OBSOLETE
See CGTM 170

CGTM No. 143
January 1973

Revised:
June 1973
November 1973
September 1974

MASTER COPY
DO NOT REMOVE

THE SLAC UNIFIED GRAPHICS SYSTEM
FORTRAN VERSION

ROBERT C. BEACH
COMPUTATION GROUP
STANFORD LINEAR ACCELERATOR CENTER
STANFORD, CALIFORNIA 94305

TABLE OF CONTENTS

TABLE OF CONTENTS

The textual part of this document was formatted using the FORMAT Text Processing Program. The figures were drawn on the 10 inch CALCOMP Drum Plotter using the SLAC Unified Graphics System and these drawings were then photographically reduced.

SECTION 1: INTRODUCTION TO THE SLAC UNIFIED GRAPHICS SYSTEM

The SLAC Unified Graphics System is a collection of PL/1 procedures and FORTRAN subroutines which may be used to program for the graphic devices which can be driven from the central computing facility at SLAC. This document describes the FORTRAN version of the system.

The graphic devices which are now supported by this system are:

1. The CALCOMP Drum Plotters (Models 564/565).
2. The CALCOMP Microfilm Plotter (Model 1675).
3. The TEKTRONIX 4013 Display Terminal. This device may be used in an essentially non-interactive mode or in a fully interactive mode.
4. The IBM 2250 Display Console.
5. The GIF-IDIION Display Console.

As new graphic devices become available at SLAC, it is intended that this system will be expanded to include them.

Since this document is rather long, the following suggestions are given for the person who is trying to read this document for the first time.

1. Read the remainder of Section 1. These sub-sections supply a basic introduction to this system.
2. In Section 2, read all of the introductory sections and the descriptions of the following subroutines: UGEINT, UGEPNT, UGELIN, UGETXT, UGOPEN, UGCLOS, UGEPUT, and UGPICT. If you are interested in interactive graphic devices, then you should also read about: UGCTRL, UGRATN, UGDATN, UGRATN, UGKPUT, and UGKGET.
3. Read the summary, in Sections A and B, about the specific graphic device in which you are interested.
4. Study the examples. To fully understand these examples you will have to look up some additional information.

SECTION 1.1: THE PURPOSE OF THE SYSTEM

SLAC has always had a number of graphic devices accessible from the central computing facility. In general, the FORTRAN programmer has had a set of subroutines available for using each of these devices. One of the problems has been that the subroutines available for one device have been totally different from those of another device. For instance, if a programmer had mastered the subroutines for producing CALCOMP plots, it was necessary to learn an entirely different set of subroutines to display the same picture on an IBM 2250 display console. Thus, changing from one graphic device to another required a programmer to learn a new set of subroutines in addition to re-programming

the problem. Part of the problem has always been that two different graphic devices often have very little in common. For example, the CALCOMP drum plotters are non-interactive and a picture can contain an arbitrarily large amount of information while an IBM 2250 display console is interactive and has severe limitations on the complexity of the picture which can be displayed.

The SLAC Unified Graphics System is an attempt to eliminate many of these difficulties for a large class of graphic applications. The FORTRAN programmer will use exactly the same set of subroutines to create a picture for one graphic device as for another. Thus, if a programmer is using more than one graphic device, the number of different subroutines that must be kept in mind is considerably reduced. In addition, the problem of changing a program from one graphic device to another is greatly simplified. For example, a program using the IBM 2250 can be converted to a program using the GIF-IDIIOM with very little effort; in fact if the programmer is careful, no programming changes at all will be required, only the JCL need be changed. At the same time the FORTRAN programmer will be able to take advantage of any of the special features of a specific display device. In taking advantage of these special features the programmer, of course, will have limited the possibilities of changing to another graphic device at some future time.

SECTION 1.2: A BRIEF DESCRIPTION OF THE SUBROUTINES

The user of the SLAC Unified Graphics System describes a picture by packing information into an array of full word integers. These arrays, called "graphic elements", are usually constructed by calling subroutines in this system to add point, line, and text data to the graphic element. A graphic element, constructed in this manner, is a device independent description of part of a picture. After a graphic element has been constructed, it may be transmitted to any of the display devices supported by this system. When a graphic element is transmitted to a display device, it is first transformed into orders for that device and then these orders are written to the device. After a graphic element has been transmitted to the device, the array containing the graphic element may be re-used; changing the array at that stage does not affect the picture. A complete picture may consist of many graphic elements.

The programmer specifies the positions of points, end points of lines, and centers of characters by giving floating point X and Y coordinates. The default drawing space (the "programmer coordinate system") for each graphic device is a square area with coordinates of (0.0,0.0) at its lower left hand corner and coordinates of (1.0,1.0) at its upper right hand corner. The picture is scissored at the outer boundaries of the display. A subroutine is provided which allows the programmer to change

these scaling and scissoring limits.

The handling of point and line data in an efficient but device-independent manner is relatively straightforward, however the handling of text data poses some substantial problems. The reason is that some devices contain hardware character generators while others require that the programmer form the characters out of short line segments (called "strokes"). A programmed stroke generator can clearly make characters of any size and at any angle to the horizontal. Hardware character generators vary greatly from device to device and usually produce very limited character sizes or orientations. This system provides a stroke generator which may be used on any device. The programmer may specify one of the following possibilities when text data is added to a graphic element.

1. The text must be produced by the character generator. The programmer specifies character size and orientation. If a graphic element containing this type of text is transmitted to a device which does not have a character generator or has a character generator which cannot satisfy the given size or orientation requirements, then the text is ignored and will not appear in the picture.
2. A suggested character size and orientation is given. The size is specified in terms of the distance between the centers of adjacent characters in the programmer coordinate system. If the device character generator can come close to matching these requirements then it is used, otherwise the stroke generator is used.
3. The character size and orientation is given and the stroke generator is always used.

For non-interactive devices, there is little more that one can do except transmit pictures to them. However, for interactive devices, much more control is possible. Interactive devices usually have alphanumeric keyboards, and sometimes have light pens, function keyboards, and other control units. These control units are capable of generating attentions which may be signalled to the program from the device. Subroutines are supplied in this system for enabling and disabling attentions. Another subroutine allows the programmer to ask if an attention has occurred from a device. If a control unit is disabled, any attentions generated by it will not be reported to the program.

A program may use more than one display device. In this case only one display device is "active" at a time. Most of the subroutines in this system communicate with the active device only. A subroutine is available to make any display device the active one.

SECTION 2: A DETAILED DESCRIPTION OF THE SUBROUTINES

This section gives a complete description of each of the subroutines provided in the FORTRAN version of the SLAC Unified Graphics System. The names of these subroutines, and all other external names, start with the letters "UG" (standing for Unified Graphics). If the user of these subroutines avoids external names beginning with "UG", there will be no naming conflicts between the user's names and names within this system.

The first argument in almost all subroutines is a character string (named OPTNS) which is used to specify information to the system which may be optional or device-dependent. The character string may contain any number of items separated by commas. Each item may be either (1) a simple string of characters or (2) a string of characters terminated by an equals sign, followed by a number, character string, or bit string. The character string must be terminated by an asterisk. Thus the line:

'SHAL,ANGLE=5.3,DDNAME=PQRS,LITES=01010*'

is an example of the kinds of strings which are valid. If specific items of information are not supplied, default values will be assumed; if invalid information is supplied, it will be ignored. For example when an element is transmitted to a display device, the user may specify that the element may be detectable with a light pen. If this information is not specified, the element will not be detectable; if the display device is not an interactive device or does not have a light pen, then the item will be ignored and no error indication will be given. The descriptions of the subroutines on the following pages include all of the items which can be utilized by any of the devices. Exactly which items in OPTNS will be recognized by a graphic device is described in a later section devoted to that specific device.

This system contains a flexible scheme to report errors to the programmer. Any errors detected by these subroutines are classified into one of four severity levels. The actions corresponding to these levels are:

1. Set error indicators.
2. Set error indicators and print a message.
3. Print a message and terminate the program without a core dump.
4. Print a message and terminate the program with a core dump.

The error indicators may be checked by the programmer at execution time to determine what the error was and possibly correct the problem. The error message contains the name of the subroutine detecting the error and an index number. Additonal information on this subject will be found in the section on the Error Processing Sub-System. The descriptions of each subroutine include a list of all the error conditions, for all devices, which may be produced by the subroutine. Both the index and level number (in parentheses) as well as a short description are

given.

Many of the subroutines have arguments which are described in this document as character strings. These arguments may be INTEGER or LOGICAL arrays of any precision.

SECTION 2.1: GRAPHIC ELEMENT GENERATION

The subroutines which are described in this section may be used to pack picture description data into a graphic element. A graphic element is nothing more than an array of full word integers. An example of a statement defining a graphic element is:

```
  INTEGER*4  ELEMNT(500)
```

As described below, the array ELEMNT may be initialized and have picture description data packed into it.

The first of the graphic element generation subroutines is UGEINT. This subroutine is used to initialize a graphic element before any picture description data is added to it. The next three subroutines, UGEPNT, UGELIN, and UGETXT, perform only the most basic of functions. They add a single point, a single line segment, or a single line of text to a graphic element. The next two subroutines, UGEPTS and UGELNS, are similar to UGEPNT and UGELIN except that each call to these two subroutines will add an array of points or line segments to the graphic element. Subroutines UGAXIS and UG3DMS perform more complex operations; they add the description of a horizontal or vertical axis, or the description of a mesh surface with hidden lines eliminated to a graphic element. Finally subroutines UGEINV and UGEDTA add information to a graphic element which can only be processed by a limited set of display devices; most devices will ignore this special information.

The OPTNS argument in these subroutines usually specifies device dependent parameters about the graphic information. When the graphic element is finally transmitted to a display device as many of these parameters as possible will be utilized. The key words used for parameters are:

- VDIM,DIMM,BRIT,VBRT Intensity levels. Any of four different intensity levels may be given. The key words stand for "very dim", "dim", "bright", and "very bright".
- WINK,STDY Wink mode specification. Some interactive devices have a feature whereby part of the display may flash on and off. The key word STDY stands for "steady".
- COL1,COL2,CCL3,COL4 Color codes. Any of four colors may be specified.
- SOLD,DASH,DDSH,DOTS Line structure specification. On some devices a line may be other than solid. The key words stand for "solid", "dashed", "dot-dashed",

and "dots".

VSML,SMAL,LARG,VLRG Character size. These key words specify that the character generator on the device must be used. They stand for "very small", "small", "large", and "very large".

When default values must be supplied by the system, these default values will be: BRIT, STDY, COL1, SOID, and SMAL.

In addition to using these subroutines to construct graphic elements, the user may also put information directly into the graphic element. The correct format for this data is given in the section on the Internal Format of a Graphic Element. The user should be warned, however, that incorrect data in a graphic element can cause unpredictable and disastrous results when it is transmitted to a display device.

The subroutines described in this section are completely independent of the rest of the subroutines in the system. Their only function is to aid in the generation of graphic elements. Since a graphic element is nothing more than an array filled with data, the user program can process it in many different ways. One obvious thing that the program can do is to transmit the element to a graphic device. Another possibility is that the user program could write the graphic element to a tape or disk data set. This capability provides a reasonably compact and device-independent means of saving pictorial data in a data set.

SECTION 2.1.1: SUBROUTINE UGEINT

This subroutine may be used to clear and initialize a graphic element. After this subroutine has been called, other subroutines may be called to add picture description data to the element. The first four words will be initialized so that they contain bookkeeping information.

The calling sequence is:

```
CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
```

The parameters in the calling sequence are:

OPTNS A character string which may contain one of the following items:

- CLEAR This is the normal use of this subroutine. The element is cleared and made ready to accept more picture description data.
- RESET The element is not cleared but is made ready to accept more data. The only time this operation is normally necessary is after a graphic element has been read from a data set and before any new data is added to it.
- CONTINUE The element is cleared except that the last line data is retained. See the

section on the Error Processing Sub-System for an example of a case when this operation is necessary.

ELEMNT The graphic element which is to be initialized.
ELTSIZ The number of words in ELEMNT (INTEGER*4).

The errors detected by this subroutine are:
1(3): The length of the array ELEMNT is too small.

SECTION 2.1.2: SUBROUTINE UGEPNT

This subroutine may be used to add a single point to a graphic element. If the previous data added to the element was points with the same options list, then two words of information are added to the graphic element; otherwise four words are added.

The calling sequence is:
CALL UGEPNT(OPTNS,X,Y,ELEMNT)

The parameters in the calling sequence are:
OPTNS A character string which may contain any of the following items:
VDIM,DIMM,BRIT,VBRT Intensity levels.
WINK,STDY Wink mode specification.
COL1,COL2,COL3,COL4 Color codes.
X X coordinate of the point (REAL*4).
Y Y coordinate of the point (REAL*4).
ELEMNT The graphic element which will have the point added to it.

The errors detected by this subroutine are:
9(1): Not enough room was available in ELEMNT to contain the new point.

SECTION 2.1.3: SUBROUTINE UGELIN

This subroutine may be used to add the end point of a single straight line segment to a graphic element. The vector may either be blanked or drawn. The user should blank to the first point and then either draw or blank to the following points to create the display. If the previous data added to the element was lines with the same options list, then two words of information are added to the graphic element; otherwise four words are added.

The calling sequence is:
CALL UGELIN(OPTNS,X,Y,BRIT,ELEMNT)

The parameters in the calling sequence are:
OPTNS A character string which may contain any of the following items:

SOLD,DASH,DDSH,DOTS Line structure specification.
VDIM,DIMM,BRIT,VBRT Intensity levels.
WINK,STDY Wink mode specification.
COL1,COL2,COL3,COL4 Color codes.

X — X coordinate of an end point of a line (REAL*4).

Y — Y coordinate of an end point of a line (REAL*4).

BBIT — The blanking bit. The line segment formed in moving to the given point is drawn if BBIT is a one, and blanked if BBIT is a zero (INTEGER*4).

ELEMNT — The graphic element which will have the end point of the line added to it.

The errors detected by this subroutine are:

9(1): Not enough room was available in ELEMNT to contain the new end point.

SECTION 2.1.4: SUBROUTINE UGETXT

This subroutine may be used to add text material to a graphic element. The text will normally occupy a single line. The actual characters will be produced either by the character generator on the device, or by a programmed stroke generator. If the previous data added to the element was text with the same options list, then [N/4]+3 words of information are added to the graphic element where N is the number of characters in the text and [X] is the greatest integer in X; otherwise [N/4]+7 words are added.

The calling sequence is:

```
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
```

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:

VSML,SMAL,LARG,VLRG Character size. The use of one of these items indicates that the text must be produced by the device character generator. If the device does not have a character generator, then this text is ignored.

XSPACING=<value> Suggested character spacing. The device character generator will be used if the between character spacing will approximately match the given value.

SPACING=<value> Character spacing. The programmed stroke generator must be used.

ANGLE=<value> The angle that the characters make with the horizontal. The angle is measured in the counter-clockwise direction.

VDIM,DIMM,BRIT,VBRT Intensity levels.
WINK,STDY Wink mode specification.
COL1,COL2,COL3,COL4 Color codes.

If no character spacing of any kind is specified, then a default of XSPACING=0.01367 is assumed. This default will result in reasonably sized characters if the default scaling parameters are in effect when the element is transmitted to the display device.

X — X coordinate of the center of the first character (REAL*4).

Y — Y coordinate of the center of the first character (REAL*4).

TEXT — The string containing the characters to be added to the graphic element.

NTEXT — The number of characters in TEXT (INTEGER*4).

ELEMNT — The graphic element which will have the text information added to it.

The errors detected by this subroutine are:

1(2): The string TEXT contained more than 255 characters.

9(1): Not enough room was available in ELEMNT to contain the new text information.

SECTION 2.1.5: SUBROUTINE UGEPTS

This subroutine may be used to add an array of points to a graphic element. The same thing could be accomplished with repeated calls to subroutine UGEPNT, but one call to this subroutine is more efficient because the OPTNS argument will be scanned only once.

The calling sequence is:

```
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
```

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:

VDIM,DIMM,BRIT,VBRT Intensity levels.
WINK,STDY Wink mode specification.
COL1,COL2,COL3,COL4 Color codes.

XARRAY — An array containing the X coordinates of the points (REAL*4, DIMENSION=NPTS).

YARRAY — An array containing the Y coordinates of the points (REAL*4, DIMENSION=NPTS).

NPTS — The number of points in XARRAY and YARRAY (INTEGER*4).

ELEMNT — The graphic element which will have the points added to it.

The errors detected by this subroutine are:

9(1): Not enough room was available in ELEMNT to contain the new points. The element is unchanged.

SECTION 2.1.6: SUBROUTINE UGELNS

This subroutine may be used to add an array of line segments to a graphic element. The same thing could be accomplished with repeated calls to subroutine UGELIN, but one call to this subroutine is more efficient because the OPTNS argument will be scanned only once.

The calling sequence is:

```
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)
```

The parameters in the calling sequence are:

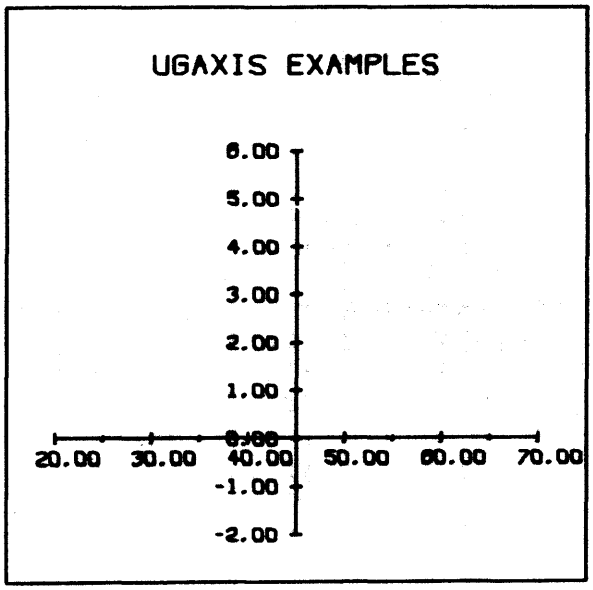
- **OPTNS** A character string which may contain any of the following items:
  - SOLD,DASH,DDSH,DOTS Line structure specification.
  - VDIM,DIMM,BRIT,VBRT Intensity levels.
  - WINK,STDY Wink mode specification.
  - COL1,COL2,COL3,COL4 Color codes.
- **XARRAY** An array containing the X coordinates of the end points of the line segments (REAL*4, DIMENSION=NPTS).
- **YARRAY** An array containing the Y coordinates of the end points of the line segments (REAL*4, DIMENSION=NPTS).
- **NPTS** The number of end points in XARRAY and YARRAY (INTEGER*4).
- **BBITS** The blanking bits. The bits are used cyclically from BBITS. A single blanking bit of one would result in a continuous curve; two blanking bits of one-zero results in a line being drawn between the first and second points, the third and fourth, etc. (INTEGER*4, DIMENSION=NBBITS or (31-NBBITS)/32).
- **NBBITS** The number of blanking bits in BBITS (INTEGER*4). If NBBITS is positive, the bits must be given one to a word; if NBBITS is negative, its absolute value is used for the count and the bits must be packed 32 to a word. When un-packed bits are used, the first blanking bit is the low order bit of BBITS(1); when packed bits are used, the first blanking bit is the high order bit of BBITS(1).
- **ELEMNT** The graphic element which will have the line segments added to it.

The errors detected by this subroutine are:

9(1): Not enough room was available in ELEMNT to contain the new line segments. The element is unchanged.

SECTION 2.1.7: SUBROUTINE UGAXIS

This subroutine may be used to add the description of a horizontal or vertical axis with labels and tic marks to a graphic element. This subroutine adds the actual data to the graphic element by calling subroutines UGELIN and UGETXT. If either of these subroutines signal an error, then the graphic element is restored to the state that it was in when UGAXIS was called and UGAXIS then signals an error.



The calling sequence is:

```
CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
  LOLAB,HILAB,NLAB,ELEMNT)
```

The parameters in the calling sequence are:

OPTNS A character string which may contain any of the following items:

- VERT Indicates that a vertical axis is required, the default setting is a horizontal axis.
- MINMV The axis will be generated with an attempt to minimize the motion of the drawing stylus, the default is to minimize the amount of data put into the graphic element.
- NOLABL This item will suppress the labels on the axis; the axis itself and the tic marks will still be generated. The default is to have labels on the axis.
- LWID=<value> The field width of the labels, the default value is 8; the given value must be between 1 and 9.
- LDEC=<value> The number of places to the right of the decimal point in the labels, the default value is 2; the given value must be between 0 and 9.
- LXOFF=<value> The offset, in the X direction, of the first of the LWID characters in the label from the axis-tic mark intersection. The default value is -0.055 for a horizontal axis and -0.120 for a vertical axis.
- LYOFF=<value> The offset, in the Y direction, of the first of the LWID characters in the label from the axis-tic mark

intersection. The default value is -0.020 for a horizontal axis and 0.000 for a vertical axis.

LOTM=<value> The length of the labeled tic marks on the negative side of the axis, the default value is 0.005.

HITM=<value> The length of the labeled tic marks on the positive side of the axis, the default value is 0.005.

NSTM=<value> The number of secondary tic marks between the labeled tic marks, the default value is 0. These tic marks are half the length of the labeled tic marks.

DUNIT=<value> This subroutine uses the library subroutine FIO999 to create the labels. FIO999 requires a dummy unit number, the default value is 99.

These default values are consistent with the default scaling and scissoring limits and the default character size.

LOPTNS An options list that will be passed to UGELIN.

COPTNS An options list that will be passed to UGETXT.

INDVAR For a horizontal axis this is the Y coordinate of the axis in the programmer coordinate system, for a vertical axis this is the X coordinate (REAL*4).

LOVAR For a horizontal axis this is the X coordinate of the low end of the axis in the programmer coordinate system, for a vertical axis this is the Y coordinate (REAL*4).

HIVAR For a horizontal axis this is the X coordinate of the high end of the axis in the programmer coordinate system, for a vertical axis this is the Y coordinate (REAL*4).

LOLAB The label to be placed at the low end of the axis (REAL*4).

HILAB The label to be placed at the high end of the axis (REAL*4).

NLAB The number of labels and primary tic marks to be put on the axis (INTEGER*4).

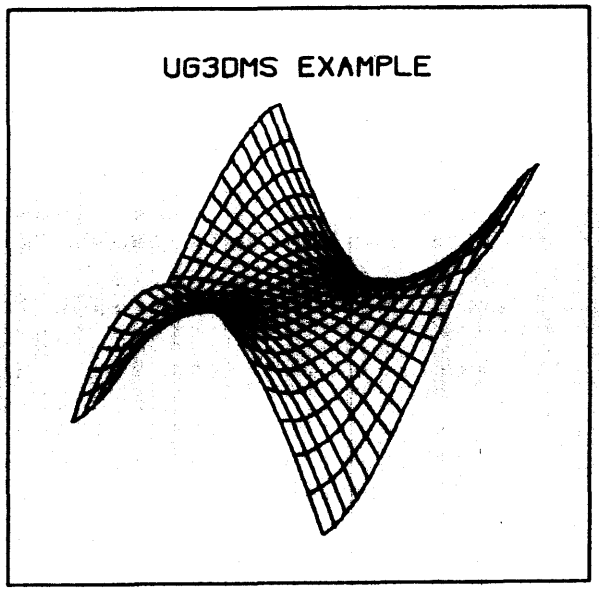
ELEMNT The graphic element which will have the description of the axis added to it.

The reader should refer to subroutine UGDXDY in the section on Miscellaneous Subroutines for help in assigning values to LOLAB, HILAB, and NLAB which results in "round numbers" being used for labels.

The errors detected by this subroutine are:

9(1): Not enough room was available in ELEMNT to contain the description of the axis. The element is unchanged.

SECTION 2.1.8: SUBROUTINE UG3DMS



This subroutine may be used to add the description of a perspective or orthogonal view of a three dimensional mesh surface with hidden lines eliminated to a graphic element. A mesh surface is a surface which is defined by giving the Z coordinates of points above a rectangular grid in the X-Y plane. The surface description is formed by joining adjacent points with straight lines. This subroutine adds the actual data to the graphic element by calling subroutine UGELIN. If UGELIN signals an error, then the graphic element is restored to the state that it was in when UG3DMS was called and UG3DMS then signals an error. The user should be warned that this subroutine can generate a large amount of data which it will try to add to the graphic element.

This subroutine does not solve the hidden line problem exactly. Instead, it produces an approximate solution. Under normal circumstances, it produces an acceptable picture with relatively fast execution speed. If the surface is very jagged, some line segments which should be eliminated may erroneously appear in the picture. This problem may usually be overcome by using a finer mesh. If the surface is very steep, some line segments which are visible may be erroneously eliminated. This second problem is accentuated by moving the eye position close to the surface in a perspective transformation. It can often be overcome by moving to a distant eye position or using an orthogonal transformation.

The calling sequence is:

```
CALL UG3DMS(OPTMS,LOPTMS,ARRAY,MDIM,NDIM,TRANS,
   WKAREA,LDIM,ELMNT)
```

The parameters in the calling sequence are:

OPTMS — A character string which may contain any of the following items:

- LOWER — Indicates that the under side of the surface is to be generated. Normally the upper side of the surface is generated. Two calls to this subroutine are necessary to generate the full view of a surface.
- NOCOMM — When both the upper and lower sides of the surface are produced, certain lines (for example, the front edge) will be duplicated. The programmer should use this option to suppress the common lines on either the upper or lower surface.

LOPTMS — An options list that will be passed to UGELIN.

ARRAY An array which contains the X, Y, and Z coordinates of the points on the surface. (REAL*4, DIMENSION=(MDIM,NDIM)). The format of ARRAY is:

```
--  X1   X2  ... XN
Y1  Z11  Z21 ... ZN1
Y2  Z12  Z22 ... ZN2
...          ...
YM  Z1M  Z2M ... ZNM
```

The sequences (X1, X1, ..., XN) and (Y1, Y2, ..., YM) must be monotonically increasing. The X's and Y's do not have to be equally spaced, but better pictures usually result if this is the case.

MDIM The first dimension of ARRAY (INTEGER*4).

NDIM The second dimension of ARRAY (INTEGER*4).

TRANS An array containing the transformation as produced by subroutine UGVIEW or UGORTH (REAL*4, DIMENSION=31). There are a few restrictions on the views which may be used here. First, the eye point must not be directly above the surface but must be off to one side; and second, the transformation must be defined with a zero vector for EDIE.

WKAREA An array which will be used as a work area (REAL*4, DIMENSION=LDIM). The amount of space that is needed in this array depends on many things including the view and the shape of the surface. A dimension of fifteen times the maximum dimension of ARRAY will be more than sufficient in most cases.

LDIM The dimension of WKAREA (INTEGER*4).

ELEMNT The graphic element which will have the description of the mesh surface added to it.

The errors detected by this subroutine are:

1(3): The array WKAREA is not large enough.

9(1): Not enough room was available in ELEMNT to contain the description of the mesh surface. The element is unchanged.

Algorithms of this nature have been described in the publications listed below. The algorithm used in UG3DMS is based on the information in [3,4].

1. B. Kubert, J. Szabo, and S. Giulieri, The Perspective Representation of Functions of Two Variables. Journal of the Association for Computing Machinery, Vol. 15, No. 2 (April 1968), pp. 193-204.
2. H. Williamson, Algorithm 420: Hidden-Line Plotting Program. Communications of the Association for Computing Machinery, Vol. 15, No. 2 (February 1972), pp. 100-103.
3. T. Wright, A Two-Space Solution to the Hidden Line Problem for Plotting Functions of Two Variables. National Center for Atmospheric Research, Boulder, Colorado 80302, Report No. NCAR 72-26 (March 1972).
4. J. Barlow and B. Franek, Graphic Representation of Functions of Two Variables. Rutherford High Energy Laboratory, Chilton, England, Report No. RHEL/R 259 (August 1972).
5. M. L. Prueitt, Fantastic Computer Pictures Give Us a

New Look at Numbers. Popular Science, Vol. 202, No. 2 (February 1973), pp. 102-105.

SECTION 2.1.9: SUBROUTINE UGEINV

On a very limited set of Display Devices, a graphic element may act as a subroutine. An element-subroutine will not be displayed except when it is invoked by another element. An element-subroutine may be invoked many times; in this way a sub-picture may appear on the screen many times while the orders to produce the sub-picture appear only once in the display file. Element-subroutines should be generated relative to an origin of (0.0,0.0). Element-subroutines may themselves invoke other element-subroutines and this nesting of invocations may be arbitrarily deep. This subroutine may be used to invoke an element-subroutine from another element.

The calling sequence is:

```
CALL UGEINV(OPTNS,X,Y,IDENT,ELEMNT)
```

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:

- SOLD,DASH,DDSH,DOTS Line structure specification.
- VDIM,DIMM,BRIT,VBRT Intensity levels.
- WINK,STDY Wink mode specification.
- COL1,COL2,COL3,COL4 Color codes.

The above specifications apply to the invoked element-subroutine unless the element-subroutine overrides this information. In addition, some display devices can accept the following:

- ANGLE=<value> The angle that the element-subroutine is to be rotated about when it is displayed. The default value is 0.0.
- SCALE=<value> The scaling factor for the element-subroutine when it is displayed. The default value is 1.0.

X — X coordinate of the relative origin of the element-subroutine (REAL*4).

Y — Y coordinate of the relative origin of the element-subroutine (REAL*4).

IDENT — The identification of the element-subroutine to be invoked (INTEGER*4).

ELEMNT — The graphic element which will have the invocation data added to it.

The errors detected by this subroutine are:

9(1): Not enough room was available in ELEMNT to contain the invocation data.

SECTION 2.1.10: SUBROUTINE UGEDTA

This subroutine may be used to add data to an element which is transmitted to the display device in unmodified form. At present, this data may be sent only to a limited set of display devices. This procedure has a very specialized purpose and its successful utilization cannot be accomplished with the information in this document.

The calling sequence is:

```
CALL UGEDTA(OPTNS,STRING,NSTR,ELEMNT)
```

The parameters in the calling sequence are:

OPTNS	A character string which may contain any of the following items: SOLD,DASH,DDSH,DOTS Line structure specification. VDIM,DIMM,BRIT,VBRT Intensity levels. WINK,STDY Wink mode specification. COL1,COL2,COL3,COL4 Color codes.
STRING	A character string containing the information to be added to the display element.
NSTR	The number of characters in STRING (INTEGER*4).
ELEMNT	The graphic element which will have the given information added to it.

The errors detected by this subroutine are:

1(2): The string STRING contained more than 255 characters.
9(1): Not enough room was available in ELEMNT to contain the given information.

SECTION 2.2: GRAPHIC DATA SET CONTROL

The subroutines in this section perform basic operations on a graphic device. Subroutine UGOPEN is used to open a graphic device, while UGCLOS is used to close it. UGSLCT can be used to select a device and make it the active graphic device. UGSCAL can be used to make changes to the default scaling and scissoring values. Finally UGINFO can be used to retrieve information about a graphic device.

SECTION 2.2.1: SUBROUTINE UGOPEN

This subroutine must be used to open a graphic device and make it ready for use. A graphic device must be opened before any use can be made of it. Opening a graphic device makes it the active device.

The calling sequence is:

```
CALL UGOPEN(OPTNS,IDENT)
```

The parameters in the calling sequence are:

OPTNS — A character string containing the graphic device type and any device dependent information which may be required. The device type may be given by one of the following specific items:

- CAL/10D — The 10 inch CALCOMP Drum Plotter.
- CAL/29D — The 29 inch CALCOMP Drum Plotter.
- CAL/6UM — The CALCOMP Microfilm Recorder with 16mm unsprocketed film.
- CAL/FCM — The CALCOMP Microfilm Recorder with Microfiche film.
- MYL4013 — MYLBUR Display Files for the TEKTRONIX 4013 are saved in a partitioned data set.
- DISKPDS — Graphic elements, in their device independent form, may be written to, or read from, a partitioned data set.
- IBM2250 — The IBM 2250 Display Console.
- GIF/IDI — The GIF-IDIION Display Console.
- TEK4013 — The TEKTRONIX 4013 Display Terminal. This item refers to the terminals which are under the control of the MILTEN Terminal Manager.

In addition to the specific selection of an output device, there are some generic names available. By using these names, the actual device is selected by a JCL statement instead of by the program. If one of the following items is used, then the options list must also contain the item DDNAME=<value>. Subroutine UGOPEN will find the internal record of the DD card whose name is given and determine the type of output device to be used.

- HDSCOPE — This item selects a refresh display scope: either an IBM 2250 or the GIF-IDIION.
- IDSCOPE — This item selects an interactive display scope: either an IBM 2250, the GIF-IDIION, or a TEKTRONIX 4013 running under MILTEN.

In addition to the items described above, there is another item whose purpose is to enable experimental systems for new devices to be checked-out without making any changes to the system.

- ISYSTEM=<value> — Where the value of this item is the name of the second level open module for the device.

The device dependent items are described in the sections on the specific graphic devices.

IDENT — A numeric value which is used to identify the graphic device being opened (INTEGER*4).

The errors detected by this subroutine are:

1(3): Duplicate or invalid identification.
2(3): Too many devices. Only four can be opened at once.

3(3): A valid device was not specified.
4(3): The DD card corresponding to the generic name cannot be found.
5(3): The DD card corresponding to the generic name does not give a valid device.
11(3): The data set cannot be opened. Check your DD cards.
12(3): Not enough display buffer space is available.

SECTION 2.2.2: SUBROUTINE UGCLOS

This subroutine must be used to terminate the use of a graphic device. No more use can be made of the graphic device until it is re-opened. If the device being closed is the active device and other devices remain open, then one of these open devices will become the active device.

The calling sequence is:
CALL UGCLOS(IDENT)

The parameter in the calling sequence is:
IDENT The identification of the device to be closed (INTEGER*4).

The errors detected by this subroutine are:
1(3): Identification is invalid, no such device is open.

SECTION 2.2.3: SUBROUTINE UGSLCT

This subroutine may be used to select any open graphic device and make it the active device. The programmer will not have to use this subroutine unless more than one graphic device is open concurrently.

The calling sequence is:
CALL UGSLCT(IDENT)

The parameter in the calling sequence is:
IDENT The identification of the device which is to become the active device (INTEGER*4).

The errors detected by this subroutine are:
1(3): The identification is invalid; no such device is open.

SECTION 2.2.4: SUBROUTINE UGSCAL

This subroutine may be used to retrieve or change the scaling and/or scissoring parameters of the active graphic device. The default values for a device are given in the sections devoted to

specific devices. More information and some examples on how these values may be used is found in the section on the Scaling and Scissoring Sub-System.

The calling sequence is:
CALL UGSCAL(OPTNS,PRCGLN,DEVCLN)

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:
- GET,PUT — Flags to indicate if the limits are to be retrieved or changed.
- PROGL — A flag to indicate that the programmer limits are to be retrieved or changed.
- DEVCL — A flag to indicate that the device limits are to be retrieved or changed.

PROGLN — An array for the programmer scaling limits (REAL*4, DIMENSION=(2,2)).

DEVCLN — An array for the device scaling limits (INTEGER*4, DIMENSION=(2,2)).

The errors detected by this subroutine are:
1(3): No device is active.
2(3): The new values are not valid.

SECTION 2.2.5: SUBROUTINE UGINFO

This subroutine may be used to determine the active device type, its identification, and certain device dependent items of information about the use of the device. This latter information is described in the sections covering the specific devices and can be useful in optimizing the use of a device.

The calling sequence is:
CALL UGINFO(STRING,IDENT,ARRAY)

The parameters in the calling sequence are:

STRING — A character string, eight characters long, which will be set to contain the specific device identifications described in subroutine UGOPEN.

IDENT — This will be set to the identification of the device (INTEGER*4).

ARRAY — This array will be set to the device dependent information (INTEGER*4, DIMENSION=5).

The errors detected by this subroutine are:
1(3): No device is active.

SECTION 2.3: DISPLAY DEVICE CONTROL

This section describes those subroutines that are directly related to controlling the picture and the graphic device itself. Subroutine UGEPUT will transmit a graphic element to a display device. Subroutine UGPICT gives the programmer control over the picture. Subroutine UGCTRL allows the programmer to control the display device itself. Finally, subroutine UGEGET may be used to retrieve pictures from a partitioned data set.

For some interactive devices, the programmer may give a numeric identification to an element when it is transmitted. This identification may then be used to manipulate the element at a later time. For instance an element may have its light pen detectability status changed, or the element may be deleted from a picture.

For most display devices it is more efficient to create a picture from a small number of large graphic elements than from a large number of small elements. This is especially true on interactive devices which allow element manipulation. When individual elements are deleted from a picture, it is more efficient to delete them in reverse order from the way they were added to the picture.

Some interactive displays can be turned on and off. This can be useful to prevent a partial picture from flashing on the screen while a display is being changed. Some displays also allow an individual element to be temporarily turned off. Such an element is said to be in the "omit" state (as opposed to the "include" state).

SECTION 2.3.1: SUBROUTINE UGEPUT

This subroutine may be used to transmit a previously constructed graphic element to a display device. When an element is transmitted to a display device, it is first translated to device-dependent orders, and then added to the display file of the device. After a graphic element has been transmitted to a display device, the programmer may re-use the array containing the graphic element.

The calling sequence is:

```
CALL UGEPUT(OPTNS,IDENT,ELEMNT)
```

The parameters in the calling sequence are:

- OPTNS — A character string which may contain any of the following items:
  - DETC — Make the element light pen detectable.
  - OMIT — Leave the element in the omit state.
  - NCMP — Send non-compact orders to the device.
  - ON,OFF — Leave the display in the "on" or "off" state.
  - RTTC — Position the graphic element relative to

the tracking pattern. Elements positioned relative to the tracking pattern are not scissored.

ESUB The element is to become an element-subroutine and will not be displayed except when it is invoked by another element. Default values of intensity levels, wink mode, color code, and line structure are not provided for the data within the element-subroutines. These values are set by the invoking element. Element-subroutines are not scissored.

MINESIZ=<value> The device-dependent form of the graphic element is expanded until its length is at least as great as the given value.

IDENT A numeric value which may be used to identify the element. A zero value means that the element is unidentified. If a display allows elements to be identified, then transmitting two elements with the same identification will cause the second to replace the first (INTEGER*4).

ELEMNT The graphic element which is to be transmitted.

The errors detected by this subroutine are:

1(3): No device is active.
11(2): The element is too large for the device dependent element buffer.
12(2): There is not enough room in the display file for this element.
13(2): The maximum element count has been exceeded.
99(2): This subroutine is not supported for the active device.

SECTION 2.3.2: SUBROUTINE UGPICT

This subroutine may be used to control the picture on a display device. On some display devices, individual elements may be manipulated or deleted. Multiple operations may be performed in one call to this subroutine as long as the operations are not contradictory.

The calling sequence is:

```
CALL UGPICT(OPTNS,IDENT)
```

The parameters in the calling sequence are:

OPTNS A character string which may contain any of the following items:

CLEAR If IDENT is zero, the entire display is cleared, otherwise the specific element is deleted.

DETC,NDET Change light pen detectable status of an element.

OMIT,INCL Change omit-include status of an element.

ON,OFF Turn the display on or off.
ALIAS=<value> If the display is being cleared to start a new picture and the output device allows pictures to be named, then this item may supply an alias for the name.

IDENT If a specific element is being manipulated, then this should give its identification (INTEGER*4).

The errors detected by this subroutine are:
1(3): No device is active.
99(2): This subroutine is not supported for the active device.

SECTION 2.3.3: SUBROUTINE UGCTRL

This subroutine may be used to perform a number of special operations on a display device. Multiple operations may be performed in one call to this subroutine as long as the operations are not contradictory.

The calling sequence is:
CALL UGCTRL(OPTNS,IARRAY,XARRAY)

The parameters in the calling sequence are:
OPTNS A character string which may contain any of the following items:
BEEP Sound the audible alarm on the display device.
FRAM The value in IARRAY(1) gives the number of regeneration cycles that should be performed before issuing a FRAM attention (if the attention is enabled).
LITES=<value> The value should be a bit string which specifies which of the lights on the function keyboard are to be turned on. A one bit causes the corresponding light to be turned on and a zero bit causes it to be turned off.
TPPUT Put the tracking pattern on the display device. The X and Y coordinates of the initial position of the tracking pattern in the programmer coordinate system must be given in XARRAY(1) and XARRAY(2).
TPGET Get the current position of the tracking pattern. The X and Y coordinates of the current position of the tracking pattern in the programmer coordinate system will be put into XARRAY(1) and XARRAY(2); the coordinates in the device coordinate system are put into IARRAY(1) and IARRAY(2). If the tracking pattern is not on the screen, then IARRAY(1) and IARRAY(2) are set to minus one.
TPRMV Remove the tracking pattern from the

display device.

TPIAC Put the display device into the inactive mode with respect to light pen input buffers. This mode is the default status for light pen input buffers.

TPDRW Put the display device into the draw mode with respect to light pen input buffers and set the segment length from IARRAY(1). In this mode the display console operator can draw freehand curves on the screen with the light pen. The segment length value is given in programmer units and specifies the approximate length of the line segments which form the curve.

TPERS Put the display device into the erase mode with respect to light pen input buffers. In this mode, the display console operator can use the light pen to erase parts of the curves which were created in the draw mode.

TPCTL This is a special item which allows a tracking pattern to be put on the screen, positioned by the console operator, and its coordinates returned to the program. The coordinates are returned in the manner that they are for the TPGET item.

ESON Put the display device into a mode where it will check for element-subroutines.

ESOFF Put the display device into a mode where it will ignore element-subroutines. This mode is the default status for element-subroutines.

ESTRC If the LPEN attention has been enabled with the OFF option, then an element-subroutine trace back of the light penned item may be obtained if it is requested before the display is restarted. The element-subroutine trace back will appear in IARRAY and will have the following form: The first word is the number of levels in the invocation trace back (if the light penned item is not within an element-subroutine, then this value is zero). The next two words contain the identification of the highest level element during the invoking and the byte offset of the invocation within the element. The next two words are for the next level of invocation, etc. Up to four levels of invocation may be reported; additional levels are lost.

SHOPEN Open the shutter on the synchronized movie camera.

SHCLOS Close the shutter on the synchronized movie camera.

IARRAY An input and output array that is used when certain

items are given in OPTNS (INTEGER*4, DIMENSION=10).

XARRAY An input and output array that is used when certain items are given in OPTNS (REAL*4, DIMENSION=2).

WARNING...The arguments IARRAY and XARRAY must be dimensioned at least 10 and 2 respectively, even if you are not supplying information in the arrays and do not expect to receive any information in them.

The errors detected by this subroutine are:

1(3): No device is active.

99(2): This subroutine is not supported for the active device.

SECTION 2.3.4: SUBROUTINE UGEGET

This subroutine may be used to retrieve an element from a partitioned data set. The element should have been written into the partitioned data set by using UGEPUT with a device type of DISKPDS. This subroutine is usable only when the active device type is DISKPDS with the INPUT option.

The calling sequence is:

```
CALL UGEGET(OPTNS,ELEMNT,ELTSIZ)
```

The parameters in the calling sequence are:

OPTNS A character string which may contain any of the following items:

NAME=<value> When this item is given, the element that will be read is the first element in the partitioned data set member with the given name. If this item is not given, the element that will be read is the next element in the partitioned data set member that was previously accessed.

ELEMNT The array which will have the graphic element stored into it. The graphic element is ready to be transmitted to any graphic device; however if additional display information is to be added to the graphic element, then subroutine UGEINT should be called with the RESET option before the new information is added to the element.

ELTSIZ The number of words in ELEMNT (INTEGER*4).

The errors detected by this subroutine are:

1(3): No device is active.

11(1): End of Picture...No more elements are available in the partitioned data set member.

12(3): No partitioned data set member with the given name is available.

13(3): The graphic element that you are trying to read is larger than the array ELEMNT.

99(2): This subroutine is not supported for the active device.

SECTION 2.4: ATTENTION CONTROL

This section describes subroutines which allow the programmer to control attentions from an interactive display device. It is by means of these subroutines that the programmer synchronizes the execution of the program with the actions of the console operator. Subroutine UGEATN may be used to enable attentions from a control unit (such as the light pen) on a display device. Subroutine UGDATN may be used to disable attentions from a control unit. When an attention is generated by an enabled control unit it is saved on an attention queue; an attention from a disabled unit is not saved. Finally, subroutine UGRATN may be used to check to see if an attention has occurred and optionally wait until one has occurred.

Attentions are enabled or disabled by specifying an attention code to the appropriate subroutine. When an attention is reported, this code as well as other useful information is made available to the program. This information is inserted into attention data arrays which must have the following declarations:

```
INTEGER*4   ATCODE
INTEGER*4   IARRAY(5)
REAL*4      XARRAY(2)
```

The following list gives (1) the valid attention codes (4 characters returned in ATCODE), (2) the contents of IARRAY(1), and (3) a description of the attention and the contents (if any) of the rest of IARRAY and XARRAY.

NONE 0 This is not an attention code but is a possible return value from UGRATN when no attention is available to report.

KBRD 1 An attention generated by a special key on the keyboard which is reserved for this use.

LPEN 2 This occurs when the light pen is pointed at a detectable graphic element and the light pen switch is closed. IARRAY(2) gives the identification of the element, IARRAY(3) gives the byte offset of the item in the element that was pointed to, IARRAY(4) and IARRAY(5) give the X and Y coordinates of the item pointed to in the device coordinate system while XARRAY(1) and XARRAY(2) give the coordinates in the programmer coordinate system in effect when the attention is reported.

FRAM 3 This attention is generated after a specified number of display regeneration cycles.

PFKM 4 Program Function Keyboard Make. IARRAY(2) gives the button number which caused the attention and IARRAY(3) will contain a one if the button had its light on or a zero if its light was off.

PFKB 5 Program Function Keyboard Break. IARRAY(2) and IARRAY(3) are the same as for PFKM.

PFLM 6 The same as PFKM except that the attention is reported only if the button's light is on.

PFLB 7 The same as PFKB except that the attention is reported only if the button's light is on.

LPSM 8 Light Pen Switch Make.

LPSB 9 Light Pen Switch Break.

When an attention is enabled on some devices, the programmer may specify the disposition of the display after the attention has occurred. Normally the display will keep on running, however subroutine UGEATN will accept OFF in its option list to indicate that the display device is to be turned off when the attention occurs.

SECTION 2.4.1: SUBROUTINE UGEATN

This subroutine may be used to enable attentions from an interactive display device. When an enabled attention is generated by a device, a record of it is put on the attention queue for that device.

The calling sequence is:
CALL UGEATN(OPTNS)

The parameter in the calling sequence is:
OPTNS A character string which may contain OFF and any of the attention codes.

The errors detected by this subroutine are:
1(3): No device is active.
99(2): This subroutine is not supported for the active device.

SECTION 2.4.2: SUBROUTINE UGDATN

This subroutine may be used to disable attentions from an interactive display device.

The calling sequence is:
CALL UGDATN(OPTNS)

The parameter in the calling sequence is:
OPTNS A character string which may contain any of the attention codes.

The errors detected by this subroutine are:
1(3): No device is active.
99(2): This subroutine is not supported for the active device.

SECTION 2.4.3: SUBROUTINE UGRATN

This subroutine may be used to retrieve an attention record from the attention queue of an interactive display device. When this subroutine is called and the queue is empty, there are a number of possible options for the programmer to specify. These options are (1) UGRATN may return immediately, (2) it may wait for an indefinite length of time for an attention, or (3) it may wait for a specified length of time and return when the time interval runs out or when an attention occurs.

The calling sequence is:

```
CALL UGRATN(TIME,ATCODE,IARRAY,XARRAY)
```

The parameters in the calling sequence are:

TIME	A zero or positive value indicates the wait time (in seconds) for this subroutine. On return, TIME contains the unexpired time. If TIME has a negative value the subroutine will wait indefinitely (REAL*4). Note that if TIME has a positive value when this subroutine is called, its value will be changed. Therefore, in this case, the programmer should use a variable and not a constant for TIME.
ATCODE	Four characters of information which specify the type of attention (INTEGER*4).
IARRAY	Attention data (INTEGER*4, DIMENSION=5).
XARRAY	Attention data (REAL*4, DIMENSION=2).

The errors detected by this subroutine are:

1(3): No device is active.
99(3): This subroutine is not supported for the active device.

SECTION 2.5: KEYBOARD INPUT BUFFER CONTROL

A "Keyboard Input Buffer" is a special kind of text element which may be displayed on an interactive display and modified by the console operator. When a keyboard input buffer is displayed, a cursor will appear in it. The console operator may type on the keyboard to insert characters into the buffer at the position marked by the cursor. Subroutine UGKPUT will put a keyboard input buffer on an interactive device and subroutine UGKGET will read the input buffer from the device. Keyboard input buffers are not scissored; it is the programmer's responsibility to see that they fit on the screen.

If the interactive device allows an element to be manipulated, then a keyboard input buffer may also be identified and manipulated. Its identification should be different from that of any other keyboard input buffer or graphic element.

On some devices, multiple keyboard input buffers are permitted. In this case there will be a key on the keyboard to move the

cursor from one keyboard input buffer to another so that the console operator can enter or change information in any keyboard input buffer.

SECTION 2.5.1: SUBROUTINE UGKPUT

This subroutine may be used to display a keyboard input buffer.

The calling sequence is:

```
CALL UGKPUT(OPTNS,X,Y,IDENT,STRING,NSTR)
```

The parameters in the calling sequence are:

- OPTNS — A character string which may contain any of the following items:
  - VSML,SMAL,LARG,VLRG — Character size.
  - VDIM,DIMM,BRIT,VBRT — Intensity levels.
  - COL1,COL2,COL3,COL4 — Color codes.
  - LCASE — On some devices, the console operator may type either upper or lower case characters. By default, all lower case characters are translated to upper case when the keyboard input buffer is read. However the programmer may specify LCASE if this translation is not wanted.
- X — X coordinate of the center of the first character (REAL*4).
- Y — Y coordinate of the center of the first character (REAL*4).
- IDENT — The identification of the keyboard input buffer (INTEGER*4).
- STRING — A character string which contains the initial values for the keyboard input buffer. This may be a string of blanks.
- NSTR — The number of characters in STRING (INTEGER*4).

The errors detected by this subroutine are:

- 1(3): No device is active.
- 11(2): STRING is longer that 256 characters.
- 12(2): There is not enough room in the display file for the buffer.
- 13(2): The maximum element count has been exceeded.
- 99(2): This subroutine is not supported for the active device.

SECTION 2.5.2: SUBROUTINE UGKGET

This subroutine may be used to read a keyboard input buffer from a display device.

The calling sequence is:

```
CALL UGKGET(IDENT,STRING,NSTR,NSTR,ICUR)
```

The parameters in the calling sequence are:

IDENT The identification of the keyboard input buffer to be read (INTEGER*4).

STRING A character string which will have the keyboard input buffer placed in it.

MSTR The maximum number of characters which can be placed in STRING (INTEGER*4).

NSTR The number of characters actually placed in STRING (INTEGER*4).

ICUR If the keyboard input buffer being read contains the cursor, then this is the index of the character containing the cursor; otherwise it is zero (INTEGER*4).

The errors detected by this subroutine are:

1(3): No device is active.

11(2): There is no keyboard input buffer with the given identification.

12(2): There is not enough room in STRING for the keyboard input buffer.

99(2): This subroutine is not supported for the active device.

SECTION 2.6: LIGHT PEN INPUT BUFFER CONTROL

A "Light Pen Input Buffer" is a special kind of element which may be displayed on some interactive devices and modified by the console operator. When a light pen input buffer is in the display file, the console operator may use the light pen to draw free-hand curves on the screen and erase parts of the curves that have been drawn. Subroutine UGLPUT will add a light pen input buffer to the display file and subroutine UGLGET will read the input buffer from the device. The identification of a light pen input buffer must be different from that of any other graphic element.

The only graphic device at SLAC which can accept light pen input buffers is the GIF-IDIION Display Console.

SECTION 2.6.1: SUBROUTINE UGLPUT

This subroutine may be used to add a light pen drawing buffer to a display file.

The calling sequence is:

```
CALL UGLPUT(OPTNS,IDENT,LENGTH)
```

The parameters in the calling sequence are:

OPTNS A character string which may contain any of the following items:

SOLD,DASH,DDSH,DOTS Line structure specification.
VDIM,DIMM,MBIT,VBRT Intensity levels.
COL1,COL2,CCL3,COL4 Color codes.

IDENT The identification of the light pen input buffer (INTEGER*4).

LENGTH The length (in bytes) of the light pen input buffer (INTEGER*4).

The errors detected by this subroutine are:

1(3): No device is active.
11(2): The element is too large for the device dependent element buffer.
12(2): There is not enough room in the display file for this element.
13(2): The maximum element count has been exceeded.
99(2): This subroutine is not supported for the active device.

SECTION 2.6.1: SUBROUTINE UGLGET

This subroutine may be used to read a light pen input buffer from a display device. The data from the screen is made available in a form that is almost the same as that required by subroutine UGBLNS.

The calling sequence is:

```
CALL UGLGET(IDENT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
```

The parameters in the calling sequence are:

IDENT The identification of the light pen input buffer to be read (INTEGER*4).

NSIZE The number of available entries in XARRAY, YARRAY, and BBITS (INTEGER*4).

XARRAY An array where the X coordinates of the end points of the line segments will be stored (REAL*4, DIMENSION=NSIZE).

YARRAY An array where the Y coordinates of the end points of the line segments will be stored (REAL*4, DIMENSION=NSIZE).

NPTS The number of end points that were stored in XARRAY and YARRAY (INTEGER*4).

BBITS An array where the blankings bits will be stored with 32 bits per word (INTEGER*4, DIMENSION=(NSIZE-31)/32).

The errors detected by this subroutine are:

1(3): No device is active.
11(2): There is no light pen input buffer with the given identification.
12(2): There is not enough room in XARRAY, YARRAY, and BBITS for the light pen data.
99(2): This subroutine is not supported for the active device.

SECTION 2.7: MISCELLANEOUS SUBROUTINES

This section contains the descriptions of subroutines which do not properly fit into any of the earlier sections.

SECTION 2.7.1: SUBROUTINE UGDXDY

This subroutine is an aid in using the subroutine UGAXIS which was described in the section on Graphic Element Generation. Consider the following problem: suppose the extent of the data in one direction can only be determined at execution time and suppose that the program has determined that the data extends from 2.637 to 7.913. Usually the programmer does not want these values to label the axis but would prefer "round numbers" to label the axis. In this case, for instance, it is preferable to have the axis run from 2.00 to 8.00 with 7 labeled tic marks, or perhaps from 2.50 to 8.00 with 12 labeled tic marks. This subroutine accepts as its input the extent of the data and limits on the number of labeled tic marks and produces values for the parameters LOLAB, HILAB, and NLAB in subroutine UGAXIS which assures that all labeled tic marks are labeled with "round numbers".

The calling sequence is:

```
CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)
```

The parameters in the calling sequence are:

LODATA	The low extent of the data (REAL*4).
HIDATA	The high extent of the data (REAL*4).
MINLAB	The minimum acceptable number of labeled tic marks (INTEGER*4).
MAXLAB	The maximum acceptable number of labeled tic marks (INTEGER*4).
LOLAB	A computed value which will be LODATA reduced to a "round number" (REAL*4).
HILAB	A computed value which will be HIDATA increased to a "round number" (REAL*4).
NLAB	A computed value which will make all of the labels "round numbers" (INTEGER*4).

No error messages are produced by this subroutine.

Algorithms of this nature have been described in the publications listed below. The algorithm used in UGDXDY is a modification of the one described in [2].

1. T. Gianno, A Mathematical Method for the Automatic Scaling of a Function. Journal of the Association for Computing Machinery, Vol. 11, No. 1 (January 1964), pp. 79-83.
2. W. J. Dixon and R. A. Kronmal, The Choice of Origin and Scale for Graphs. Journal of the Association for Computing Machinery, Vol. 12, No. 2 (April 1965), pp. 259-261.
3. C. R. Lewart, Algorithm 463: Algorithms SCALE1, SCALE2,

and SCALE3 for Determination of Scales on Computer Generated Plots. Communications of the Association for Computing Machinery, Vol. 16, No. 10 (October 1973), pp. 639-640.

SECTION 2.7.2: SUBROUTINE UGVIEW

This subroutine may be used to define a projective transformation from three space into two space. The transformation may be used with subroutine UGPROJ to project a point in three dimensional space into the programmer coordinate system. The meaning of the input to this subroutine is illustrated in Figure 2.7.1. First a reference point, REFP, and a view direction, VDIR, are given. The reference point may be thought of as a point on the forehead of a person and the view direction as the direction in which the person is looking. Along the view direction, at a distance of SCRD, is a projection screen. This screen is a square with a side length of SCRZ and its horizontal axis is defined by the vector HDIR. Finally an eye point, E, is defined by moving a distance EYED from REFP in the direction of HDIR. The transformation takes a point P in three dimensional space and projects it by means of a straight line from E through P onto the screen to define the point Q. The point Q is the projective transform of P and its coordinates are (t,u).

The calling sequence is:

```
CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
```

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:

- EYED=<value> A parameter which is useful in making stereo pairs; a positive value will produce a right eye transformation and a negative value produces a left eye transformation. The default value is 0.0.
- XLO=<value> The X coordinate at the left hand side of the screen. The default value is 0.0.
- XHI=<value> The X coordinate at the right hand side of the screen. The default value is 1.0.
- YLO=<value> The Y coordinate at the bottom of the screen. The default value is 0.0.
- YHI=<value> The Y coordinate at the top of the screen. The default value is 1.0.

REFP — The projective reference point (REAL*4, DIMENSION=3).

VDIR — The view direction (REAL*4, DIMENSION=3).

HDIR — The horizontal direction of the projection screen (REAL*4, DIMENSION=3). If this vector is given as (0.0,0.0,0.0), then a vector parallel to the X-Y plane will be supplied.

SCRD — The distance from REFP to the screen (REAL*4).

SCRZ The size of the screen (REAL*4).
TRANS An array which will be set to the projective transformation (REAL*4, DIMENSION=31). This array will contain a 3 by 4 projection matrix as well as the given projective parameters.

No error messages are produced by this subroutine.

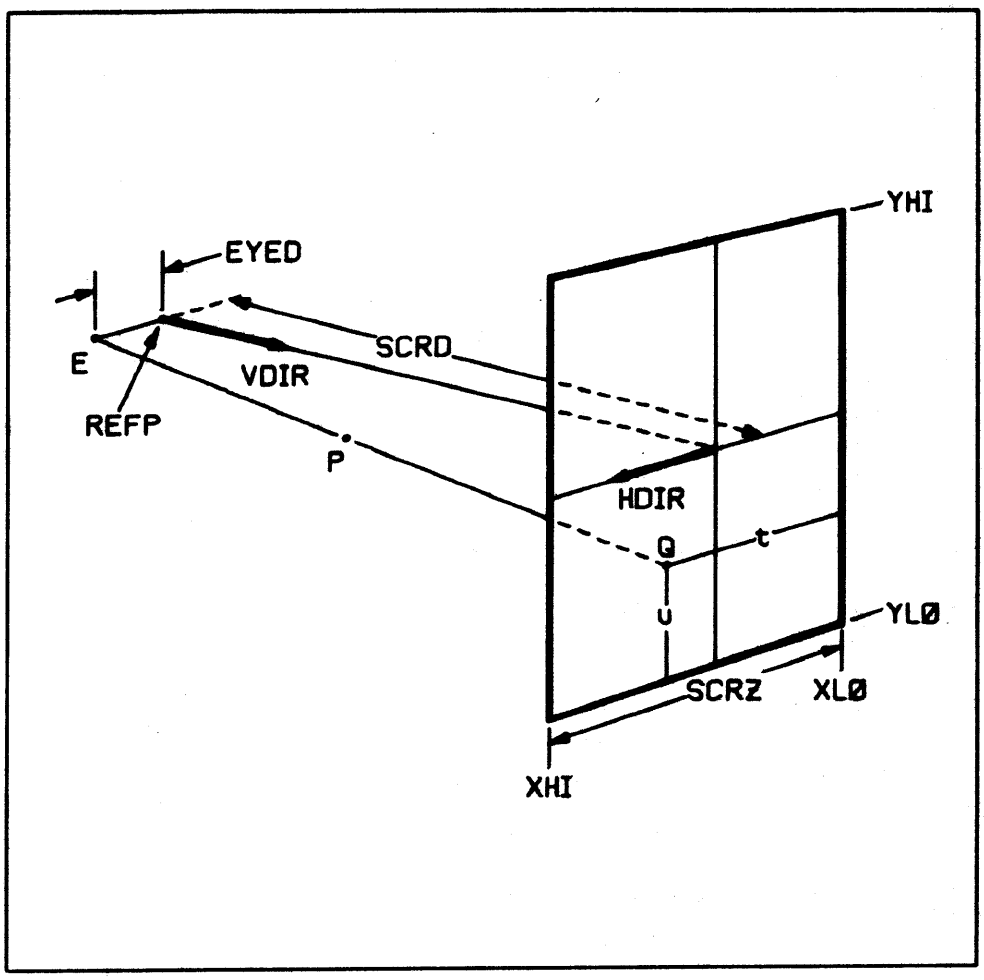


Figure 2.7.1: The definition of a Projective Transformation.

SECTION 2.7.3: SUBROUTINE UGORTH

This subroutine may be used to define an orthogonal transformation from three space into two space. The transformation may be used with subroutine UGPROJ to project a point in three dimensional space into the programmer coordinate system. The meaning of the input to this subroutine is essentially the same as for UGVIEW. The basic difference is that the point P is projected onto the screen parallel to the vector VDIR. The user will notice that the position of REFP is not critical, it may be moved along VDIR without changing the transformation. Also the value of SCRD is completely redundant.

Nevertheless, the programmer should supply reasonable values for these parameters because this information is saved in TRANS and is utilized by certain other subroutines.

The calling sequence is:

```
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
```

The parameters in the calling sequence are:

OPTNS — A character string which may contain any of the following items:

- XLO=<value> The X coordinate at the left hand side of the screen. The default value is 0.0.
- XHI=<value> The X coordinate at the right hand side of the screen. The default value is 1.0.
- YLO=<value> The Y coordinate at the bottom of the screen. The default value is 0.0.
- YHI=<value> The Y coordinate at the top of the screen. The default value is 1.0.

REFP — The orthogonal reference point (REAL*4, DIMENSION=3).

VDIR — The view direction (REAL*4, DIMENSION=3).

HDIR — The horizontal direction of the projection screen (REAL*4, DIMENSION=3). If this vector is given as (0.0,0.0,0.0), then a vector parallel to the X-Y plane will be supplied.

SCRD — The distance from REFP to the screen (REAL*4).

SCRZ — The size of the screen (REAL*4).

TRANS — An array which will be set to the orthogonal transformation (REAL*4, DIMENSION=31). This array will contain a 3 by 4 projection matrix as well as the given orthogonal parameters.

No error messages are produced by this subroutine.

SECTION 2.7.4: SUBROUTINE UGPROJ

This subroutine uses a transformation defined by subroutine UGVIEW or UGORTH to project a three dimensional point into two dimensions.

The calling sequence is:

```
CALL UGPROJ(TRANS,PT3D,PT2D)
```

The parameters in the calling sequence are:

TRANS — An array containing the transformation (REAL*4, DIMENSION=31).

PT3D — The coordinates of the given three dimensional point (REAL*4, DIMENSION=3).

PT2D — The projected point (REAL*4, DIMENSION=2).

No error messages are produced by this subroutine.

SECTION 2.7.5: SUBROUTINE UGCTOL

This subroutine will accept a character string as input, invoke the character stroke generator, and supply the resulting line segments and blanking bits as output. The line segments are made available in a form that is almost the same as that required by subroutine UGSLNS. Before passing these line segments on to UGSLNS, the programmer may transform them in any manner. One simple thing a programmer could do is create italic lettering.

The calling sequence is:

```
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
```

The parameters in the calling sequence are:

- **OPTNS** A character string which may contain any of the following items:
  - X=<value> The X coordinate of the center of the first character. The default value is 0.0.
  - Y=<value> The Y coordinate of the center of the first character. The default value is 0.0.
  - SPACING=<value> The character spacing value which will be used to develop the strokes. The default value is 0.01367.
  - ANGLE=<value> The angle that the characters will make with the horizontal. The default value is 0.0.
- **TEXT** The string containing the characters to be converted to line segments.
- **NTEXT** The number of characters in TEXT (INTEGER*4).
- **NSIZE** The number of available entries in XARRAY, YARRAY, and BBITS (INTEGER*4).
- **XARRAY** An array where the X coordinates of the end points of the line segments will be stored (REAL*4, DIMENSION=NSIZE).
- **YARRAY** An array where the Y coordinates of the end points of the line segments will be stored (REAL*4, DIMENSION=NSIZE).
- **NPTS** The number of end points that were stored in XARRAY and YARRAY (INTEGER*4).
- **BBITS** An array where the blankings bits will be stored with 32 bits per word (INTEGER*4, DIMENSION=(NSIZE+31)/32).

The errors detected by this subroutine are:

1(2): The string TEXT contained more than 255 characters.
2(2): There is not enough room in XARRAY, YARRAY, and BBITS for the line segment data.

SECTION 2.7.6: SUBROUTINE UGBDIV

This subroutine may be used to divide a previously generated element into two smaller elements. The primary purpose of this subroutine is to divide elements that have been retrieved by

subroutine UGEGET from a partitioned data set. Such an element may be too large for display on a given display device. This subroutine operates by first trying to divide the element at a boundry between different types of display data. Thus if an element contains line data followed by point data, the first divided element will contain only points and the second will contain only lines. If the original element contains only one type of data, then an attempt will be made to divide that data into two parts. Only point, line, and character data can be divided in this latter manner.

The calling sequence is:

```
CALL UGEDIV(ELMNT1,ELMNT2)
```

The parameters in the calling sequence are:

ELMNT1 An array which contains the original element on input, and the first part of the divided element on output.

ELMNT2 An array which will contain the second part of the divided element on output. On input, this array must have been cleared by subroutine UGEINT. In certain cases this array will have to be almost as large as the graphic element in ELMNT1 although it usually need only be about half as large.

The errors detected by this subroutine are:

1(3): The given element could not be divided.

There are two program libraries that the programmer must be aware of. One contains modules which must be made available to the LINK-EDITOR/LOADER, and the other contains modules which must be made available at execution time.

The first of these program libraries is WYL.CG.RCB.UGPLIB. In this library are all of the subroutines that have been described in addition to some second level subroutines that the programmer does not normally need. If the LINK-EDITOR is used, this data set should be concatenated with the SYSLIB data sets in the LKED step. If the LOADER is used, then it should be concatenated with the SYSLIB data sets in the GO step. The modules in this data set are essentially device independent.

The second program library is WYL.CG.RCB.UGXLIB. This library must be made available either to the job in a JOBLIB statement, or to the GO step in a STEPLIB statement. The modules in this library are loaded dynamically and contain most of the device dependent code.

The programmer may use the LINK-EDITOR to create overlay structures. Any of the modules in this package may be overlaid with one exception. This exception is that the module named UGX000 must always be in the root segment.

This section contains some examples of complete programs which use the SLAC Unified Graphics System. These examples include the complete JCL that is required to run the programs.

SECTION 4.1: PLOTTING A MESH SURFACE

This program produces a perspective view of a mesh surface on the CALCOMP Drum Plotter. The program, with its comments, is relatively self-explanatory except for two items. First, the extended character stroke generator with upper and lower case capability is used; this is described in the section on the Character Stroke Generating Sub-System. Second, an error processing subroutine is used; this is described in the section on the Error Processing Sub-System. Without this error processing subroutine, the array ELEMNT would have to be approximately seven times larger than its present size.

```
//uuuMSURF JOB 'uuu$gg',CLASS=B
//         EXEC FORTGCLG,
//              LKEDLB1='WYL.CG.RCB.UGFLIB',
//              GOSL1='WYL.CG.RCB.UGXLIB'
//FORT.SYSIN   DD *
C  SAMPLE PROGRAM:  PLOTTING A MESH SURFACE
C
      REAL*4      REFP(3)/50.0,75.0,40.0/
      REAL*4      VDIR(3)/-50.0,-75.0,-30.0/
      REAL*4      HDIR(3)/0.0,0.0,0.0/
      REAL*4      TRANS(31)
      REAL*4      ARRAY(32,52)
      REAL*4      WKAREA(780)
      COMMON      ELEMNT(1000)
      INTEGER*4   C20(5)
      REAL*4      X,Y,R
      INTEGER*4   I,J
C
C  INITIALIZE THE PROGRAM:  OPEN THE GRAPHIC DEVICE AND
C  ASSURE THAT A FRESH PLOTTING AREA IS AVAILABLE, FILL
C  IN THE ARRAY WHICH DEFINES THE SURFACE, AND GENERATE
C  THE PROJECTIVE TRANSFORMATION.
      CALL UGOPEN('CAL/10D*',99)
      CALL UGPICT('CLEAR*',0)
      DO 102 I=2,52
        X=I-27
        ARRAY(1,I)=X
        DO 101 J=2,32
```

```
            Y=J-17
            ARRAY(J,1)=Y
            R=SQRT(X**2+Y**2)
            ARRAY(J,I)=((750.0/(R**2+75.0))+5.0)*COS(0.4*R)
  101    CONTINUE
  102 CONTINUE
      CALL SGVIEW('*',REFP,VDIR,HDIR,100.0,75.0,TRANS)
C
C  CREATE THE PICTURE:  THE GRAPHIC ELEMENT IS CLEARED,
C  A BORDER IS ADDED TO THE ELEMENT, A TITLE IS ADDED,
C  THE SURFACE ITSELF IS ADDED TO THE ELEMENT, AND
C  FINALLY THE GRAPHIC ELEMENT IS TRANSMITTED TO THE
C  GRAPHIC DEVICE.
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGELIN('*',0.0,0.0,0,ELEMNT)
      CALL UGELIN('*',1.0,0.0,1,ELEMNT)
      CALL UGELIN('*',1.0,1.0,1,ELEMNT)
      CALL UGELIN('*',0.0,1.0,1,ELEMNT)
      CALL UGELIN('*',0.0,0.0,1,ELEMNT)
      CALL UGPTOX('MESH SURFACE EXAMPLE',
     X            ' LLL  LLLLLL  LLLLLL',C20,20)
      CALL UGETXT('SPACING=0.04*',0.2,0.8,C20,20,ELEMNT)
      CALL UG3DMS('UPPER*','*',ARRAY,32,52,TRANS,
     X  WKARRA,780,ELEMNT)
      CALL UG3DMS('LOWER,NOCONN*','*',ARRAY,32,52,TRANS,
     X  WKARRA,780,ELEMNT)
      CALL UGEPUT('*',0,ELEMNT)
C
C  TERMINATE THE PROGRAM:  THE GRAPHIC DEVICE IS CLOSED
C  AND THE PROGRAM RETURNS TO THE SYSTEM.
      CALL UGCLOS(99)
      RETURN
C
      END
C  ERROR PROCESSING SUBROUTINE
C
      SUBROUTINE UGXERR(LEVEL,NAME,INDEX)
C
      INTEGER*4  LEVEL,NAME(2),INDEX
      COMMON     ELEMNT(1000)
C
C  IF THE ERROR IS AN INDICATION THAT NO MORE SPACE IS
C  AVAILABLE IN THE GRAPHIC ELEMENT THEN THE CURRENT
C  CONTENTS OF THE ELEMENT ARE TRANSMITTED TO THE
C  GRAPHIC DEVICE, THE ELEMENT IS RE-INITIALIZED, AND
C  THE ERROR INDICATOR IS RE-SET.
      IF (INDEX.NE.9) GO TO 101
      CALL UGEPUT('*',0,ELEMNT)
      CALL UGEINT('CONTINUE*',ELEMNT,1000)
      LEVEL=0
  101 CONTINUE
      RETURN
C
      END
//LKED.SYSIN   DD *
        INCLUDE SYSLIB(UGX103A)
//GO.PLOTTAPE  DD DSNAME=&&PLOT,DISP=(NEW,PASS),
```

```
//          VOLUME=SER=PLOTAP,UNIT=T7,LABEL=(1,NL),
//          DCB=(RECFM=U,BLKSIZE=3000,DEN=0)
//
```

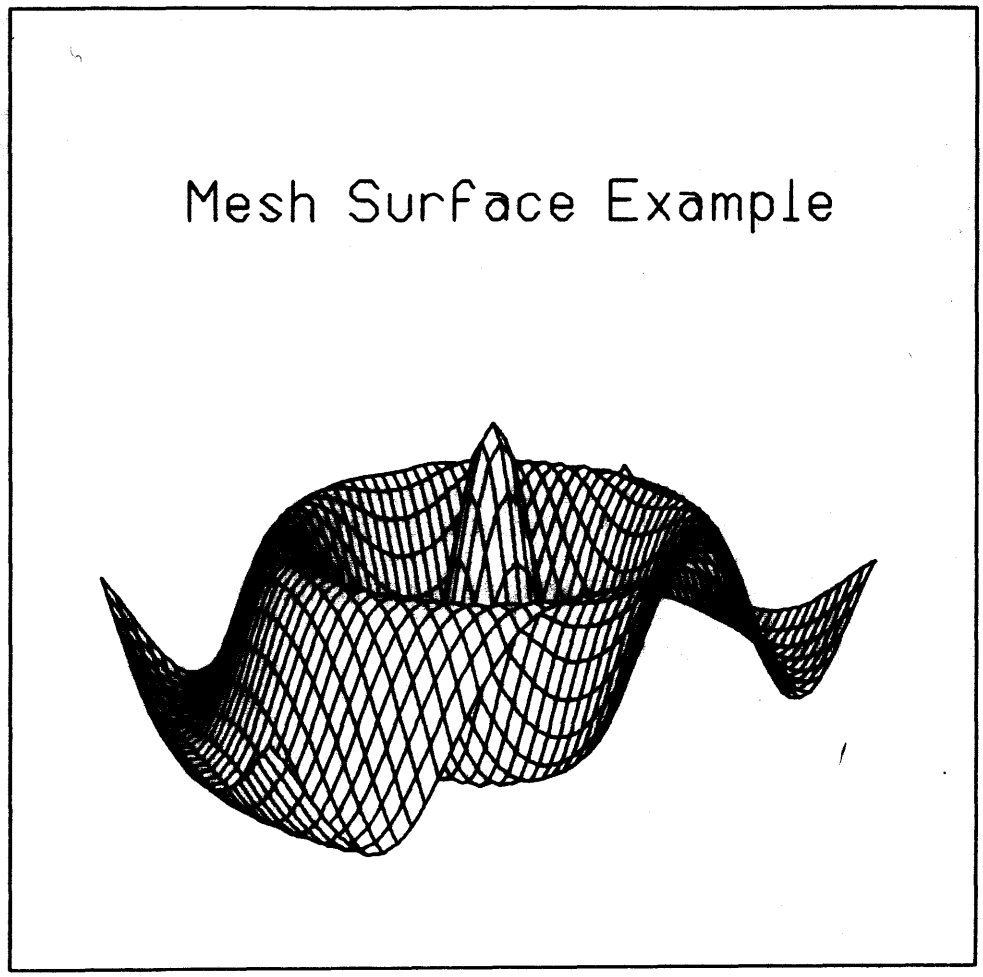


Figure 4.1.1: The Mesh Surface.

SECTION 4.2: INTERACTIVE LISSAJOUS FIGURES

This program is an interactive program which runs on the IBM 2250 Display Console. The first picture which appears on the screen contains some descriptive material, a keyboard input buffer, and a light pen message to terminate the program. The console operator may use the light pen to terminate the program or he may modify the curve parameters in the keyboard input buffer and generate a keyboard attention. After a keyboard attention is generated, a second picture will appear on the screen. The second picture contains the graph of the figure and two light pen messages. The console operator may use the light pen to delete the coordinate axes in the picture or he may return to the first picture.

Notice that this program always causes the display to be turned off when an attention occurs and never turns the display back on until a complete picture is available. This results in two desirable features. First, the picture will not flicker on the screen while elements are being changed. Second, the appearance of a picture signals the console operator that the program is waiting for him.

This program illustrates an important principle which should be followed in writing interactive programs: it is especially important that interactive programs do not terminate abnormally because the console operator has made a minor error. In this program, for instance, it is very difficult for the console operator to enter information into the keyboard input buffer which is invalid or which will cause an undetected conversion error.

```
//uuuLSAJF JOB 'uuu$gg',CLASS=O
//         EXEC FORTGCG,
//              LKEDLB1='WYL.CG.RCB.UGFLIB',
//              GOSL1='WYL.CG.RCB.UGXLIB'
//FORT.SYSIN    DD *
C  SAMPLE PROGRAM:  INTERACTIVE LISSAJOUS FIGURES
C
      EXTERNAL    ERRSUB
      COMMON      ERRFLG
      INTEGER*4   ERRFLG
      REAL*8      ERR215
C
      INTEGER*4   LPEN/'LPEN'/
      INTEGER*4   ATCODE,IARRAY(5)
      REAL*4      XARRAY(2)
      INTEGER*4   PARMS(5)
      INTEGER*4   ELEMNT(1000)
      INTEGER*4   BBIT
      REAL*4      A,T,X,Y
      INTEGER*4   M,N,MAX,MT,NT,I,J
C
C  INITIALIZE THE PROGRAM:  OPEN THE GRAPHIC DEVICE, STOP
C  THE DISPLAY, ENABLE THE LIGHT PEN, GENERATE THE TITLE,
C  ESTABLISH INTERNAL I/O BUFFER (WITH LIBRARY SUBROUTINE
C  FIO999), AND INITIALIZE THE LISSAJOUS FIGURE PARAMETERS.
      CALL UGOPEN('IBM2250*',99)
      CALL UGPICT('OFF*',0)
      CALL UGEATN('LPEN,OFF*')
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGETXT('LARG*',0.244,0.97,
     X  'LISSAJOUS FIGURE GENERATOR',26,ELEMNT)
      CALL UGELIN('*',0.0,0.05,0,ELEMNT)
      CALL UGELIN('*',1.0,0.05,1,ELEMNT)
      CALL UGEPUT('*',0,ELEMNT)
      CALL FIO999(90,PARMS,5,5)
  101 M=2
      N=3
      A=0.25
C
```

```
C  PUT PARAMETER REQUEST ON THE SCREEN:  THE DISPLAY
C  CONSISTS OF A DESCRIPTION OF THE LISSAJOUS FIGURES, A
C  KEYBOARD INPUT BUFFER FOR ENTERING THE PARAMETERS, AND
C  A LIGHT PEN MESSAGE FOR TERMINATING THE PROGRAM.
  102 CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGETXT('SMAL*',0.199,0.7,
     X  'THE EQUATION OF A LISSAJOUS FIGURE IS:',38,ELEMNT)
      CALL UGETXT('SMAL*',0.269,0.68,
     X  'X=COS(2*PI*(M*T/N+A))',21,ELEMNT)
      CALL UGETXT('SMAL*',0.269,0.66,
     X  'Y=COS(2*PI*T)',13,ELEMNT)
      CALL UGETXT('SMAL*',0.199,0.5,
     X  'YOU MAY NOW CHANGE THE PARAMETERS M, N, AND A',45,
     X  ELEMNT)
      CALL UGETXT('SMAL*',0.199,0.48,
     X  'AND GENERATE A KEYBOARD ATTENTION; OR YOU MAY',45,
     X  ELEMNT)
      CALL UGETXT('SMAL*',0.199,0.46,
     X  'LIGHT PEN THE TERMINATE MESSAGE TO QUIT.',40,
     X  ELEMNT)
      CALL UGEPUT('*',10,ELEMNT)
      WRITE(90,109) M,N,A
      CALL UGKPUT('SMAL*',0.371,0.3,11,PARMS,20)
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGETXT('SMAL*',0.7,0.025,'TERMINATE',9,ELEMNT)
      CALL UGEPUT('ON,DETC*',1,ELEMNT)
C
C  PROCESS OPERATOR ACTION:  THE KEYBOARD IS ENABLED AND
C  THE PROGRAM WAITS FOR AN ATTENTION.  WHEN AN ATTENTION
C  IS RECEIVED, THE KEYBOARD IS DISABLED.  A LIGHT PEN
C  ATTENTION CAUSES THE PROGRAM TO TERMINATE.  A KEYBOARD
C  ATTENTION CAUSES THE INPUT BUFFER TO BE READ, THE
C  PICTURE TO BE CLEARED, AND THE INPUT BUFFER TO BE
C  CONVERTED TO NUMERICS AND CHECKED.  THE EXTENDED ERROR
C  HANDLER IS USED TO CHECK FOR CONVERSION ERRORS.
      CALL UGEATN('KEBD,OFF*')
      CALL UGRATN(-1.0,ATCODE,IARRAY,XARRAY)
      CALL UGDATN('KEBD*')
      IF (ATCODE.EQ.LPEN) GO TO 108
      CALL UGKGET(11,PARMS,20,I,J)
      CALL UGPICT('CLEAR*',1)
      CALL UGPICT('CLEAR*',11)
      CALL UGPICT('CLEAR*',10)
      CALL ERRSAV(215,ERR215)
      CALL ERRSET(215,256,-1,1,ERRSUB)
      ERRFLG=0
      READ(90,109) M,N,A
      CALL ERRSTR(215,ERR215)
      IF (ERRFLG.NE.0) GO TO 101
      IF ((M.LE.0).OR.(N.LE.0)) GO TO 101
C
C  CREATE THE LISSAJOUS FIGURE:  THE FIGURE IS GENERATED
C  BY LETTING THE PARAMETER T RUN FROM ZERO TO (N DIVIDED
C  BY THE GREATEST COMMON DIVISOR OF M AND N).  THEN A
C  HORIZONTAL AND VERTICAL AXIS AND TWO LIGHT PEN
C  MESSAGES ARE ADDED TO THE PICTURE.
      MT=M
```

```
      NT=N
  103 IF (NT.LE.NT) GO TO 104
      I=NT
      NT=NT
      NT=I
  104 I=NT/NT
      NT=NT-NT*I
      IF (NT.NE.0) GO TO 103
      MAX=N/NT
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      BBIT=0
      DO 105 I=1,401
        T=FLOAT((I-1)*MAX)/400.0
        X=COS(6.2831853*(((M*T)/N)+A))
        Y=COS(6.2831853*T)
        CALL UGELIN('*',0.4*X+0.5,0.4*Y+0.5,BBIT,ELEMNT)
        BBIT=1
  105 CONTINUE
      CALL UGEPUT('*',10,ELEMNT)
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGAXIS('HORZ,NSTH=4*','*','SMAL*',0.5,0.1,0.9,
     X  -1.0,1.0,5,ELEMNT)
      CALL UGAXIS('VERT,NSTH=4*','*','SMAL*',0.5,0.1,0.9,
     X  -1.0,1.0,5,ELEMNT)
      CALL UGEPUT('*',11,ELEMNT)
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGETXT('SMAL*',0.2,0.025,'NEW FIGURE',10,ELEMNT)
      CALL UGEPUT('DETC*',1,ELEMNT)
      CALL UGEINT('CLEAR*',ELEMNT,1000)
      CALL UGETXT('SMAL*',0.7,0.025,'DELETE AXES',11,ELEMNT)
      CALL UGEPUT('CM,DETC*',2,ELEMNT)
C
C  PROCESS OPERATOR ACTION:  THE PROGRAM WAITS FOR AN
C  ATTENTION.  A LIGHT PEN DETECT ON THE 'DELETE AXES'
C  MESSAGE CAUSES THE AXES ONLY TO BE DELETED, OTHERWISE
C  THE ENTIRE PICTURE IS DELETED AND THE FIRST DISPLAY IS
C  RESTORED.
  106 CALL UGRATM(-1.0,ATCODE,IARRAY,XARRAY)
      CALL UGPICT('CLEAR*',2)
      CALL UGPICT('CLEAR*',11)
      IF (IARRAY(2).NE.2) GO TO 107
      CALL UGPICT('CM*',0)
      GO TO 106
  107 CALL UGPICT('CLEAR*',1)
      CALL UGPICT('CLEAR*',10)
      GO TO 102
C
C  TERMINATE THE PROGRAM:  THE GRAPHIC DEVICE IS CLOSED
C  AND THE PROGRAM RETURNS TO THE SYSTEM.
  108 CALL UGCLOS(99)
      RETURN
  109 FORMAT(2I5,F10.4)
C
      END
C  THIS SUBROUTINE IS USED BY THE EXTENDED ERROR HANDLER TO
C  SIGNAL CONVERSION ERRORS TO THE MAIN PROGRAM.
C
```

```
      SUBROUTINE ERRSUB(IRETCD,INO)
C
      INTEGER*4  IRETCD,INO
      COMMON     ERRFLG
      INTEGER*4  ERRFLG
C
      ERRFLG=1
      IRETCD=0
      RETURN
C
      END
//GO.SCOPE50   DD UNIT=0D1
//
```

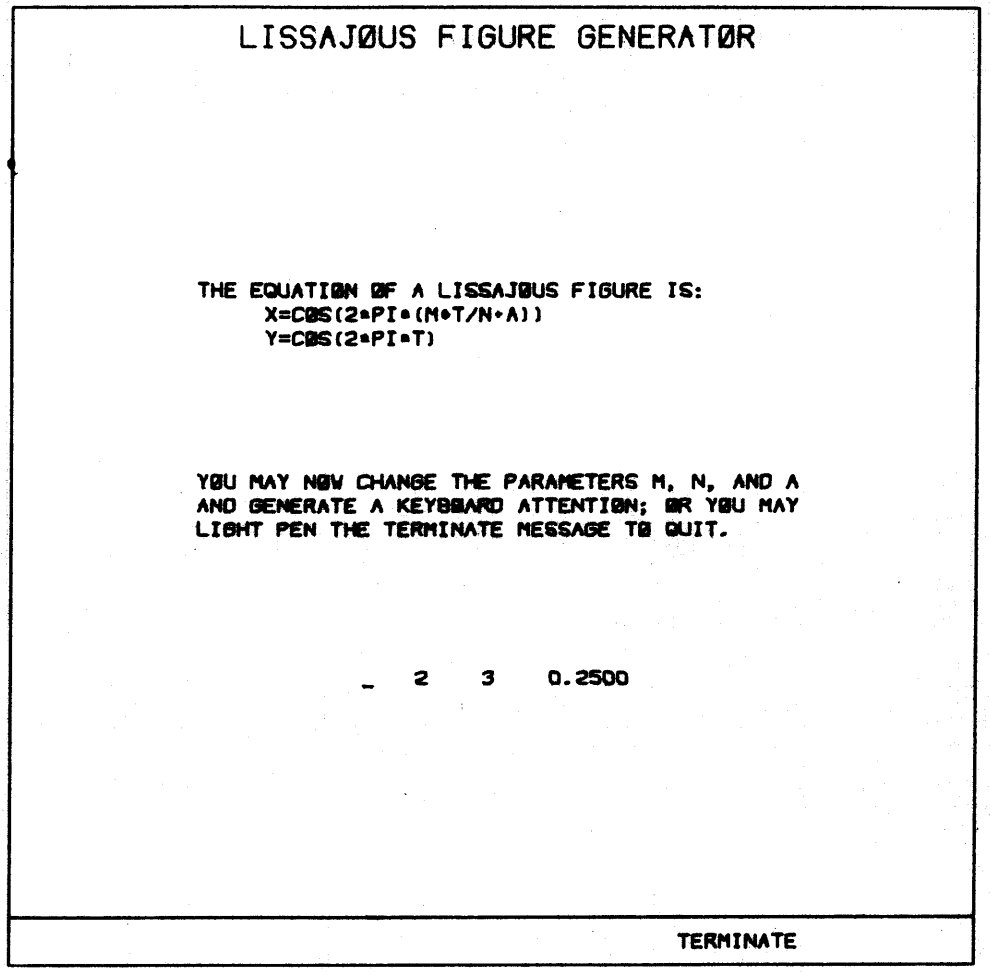


Figure 4.2.1: The first picture showing suggested parameters.

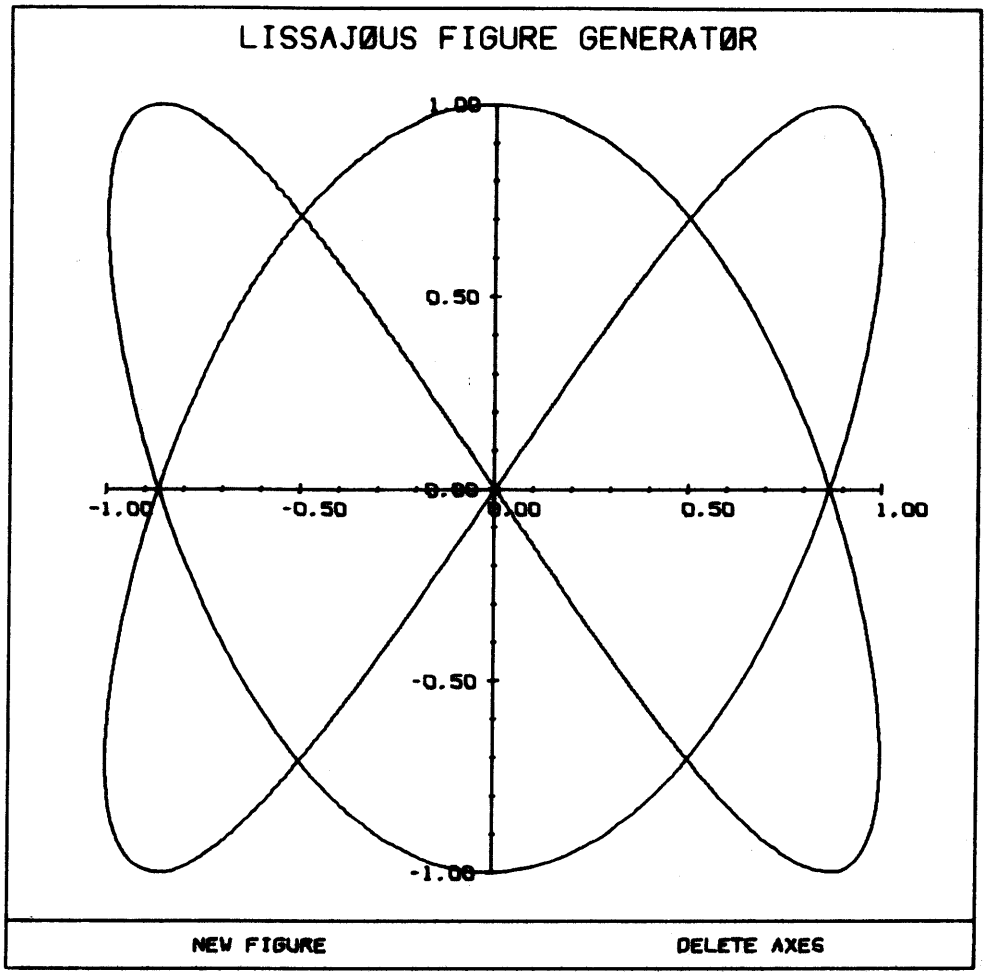


Figure 4.2.2: The second picture when suggested parameters are used.

This section gives a detailed description of each of the non-interactive devices that are supported by this system. For each device there is a description of the hardware including its features and limitations, and a review of the capabilities of each subroutine as it applies to the device. In particular the valid and default items in the OPTNS list for each subroutine are given.

SECTION A.1: THE CALCOMP DRUM PLOTTERS (MODELS 564/565)

The CALCOMP Drum Plotters are off-line electro-mechanical plotting devices. A program which produces pictures for a CALCOMP Drum Plotter will write plotting commands on a 7-track magnetic tape. This tape is then mounted on a CALCOMP plotter which reads the commands on the tape and draws the pictures.

Two different CALCOMP units are available. The first draws on paper that is 10 inches wide (the Y direction) and essentially unlimited in length (the X direction). The pen is moved incrementally in the X and Y directions in steps of 0.01 inches. The second plotter differs in that the paper is 29 inches wide and its step size is 0.005 inches. These devices do not have a built-in character generator.

Special attention should be given to the construction of a graphic element if it is to be transmitted to a CALCOMP Drum Plotter. The reason is that this device is quite slow; a complicated picture can require hours of plotting time. Therefore the programmer should try to minimize pen motion. Operations such as moving from the lower left section of a picture to the upper right, drawing a few lines, and then moving back to the lower left should clearly be avoided.

A DD card is necessary at execution time to define the output data set (normally a tape). A typical DD card is:

```
//PLOTTAPE DD DSNAME=&&PLOT,DISP=(NEW,PASS),
//            VOLUME=SER=PLOTAP,UNIT=T7,LABEL=(1,NL),
//            DCB=(RECFM=U,BLKSIZE=3000,DEN=0)
```

The ddname, PLOTTAPE in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN. The BLKSIZE parameter in the DCB must be at least 256; a value around 3000 is suggested.

The subroutines which may be used with this device are:

CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)

When an element is transmitted to this device, all intensity level, wink mode, and color information is ignored. All lines are of the SOLD type. Since the device has no character generator, only that text with the XSPACING or SPACING options will appear in the picture.

CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DMS(OPTNS,LOPTNS,ARRAY,MDIM,NDIM,TRANS,
WKAREA,LDIM,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)

The valid items in OPTNS are:

CAL/10D Specifies the 10 inch plotter.

CAL/29D Specifies the 29 inch plotter.

DDNAME=<value> The ddname of the output tape. The default value is PLOTTAPE.

TITLE=<value> A character string of at most 16 characters which will be used to identify the output. Characters 1-8 and 10-16 are used to prepare an initial plot to identify the output. The default is a title composed of the job name and output bin number. The programmer should not normally change the default value.

CALL UGCLOS(IDENT)
CALL UGSLCT(IDENT)
CALL UGSCAL(OPTNS,PROGLM,DEVCLM)

The default values for the programmer and device limits for the 10 inch plotter are:

```
[ 0.0   1.0 ]        [ 0   1000 ]
[ 0.0   1.0 ]        [ 0   1000 ]
```

Those for the 29 inch plotter are:

```
[ 0.0   1.0 ]        [ 0   5800 ]
[ 0.0   1.0 ]        [ 0   5800 ]
```

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2)...ARRAY(5) Zero.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

For this device, the contents of both OPTNS and IDENT are ignored.

CALL UGPICT(OPTNS,IDENT)

The only valid item in options is CLEAR. The contents of IDENT is ignored and assumed to be zero. This clearing operation causes the pen to move over to a fresh plotting area where the programmer may begin another picture. There will be about ten

inches of blank paper between pictures.

```
CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)
CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
CALL UGRDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,RC,NSTR)
CALL UGXTOP(CPP,CPS,RC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)
```

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGCALD02 and their description is:

N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION A.2: THE CALCOMP MICROFILM PLOTTER (MODEL 1675)

The CALCOMP Microfilm Plotter at SLAC is a device with a 5 inch, flat-faced, CRT. This CRT is photographed by a camera which can contain either 16mm unsprocketed film or 105mm Microfiche film. Pictures may be transmitted to the device off-line by writing the pictures on a magnetic tape and mounting the tape on the device, or on-line by transmitting the pictures directly over a channel.

This unit can display points, lines and characters. The manufacturer claims that 30 intensity levels are possible, but these cannot normally be distinguished by the eye and only four intensity levels are supported by this system. The character generator can produce horizontal characters of a single size. The following table gives the between character spacing and suggested between lines spacing assuming the default programmer coordinate system.

Character Size	Character Spacing	Line Spacing	Characters per Line	Lines per Display
SMAL	0.00916	0.01500	109	66

When the FULSCR option is used in procedure UGOPEN, then 132 characters will fit on a single line. The LARGSCR option results in additional characters per line and lines per display being available.

A DD card is necessary at execution time to define the output data set. A typical DD card for off-line operation is:

```
//PLOTDATA DD DSNAME=&&PLOT,DISP=(NEW,PASS),
//            VOLUME=SER=uuuuuu,UNIT=T9-1600,LABEL=(1,SL),
//            DCB=(RECFM=F,LRECL=1500,BLKSIZE=1500,DEN=3)
```

On-line operation is not yet possible at SLAC. The ddname, PLOTDATA in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN.

Microfiche contains 63 pictures per fiche arranged in 7 rows and 9 columns. These pictures are ordered by columns; the first picture is at the upper right, the second picture is below it, etc.

The subroutines which may be used with this device are:

CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)

When an element is transmitted to this device, all wink mode and color information is ignored. Intensity levels of VDIM, DIMM, BRIT, and VBRT will be correctly processed. All lines are of the SOLD type. Horizontal text with the VSML, SMAL, LARG, or VLRG options will be produced by the character generator.

CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DNS(OPTNS,LOPTNS,ARRAY,MDIM,NDIM,TRANS,
NKAREA,LDIM,ELEMNT)
CALL UGEDTA(OPTNS,STRING,NSTR,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)

The valid items in OPTNS are:

CAL/6UM Specifies 16mm Unsprocketed Film.

CAL/PCM Specifies Microfiche Film.

DDNAME=<value> The ddname of the output data set. The default value is PLOTDATA.

FULSCR, LARGSCR Flags which specify the size of the image on the output. For 16mm the default is a square picture which is the correct size for viewing on SLAC's microfilm viewers. FULSCR means that the full rectangular area visible with the viewer may be used. LARGSCR means that the largest possible square picture will be produced. Finally, FULSCR and LARGSCR together give the maximum rectangular plotting area on the film. For microfiche, the default is a square picture and FULSCR produces the larger rectangular plotting area.

LEADER=<value> The number of frames of leader which will be put at the beginning and end of film output. The default value is 20. The programmer should not normally change the default value.

TITLE=<value> A character string of at most 24 characters which will be used to identify the output.

These 24 characters will appear at the top of each microfiche and part of them (characters 1-8 and 10-16) is used in the leader for film output. The default is a title composed of the job name and output bin number. The programmer should not normally change the default value.

CALL UGCLOS(IDENT)

CALL UGSLCT(IDENT)

CALL UGSCAL(OPTNS,PROGLN,DEVCLN)

The default values for the programmer and device limits for 16mm unsprocketed film are:

```
┌                 ┐   ┌                 ┐
│ 0.0   1.0 │       │ 4260   12123 │
│ 0.0   1.0 │       │ 4260   12123 │
└                 ┘   └                 ┘
```

When FULSCR is used, the values are:

```
┌                       ┐ ┌                 ┐
│ -0.10429   1.10429 │ │ 3440   12943 │
│  0.0       1.0     │ │ 4260   12123 │
└                       ┘ └                 ┘
```

When LARGSCR is used, the values are:

```
┌                 ┐   ┌                 ┐
│ 0.0   1.0 │       │ 2785   13598 │
│ 0.0   1.0 │       │ 2785   13598 │
└                 ┘   └                 ┘
```

When FULSCR and LARGSCR are used, the values are:

```
┌                       ┐ ┌                 ┐
│  0.0       1.0     │ │ 2785   13598 │
│ -0.09868   1.09868 │ │ 1638   14581 │
└                       ┘ └                 ┘
```

The default values for the programmer and device limits for microfiche film are:

```
┌                 ┐   ┌                 ┐
│ 0.0   1.0 │       │ 4260   12123 │
│ 0.0   1.0 │       │ 4260   12123 │
└                 ┘   └                 ┘
```

When FULSCR is used, the values are:

```
┌                       ┐ ┌                 ┐
│ -0.10429   1.10429 │ │ 3440   12943 │
│  0.0       1.0     │ │ 4260   12123 │
└                       ┘ └                 ┘
```

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2)...ARRAY(5) Zero.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

For this device, the contents of both OPTNS and IDENT are ignored.

CALL UGPICT(OPTNS,IDENT)

The only valid item in options is CLEAR. The contents of IDENT is ignored and assumed to be zero. This clearing operation causes the film to advance.

CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)

CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)

```
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOI(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,NBITS)
CALL UGEDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,RC,NSTR)
CALL UGXTOP(CPP,CPS,RC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)
```

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGCALM02 and their description is:

N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION A.3: WYLBUR DISPLAY FILES FOR THE TEKTRONIX 4013

The TEKTRONIX 4013 is an interactive storage display terminal with an eight inch wide by six inch high screen. This section describes a method of using this device in an essentially non-interactive way in conjunction with the SLAC/WYLBUR Text Editing System.

To use the TEKTRONIX 4013 in this manner, the programmer runs a job which uses this device sub-system. That job will write its pictures into a card image partitioned data set with each picture as a separate member. The user may then sign onto WYLBUR from a TEKTRONIX 4013 terminal and issue a 'USE' command to obtain a member of the data set as the active file. The WYLBUR command 'LIST UNNUMBERED CLEAN' will then cause the screen to be cleared and the picture drawn. The audible alarm will sound when the picture is complete.

These units can display points, lines, and characters at a single intensity level. The character generator can produce horizontal characters of a single size. The following table gives the between character spacing and suggested between lines spacing assuming the default programmer coordinate system.

Character Size	Character Spacing	Line Spacing	Characters per Line	Lines per Display
SMAL	0.01797	0.02824	56	35

When the FULSCR option is used in subroutine UGOPEN, then 74 characters will fit on a single line.

A DD card is necessary at execution time to define the output data set. A typical DD card is:

```
//WYLXPICT DD DSNAME=WYL.gg.uuu.name,DISP=(NEW,KEEP),
//            VOLUME=SER=WYL001,UNIT=2314,SPACE=(TRK,(5,1,3)),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=1600)
```

The ddname, WYLXPICT in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN. The BLKSIZE parameter in the DCB can be any multiple of 80.

The members of the output data set contain information in card images with at most 72 characters per card. The first card contains a title identifying it as a WYLBUR display file, a clear screen command, and some idle characters. The second card contains only idle characters. The picture itself starts on the third card. If you are displaying the pictures on a dial-up terminal (300 baud) you may delete the second card before listing the file. If you are using a hard-wired terminal (1200 baud) you will need the extra time supplied by the additional idles in the second card for the screen to fully clear.

The subroutines which may be used with this device are:

CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,EBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)

When an element is transmitted to this device, all intensity level, wink mode, and color information (with one exception) is ignored. The exception is that points with the DIMM or VDIM option are plotted as a single raster point while all other points are plotted as four raster points. All lines are of the SOLD type. Horizontal text with the VSML, SMAL, LARG, or VLRG options will be produced by the character generator.

CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DMS(OPTNS,LOPTNS,ARRAY,NDIM,NDIM,TRANS,
WKAREA,LDIM,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)

The valid items in OPTNS are:

- WYL4013 Specifies that WYLBUR Display Files for the TEKTRONIX 4013 are to be produced.
- DDNAME=<value> The ddname of the partitioned data set. The default value is WYLXPICT.
- PICTID=<value> The first four characters of the member names in the PDS. If the given value is less than four characters long, it is padded on the right with zeros. The default value is PICT.
- PICTSQ=<value> An integer which will be converted to three numeric digits and concatenated to the PICTID value to form the complete member name in the PDS. This value is incremented after each picture. The default value is 1.
- FULSCR A flag which specifies that the picture is to be

scissored at the screen boundaries and not at a square area within the screen.

If the full member name of the picture is the same as a pre-existing member of the data set, then the member is replaced; otherwise the new member is added to the data set. The disk space occupied by replaced members is not made available for re-use until the data set is compressed. UGPICT may be used to supply an alias for the name of a member.

CALL UGCLOS(IDENT)
CALL UGSLCT(IDENT)
CALL UGSCAL(OPTNS,PROGLM,DEVCLM)

The default values for the programmer and device limits are:

```
[ 0.0   1.0 ]        [ 122   901 ]
[ 0.0   1.0 ]        [   0   779 ]
```

The default values when FULSCR is used are:

```
[ -0.15661   1.15661 ] [ 0   1023 ]
[  0.0       1.0     ] [ 0    779 ]
```

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2)...ARRAY(4) Zero.

ARRAY(5) The number of card images which have been produced.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

For this device, the contents of both OPTNS and IDENT are ignored.

CALL UGPICT(OPTNS,IDENT)

The only valid items in OPTNS are CLEAR and ALIAS. The contents of IDENT is ignored and assumed to be zero. This clearing operation causes a new picture to be started.

CALL UGDXDY(LODATA,HIDATA,MINIAB,MAXIAB,LOLAB,HIIAB,NLAB)
CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
CALL UGEDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,EC,NSTR)
CALL UGXTOP(CPP,CPS,EC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGNYLX02 and their description is:

0(4): Not enough directory blocks are available in the output data set.

N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION A.4: SAVING PICTURES IN A PARTITIONED DATA SET

This section does not describe a display device but instead describes a method by which pictures may be saved in a partitioned data set. The graphic elements are written into the PDS without modification. A method is provided to read the graphic elements from the PDS. A program which makes use of this feature will appear the same as a program which prepares pictures for any non-interactive display device; only the call to UGOPEN will be different.

Each graphic element will be a separate record in the output data set and each picture will be a separate member. In addition, the programmer scaling and scissoring units are saved in the data set when the first element is written. Therefore, under most circumstances, the programmer should create the pictures so that they all depend on the same scaling limits and these limits should be set by UGSCAL before the first element is saved in the data set.

To read a data set written in this manner, the programmer should open the data set with the INPUT flag and use UGEGET to obtain the graphic elements. When the first graphic element of a picutre is read, the programmer scaling and scissoring limits are also read. The programmer may then use UGSCAL to retrieve these limits.

A DD card is necessary at execution time to define the output data set. A typical DD card is:

```
//PICTURES DD DSNAME=WYL.qq.uuu.name,DISP=(NEW,KEEP),
//            VOLUME=SER=WYL001,UNIT=2314,SPACE=(TRK,(5,1,3)),
//            DCB=(RECFM=U,BLKSIZE=4000)
```

The ddname, PICTURES in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN. The BLKSIZE parameter in the DCB must be at least as large as the largest graphic element which will be written into the data set. Remember that the BLKSIZE value is in bytes while graphic element length is declared in words.

The subroutines which may be used with this device are:

```
CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)
```

When an element is transmitted, all intensity level, wink mode,

color, character size, and line structure information is transmitted without modification.

CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
LOLAB,HILAB,NLAB,ELEMNT)

CALL UG3DMS(OPTNS,LOPTNS,ARRAY,MDIM,NDIM,TRANS,
WKAREA,LDIM,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)

The valid items in OPTNS are:

DISKPDS Specifies that the pictures are to be saved or retrieved from a partitioned data set in un-modified form.

DDNAME=<value> The ddname of the partitioned data set. The default value is PICTURES.

PICTID=<value> The first four characters of the member names in the PDS. If the given value is less than four characters long, it is padded on the right with zeros. The default value is PICT.

PICTSQ=<value> An integer which will be converted to three numeric digits and concatenated to the PICTID value to form the complete member name in the PDS. This value is incremented after each picture. The default value is 1.

INPUT A flag which specifies that the partitioned data set is to be read. The default is to open the data set for output.

If the full member name of the picture is the same as a pre-existing member of the data set, then the member is replaced; otherwise the new member is added to the data set. The disk space occupied by replaced members is not made available for re-use until the data set is compressed. UGPICT may be used to supply an alias for the name of a member.

CALL UGCLOS(IDENT)

CALL UGSLCT(IDENT)

CALL UGSCAL(OPTNS,PROGIN,DEVCLM)

The default values for the programmer and device limits are:

$$\begin{bmatrix} 0.0 & 1.0 \\ 0.0 & 1.0 \end{bmatrix} \qquad \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$$

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2)...ARRAY(5) Zero.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

For this device, the contents of both OPTNS and IDENT are ignored.

CALL UGPICT(OPTNS,IDENT)

The only valid items in OPTNS are CLEAR and ALIAS. The contents of IDENT is ignored and assumed to be zero. This clearing operation causes a new picture to be started.

CALL UGEGET(OPTNS,ELEMNT,ELTSIZ)

CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)

CALL UGVIEW(OPTNS,REFP,VDIR,NDIR,SCRD,SCRZ,TRANS)

```
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
CALL UGEDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,EC,NSTR)
CALL UGXTOP(CPP,CPS,EC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)
```

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGDPDS02 and their description is:

- 0(4): Not enough directory blocks are available in the output data set.
- 1(4): An error has been detected while trying to read the data set.
- N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

This section gives a detailed description of each of the interactive devices that are supported by this system. For each device there is a description of the hardware including its features and limitations, and a review of the capabilities of each subroutine as it applies to the device. In particular the valid and default items in the OPTNS list for each subroutine are given.

SECTION B.1: THE IBM 2250 DISPLAY CONSOLE

The IBM 2250 is an on-line interactive display console. There are three IBM 2250/Model 2 consoles at SLAC. These devices consist of a CRT with a 10 inch by 10 inch working area, an alphanumeric keyboard, and a light pen.

The IBM 2250's are connected to the central computer system through an IBM 2840 display controller. This unit contains a 16,384 byte buffer which is shared by the three display consoles. A program running on the central computer system and using an IBM 2250 can write display orders into an area of the buffer allocated to the display. The orders present in the buffer constitute a "display file". In order to keep a picture on the screen, it is re-generated from the display file 40 times a second.

These units can display points, lines, and characters at a single intensity level. The character generator can produce horizontal characters of two sizes. The following table gives the between character spacing and suggested between lines spacing assuming the default programmer coordinate system.

Character Size	Character Spacing	Line Spacing	Characters per Line	Lines per Display
SMAL	0.01367	0.01953	74	52
LARG	0.02051	0.02930	49	35

A DD card is necessary at execution time to select the display console to be used. A typical DD card is:

```
//SCOPE50 DD UNIT=0D1
```

The ddname, SCOPE50 in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN. The device address, 0D1 in the example, is the address of the display console assigned to the "0" job class.

The keyboard on the IBM 2250's contains a number of special keys. The key labeled JUMP may be used to move the cursor from one keyboard input buffer to another. There are also keys labeled BACKSPACE and ADVANCE for moving the cursor within a keyboard input buffer without changing the content of the buffer. If the CONTINUE key is held down and another key is depressed, the function of the second key is repeated 40 times a second. The CONTINUE key is especially useful when used with the BACKSPACE or ADVANCE keys to move the cursor around. The keyboard attention is generated by holding the ALT key down and depressing the key labeled END.

The IBM 2250's at SLAC have a serious problem that the console operator should be aware of. If the cursor is not present and a key on the keyboard is depressed, the entire unit becomes locked and nothing will operate correctly including the light pen. The unit may be unlocked by holding the SHIFT key down and depressing the ALT key.

The light pen attention is generated by pointing at a light pen detectable element and depressing the foot pedal. The programmer should be aware that the non-detectability of elements, on this device, is produced by software. This means that if the console operator points at a detectable element which is very close to a non-detectable element, the hardware-software combination may decide that the console operator was pointing at the non-detectable element and discard the attention. For this reason, the programmer should keep detectable elements clear of all other elements.

The subroutines which may be used with this device are:

```
CALL UGBINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGBPNT(OPTNS,X,Y,ELEMNT)
CALL UGBLIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGBTXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGBPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGBLNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)
```

When an element is transmitted to an IBM 2250, all intensity level, wink mode, and color information is ignored. All lines are of the SOLD type. Horizontal text with the VSML or SMAL options will be produced in the small size and horizontal text with the LARG or VLRG option will be produced in the large size.

```
CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
  LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DMS(OPTNS,LOPTNS,ARRAY,MDIM,NDIM,TRANS,
  WKAREA,LDIM,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)
```

The valid items in OPTNS are:

IBM2250 Specifies the IBM 2250.

MAXENUM=<value> The maximum number of elements which may be present in a single picture. The default value is 25.

MAXBSIZ=<value> The maximum number of bytes that may be

in an element after it has been translated to device orders. The default value is 2000.

MAXDFIL=<value> The maximum number of bytes that may be in a complete display file (in the IBM 2840) at one time. The default value is 4096.

DDNAME=<value> The ddname of the display unit. The default value is SCOPE50.

CALL UGCLOS(IDENT)

CALL UGSLCT(IDENT)

CALL UGSCAL(OPTNS,PROGLM,DEVCLM)

The default values for the programmer and device limits for this device are:

$$\begin{bmatrix} 0.0 & 1.0 \\ 0.0 & 1.0 \end{bmatrix} \qquad \begin{bmatrix} 0 & 4095 \\ 0 & 4095 \end{bmatrix}$$

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2) The largest number of bytes in an element after it has been translated to device orders.

ARRAY(3) The maximum number of elements which were present in a single picture.

ARRAY(4) The maximum number of bytes that were in a single display file.

ARRAY(5) When subroutine UGEPUT transmits an element to the display device, this location is set to the length of the element after it has been translated to device orders. Other subroutines do not modify this value.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

The items in OPTNS which will be recognized and processed are DETC, OMIT, ON, and OFF.

CALL UGPICT(OPTNS,IDENT)

The items in OPTNS which will be recognized and processed are CLEAR, DETC, NDET, OMIT, INCL, ON and OFF. Elements may be fully manipulated.

CALL UGCTRL(OPTNS,IARRAY,XARRAY)

The only item in OPTNS which will be recognized is BEEP.

CALL UGEATN(OPTNS)

OPTNS may contain OFF, KBRD, LPEN, or FRAM. The number of display regeneration cycles after a frame interrupt is fixed at one.

CALL UGDATN(OPTNS)

CALL UGRATN(TIME,ATCODE,IARRAY,XARRAY)

CALL UGKPUT(OPTNS,X,Y,IDENT,STRING,NSTR)

Character size VSML and SMAL result in small sized characters while LARG and VLRG give large sized characters. All other items in OPTIONS are ignored. The input buffer should consist of an even number of characters.

CALL UGKGET(IDENT,STRING,MSTR,NSTR,ICUR)

CALL UGRXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)

CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)

```
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,EBITS)
CALL UGRDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,EC,NSTR)
CALL UGXTOP(CPP,CPS,EC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)
```

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGIB5002 and their description is:

O(4): An asynchronous buffer error has occurred; the display unit is malfunctioning.

N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION B.2: THE GIF-IDIION DISPLAY CONSOLE

The GIF-IDIION is an on-line interactive display console. The Graphic Interpretation Facility (GIF) is operated by the SLAC Computation Group as a research facility for on-line graphic systems. The facility consists of a Varian 620/I computer and an IDIION display console with a 21 inch CRT, an alphanumeric keyboard, a light pen, a function keyboard with 32 buttons, and a number of other special devices that have been developed.

The Varian 620/I computer is connected to the central computer system through an IBM 2701 Parallel Data Adaptor. A program running on the central computer system and using the GIF-IDIION will transmit display orders through the IBM 2701 to the Varian 620/I. The Varian 620/I assembles these orders into a valid display file and transmits this picture to the IDIION display console 60 times a second. The three sense switches on the Varian 620/I console control the mode in which the Varian 620/I is running. For normal operation these switches should be [Down-Down-Down]. To change these switches the console operator should do the following: (1) bring the program to a state where no I/O between the central computer and the Varian 620/I is in progress, (2) change the sense switch setting and, (3) push the halt button on the IDIION console twice to signal the program of the change.

The GIF-IDIION can display points, lines, and characters at four intensity levels. Lines may be drawn with four structures: solid, dashed, dot-dashed, and dotted. The character generator can produce horizontal or vertical characters of four sizes. The following table gives the between character spacing and suggested

between lines spacing assuming the default programmer coordinate system.

Character Size	Character Spacing	Line Spacing	Characters Per Line	Lines per Display
VSML	0.00781	0.01172	128	85
SMAL	0.01367	0.02051	73	48
LARG	0.02051	0.02930	48	34
VLRG	0.02734	0.04102	36	24

A DD card is necessary at execution time to define the display console. A typical DD card is:

```
//GIFLINK DD UNIT=GIF
```

The ddname, GIFLINK in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN. The device address, GIF in the example, is the symbolic address of the port on the IBM 2701 connected to the Varian 620/I. Jobs using the GIF-IDIIOM run in the "G" job class.

The keyboard on the IDIIOM can be used to perform a number of special operations on a keyboard input buffer in addition to simply entering information. Many of these operations are performed by holding the CONTROL key down and depressing an alphabetic key. These operations are:

FS	Advance the cursor to the next character without changing the current character.
(CONTROL)+A	Same as FS.
BS	Backspace the cursor without changing the current character.
(CONTROL)+B	Same as BS.
(CONTROL)+N	Move the cursor to the next keyboard input buffer.
(CONTROL)+R	Move the cursor to the beginning of the current keyboard input buffer.
(CONTROL)+C	Move the cursor to the beginning of the current keyboard input buffer and reset the entire keyboard input buffer to blanks.
(CONTROL)+D	Delete the character at the current cursor position and move the following characters one space to the left.
(CONTROL)+I	Move the character over the cursor and the following characters one space to the right and insert a blank at the current cursor position.
(CONTROL)+S	Set a tab at the current cursor position.
(CONTROL)+T	Tab the cursor to the next position with a set tab.
(CONTROL)+U	Clear the current position of a set tab.
(CONTROL)+V	Clear all set tabs.

The keyboard attention is generated by the ESCAPE key.

The light pen attention is generated by pointing at a light pen detectable element and pressing the button on the side of the pen. On the IDIIOM, a light pen detectable element will brighten on the screen when the light pen is pointing at it.

A tracking pattern (a small cross, about one half inch tall and wide) may be put on the screen. When the light pen is pointing

at this tracking pattern, the pattern will center itself in the field of view of the light pen. When the console operator moves the light pen around the screen, the tracking pattern will follow the light pen. The programmer may determine the position of the tracking pattern at any time. In addition, the light pen and tracking pattern may be used to draw free-hand curves on the screen. This is done by adding a light pen input buffer to the display file and putting the IDIION into the drawing mode. In this mode, the console operator may draw curves on the screen by holding the button on the light pen down and moving the tracking pattern about. When the IDIION is put into the erase mode and the light pen drawing buffer is made light pen detectable, then the console operator may delete segments of these curves by holding the button on the light pen down and pointing to the segments to be deleted. Finally, a light pen input buffer may be read from the display.

In the IDIION, a display element may act as a subroutine. This type of element does not appear on the screen unless it is invoked by another element. In this way, a sub-picture may appear on the screen many times while the orders to draw that sub-picture are in the display file only once. Invocations of element-subroutines may be nested to any depth.

One of the special devices connected to the GIF-IDIION is a 16 millimeter, Model 16M ARRIFLEX motion picture camera with a standard motor and an animation motor. An interface between the movie camera and the Varian 620/I has been designed and built at SLAC. Through this interface, the Varian 620/I can control the animation motor and sense when the shutter is open. The movie camera may be operated in any of three modes. These modes, and the corresponding positions of the sense switches on the Varian 620/I are:

1. Over the Shoulder Mode [Down-Down-Up]: In this mode, the movie camera use the standard motor and runs at its normal speed of 24 frames per second. The Varian 620/I continually senses the shutter open signal from the camera. When the shutter initially opens, the Varian 620/I will start the display. After going through the display file once, the display is turned off until the next time the shutter opens. This mode may, therefore, be used to take flicker-free movies of a person operating the console. The operation of any existing interactive program may be filmed.
2. Single Pulse Animation Mode [Down-Up-Down]: In this mode, the Varian 620/I sends signals to the camera telling it when to open its shutter. After the shutter has opened, the display will be started. The length of time that the shutter remains open is controlled by a switch on the animation motor. This switch may be set to give exposure times of 1/8, 1/4, and 1/2 seconds. A single pulse animation program is written in the following manner:
   A. The FRAM attention should be enabled and the regeneration count set to a small value (usually 2, 3, or 4) with the FRAM option of subroutine UGCTRL.

B. The elements for a single frame should be transmitted to the GIF-IDIIOM and the display should be started.

C. The occurrence of the FRAM attention indicates that one frame of movie film has been exposed. Step B may then be repeated.

This type of animation program may be checked out as a normal interactive display program. The only difference is that the final movie will run at 24 frames per second, while many factors can affect the rate at which the frames appear on the CRT.

3. Double Pulse Animation Mode [Down-Up-Up]: This mode is a generalization of the previous mode. It covers the case where a single frame is composed of many display files. Thus, a single frame of movie film may contain a more complex picture than can be viewed in the normal interactive mode. A double pulse animation program is written in the following manner:

A. The FRAM attention should be enabled and the regeneration count should be set.

B. The shutter should be opened with the SHOPEN option in subroutine UGCTRL.

C. The elements for a single display file should be transmitted to the GIF-IDIIOM and the display should be started.

D. The occurrence of the FRAM attention indicates that the display file has been exposed. Step C may then be repeated.

E. When all display files have been exposed, the shutter should be closed with the SHCLOS option in subroutine UGCTRL. Step B may then be repeated.

This type of animation may also be run and checked out in the normal interactive mode because the shutter open and close commands are ignored if the sense switches are not in the double pulse animation mode. However, the console operator may have to use considerable imagination to visualize the final movie.

Another of the special devices which is connected to the GIF-IDIIOM is a 3-D viewer. This viewer is a device which contains a motor driven rotating disk. The disk contains clear and opaque areas. When the console operator looks through this device, the left and right eyes will alternately be blocked by the opaque areas on the disk. An interface has been built at SLAC which allows the Varian 620/I to sense when the left or right eye has a clear view. By flashing different images on the screen when each eye is open, it is possible to present the user with a stereoscopic picture. A program which uses the 3-D viewer should obey the following conventions: (1) elements which are to be presented to the left eye only should have identifications which are less than -1000, (2) elements which are to be presented to the right eye only should have identifications which are greater than +1000, (3) elements which are to be presented to both eyes should have identifications between -1000 and +1000 (inclusive). In addition, the three sense switches on the Varian 620/I should be in the [Up-Down-Down] position. This setting of the sense

switches signals the program that it is to synchronize the display with the 3-D viewer.

On-line animation may be done by simply re-generating and re-transmitting a changing graphic element at regular intervals. Normally when an element is being changed, the Varian 620/I will turn off the CRT while the display file is being changed. However this can cause an annoying amount of flicker when on-line animation is being attempted. A solution is to use a special setting of the sense switches, [Up-Down-Up], and assure, by using the MINESIZ option in subroutine UGEPUT, that the element being changed is of constant size. Under these conditions, the display is turned off for a considerably shorter time and the element being changed can simply be read into the same space occupied by its earlier version.

The subroutines which may be used with this device are:

```
CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)
```

The IDIICM will correctly process the intensity levels VDIM, DIMM, BRIT, VBRT; the wink mode specifications WINK and STDY; and the line structure specifications SOLD, DASH, DDSH, and DOTS. Color information is ignored. Character sizes of VSML, SMAL, LARG, and VLRG may be used. The intensity level and line structure information is not very useful because of minor design flaws in the early model IDIICM that we have at SLAC.

```
CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
  LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DMS(OPTNS,LOPTNS,ARRAY,NDIM,NDIM,TRANS,
  WKAREA,LDIM,ELEMNT)
CALL UGEINV(OPTNS,X,Y,IDENT,ELEMENT)
```

The ANGLE and SCALE data will be ignorred and assumed to be 0.0 and 1.0 respectively.

```
CALL UGEDTA(OPTNS,STRING,NSTR,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)
```

The valid items in OPTNS are:

- GIF/IDI Specifies the GIF-IDIICM.
- MAXNUM=<value> The maximum number of elements which may be present in a single picture. The default value is 25.
- MAXESIZ=<value> The maximum number of bytes that may be in an element after it has been translated to device orders. The default value is 2000.
- DDNAME=<value> The ddname of the display unit. The default value is GIFLINK.

```
CALL UGCLOS(IDENT)
CALL UGSLCT(IDENT)
CALL UGSCAL(OPTNS,PROGLM,DEVCLM)
```

The default values for the programmer and device limits for this device are:

```
[ 0.0   1.0 ]          [ 0   1023 ]
[ 0.0   1.0 ]          [ 0   1023 ]
```

CALL UGINFO(STRING,IDENT,ARRAY)

The array ARRAY will contain the following:

ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.

ARRAY(2) The largest number of bytes in an element after it has been translated to device orders.

ARRAY(3),ARRAY(4) Zero.

ARRAY(5) When subroutine UGEPUT transmits an element to the display device, this location is set to the length of the element after it has been translated to device orders. Other subroutines do not modify this value.

CALL UGEPUT(OPTNS,IDENT,ELEMNT)

The items in OPTNS which will be recognized and processed are DETC, OMIT, ON, OFF, NCMP, RTTC, ESUB, and MINESIZ. NCMP signifies that the element is to be translated to non-compact orders. This option makes it possible to determine the exact point or line that was pointed to in a light penned element.

CALL UGPICT(OPTNS,IDENT)

The items in OPTNS which will be recognized and processed are CLEAR, DETC, NDET, OMIT, INCL, ON and OFF. Elements may be fully manipulated.

CALL UGCTRL(OPTNS,IARRAY,XARRAY)

The valid items in OPTNS are:

FRAM The regeneration count for the FRAM attention may be any positive value.

LITES=<value> If the given bit string does not contain 32 bits, it is padded on the right with zeros. The function keyboard is arranged in 4 rows of 8 buttons. Button number one is in the top row on the left, button number two is in the top row next to button number one, etc.

TPPUT,TPGET,TPRMV The tracking pattern may be put on the screen, its position may be obtained, and it may be removed from the screen.

TPIAC,TPDRW,TPERS The IDIION may be put into the inactive, draw, or erase mode with respect to light pen input buffers.

ESON,ESOFF,ESTRC The IDIION may be instructed to check for or ignore element-subroutines, and the programmer may request an element-subroutine trace.

SHOPEN,SHCLOS The shutter on the synchronized movie camera may be opened and closed in the double pulse animation mode.

CALL UGEATN(OPTNS)

OPTNS may contain OFF, KBRD, LPEN, FRAM, PFKM, PFKB, PFLM, PFLB, LPSM, or LPSB.

CALL UGDATN(OPTNS)

CALL UGRATN(TIME,ATCODE,IARRAY,XARRAY)

CALL UGEPUT(OPTNS,X,Y,IDENT,STRING,NSTR)

The character sizes VSML, SMAL, LARG, and VLRG; and the

intensity levels VDIM, DIMM, BRIT, and VBRT will be correctly processed. The input buffer should consist of an even number of characters.

```
CALL UGMGET(IDENT,STRING,MSTR,NSTR,ICUR)

CALL UGLPUT(OPTNS,IDENT,LENGTH)
```

The intensity levels VDIM, DIMM, BRIT, and VBRT; and the line structure specifications SOLD, DASH, DDSH, and DOTS will be correctly processed.

```
CALL UGLGET(IDENT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)

CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)
CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)
CALL UGPROJ(TRANS,PT3D,PT2D)
CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,BBITS)
CALL UGEDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,EC,NSTR)
CALL UGXTOP(CPP,CPS,EC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)
CALL UGX002(OPTNS,INDATA,EXDATA)
CALL UGX203(NAME,COUNT,DVNAME)
```

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGGIFI02 and their description is:

1(4): The light pen input buffer in the Varian 620/I is full.
N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION B.3: THE TEKTRONIX 4013 DISPLAY TERMINAL

The TEKTRONIX 4013 is an interactive storage display terminal with an eight inch wide by six inch high screen and a keyboard. The CRT on the TEKTRONIX 4013 differs from the CRT's on the previous devices in that partial erasure of a picture is impossible; once a display item is drawn on the screen it remains there until the entire screen is cleared.

The TEKTRONIX 4013 terminals are under the control of the MILTEN Terminal Manager. A program which sends information to and receives information from a terminal must communicate with MILTEN. To run an interactive program using the TEKTRONIX 4013 the user should:

1. Sign on the terminal and begin using the WYLBUR Text Editing System in the usual manner.
2. Submit a job which runs in one of the interactive partitions and wait until it identifies itself as a sub-system to MILTEN. The command SHOW SYSTEMS will

list the currently running systems. The name of your sub-system will be the same as the job name.

3. When your sub-system is known to MILTEN, you may type its name to connect your terminal to your sub-system. However before this connection is made, MILTEN will ask for the sub-system's Magic Word (see options under UGOPEN). Once you have correctly entered the Magic Word, no other terminal will be allowed to use the sub-system.
4. When running in the interactive mode, the keyboard attention is generated by the RETURN key. If you have been typing some information and wish to cancel what you have done and start all over, you may hit the BREAK key. In addition, you may temporarily return to WYLBUR by typing $WYL and hitting the RETURN key. When you are finished using WYLBUR you may type the name of your sub-system to resume.

The TEKTRONIX 4013 can display points, lines, and characters at a single intensity level. The character generator can produce horizontal characters of a single size. The following table gives the between character spacing and suggested between lines spacing assuming the default programmer coordinate system.

Character Size	Character Spacing	Line Spacing	Characters per Line	Lines per Display
SMAL	0.01797	0.02824	56	35

When the PULSCR option is used in subroutine UGOPEN, then 74 characters will fit on a single line.

A DD card is not needed unless you are using the IDSCOPE option in UGOPEN. In this case your JCL should include:

```
//ANYNAME  DD DUMMY
```

The ddname, ANYNAME in the example, must correspond to the value given in the DDNAME item in the options list of UGOPEN.

Only one keyboard input buffer can be on the screen at a time. If you attempt to put more than one on the screen, only the last one will be active.

These display units have a limited tracking facility. A set of vertical and horizontal cross-hairs may be put on the screen and moved by the console operator with the thumb wheels on the right hand side of the keyboard. When the cross-hairs are on the screen the console operator may strike a printing key, <u>not the carriage return</u>, to cause the coordinates to be sent to the central computer and the cross-hairs removed from the screen. Since the position is sent when the console operator strikes a key, it means that the keyboard cannot be used to enter text while the cross-hairs are present.

The subroutines which may be used with this device are:

```
CALL UGEINT(OPTNS,ELEMNT,ELTSIZ)
CALL UGEPNT(OPTNS,X,Y,ELEMNT)
CALL UGELIN(OPTNS,X,Y,BBIT,ELEMNT)
CALL UGETXT(OPTNS,X,Y,TEXT,NTEXT,ELEMNT)
CALL UGEPTS(OPTNS,XARRAY,YARRAY,NPTS,ELEMNT)
CALL UGELNS(OPTNS,XARRAY,YARRAY,NPTS,BBITS,NBBITS,ELEMNT)
```

When an element is transmitted to this device, all intensity level, wink mode, and color information (with one exception) is ignored. The exception is that points with the DIMM or VDIM option are plotted as a single raster point while all other points are plotted as four raster points. All lines are of the SOLD type. Horizontal text with the VSML, SMAL, LARG, or VLRG options will be produced by the character generator.

```
CALL UGAXIS(OPTNS,LOPTNS,COPTNS,INDVAR,LOVAR,HIVAR,
  LOLAB,HILAB,NLAB,ELEMNT)
CALL UG3DMS(OPTNS,LOPTNS,ARRAY,MDIM,NDIM,TRANS,
  WKAREA,LDIM,ELEMNT)

CALL UGOPEN(OPTNS,IDENT)
```

The valid items in OPTNS are:

- TEK4013 Specifies the TEKTRONIX 4013.
- MAGICWD=<value> The Magic Word that MILTEN will request. The Magic Word may have from one to eight characters and has a default value of XXXXXXXX.
- DDNAME=<value> The ddname of the display unit when IDSCOPE is used. No default value is supplied.
- FULSCR A flag which specifies that the picture is to be scissored at the screen boundaries and not at a square area within the screen.

When UGOPEN is called, your program will identify itself to MILTEN as a sub-system and wait until you have made the connection between your sub-system and your terminal.

```
CALL UGCLOS(IDENT)
CALL UGSLCT(IDENT)
CALL UGSCAL(OPTNS,PROGLM,DEVCLM)
```

The default values for the programmer and device limits are:

```
[ 0.0   1.0 ]        [ 122   901 ]
[ 0.0   1.0 ]        [   0   779 ]
```

The default values when FULSCR is used are:

```
[ -0.15661   1.15661 ] [ 0   1023 ]
[  0.0       1.0     ] [ 0    779 ]
```

```
CALL UGINFO(STRING,IDENT,ARRAY)
```

The array ARRAY will contain the following:

- ARRAY(1) The number of words used in the largest graphic element that has been transmitted to the device.
- ARRAY(2)...ARRAY(5) Zero.

```
CALL UGEPUT(OPTNS,IDENT,ELEMNT)
```

For this device, the contents of both OPTNS and IDENT are ignored. Hitting the BREAK key while a picture is being drawn will terminate that call to UGEPUT with no other effect on the program.

```
CALL UGPICT(OPTNS,IDENT)
```

The only valid item in OPTNS is CLEAR. The contents of IDENT is ignored and assumed to be zero.

CALL UGCTRL(OPTNS,IARRAY,XARRAY)

The only valid items in OPTNS are BEEP and TPCTL. TPCTL causes the cross-hairs to be put on the screen and the console to be put into the wait state. When the console operator strikes a printing key, the cross-hair coordinates are read and UGCTRL returns to the calling subroutine.

CALL UGEATN(OPTNS)

The only item in OPTNS which will be recognized is KBRD.

CALL UGDATN(OPTNS)

CALL UGRATN(TIME,ATCODE,IARRAY,XARRAY)

CALL UGKPUT(OPTNS,X,Y,IDENT,STRING,NSTR)

OPTNS may contain LCASE; all character size information is ignored. The contents of STRING will not be displayed because the typed characters would not then be readable on the storage scope.

CALL UGKGET(IDENT,STRING,NSTR,NSTR,ICUR)

The characters that are read are exactly those characters that the console operator has typed.

CALL UGDXDY(LODATA,HIDATA,MINLAB,MAXLAB,LOLAB,HILAB,NLAB)

CALL UGVIEW(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)

CALL UGORTH(OPTNS,REFP,VDIR,HDIR,SCRD,SCRZ,TRANS)

CALL UGPROJ(TRANS,PT3D,PT2D)

CALL UGCTOL(OPTNS,TEXT,NTEXT,NSIZE,XARRAY,YARRAY,NPTS,RBITS)

CALL UGEDIV(ELMNT1,ELMNT2)

CALL UGPTOX(CPP,CPS,EC,NSTR)

CALL UGXTOP(CPP,CPS,EC,NSTR)

CALL UGX001(LEVEL,DVNAME,INDEX)

CALL UGX002(OPTNS,INDATA,EXDATA)

CALL UGX203(NAME,COUNT,DVNAME)

In addition to the errors described with each subroutine, there are some other errors which may be detected. These errors are identified by a subroutine name of UGTK1302 and their description is:

N(4): (Where N is greater than 255.) An extremely unusual error condition has been detected.

SECTION C: THE CHARACTER STROKE GENERATING SUB-SYSTEM

The Character Stroke Generator Sub-System is that part of this system which converts text data in a graphic element into short line segments forming the characters. The stroke generator will be used in the following cases:

1. The programmer has specified that it must be used by giving the SPACING option when the data was added to the graphic element.
2. The programmer has specified that either the stroke generator or the device character generator may be used by giving the XSPACING option, but either the device has no character generator or it has one which cannot satisfy all of the requirements.

The stroke generator is a program module which contains tables to describe how each character is formed from line segments. The standard stroke generator is able to process all of the characters on the IBM 029 keypunch in addition to the ten plotting symbols. Also the EBCDIC codes for lower case letters are produced as upper case. The characters produced by the standard stroke generator are shown in lines one, five, and six of Figure C.1.1.

SECTION C.1: MODULE UGX103A

The characters produced by the standard stroke generator should be sufficient for most applications. However, some applications can require additional characters such as Greek letters, superscripts, or subscripts. For this reason an alternate program module is available. If the programmer creates the load module with the LINK-EDITOR and includes the card:

```
INCLUDE SYSLIB(UGX103A)
```

in the SYSIN data set, then this alternate module will be used. This alternate module is larger than the standard module; it has the following additional capabilities:

1. Upper and lower case Roman and Greek letters may be produced.
2. Many additional special characters are available.
3. Characters are available which cause the stroke generator to enter superscript or subscript mode. Superscripts or subscripts may themselves have superscripts or subscripts.

This alternate module differs from the standard stroke generator in one other important respect. The standard module generates characters which all have the same width (their width is two-thirds of the value given by the SPACING or XSPACING option in UGTEXT and their height is the same as that value). This alternate module generates characters of differing widths and heights, thus the upper case letter "M" is twice as wide as an

"I", and most lower case letters are three-fourths as wide as most upper case letters. This results in text with a more pleasing appearance, but also causes a problem; if, for instance, a letter is to carry both a superscript and subscript, something equivalent to a backspace would be necessary, but the amount backspaced would depend on the characters in the superscript (or subscript). To overcome this problem, a character has been introduced which causes the stroke generator to save its current position and state. Another special character in a later part of the string can cause the earlier state of the character generator to be restored. There are three independent save-restore character pairs available.

The following table gives the hexadecimal equivalent of each character. The meaning and use of the character pairs will be described in a following section on subroutines UGPTOX and UGXTOP.

Hex. Code	Char Pair	Character Description	Hex. Code	Char Pair	Character Description
00	¤S	Null	08	QG	L.C. Theta
01	AG	L.C. Alpha	09	IG	L.C. Iota
02	BG	L.C. Beta	0A	IS	Integral Sign
03	GG	L.C. Gamma	0B	XS	Times Sign
04	DG	L.C. Delta	0C	:S	Division Sign
05	EG	L.C. Epsilon	0D	ES	Approximately Equal
06	ZG	L.C. Zeta	0E	PS	Partial Derivative
07	HG	L.C. Eta	0F	DS	Del
10	?S	Interbang	18	RG	L.C. Rho
11	KG	L.C. Kappa	19	SG	L.C. Sigma
12	LG	L.C. Lambda	1A	UA	Up Arrow
13	MG	L.C. Mu	1B	DA	Down Arrow
14	NG	L.C. Nu	1C	LA	Left Arrow
15	XG	L.C. Xi	1D	RA	Right Arrow
16	OG	L.C. Omicron	1E	BA	Left/Right Arrow
17	PG	L.C. Pi	1F		Unassigned
20	MX	Membership Symbol	28	YG	L.C. Psi
21	NX	Membership Negation	29	WG	L.C. Omega
22	EX	Existential Quant.	2A	IX	Intersection
23	AX	Universal Quant.	2B	UX	Union
24	TG	L.C. Tau	2C	<X	Contained in
25	UG	L.C. Upsilon	2D	>X	Contains
26	FG	L.C. Phi	2E	LX	Contained in/Equal
27	CG	L.C. Chi	2F	RX	Contains/Equal
30	0C	Enter Superscr Mode	38	8C	Save Position-3
31	1C	Leave Superscr Mode	39	9C	Restore Pos-3
32	2C	Enter Subscr Mode	3A		Unassigned
33	3C	Leave Subscr Mode	3B		Unassigned
34	4C	Save Position-1	3C		Unassigned
35	5C	Restore Pos-1	3D		Unassigned
36	6C	Save Position-2	3E	EC	Increase Size
37	7C	Restore Pos-2	3F	FC	Decrease Size

Hex. Code	Char Pair	Character Description
40	¤¤	Blank
41	AH	U.C. Alpha
42	BH	U.C. Beta
43	GH	U.C. Gamma
44	DH	U.C. Delta
45	EH	U.C. Epsilon
46	ZH	U.C. Zeta
47	HH	U.C. Eta
50	&¤	Ampersand
51	KH	U.C. Kappa
52	LH	U.C. Lambda
53	MH	U.C. Mu
54	NH	U.C. Nu
55	XH	U.C. Xi
56	OH	U.C. Omicron
57	PH	U.C. Pi
60	-¤	Minus Sign
61	/¤	Slash Mark
62	+S	Group Plus
63	*S	Group Multiply
64	TH	U.C. Tau
65	UH	U.C. Upsilon
66	FH	U.C. Phi
67	CH	U.C. Chi
70		Unassigned
71		Unassigned
72		Unassigned
73		Unassigned
74		Unassigned
75		Unassigned
76		Unassigned
77		Unassigned
80		Unassigned
81	AL	L.C. A
82	BL	L.C. B
83	CL	L.C. C
84	DL	L.C. D
85	EL	L.C. E
86	FL	L.C. F
87	GL	L.C. G
90		Unassigned
91	JL	L.C. J
92	KL	L.C. K
93	LL	L.C. L
94	ML	L.C. M
95	NL	L.C. N
96	OL	L.C. O
97	PL	L.C. P

Hex. Code	Char Pair	Character Description
48	QH	U.C. Theta
49	IH	U.C. Iota
4A	¢¤	Cent Sign
4B	.¤	Period
4C	<¤	Less Than
4D	(¤	Left Parenthesis
4E	+¤	Plus Sign
4F	|¤	Vertical Line
58	RH	U.C. Rho
59	SH	U.C. Sigma
5A	!¤	Exclamation Mark
5B	$¤	Dollar Sign
5C	*¤	Asterisk
5D	)¤	Right Parenthesis
5E	;¤	Semi-Colon
5F	¬¤	Not
68	YH	U.C. Psi
69	WH	U.C. Omega
6A	GS	Dagger
6B	,¤	Comma
6C	%¤	Percent
6D	_¤	Underline
6E	>¤	Greater Than
6F	?¤	Question Mark
78	LS	Left Angle Bracket
79	RS	Right Angle bracket
7A	:¤	Colon
7B	#¤	Pound Sign
7C	@¤	At Sign
7D	'¤	Apostrophy
7E	=¤	Equals Sign
7F	"¤	Quote Marks
88	HL	L.C. H
89	IL	L.C. I
8A		Unassigned
8B	AS	Left Brace
8C	<S	Less or Equal
8D		Unassigned
8E	HS	H-Bar
8F	WS	Lambda-Bar
98	QL	L.C. Q
99	RL	L.C. R
9A		Unassigned
9B	ZS	Right Brace
9C		Unassigned
9D		Unassigned
9E	SS	Plus or Minus
9F		Unassigned

Hex. Code	Char Pair	Character Description	Hex. Code	Char Pair	Character Description
A0		Unassigned	A8	YL	L.C. Y
A1	OS	Degrees	A9	ZL	L.C. Z
A2	SL	L.C. S	AA		Unassigned
A3	TL	L.C. T	AB		Unassigned
A4	UL	L.C. U	AC		Unassigned
A5	VL	L.C. V	AD	(S	Left Bracket
A6	WL	L.C. W	AE	>S	Greater or Equal
A7	XL	L.C. X	AF		Unassigned
B0	0P	Plot Sym V Cross	B8	8P	Plot Sym Star
B1	1P	Plot Sym D Cross	B9	9P	Plot Sym Octagon
B2	2P	Plot Sym Diamond	BA		Unassigned
B3	3P	Plot Sym Square	BB		Unassigned
B4	4P	Plot Sym F Diamond	BC		Unassigned
B5	5P	Plot Sym F Square	BD	)S	Right Bracket
B6	6P	Plot Sym F V Cross	BE	=S	Not Equal
B7	7P	Plot Sym F D Cross	BF		Unassigned
C0		Unassigned	C8	Hu	U.C. H
C1	Au	U.C. A	C9	Iu	U.C. I
C2	Bu	U.C. B	CA	1V	Half Up
C3	Cu	U.C. C	CB	2V	Half Down
C4	Du	U.C. D	CC	3V	Third Up
C5	Eu	U.C. E	CD	4V	Third Down
C6	Fu	U.C. F	CE	5V	Sixth Up
C7	Gu	U.C. G	CF	6V	Sixth Down
D0	0U	Backwards Blank	D8	Qu	U.C. Q
D1	Ju	U.C. J	D9	Ru	U.C. R
D2	Ku	U.C. K	DA	1U	Extra Half Blank
D3	Lu	U.C. L	DB	2U	Half Back Blank
D4	Mu	U.C. M	DC	3U	Extra Third Blank
D5	Nu	U.C. N	DD	4U	Third Back Blank
D6	Ou	U.C. O	DE	5U	Extra Sixth Blank
D7	Pu	U.C. P	DF	6U	Sixth Back Blank
E0	/S	Backwards Slash	E8	Yu	U.C. Y
E1		Unassigned	E9	Zu	U.C. Z
E2	Su	U.C. S	EA		Unassigned
E3	Tu	U.C. T	EB		Unassigned
E4	Uu	U.C. U	EC		Unassigned
E5	Vu	U.C. V	ED		Unassigned
E6	Wu	U.C. W	EE		Unassigned
E7	Xu	U.C. X	EF		Unassigned
F0	0u	Numeral 0	F8	8u	Numeral 8
F1	1u	Numeral 1	F9	9u	Numeral 9
F2	2u	Numeral 2	FA		Unassigned
F3	3u	Numeral 3	FB		Unassigned
F4	4u	Numeral 4	FC		Unassigned
F5	5u	Numeral 5	FD		Unassigned
F6	6u	Numeral 6	FE		Unassigned
F7	7u	Numeral 7	FF	OS	Infinity

Figure C.1.1 shows examples of all of the characters that this alternate module is capable of producing.

ABCDEFGHIJKLMNØPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ
αβγδεζηθικλμνξοπρστυφχψω
0123456789 +×◇□+⋇⋇⋇⋇○
⌽.<(+|&!$*);¬-/,%_>?:#@'="
∫×∓≅∂∇⁇↑↓←→↔∈∉∃∀∩∪⊂⊃⊆⊇⊕⊗†⟨⟩{≤⋂⋃}±°[≥]*\∞

Figure C.1.1: The Extended Character Set.

SECTION C.2: SUBROUTINES UGPTOX AND UGXTOP

To create text containing these additional characters requires that the programmer generate character strings whose individual characters have unusual bit patterns. These strings can then be packed into a graphic element with subroutine UGPTXT and then transmitted to a display device with subroutine UGPPUT. The subroutines UGPTOX and UGXTOP are made available to help the programmer create and manipulate character strings containing these unusual characters.

The arguments basically consist of three character strings, a string of primary characters, a string of secondary characters, and a string of extended characters. Subroutine UGPTOX uses the primary and secondary pairs to generate the extended string and subroutine UGXTOP does the inverse operation. For an example using UGPTOX suppose that the character for a lower case Greek delta is to be put into the third position in the extended string. The table in the preceding section shows that the character pair for this character is "DG". Therefore, before UGPTOX is called, the programmer must put a "D" in the third position of the primary character string and a "G" in the third position of the secondary character string. The symbol "n" in the table stands for a blank. Notice that there is a pattern to the secondary characters; lower case Roman letters are designated by an "L", lower case Greek by a "G", upper case Greek by a "B", control functions by a "C", plotting symbols by a "P", and special characters by "A", "S", or "X". Finally, the standard characters are all designated by a blank secondary character.

The calling sequences are:

```
  CALL UGPTOX(CPP,CPS,EC,NSTB)
  CALL UGXTOP(CPP,CPS,EC,NSTB)
```

The parameters in the calling sequence are:

CPP	A character string containing the primary character pairs.
CPS	A character string containing the secondary character pairs.
EC	A character string containing the extended characters.
NSTR	The number of characters in the strings (INTEGER*4).

No error messages are produced by these subroutines.

Figures C.2.1 and C.2.2 give examples of the use of the alternate character stroke generator. Each figure shows the primary and secondary character strings and the corresponding line of text.

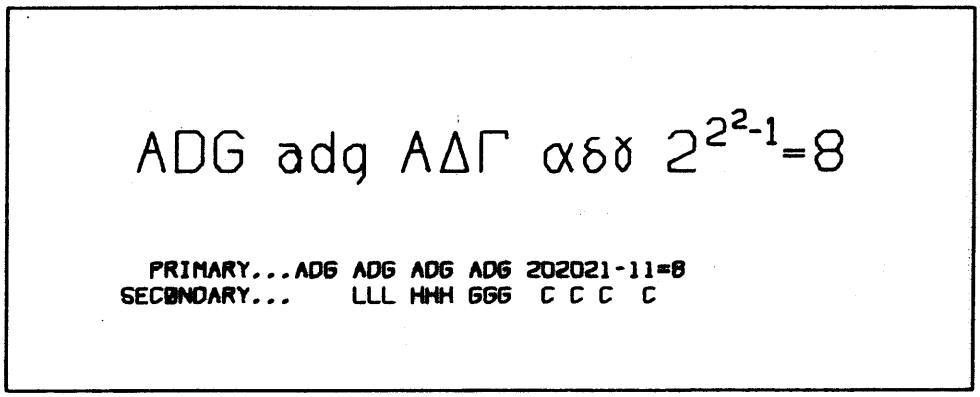


Figure C.2.1: Some Simple Examples.

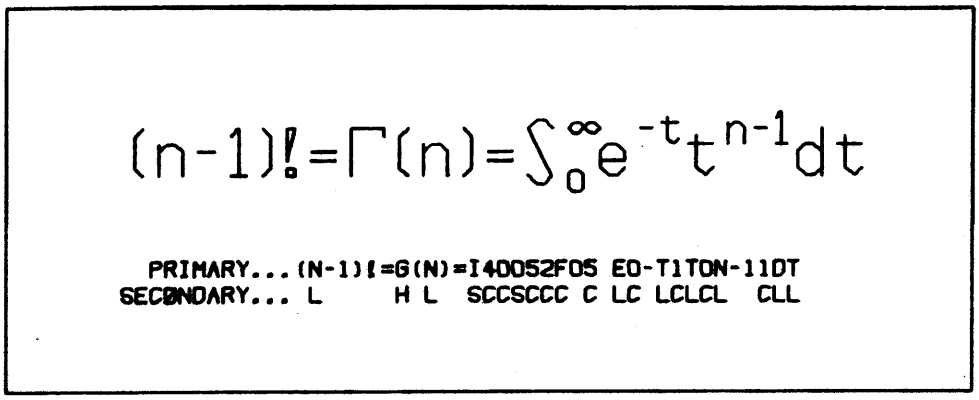


Figure C.2.2: A More Elaborate Example.

SECTION C.3: MODULE UGX103Z

It is possible to write programs for graphic devices which never use the stroke generator; either the device character generator is sufficient or the pictures do not contain any text material. For these programs it is wasteful to have the stroke generator using core space at execution time. Therefore, a second alternate program module is available. If the programmer creates

the load module with the LINK-EDITOR and includes the card:

```
INCLUDE SYSLIB(UGX103Z)
```

in the SYSIN data set, then this alternate module will be used. This alternate module is much smaller than the standard module. If a program with this alternate module tries to use the stroke generator, then that text material will not appear in the picture.

When the Unified Graphics System detects an error it has three pieces of information available to it. The first is the name of the subroutine that detected the error, the second is an index whose value describes the error, and the third item is the severity level of the error. There are four levels of errors which may be reported. These levels and the actions of the error processor are:

1. Minor Errors: The subroutine name and index are saved in some error indicators.
2. Errors: The error indicators are saved and a message is printed. The message contains the subroutine name and index.
3. Severe Errors: A message is printed and the program is terminated without a core dump.
4. Terminal Errors: A message is printed and the program is terminated with a core dump.

At execution time, the programmer can check for the first two types of errors and try to recover from them. One way to do this is to check the error indicators after a subroutine has been called. The error indicators are declared by the statements:

```
COMMON      /UGERR/UGNAM(2),UGIND
INTEGER*4   UGNAM,UGIND
```

When a Minor Error or Error has occurred, UGNAM will contain the subroutine name and UGIND will contain the index. If no error has occurred, UGNAM will contain blanks and UGIND will contain zero.

A second and more versatile way of processing errors is by means of a user written error processing subroutine called UGXERR. If the user includes a subroutine with this name, it will be called whenever any error is detected. The skeleton for the subroutine is:

```
SUBROUTINE UGXERR(LEVEL,NAME,INDEX)
INTEGER*4  LEVEL,NAME(2),INDEX
   ...        ...
END
```

This subroutine can do almost anything to try to recover from the error including calling other subroutines in this system. However it is the programmer's responsibility to see that no FORTRAN subroutine is entered recursively. In particular this means that if subroutine UGXERR calls other subroutines in this system, these subroutines must not themselves generate errors because that would mean a recursive call on UGXERR. If an attempt is made to call UGXERR recursively, the message for the second error will be printed followed by a message with a subroutine name of UGXERR whose description is:

1(4): An attempt was made to use UGXERR recursively.

Subroutine UGXERR may also change its arguments; in particular, LEVEL may be set to zero to cause the system to suppress further error action.

An example of a non-trivial use of an error processing subroutine will now be given. Suppose a program has been written which generates large complicated pictures for the CALCOMP Drum Plotter and suppose it is written as follows:

1. Before each plot, the graphic element is cleared by calling subroutine UGEINT with the CLEAR option.
2. The graphic element generators are used to create the graphic element.
3. The graphic element is transmitted to the CALCOMP.

Eventually this simple program will fail at Step 2 because the graphic element will become full. However, this program can be made to work by doing the following:

1. Put the graphic element in a COMMON block.
2. Prepare a UGXERR subroutine which recognizes a graphic element overflow error as signalled by the graphic element generators (These are distinguished by an index number of 9). In this case UGXERR should transmit the graphic element to the CALCOMP by calling subroutine UGEPUT and then clear the graphic element by calling subroutine UGEINT with the CONTINUE option. The CONTINUE option is needed here because of the way subroutine UGELIN works. It draws from the last point to the given point. The CONTINUE option causes the last point to be saved. Subroutine UGXERR may then reset the level number to zero and return.

With these modifications and additions, the original program will work because of a property of the basic graphic element generators. When they find that all of the new data will not fit, they report this condition to the error processor. If the error processor returns, the element generators again try to put the data into the graphic element before returning.

SECTION D.1: SUBROUTINE UGX001

When a subroutine in this system detects an error, it is reported by calling a subroutine named UGX001. A programmer may also make use of this subroutine if he wishes to process errors in this same manner.

The calling sequence is:

```
CALL UGX001(LEVEL,DVNAME,INDEX)
```

The parameters in the calling sequence are:

LEVEL	The level number of the error (INTEGER*2). A value of zero will cause the error flags to be cleared.
DVNAME	A dope vector for the name of the subroutine identifying the error (INTEGER*4, DIMENSION=2). A dope vector may be constructed by using the subroutine named UGX203.
INDEX	The index of the error (INTEGER*2).

SECTION D.2: SUBROUTINE UGX203

The purpose of this subroutine is to provide a means of constructing the dope vectors which must be passed to UGX001. Dope vectors are passed to UGX001 because this assures compatibility with the PL/1 version of this system.

The calling sequence is:

```
CALL UGX203(NAME,COUNT,DVNAME)
```

The parameters in the calling sequence are:

NAME	A character string. When a dope vector is being constructed for UGX001, this parameter should contain the name of the subroutine identifying the error.
COUNT	The number of characters in name (INTEGER*4). When a dope vector is being constructed for UGX001, the parameter should have a value of eight.
DVNAME	The dope vector which will be constructed (INTEGER*4, DIMENSION=2).

SECTION D.3: MODULE UGX001A

Under some circumstances, the programmer may find it desirable to relax the constraint against recursive use of UGXERR. If the programmer creates the load module with the LINK-EDITOR and includes the card:

```
INCLUDE SYSLIB(UGX001A)
```

then an alternate error processing sub-system will be loaded which permits recursive use of UGXERR. This means that the copy of UGXERR in the load module must be coded in Assembler Language and must be capable of being used recursively.

This section describes two related functions. Scaling is the operation of taking the given floating point coordinates in the programmer coordinate system and transforming them to the device coordinate system. Scissoring is the operation of deleting those points, parts of lines, and characters which lie outside a rectangular area. Scaling is always necessary and scissoring can be important because a distorted picture can result if coordinates are given which extend beyond the physical limits of a graphic device.

The programmer and device limits are specified as 2 by 2 matrices and are manipulated by subroutine UGSCAL. These matrices have the following form:

```
[ PXLO  PXHI ]      [ DXLO  DXHI ]
[ PYLO  PYHI ]      [ DYLO  DYHI ]
```

The programmer limits are given in floating point form and the device limits are in fixed point form. To scale the X coordinate, PXLO maps into DXLO, PXHI maps into DXHI, and intermediate values are linearly interpolated. Y coordinates are mapped similarly. The picture is scissored at the device limit matrix.

The scissoring of points and characters, those produced by the device character generator, is simple and fast because the item is either in the picture or out of it. The case for line segments is not so simple; a line may be in the picture, partially in, or out of it. A line segment that is partially in the picture may intersect the device limits rectangle once or twice.

An example of a non-trivial use of the scaling and scissoring system will now be given. Suppose a program is to be written which generates 10 inch by 25 inch plots on the 10 inch CALCOMP Drum Plotter and the programmer wishes to specify the coordinates on the paper in terms of inches. The proper matrices are:

```
[ 0.0  25.0 ]      [ 0  2500 ]
[ 0.0  10.0 ]      [ 0  1000 ]
```

Suppose, at some later time, the programmer wishes to display these pictures on an IBM 2250 with the image using the full width of the screen and centered on the screen vertically. One inch on the CALCOMP will correspond to 4095/25 raster units on the IBM 2250. Therefore the height of the image is 10*(4095/25)=1638 raster units. Since the height of the picture on the IBM 2250 is 4095 raster units, this leaves (4095-1638)/2=1229 raster units above and below the image. Therefore, the proper matrices for the IBM 2250 are:

$$\begin{bmatrix} 0.0 & 25.0 \\ 0.0 & 10.0 \end{bmatrix} \qquad \begin{bmatrix} 0 & 4095 \\ 1229 & 2867 \end{bmatrix}$$

The same graphic elements that were generated for the CALCOMP could be transmitted to the IBM 2250 to produce the identical, but smaller, image with these limits. Scissoring would take place in exactly the same way in both cases.

Suppose further, that the programmer now wished to enlarge the upper right 3 inch by 3 inch section of the CALCOMP plot and display it full screen on the IBM 2250. These matrices are:

$$\begin{bmatrix} 22.0 & 25.0 \\ 7.0 & 10.0 \end{bmatrix} \qquad \begin{bmatrix} 0 & 4095 \\ 0 & 4095 \end{bmatrix}$$

After these matrices are made available to the system, the graphic elements could again be transmitted to produce the desired picture.

Some warnings must be given in regard to this manipulation of scaling and scissoring limits:

1. The manipulations described in the preceding example are completely device dependent. The same manipulations could, however, be done in a much more device independent manner. This can be done by first reading the default device limits to get the upper and lower limits of the device. For example if the retrieved default upper Y limit of the IBM 2250 were used instead of 4095 in the above calculation, then the resulting program would be valid for both the IBM 2250 and the GIF-IDIICM.
2. No check is made in subroutine UGSCAL to see if the given device limits are valid for the device. For example, on the IBM 2250, negative lower limits or upper limits larger than 4095 are not detected as being erroneous.
3. In the horizontal direction, the number of device units per programmer unit is (DXHI-DXLO)/(PXHI-PXLO). In the vertical direction this ratio is (DYHI-DYLO)/(PYHI-PYLO). Under normal conditions these two ratios should be the same. If the ratios are not the same, certain operations performed by the character stroke generator are ambiguous and the programmer could be surprised or unhappy over the result.

SECTION E.1: MODULE UGX112Z

It is possible to write programs for a graphic device which never need the scissoring system because the programmer has assured that nothing will ever be positioned outside the device limits. For these programs it is wasteful to have the scissoring module using core space and slowing the computation at execution time. Therefore an alternate program module is available. If the

programmer creates the load module with the LINK-EDITOR and includes the card:

```
INCLUDE SYSLIB(UGX112Z)
```

in the SYSIN data set, then this alternate module will be used. This alternate module is much smaller and considerably faster because no scissoring is done.

Many of the subroutines in this system contain a character string argument to specify optional or device-dependent information. This section describes the subroutine that is used to scan these option lists to obtain the information from them. The programmer may make use of this subroutine.

SECTION F.1: SUBROUTINE UGX002

This subroutine may be used to scan a character string for certain items. The items to be searched for are described in an input structure, and the results of the scan are inserted into an output structure.

The calling sequence is:

```
CALL UGX002(OPTNS,INDATA,EXDATA)
```

The parameters in the calling sequence are:

OPTNS — The options list which will be scanned. A special character, usually an asterisk, terminates the string.

INDATA — An input structure which specifies the items to be scanned for and the format of the output array. The items which may be scanned for are of five types:

1. A simple flag.
2. A flag, followed by an equals sign, followed by a fixed point number.
3. A flag, followed by an equals sign, followed by a floating point number.
4. A flag, followed by an equals sign, followed by a string of characters (this string of characters cannot include blanks, commas, or the terminal character).
5. A flag, followed by an equals sign, followed by a string of bits (zeros or ones).

INDATA consists of halfwords and character strings intermixed. Its basic format consists of:

1. The number of descriptors in INDATA. This halfword may also be used to supply an alternate string terminator. If the high order byte is zero, the default asterisk is used; if the high order byte is not zero, then this byte specifies the terminating character.
2. Descriptors of the items to be scanned for.

The descriptors have the following format:

1. The descriptor type (1 thru 5).
2. The number of bytes in the flag.
3. A byte offset in the output array where the result of finding a match is to be stored.

4. A type-dependent value (see below).
5. The flag (padded on the right to an even number of bytes).

The type-dependent value for the 5 types has the following meaning:

1. A value which is stored into the two bytes in the output structure if the byte offset is positive, or a value which is OR'ed into the two bytes if the byte offset is not positive.
2. Not used. The number is stored in the output structure as a 2 byte integer.
3. Not used. The number is stored in the output structure as a 4 byte floating point number.
4. The number of bytes in the output structure which are available to hold the characters. Unspecified characters are set to blanks.
5. The number of bytes in the output structure which are available to hold the bits. Unspecified bits will be set to zero.

EXDATA An output structure which will have the processed information stored in it.

No error messages are produced by this subroutine. Any unrecognizable items in the options list are ignored.

The following example may help explain this subroutine. Suppose we wish to scan for items of the form 'CAL/10D', or 'DDNAME=<string>'. First let us specify the output structure. In this structure we need a two byte integer for the first item and an eight byte string for the second item. Therefore:

```
      INTEGER*2    EXDATA(5),FLAG,DDNM(4)
      EQUIVALENCE  (FLAG,EXDATA(1)),(DDNM(1),EXDATA(2))
```

Now that the byte offsets in the output array are known, we can specify the input array as follows:

```
      INTEGER*2    INDATA(16)/2,
     X                        1,7,0,5,'CA','L/','10','D ',
     X                        4,6,2,0,'DD','NA','ME'/
```

With these structures defined, we may now write code to initialize the output array and call the options scanning routine as follows:

```
      FLAG=0
      DO 100 I=1,4
  100 DDNM(I)=0
      CALL UGX002(OPTNS,INDATA,EXDATA)
```

If OPTNS contained 'CAL/10D' then FLAG will be changed to 5; if OPTNS contained 'DDNAME=<string>' then DDNM will be changed so that it contains the given string.

SECTION G: THE INTERNAL FORMAT OF A GRAPHIC ELEMNT

This section describes, in detail, the content of a graphic element. Normally the user will construct graphic elements using the subroutines described in the section on Graphic Element Generation and will not need the information in this section. If the programmer uses this information to construct graphic elements directly, it should be remembered that little checking for invalid graphic elements is done at execution time.

A graphic element is an array of full words reserved to contain picture description information. Basically, the content of a graphic element is a few items of information at the beginning, followed by "blocks" of picture data. Each block begins with a "block specification" and contains either points, lines, text, or other miscellaneous information. In detail, this is:

```
  ELEMNT(1):  Current length of the graphic element (I).
  ELEMNT(2):  The  index of the start of the first block (J).
  ELEMNT(3):  The  index  of the start of the last block (K).
    ...           ...
  ELEMNT(J):  The start of the first block.
    ...           ...
  ELEMNT(K):  The start of the last block.
    ...           ...
  ELEMNT(I+1): The maximum length of the graphic element.
```

Notice that if a graphic element is to be saved in a data set, ELEMNT(1) gives the number of words which must be written. The value in ELEMNT(I+1) need not be saved because its value will depend on the size of the array that will contain the graphic element when it is retrieved.

When subroutine UGEINT is called with the CLEAR option, it resets the graphic element to the following:

```
  ELEMNT(1):  3
  ELEMNT(2):  4
  ELEMNT(3):  0
  ELEMNT(4):  ELTSIZ-1
```

When the RESET option is used, UGEINT sets:

```
  ELEMNT(ELEMNT(1)+1):  ELTSIZ-1
```

The CONTINUE option instructs UGEINT to do the same thing as for CLEAR unless the last block specification was for line data. In that case it sets:

```
  ELEMNT(1):  I
  ELEMNT(2):  4
  ELEMNT(3):  4
  ELEMNT(4)...ELEMNT(I):  A copy of the  block  specification
              for  the  lines and the last end point from the
              line data with the blanking bit set to zero.
  ELEMNT(I+1):  ELTSIZ-1
```

The graphic element generators work by moving the words with the maximum length down, and inserting a block of data into the element. ELEMNT(1), and if necessary ELEMNT(3), are then reset.

The graphic element generators use the pointer to the last block to avoid adding a new block specification when it is not needed.

A point data block consists of the following:

ELEMNT(I): The first halfword contains the characters 'P ' and the second halfword contains the number of full words in the block.

ELEMNT(I+1): The intensity, color, and wink bits. Bits 4 through 7 are reserved for VBRT, BRIT, DIMM, and VDIM; bits 8 through 11 are for COL4, COL3, COL2, and COL1; bit 15 is reserved for WINK.

Following this are the X and Y coordinates in floating point form.

A line data block consists of the following:

ELEMNT(I): The first halfword contains the characters 'L ' and the second halfword contains the number of full words in the block.

ELEMNT(I+1): The intensity, color, wink, and line structures bits. Bits 28 through 31 are reserved for DOTS, DDSH, DASH, and SOLD.

Following this are the X and Y coordinates in floating point form of the end points of the line segments. The blanking bit is in bit 31 of the Y coordinate.

A text data block consists of the following:

ELEMNT(I): The first character contains 'C'; the second contains '1' (for stroke generator only), '2' (for character generator if possible), or '3' (for character generator only) and the second halfword contains the number of full words in the block.

ELEMNT(I+1): The intensity, color, and wink bits.

ELEMNT(I+2): The rotation angle in floating point form.

ELEMNT(I+3): Either the character spacing for the stroke generator in floating point form or the character sizes VLRG, LARG, SMAL, and VSML coded in bits 28 through 31.

Following this may be an arbitrary number of sub-blocks consisting of the following:

ELEMNT(I): X coordinate of the center of the first character in floating point form.

ELEMNT(I+1): Y coordinate of the center of the first character in floating point form.

ELEMNT(I+2): The start of the characters, four to a word and one to a byte, with the first byte containing the number of characters.

A data block for invoking element-subroutines consists of the following:

ELEMNT(I): The first halfword contains the characters 'I ' and the second halfword contains the number of full words in the block.

ELEMNT(I+1): The intensity, color, wink, and line structure bits.

ELEMNT(I+2): The rotation angle in floating point form.

ELEMNT(I+3): The scaling value in floating point form.

Following this may be an arbitrary number of sub-blocks consisting of the following:

ELEMNT(I): X coordinate of the relative origin of the element-subroutine in floating point form.

ELEMNT(I+1): Y coordinate of the relative origin of the element-subroutine in floating point form.

ELEMNT(I+2): The first halfword is not used; the second halfword contains the identification of the element-subroutine.

A data block containing information which is to be transmitted to the display device in unmodified form consists of the following:

ELEMNT(I): The first halfword contains the characters 'X ' and the second halfword contains the number of full words in the block.

ELEMNT(I+1): The intensity, color, wink, and line structure bits.

Following this may be an arbitrary number of sub-blocks consisting of the following.

ELEMNT(I): The start of the information, four bytes to the word, with the first byte containing the number of bytes in the sub-block.

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

V

W

X

Y