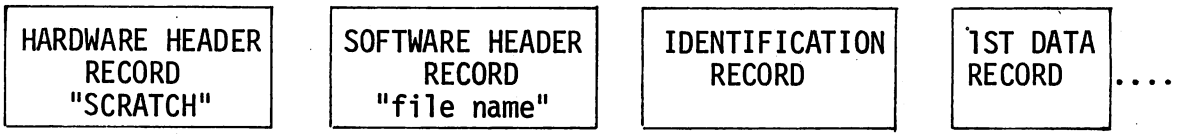


Figure 8-1. Tape File Format

On disk, the Identification record is the first record in an image data file.

The length, type, and order of the fields in the Identification record are shown below:

Table 8-1
Fields in the Identification Record

RECORD TYPE	FIELD LENGTH (BYTES)	CONTENTS
1. alpha	2	"ID" (identifies this record as an Identification record)
2. alpha	50	ID line #1
3. alpha	50	ID line #2
4. numeric	8	X-Scale Factor
5. numeric	8	Y-Scale Factor
6. numeric	8	X-Rotation Factor
7. numeric	8	Y-Rotation Factor
8. numeric	8	Rotation Angle of Real X-Axis Above Absolute

8.5 IMAGE FILE DATA RECORDS

Data records containing the coordinates of digitized points from each section are written immediately following the Identification record in an image data file. Data records are created by reading digitized points into memory and packing them into an alphanumeric array of 40 elements (each point is packed into five bytes; the sign is lost as a result of the packing operation). When the array is filled, it is saved out as a single data record on disk or tape, along with two control fields:

Table 8-2
Fields in an Image Data Record

FIELD TYPE	FIELD LENGTH (BYTES)	CONTENTS
1 alpha	2	"PT" (Identifies this record as a data record)
2 numeric	8	Number of valid points in this record (normally, 40)
3-43 alpha	5 each	40 alpha fields, with one set of digitizer coordinates PACKed in each field.

8.6 OPERATING INSTRUCTIONS - IMAGE STORING (TAPE VERSION)

> NOTE:
>
> Due to extensive differences in the prompts, the tape and disk versions of Image Storing have separate sets of operating instructions. The operating instructions for the tape version are contained in this section, while disk version operating instructions are found in Section 8.7.

	Display	Comments
1.	(The Program Menu is displayed.)	1. Depress Special Function Key 02 to load and run Image Storing.
2.	MOUNT DATA TAPE IN TAPE UNIT KEY RETURN(EXEC) TO RESUME ?_	2. Mount a data tape in the console tape drive, address 10A. Key (EXEC).
3.	DOES THIS DATA TAPE HAVE IMAGE STORING DATA FILES? (Y OR N) ?_	3. If the tape already has one or more image files, key Y, (EXEC). The system then searches to the end of the tape, and checks the special end-of-tape control record to determine whether there is room left on the tape. If the tape is full, a message is displayed instructing the operator to mount a new tape. If the tape is not full, the program skips to Step 5. If the tape is fresh, and contains no existing files, key N, (EXEC), and proceed to Step 4. Note: Do not store image files and menu files on the same tape.
4.	ENTER 1 - 75 FT. TAPE OR 2 - 150 FT. TAPE ?_	4. Enter 1 or 2 to signify tape length, key (EXEC).
5.	ENTER FILE NAME (MAX. 6 CHARACTERS) ?_	5. Enter the image name. This name is concatenated with the section I.D. (entered at Step 6 below) to construct a data file name for the current section.
6.	ENTER SECTION ID (MAX. 2 CHARACTERS)	6. Enter the I.D. for this section, key (EXEC).

7. ENTER IDENTIFICATION LINE #1 ENTER IDENTIFICATION LINE #2	7. Two 50-character lines are provided for a verbal description of the material digitized in this section. If you do not wish to enter a description, simply key (EXEC) in response to each prompt.
8. TURN DIGITIZER ON AND SET TO POINT MODE KEY RETURN(EXEC) TO RESUME	8. Digitizing an image in Stream Mode is not recommended, since too many points are lost during the tape storage operations.
9. DIGITIZE POINT ?-	9. Digitize a point with the Flag 0 or Flag 1 buttons. Points are accepted by the system and stored in an array. As the array is filled, it is dumped out on tape. If the tape is filled, the system writes special control information on it, and instructs the operator to mount a fresh tape.

NOTE:

The Image Plotting program interprets Flag 0 as pen down (i.e., draw a line to this point), and Flag 1 as pen up (i.e., move to this point without drawing a line). Keep this distinction in mind if you intend to reproduce the image with Image Plotting. Otherwise, the Flag 0 and Flag 1 buttons may be used interchangeably. The Flag 2 and Flag 4 buttons have the following special meanings:

Flag 2 - Operator Intervention
(Used to terminate digitizing temporarily without closing the file on tape.)

Flag 4 - End of Section

```
**********************************************************************
*                    END OF SECTION (FLAG 4)                         *
*                                                                    *
* When you have completed digitizing a section, signal this fact     *
* by depressing the Flag 4 button. The program proceeds to Step 10   *
* below.                                                             *
**********************************************************************
```

10. DO YOU WISH TO CHANGE SECTION ID? (Y OR N) ?_	10. If you wish to start a new section, enter Y, key (EXEC), and proceed to Step 11. If you do not wish to begin a new section for this image, key N, (EXEC), and skip to Step 12.
11. ENTER NEW SECTION ID ?_	11. Enter a new section I.D. (two characters), and return to Step 7.
12. DO YOU WISH TO START A NEW JOB? (Y OR N) ?_	12. If you indicated at Step 10 that you did not wish to open a new section for the present job, the system now asks if you wish to start a new job. If yes, key Y, (EXEC), and return to Step 5. If no, key N, (EXEC), and proceed to Step 13.
13. REMOVE DATA TAPE AND INSERT PROGRAM TAPE KEY RETURN(EXEC) TO RESUME ?_	13. Remove the data tape, and re place it with the program tape. Key (EXEC). The starter program is automatically loaded in, and the Program Menu is displayed.

8.7 OPERATING INSTRUCTIONS - IMAGE STORING (DISK VERSION)

Display	Comments
1. ENTER A-ADD, D-DELETE, R-REVISE, OR E-END	1. If you key A, (EXEC), proceed to Step 2. If you key D, (EXEC), skip to Step 11. If you key R, (EXEC), skip to Step 15. If you key E, (EXEC), the program is cleared, and the Program Menu is loaded and displayed.
2. ENTER FILE NAME (MAX 6 CHARACTERS) ?-_-----/	2. The file name applies to the entire image. Individual sections of the figure are further identified by section I.D. numbers. Enter the image file name, key (EXEC).
3. ENTER SECTION ID (2 CHARACTERS) ?-_-	3. Each section of the figure is identified by a unique section I.D. number. Enter the section I.D., key (EXEC).

4. REMOVE PROTECT TAB FROM DISK KEY RETURN(EXEC) TO RESUME ?_	4. Withdraw the program disk from the 'F' drive, and peel off its red Protect Tab. The program disk contains a portion of scratch space which is used to contain the image data files. Replace the disk in the 'F' drive, and key (EXEC).
5. ENTER IDENTIFICATION LINE #1 ?- --------- ENTER IDENTIFICATION LINE #2 ?----------	5. Each section can be identified with a maximum of two lines of text describing that section (maximum 50 characters per line). If you do not wish to enter any descriptive text, simply key (EXEC).
6. TURN DIGITIZER ON AND SET TO DESIRED MODE KEY RETURN(EXEC) TO RESUME ?_	6. The legal operating modes are Single Point and Switch Stream.
7. DIGITIZE POINT ?_	7. Begin digitizing points in the current section of the image. Flag usage is described in the note below.

NOTE:

Flags have the following significances:

Flag 0 - Pen Down
Flag 1 - Pen Up
Flag 2 - Operator Intervention (used for changing modes of operation)
Flag 4 - END

Flags 0 and 1 are meaningful only if the image is to be reproduced subsequently on a plotter with the Image Plotting program. In that case, Flag 0 signals pen down (i.e., draw a line to this point); while Flag 1 signals pen up (i.e., move to this point without drawing a line). In general, you should digitize the first point with the Flag 1 (pen up) button. Digitize all subsequent normal points with Flag 0. Flag 2 signals operator intervention, and causes the program to return to Step 6. Flag 4 signals the end of the section, and causes the program to proceed to Step 8.

```
**********************************************************************
*                                                                    *
*                    END OF SECTION (FLAG 4)                         *
*                                                                    *
* When the Flag 4 button is depressed, the program closes out        *
* the current section, and asks whether you wish to start a          *
* new section for the same image.                                    *
*                                                                    *
**********************************************************************
```

8. DO YOU WISH TO CHANGE SECTION ID (Y OR N)?	8. If you wish to start a new section for the same figure, key Y, (EXEC) and proceed to Step 9. If you wish to end the whole job, key N, (EXEC) and skip to Step 10.
9. ENTER NEW SECTION ID ?-_-	9. Assuming you wish to start a new section for this job, enter the new section I.D., key (EXEC), and return to Step 5.
10. DO YOU WISH TO START A NEW JOB (Y OR N)? ?_	10. If you want to start a new image, key Y, (EXEC), and return to Step 2. If you want to end this routine key N, (EXEC), and return to Step 1, where you may begin a deletion or replacement routine, or end the program.

```
**********************************************************
*                                                        *
*                   DELETION ROUTINE                     *
*                                                        *
*If you entered D, (EXEC) in response to the prompt      *
*at Step 1, the program skips to Step 11 below.         *
**********************************************************
```

11. ENTER THE NO. OF DELETIONS DESIRED ?_	11. Only complete sections may be deleted. Enter the total number of sections you wish to delete (the sections may belong to one or more images), and key (EXEC).
12. ENTER FILE NAME OF DELETION NO. XX (6 CHAR.) ?_	12. Enter the name of the image file in which a section to be deleted resides, and key (EXEC).
13. ENTER SECTION ID OF DELETION NO. XX (2 CHAR.) ?_	13. Enter the section I.D. of the section(s) to be deleted, key (EXEC).

14. - CONDENSING DISK -

14. The system now deletes the data file(s) corresponding to the specified section(s), and moves up all active files to occupy the empty space(s). Upon completion of the disk condense operation, the program returns to Step 1.

```
**********************************************************************
*                          REVISION ROUTINE                          *
*                                                                    *
* If you entered R, (EXEC) in response to the prompt at Step         *
* 1, the program skips to Step 15 below. The revision process        *
* entails deleting a complete section, and then redigitizing         *
* the entire section. The Revision Routine is therefore a            *
* combination of the Deletion and Addition routines.                 *
**********************************************************************
```

15. ENTER FILE NAME
(MAX. 6 CHARACTERS)
?_

15. Enter the name of the image containing the section which is to be revised, key (EXEC).

16. ENTER SECTION ID
(2 CHARACTERS)
?_

16. Enter the I.D. of the section which is to be revised. Key (EXEC).

17. - CONDENSING DISK -

17. The program now deletes the specified section, and moves all active sections up to occupy its space in the file. When the disk condense operation is complete, the program returns to Step 5, where the section must be redigitized. Its image file name and section I.D. are not changed, however.

NOTE:

For flexibility in revising images, it is suggested that images be broken up into a number of sections which can be easily identified and redigitized. Because the Image Storing routine stores "absolute" coordinates rather than "real" coordinates, it is imperative that the document be accurately placed in its original position on the digitizer tablet when redefining a section during the revision routine. Otherwise, the redefined section will not be compatible with the adjoining sections. It is recommended that some type of reference grid be layed out on the tablet surface with masking tape or India ink to facilitate accurate repositioning of the document.

CHAPTER 9

IMAGE PLOTTING

9.1 INTRODUCTION

The Image Plotting utility plots images which have been stored on disk with the Image Storing Utility. One or more sections from an image file may be plotted. The plotted image may be enlarged or reduced, and its resolution factor is specified by the operator. Either the Model 2212 or the Model 2232A plotter can be used (the Model 2202 is not legal). It is left to the operator to ensure that the plot will fit on the plotter.

The operator must enter the following information:

- Resolution Factor - roughly, the minimum distance between points to be plotted. The resolution factor is expressed in digitizer units (i.e., hundredths of an inch), and is used to cause the plotter to ignore points which are not a minimum distance apart, thereby eliminating unnecessary detail and speeding up the plotting operation.

- Type of Plotter - 1 for the 2212, 4 for the 2232A. The system automatically adjusts for differences between the two plotters.

- Multiplication Factor - A proportionality factor which allows the operator to enlarge or reduce the plot. 1 is the same size, 2 is twice the original size, .5 is one-half the original size, etc.

- File Name - the name of the file containing the image to be plotted.

- Number of Sections - the number of sections from the designated file which are to plotted.

- Section I.D.'s - Identification numbers of the sections to be plotted. Sections are plotted in the order in which their I.D.'s are entered.

If a file name or section I.D. is entered which cannot be found on the disk, an error message is displayed along with an error recovery prompt.

9.2 THEORY OF OPERATION

The image file name is concatenated with a section I.D. to form a unique data file name for each section. In disk-based systems, this file name is searched as it is entered, and its presence in the catalog verified. If a file name cannot be found on the disk, the entry routine is terminated, and an error message is displayed. In tape-based systems, the procedure is somewhat different. No check is made on the files as they are entered (this would be too time-consuming). The file names entered are displayed throughout the plotting phase. Sections are plotted as they are found on the tape (rather than in the order of entry). As a section is found and plotted, its file name is flagged in the display with an asterisk ('*'). When the plotting is complete, the file names of all plotted sections are asterisked. File names of sections not found on tape are not marked with asterisks.

Once the file is open, the plotter type, multiplication factor, and resolution factor entered by the operator are used as constants for the program. The number entered for the type of plotter (1 or 4) is used to adjust for the difference in increment size between the Model 2212 and the Model 2232A plotters. The Model 2212 plots 100 units per inch, while the Model 2232A plots 400 units per inch. Thus, the numbers used to represent plotter type (1 and 4) also represent the ratio of the Model 2212 plotting scale to that of the Model 2232A (100 : 400 or 1 : 4). The number entered for plotter type is therefore simply multiplied times the delta X and delta Y of each point to be plotted in order to adjust for the corresponding plotter.

The multiplication factor also is multiplied times delta X and delta Y for each point, to reduce or enlarge the size of the plotted image.

The resolution factor, finally, instructs the program to ignore points which are not a certain minimum number of digitizer units (.01 inch) apart.

9.3 OPERATING INSTRUCTIONS - IMAGE PLOTTING

Display	Comments
1. IMAGE PLOTTING, INPUT PHASE ENTER PLOTTER TYPE 1-2212, 4-2232 ?_	1. Enter the plotter type, key (EXEC).
2. ENTER RESOLUTION FACTOR (5 IS THE RECOMMENDED MINIMUM) ?_	2. The resolution factor is roughly the minimum distance between points to be plotted, expressed in digitizer units (hundredths of an inch). Thus, for example, a resolution factor of 7 equals .07 inch. The plotter ignores all points which are less than the minimum distance apart. The recommended minimum is .05 inch (i.e., a resolution factor of 5).
3. ENTER THE MULTIPLICATION FACTOR (LESS THAN 1 = REDUCTION) (GREATER THAN 1 = ENLARGEMENT) ?_	3. The multiplication factor determines the percentage of enlargement of reduction. A multiplication factor of 1 indicates same size; a factor of 2 indicates twice the original size; a factor of .5 indicates one-half the original size, etc.
4. ENTER THE NAME OF THE FILE TO BE PLOTTED ?_	4. The image file name is a maximum of six characters in length. Enter the name, key (EXEC).
5. IS FILE NAME CORRECT? (Y/N) ?_	5. Enter Y if correct, N if not. Key (EXEC).

6. ENTER THE NUMBER OF SECTIONS TO BE PLOTTED ?_	6. Each image file may consist of one or more sections. Enter the number of sections to be plotted from this file, key (EXEC).
7. ARE THE NUMBER OF SECTIONS CORRECT? (Y/N) ?_	7. Enter Y if correct, N if not. Key (EXEC).
8. MOUNT DATA DISK - UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	8. Remember that each data disk for image files must also contain all digitizer utility programs. If the disk containing the desired image file(s) is not already mounted, mount it and key (EXEC). Otherwise, simply key (EXEC).
9. IMAGE PLOTTING, INPUT SECTION ID PHASE ENTER SECTION ID ?_	9. Enter the Section Identification Numbers of the sections to be plotted. As each section is located on disk, its I.D. is displayed for the operator's verification. Step 9 is repeated for each section I.D. up to the number of sections entered at Step 6.
10. ARE THE SECTION ID'S CORRECT" (Y/N) ?_ SECTION --- SECTION ---	10. Verify that all Section I.D.'s are correct by keying Y, (EXEC). If there is a problem, key N (EXEC), and return to Step 9. The sections now are plotted, in the order in which they were entered.

PROGRAM TERMINATION

When the last section has been plotted, the program displays a prompt asking the operator whether he wishes to start a new image or end the program.

11. DO YOU WANT TO PLOT ANY OTHER FILES OR SECTIONS? (Y/N)	11. If you wish to plot another image, enter Y, key (EXEC), and the program returns to Step 1. If not, enter N, key (EXEC). The program is cleared, and the Program Menu displayed.

CHAPTER 10

DIRECTION AND DISTANCE

10.1 INTRODUCTION

The Direction and Distance program calculates the distance in real units between two digitized points and the angular direction of the new point relative to the user's (real) X axis.

Direction and Distance does not, however, compute a scale, nor does it permit the operator to enter one. It is therefore necessary to run a scaling routine prior to running the Direction and Distance program. If the operator is careful not to clear memory or Master Initialize between the conclusion of the scaling routine and the execution of Direction and Distance, the scale factors (which are stored in common variables) will be passed automatically to the new program.

No operator input is required for Direction and Distance.

10.2 THEORY OF OPERATION

The Phythagorean Theorem is utilized to compute the distance between two points. Consider the two points A and B in Figure 10-1 below:

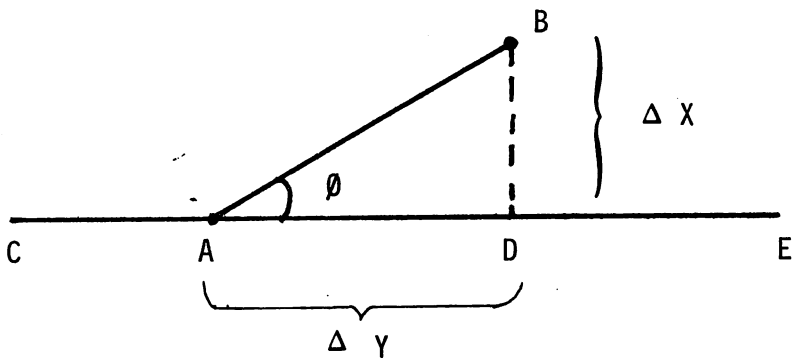


Figure 10-1

Line CE is an imaginary line running parallel to the real X axis (the location of the real X axis is known from the scaling factors passed to this program from a scaling routine).

It is a simple matter, then, to ascertain the length of line AB. Assuming the coordinates of point A are (X_1, Y_1) and those of point B are (X_2, Y_2), then:

$$\Delta X = X_2 - X_1$$

$$\Delta Y = Y_2 - Y_1$$

and

$$\text{Length AB} = \sqrt{(\Delta X)^2 + (\Delta Y)^2}$$

The angular direction of point B is the measure of the angle $\emptyset$ formed by line AB and the real X axis. The legal range of this angle is + 180 degrees. Since the hypotenuse and both adjacent sides of the right triangle are known, the measure of angle $\emptyset$ is easily determined:

$$\text{COS } \emptyset = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{\Delta X}{AB}$$

$$\emptyset = \text{arccos} \left(\frac{\Delta X}{AB}\right)$$

Since both x and the AB are always positive, however, the arccosine will always yield an angle between 0 and 180 degrees. In order to extend the range to + 180 , the result must be multiplied by the sine of y:

$$\emptyset = \text{SIN } (\Delta y) * \text{arcos} \left(\frac{\Delta x}{AB}\right)$$

A problem might arise if both x and y equal zero, implying that the same point was digitized twice. In this case, the length of AB also equals zero, and the program would bomb out on an attempt to divide by zero. This problem is obviated, however, by checking to be sure that x and y have positive values before proceeding with the calculations. If they are both equal to zero, the program displays an error message and halts.

10.3 OPERATING INSTRUCTIONS - DIRECTION & DISTANCE

Display	Comments
1. TURN DIGITIZER ON AND SET TO POINT MODE KEY RETURN(EXEC) TO RESUME ?_	
2. DIGITIZE 1ST POINT ?_ X UNITS/INCH= ---- Y UNITS/INCH= --- FLAG 0-NORMAL POINT FLAG 1=INITIAL POINT FLAG 2=LAST POINT FLAG 4=LAST POINT	2. Digitize the initial point with the Flag 1 button. Digitize all succeeding points up to the last point with the Flag 0 button. Note that the scale shown for X and Y was computed previously with a Scaling program, and automatically passed to this program.

As you digitize each normal point (Flag 0), the program computes and displays the following information:

1. Coordinates of last two points digitized.
2. Distance in real units between last two points digitized.
3. Direction (angle) of line containing last two points relative to real X-axis.
4. Distance along X and Y axes between first and second points digitized (Delta X and Delta Y):

3.

DIRECTION & DISTANCE

FROM (XXXX,YYYY)	TO (XXXX,YYYY)
DELTA X= ----	DELTA Y= ----
LENGTH= ----	DIRECTION= ---- (TO USER'S X AXIS)

4. DIGITIZE POINT ?_	4. If you wish to start a new line, use the Flag 1 button to digitize the first point. Indicate "last point" with a Flag 2 or 4 button only when you have completed all analysis, since these flags cause the program to be cleared, and the Program Menu to be reloaded and displayed. You may digitize as many different lines as you wish always being sure to indicate the beginning point of a new line with a Flag 1 button.

CHAPTER 11

INQUIRY/LIST

11.1 INTRODUCTION

The Inquiry/List program displays and/or prints file names, section IDs, and, optionally, identification records created by the Image Storing program (Chapter 8). The display/print option is offered for all file names and sections, individual files and sections, or a specified range of file names and sections.

Inquiry/List can be used to list data files other than image files (including Menu files), but the operator must be aware that the data file name is broken into two parts for image files (a six-character image file name and a two-character section I.D.). If non-image files are to be listed with this program, the file names must be entered in two parts. Note, also, that if the identification record is requested, only image files can be listed, since in this case a file which does not contain an identification record (such as a Menu file) will produce an error.

11.2 THEORY OF OPERATION

The Inquiry/List program searches through the Catalog Index of a data disk, or a digitizer data tape, and lists the image file name and section I.D. for each requested file. Optionally, the identification record for each section (consisting of two lines of text identifying that section) also may be listed.

The Range option requires the operator to enter a lower and upper bound for the image file names and section I.D.'s which are to be listed. For section I.D.'s, the program lists all I.D.'s sequentially between and including the I.D.s specified as the lower and upper bounds. For image file names, the program performs a series of alphanumeric comparisons, listing all image names which are identical to or greater than the name entered as lower bound and identical to or less than the name entered as upper bound.

11.3 OPERATING INSTRUCTIONS - INQUIRY/LIST

Display	Comments
1. (The Program Menu is displayed.)	1. Depress Special Function Key 08 to load and run Inquiry/List.
2. MOUNT DATA DISK IN UNIT 310 OR MOUNT DATA TAPE IN UNIT 10A KEY RETURN(EXEC) TO RESUME ?_	2. Mount the data disk or tape in the appropriate unit. Key (EXEC).
3. CHOOSE THE OPTION DESIRED FOR FILE NAMES ENTER A-ALL, R-RANGE, I-INDIVIDUAL, OR E-END ?_	3. To list all image file names, enter A, key (EXEC), and skip to Step 5. To list a range of image file names between and including two specified names, enter R, key (EXEC), and skip to Step 9. To list an individual image file name, enter I, key (EXEC), and proceed to Step 4. To end the program, enter E, key (EXEC). The program is cleared, and the Program Menu displayed.

**** For Individual files: ****

4. ENTER THE DESIRED FILE NAME ?_	4. An image file name may be a maximum of six characters in length. Enter the name, key (EXEC).

**** For Individual files or ALL files: ****

(If a Range of files were selected at Step 3, the system automatically lists all section I.D.'s for each image file name within the specified range. In that case, therefore, Steps 5-8 are skipped.)

5. CHOOSE THE OPTION DESIRED FOR SECTION ID's ENTER A-ALL, R-RANGE, OR I-INDIVIDUAL ?_	5. To list all section I.D.s for each image file name, enter A, key (EXEC), and skip to Step 9. To list a range of section I.D.s between and including two specified I.D.s, enter R, key (EXEC), and skip to Step 7.

To list an individual section I.D., enter I, key (EXEC), and proceed to Step 6.

**** For Individual Section I.D.'s: ****

6. ENTER SECTION ID
?_

6. Enter the desired section I.D. (two characters), and key (EXEC). Skip to Step 9.

**** For a Range of Section I.D.'s: ****

7. ENTER THE STARTING SECTION ID
?_

8. ENTER THE ENDING SECTION ID
?_

7.& Enter the starting and ending
8. section I.D.s. All section I.D.s between and including the two specified I.D.s are listed.

**** Display/Print Options: ****

9. ENTER S-SCREEN ONLY, H-HARDCOPY ONLY, OR B-BOTH
?_

9. For screen out (display only), enter S, key (EXEC).
For printed output (hardcopy only), enter H, key (EXEC).
For both screen and printed output, enter B, key (EXEC).

NOTE 1: If a display option (S or B) is chosen, the program displays one page (15 lines) at a time. In order to display the next page, the operator must touch a key on the keyboard (any key will do). This process continues until all requested files are displayed.

NOTE 2: For printed output (H or B), the printer must be equipped with paper, turned on, and selected. The program assumes a line printer (address 215). If an output writer or other printer with an address other than 215 is used, the program must be altered appropriately.

10. DO YOU DESIRE AN IDENTIFICATION RECORD TO BE LISTED? (Y OR N)
?_

10. The "identification record" consists of two 50-character lines of descriptive text entered for each section. Enter Y, key (EXEC) to list the identification record, or enter N, key (EXEC) to ignore it. Note that if you request the identification record, only image file names may be listed; any other data file will produce an error.

CHAPTER 12

REGRESSION ANALYSIS

12.1 INTRODUCTION

The digitizer Regression Analysis utility provides a routine for polynomial regression with coefficients only. The utility consist of several routines:

- A start-up routine
- A data entry routine for digitizer input
- A data entry routine for input from storage (tape cassette)
- A data correction routine
- The polynomial regression analysis (coefficients only) routine
- An output routine.

Input for the Polynomial Regression routine consists of the X and Y coordinates of a specified number of data points, referred to as "observations". These coordinates are entered with the digitizer. The input data is stored out on tape cassette at this time (disk storage is not supported). In a subsequent run, the data can be recalled from tape storage, updated, and reprocessed.

> NOTE:
>
> The digitizer must be scaled before coordinates are entered for Polynomial Regression. In tape-based systems, the Unequal Scaling routine is included as part of the Regression Utility program, and may be called to scale the digitizer during execution of the Regression program. In disk-based systems, however, no scaling program is included in the Regression Utility. One of the scaling routines must therefore be run prior to running Regression.

Printed output from this program includes the following items:

- The number of observations (i.e., data points)
- The order of the polynomial
- The input data (X and Y coordinates)
- The summations of the raw data values, of their powers, and of their cross-products.
- The regression coefficients $b_o, b_1, \ldots b_n$, etc.
- A table of raw data, corresponding calculated values, and their residuals.

Once the analysis has been completed, individual calculated values of Y on the curve can be output for given values of X. Optionally, a plotted scatter diagram of the raw data and a drawing of the deduced curve may be produced on a Model 2202 or 2212 plotter.

12.2 SPECIAL PROCEDURE FOR THE TAPE VERSION OF REGRESSION

The Regression Utility is a lengthy program. To minimize access time for the other utilities, Regression is recorded as the last program on the system tape. Unhappily, this technique also maximizes the access time for Regression itself, since the system must search forward over all of the other utilities before loading a Regression module. Because Regression consists of five separate modules, each of which is called at a different point in the program, the cumulative access time becomes quite significant.

In order to reduce the access time for Regression, it is suggested that the Regression modules be copied to a separate tape. Since the second tape will contain only the Regression routines, with none of the other utilities, search time is minimized, and total loading time for the Regression utility is considerably reduced.

The Regression modules must be copied to the new tape in the order in which they are recorded on the system tape. The module names are listed below, in the order in which they are stored on the system tape:

1. REGRESS
2. INPUT1
3. REG107AA
4. PLOT

Each module must be loaded and saved individually by name (e.g., LOAD "REGRESS", SAVE "REGRESS", etc.). In systems with only a single tape drive, this procedure is a time-consuming one. Remember, though, that it is a one-shot operation which will result in a significant time savings each time the Regression utility is run.

12.3 THEORY OF OPERATION

Polynomial Regression (for coefficients only)

A function described by an expression of the form:

$$y = b_0 + b_1 X + b_2 X^2 + \ldots + b_n X^n$$

is fitted to a set of m data points $[(x_1,y_1), (x_2,y_2),\ldots,(x_m,y_m)]$ $(m\ n+1)$ with regression analysis by the method of least squares by solving the following simultaneous equations:

$$mb_0 + (\Sigma X)b_1 + \ldots + (\Sigma X^n)\,b_n = \Sigma Y$$
$$(\Sigma X)b_0 + (\Sigma X^2)b_1 + \ldots + (\Sigma X^{n+1})b_n = \Sigma XY$$
$$\vdots$$
$$(\Sigma X^n)b_0 + (\Sigma X^{n+1})b_1 + \ldots + (\Sigma X^{2n})b_n = \Sigma X^n Y$$

The summation is over i = 1 to m.

12.4 OPERATING INSTRUCTIONS - REGRESSION ANALYSIS

DISPLAY	COMMENTS
1. (The Program Menu is displayed.)	1. Depress Special Function Key 09 to load and run Regression.

> NOTE:
>
> Step 2 below applies only to tape systems. If you are running a disk system, skip directly to Step 3.

2. MOUNT REGRESSION PROGRAM TAPE KEY RETURN(EXEC) TO RESUME ?_	2. The "Regression Program Tape" is a user-created tape containing only the Regression modules (see Section 12.2). If you have not created a special Regression tape, simply leave the system tape in place. Key (EXEC). The first Regression module is loaded from tape.
********** *SYSTEM NOW LOADING* **********	
3. DO YOU WISH TO INITIALIZE SCRATCH TAPES? (Y OR N) ?_	3. All tapes to be used for data storage must be initialized before any data can be stored on them. The first time a cassette is used to store data, therefore, enter Y, key (EXEC), and proceed to step 4 to initialize the tape. For subsequent runs with the same cassette, enter N, (EXEC), and skip to Step 6. (Each cassette need be initialized only once.)

4. MOUNT SCRATCH CASSETTE TO BE LABELED IN LOGICAL UNIT 1
(E = END)
KEY RETURN(EXEC) TO RESUME
?_

4. Mount the cassette which is to be used for data, and key (EXEC). Repeat this procedure for all data tapes. When the last tape has been initialized, enter E, key (EXEC), and proceed to Step 5. Note: Logical Unit 1 is the tape drive with address 10A.

5. MOUNT PROGRAM CASSETTE IN LOGICAL UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

5. Remove the initialized data cassette and mount the Regression program tape. Key (EXEC). (This step is skipped for disk systems.)

Remember to label all initialized cassettes so that they may be easily identified. Inadvertent use of a non-initialized cassette for data storage will produce an error.

6. DO YOU WISH TO SCALE THE DIGITIZER? (Y/N)
?_

6. This step appears in tape versions only. For disk versions, the digitizer must be scaled with one of the scaling utilities prior to running Regression. In tape systems, if a scaling utility has not already been run, enter Y, key (EXEC), and the system loads in the Unequal Scaling utility. If you key Y, go to Chapter 6 for the Unequal Scaling operating instructions. If you key N, proceed to step 7.

NOTE:

Operating instructions for the Unequal Scaling utility are listed in Chapter 6, Section 6.3. The operating instructions are not reproduced here.

7. TEST INFORMATION
ENTER PROJECT NAME
?---

7. "Project name" is printed on the top of both printed and plotted output. To input a project or user name that contains a comma, enclose it within double quotes ("). Enter up to 32 characters for a project name, key (EXEC).

8. TEST INFORMATION
ENTER USER'S NAME
?--

8. Enter up to 32 characters for user's name, key (EXEC).

9. TEST INFORMATION
ENTER TODAY'S DATE AS MM/DD/YY
?--------

9. Enter date, key (EXEC).

10. TEST INFORMATION
ENTER DATA FILE NAME
?---

10. The file name entered here (maximum eight characters) is recorded on the data tape as the data file name, and must be used whenever that data is subsequently recalled from tape. Enter the file name, key (EXEC).

11. TEST INFORMATION
IS INFORMATION OK (Y OR N)
?_
PROJECT: .....
RUN BY: .....
DATE: .....
DATA FILE: .....

11. Enter Y or N, key (EXEC). If information is incorrect, enter N and return to step 7. Otherwise, enter Y and proceed to Step 12.

LOADING INPUT ROUTINE

While the INPUT display appears, the routine for storing and correcting data on cassettes is loaded into the CPU.

12. INPUT INFORMATION
IS INPUT FROM DIGITIZER
'D' OR STORAGE 'S'
?_

12. To enter data points from the digitizer, enter D, key (EXEC), and proceed to Step 13. To recall previously digitized points from cassette storage, enter S, key (EXEC), and skip to Step 23.

```
*****************************
*                           *
* DATA INPUT FROM DIGITIZER *
*                           *
*****************************
```

13. MOUNT SCRATCH VOL. TO
BECOME VOL. 1 OF FILE
UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

13. Mount a previously initialized scratch tape in Unit 1 (address 10A). Note that if the scratch tape has not been initialized, an ERR 49 is displayed. In this case, either mount an initialized cassette and enter RUN, (EXEC), or clean the input module, reload "REGRESS", and initialize a scratch tape. If you mount a tape which has been used before with a file name other than that entered at Step 10 above, the message INCORRECT VOL. is displayed. Either mount a correct cassette, or reinitialize the present cassette before using it for this file (existing data on the cassette will be lost).

14. PARAMETER INPUT
ENTER NUMBER OF DATA
OBSERVATIONS
?

14. The number entered is recorded on the data tape, and used to determine how many data points will be requested by the program. Enter the number of observations, key (EXEC).

15. PARAMETER INPUT
IS PARAMETER OK? (Y OR N)
?_

15. Enter Y, key (EXEC) if the number of observations is correct. If not, enter N, key (EXEC), return to Step 14.

16. DATA INPUT FOR OBS #--
?_

16. Digitize the first data point. This request is repeated until the number of observations entered at Step 14 is received.

17. CORRECTION ROUTINE
IS DATA OK? (Y OR N)
?_

17. This prompt appears routinely after every seven observations, and also following the last observation. If the data so far entered is OK, enter Y, (EXEC) and continue to digitize points, or, if all points have been digitized, skip to Step 21. If there is a problem with the data, enter N, key (EXEC), and follow the correction routine starting at Step 18.

18. CORRECTION ROUTINE
ENTER OBS # OF BAD DATA
?_

18. Enter the number of the observation you wish to change, key (EXEC).

19.	CORRECTION ROUTINE FOR OBS. #-- DIGITIZE CORRECT POINT ?_	19. Redigitize the point in question.
20.	CORRECTION ROUTINE IS DATA OK? (Y OR N) ?_	20. If there remain erroneous data, enter N, key (EXEC), and return to Step 18 to repeat the correction routine. If all data is now acceptable, enter Y, key (EXEC), and proceed to Step 21.
21.	REMOVE AND LABEL VOL.-- OF FILE---------UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	21. As each batch of observations is declared to be valid, it is recorded on the data tape. When all data has been recorded, or when the cassette is full, a message is displayed instructing the operator to remove and label the cassette. If multiple cassettes are needed, the system automatically assigns each cassette a new volume number. Key (EXEC), and proceed to Step 22, if more tapes are needed. If all data is recorded, skip to Step 36 to execute the Polynomial Regression routine and generate output.
22.	MOUNT SCRATCH VOL. TO BECOME VOL.--OF FILE------UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	22. If multiple volumes are necessary, the system requests additional scratch tapes as needed, and automatically numbers each new volume. Return to Step 16 after mounting a new cassette and keying (EXEC).

NOTE:

When all data points have been entered from the digitizer, skip to Step 36 to perform a regression analysis and output the results.

```
**************************
*                        *
* DATA INPUT FROM STORAGE *
*                        *
**************************
```

(If you entered 'S' at Step 12 above, the program skips to this point.)

23. CORRECTION ROUTINE
DO YOU WISH TO UPDATE DATA? (Y OR N)

23. Enter Y or N, key (EXEC). If Y, proceed to Step 24 to update your data. If N, skip directly to the output routine (step 36).

24. CORRECTION ROUTINE
ENTER # OF TAPE DRIVES
(1 OR 2)

24. Enter 1 or 2.

> NOTE:
>
> With two tape drives you are asked to put your input tape on Unit 1 (10A) and your output tape on Unit 2 (10B). With a single drive, updating is done in place overwriting your original data. With two tape drives, updating must be done sequentially; with one drive, the tape is rewound after each entry and updating can be done in any order. If you have two drives available, it is recommended that you use two-drive corrections.

25. MOUNT VOL. 1 OF FILE
..... - UNIT 1
KEY RETURN(EXEC) TO RESUME
?

25. Mount the data cassette in unit 1 (address 10A). Note that the file name must be identical to the data file name entered at Step 10 during the input phase. If the file consists of multiple volumes, each new volume is automatically requested as necessary.

26. PARAMETER INPUT
ENTER THE NUMBER OF DATA OBSERVATIONS
?_

26. The number entered determines the type of update routine to be followed:

(a) If you wish to update one or more existing observations, enter the current total number of observations in the data file.

(b) If you wish to delete one or more existing observations, enter the number of observations which will be left following all deletions. The program then subtracts this number from the total number of observations in the file, and interprets the difference as the number to be deleted (e.g., if there are 10 observations in the file and you wish to delete 2, enter the difference (8), and the program subtracts 8 from 10).

(c) If you wish to add one or more observations to the file, enter the new total number of observations after all new observations have been added (e.g., if there are 10 observations in the file and you wish to add 2, enter the sum, 12).

27. PARAMETER INPUT
IS PARAMETER OK? (Y OR N)
?_

27. Enter Y or N, key (EXEC). If N, return to Step 26. To change observations, continue. To delete observations, go to step 32. To add observations, go to step 34.

28. MOUNT SCRATCH VOL. TO BECOME
VOL.--OF FILE-----UNIT 2
KEY RETURN(EXEC) TO RESUME
?_

28. Mount an initialized scratch volume in unit 2 (address 10B).

NOTE:
This prompt does not appear if you are updating with a single tape drive.

NOTE:
This instruction does not apply if working with only one tape drive.

****
*
* UPDATE EXISTING OBSERVATIONS *
* ROUTINE *
*
****

29. CORRECTION ROUTINE
ENTER OBS # OF BAD DATA
(0 IF END)
?_

29. Enter obs. #, key (EXEC). The X and Y coordinates for this observation are displayed. When you have corrected all observations, enter 0, key (EXEC), and return to step 23.

> NOTE:
>
> If working with two tape drives, observations must be updated in ascending sequential order.

30. CORRECTION ROUTINE
IS DATA OK? (Y OR N)
?_

30. If you wish to change this observation, key N, (EXEC), and proceed to Step 31. If the data is all right, enter Y, key (EXEC), and return to Step 29.

31. CORRECTION ROUTINE FOR OBS.#
DIGITIZE CORRECT POINT
?_

31. Redigitize the point, and return to Step 30 to validate the new coordinates.

```
**********************
*                    *
* DELETE OBSERVATIONS *
*      ROUTINE       *
*                    *
**********************
```

32. CORRECTION ROUTINE
ENTER OBS # TO BE DELETED
?_

32. This prompt is repeated for each obs. to be deleted. Enter an appropriate observation number, key (EXEC). The observation is not actually deleted from the file at this step, however.

33. CORRECTION ROUTINE
IS OBS. BELOW TO BE DELETED?
(Y OR N)
?_

33. Before the observation is deleted, it is displayed for your verification. If you wish to delete, enter Y, key (EXEC), and this obs. is removed from the file. If not, enter N, key (EXEC), and return to Step 32. When the specified number of observations have been deleted, return to Step 23.

```
**********************
*                    *
* ADD OBSERVATIONS   *
*      ROUTINE       *
*                    *
**********************
```

34. DATA INPUT FOR OBS #
    ?_

    34. Digitize the new point. This prompt is repeated for each observation to be added to the file.

35. CORRECTION ROUTINE
    IS DATA OK? (Y OR N)
    ?_

    35. The new observation is displayed. If it is all right, enter Y, key (EXEC), and return to step 34 (if more observations are to be added).
    If the coordinates are not acceptable, enter N, key (EXEC), and return to Step 29 (the Update Routine) to correct the erroneous observation. After all additional observations have been digitized and verified, return to Step 23.

```
****************************
*                          *
* REGRESSION ANALYSIS AND  *
*      OUTPUT ROUTINE      *
*                          *
****************************
```

36. OUTPUT INFORMATION
    DO YOU WISH TO PRINT INPUT
    DATA? (Y OR N)
    ?_

    36. Enter Y or N, key (EXEC). If you wish to end program execution, enter 'N' for this step and the next.

37. OUTPUT INFORMATION
    DO YOU WISH TO EXECUTE
    PROGRAM? (Y OR N)
    ?_

    37. Enter Y or N, key (EXEC). If you wish to display the input data only, without executing the regression analysis routine, enter N, key (EXEC), and skip to Step 42.
    To execute Polynomial Regression, enter Y, key (EXEC).
    If you enter a response of 'N' to both Steps 36 and 37, program execution is terminated, and the system displays:
    STOP - END OF PROGRAM

38. PARAMETER INPUT
ENTER ORDER OF REGRESSION
POLYNOMIAL
?_

38. Enter order, key (EXEC).

39. PARAMETER INPUT
IS PARAMETER OK (Y OR N)
?_

39. Enter Y or N, key (EXEC).
If N, return to Step 38.
If Y, continue to Step 40.

40. OUTPUT INFORMATION
DO YOU WISH TO PLOT RESULTS
(Y OR N)
?_

40. Enter Y or N, key (EXEC).
If N, skip to Step 42.
If Y, continue to Step 41.

41. OUTPUT INFORMATION
ENTER PLOTTER TYPE
SYMBOL
?--

FOR 2202, KEY '02'
FOR 2212, KEY '12'

41. Enter appropriate symbol, key (EXEC).

> NOTE:
>
> Do not enter single quotes (e.g., enter 02, not '02').

42. ENTER OUTPUT DEVICE SYMBOL
?--

FOR CRT ONLY	KEY RETURN(EXEC)
FOR HIGH-SPEED	KEY 'HS'
FOR THERMAL	KEY 'TH'
FOR PLOTTER (2202)	KEY 'P'
FOR TYPEWRITER	KEY 'TY'

42. Enter symbol, key (EXEC).

NOTE:

> Enter symbol only, not single quotes.
> 'HS' symbol refers to all High-Speed Printers -- 2221, 2231, and 2261. Output is not more than 80 columns wide.

43. MOUNT PROGRAM CASSETTE IN
LOGICAL UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

43. Remove data tape from unit 1 (address 10A), and mount program cassette.

> NOTE:
>
> This prompt does not appear unless you have been recording data on tape. If it does not appear, continue to Step 44.

44. LOADING

44. The polynomial regression (coefficients only) routine is loaded into memory.

45. MOUNT VOL. 1 OF FILE----
- UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

45. Mount data cassette and depress REWIND.
Be sure printer is ON and SELECTed (SELECT lamp lit) if print output was requested; key (EXEC).

46. KEY RETURN(EXEC) TO RESUME
?_

NO. OF OBSERVATION = --
ORDER OF POLYNOMIAL = --

46. The number of observations on file and the order of the polynomial are displayed.
Key (EXEC).

47. KEY RETURN(EXEC) TO RESUME
?_

INPUT DATA:

OBS. #	X	Y	W
1	-	-	-
2	-	-	-

47. The input observations are displayed (if input display was requested at Step 36).
Key (EXEC).

48. EXECUTING PROGRAM

49. DO YOU WISH TO PRINT SUMMATIONS TABLE (Y OR N)
?_

49. Enter Y or N, key (EXEC).
If Y, continue to Step 50.
If N, skip to Step 52.

50. KEY RETURN(EXEC) TO RESUME
?_

SUMS OF RAW DATA, POWERS, AND CROSS PRODUCTS:

_ _ _ _

50. Key (EXEC).

51. EXECUTING PROGRAM

52. DO YOU WISH TO PRINT TABLE OF RESIDUALS (Y OR N)
?_

52. Enter Y or N, key (EXEC).

REGRESSION COEFFICIENTS:

_ _
_ _
_ _

53. DO YOU WISH TO ESTIMATE Y'S FROM THE REGRESSION CURVE (Y OR N)
?_

53. Enter Y or N, key (EXEC).
If Y, continue to Step 54.
If N, proceed to Step 55 (Plotting Routine) if plotting was requested. Otherwise, the program ends.

TABLE OF RESIDUALS

54. ESTIMATE OF Y FROM THE REGRESSION CURVE
ENTER X VALUE (9E99 IF END)
?_

54. Enter X value, key (EXEC).
To exit from this routine, enter 9E99, key (EXEC), and proceed to Step 55 (Plotting Routine) if plotting was requested.
Otherwise, the program ends.

NOTE:

To return to the Program Menu, clear memory, load and run "START".

```
********************
*                  *
* PLOTTING ROUTINE *
*                  *
********************
```

NOTE:

The Plotting Routine is not loaded until all other requested output (such as summation tables, etc.) has been printed or displayed. Be sure your plotter is properly set up and SELECTed (see Appendices A and B) before running the Plotting Routine.

55. MOUNT VOL. OF FILE..... -
UNIT 1
KEY RETURN(EXEC) TO RESUME
?_

55. The plotter must be on and properly set up.

Mount the first data cassette of the file to be plotted; the program automatically displays a prompt for additional volumes as they are needed. Key (EXEC).

56. CHANGE PAPER ON PLOTTER
KEY RETURN(EXEC) TO RESUME
?_

56. Insert fresh paper in the plotter as needed.
Axes are printed and labeled as the message PLOTTING AXIS is displayed.

57. KEY RETURN(EXEC) TO RESUME
?_

57. Change pens if desired.
This step is repeated once more after the scatter diagram has been plotted. As the scatter diagram is plotted the message PLOTTING DATA POINTS FOR...is displayed; as the regression curve is drawn, the message PLOTTING FUNCTION FOR...is displayed. In the final plotting step, a heading is drawn on the plot and the data tape is rewound.

NOTE:

This display does not appear if using a Model 2202 plotter. If it does appear, go to step 4.

58. STOP END OF PROGRAM	58. Remove data tape and turn off plotter. To return to the Program Menu, clear memory, load and run "START".

NOTE:

To reproduce the same plot, key RUN, (EXEC).

CHAPTER 13

INTERPOLATION

13.1 INTRODUCTION

The Interpolation program offers the capability to interpolate the values of points on a line between two known points. The program performs its own scaling operation on the basis of input parameters, and produces the distance in real units of a digitized point from the first of two known reference points. Consider, for example, Figure 13-1 below.

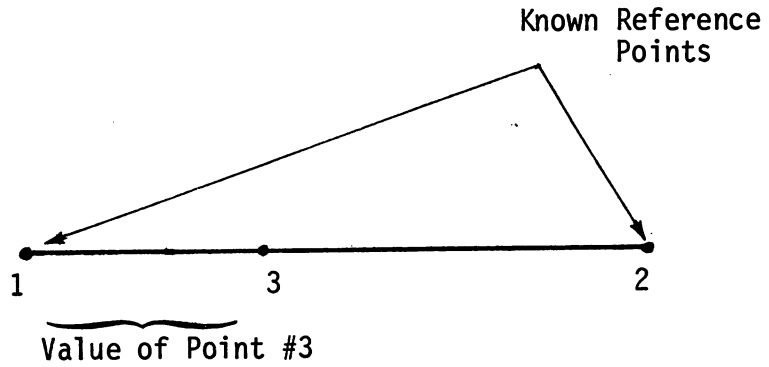


Figure 13-1

In this figure, points #1 and #2 are the reference points whose values are known, and point #3 is a point lying on the same line between them. The interpolated value of point #3 is the distance (in real units) between point #1 and point #3.

Required input for this program includes the following information:

1. The values of two known points, in real units.
2. The absolute coordinates of the two reference points, obtained by digitizing those points.

From this information, the following output is produced:

1. The scale factor in units per inch.
2. The value in real units of each digitized point lying on a line between the two reference points.

13.2 THEORY OF OPERATION

The program's first task is to examine and compare the input values of points #1 and #2. If the two points are identical, an error message is displayed and the program halts. The program requires that the value of point #2 be greater than that of point #1. If this is not the case (that is, if point #2 has a smaller value than point #1), the values of the two points are simply exchanged. By definition, therefore, point #1 is always taken to be the smaller of the two values entered.

The scale factor is computed as the distance between points #1 and #2 in real units divided by the distance in digitizer units. A displacement factor also is required; it is taken to be the value of point #1 after the exchange of values, if necessary.

With this information, the program computes the value of a digitized point lying between points #1 and #2 by finding its distance from point #1, multiplying it by the scale factor, and adding the displacement. Note that the program may not produce accurate values for points lying outside the line segment between points #1 and #2.

13.3 OPERATING INSTRUCTIONS - INTERPOLATION

	Display	Comments
1.	(The Program Menu is displayed).	1. Depress Special Function key 10 to load and run Interpolation.
2.	ENTER THE VALUE OF POINT #1 ?_	2. Enter the value of the first point in real units, key (EXEC).
3.	ENTER THE VALUE OF POINT #2 ?_	3. Enter the value of the second reference point in real units. This value should be larger than that entered for point #1. Key (EXEC).
4.	DIGITIZE POINT #1 ?_	4. Use the Flag 0 button to digitize the first reference point.
5.	DIGITIZE POINT #2 ?_	5. Use the Flag 0 button to digitize the second reference point.
	The scale is now automatically computed and displayed in units per inch, and the operator is asked to verify its acceptability.	
6.	IS SCALE OK? (Y/N) ?_	6. If the scale is acceptable, key Y, (EXEC), and proceed to Step 7. If not, key N, (EXEC), and return to Step 1.

7. DIGITIZE POINT # -- (FLAG 4 = END)	7. Digitize one or more points lying on the line between points #1 and #2, and their values in real units are displayed. (If a point outside of points #1 and #2 is digitized, its value may be erroneous.) Use the Flag 0, 1, or 2 button.

PROGRAM TERMINATION (FLAG 4)

The Flag 4 (END) button is used to terminate the interpolation routine. When a point is digitized with the Flag 4 button, the program ends, and the operator has the option to rerun Interpolation or reload the Program Menu.

8. DO YOU WANT TO RUN THIS PROGRAM AGAIN? (Y/N)	8. If you wish to rerun the program, enter Y, key (EXEC), and return to Step 2. If not, enter N, key (EXEC), and the program is cleared and the Program Menu displayed.

CHAPTER 14

BACK-UP

14.1 INTRODUCTION

The Back-Up routine is used to create back-up copies of data disks containing digitizer image or menu files in systems equipped with a single flexible disk or diskette drive and a tape cassette drive. If the system provides a multiple (dual or triple) flexible disk drive, the Back-Up routine is superfluous, since, platters can be duplicated with a MOVE or COPY operation. If the system offers a single flexible drive along with a fixed/removable drive, a simple routine can be written utilizing direct addressing statements to transfer the contents of a flexible disk or diskette to the large disk, enable the operator to mount a fresh platter in the flexible drive, and then copy the information back onto the fresh platter. In this case, too, the Back-Up routine is of no value. Whichever method the programmer chooses, he should bear in mind the importance of backing up all important files.

14.2 THEORY OF OPERATION

The Back-Up utility copies a complete disk image from a flexible disk platter or diskette to one or more tapes, and subsequently recopies the image from tape to a fresh platter, thus producing an exact duplicate of the original platter. The statements DATALOAD BA, DATASAVE BT, DATALOAD BT, and DATASAVE BA are used to transfer data from disk to tape and back to disk in 256-byte blocks, without altering the disk format information in the process. Note that the disk utility programs must be resident, along with the data files, on the platter which is to be duplicated.

14.3 OPERATING INSTRUCTIONS - BACK-UP

	Display	Comments
1.	(The Program Menu is displayed).	1. Depress Special Function Key 11 to load and run Back-Up.
2.	MOUNT DISK TO BE COPIED TO TAPE IN UNIT 310 KEY RETURN(EXEC) TO RESUME ?_	2. Mount the data disk to be copied in the disk drive. Key (EXEC).
3.	MOUNT TAPE NUMBER -- - UNIT 10A KEY RETURN(EXEC) TO RESUME ?_	3. Mount a blank tape in the console tape drive, address 10A. Key (EXEC).
4.	ENTER THE TAPE LENGTH 1 - 75' 2 - 150' 3 - 175' ?_	

When you have entered the number for the appropriate tape length and keyed (EXEC), the system begins transferring the Catalog Index and Catalog Area from disk to tape. If the tape is filled before all sectors have been copied, the system halts and displays a prompt requesting the operator to mount a fresh tape. During this entire operation, the following message is displayed:

```
COPYING SECTOR ---- OF ----

**************************
      DO NOT DISTURB
  CREATING TAPE FROM DISK
**************************
```

When the transfer operation is complete, the program loads in a second module from the newly created tape (previously copied from the disk) which transfers the disk image from tape onto a new disk or diskette.

5. MOUNT A FORMATTED DISK IN UNIT 310 KEY RETURN(EXEC) TO RESUME ?_	5. The disk platter or diskette must be formatted, but it need not be scratched. Key (EXEC) when the platter is mounted.
6. MOUNT TAPE #--- UNIT 1 KEY RETURN(EXEC) TO RESUME ?_	6. If the disk image is stored on more than one tape, be sure that the first tape is mounted in the console tape drive (address 10A). Key (EXEC). Subsequently, whenever a new tape is required, it will be requested by the program.

The program now transfers the disk image from tape to the new platter:

```
  COPYING SECTOR --- OF ---
**************************
      DO NOT DISTURB
  *CREATING DISK FROM TAPE*
**************************
```

When the last sector has been transferred from tape to disk, a message announcing this fact is displayed:

COPY COMPLETE
REMOVE AND LABEL DISK

The Back-Up program does not automatically return to the Program Menu upon completion. To display the Program Menu, key CLEAR, (EXEC), LOAD DCF "START", (EXEC), and RUN, (EXEC).

APPENDIX A

SET UP OF THE MODEL 2202 PLOTTING OUTPUT WRITER

1. Set margins manually at 5 and 130.

2. Position pin-feed paper so that the between-page perforation lies directly under the paper bail when the bail is down.

3. Check that the Paper Release and Copy Control Levers are back and that the Motor Control Switch is ON.

4. The plotter must be ON, in AUTO Mode and properly SELECTed.

NOTE:
If the plotter starts plotting all points in one place, touch RESET, key (EXEC), enter PLOT, key (EXEC), and touch RUN, (EXEC). The PLOT routine should resume correct operation.

See the Model 2202 Plotting Output Writer Reference Manual for further information on the plotter.

APPENDIX B

SET UP OF THE MODEL 2212 ANALOG FLATBED PLOTTER

1. Turn on the plotter and position paper in it. Push the CHART toggle switch to the HOLD position.

2. When the "CHANGE PAPER" prompt appears on the CRT (see Operating Instructions below), you must set the zero reference and scale adjust controls as follows:

   zero reference: press Zero Reference Check button; set reference X and Y dials at X = 3, Y = 0.5.

   scale adjust: press Scale Adjust Check button; set scale X and Y dials at X = 12, Y = 9.5.

3. The message "KEY RETURN(EXEC) TO RESUME" is displayed twice during plotting. This allows the user to change pens in the plotter. The message appears after the axes and coordinates have been drawn and labeled, and after the scatter diagram has been plotted.

For more information on the plotter, see the Model 2212 Analog Flatbed Plotter Reference Manual.

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