VT15 XVM GRAPHICS SOFTWARE MANUAL

DEC-XV-GVTAA-A-D

XVM Systems

digital

VT15 XVM GRAPHICS SOFTWARE MANUAL

DEC-XV-GVTAA-A-D

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LIST OF ALL XVM MANUALS

The following is a list of all XVM manuals and their DEC numbers, including the latest version available. Within this manual, other XVM manuals are referenced by title only. Refer to this list for the DEC numbers of these referenced manuals.

BOSS XVM USER'S MANUAL	DEC-XV-OBUAA-A-D
CHAIN XVM/EXECUTE XVM UTILITY MANUAL	DEC-XV-UCHNA-A-D
DDT XVM UTILITY MANUAL	DEC-XV-UDDTA-A-D
EDIT/EDITVP/EDITVT XVM UTILITY MANUAL	DEC-XV-UETUA-A-D
8TRAN XVM UTILITY MANUAL	DEC-XV-UTRNA-A-D
FOCAL XVM LANGUAGE MANUAL	DEC-XV-LFLGA-A-D
FORTRAN IV XVM LANGUAGE MANUAL	DEC-XV-LF4MA-A-D
FORTRAN IV XVM OPERATING ENVIRONMENT MANUAL	DEC-XV-LF4EA-A-D
LINKING LOADER XVM UTILITY MANUAL	DEC-XV-ULLUA-A-D
MAC11 XVM ASSEMBLER LANGUAGE MANUAL	DEC-XV-LMLAA-A-D
MACRO XVM ASSEMBLER LANGUAGE MANUAL	DEC-XV-LMALA-A-D
MTDUMP XVM UTILITY MANUAL	DEC-XV-UMTUA-A-D
PATCH XVM UTILITY MANUAL	DEC-XV-UPUMA-A-D
PIP XVM UTILITY MANUAL	DEC-XV-UPPUA-A-D
SGEN XVM UTILITY MANUAL	DEC-XV-USUTA-A-D
SRCCOM XVM UTILITY MANUAL	DEC-XV-USRCA-A-D
UPDATE XVM UTILITY MANUAL	DEC-XV-UUPDA-A-D
VP15A XVM GRAPHICS SOFTWARE MANUAL	DEC-XV-GVPAA-A-D
VT15 XVM GRAPHICS SOFTWARE MANUAL	DEC-XV-GVTAA-A-D
XVM/DOS KEYBOARD COMMAND GUIDE	DEC-XV-ODKBA-A-D
XVM/DOS READERS GUIDE AND MASTER INDEX	DEC-XV-ODGIA-A-D
XVM/DOS SYSTEM MANUAL	DEC-XV-ODSAA-A-D
XVM/DOS USERS MANUAL	DEC-XV-ODMAA-A-D
XVM/DOS V1A SYSTEM INSTALLATION GUIDE	DEC-XV-ODSIA-A-D
XVM/RSX SYSTEM MANUAL	DEC-XV-IRSMA-A-D
XVM UNICHANNEL SOFTWARE MANUAL	DEC-XV-XUSMA-A-D

PREFACE

This manual describes the software provided for the VT15 Graphics Display Processor and its optional:

a) VL04 Light Pen
b) LK35 Keyboard
c) VW01BP Writing Tablet and Control

The information provided is applicable for users employing the XVM Disk Operating System (DOS).

It was assumed in the preparation of this manual that the user is familiar with the DIGITAL XVM hardware and operating system.

The following manuals contain information useful in understanding and utilizing the contents of this manual.

Software Manuals

a) XVM/DOS Users Manual
b) FORTRAN IV XVM Language Manual
c) FORTRAN IV XVM Operating Environment Manual
d) MACRO XVM Assembler Language Manual
e) Various Utility Program Manuals

Hardware Manuals

a) Graphic-15 Reference Manual
b) VW01 Writing Tablet, Vol. 1

The GRAPHIC-15 Reference Manual is of particular importance to the VT15 programmer. The manual describes the basic Graphic 15 processor and its interfacing arrangement with the XVM computer. The information in this manual provides the user with the data needed for machine level programming and familiarizes the user with the operation of the Graphic System.

CHAPTER 1

INTRODUCTION

This manual presents a detailed description of the DIGITAL XVM VT15 Graphics Subprogram Package and is primarily concerned with those display subroutines and calling user programs employed to exhibit information and communicate with the computer. The Graphics subprograms generate display commands that allow the user to define display elements and direct the linking, displaying, and deleting of those elements. Their primary purpose is to provide a simplified means of using the VT15 Graphic Display device without requiring detailed familiarity with the hardware.

In this manual, Graphic Routines are described in detail as follows:

Chapter 2.	Subpicture Routines
3.	Main Display File Routines
4.	Input Routines
5.	Relocating Routines
6.	System I/O Device Handler
7.	LK35 Keyboard Handler (LKA)
8.	VW01 Writing Tablet Handler (VWA)
9.	Text Display/Edit Functions

Subprograms which consist of Graphic Routines mentioned above are called by user programs written in MACRO or FORTRAN IV language. The depth of coverage of these routines is intended to provide a basic understanding of the use of the VT15 Graphic Display system. Much useful information may be found in appendices following Chapter 6.

The DIGITAL XVM is designed with an autonomous systems structure and the VT15 follows this same philosophy; it operates asynchronously from the basic processor. Features include a cycle time of 750 nanoseconds, a character generator (with 64 printing characters and 4 control characters), a hardware program counter, a fast vector capability (1/4 inch to 1 μsec), and a wide range of hardware options.

Introduction

The minimum system configuration for the VT15 Graphics Software is discussed in the XVM/DOS User's Manual. The minimum display hardware is one VT15 display processor, and one VT04 display console.

The Graphics Software consists of a group of routines that can be called by user programs. Calls to these routines build display files in a portion of XVM memory that has been allocated by the calling program for such a purpose. The display files contain instructions and data upon which the VT15 Processor operates and to which its digital control and analog outputting circuits respond. The VT15 Processor has a set of 12 basic machine-language instructions which give it excellent versatility in the display of points, basic vectors, graphic plots, and ASCII characters. The commands contained in a main display file link together individual subpicture files causing the desired image to be displayed. Calls to other routines control the flow of the program upon the occurrence of light pen or push button interrupt. In this way, program paths can be enabled to modify the sequence of display commands and therefore modify the picture.

The VT15 Graphics Software is designed to run in Bank/Page Mode and to be used with either FORTRAN IV or MACRO XVM programs. FORTRAN IV programs composed by the user will consist of standard FORTRAN IV statements and calls to routines within the VT15 Graphics package. Other than system software normally used for compilations, assemblies, loading, etc., the VT15 Graphics software does not require use of any other programs.

In PDP-15 DOS V3A, the internal format of FORTRAN subroutine calls was changed. FORTRAN version 044, and later, have the new format. Since the Graphics Software is called by FORTRAN, its subroutine call format must match that used by FORTRAN. The following versions or later should be used with FORTRAN Version 044 or later:

```
VTPRIM 004
LTORPB 002
TRACK  002
```

Distributions of PDP-15 DOS V3A software and later contain matched sets of FORTRAN and Graphics of the new format. Under the new format, references of the form LARRAY are equivalent to LARRAY(1), so that these forms may be used interchangeably.

CHAPTER 2

SUBPICTURE ROUTINES

Subpicture routines allow the user to incorporate point plotting, line drawing, and text display in his programs with minimum effort. Calls these routines together with standard FORTRAN or MACRO statements build self-contained subpicture display files which are subscripted program arrays with executable display instructions. Each subpicture file contains all the display instructions needed to generate a specific image on the VTØ4 Display console. These files are accessed by a Main Display File (described in Chapter 3) in any order or sequence during the execution of the display program. Most Subpicture Routines will normally be called prior to initiating execution of a Main Display File, thus building a library of accessible graphics (i.e., complete or partial pictorial images) from which complex images may be formed. The subpicture display routines and their functions are:

- LINE - Draws a line (intensified) or moves the beam (not intensified) from current position. (Provides for using random vector option, if available.)
- TEXT - Displays strings of 5/7 ASCII text previously defined by the user in dimensioned arrays.
- COPY - Links subpicture files (similar to subroutining) to form a composite display image. Provides for using hardware SAVE/RESTORE feature, if desired.
- PRAMTR - Sets scale, intensity, light pen sensitivity, blink, etc., for this subpicture, or some portion thereof.
- GRAPH - Displays specified data points in graph form.
- BLANK - Inhibits display of any copy of this subpicture.
- UNBLNK - Reverses the action of the BLANK subroutine.

All display file storage is created by the FORTRAN user in the form of dimensioned integer arrays; MACRO XVM users must also allocate display file storage in some appropriate manner. To facilitate storage management, the first location of each file contains the length of the file. Limited reuse of storage is provided for in the Main Display File routines.

Subpicture Routines

The first location of a subpicture file, PNAME(1), contains its current length - this value must be set to zero before the first reference to the subpicture display file is made. After the first reference, the contents of PNAME(1) are set equal to the length of the subpicture file; this value is automatically updated by any subsequent calls to the subpicture display routines. (See Figure 2-1.) Each display ELEMENT is added at the current end of the subpicture file.

LOCATION	CONTENTS
PNAME	(6)
+1	return†
+2	vector command
+3	vector command
+4	vector command
+5	vector command
+6	DJMP* PNAME+1

†Return address stored by any display JMS (DJMS) to this subpicture.

Figure 2-1
Subpicture File Containing Four Vector Commands

Since display files are generated and stored in arrays dimensioned by the user, they are fully accessible to the user and can be written out or read in using FORTRAN unformatted I/O statements.

Storage overhead for each subpicture display file is three words; the first word contains the file length, the second is used for a return address, and the third (last in file) contains the VT15 display command DJMP* PNAME+1.

The procedure for generating a subpicture file such as that illustrated in Figure 2-1 requires some further explanation. The four calls to subroutine LINE, shown below, will result in such a file. This subpicture file will simply draw a square when accessed by the Main Display File or another subpicture file.

```
      DIMENSION IPNAME(1Ø)
      IPNAME(1)=Ø
          :
      CALL LINE (1ØØ,Ø,1,IPNAME(1))
      CALL LINE (Ø,1ØØ,1)
      CALL LINE (-1ØØ,Ø,1)
      CALL LINE (Ø,-1ØØ,1)
          :
```

Note in the above example that storage allocation for the subpicture file was provided by the DIMENSION statement. Also, the first location, IPNAME(1), was set to zero before the first reference to it, thus indicating a new file. The identity of a subpicture file is the address of its first location (PNAME) and is given or implied, as an argument in all calls to subpicture routines. Each subpicture file is left in displayable form so that it can be manipulated dynamically while being displayed.

Limited reuse of storage is provided for in the main display file routines RSETPT, REPLOT, and DELETE which are explained in Chapter 3. In this chapter, the number of locations required for display instructions generated by each subroutine call is indicated in each of the subroutine descriptions. Naturally, the total number of locations that can be allocated for display files is limited by the amount of core memory available.

2.1 GENERAL RESTRICTIONS

The following general restrictions apply to all subpicture routines except BLANK and UNBLNK.

a. All arguments (constants or variables) must be of integer form.

b. The variable PNAME must be set equal to zero before the first call referencing it.

c. The PNAME array must be of sufficient size to contain the entire subpicture file (the software does not check for overflow).

2.2 LINE SUBROUTINE

The LINE subroutine adds to the end of the specified subpicture file the commands necessary to draw a line (beam intensified) or move the beam (not intensified) through a specified displacement from the current beam position.

The call statement has the form:

```
CALL LINE (DELTAX,DELTAY,INT[,PNAME])
```

where the enclosing brackets [ ] indicate an optional argument.

Subpicture Routines

DELTAX represents the horizontal component of beam displacement in raster units and DELTAY represents the vertical components. A raster unit is the distance between two adjacent points along the X or Y axis, and differs in size with different picture tubes. The integer variable INT indicates whether the line is to be intensified (INT=1, the line will be visible; INT=0 the line will not be visible). The variable PNAME represents the first location of this subpicture file. If this optional argument is not provided, the display code is appended to the array whose PNAME was last provided in any call to a subpicture routine. For example, if a subpicture is to start in the dimensioned array ILEMNT, the form is:

```
CALL LINE(DELTAX,DELTAY,INT,ILEMNT(1))
```

Each subroutine LINE call adds one command to the display file if DELTAX and DELTAY define one of the eight basic directions:

VN![INT!]INCR (where VN is vector direction n, [INT] is only included if the line is to be intensified, and INCR is units) (the exclamation operator indicates an inclusive OR function)

If DELTAX and DELTAY do not define one of the eight basic directions, LINE tests for availability of the random vector option, and, if available, adds two commands to the display file:

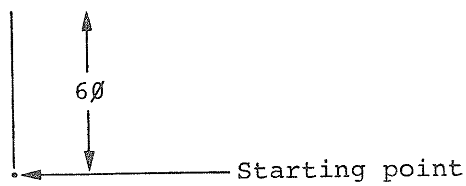
SVX!DELTAX (stroke vector, x displacement)
SVY!DELTAY (stroke vector, y displacement)

If not one of the eight basic directions, and if the random vector option is not available, LINE approximates the required line with a series of basic vectors. The contents of the location PNAME is incremented by the number of commands added to the display file.

In addition to the general restrictions (paragraph 2.1) outlined previously for subpicture routines, there is another restriction that should be considered when using subroutine LINE: DELTAX and DELTAY should always be signed integers with magnitudes not exceeding 1Ø23. The following two statements illustrate the use of the LINE subroutine.

```
CALL LINE (Ø,6Ø,1,ILINE(1))
```

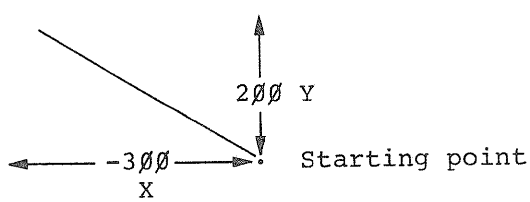
This statement generates a display instruction to draw a vertical line 6Ø raster units long. The display instruction (a basic vector) is stored at the end of subpicture file ILINE.



The following statement illustrates use of the LINE routine to draw a sloped line:

```
CALL LINE(IDX,IDY,1,ILINE(1))
```

where IDX = -3ØØ and IDY = 2ØØ, we obtain the following:



Note that the random vector option is assumed to be available (otherwise, such a line would be approximated).

2.3 TEXT SUBROUTINE

The TEXT subroutine adds to the specified subpicture file commands necessary to display an identified text string - starting at the current beam position. The standard text font is drawn on a 1Ø by 14 dot matrix. Each character causes an increment of 14 raster units to the X position of the beam. The form is:

```
CALL TEXT(STR,N[,PNAME])
```

The input variable STR identifies the dimensioned real array that contains the string of characters to be displayed in IOPS ASCII (Hollerith) form - five 7-bit characters packed in two words. The variable, N, is an integer variable that indicates the number of characters to be displayed in the referenced array. If N≠Ø, an ALT MODE will be inserted after the n^{th} character to allow escape from the character mode. If N=Ø, ALT MODE will not be inserted in the TEXT array. The variable PNAME(1) is the first location of this subpicture file, as in the call to LINE.

The TEXT subroutine adds three locations to the assembled display file; three is added to the contents of PNAME(1).

```
CHARS*  .+2
DJMP    .+2
(FULL 17-BIT ADDRESS)
```

NOTE

If 5/7 ASCII is loaded into the array from an external source (as opposed to being defined in a FORTRAN DATA statement), it may contain certain non-printing characters (such as carriage return, line feed, etc.) that must be allowed for when specifying the argument N.

In addition to the general restrictions outlined in paragraph 2.1, the array referred to by TEXT must be of sufficient size to accommodate the escape character that will be inserted by TEXT. Also, to ensure that the display processor is conditioned to escape on ALT MODE, it is necessary to start up an empty Main File with a call to DINIT (described in Chapter 3). When this is done, a display parameter word is inserted in the new Main File to enable escape on ALT MODE only. (The alternative is to escape on carriage return or ALT MODE, whichever comes first; however, this option is not selectable using Main File or subpicture routines.)

The following example illustrates the manner in which TEXT to be displayed is set up and called:

Setup to display "15 ASSABET RD." is

```
DIMENSION ADDR(4)
DATA ADDR(1)/5H15 AS/,ADDR(2)/5HSABET/,ADDR(3)/4H RD./
```

The call statement to display the TEXT from subpicture IPIC is:

```
CALL TEXT(ADDR(1),14,IPIC(1))
```

2.4 COPY SUBROUTINE

The COPY subroutine enables two or more subpicture display files to be linked together to generate a composite display image. This is accomplished by a display subroutining technique. COPY adds to one subpicture display file the commands necessary to call a second subpicture. The second subpicture begins at the last beam position specified by the first subpicture. The form is:

```
CALL COPY(RST,PNAME1[,PNAME])
```

The variable, RST, indicates whether to save and restore display parameters[1] when copying the specified subpicture. RST may be set to Ø or 1; Ø indicates no SAVE/RESTORE option and 1 indicates SAVE/RESTORE option is to be used. The variable PNAME1 is the first location of the subpicture to be copied. PNAME is the first location of the subpicture file to which display instructions generated by this call are to be added.

The COPY subroutine adds three locations to the display file when the SAVE/RESTORE option is not specified. These three locations are as follows:

```
DJMS*     .+2
DJMP      .+2
(ADDRESS of PNAME1+1)
```

However, when SAVE/RESTORE is specified, COPY adds six locations to the display file as follows:

```
SAVE      .+4
DJMS*     .+2
DJMP      .+3
(ADDRESS of PNAME1+1)
(STATUS)
RSTR      .-1
```

[1]These parameters include (but are not limited to) scale, intensity, blink, offset, and rotate, which can be set by calling subroutine PRAMTR (see paragraph 2.5.1). For a detailed description of parameters affected by the SAVE/RSTR instruction, refer to GRAPHIC-15 Reference Manual.

where the SAVE instruction stores the affected display parameter settings in the STATUS word before executing the normal sequence of COPY commands. Upon returning from the subpicture, these parameters are restored to their original settings by the RSTS instruction. The contents of PNAME is increased by three or six, as required.

In addition to the general restrictions outlined in paragraph 2.1, PNAME 1 need not be defined when COPY is called but must be a defined subpicture when PNAME is displayed. The following statement:

```
CALL COPY(Ø,WINDOW(1),HOUSE(1))
```

adds a call to the window subpicture file to the file identified as HOUSE. Note that the SAVE/RESTORE option was not specified.

2.5 PRAMTR SUBROUTINE

WARNING

> The display of small display files at high intensities without the SYNC option may damage the scope phosphor. It is recommended that SYNC be used throughout.

The PRAMTR subroutine allows the user to add to the specified subpicture file the commands necessary to set up the following display features. (See Graphic-15 Reference Manual for more detailed information.)

Scale setting - Setting the scale has a different effect, depending on where it is used. If used when plotting characters or vectors, it specifies the number of times (Ø - 15) that the unscaled vector (or stroke of a character) is to be repeated. If used in conjunction with the graph subroutine, the scale specifies the coordinate distance between given points.

Intensity Setting - The brightness of the display can be controlled in eight incremental steps between maximum dark and maximum light by specifying an integer variable or constant to represent the wanted brightness, between Ø and 7.

Light Pen Sensitivity - The ability of the light pen to sense a "hit" can be controlled by means of this feature.

Subpicture Routines

Blink Setting - Use of this feature enables blinking of some portion or all of the displayed image. This feature causes characters as well as vectors to blink at a rate of approximately four times a second.

Dash Setting - This feature enables drawing of dashed lines and can be set from Ø to 3 as follows:

Setting	Illuminated Raster Points
Ø	ALL ON
1	3 ON 1 OFF
2	4 ON 2 OFF
3	4 ON 4 OFF

Offset Setting - Since the VT15 display processor defines a square drawing area, a standard rectangular tube would normally have some unused area. The VT15 makes use of this area by means of the offset feature. When the offset is enabled, the absolute origin is relocated to the lower right-hand corner of the normal display area. This small area (approximately 9-1/2 x 1-1/2 in.) can be used for light buttons, special figures, etc., without disturbing the normal graphics area.

Rotate Setting - This feature allows the displayed image to be rotated 9Ø degrees in the counterclockwise direction or returned to its normal orientation if it is currently rotated. This could be useful for labeling graphs on the vertical axis or for any of a number of other applications.

Name Register Setting - The ability to set the Name Register is required to identify the location of light pen hits when using subroutine LTORPB. However, it is a feature which, when used at the programmer's discretion, can be helpful in many other applications. Once set, it retains its value until set to a different value.

Sync Feature - This feature can be used to avoid phosphor burnout when displaying files that require 32 milliseconds or less for execution. The display will halt and remain stopped until a sync pulse, derived from the local power main, enables execution to resume. This essentially locks execution of the display file to the power line frequency, which eliminates a visible swimming effect on the CRT.

The PRAMTR call statement allows more than one feature (each with its corresponding settings) to be specified, using the following technique:

1. Add together the integer code numbers that identify the selected features and assign this value to the variable FEATR. For example: For scale (1) and Intensity (2), FEATR will have the value 3.

2. List the desired settings, as arguments, in ascending order according to the values of the numeric assigned to their corresponding features (the argument list 3,2,6 would specify a value of 2 for scale (feature 1) and of 6 for Intensity (feature 2)). The general call statement form is:

   (a) One feature - CALL PRAMTR(FEATR,VALUE[,PNAME])

   (b) More than one feature and setting -

   CALL PRAMTR(FEATR(S),VALUE1,VALUE2...[,PNAME])

The variable FEATR represents the display feature being set. The variable VALUE is the value to which FEATR is set. (See Table 2-1 for FEATR and VALUE settings.) PNAME is the first location of this subpicture file.

Table 2-1
Display Parameter Settings

Parameter	Integer Code for FEATR	Possible Settings
Scale	1	Ø (Low) to 15 (High)
Intensity	2	Ø (Low) to 7 (High)
Light Pen	4	Ø (OFF) and 1 (ON)
Blink	8	Ø (OFF) and 1 (ON)
Dash	16	Ø (Solid) to 3 (Finest dash)
Offset	32	Ø (OFF) and 1 (ON)
Rotate	64	1 (CCW 90°) and Ø (Return CW 90°)
Name Reg.	128	Ø (Lowest) to 127 (Highest)
Sync	256	Ø (OFF) and 1 (ON)

Note: The abbreviation CCW = counterclockwise
CW = clockwise

The PRAMTR subroutine adds from one to four commands to the display file, depending on the type of argument list used.[1] The number of commands added to the file is added to the contents of location PNAME.

In addition to the general restrictions, the PRAMTR subroutine must be used with care, since the setting given is in effect until explicitly changed. Thus, if the blink is turned on at the beginning of a subpicture, it must be turned off at the end, otherwise the entire display image will blink (unless, of course, the SAVE/RESTORE option is used in calls to this subpicture).

The following single feature statement:

```
CALL PRAMTR (2,7,HOUSE(1))
```

specifies an intensity level of 7, for the subpicture display file starting at the first location of array HOUSE. The following multiple-feature statement:

```
CALL PRAMTR (SCALE+INT+LPEN,Ø,4,1,IN(1))
```

specifies the values Ø and 4 for scale and intensity, and turns on the light pen sensitivity. Appropriate display commands are added to the file that begins with the first location of array IN.

2.6 GRAPH SUBROUTINE

The GRAPH subroutine adds to the specified subpicture file the commands necessary to display in graph form the identified set of data points. One coordinate is sequentially set to the value of each data point, the other coordinate is then automatically incremented (in the current scale), leaving the beam positioned one increment past the end of the graph. Note that axes and labeling must be provided separately. The call statement form is:

```
CALL GRAPH (DTA,N,A[,PNAME])
```

---

[1]Scale and intensity settings, when combined, generate only one display command. Light pen, blink, offset, and rotate, when combined, generate only one display command. Sync and dash features, when combined, generate only one display command. Setting the Name Register generates one command.

DTA represents an INTEGER array that contains the set of data points, one per word, in the range Ø to 1Ø23. The variable N indicates the number of data points to be displayed. The variable A indicates which axis to increment, where A is set to either Ø or 1. (A=Ø specifies incrementing the X axis and setting Y to data values; A=1 specifies incrementing the Y axis and setting X to data values.) The variable PNAME specifies the first location of the subpicture file to which the generated display commands are to be added.

The GRAPH subroutine adds to the subpicture file a number of graph-plot commands equal to the number of entries in the data set, as shown below. The number of commands added to the file is added to the contents of PNAME.

```
          GX!VAL1           GY!VAL1
          GX!VAL2           GY!VAL2
            .                 .
            .                 .
            .       or        .
          GX!VALn           GY!VALn
```

One way to summarize the discussion up to this point is to review a program, (Figure 2-2 Sine Wave Program Example) which illustrates the use of GRAPH and other subroutines.

2.7 BLANK SUBROUTINE

The BLANK subroutine is used to prevent the displaying of any copy of the specified subpicture. However, the display file length is not changed. The form is:

```
          CALL BLANK (PNAME)
```

where the variable PNAME is the subpicture to be blanked.

In Figure 2-3 the command in location PNAME+2 (the first executable command in the subpicture file) is interchanged with the DJMP* PNAME+1 located at the end of the subpicture file. PNAME must be a defined subpicture file (BLANK has no meaning as the first call referring to PNAME). The subpicture files should not be modified while BLANKed. The following example would prevent the subpicture display file starting at the first location of array IPIC from being displayed.

```
          CALL BLANK (IPIC(1))
```

```
C
C  ARRAY INITALIZATION
        INTEGER SINWV(300),Y(200)
        DIMENSION TITL(10),MAINFL(20)
        DATA TITL(1),TITL(2),TITL(3),TITL(4)/5HTHIS ,
        1 5HIS A ,5HSINE ,4HWAVE/
C
C  SET UP INTEGER ARRAY OF VALUES TO BE PLOTTED.
C
10      X=0
        DO 20 I=1,200
        Y(I)=IFIX(SIN(X)*256.)+512
        X=X+.0628
20      CONTINUE
C
C  SET UP SUBPICTURE TO PLOT THOSE VALUES.
C
        SINWV(1)=0
        CALL PRAMTR(3,0,7,SINWV(1))
        CALL LINE(1000,0,1)
        CALL LINE(-1000,0,0)
        CALL LINE (0,250,0)
        CALL LINE(0,-500,1)
        CALL LINE (0,250,0)
        CALL PRAMTR (1,4)
        CALL GRAPH (Y(1),100,0)
        CALL GRAPH (Y(101),100,0,SINWV(1))
C
C  SET UP MAIN FILE TO DISPLAY THE GRAPH.
C  (MAIN FILE CALLS BELOW, DESCRIBED IN CHPT. 3)
C
        MAINFL(1)=0
        CALL DINIT (MAINFL(1))
        CALL SETPT (10,512)
        CALL PLOT (0,0,SINWV(1))
        CALL SETPT (100,100)
        CALL PLOT (2,1,1)
        CALL PLOT (3,TITL(1),19)
        CALL DCLOSE
        PAUSE
        STOP
        END
```

Figure 2-2
Sine Wave Program Example

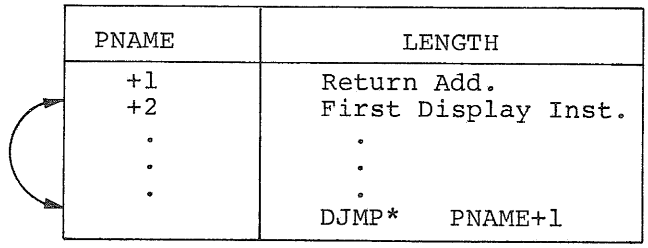


Figure 2-3
Operation of BLANK/UNBLNK Subroutine

2.8 UNBLNK SUBROUTINE

The UNBLNK subroutine reverses the action of the BLANK subroutine, allowing a previously BLANKed subpicture to be displayed. The form is,

```
CALL UNBLNK (PNAME)
```

where the variable PNAME is the subpicture to be UNBLNKed. The command in the last location of the subpicture file (placed there by a call to BLANK) is interchanged with the DJMP* in location PNAME+2. If the referenced subpicture is not already BLANKed, UNBLNK will return without changing the file.

The following statement will enable the previously BLANKed subpicture IPIC to be displayed.

```
CALL UNBLNK (IPIC(1))
```

2.9 CIRCLE SUBROUTINE

The CIRCLE subroutine is provided as a FORTRAN source, and must be compiled before use. The CIRCLE Subroutine enables the user to construct approximations of arcs and circles as subpictures by specifying the length of a series of chords and the start and stop points of the arc or circle to be constructed.

The form of the FORTRAN call for the CIRCLE subroutine is:

```
CALL CIRCLE (R,THETA,GAMMA,DEG,PNAME)
```

where the call variables in floating point except PNAME, are defined as:

1) R, the radius, in raster units, of the circle to be constructed.

2) THETA, the start of a constructed arc expressed in degrees from the **X-axis**, rotating counterclockwise about the center of the circle/arc.

3) GAMMA, the end point of a constructed arc, expressed in degrees, rotating counterclockwise about the center of the circle/arc.

4) DEG, length of approximating chord in degrees

5) PNAME, the name of the display file to which the CIRCLE subroutine will add the new subpicture array, as the first element in the display. The previous contents of the display file are destroyed by this call.

In DOS V3A, the calling arguments remain the same. However, at the conclusion of the arc or circle, the beam is returned to the center of the circle, not left at the edge as in DOS V2A.

The call to the CIRCLE subroutine has no effect if DEG is less than 0.001 degrees absolute, or if R is less than one raster unit. THETA and GAMMA are measured counterclockwise from the positive **X-axis** (modulo 360). If DEG is positive, arcs are drawn counterclockwise from THETA to GAMMA. If DEG is negative, arcs are drawn clockwise from THETA to GAMMA. A full circle is drawn if THETA and GAMMA are within 0.001 degrees. GAMMA may be less than THETA.

The MACRO form of the call to the CIRCLE subroutine using the same variable representations as above is:

```
.GLOBL          CIRCLE
JMS*            CIRCLE
JMP             .+6
.DSA            R
.DSA            THETA
.DSA            GAMMA
.DSA            DEG
.DSA            PNAME
```

NOTE

> CIRCLE Subroutines require the VV15 arbitrary vector hardware option.

2.10 ROTATE SUBROUTINE

The ROTATE subroutine is provided as a FORTRAN source, and must be compiled before use. The ROTATE subroutine enables the user to plot three-dimensional figures from basic two-dimensioned figures. Displayed items may be rotated about a specified axis through a designated angle of rotation. ROTATE takes X, Y, and Z coordinates from the user arrays, computes, and returns the new coordinates into the same arrays.

A single call to the ROTATE subroutine can effect a rotation about one or more of the X-, Y-, or Z-axes. The rotation of a display about any other axis requires more than one call to be made to the subroutine.

The ROTATE subroutine utilizes the same left-handed system that is used throughout the graphics software, that is:

a) X, horizontal movement, positive to the right
b) Y, vertical movement, positive is up
c) Z, axis into the display screen (positive movement)

The setpoint defines the origin of the axis of rotation.

CAUTION

> The ROTATE subroutine should be used carefully, particularly when rotating large figures, or off-center origins.

If, during rotation, the end-point of a line of the rotating figure passes off screen, part or all of the figure may be lost. It is good practice in rotating large figures to save the original buffer before calling ROTATE.

The following restrictions must be observed:

1) The values in the user's rotation arrays must be in floating point format.

2) The user must calculate the sine and cosine of the angle of rotation before he calls ROTATE.

3) The user must change integers into floating point numbers, and make the correct calls for displaying the rotated figure.

The FORTRAN and MACRO formats for calls to ROTATE are:

FORTRAN:

```
CALL ROTATE(ISTR,IA,IB,IC,X,Y,Z,SINA,CSA)
```

MACRO:

```
.GLOBL      ROTATE
JMS*        ROTATE
JMP         .+12
.DSA        ISTR
.DSA        IA
.DSA        IB
.DSA        IC
.DSA        X
.DSA        Y
.DSA        Z
.DSA        SINA
.DSA        CSA
```

where the input variables are defined as:

1. ISTR, the array length.
2. IA, specifies whether rotation about the X-axis is desired.

   If IA=1, rotation will occur about the X-axis.

   If IA=Ø, there will be no rotation about the X-axis.
3. IB, specifies whether rotation about the Y-axis is desired.

   IB=1 indicates rotation is desired, as with IA.
4. IC, specifies whether rotation about the Z-axis is desired.

   IC=1 indicates rotation is desired, as with IA.
5. X, the name of the X array.
6. Y, the name of the Y array.
7. Z, the name of the Z array.
8. SINA, the sine of the angle of rotation.
9. CSA, the cosine of the angle of rotation.

CHAPTER 3

MAIN DISPLAY FILE ROUTINES

A call to the display startup routine DINIT starts the VT15 graphics processor executing a specified display file. This file is now known as the "Main Display File". All calls to the Main Display File Routines implicitly reference this file until another DINIT is issued.

A Main Display File resides in a FORTRAN dimensioned array just as does a subpicture file. A subpicture file may be DINIT'ed to be a Main Display File. Alternately, the Main File may be empty when DINIT'ed and subsequently the picture is created by Main File graphics calls. Typically, the Main File will call various subpicture files to create the whole graphics image. However, it is possible to build the entire image in the Main File.

Most Main File calls have an optional argument CNAME. When provided, this argument is returned with the address of the display code just written into the Main File. These CNAME pointers are input arguments to the code modification routines REPLOT, DELETE, and RSETPT. The code modification routines allow replacement of graphics code with other graphics code (assuming it can fit into the available space). The Main File routines and their functions are:

- DINIT - initializes and starts the display via device number (.DAT SLOT) 10
- DCLOSE - stops the display and leaves the main file in a form such that it can be called as a subpicture file.
- SETPT - sets absolute starting point of display. (Point not intensified.)
- PLOT - displays predefined but not necessarily complete subpictures, individual LINEs, or ASCII text; also used to define display parameters.
- DELETE - replaces the specified graphics element with no-op's.
- REPLOT - similar to PLOT, but permits reuse of previously defined areas in the main file.
- RSETPT - similar to SETPT, but permits reuse of previously defined areas in the main file.

Main Display File Routines

In XVM systems, the format of the CNAME pointer has been changed. Since 17 bit addresses are supported, there is no longer room for a 3-bit count field in the top of the CNAME pointer. This count field previously served to notify the graphics system whether or not a REPLOT'ed item could fit into the Main Display File in the space occupied by its predecessor. For XVM, the graphics system has been modified to determine the CNAME count by examination of the display file. This change in the graphics leads to several restrictions.

First, user programs that modify CNAME count or specifically depend on CNAME count values will not function correctly under XVM.

Second, programs that use the CNAME mechanism to REPLOT graphics code not created by a standard graphics call will not function correctly under XVM.

Third, users who do not have the VV15 arbitrary vector option may find that their display files increase in size. The general form of an approximated arbitrary vector in core is:

```
SKP
(COUNT=N+2)
V1
V2
.
.
Vn
```

Under XVM the two word SKP-COUNT header is present for all approximated random vectors. Under previous systems, the SKP-COUNT header was absent if the vector count was less than 7. Thus, some lines will require two more core locations.

Finally, there are some display file size differences involved with PLOTing and REPLOTing parameter instructions. A PLOT (2,,,,CNAME) call requires one more location than previously. However, this location is reclaimed if any display element other than a parameter instruction is subsequently added to the display file. Parameter instructions are placed by calls to PRAMTR, and type 2 calls to PLOT.

If a REPLOT (2,,CNAME) call is used to write parameter instructions over a non-parameter display group, additional space may be needed for this REPLOT. A lack of this additional space will cause the REPLOT to fail. An additional location is required for both an immediately preceding and an immediately following parameter instruction in the display file.

3.1 DINIT (DISPLAY INITIALIZE) SUBROUTINE

The DINIT subroutine initializes the display via device number (.DAT slot) 1Ø. The VT15 device handler (VTA) must be associated with .DAT slot 1Ø as DINIT contains .IODEV 1Ø, which causes the device handler associated with .DAT slot 1Ø to be loaded. DINIT can be used to set up for a new display main file, to start up an old one, or to start up any previously defined subpicture as the current main file. The call statement form is:

```
CALL DINIT (MAINFL(1))
```

MAINFL is the first location of the Main Display File. Like PNAME, it is an element of a dimensioned integer array. Location MAINFL contains the length of the Main Display File. This is updated by all main file routines.

Subroutine DINIT stores a DJMP* MAINFL+1 at the end of the main file, inserts the address of MAINFL+2 into MAINFL+1, initializes the display, and starts the display running at MAINFL+2.

Certain restrictions must be noted when using DINIT. If a new display file is being formed, location MAINFL must contain zero; if this is a previously defined file, location MAINFL contains the file length and must not be altered. Sufficient storage must follow MAINFL to accommodate the main display file that is to be generated. Only one main display file can be running at a time.

NOTE

> When a new main display file is being initialized, DINIT inserts a display parameter word to turn off blink, offset, rotate and light pen, and to enable character string escape on ALT MODE (175_8). To change the initial settings for blink, offset, rotate, and light pen, or to ensure that other display features (i.e., scale, intensity, dash, name register, and sync) are initially set as desired, the calling program should contain a PRAMTR type call to PLOT (described in paragraph 3.4.3) following the call to DINIT.

The following statement initializes the execution of the Main Display File starting at the first location of array MAINFL.

```
CALL DINIT (MAINFL(1))
```

3.2 DCLOSE (DISPLAY TERMINATE) SUBROUTINE

The DCLOSE subroutine is used to stop the display. DCLOSE also leaves the current main file in displayable form such that it can later be called as a subpicture file or restarted as a main file. Note, a DCLOSE, while turning off the display processor, does NOT alter the definition of the current Main File. The Main Display File routine will still function correctly to this Main File with the display processor stopped. The call statement form is simply:

```
CALL DCLOSE
```

3.3 SETPT (SET POINT) SUBROUTINE

The SETPT subroutine is used to locate the beam on the display surface in absolute display coordinates (raster units). The beam is not intensified with this call. The call statement form is:

```
CALL SETPT (X,Y[,CNAME])
```

where the variable X represents the horizontal coordinate of beam location and Y represents the vertical coordinate of beam location. The variable CNAME is a pointer to the first location of the display commands generated by this call. SETPT adds two commands to the main file, as follows:

```
PY!Y
PX!X
```

Two is added to the contents of location MAINFL. The location PY!Y is stored in CNAME (if given).

The variables X and Y must be positive integers and their values must not exceed 1Ø23. A call to SETPT causes the beam to be given an absolute location, as opposed to a relative displacement. This action effectively severs any following parts of the display from any preceding parts; if a section of the display is completely defined in terms of relative vectors, then its location on the display surface depends on where the beam was initially located, and it can be made to move as a unit by changing the initial setting. Giving the beam an absolute location disregards any previous motion and serves as a new reference point in the display.

CNAME is an optional output of this subroutine. Use of the same variable name as one used in a previous call will destroy the previous contents. The following statement establishes an absolute beam position with display coordinates X = 1Ø, Y = 1Ø.

```
CALL SETPT (1Ø,1Ø)
```

3.4 PLOT SUBROUTINE

The PLOT subroutine is the prime active agent in the generation of the Main Display File. There are four forms of calls corresponding to the four subpicture routines, COPY, LINE, PRAMTR, and TEXT. These calls are used to display predefined (but not necessarily complete) subpictures, individual lines or text strings, and to introduce appropriate display control commands. In all cases, the requested display or control function may be identified as a separate entity and manipulated independently of the rest of the display. The first entry in the argument list defines the type of call to PLOT as follows:

FIRST ARG	TYPE OF PLOT
Ø	COPY
1	LINE
2	PRAMTR
3	TEXT

3.4.1 Plot a Subpicture (COPY)

The call statement form is:

```
CALL PLOT (Ø,RST,PNAME[,CNAME])
```

where the value Ø indicates this is a COPY type call to PLOT. RST is the indicator for the SAVE/RESTORE option (same as COPY). PNAME is the name (first location) of the subpicture to be displayed.

CNAME is an optional output argument that will contain a pointer to the first location of the group of display commands generated by this call. The number of commands added to the display file is added to the contents of MAINFL(1). In general, the same restrictions apply as for the COPY subroutine. Again, multiple use of the same variable CNAME will destroy previous contents. The following example illustrates use of a COPY type call to PLOT:

```
CALL PLOT (COPI,Ø,HOUSE(1),MAIN)
```

In this example, COPI has the integer value Ø; the next argument (Ø) is the indicator for the SAVE/RESTORE option; HOUSE identifies the subpicture file to be displayed; and MAIN is an optional output argument by which the group of display instructions inserted for this call may be referenced.

3.4.2 Plot a Line (or Reposition the Beam)

The call statement form is:

```
CALL PLOT (1,DELTAX,DELTAY,INT[,CNAME])
```

This type of PLOT is basically the same as the LINE subpicture routine, except for the first argument which defines this as a line type call to PLOT. The variable CNAME is an optional output argument and will contain a pointer to the first location of the group of display commands generated by this call. The number of commands added to the display file is added to the contents of MAINFL. The location of the first display command is stored in CNAME (if given).

As in SETPT, CNAME is an output variable and multiple use of the same variable name will destroy previous contents. Otherwise, the same general restrictions apply as for the LINE subpicture routine. The following example illustrates a LINE type call to PLOT.

```
CALL PLOT (LYNE,1ØØØ,1ØØ,ON,IEDGE(1))
```

where LYNE and ON have assigned values of 1 and IEDGE(1) is a display identifier to be used for later reference to this LINE.

3.4.3 Plot a Control Command (PRAMTR)

The call statement form is:

```
CALL PLOT (2,FEATR,VALUE[,CNAME])
```

where FEATR and VALUE must be specified in the same manner as for PRAMTR subpicture calls. Also, as with the PRAMTR call, multiple features can be specified in a single PLOT call of the following form:

```
CALL PLOT (2,FEATRs,VALUE1,VALUE2,...,VALUEn[,CNAME])
```

The number of commands added to the display file is added to the contents of MAINFL. The location of the first command is stored in CNAME (if given). The same general restrictions apply as for the PRAMTR subpicture routine. The following example illustrates the use of this type of PLOT to set the BLINK feature in a Main File.

```
CALL PLOT (2,8,1)
```

The multiple-feature statement

```
CALL PLOT (PRAM,SCALE+INT+LPEN,Ø,4,1,IN)
```

establishes values Ø and 4 for display features SCALE and INT, and turns the light pen sensitivity on. The variable IN is supplied for the optional CNAME output argument. (PRAM=2, to specify a PRAMTR type call to PLOT.)

In XVM systems, a special marker no-op is placed in the display file to terminate the PLOT (2,,,,CNAME). At this point, the display file is one location longer than in previous systems. If any display element other than a PRAMTR or PLOT,(2,,,[CNAME]) is added to the display file, this special marker is written over, reclaiming the space. (This other group will serve to terminate the list of parameter instructions in the display file.)

3.4.4 Plot a Text String (TEXT)

The call statement form is:

```
CALL PLOT (3,STR,N[,CNAME])
```

This type of call to PLOT is essentially the same as that for the TEXT subpicture routine, except for the first argument which defines this as a TEXT type call to PLOT. The number of commands added to the display file is added to the contents of MAINFL. The location of the first generated display command is returned in CNAME (if given). The same restrictions apply as for the TEXT subroutine. The following example illustrates the use of the TEXT type call to PLOT.

```
CALL PLOT (3,STRING,15,SAVNAM)
```

where STRING contains the 15 characters to be displayed, and SAVNAM will contain a pointer to the group of display commands inserted by this call.

3.5 DELETE FUNCTION

The DELETE function is used to delete from the Main Display File any display entity formed by a single call to a main file routine and assigned to CNAME.

The call statement form is:

```
CALL DELETE (CNAME)
```

The input variable CNAME is the location of the group of display commands to be deleted. The group of graphics instructions pointed to by CNAME is converted to display no-op's. In contrast to previous systems, DELETE cannot fail. The Boolean form:

```
I = DELETE (CNAME)
```

is still accepted; the variable I, of course, will always be TRUE.

The example:

```
CALL DELETE (NAME(2))
```

deletes from the Main Display File the display entity whose first command is pointed at or identified by the second element of array NAME.

3.6 REPLOT FUNCTION

The function REPLOT allows use to be made of previously defined locations in the Main Display File. This can serve two purposes: (1) to reuse locations freed by DELETE, and (2) to change an existing group of display commands. REPLOT checks whether the group being inserted is longer than the space pointed at by CNAME, if it is, REPLOT then checks to see if there are enough DNOPed locations following the group to be overlaid. If there still are not sufficient locations available, the REPLOT fails and the display file is not affected. By manipulating CNAME, smaller groups can be packed into the space formerly used by a larger group. For example, up to three control commands could be inserted into the space left by a DELETEd copy group. There are four forms of call to REPLOT, each of which is similar to the corresponding call to PLOT (Paragraph 3.4).

The first entry in the argument list defines the type of call to REPLOT as follows:

FIRST ARG	TYPE OF REPLOT
Ø	COPY
1	LINE
2	PRAMTR
3	TEXT

It is important to note that while CNAME is an optional output of PLOT it is a required input of REPLOT since it identifies the location to be modified in the Main Display File. It also must be recognized that CNAME must have been given as an argument to a PLOT call for it to be available for REPLOT.

Since all of the REPLOT functions are similar to corresponding calls to PLOT, only the COPY type REPLOT is described as an example. The call statement forms for a COPY type REPLOT are:

```
I = REPLOT (Ø,RST,PNAME,CNAME)
```

or

```
CALL REPLOT (Ø,RST,PNAME,CNAME)
```

The input variables are the same as in the corresponding call to PLOT, except CNAME, which points to the first location of a block in which to store the display commands generated. The output variable I is a logical success indicator: TRUE indicates that the REPLOT was successful, and FALSE indicates that there was not enough room at the location pointed to by CNAME. It should be emphasized that if the above form is used, both I and REPLOT must be declared as LOGICAL in a type statement.

The COPY type REPLOT checks whether CNAME points to a large enough block of locations; no action is taken if the block is not large enough. Otherwise, REPLOT inserts the necessary commands starting at the location pointed to by CNAME, and inserts DNOP's in any remaining locations within the block. The same general restrictions apply as for the corresponding call to PLOT. The following example illustrates a COPY type call to REPLOT:

```
CALL REPLOT (Ø,IRST,SLIDE(M),NAME)
```

where Ø indicates that this is a COPY type call. IRST is equal to zero to indicate no SAVE/RESTORE option, M represents the first location of the subpicture display file (in array SLIDE) and NAME identifies the first location in the display file into which this group of commands is to be inserted.

Note, when a REPLOT (2,,,,CNAME) replaces a group of instructions that are not parameter instructions, it is necessary for the graphics system to add a no-op to the beginning of the new group if parameter instructions precede, and to the end of the group if parameter instructions follow. The REPLOT (2,,,,CNAME) may fail if there is insufficient space for these no-op's.

3.7 RSETPT FUNCTION

Like SETPT, the function RSETPT permits absolute beam locations to be defined; it can be used in the same manner as REPLOT to reuse any deleted locations or to change any existing group of commands. The same checking of needed space versus available space is done by RSETPT as in REPLOT.

The call statement forms are:

```
I = RSETPT (X,Y,CNAME)
```

or

```
CALL RSETPT (X,Y,CNAME)
```

The variable X represents the horizontal coordinate of beam location; Y represents the vertical coordinate of beam location. CNAME is an input argument that points to the first location of a block in which to store the display commands that are generated. If the function form (I=) is used with RSETPT, both I and RSETPT must be declared as LOGICAL in a type statement. RSETPT first checks whether CNAME points to a large-enough block of locations; no action is taken if the block is not large enough. Otherwise, RSETPT inserts two positioning commands at the location pointed to by CNAME:

```
PY!Y
PX!X
```

RSETPT also inserts DNOPs in any remaining locations belonging to a former command group at this address. The following example illustrates the use of a call to RSETPT:

```
CALL RSETPT (1Ø,1Ø,NAME)
```

where the value of 1Ø is assigned to the X and Y coordinates and NAME identifies the starting location of a block within the display file into which the positioning commands are to be inserted.

CHAPTER 4

INPUT ROUTINES

Input routines enable the user (through his program) to deal with display console interaction using the light pen and pushbuttons. Routine LTORPB can inform the user whether there has been a light pen or pushbutton action and, if so, return the appropriate information that is required. The user program is not (logically) interrupted when such action occurs. The light pen or pushbutton action at the console merely causes an indicator to be set in the corresponding routine. This may affect the user's flow of control at his discretion. The light pen tracking routine (TRACK) provides a somewhat different use of the light pen, allowing the user to control input and generation of graphics.

4.1 LTORPB FUNCTION

The function LTORPB is used to determine whether a light pen or pushbutton hit has occurred. If it has not, the function returns an indicator to this effect. If a hit has occurred, the logical (contents of name register) and physical (Y and X raster coordinates) location of the light pen and the status of the pushbutton box are returned as well as the indicator that a hit has occurred. For example, this routine may be used as a switch in a FORTRAN logical IF statement (see example below). The IF statement could branch to itself if no hit has occurred, or to the user's light pen hit processing code if a hit has occurred.

The function statement form is:

```
I = LTORPB (IX,IY,NAMR,PB,IWICH)
```

LTORPB and the variables I and PB must be declared logical in a TYPE statement.

The output variable I is a logical success indicator; TRUE indicates that a light pen or pushbutton hit has occurred, and FALSE indicates no light pen hit has occurred. It should be emphasized that if I is FALSE, IX, IY, NAMR, and PB have no meaning.

Input Routines

The variable IX is the horizontal coordinate at end of the vector that caused a light pen hit. IY is the vertical coordinate at end of vector which caused a light pen hit. The variable NAMR will contain the value of the name register at the time of the light pen hit. PB should be defined in the calling program as a six-element array. Each element will contain the logical TRUE or FALSE corresponding to ON or OFF for each of the six pushbuttons. IWICH will be either of two values; IWICH=1 if a light pen hit has occurred, or IWICH=2 if a pushbutton hit has occurred.

LTORPB issues a .READ on light pen or pushbutton interrupt to the display device handler. It returns if no interrupt was posted. Otherwise, it reads appropriate display registers and returns with appropriate output variables.

The following statement illustrates use of LTORPB as a switch in a FORTRAN IF statement:

```
IF (LTORPB(LPX,LPY,NAME,PB,IWICH)) GOTO 100
```

In the above statement, if a hit has occurred (LTORPB is TRUE) LPX and LPY contain the X and Y coordinates of the end of the vector that was hit. Also, the contents of the name register is set, the status of the pushbuttons is stored in the pushbutton array, and the variable IWICH is set to indicate whether the hit was due to a pushed button or to the light pen. Then, program execution is transferred to statement 100.

NOTE

> Each interrupt from either light pen or pushbuttons requires at least a pair LTORPB's to be issued. The first LTORPB acts as an initialization, telling VTA that interrupts are to be accepted. This first LTORPB can only return a FALSE value. Interrupts that may have occurred prior to the first LTORPB have been ignored. The first LTORPB that occurs AFTER an interrupt(s) returns the light pen and pushbutton conditions at the time of the last interrupt, and notifies VTA to ignore further interrupts. This brings us back to the initial condition.

The general intent of the LTORPB function is wait until something happens. For some types of programs, the user might rather have the pushbuttons act as dynamic switches to an executing display program. In this case it is probably simpler to make up a MACRO subroutine that reads the buttons, disregarding interrupts altogether.

4.2 TRACK SUBROUTINE

The TRACK subroutine is used for light pen tracking and drawing. Tracking allows the scope user to return an X-Y coordinate pair to the program. A tracking symbol is displayed at a location specified by the program. (The tracking symbol is an octagon with a point in its center.) The scope user then positions the tracking symbol with the light pen. A hit on any pushbutton terminates tracking, and returns to the program the coordinates of the central point of the tracking symbol. The form of the call is as follows:

```
CALL TRACK(IX,IY,IOPT,IARRAY[,ISIZE])
```

IX and IY are positive integer variables (0-1023 defining the initial position of the tracking symbol. The final position of the tracking symbol is returned in these same variables. IOPT is a positive integer (Ø-6) restricting the axes (see Table 4-1) along which the tracking symbol may move. An IOPT value of zero means no restriction. IARRAY is zero to indicate that tracking is to occur. IARRAY, for drawing, is the address of the array, empty before drawing, to contain the vectors describing the path of the tracking symbol. In DOS V3A and later systems, ISIZE, the integer size of the array IARRAY, must be specified for the draw option. During drawing, the path appears on the screen; after drawing, the path subpicture file is disconnected from the main file. It remains as an ordinary subpicture file. Note that drawing may easily insert 100 vectors per second into the path subpicture file. When the path file is full, drawing terminates. For tracking, ISIZE may not be provided.

Examples of the use of these arguments can be found in the following sample program that calls TRACK.

```
C     THE FOLLOWING FORTRAN PROGRAM USES THE TRACKING ROUTINE
C     TO DETERMINE THE DISTANCE BETWEEN (100,400), THE INITIAL
C     POSITION OF THE TRACKING PATTERN AND ANY POINT ON A LINE
C     OF SLOPE 20, DRAWN FROM A SET POINT AT X=750 Y=250
C
         DIMENSION MF(150),IUSER(200)
         MF(1)=0
         IOPT=3
         IX1=100
         IY1=400
C
C     INITIALIZE THE DISPLAY
C     CALL SET POINT TO POSITION BEAM
C     DRAW LINE FROM SET POINT
C     CALL TRACKING ROUTINE
C
         CALL DINIT(MF(1))
         CALL SETPT(750,250)
         CALL PLOT(1,25,500,1)
         IX2=IX1
         IY2=IY1
         CALL TRACK(IX1,IY1,IOPT,IUSER)
C
C     GET CHANGE IN X VALUE
C     GET CHANGE IN Y VALUE
C     CALCULATE DISTANCE BETWEEN POINTS
C
         IDELX=IX1-IX2
         IDELY=IY1-IY2
         IDELAB=SQRT((IDELX**2)+(IDELY**2))
         STOP
         END
```

Figure 4-1
Sample TRACK Program (FORTRAN Example)

Table 4-1
Description of CALL TRACK Arguments

Example:

```
CALL TRACK (IX,IY,IOPT,IARRAY)
```

INPUT VARIABLES:	
IX	Initial Absolute X-Position of Tracking Point (Ø-1Ø23)
IY	Initial Absolute Y-Position of Tracking Point (Ø-1Ø23)
IOPT	Tracking Direction Option (Ø-6)
IARRAY	- Tracking Draw Option

IOPT options:

OPTION	ALLOWABLE TRACKING DIRECTIONS		
Ø	ALL AXIS DIRECTIONS		
1	+X	-X	
2	+Y	-Y	
3	+X	+Y	-Y
4	+X	-X	+Y
5	-X	+Y	-Y
6	+X	-X	-Y

IARRAY options:

	DRAW OPTION DESIRED
USER DIMENSIONED ARRAY	Intensified Vectors Following the Light Pen Movement Are Stored in This Array and are Displayed.
Ø	DRAW OPTION NOT DESIRED

OUTPUT VARIABLES	
IX -	Final Absolute X - Position of Tracking Point (Ø-1Ø23)
IY -	Final Absolute Y - Position of Tracking Point (Ø-1Ø23)

Input Routines

When TRACK is called, the X and Y input arguments are inserted into the track display file. The track display file is then linked to the main file by inserting into main file a DJMS* to a second location in the main file; into which has been inserted the address of the track display file. The direction option is then used to increment down a dispatch table which in turn sets up a second table so only light pen hits on certain sides of the tracking octagon are valid. The draw option is tested for, and if desired, the user's vector storage array is set up and linked to the track display file in the same manner that it was linked to the main file. Track then issues a .READ on Light Pen or Pushbutton interrupt, to the display device handler. If a light pen hit on a valid side of the octagon occurs, the tracking octagon is moved two raster units in the appropriate direction. If the draw option was specified, track adds a two raster unit vector to the user's vector storage array or increases the length of the last vector in the array if the hit was on the same side of the octagon as the previous hit. If a pushbutton interrupt occurs, TRACK removes all the created links and restores the main file to its previous form. The final X and Y coordinates of the tracking point are returned and control is released to the calling program.

The macro calling sequence to track is as follows:

```
.GLOBL    TRACK
JMS*      TRACK
JMP       .+5
.DSA      IX
.DSA      IY
.DSA      IOPT
.DSA      IARRAY
```

Internal Structures Created by Track:

Main File Link to Track:

```
MFTOP     LENGTH
          .+1
          DJMS*    .+2
          SKP
          ADDRESS
             .
             .
             .
          DJMS*    .+2          /Link to track display file
          DJMP*    MFTOP+1      /Jump to top of MAIN FILE
          TRCK                  /Address of Track display file
```

NOTE

TRACK requires two temporary locations in the user's main file. A main file must be running when TRACK is called.

Vector Array for Draw Option:

```
ARTOP       LENGTH                  /File length
            Ø                       /Return address
            PX                      /X set point
            PY                      /Y set point
            VI                      /Intensified vectors
            VI
             .
             .
             .
            DJMP*  ARTOP+1          /Display Jump to calling file
```

Note: The X and Y set points must be modified to relocate an array of intensified vectors, when it is recalled.

ARTOP(3) = ARTOP(3) + IDX
ARTOP(4) = ARTOP(4) + IDY

(See MACRO XVM TRACK program page 4-8).

NOTE

TRACK uses name registers 120-127 decimal.

```
/       THE FOLLOWING MACRO 15 PROGRAM USES THE TRACKING ROUTINE
/       TO LOCATE OR POSITION A SET POINT ON THE DISPLAY SCREEN.
/       THE POSITIONED SET POINT IS THEN USED TO DRAW A FIGURE.
/
        .GLOBL  DINIT
SAMP2   JMS*    DINIT               /INITIALIZE THE DISPLAY
        JMP     .+2
        .DSA    MAINBF
CHK0    LAC     (450                /SET INITIAL POSITION OF TRACKING PATTEN
        DAC     IX1
        DAC     IY1
        .GLOBL  TRACK
CHK1    JMS*    TRACK               /CALL TO TRACKING ROUTINE
        JMP     .+5
        .DSA    IX1                 /X-POSITION
        .DSA    IY1                 /Y-POSITION
        .DSA    CNST4               /DIRECTION OPTION
        .DSA    CNST4               /DRAW OPTION
        .GLOBL  SETPT
CHK2    JMS*    SETPT               /CALL TO SET POINT ROUTINE
        JMP     .+3
        .DSA    IX1                 /X-POSITION RETURNED FROM TRACKING
        .DSA    IY1                 /Y-POSITION RETURNED FROM TRACKING
        .GLOBL  PLOT
CHK3    JMS*    PLOT                /CALL TO PLOT ROUTINE
        JMP     .+5
        .DSA    CNST0               /ARG. TO PLOT A LINE
        .DSA    CNST1               /DELTA X
        .DSA    CNST1               /DELTA Y
        .DSA    CNST0               /INTENSIFY THE LINE
CHK4    JMS*    PLOT
        JMP     .+5
        .DSA    CNST0
        .DSA    CNST1
        .DSA    CNST2
        .DSA    CNST0
CHK5    JMS*    PLOT
        JMP     .+5
        .DSA    CNST0
        .DSA    CNST3
        .DSA    CNST4
        .DSA    CNST0
        HLT
MAINBF  .BLOCK 50                   /DISPLAY MAIN FILE BUFFER
IX1     0
IY1     0
CNST0   1
CNST1   25
CNST2   -25
CNST3   -50
CNST4   0
        .END
```

Figure 4-2
Sample TRACK Program (MACRO XVM Example)

CHAPTER 5

RELOCATING ROUTINES

The subroutines DYSET and DYLINK are used to allow display main or subpicture files, which refer to each other (via COPY or PLOT(0....)), to be output and input to some external medium relocatably. This includes arrays of 5/7 ASCII that are referred to via TEXT or PLOT(3....). Prior to outputting, interdependent display files and their user-assigned ASCII names are listed as arguments in a call to DYSET, which converts each subpicture call to the ASCII name of the subpicture being called. After input, and prior to displaying, a corresponding call is made to DYLINK, which uses the listed ASCII names to reinstate the appropriate subpicture calls or text references. A display file cannot be displayed after having been processed by DYSET; DYLINK must be used to return it to displayable form.

NOTE

> READ's and WRITE's cannot access above 32K. If code to DYSET-DYLINK'ed is above 32K, it must be moved to a temporary array below 32K for I/O.

5.1 DYSET SUBROUTINE

The DYSET subroutine converts subpicture calls or text references to a symbolic form independent of core memory location, using specified ASCII strings. The forms are,

```
CALL DYSET (PNAME1,ASCII1,...,PNAMEN,ASCIIN)
```

or

```
CALL DYSET (PNAME1,ASCII1,...,PNAMEK,ASCIIK,Ø,PNAMEL,ASCIIL,...
                               ,PNAMEN,ASCIIN)
```

The variable PNAMEs are the first locations of the interdependent display files, both calling and called. If a Ø argument appears in the argument string, subsequent PNAMEs refer to arrays of 5/7 ASCII text. (These files will not be searched for memory references.) The ASCIIs are the names of real arrays containing nine characters of 5/7 IOPS ASCII, which may be used for filenames on output.

Subroutine DYSET searches each listed display file (PNAME) for a DJMS or CHARS instruction. When it finds one, it appends the ASCII name of the file referenced to the file being searched, if that name is not already there. The operand of the DJMS is made a relative pointer to the ASCII name of the referenced file. The first location of the file being searched is increased by four each time an ASCII name is appended to the file.

Certain restrictions must be noted; space provided for a display file must include four locations for each subpicture or text array that is called. Display commands must not be added to a display file nor can a file be displayed once it has been processed by DYSET, or until after it has been processed by DYLINK. (Thus DYSET must be called after DCLOSE for a main display file.) Also, it is the user's responsibility to list all relevant display files when calling DYSET. The subroutine does not check the list for completeness in order to allow multiple calls to it. Once a zero appears in the argument string, all subsequent PNAMEs must refer to arrays of 5/7 ASCII text.

5.2 DYLINK SUBROUTINE

The DYLINK subroutine converts file names to appropriate DJMS or CHARS instruction references to the corresponding files. The forms are:

```
CALL DYLINK(PNAME1,ASCII1,...,PNAMEN,ASCIIN)
```

or

```
CALL DYLINK(PNAME1,ASCII1,...,PNAMEK,ASCIIK,Ø,PNAMEL,
            ASCIIL,...,PNAMEN,ASCIIN)
```

where the input variables are the same as for DYSET. DYLINK searches each listed display file for a DJMS or CHARS instruction. When it finds one, it searches the argument list for a pointer to an ASCII string equal to the one pointed at by the operand of the DJMS or CHARS instruction. This operand is replaced by the address of the corresponding file, obtained from the argument list. The first location of each display file that is searched is reduced to the actual number of display commands in the file (excluding the ASCII blocks).

It is the user's responsibility to list all relevant display files when calling DYLINK. The subroutine does not check the argument list for completeness, to allow multiple calls. Once a zero appears in the argument string, all subsequent PNAMEs must refer to arrays of 5/7 ASCII text. See Figure 5-1 for DYSET/DYLINK Program.

```
C
C  ARRAY INITALIZATION
C
       DIMENSION NWPIC0(40), NWPIC1(20), NWPIC2(20)
       DIMENSION RTXTA(2), RTXTB(2)
       DIMENSION IMAIN(40), IPICA(20), IPICB(20)
       DIMENSION TEXTA(2), TEXTB(2)
       DIMENSION TITL1(2), TITL2(2), TITL3(2), TITL4(2), TITL5(2)
       DATA TITL1(1), TITL1(2)/5HJPIC0, 4H BIN/,
       2TITL2(1), TITL2(2)/5HJPICA, 4H BIN/,
       3TITL3(1), TITL3(2)/5HJPICB, 4H BIN/,
       4TITL4(1), TITL4(2)/5HCHRSA, 4H BIN/,
       5TITL5(1), TITL5(2)/5HCHRSB, 4H BIN/
       DATA TEXTA(1), TEXTA(2)/5HI AM ,4HBOXA/,
       1TEXTB(1), TEXTB(2)/5HI AM , 4HBOXB/
C
C  INITIALIZE DISPLAY FILES.
C
       IMAIN(1)=0
       IPICA(1)=0
       IPICB(1)=0
C
C  BUILD BOXB  (IPICB)
C
       CALL TEXT (TEXTB(1),9, IPICB(1))
       CALL LINE (100,0,1)
       CALL LINE (0,100,1)
       CALL LINE (-100,0,1)
       CALL LINE (0,-100,1)
C
C  BUILD BOXA  (IPICA)
C
       CALL LINE (300,0,1,IPICA(1))
       CALL LINE (0,300,1)
       CALL LINE (-300,0,1)
       CALL LINE (0,-300,1)
       CALL LINE (30,30,0)
       CALL COPY (0,IPICB(1))
C
C  BUILD MAIN (IMAIN)
C
       CALL DINIT (IMAIN(1))
       CALL PLOT (2,19,0,4,0)
       CALL SETPT (20,20)
       CALL PLOT (3,TEXTA(1),9)
       CALL PLOT (0,1,IPICA(1))
       CALL SETPT (534,20)
       CALL PLOT (3,TEXTA(1),9)
       CALL PLOT (0,0,IPICA(1))
C
C
C  DCLOSE, CALL DYSET, AND OUTPUT TO DECTAPE (DAT 5)
C
C
       CALL DCLOSE
       CALL DYSET (IMAIN(1),TITL1,IPICA(1),TITL2,IPICB(1),TITL3,0,
       1TEXTA(1),TITL4,TEXTB(1),TITL5)
       CALL ENTER (5,TITL1)
       J=IMAIN(1)+1
       WRITE (5) (IMAIN(I), I=1,J)
       CALL CLOSE (5,TITL1)
```

Figure 5-1
DYSET/DYLINK Program Example

```
      CALL ENTER (5,TITL2)
      J=IPICA(1)+1
      WRITE (5) (IPICA(I), I=1,J)
      CALL CLOSE (5,TITL2)
C
C
      CALL ENTER (5,TITL3)
      J=IPICB(1)+1
      WRITE (5) (IPICB(I), I=1,J)
      CALL CLOSE (5,TITL3)
C
C
      CALL ENTER (5,TITL4)
      WRITE (5) (TEXTA)
      CALL CLOSE (5,TITL4)
C
C
      CALL ENTER (5,TITL5)
      WRITE (5) (TEXTB)
      CALL CLOSE (5,TITL5)
      PAUSE 222
C
C  INPUT FROM DECTAPE, CALL DYLINK AND DINIT
C
      CALL SEEK (5,TITL1)
      READ (5) J, (NWPICØ(I+1), I=1,J)
      NWPICØ(1)=J
      CALL CLOSE (5,TITL1)
C
C
      CALL SEEK (5,TITL2)
      READ (5) J, (NWPIC1(I+1), I=1,J)
      NWPIC1(1)=J
      CALL CLOSE (5,TITL2)
C
C
      CALL SEEK (5,TITL3)
      READ (5) J,  (NWPIC2(I+1), I=1,J)
      NWPIC2(1)=J
      CALL CLOSE (5,TITL3)
C
C
      CALL SEEK (5,TITL4)
      READ (5) RTXTA
      CALL CLOSE (5,TITL4)
C
C
      CALL SEEK (5,TITL5)
      READ (5) RTXTB
      CALL CLOSE (5,TITL5)
C
C
      CALL DYLINK (NWPICØ(1),TITL1,NWPIC1(1),TITL2,NWPIC2(1),TITL3,Ø,
     1RTXTA(1),TITL4,RTXTB(1),TITL5)
      CALL DINIT (NWPICØ(1))
      STOP
      END
```

Figure 5-1 (Cont.)
DYSET/DYLINK Program Example

CHAPTER 6

SYSTEM I/O DEVICE HANDLER

The VT15 Graphic Display Device Handler provides an interface between the user and the hardware. Input or output functions are initiated by standard user program commands and all display interrupt management is done automatically by the handler. The primary goals of the device handler are to relieve the user from writing his own device handling subprograms and to centralize all direct communication between the XVM and the display processor. To start up a display, the user generates a display file consisting of display commands then calls the device handler to start it running. To interact with it, the device handler is used to read display controller registers and to dispatch on appropriate interrupts.

6.1 .INIT (INITIALIZE) MACRO

The macro .INIT causes the display to be initialized and must be given before any other I/O macro to the display is issued. The display is initialized according to four words of standard settings contained in the handler. The user may substitute his own settings for any of these.

The Device Handler is connected to the Monitor Interrupt system (PIC or API) in the same manner as other system device handlers.

The form is:

```
        .INIT  A, F, R

    A = Device Assignment Table (.DAT) slot number

    F = initialization flag
        Ø  use standard display initialization
        1  user's initialization is pointed to by R

    R = optional pointer to user's initialization settings

    If F = 1, R points to a word containing initial settings

    If F = Ø and R = 1, clearing the READ BUSY switch is the
        only action taken by the handler.
```

System I/O Device Handler

The expansion is:

```
LOC     CAL + F(7-8) + A(9-17)
LOC+1   1
LOC+2   R
```

The default settings of the initialization word are:

a. Set display status to

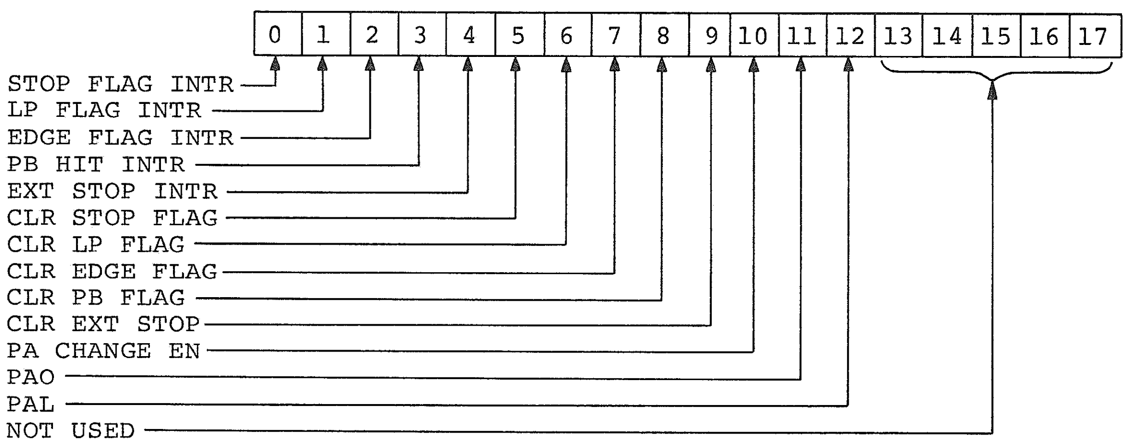
   1. DISABLE edge flag interrupts
   2. ENABLE light pen interrupts
   3. ENABLE pushbutton interrupts
   4. DISABLE external stop interrupts
   5. ENABLE full 12-bit X and Y beam position registers
   6. ENABLE internal stop interrupts

b. Connect handler to PIC or API

c. Clear READ BUSY switch

Initialization IOT

SIC (7Ø3Ø24) Set Initial Conditions - SIC sets up a number of status registers in the display. The instruction enables five display flags onto the Interrupt Line. The IOT is issued with settings loaded in the AC in the following format:



Ø	Sets the Stop Flag Interrupt Enable Flop
1	Sets the LP Flag Interrupt Enable Flop
2	Sets Edge Flag Interrupt Enable Flop
3	Sets PB Hit Interrupt Enable Flop
4	Sets External Stop Interrupt Enable Flop
5	Clears Stop Flag
6	Clears LP Flag
7	Clears Edge Flag
8	Clears PB Flag
9	Clears External Stop Flag
10	Allow a Change in Virtual Paper Size
11	New Virtual Paper Size
12	New Virtual Paper Size

Bits 11 & 12 (New Paper Size)

ØØ = 9.5 inch (1Ø bits)
1Ø24 raster units

Ø1 = 19 inch
2Ø48 raster units

1Ø = 28.4 inch
3Ø72 raster units

11 = 38 inch (12 bits)
4Ø96 raster units

6.2 .READ MACRO

The .READ macro is used for input to the user program from the hardware registers of the display controller. The user may select standard groups of registers to be read, in response to each possible display interrupt flag, or he may indicate his own group of flags and registers. This is done with an optional descriptive word following the .READ macro, the first five bits of that word indicate which interrupts are of interest and the next nine indicate the registers to read if any of those interrupts are set.

The form is,

```
.READ A, M, L, W
NSTD
```

where NSTD = optional word describing non-standard groups.

The variables A = .DAT slot number, M = type of read:

Ø = READ,PB,XP,YP,S1,S2	Read now, no interrupts
1 = READ,PB,XP,YP,DPC,S1,S2,NR	If stop flag interrupt flag is set
2 = READ,PB,XP,YP,DPC,S1,S2,NR	If pushbutton interrupt flag is set

3 = READ,PB,XP,YP,DPC,S1,S2,NR — If light pen interrupt flag is set

4 = READ,PB,XP,YP,DPC,S1,S2,NR — If edge flag interrupt flag is set

5 = READ,PB,XP,YP,DPC,S1,S2,NR — If external stop interrupt flag is set

7 = NSTD specifies registers and interrupt flags as follows:

```
Bit Ø on service internal stop interrupt
Bit 1 on service pushbutton interrupt
Bit 2 on service light pen interrupt
Bit 3 on service edge flag interrupt
Bit 4 on service external stop interrupt
Bit 5 on read pushbuttons (PB)
Bit 6 on READ X position register (XP)
Bit 7 on READ Y position register (YP)
Bit 8 on READ DISPLAY program counter (DPC)
Bit 9 on READ STATUS ONE (S1)
Bit 10 on READ STATUS TWO (S2)
Bit 11 on READ NAME REGISTER (NR)
Bit 12 on READ SLAVE GROUP 1 (SG1)
Bit 13 on READ SLAVE GROUP 2 (SG2)
```

L = return buffer address, C(1) = descriptive word showing what this interrupt was and which registers were read in the order listed above. C(L+1) = contents of first register actually read, C(L+2) = contents of second register read, etc. W = 1 (W must equal 1).

The expansion is:

```
LOC      CAL + M(6-8) + A(9-17)
LOC+1    1Ø
LOC+2    L
LOC+3    -W    /DECIMAL
LOC+4    NSTD
```

.READ determines interrupts to be served and turns on read busy flag.

6.3 .WRITE MACRO

The .WRITE macro is used to transmit information from the user program to the display controller, once a display file has been generated. Its location is passed on to the display controller by a call to .WRITE, and the display starts up.

.WRITE is also used to stop the display, by issuing an external stop, and to start the display if it has been stopped. A .WRITE to the display is done immediately and requires no waiting.

The form is,

```
.WRITE A, M, L, W
```

A = .DAT slot number

M = type of write,

where Ø = restart display (L not required)
1 = resume display after internal stop

Note: The display is automatically resumed after LP or EDGE violation interrupt

2 = stop display (external stop)
4 = start display pointed to by L

L = display file starting address (17 bits)

W = not used

The expansion is:

```
LOC      CAL + M(6-8) + A(9-17)
LOC+1    11
LOC+2    L
         .DEC
LOC+3    -W     /DECIMAL
```

6.4 .WAIT MACRO

The .WAIT macro is used to synchronize the user program with the interrupt activity of the display. .WAIT is only defined with respect to .READ. If a .WAIT is given, the user program waits until the previous .READ has completed, that is, the interrupt has occurred. If the previous .READ specified more than one kind of interrupt flag, the descriptive word(s) in the input buffer can be interrogated to determine what flags were set. .WAIT does not initiate any display activity.

The form is,

```
.WAIT A
```

The variable A = .DAT slot number.

The expansion is,

```
LOC      CAL + A(9-17)
LOC+1    12
```

.WAIT allows a previous .READ to be completed and turns off input busy flag.

6.5 .WAITR MACRO

The .WAITR macro allows the user program to proceed in line if the previous .READ is complete. If the previous .READ is not complete, control is given to the location in the user program specified by the .WAITR call. This allows the user to branch to some other part of his program while waiting for the .READ to finish. The user must continue to check for completion by periodically issuing .WAITRs or by issuing a .WAIT.

The form is,

```
        .WAITR A, ADDR
```

The variables A = .DAT slot number, and ADDR = location in the user program to branch to if input is not completed.

The expansion is,

```
        LOC     CAL+1ØØØ + A(9-17)
        LOC+1   12
        LOC+2   ADDR
```

6.6 .CLOSE MACRO

The .CLOSE macro is used to terminate the current display. External STOP and CLEAR flags IOTs are issued. It is up to the user to save the display file if desired.

The form is .CLOSE A where A = .DAT slot number.

The expansion is,

```
        LOC     CAL + A(9-17)
        LOC+1   6
```

6.7 .FSTAT MACRO

The .FSTAT macro checks the status of a file specified by the file entry block. On return, the AC will contain zero and bits Ø-2 of LOC+2 will also be zero, stating that the device was nonfile-oriented.

The form is,

```
.FSTAT A, D
```

where the variables A = .DAT slot number, and D = starting address of three word block of storage in user area containing the filename and extension of the filename whose presence on the device associated with .DAT slot A is to be examined.

The expansion is:

```
LOC      CAL+3ØØØ + A(9-17)
LOC+1    2
LOC+2    D
```

6.8 IGNORED FUNCTIONS

The following system I/O macros are ignored by the VT15 display device handler:

1. .DLETE
2. .RENAM
3. .ENTER
4. .CLEAR
5. .MTAPE
6. .SEEK
7. .TRAN

CHAPTER 7

LK35 KEYBOARD HANDLER

The LK35 Keyboard device handler (LKA) provides an interface between the user and the hardware. Since the LK35 is a send-only device, the LKA handler provides only input functions. Input functions are initiated by standard user program commands; all interrupt management is done automatically by LKA.

The LKA handler relieves the user of the task of writing his own device handling subprograms and centralizes all direct communications between the XVM computer and the LK35 Keyboard. This handler only inputs IOPS ASCII or IMAGE ASCII data into a user-designated buffer; it is up to the user to develop the display of any input text on the VT04 display CRT or output it to any other device. The LK35 Keyboard is connected to either an LT15 or an LT19D controller.

The LKA handler is a resident program, it resides with the Keyboard Monitor and other required device handlers. It does not require EAE and it operates with both PI and API.

7.1 .INIT (INITIALIZE) MACRO

This macro initializes the LK35 Keyboard; it must be called before any other I/O macro is issued to this device.

When .INIT is issued it initializes the LKA handler, which returns the size of the current line buffer (34_{10} standard) to the macro.

If .INIT is issued during a .READ, it will abort this operation.

The form of this macro is:

```
.INIT a,f,r
```

where:

a = .DAT slot number
f = ignored by LKA
r = control p address

The expansion of this macro is

```
LOC      CAL+f7-8+a9-17
LOC+1    1
LOC+2    r
LOC+3    n        (standard buffer size 34(10))
```

7.2 .READ MACRO

This macro performs the operations required to input data from the LK35 Keyboard and transfer it to the memory input line buffer. In performing this function, the .READ macro:

a) allows any previous input operation to terminate,

b) sets the "input underway" indicator,

c) accepts and performs the operations indicated by:

   1) RUBOUT - delete previously entered (typed) character,
   2) CTRL U (↑U) - delete all entries made prior to ↑U.

d) recognizes IOPS ASCII string terminators ALT MODE and RETURN (carriage return),

e) is terminated, during IMAGE ASCII read operations when the given line buffer word count (see form) is reached.

The form of the .READ macro is:

```
.READ a,M,L,W
```

where:

a = .DAT slot number

M = Data Mode

   2 = IOPS ASCII
   3 = IMAGE ASCII

L = Line buffer address

W = Line buffer word count (including 2-word header pair)

The expansions of this macro are:

```
LOC      CAL+M7-8+a9-17
LOC+1    1Ø
LOC+2    L
LOC+3    -W
```

7.3 .WAIT MACRO

The .WAIT macro is used to detect the availability of the user's line buffer for data transfer operations. If the buffer is unavailable when tested, control remains with the macro; if the buffer is available, control is returned to the user.

The form of this macro is:

```
.WAIT a
```

where a represents a .DAT slot number.

The expansion of the macro is:

```
LOC      CAL+a(9-17)
LOC+1    12
```

7.4 .WAITR MACRO

This macro enables the user to test the status of a previously initiated .READ operation. If the .READ operation is complete the user's program is permitted to proceed in line; if the .READ operation is not complete control is given to a user-specified location expressed in the .WAITR macro call. The latter feature permits the user to branch to some other part of his program while waiting for the completion of the .READ operation.

The form of this macro is:

```
.WAITR a,ADDR
```

where:

```
a    = .DAT slot number
ADDR = location to branch to if .READ operation is incomplete.
```

The expansion of this macro is:

```
LOC      CAL+1ØØØ+A(9-17)
LOC+1    12
LOC+2    ADDR
```

7.5 .CLOSE MACRO

The LKA handler regards the .CLOSE macro as being the same as the .WAIT macro (see 7.3).

The form of this macro is:

```
.CLOSE a
```

where a = .DAT slot number.

The expansion of this macro is:

```
LOC      CAL+a(9-17)
LOC+1    6
```

7.6 .FSTAT MACRO

If used, this macro will return a zero to the AC since the LK35 is a non-directoried device. The form of this macro is:

```
.FSTAT a,D
```

where:

a = .DAT slot number
D = ignored by LKA.

The expansion of .FSTAT is:

```
LOC      CAL+3ØØØ+a(9-17)
LOC+1    2
LOC+2    D
```

7.7 IGNORED FUNCTION

The .SEEK macro is ignored by the LKA handler.

7.8 ILLEGAL FUNCTIONS

The following macros are illegal with regard to the LKA handler.

.WRITE
.DLETE
.RENAM
.ENTER
.CLEAR
.MTAPE
.TRAN

7.9 LEGAL CONTROL CHARACTERS

The following keyboard control entries are recognized by LKA:

	ENTRY	OPERATION
1)	CTRL C (↑C)	Performs on .EXIT to the Monitor.
2)	CTRL P (↑P)	Transfers control to the address given in the INIT cal.
3)	CTRL D (↑D)	Gives an End-of-Medium header word pair to the user.

CHAPTER 8

VW01 WRITING TABLET HANDLER

The VW01 Sonic Digitizer Writing Tablet converts graphical information, in the form of X- and Y-coordinates, to digital data that can be input to a digital computer. The major components of the VW01 are the writing tablet, spark pen, component box, and computer interface logic.

The user places a sheet of paper on the writing tablet and draws sketches, schematics, and hand-written symbols or characters using the special ball-point spark pen. The sound of the spark emitted by the pen is picked up by microphones located along the X- and Y-axes of the writing tablet. The time lapse, from spark emission until the sound is picked up by each bank of microphones, is accurately measured to provide a digital record of the X- and Y-coordinates of the spark pen location on the paper.

The digitized graphic data is input to a digital computer via the VWA handler for immediate or delayed processing.

The VW01 operates in either of two modes: Single Point or Data Input.

In the Single Point mode of operation, a single spark is generated each time the spark pen is pressed against the writing surface. The spark is initiated by the closure of a microswitch within the spark pen. The Single Point mode is used if the operator desires to plot points. For example, to plot points at four different locations, he positions the pen point at each location. Then, by pressing and releasing the pen at each position, the corresponding X-Y coordinate pairs are sensed and digitized.

In the Data Input mode, a continuous series of sparks is generated at a constant rate, under control of clock pulses. The X-Y coordinate pairs are continuously generated and input to the computer. This mode allows the user to draw continuous lines, circles, curves, etc., that can be displayed on the CRT.

At the time a spark is generated, X- and Y-clock pulses are initiated which increment X- and Y-hardware registers until the sound of the spark is received by the X- and Y-microphones. As soon as a microphone detects the sound, the associated X- or Y-clock pulses are inhibited, and the register stops incrementing. The binary numbers contained in the X- and Y-registers will then be directly proportional to the X- and Y- coordinates of the position at which the spark was emitted.

The VWA device handler for the VW01 Sonic Digitizer Writing Tablet provides an interface between the user and the hardware. Initialize and input functions are initiated by standard user program commands (system macros). The device handler relieves the user from writing his own device handling subprograms.

The Writing Tablet handler makes no tests on incoming X- and Y-coordinates. All coordinates are handled directly back to the user. This means that if the pen stays on the same spot (Data Input mode) or is pushed on at the same spot more than once (Single Point mode) the same X- and Y-coordinates are handled to the user. Repetitive X- and Y-coordinates should not be sent directly to the VT-handler since they could cause a hole to be burned on the display-screen. For this reason it is the user's responsibility to ignore X- and Y-coordinates which are generated on one and the same spot. The number of times the same coordinates could be accepted also depends on the intensity.

8.1 .INIT (INITIALIZE) MACRO

The macro .INIT causes the Writing Tablet to be initialized and must be given prior to any other I/O command referencing this device.

The .INIT macro clears one software and two hardware flags. These flags are:

1)	Handler Busy flag	/Software
2)	Data Ready flag	/Hardware
3)	Pen Data flag	/Hardware

The form is:

```
.INIT A,F,R,n
```

where:

A = Device Assignment Table (.DAT) slot number
F = Not used
R = Not used
n = Not used

The expansion is:

```
LOC     CAL+F(7-2)+A(9-17)
LOC+1   1                       /Function code for .INIT
LOC+2   R
LOC+3   n
```

8.2 .READ MACRO

The .READ macro is used for input point data to the user from the Writing Tablet. The input always consists of one status word and two words containing the X- and Y-point coordinates.

The status word has the following format:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Bit 0: Input .DAT flag; Bits 14–17: Writing Tablet Identifier Bits

where:	means:
Bit 0 = 0	Input from "DATA READY"
= 1	Input from "PEN DATA"
Bit 14 = 1	Input from Writing Tablet 1
Bit 15 = 1	Input from Writing Tablet 2
Bit 16 = 1	Input from Writing Tablet 3
Bit 17 = 1	Input from Writing Tablet 4

The form is:

```
.READ A,M,L,W
```

where:

A = Device Assignment Table (.DAT) Slot Number

M = Data Mode:

```
0 = Single Point
1 = Single Point multiplexed
2 = Data Input (not scan!)
3 = Data Input multiplexed (scan!)
```

L = Line buffer address

Points to a data buffer of minimum size 3W words.

W = Data point count

The number of data points that are to be returned with this read. Each point returns three data words: status, X position and Y position.

The expansion is:

```
LOC       CAL+M(6-8)+A(9-17)
LOC+1     1Ø                         /Function code for .READ
LOC+2     L
LOC+3  -  W
```

8.3 .WAIT MACRO

The .WAIT macro is used only with respect to the .READ macro. If a .WAIT is given the user program waits until the .READ has completed, that is, when the line buffer is filled and is again available for the user program. If the line buffer is available, control is returned to the user immediately after the .WAIT macro expansion (LOC+2). If the input of data has not yet been completed, control is returned to the .WAIT macro.

The form is:

```
.WAIT    A
```

where: A = Device Assignment Table (.DAT) slot number

The expansion is:

```
LOC      CAL+A(9-17)
LOC+1    12                /Function code for .WAIT
```

8.4 WAITR MACRO

The .WAITR macro is also used only with respect to the .READ. If the previous .READ is done, control is returned to the user immediately after the .WAIT in order to proceed in line. If the input of data has not yet been completed, however, control is given to a location in the user program specified in the .WAITR call.

The form is:

```
.WAITR    A,ADDR
```

where: A = Device Assignment Table (.DAT) slot number

ADDR = Location in the user program to which control must be transferred if input is not completed.

The expansion is:

```
LOC      CAL+1000₈+A(9-17)
LOC+1    12                       /Function code for .WAITR
LOC+2    ADDR
```

8.5 .FSTAT MACRO

The .FSTAT macro checks the status of a file specified by the file entry block. On return the AC will contain zero and bits 0-2 of LOC+2 will also be zero, stating that the device was non-directoried.

The form is:

```
.FSTAT A,D
```

where:

A = Device Assignment Table (.DAT) slot number

D = Address of a 3-word block of storage (directory entry block) in user area containing the filename and the extension of the file whose presence is to be examined.

The expansion is:

```
LOC       CAL+3ØØØ8+A(9-17)
LOC+1     2                          /Function code for .FSTAT
LOC+2     D
```

8.6 .CLOSE MACRO

Once input has been initiated (.INIT and .READ) it must be terminated by the .CLOSE macro. The hardware flags (Data Ready and Pen Data) are cleared and the Writing Tablet(s) is disabled in order to prevent illegal interrupts.

The form is:

```
.CLOSE  A
```

where: A = Device Assignment Table (.DAT) slot number

The expansion is:

```
LOC       CAL+A(9-17)
LOC+1     6                          /Function code for .CLOSE
```

8.7 IGNORED FUNCTIONS

The following macros are ignored by the VWA device handler:

1) .SEEK
2) .ENTER
3) .CLEAR
4) .MTAPE
5) .WRITE
6) .TRAN
7) .DLETE
8) .RENAM

CHAPTER 9

TEXT DISPLAY/EDIT FUNCTIONS

The VT15 GRAPHICS software provides the user with a complete text editing program, EDITVT, and a soft copy display feature, CONTROL X.

The EDITVT program has the same command and editing structure as the standard Editor except that the majority of the text presentation takes place on the VT04 display CRT. The Control X (CTRL X) feature enables the user to, essentially, replace the console printer with the display CRT when desired. The operation of EDITVT is described in the EDIT/EDITVP/EDITVT XVM Utility Manual.

9.1 CONTROL X FEATURE

The Control X feature gives the user the ability to change from hard to soft copy at any time during Monitor operation. When Soft copy is desired the user types VT ON when under Monitor Control and then a Control X. The VT ON command sets up the necessary linkage in the Teletype[1] handler and also reserves a segment of core to be used for the Display Buffer. The Control X command may be typed during Monitor Control or during System Program Control; it switches output from the device presently being used to the alternate device. (Teletype to display or display to Teletype.) When the display is being used, Teletype input is echoed on both the Teletype and on the display while Teletype output appears only on the display.

9.1.1 SCROLL Mode

When text is being output to the display and the display screen is filled (56) lines, the next incoming line appears on the bottom of the screen and the oldest or top line on the screen disappears. It appears as if the text is rotating from screen bottom to screen top. The display screen may be cleared at any time and new text begins at screen top by changing the position of pushbutton number 6; and then typing a carriage return.

---

[1]Teletype is a registered trademark of the Teletype Corporation.

9.1.2 PAGE Mode

The display may be put in page mode operation. That means that when the display has 56 lines being presented it stops output to it so the user can inspect the text and it then waits for the user to advance to the next page. This feature is useful for doing a PIP transfer of a large file to the display; the file can be read on the display a page at a time. It is also useful for looking at Macro Assemblers and FORTRAN compilations on the display. Page Mode operation is entered by setting pushbutton number 5 to the ON position; for normal operation (text rotation across screen) pushbutton number 5 should be in the OFF position. When in page mode, a page is advanced by changing the position of pushbutton number 6.

9.1.3 VT ON/OFF Monitor Commands

The VT ON command sets up the interface between the VT15 Display System and the Teletype Handler Section of the Resident Monitor. The Display Interface Code is moved to a position directly above the Resident Monitor and essentially becomes a part of the resident monitor. The VT ON command also reserves a segment of core for use as the Display Buffer. Once the VT ON command has been issued the user has the ability to switch his output device from Teletype to display and from display to Teletype. The output device switching is accomplished by typing a ↑X (Control X); and may be done when under monitor control or user program control.

The feature gives the user the ability to work from an extremely fast, soft copy output device; and easily switch to hard copy when it is desired. When ↑X is typed, an Up-Arrow (↑) is echoed on the device selected for output. The VT OFF command releases the reserved core segment and it frees the area of core directly above the Resident Monitor where the Display Interface Code was moved. The VT ON command remains in effect until VT OFF is issued or the Monitor System is bootstrapped. If the VT15 Display System is desired as the primary output device, VT ON may be set at System Generation time. The VT OFF command can override the System Generation setting, allowing selection of hard copy output.

9.1.4 HALF ON/OFF Monitor Command

The HALF ON/OFF command can be used in ↑X operations.

APPENDIX A

MNEMONICS COMMONLY USED IN GRAPHICS SUBPROGRAM CALLS

The following mnemonics are commonly used in describing subroutine call statements throughout this manual.

Mnemonic	Definition
1. DELTAX	An integer number or variable which represents in raster units the amount the CRT beam is to be displaced from its current position in a horizontal direction. This quantity is signed to indicate the direction of displacement (i.e., + = move beam right, - = move beam left).
2. DELTAY	Same as DELTAX except that the indicated displacement is made on a vertical direction and the directions indicated by the sign are: + = move beam up, - = move beam down.
3. INT	This variable is restricted to the Integer values 1 and Ø to indicate if the CRT beam movement is to be visible, (INT = 1) to draw a line, or invisible (INT = Ø).
4. PNAME	The subpicture display files generated by the graphic subpicture calls are stored in dimensioned integer arrays specified by the user. The integer variable PNAME specifies the first element of the array into which commands generated by a particular call are to be stored. PNAME is always represented as a subscripted variable; it will contain the length of the file and is the variable by which the file is referenced in later manipulations. NOTE The variable PNAME may be dropped from the statement argument lists; if dropped, the last given value for PNAME will be assumed.
5. STR	Identifies the dimensioned real array which contains the string of characters to be displayed in IOPS ASCII (Hollerith) form (five 7-bit characters per word).
6. FEATR	An integer number which identifies a hardware feature(s) to be specified in the call (e.g., 1 = scale, 2 = intensity, 4 = light pen, and 8 = blink).

Mnemonics Commonly Used in Graphics Subprogram Calls

Mnemonic	Definition
7. VALUE	A single integer variable or constant that indicates the value or setting is specified for a selected display feature.
8. DTA	Contains the set of data points, one per word, in the range Ø to 1Ø23 (Integer).
9. N	Used by GRAPH subprogram to indicate the number of points to graph. Also used by TEXT subprogram to indicate the number of characters to be displayed.
10. A	An integer variable or constant restricted to the values Ø and 1. Indicates which axis to increment for GRAPH subprogram, Ø = increment X, set Y to data values; 1 = increment Y, set X to data values.
11. MAINFL	Similar to PNAME, the value of MAINFL represents the first array element of the dimensioned Integer array specified by the user for storing main display file commands. MAINFL is represented as a subscripted integer variable, it contains the length of the file and is the variable by which the file is referenced.
12. CNAME	An integer variable that identifies the location or first location which contains the display command(s) generated by the call in which CNAME is an output argument.
13. NAMR	An integer which represents the contents of the name register at the time of a light pen hit (restricted to values ranging from Ø to 127).
14. PB	A 6-element integer array which will contain a logical .T, or .F, for each of the six pushbuttons.
15. RST	This variable, restricted to the integer values of 1 and Ø, indicates whether the hardware SAVE/RESTORE option is to be used when copying subpicture files. The value Ø indicates that the SAVE/RESTORE option is not to be used; the value 1 indicates that it is to be used.

APPENDIX B

DISPLAY INSTRUCTION GROUPS GENERATED BY GRAPHICS SUBPROGRAM CALLS

SUBPROGRAM CALL	NUMBER OF COMMANDS	COMMANDS GENERATED
LINE PLOT(Ø,... REPLOT(Ø,...	1	If one of the eight basic directions: VN!INCR
	2	If random vector option is used: SVX! DELTAX SVY! DELTAY
	N+2	If not one of the above, required line is approximated with a series of basic vectors: SKP (COUNT=N+2) V1 V2 . . . VN
TEXT PLOT(3,... REPLOT(3,...	3	CHARS* .+2 DJMP .+2 (FULL 15-BIT ADDRESS)
COPY PLOT(Ø,... REPLOT(Ø,...	3	When SAVE/RESTORE is not used: DJMS* .+2 DJMP .+2 (FULL 15-BIT ADDRESS)
	6	When SAVE/RESTORE is specified: SAVE .+4 DJMS* .+2 DJMP .+3 (FULL 15-BIT ADDRESS) (STATUS) RSTR .-1
PRAMTR PLOT(2,... REPLOT(2,...	1-4	Adds from one to four parameter words to the display file, depending on the type of argument list used.

Display Instruction Groups Generated by Graphics Subprogram Calls

SUBPROGRAM CALL	NUMBER OF COMMANDS	COMMANDS GENERATED
GRAPH	N	Adds N graph plot commands to the display file, where N is equal to the number of points in the data set: GY!Y1 GY!Y2 . . . GY!YN or GX!X1 GX!X2 . . . GX!XN
SETPT RSETPT	2	PY!Y PX!X

APPENDIX C

MACRO EXPANSION OF GRAPHICS SUBPROGRAM CALLS

Subpicture Routines

LINE

```
 .GLOBAL    LINE
 JMS*       LINE
 JMP        .+5
 .DSA       DELTAX
 .DSA       DELTAY
 .DSA       INT
[.DSA       PNAME]
```

TEXT

```
 .GLOBL     TEXT
 JMS*       TEXT
 JMP        .+4
 .DSA       STR
 .DSA       N
[.DSA       PNAME]
```

COPY

```
 .GLOBL     COPY
 JMS*       COPY
 JMP        .+4
 .DSA       RST
 .DSA       PNAME1
[.DSA       PNAME]
```

PRAMTR

```
 .GLOBL     PRAMTR
 JMS*       PRAMTR
 JMP        .+N
 .DSA       FEATR
 .DSA       VALUE
[.DSA       PNAME]
where N+2+(Number of
Features specified)+1
if PNAME is given
```

GRAPH

```
 .GLOBL     GRAPH
 JMS*       GRAPH
 JMP        .+5
 .DSA       DTA
 .DSA       N
 .DSA       A
[.DSA       PNAME]
```

BLANK

```
 .GLOBL     BLANK
 JMS*       BLANK
 JMP        .+2
 .DSA       PNAME
```

UNBLNK

```
 .GLOBL     UNBLNK
 JMS*       UNBLNK
 JMP        .+2
 .DSA       PNAME
```

CIRCLE

```
 .GLOBL     CIRCLE
 JMS*       CIRCLE
 JMP        .+6
 .DSA       R
 .DSA       THETA
 .DSA       GAMMA
 .DSA       DEG
 .DSA       PNAME
```

ROTATE

```
 .GLOBL     ROTATE
 JMS*       ROTATE
 JMP        .+12
 .DSA       ISTR
 .DSA       IA
 .DSA       IB
 .DSA       IC
 .DSA       X
 .DSA       Y
 .DSA       Z
 .DSA       SINA
 .DSA       CSA
```

Macro Expansion of Graphics Subprogram Calls

Subpicture Routines (Cont.)

LTORPB

```
.GLOBL    LTORPB
JMS*      LTORPB
JMP       .+6
.DSA      IX
.DSA      IY
.DSA      NAMR
.DSA      PB
.DSA      IWICH
DAC       I
```

TRACK

```
.GLOBL    TRACK
JMS*      TRACK
JMP       .+5
.DSA      IX
.DSA      IY
.DSA      IOPT
.DSA      IARRAY
```

Relocating Routines

DYSET

```
.GLOBL    DYSET
JMS*      DYSET
JMP       2*N+.+1
.DSA      PNAME
.DSA      ASCII
     .
     .
     .
.DSA      PNAMEN
.DSA      ASCIIN
          (where N =
          number of files)
```

DYLINK

```
.GLOBL    DYLINK
JMS*      DYLINK
JMP       2*N+.+1
.DSA      PNAME1
.DSA      ASCII1
     .
     .
     .
.DSA      PNAMEN
.DSA      ASCIIN
          (where N =
          number of files)
```

Main Display File Routines

DINIT

```
.GLOBL    DINIT
JMS*      DINIT
JMP       .+2
.DSA      MAINFL
```

SETPT

```
 .GLOBL    SETPT
 JMS*      SETPT
 JMP       .+4
 .DSA      X
 .DSA      Y
[.DSA      CNAME]
```

DCLOSE

```
.GLOBL    DCLOSE
JMS*      DCLOSE
```

PLOT a COPY

```
 .GLOBL    PLOT
 JMS*      PLOT
 JMP       .+5
 .DSA      (Ø
 .DSA      RST
 .DSA      PNAME
[.DSA      CNAME]
```

REPLOT

```
.GLOBL    REPLOT
JMS*      REPLOT
JMP       .+5
.DSA      (Ø
.DSA      RST
.DSA      PNAME
.DSA      CNAME
DAC       I/ if used as function
```

Main Display File Routines (Cont.)

PLOT a LINE

```
.GLOBL    PLOT
JMS*      PLOT
JMP       .+6
.DSA      (1
.DSA      DELTAX
.DSA      DELTAY
.DSA      INT
[.DSA     CNAME]
```

REPLOT a LINE

```
.GLOBL    REPLOT
JMS*      REPLOT
JMP       .+6
.DSA      (1
.DSA      DELTAX
.DSA      DELTAY
.DSA      INT
.DSA      CNAME
DAC       I/ if used as function
```

PLOT a PRAMTR

```
.GLOBL    PLOT
JMS*      PLOT
JMP       .+5
.DSA      (2
.DSA      FEATR
.DSA      VALUE
[.DSA     CNAME]
```

REPLOT a PRAMTR

```
.GLOBL    REPLOT
JMS*      REPLOT
JMP       .+5
.DSA      (2
.DSA      FEATR
.DSA      VALUE
.DSA      CNAME
DAC       I/ if used as function
```

PLOT a TEXT string

```
.GLOBL    PLOT
JMS*      PLOT
JMP       .+5
.DSA      (3
.DSA      STR
.DSA      N
[.DSA     CNAME]
```

REPLOT a TEXT string

```
.GLOBL    REPLOT
JMS*      REPLOT
JMP       .+5
.DSA      (3
.DSA      STR
.DSA      N
.DSA      CNAME
DAC       I/ if used as function
```

DELETE

```
.GLOBL    DELETE
JMS*      DELETE
JMP       .+2
.DSA      CNAME
DAC       I/ if used as
             function
```

RSETPT

```
.GLOBL    RSETPT
JMS*      RSETPT
JMP       .+4
.DSA      X
.DSA      Y
.DSA      CNAME
DAC       I/ if used as function
```

APPENDIX D

CONDITIONAL ASSEMBLY OF GRAPHICS SUBPROGRAMS

For VT15 configurations that include the Arbitrary Vector Option, the Graphics Subprogram Package (VTPRIM) can be conditionally assembled to eliminate coding required for line approximation. This procedure saves approximately 174_8 locations. The standard procedure for conditional assembly may be followed; it is only necessary to define a value for the variable ARBVEC when assembling VTPRIM SRC.

WARNING

In writing MACRO routines, the exclamation point (!) must not be used in memory reference type instructions to separate the Op-code and address fields. The symbol ! used in this manner causes the contents of the Op-code and address fields to be OR'd together resulting in an erroneous 15-bit address.

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their definitions

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