Acknowledgements

The following people have contributed significantly in the development, implementation, verification, and installation of the Common Graphics Library (CGL): David L. Miner, Alicia S. Hofler, Michelle S. Hollis, Scott Nolf, and Debbie M. Garrett. Also contributing in these regards are: Bradford D. Bingel, Eric L. Everton, Mary M. Johnson, Erma L. Wilson, and Helen O. Yue.

We thank the following individuals for their careful reading and constructive comments: Connie Curran, Wesley L. Goodman, Christopher J. Harris, Mary K. McCaskill, and Eleanor C. Wynne.
# Common Graphics Library (CGL)
## Volume II: Low-Level User's Guide
April 1989

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How To Use This Document

Volume II documents the use of the Common Graphics Library's (CGL) Low-Level routines. This manual is intended to serve both as a user's guide and reference manual.

Section 1 provides an introduction to the CGL by describing its purpose and capabilities. This section acquaints the user with an overview of the New Graphics System (NGS) and reveals the significance of the Common Graphics Library.

Section 2 consists of basic terms and definitions which are used throughout the remainder of the document.

Section 3 consists of a detailed description of how to use the Low-Level routines. This section is primarily intended to provide a basic understanding of the necessary attributes, primitives, graphic components, coordinate systems, and graphical environment necessary to use the Low-Level routines.

Section 4 gives an overview of the error detection and debugging capabilities available in the Low-Level routines.

Section 5 describes how to interface the CGL Low-Level routines with other graphics packages. This section will discuss the requirements necessary to interface the Low-Level routines with any graphics package, then use the LEZ routines as a specific example.

Section 6 gives a general overview of postprocessing considerations.

Appendix A supplies a complete description of each Low-Level routine, providing a description of the arguments, the routine's restrictions, and any relevant notes.

Appendix B is a collection of commented test cases accompanied with the corresponding graphics output. The examples in this section are intended to reflect some of the typical charts generally desired by various groups at Langley.

Appendix C provides a list of DI-3000 routines. Although the user must know DI-3000 to use the Low-Level routines, this list is included for completeness, and provides the functionality of the DI-3000 calls.

Appendix D shows the user how to access and execute the CGL on various computers.
Glossary

ACD  Analysis and Computation Division

attribute  An inherent characteristic generally used in describing an external appearance of an entity (e.g., color, height, etc.)

bar chart  A chart consisting of rectangles with heights representing a dependent value at an associated independent position.

CDC  Control Data Corporation

character axis  An axis which has evenly spaced tick marks with text tick mark labels.

chart  A graphical representation giving information in tabular form. Plots which are "bars" are referred to as "bar charts", while plots which use "pie segments" are referred to as "pie charts".

Common Library  A subroutine library which satisfies LaRC local requirements and generates features not supported by other graphics libraries.

composite chart  A collection of two or more charts on a single display area (terminal screen, graphics frame, etc.).

CORE  A proposed graphics standard developed by the Association of Computing Machinery's Special Interest Group on Graphics (SIGGRAPH).

data coordinates  A user-defined set of coordinates in which the data is to be plotted. This term is used interchangeably with data space. See section 2 for a description and example.

defaults  A set of initial values for a set of attributes.
device driver | A device-dependent program that supports a specific graphics device. The device driver generates device-dependent output from device-independent input and handles device-dependent interaction.

device independence | The ability to control all graphics devices uniformly.

frame | A complete unit of plotting. A final figure. A page.

frame eject | A frame eject clears the display area of the selected graphics device in preparation for the next frame of picture(s).

FSGB | Flight Software and Graphics Branch of ACD

GKS | Graphics Kernel System - a graphics standard approved by ISO.

graphics session | time in which interaction with, or use of a graphics package takes place.

High-Level routines | A set of routines providing an interface to generate specific chart types.

interval units | The increment between numeric major tick labels.

ISO | International Standards Organization

kernel | A subroutine library which contains all required functions for performing interactive and passive graphics tasks.

key | A list of words or phrases giving an explanation of symbols or abbreviations.

LaRC | Langley Research Center

LARCGOS | A library of locally written graphics subroutines and a set of postprocessors that drive the ACD Production Devices. LARCGOS is part of the Old Graphics System (OGS).
line graph  A graph in which points represent values of a variable for suitable values of an independent variable and are connected by line segments. Line graphs available in the Common Graphics Library include linear charts (those with linear axes) and logarithmic charts (those with logarithmic axes).

linear axis  An axis which has a linear progression of numeric major tick mark labels.

linear chart  A chart in which both axes are linear (see section 2 for a description and an example).

logarithmic axis  An axis which has a logarithmic progression of numeric major tick mark labels.

logarithmic chart  A chart in which both axes are logarithmic (see section 2 for a description and an example).

Low-Level routines  A set of routines in the Common Graphics Library which provide graphical support in the generation of plots unique to the graphics requirements of LaRC.

metafile  A sequential file which contains the device-independent picture information necessary to produce the desired graphical output.

metafile translator  The program which interprets the device-independent metafile commands for specific physical devices.

MOVIE.BYU  A graphics display system written at Brigham Young University.

NASA line patterns  A set of LaRC preferred line patterns used to represent data in line charts.

NASA Logo  An emblem officially recognized by NASA.

NASA symbols  A set of LaRC preferred symbols used to represent data in line graphs.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAR</td>
<td>A library of graphics subroutines written at the National Center for Atmospheric Research.</td>
</tr>
<tr>
<td>NGS</td>
<td>New Graphics System at LaRC</td>
</tr>
<tr>
<td>NOS</td>
<td>Network Operating System running on Control Data computers.</td>
</tr>
<tr>
<td>OCO</td>
<td>Operations Control Office in Building 1268 at LaRC</td>
</tr>
<tr>
<td>OGS</td>
<td>Old Graphics System at LaRC</td>
</tr>
<tr>
<td>page coordinates</td>
<td>A user-defined set of coordinates in which all charts and their components can be described.</td>
</tr>
<tr>
<td>passive graphics</td>
<td>Graphics requiring no dynamic interaction with the display.</td>
</tr>
<tr>
<td>PC</td>
<td>Personal computer (e.g., IBM PC XT)</td>
</tr>
<tr>
<td>pie chart</td>
<td>A diagram consisting of a circle which is divided by radii, called pie segments, each of which represent a part of a whole entity.</td>
</tr>
<tr>
<td>pie segment</td>
<td>Section of a circle consisting of an area swept out by a radius.</td>
</tr>
<tr>
<td>postprocessor</td>
<td>A device-dependent program that drives an ACD production device.</td>
</tr>
<tr>
<td>PRIMOS</td>
<td>PRIME Operating System</td>
</tr>
<tr>
<td>production devices</td>
<td>Batch graphics output facilities at the Central site; includes Calcomp, Varian, and Versatec.</td>
</tr>
<tr>
<td>publication standards</td>
<td>A set of requirements describing the appearance and contents of plots which must be satisfied for use in technical documents published through the NASA publication process.</td>
</tr>
<tr>
<td>PVI</td>
<td>Precision Visuals, Inc. of Boulder, Colorado</td>
</tr>
<tr>
<td>scale factor</td>
<td>The change in value per scale increment (between major tick marks).</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>scale origin</td>
<td>The beginning lower scale value. This is usually the minimum value or an adjusted minimum value.</td>
</tr>
<tr>
<td>selected graphics</td>
<td>A graphics device which is enabled to receive graphics output or to send graphics input.</td>
</tr>
<tr>
<td>device</td>
<td></td>
</tr>
<tr>
<td>semi-log chart</td>
<td>A chart with one linear and one logarithmic axis.</td>
</tr>
<tr>
<td>tick mark</td>
<td>Short lines at specified intervals denoting grid.</td>
</tr>
<tr>
<td>viewgraph</td>
<td>A set of requirements describing the appearance and contents of plots which must be satisfied for use in audience presentations.</td>
</tr>
<tr>
<td>standards</td>
<td></td>
</tr>
<tr>
<td>workstation</td>
<td>An abstract logical unit consisting of zero or one display surface and zero or more input devices.</td>
</tr>
<tr>
<td>2D</td>
<td>Two-dimensional</td>
</tr>
<tr>
<td>3D</td>
<td>Three-dimensional</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

The Common Graphics Library (CGL) is a simple-to-use, yet powerful graphics package which enables the user to view data quickly and easily, provides a means of generating publication and/or viewgraph quality charts, and satisfies LaRC's unique graphics requirements.

The use of the Low-Level routines of the CGL, documented in this manual, requires a working knowledge of the DI-3000 graphics package. In developing a graphics program, the Low-Level routines work in conjunction with the DI-3000 routines. The LEZ routines of the CGL should be examined to determine if the user's application can be accomplished at the highest level (i.e., LEZ routines).

The graphics requirements at LaRC are very diverse in nature, reflecting the variety of applications (i.e., scientific, engineering, business, etc.) present at NASA Langley. The CGL and this manual concentrate on 2D chart generation. The three basic chart types generated by the CGL include: line/logarithmic charts, bar charts, and pie charts (see Figure 1-1). A few of the library's most sought after features include:
- multiple plots per frame;
- multiple data sets per plot;
- the ability to access multiple fonts (i.e., Greek, math symbols, etc.) and text mnemonics (i.e., subscripts, superscripts, etc.);
- color capability;
- the creation of metafiles (for hard copy postprocessing); and
- the ability to automatically scale and determine increments for axes suitable for publication quality reports.

1.1 Capabilities and Structure of the Common Graphics Library

The CGL has two user interface levels, a set of generalized High-Level (Langley Easy, or LEZ) routines [G-12], and a set of specific Low-Level routines [G-13] (see Figure 1-2). These two levels reflect the degree of sophistication both in terms of difficulty of use and provided capabilities.

The LEZ routines, intended for users with no graphics experience, provide a stand-alone means to generate complete report-quality charts. At this level, the user controls aspects of an entire chart, that is conceptually designs and composes complete charts without being involved in the complexity of the underlying graphics package. While this level of separation frees the user from learning the underlying graphics package, it also ensures that the application program will require no or little change even if the underlying graphics package is modified or replaced (i.e., possibly by a graphics standard like the Graphics Kernel System - GKS).
a) Composition of Superalloy

b) Low pressure fatigue of Superalloy

c) Temperature vs. entropy for Superalloy

Figure 1-1. Three basic chart types. Pie chart (top); bar chart (middle); line chart (bottom).
The **Low-Level routines**, which require the user to have an *applied knowledge of DI-3000*, allow the user to manipulate chart components, and thereby design specific report-quality charts for unique or unusual purposes. The features at this level can be used alone with the base graphics package, or in conjunction with other packages (e.g., LEZ, etc.) to enhance or augment their capabilities. Since the user is constructing a chart from components, the user has a greater range in the diversity of charts to be generated. However, this diversity is offset by a greater programming effort. It is recommended that the LEZ routines be examined first to determine if the user's application can be accomplished at the highest level possible.

The capabilities of both levels are presented as an *application-independent* graphics package written in ANSI FORTRAN 77, and currently uses DI-3000 as its underlying graphics package. The library is therefore machine-independent, providing support for *centralized and/or distributed* computer systems.

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**Figure 1-2. Structure of the Common Graphics Library from an application viewpoint.**
1.2 Common Graphics Library’s Prominence in the New Graphics System (NGS)

The Common Graphics Library is a FORTRAN user-callable library which can be used independently or in conjunction with other graphics packages. This subsection is intended to briefly describe how the Common Graphics Library is related to NGS. The Graphics MINI Manual [G-1] identifies and describes the various graphics software and hardware components, details the interfaces between these components, and provides information concerning the use of these components at LaRC. Figure 1-3, the NGS hierarchy structure, shows the major graphics software packages and hardware devices currently supported.

As previously described, the Low-Level routines of the Common Graphics Library interface with the underlying graphics package directly. The level of sophistication of the Low-Level routines enable the software packages which are functionally higher in the hierarchy to utilize these capabilities. To interface the CGL with other graphics packages, the user must either directly modify the package calling the CGL or use the CGL in conjunction with the calling package adhering to the constraints of both packages.

1.2.1 Underlying Graphics Package

Currently, DI-3000 is the application independent, underlying graphics package serving as a primary component of the CGL. The LEZ routines provide an abstract interface which is “commercial graphics package independent”. This implies that the calling sequence and arguments supplied to the LEZ routines do not rely on a specific underlying graphics package. This independence is conducive to future transitions of the LEZ routines from DI-3000 to another underlying graphics package (e.g., GKS).

The Low-Level routines interface with DI-3000 directly, and are therefore “context sensitive” (i.e., must conform to the requirements of “where” and “how” the graphical components can be created and generated). Additionally, the capabilities of the Low-Level routines depend heavily upon the primitives and attributes present in the underlying graphics packages (e.g., color, character, fonts, interim line patterns, etc.).
Figure 1-3. NGS hierarchy structure.
1.2.2 Device Drivers

The following is an overview of the NGS device drivers, and how the CGL interfaces with them. The user is referred to the Graphics Mini Manual [G-1] for a more detailed description of the device drivers.

Each of the NGS software components interface to a hardware device through a device driver. A DI-3000 device driver is a collection of device specific subroutines that drive a particular display device. A separate DI-3000 device driver is associated with each graphics output device. A special device driver, the metafile driver, produces a file of device independent graphics information that may be processed by the METAFILE TRANSLATOR [G-6]. The features of each device driver are documented in the Device Driver Guide [G-10]. Although the device driver is linked at load-time, the user must initialize, select, and perform other device action from within the application program. Each device is assigned as an integer number. For load-time device selection, the metafile driver is assigned "0" and any other device is assigned "1".

Since the LEZ routines are not restricted to a specific general purpose graphics package, but provides an abstract interface, the following call selects and initializes the identified device(s):

\[
\text{CALL LEZINI (IDEV)}
\]

where IDEV is the assigned device name (0 - metafile, 1 - Interactive device, 2 - both metafile and interactive device). Note, this routine can be called again to select and deselect specific devices. A complete description of selecting and initializing the underlying graphics package from the LEZ routines can be found in Appendix A [G-12] in the description of LEZINI.

When the Low-Level routines are used solely in conjunction with the underlying graphics package, then the underlying graphics package will provide the means by which the device drivers are initialized and selected. In the case of the Low-Level routines of the CGL, and the underlying graphics package DI-3000, the device driver must be selected and initialized with the following DI-3000 calls

\[
\begin{align*}
\text{CALL JDINIT (IDEV)} \\
\text{CALL JDEVON (IDEV)}
\end{align*}
\]

where IDEV is the assigned device number (0 - metafile, 1 - interactive device). A complete description of selecting and initializing DI-3000 can be found in the DI-3000 User's Guide [G-5].
1.3 LaRC's Unique Plotting Requirements

The graphics requirements at LaRC are very diverse in nature, reflecting the variety of applications (business, CAD/CAM, engineering, and scientific, etc.) present at NASA Langley. The CGL and this manual concentrate on 2D chart generation. These types of charts include: line/logarithmic charts, bar charts, and pie charts. See Section 2 for a description of each chart type.

Unlike a commercially developed general purpose graphics package which is typically designed for the graphics user community at large, the CGL is tailored toward a specific set of restrictions proposed by LaRC. This set of requirements necessitated the development of a Langley specific graphics library, the Common Graphics Library. One of the chief considerations in the design of the CGL was the capability of generating publication quality charts requiring a minimal of effort.

The format of computer-generated charts must conform to various criteria depending on where and how the charts are to be used. Several types of journals and technical papers require that the charts are acceptable to the Langley publication process. The remainder of this subsection will provide only the basic characteristics of this criteria, whereas a complete description can be found in "Guidelines in Preparing Computer-Generated Plots for NASA Technical Reports with the LaRC Graphics Output System" [G-2].

A fundamental intent of the CGL is to provide a set of primitive routines unique to LaRC. These requirements partially consist of: the NASA line patterns, the NASA symbols, and the NASA logo.

The NASA line patterns consist of the following eight line patterns in the following sequence:

```
1
2
3
4
5
6
7
8
```

Figure 1-4. NASA standard line patterns.
The NASA symbols consist of the following symbols in the following sequence:

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16
   ○  □  ◊  △  △  ○  ○  ◊  ◊  △  +  △  ○  ○  ○  ○

Figure 1-5. NASA standard symbols.

If a flag is desired, add 100, 200, 300, ..., 800 to the base symbol number. Note, symbols one through ten are recommended for publication quality plots.

1  101  201  301  401  501  601  701  801
   ○  ○  ○  ○  ○  ○  ○  ○  ○

Figure 1-6. NASA standard symbols with flags.

If a solid filled symbol is desired, add 900 to the base symbol number. Note, however, the use of solid filled symbols is not desirable for publication quality charts.

901

Figure 1-7. NASA standard symbols - solid filled.

The NASA logo is an emblem officially recognized by NASA. The policy governing the use of the NASA logo is documented in the NASA Management Manual (NMI 1020.1G Paragraph 13b).

Figure 1-8. NASA logo.
1.4 Use of the CGL for Publication Purposes

In addition to these primitives, the page layout and the contents of the charts must conform to the criteria determined by the chart's intended audience. For example, the sizes and distances between various chart elements must be sufficient to provide a clear and legible chart.

The intent of the publication quality standard is to ensure that charts will consistently be published legibly with no loss of integrity. As such, a set of publication parameters are defined that control the size of the characters used for labeling, the distances to the labels, the distances between lines and columns, the length of tick marks, and the symbol sizes. Whereas, the use of viewgraph standards ensures that charts being presented to a group will show the data clearly and legibly.

The Common Graphics Library provides a method to obtain publication and viewgraph quality charts. By default, the CGL will conform to publication quality standards by providing:

- appropriate sizes and distances between various chart components;
- data curves using lines and symbols, such that the line does not pass through the symbols;
- text attributes suitable to acceptable publication standards; and
- appropriate distancing between tick mark labels and the axes.

Because the CGL defaults to the use of these NASA standards, the user is required to have a minimum knowledge of the actual specifications needed to obtain these charts. However, the user is responsible for using the library in such a way as to stay within the criteria of the publication process. The user should ensure that:

- user defined text heights and widths are acceptable;
- appropriate capitalization of text conforms to standards;
- numeric tick mark labels have suitable scale factors;
- text does not overwrite other components (and/or text); and
- content is appropriate for the audience's clarity.
1.5 Planning Figures for Publication

It is a common practice that most of the figures in NASA reports are grouped together at the end of the report instead of inserted in the text; therefore, all figures should be as uniform as possible. However, authors are instructed to discuss requirements with the editors if they want figures integrated in the text. The basic rules to follow in planning uniform figures are:

1. The chart perspective should be read from one point; the person reading the charts should not have to rotate the paper to read the charts. The one exception to this rule is a long vertical label.

2. The plot areas should be kept the same size and the charts should be oriented the same throughout the report.

3. The same scale per unit value (scale increment) should be used on similar data, even if the data are in different ranges. For example, a scale increment, for an angle should remain the same even if the range is 0 to 90 for one chart and 90 to 180 for another chart.

4. The vertical figure orientation (see Figure 9) is preferred. The vertical measurement is 9 3/16 inches (233.4 mm.) and the horizontal measurement is 7 1/8 inches (181.0 mm.).

5. The horizontal figure orientation (see Figure 10) is not preferred because the report must be physically rotated to view the figure, but there are times when the data necessitates using the horizontal figure. The horizontal measurement is 9 3/16 inches (233.4 mm.) and the vertical measurement is 7 1/8 inches (181.0 mm.).

6. All labeling within the plot area should be the same size even if the figure is divided into multiple parts. If a figure is divided into multiple parts, the height of the full-size character for labeling is based on the size of the whole figure, not each separate part.

7. Horizontal axis should represent independent data, vertical axis should represent dependent data.

8. Character heights should be 1/4 greater than widths (or conversely width should be 0.8 of height).
Figure 1-9. Vertical figure orientation.
Figure 1-10. Horizontal figure orientation.
2. BASIC CONCEPTS AND TERMINOLOGY

This section provides an overview of the various types of charts and identifies and illustrates their various components. This section is intended as a reference only. Conceptually, this section begins with the more abstract concepts and breaks them into smaller, more refined elements.

2.1 Terms 'Chart' and 'Plot'

The terms chart and plot are often used interchangeably, but have subtle differences depending on the context in which they are used.

chart - a diagram (a series of one or more symbols, lines, line segments, curves, tabular data, or areas) that represents the variation of a variable in comparison with that of one or more other variables. Charts which depict linear data are referred to as "line charts" or "linear charts". Charts which depict logarithmic data are referred to as "log charts" or "logarithmic charts". Charts which use "bars" are referred to as "bar charts", while plots which use "pie segments" are referred to as "pie charts". There are three basic chart types: linear/logarithmic charts, bar charts, and pie charts (see Figure 1-1). Each type is explained in a following subsection, and concepts specific to each are detailed.

plot - one or more charts on a single display area (terminal screen, graphics frame, etc.). Thus, "plot" is used interchangeably in this document as a generic term for "chart".

composite chart - a collection of two or more charts on a single display area (terminal screen, graphics frame, etc.).
2.2 Coordinate Systems

A fundamental approach in chart generation using the CGL routines is to conceptually distinguish between entities framing the data (e.g., axes, text, etc.), and the data itself. To facilitate chart generation, two independent windows are typically established, and are referred to as page coordinates and data coordinates.

**Page coordinates** - The CGL routines allow the user to define a coordinate system in which to describe all charts and their components. This system provides a unit of measure allowing the user to establish lengths and distances (e.g., axis length, axis positioning, etc.). This coordinate system is referred to as page coordinates (or page space). The units used to describe the page boundaries can be determined by the user, and can represent any unit of measure the user wishes. If the user is going to send the charts to a postprocessing device, a compatible unit of measure is desirable (e.g., inches or millimeters).

![Figure 2-1. Page coordinates.](image-url)
data coordinates (or data space) - The CGL routines allow the user to define a coordinate system in which the data is to be plotted. The user controls the range and values of the data coordinate system through calls to the appropriate routines. The data coordinates only affect how and where the data is to be plotted on the page. If data to be plotted lies outside the data space, then those data values may optionally be clipped (i.e., not plotted). The location of the data coordinate system is typically determined by the boundaries formed by a set of axes (two or more).

\[ y = \left| 100 \cos(18x) \right| \]

Figure 2-2. Data coordinates.
2.3 **Linear/Logarithmic Charts**

A linear/logarithmic chart is a diagram which uses a series of one or more symbols, lines, line segments, and/or a combination of these to represent data. For a linear chart, the scale factor (i.e., the change in values between major tick marks) progresses in a linear fashion. For a logarithmic chart, the scale factor progresses in a logarithmic fashion.

Charts are further classified based on the scale factors for the dependent and independent axes:

- **linear chart** - both axes are linear
- **logarithmic chart** - both axes are logarithmic
- **semi-log chart** - one axis is linear and logarithmic.

The CGL line plotting routines will generate publication and/or viewgraph line charts with the NASA line patterns and symbols. When a data curve is represented with both lines and symbols, the CGL routines will display the data with the line not passing through the symbol. The user may plot linear, logarithmic, or semi-log charts. The CGL line routines offer the capability of generating a "key", which provides additional information about the data in the chart. By the use of unique line patterns and symbols, it is possible to plot a family of curves which can clearly be seen either on a color viewgraph, or on a black and white printed report.
1) **horizontal axis** -
   the axis parallel to the bottom of the figure orientation when viewing the page from the intended perspective. The horizontal axis usually represents the independent data.

2) **vertical axis** -
   the axis parallel to the side of the figure orientation when viewing the page from the intended perspective. The vertical axis usually represents the dependent data.

3) **major tick mark** -
   short lines at specified intervals perpendicular to the axis being denoted.

4) **major tick mark labels** -
   a character or numeric description associated with a major tick mark. Often referred to as "tick mark labels".

5) **minor tick marks** -
   short lines (preferably shorter than major tick marks) between major tick marks perpendicular to the axis being denoted.

6) **scale factor** -
   the change in value between numeric major tick marks.

7) **axis label** -
   a text string describing the properties associated with an axis.

8) **key** -
   a block of information placed within the page boundaries, explaining any codes or symbols used on the chart.

9) **key entry** -
   a line consisting of a description associated with a symbol and/or line.

10) **caption** -
    the figure number and title. Often referred to as a chart title.
The following figure illustrates the various components of linear/logarithmic charts.

Vortex flow about a 60° delta wing with α=20°

Figure 2-3. Linear/logarithmic chart components.
2.4 Bar Charts

A bar chart is a diagram which uses a series of rectangles. The height of each rectangle represents a dependent value at an associated independent position.

The charts may be represented in an absolute manner (side by side) contrasting the data distinctly. The charts may be represented in an additive manner (stacked) showing their cumulative properties. A key option can be used to provide additional information concerning multiple data sets.

1) **horizontal axis** -
   the axis parallel to the bottom of the figure orientation when viewing the page from the intended perspective. The horizontal axis usually represents the independent data.

2) **vertical axis** -
   the axis parallel to the side of the figure orientation when viewing the page from the intended perspective. The vertical axis usually represents the dependent data.

3) **major tick mark** -
   short lines (preferably shorter than major tick marks) between major tick marks perpendicular to the axis being denoted.

4) **major tick mark labels** -
   a character or numeric description associated with a major tick mark. Often referred to as "tick mark labels".

5) **minor tick marks** -
   short lines between major tick marks perpendicular to the axis being denoted.

6) **scale factor** -
   the change in value between numeric major tick marks.

7) **axis label** -
   a text string describing the properties associated with an axis.

8) **key** -
   a block of information placed within the page boundaries, explaining any codes or symbols used on the chart.
9) key entry -
   a line consisting of a description associated with a symbol and/or line.

10) caption -
    the figure number and title. Often referred to as a chart title.

Figure 2-4. Bar chart components.
2.5 Pie Charts

A pie chart is a diagram consisting of a circle which is divided by radii, called pie segments, each of which represent a part of a whole entity. The following figure illustrates the various components of a pie chart. Pies are most often used in showing the "percent of" or "composition of" a particular item.

The LEZ routines generates complete pie charts. Although there are no Low-Level pie routines, this type of chart is presented in the Low-Level document because it is often requested, and can easily be generated from the underlying graphics package and the Low-Level routines.

1) **radius** -
   the length of a line segment extending from the center of a pie segment to the pie segment circumference.

2) **origin** -
   the center of the pie.

3) **pie segment** -
   a wedge-shaped polygon representing a percentage of the entire pie.

4) **pie segment text label** -
   a description associated with a pie segment.

5) **pie segment quantity label** -
   the actual value of which the segment represents.

6) **pie segment percentage label** -
   the percentage of the pie which the segment denotes.

7) **key** -
   a block of information placed within the page boundaries, explaining any codes or symbols used on the chart.

8) **key entry** -
   a line consisting of a description associated with a symbol and/or line.

9) **caption** -
   the figure number and title. Often referred to as a chart title.
Present responsibilities

- Second project
- Supervise workers
- Meet with supervisor
- Main project
- Answer questions
- Others

25 employees 3.2 35.6%

All employees

1 employee 1.0 11.1%

3 employees 1.5 16.7%

16 employees 0.5 5.6%

12 employees

Daily activities

All employees 1.2 13.3%

1.6 17.8%

Figure 2-5. Pie chart components.
2.6 Composite Charts

The CGL routines can easily generate multiple charts per page, hereafter referred to as composite charts. The number and type of charts that can be placed on a page is limited only by the user-definable page size.

Vortex flow about a 60° delta wing

Figure 2-6. Example of a composite chart.
3. THE LOW-LEVEL ROUTINES

This section focuses on the prerequisites and criteria needed to use the Low-Level routines. Since the CGL is written in ANSI FORTRAN 77, resides on top of the general purpose graphics package, and has no machine dependencies, the following section applies to all machines. However, the method of linking this library during execution time, is system dependent, and can be found in Appendix D.

3.1 Introduction

The Low-Level routines are a group of ANSI FORTRAN 77 routines, which utilize the graphics primitives of the underlying graphics package. A graphics routine call will either cause graphical operations to be performed (i.e., move, draw, etc), or will modify graphical attributes (i.e., color, text size, etc.). The CGL includes both the manipulation of graphical output, and the setting of environmental attributes, in addition to its own graphical operations.

The generation of a chart typically consists of displaying data in one or more regions associated by a set of scales (i.e., axes, grids, etc.). Subsection 3.3 will describe several techniques of establishing several regions, and a method to conveniently display the associated data sets. But, in order to use the Low-Level routines it is necessary to understand how these routines interface with the underlying graphics package. Note, the Section 3.2 will provide an overview of the characteristics of the graphical interface, Section 3.3 provides a step by step basis demonstrates these points while generating a line chart.

3.2 Underlying Graphics Package Characteristics used by the Low-Level Routines (using DI-3000 as an Example)

The Low-Level routines assume the user is familiar with DI-3000 or a similar general purpose graphics package (e.g., GKS). This section will describe how the Low-Level routines interface with the underlying graphics package. Appendix C contains a list of all DI-3000 routines with a brief description of their purpose.

The basic skeleton of a graphics program is outlined in Figure 3-1, and is described in the DI-3000 User’s Guide [G-5]. The three major components consist of a graphical environment, coordinate systems, and graphical primitives and attributes. The Low-Level routines provide an additional set of graphical output capabilities with associated attributes. These graphical
capabilities (e.g., axes, grids, etc.), although not themselves primitives (i.e., move, draw, etc.) are built using the output primitives of the underlying graphics package.

Most DI-3000 programs have the same basic program structure as shown below. The following figure comes from the DI-3000 User's Guide [G-5], and is described there in more detail.

![DI-3000 basic skeleton program.](image)

Figure 3-1. DI-3000 basic skeleton program.
3.2.1 Graphical Environment

The graphical environment consists of the establishment (i.e., initialization and termination) of the graphics package and the graphics devices, in addition to providing an appropriate graphical context necessary to use the Low-Level routines.

Unlike the CGL LEZ routines which provide a high-level abstract user interface incorporating the establishment of the graphical environment, the Low-Level routines must be called after the user has ensured the appropriate graphical environment has been established. The Low-Level routines only augment the existing graphics package capabilities.

The first Low-Level routine to be called must be CBEGIN. This routine initializes all CGL related variables. Each variable has an associated default which is assumes when CBEGIN is called. The invocation of CBEGIN is functionally independent of DI-3000, and can be called anytime at any place. However, subsequent invocations will reset any user defined CGL attributes.

**CALL CBEGIN**

The majority of the Low-Level routines must be called at a point which is appropriate to their function. CBEGIN initializes CGL variables and can be called anytime; whereas Low-Level routines which perform graphical operations (i.e., output, attribute setting, etc.) must be called in context when graphical output can be generated. In DI-3000, this context is referred to as an opened segment. Figure 3-2, described in the DI-3000 User's Guide[G-5], shows a DI-3000 skeleton program necessary to establish the graphical environment.

Within this framework a combination of DI-3000 based packages may be used. For example, DI-3000 primitives and CGL primitives could be invoked independently, or in combination. Other DI-3000 graphics packages, such as GRAFEASY or GRAFMAKER, may already incorporate parts of the graphical environment into its structure, such as initialization/termination, or the opening/closing of segments. Thus, each package's environment may vary. A more detailed discussion of how to intermix other graphics packages with the Low-Level routines can be found in Section 5.
3.2.2 Coordinate Systems

Once the appropriate graphical environment and associated primitive attributes have been established, then the graphical output routines can be invoked. Note, the graphical output will be generated to the current segment which must be opened prior by the user.

Additionally, the positioning and sizing of the graphical output generated will be in accordance with the current coordinate system established (i.e., world and virtual coordinate systems). The routine CVSPAC determines the largest possible viewspace, based on the width and height passed, and calls JVSPAC accordingly. Most notably, this routine sets an internal variable (VUINCH), which is the relationship between virtual coordinates and page coordinates.

Each CGL graphical routine has a unique set of routine arguments and attributes. For example, Figure 3-3 illustrates the invocation of the routine CNASA. This routine will use the current position (CP) of the present world coordinate system and the current text justification (JJUST) to determine the current point's relationship within the resultant logo. Figure 3-3 shows a partial program using the current coordinate system and the CGL.
PROGRAM ...

C----------------------------------------------------------------------
C SIMPLE PROGRAM TO DEMONSTRATE THE USE OF A COORDINATE SYSTEM
C----------------------------------------------------------------------
C INITIALIZE DI-3000
CALL JBEGIN

C----------------------------------------------------------------------
C THIS MUST BE THE FIRST CGL CALL TO INITIALIZE THE CGL
CALL CBEGIN

C----------------------------------------------------------------------
C WRITE TO THE IDEV DEVICE
   IDEV=0
   CALL JINIT(IDEV)
   CALL JDEVON(IDEV)

C----------------------------------------------------------------------
C SET UP THE VIEWING WINDOW
   CALL JWINO(0.,11.,0.,11.)

C----------------------------------------------------------------------
C OPEN CURRENT SEGMENT
   CALL JOPEN

C----------------------------------------------------------------------
C A LOOP WHICH PRINTS NASA LOGO USING TEXT JUSTIFICATION (JJUST), AND
C WORLD COORDINATES (JMOVE).
   DO 1 I=1,10
      CALL JJUST(I,1)
      CALL JMOVE(REAL(I),1.)
   1 CALL CNASA(0.,0.3,0)

C----------------------------------------------------------------------
C ENDS ALL GRAPGICS AND CLOSES CURRENT SEGMENT
   CALL JPAUSE(IDEV)
   CALL JCLOSE
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
   STOP
   END

Figure 3-3. Example of the use of a coordinate system.
3.2.3 Page Coordinates and Describing Components

A convenient approach to aid the user in designing a chart is to establish a coordinate system, referred to here as page coordinates, which easily enables the user to arrange and describe the chart components. The page coordinates can be of any dimension and represent any unit. Since publication-quality charts are often requested, the page coordinates described in the document are typically in terms of inches to coincide with the postprocessors (plotters).

A call to CVSPAC will set up the viewspace and viewport, and set appropriate internal CGL attributes. For example, the following calls will establish a square viewspace, and internally determine how virtual coordinates relate to the associated page coordinates.

CALL CVSPAC(9., 9.)

In this example, the viewspace and viewport will be set to the largest possible square on the device. The internal relationship between page coordinates and virtual coordinates (determined by CVSPAC) is the extent of the viewspace to a 9 by 9 region. In DI-3000, the viewspace boundaries are -1 to 1, thus the relationship is 2/9.

CALL JWINDO(0., 9., 0., 9.)

A call to JWINDO(0., 9., 0., 9.) will establish the current window to match the virtual coordination system, and the internal relationship. Note, it is important to have the same aspect ratio for the window (JWINDO) and viewport (CVSPAC) to avoid distortion.

Once the page coordinates have been recognized, the user can position and describe objects in terms of the page coordinates. For example, the following code will output a graphics string as a title, and draw a set of axes to illustrate positioning and sizing (as shown in Figure 3-6).
C SET VIEWSPACE AND WINDOW
CALL CVSPAC(9., 9.)
CALL JWINDO(0., 9., 0., 9.)
C OPEN A SEGMENT
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.2, .2*1.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER, CENTER)
CALL JMOVE(4.5, YORG+YLEN+.5)
CALL JJUST(2, 2)
C OUTPUT THE STRING
CALL JHSTRG('A Title')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1, .1*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG, YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS', 1)
CALL CHAXIS(5., 10., 1., XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXIS', 1)
CALL CVPREC(3)
CALL CVAXIS(.0, .01, .001, YLEN)

A Title

Figure 3-4. Example of outputting a set of linear axes.
3.2.4 Graphics Primitives and Attributes

Each type of output primitive has an associated set of primitive attributes. Attributes determine the appearance and characteristics of the graphics output. For example, drawing attributes involve such factors as line attributes (i.e., line color, line width, etc.), marker attributes (i.e., symbol number, symbol size, etc.), polygon attributes (i.e., interior color, interior pattern, etc.), and text attributes (i.e., text font, size, and justification).

The CGL uses a combination of underlying attributes and CGL attributes associated with a particular output primitive. The specific attributes required for each CGL routine are identified in Appendix A. Thus the user must coordinate and keep track of both sets of attributes which affect the graphical output. Figure 3-4 shows a partial program using DI-3000 and the CGL primitives and attributes.

```
C Set the world coordinates to describe page components
   CALL JWINDO(0.,11.,0.,11.)
C Open the window
   CALL JOPEN
C Set DI-3000 attributes
   CALL JPINTR(1)
C Set CGL attributes
   CALL CSYMSZ(0.5)
   DO 1 I=1,10
   C Set the symbol number
      CALL CSYMNO(I)
   C Call the CGL routine to draw a symbol at coordinates (I,1.)
      1      CALL CPNTPT(REAL(I),1.)
```

Figure 3-5. Example of the use of graphics primitives and attributes.
Each CGL attribute is set to a default when CBEGIN is called. To assign another value to a CGL attribute, the user should call the specific routine associated with the attribute. Most CGL attributes begin with "N" (e.g., NHBTIC, NHLABJ, NSYMNO, NSYMSZ, NLNPAT, etc.), and can be assigned through a corresponding "C" routine (e.g., CHBTIC, CHLABJ, CSYMNO, CSYMSZ, CLNPAT, etc.).

The CGL attribute values will retain their initial values until overwritten by the user. All attribute values will then retain these new values unless subsequently changed. Note, reinvoking CBEGIN will set all CGL attributes to their default values. Figure 3-5 shows a partial program setting and resetting CGL attributes.

```
C INITIALIZE CGL ATTRIBUTES TO DEFAULTS AND SET CURRENT WINDOW
CALL CBEGIN
CALL JWINDO(0.,11.,0.,11.)
C OPEN CURRENT SEGMENT
CALL JOPEN
C OUTPUT SYMBOL (WITH DEFAULT SYMBOL NUMBER AND SYMBOL SIZE)
CALL CPNTPT(1.,1.)
C CHANGE SYMBOL NUMBER TO 3, SYMBOL SIZE TO .5, AND DISPLAY
CALL CSYMNO(3)
CALL CSYMSZ(.5)
CALL CPNTPT(2.,1.)
C RESET CGL ATTRIBUTES BACK TO DEFAULTS
CALL CBEGIN
CALL CPNTPT(3.,1.)
C END ALL GRAPHICS AND CLOSE CURRENT SEGMENT
CALL JPAUSE(IDEV)
```

Figure 3-6. Setting and resetting CGL attributes.
3.3 Steps in the Generation of Linear and Logarithmic Line Charts

This section enumerates and describes the steps needed to generate an XY line chart. These steps are explained separately, then combined and illustrated as a complete program generating a complete chart. As previously mentioned, the three primary ingredients are:

- establishing a graphical environment;
- setting the world coordinate systems; and
- calling the graphical primitives after setting their corresponding attributes.

This section describes each of these ingredients, and walks through the major steps of generating an XY line chart. This section naturally progresses from a simple XY line chart with a single data set by adding multiple data sets, including a key, and showing how to generate publication-quality axes. Subsequent sections address the topics of logarithmic and semi-log axes, and grids.

3.3.1 Plotting Linear Data

Typically, the range of the data coordinates will not coincide with the page coordinates. In the previous example, the page coordinates were defined to be 9 by 9-units, whereas the data ranged from 5 to 10 in the x-direction, and 0.0 to 0.01 in the y-direction.

In order to plot the linear data within the area bounded by the axes, the data coordinates will need to be mapped onto the page bounded by the axes. A convenient approach is to save off the virtual coordinates of the axes boundaries described in terms of page coordinates. This is accomplished by two calls to JCONWV, one for the lower-left intersection of the axes (i.e., the point denoted XORG,YORG), the other for the upper-right boundary of the axes (i.e., the point denoted XORG+XLEN, YORG+YLEN).

C XORG,YORG - THE INTERSECTION OF THE AXES
C VX1,VY1 - THE VIRTUAL COORDINATES OF XORG,YORG
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
C XLEN, YLEN - THE LENGTHS OF THE AXES
C VX2,VY2 - THE VIRTUAL COORDINATES OF THE OPPOSITE
C DIAGONAL OF THE AXES
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
Next, in order to plot the linear data, which has different scales than the page coordinates (i.e., data versus page coordinates), the user must close the segment, set the new world coordinates to match the data extremes, then set the viewport to match the virtual coordinates corresponding to axes boundaries inquired above. In essence, we are mapping the data coordinate system onto the virtual coordinates bounded by the axes. Since the data and world coordinates are linear, no additional conversion is needed to plot the data.

\[
CALL \text{JCLOSE} \\
CALL \text{JWINDO}(5.,10.,0.,.01) \\
C \ 5.,10. \ - \ X-\text{DIRECTION DATA COORDINATES} \\
C \ 0.,.01 \ - \ Y-\text{DIRECTION DATA COORDINATES} \\
CALL \text{JVPORT(VX1,VX2,VY1,VY2)} \\
\]

In case the data exceeds the current world coordinates, set clipping "on" (.TRUE.) to suppress unwanted data.

\[
CALL \text{JWCLIP(.TRUE.)} \\
\]

Finally, open the segment, set the desired plotting attributes, and plot the data. The routine CLNPLT will plot an array of values in the current window. Thus, the window must be set to match or coincide with the data. The appearance of the points to be plotted will be determined by the attributes associated with CLNPLT. A few notable attributes are: NSYMNO (symbol number), NSYMSZ (symbol size), and NLNPAT (line pattern). After plotting the data, the window for the data can be closed.

\[
CALL \text{JOPEN} \\
CALL \text{CSYMNO(1)} \\
CALL \text{CLNPLT(X,Y,NPTS)} \\
CALL \text{JCLOSE} \\
\]

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Figure 3-7. Example of plotting data in a linear chart.
3.3.2 **Complete Program Plotting Multiple Linear Data Sets**

The routine CLNPLT must be invoked for every data set. Thus for multiple data sets, CLNPLT will be called more than once. To distinguish between the data sets, the attributes controlling the data's appearance should be altered.

```plaintext
CALL JOPEN
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y1,NPTS)

CALL JOPEN
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y2,NPTS)
```

The following is a complete program combining the method previously described in context. The corresponding graphics output can be found in Figure 3-8.

```plaintext
PROGRAM CDR5
C------------------------------------------------------
C COMPLETE LINE CHART
C------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA Y(KI,1),KI=1,10)
+ /,.001,.003,.005,.004,.006,.008,.009,.005,.003,.002/
DATA Y(KI,2),KI=1,10)
+ /,.0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/
C------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
```

3-14
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
   CALL JSIZE(.2,.2*.125)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)
   CALL JMOVE(4.5,6.0)
   CALL JJUST(2,2)
C OUTPUT THE STRING
   CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
   CALL JSIZE(-1,.1*.125)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
   XORG=2.
   YORG=2.
   CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
   CALL CHLAB('HORIZONTAL AXIS',1)
   XLEN=4.0
   CALL CHAXIS(5.0,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
   CALL CVLAB('VERTICAL AXIS',1)
   CALL CVPREC(3)
   YLEN=3.5
   CALL CVAXIS(.0,.01,.001,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
   CALL JCONWV(XORG,YORG,0.,VX1,VY1)
   CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
   CALL JCLOSE
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
   CALL JWINDO(5.10.,0.,.01)
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
   CALL JVPOR(VX1,VX2,VY1,VY2)
   CALL JOPEN
C PLOT FIRST DATA CURVE
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,Y(1,1),MAXPTS)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
   CALL CSYMNO(2)
   CALL CLNPAT(2)
   CALL CLNPLT(X,Y(1,2),MAXPTS)
   CALL JCLOSE
C---------------------------------------------
C TERMINATE GRAPHS
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
   STOP
END
3.3.3 Adding a Key

The previous subsections have shown how to establish the graphical environment, manipulate coordinate systems, use primitives, and set attributes. In context, a simple XY line chart with multiple data sets has been demonstrated. The next evolutionary step is the addition of a key. A key is a list of words or phrases giving an explanation of symbols or abbreviations (Figure 2-4 indicates a key in a XY line chart).

In order to add a key, four steps are necessary:

1) declare and allocate key related variables;
2) initialize the key related variables by calling CKEYIN;
3) for each data set to be represented in the key, call CKEYLB. This call should be performed when the data is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active; and
4) finally to plot the key, call CKEYPL. This call should be performed in page coordinates. Thus, the window and viewport may have to be reset.

Step 1 - Declare and allocate variables

A key is a series of entries (lines), where each entry is stored internally as a collection of attributes. The user is required to declare and allocate storage for these attributes. Specifically, two variables are needed, ISTORE (storage array for attributes) and KEYCHR (storage array for line labels). The dimensions of these arrays should be large enough to accommodate the largest number of data sets plotted at one time. See the description of the routine CKEYPL in Appendix A for a more detailed description.

```
PARAMETER (NLINS=2, NCOLS=1)
C NLINS - the maximum number of lines in the key
C NCOLS - the number of columns for an entry
C *20   - the largest character string per entry
C       (including mnemonics)
C (Note, in this example 20 is used, could be any value.)
CHARACTER KEYCHR(NCOLS,NLINS)*20
INTEGER   ISTORE(15,NLINS)
```

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**Step 2** - Initialize the key related variables by calling CKEYIN. This initialization can be performed anywhere, at anytime (i.e., the variables passed to CKEYIN will be reset).

```c
CALL JWINDO(5.,10.,0.,0.01)
```

- `5,10` - the data coordinate boundaries in the X-direction
- `0.,0.01` - the data coordinate boundaries in the Y-direction

**Step 3** - For each data set to be represented in the key, call CKEYLB. This call should be performed when the data is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active. The key related variables will be assigned values to be plotted when all the key entries have been obtained. This typically requires the plotting of the data (in terms of data coordinates).

```c
CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLC]ATA SET 1')
CALL CLNPLT(X,Y(1,1),MAXPTS)
CALL CSYMNO(2)
CALL CLNPAT(2)
```

---

3-17
**Step 4** - Finally to plot the key, call CKEYPL. When all the key entries have been made, a call to CKEYPL will plot the key based on the attributes stored in ISTORE and KEYCHR (and a few internal variables). The call to CKEYPL should be performed in page coordinates, and since most data is plotted in data coordinates (where the attributes are saved by CKEYLB), the window and viewport will probably have to be reset.

```
C Now output the key
C Set the window and viewport for page coordinates
   CALL JVPORT(-1.,1.,-1.,1.)
   CALL JWINDO(0.,9.,0.,9.)
   BPOS(1)=9.
   BPOS(2)=2.+3.5
   CALL JOPEN
   CALL JSIZE(0.1,0.1*1.25)
   CALL CKEYPL(ISTORE,KEYCHR,'KEY TITLE',
                + 'COLUMN TITLE',BPOS,5,JCOL,1)
   CALL JCLOSE

C Terminate graphics
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
```
3.3.4 Complete Program Plotting Multiple Linear Data Sets with a Key

The following program is used to demonstrate how to embed these four steps into a complete program. The key related statements have been additionally commented for clarity. Figure 3-9 shows the graphics output from the following program.

```
PROGRAM CDR6

C COMPLETE LINE CHART WITH A LEGEND
C---------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10, MAXSET=2)
REAL X(MAXPTS), Y(MAXPTS, MAXSET), BPOS(4)
PARAMETER (NLINS=2, NCOLS=1, NTLINS=1)
CHARACTER KEYCHR(NCOLS, NLINS)*20
INTEGER ISTORE(15, NLINS), JCOL(NCOLS)
DATA X/5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0/
DATA JCOL/1 /
DATA (Y(KI,1), KI=1, 10)
+ / .001, .003, .0075, .004, .006, .008, .009, .005, .003, .002/
DATA (Y(KI,2), KI=1, 10)
+ / .0015, .004, .007, .0045, .0065, .0078, .0085, .0055, .0032, .002/
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9., 9.)
CALL JWINDO(0., 9., 0., 9.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.1, .2*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)
CALL JMOVE(4.5, 6.0)
CALL JJUST(2.2)
C OUTPUT THE STRING
CALL JHSTRG('A TABLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1, .1*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG, YORG)
```

---

3-19
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('H[BLC]OРИЗОНТАЛЬ [BUC]А[BLC]ХИС',1)

C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)

C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('V[BLC]ЕРТИКАЛЬ [BUC]А[BLC]ХИС',1)
CALL CVPREC(3)

C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(.0,.01,.001,YLEN)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,.0,.VX1, Vy1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,.0,.VX2, Vy2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,.0,.01)
C 5,10  - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)

C PLOT FIRST DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLC]АTA SET 1')
CALL CLNPLT(X,Y(I,~),MAXPTS)

C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLC]АTA SET 2')
CALL CLNPLT(X,Y(1,2),MAXPTS)

C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
CALL JVPORT(-1.,1.,-1.,1.)
CALL JWINDO(0.,9.,0.,9.)
BPOS(1)=9.
BPOS(2)=2.+3.5
CALL JOPEN
CALL JSIZE(.1,.1*1.25)
CALL CKEYPL(ISTORE,KEYCHR,'К[BLC]ЕНЬ TITLE','C[BLC]ОЛУМН TITLE', +
BPOS,5,JCOL,1)

CALL JCLOSE

3-20
A Title

![Complete XY line chart with a key.](image)

Figure 3-9. Complete XY line chart with a key.
3.3.5 Determining Publication Quality Axis Scale Factors

When the range of the data is predetermined, the user can generate a chart with appropriate axes scales suitable for publication. When the range of the data is unknown, the user can call subroutine CScale to aid in determining suitable axis characteristics (i.e., scale factors, number of major and minor tick marks, etc.).

First, the user must establish the data's minimum and maximum values:

CALL CMNMX(X,NPTS,XMIN,XMAX)

Next, the user can call CScale with the minimum and maximum:

CALL CScale(XMIN,XMAX,AMIN,AMAX,NMAJOR,NMINOR,
           XINCR,NLEFT,NRIGHT)

where:

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>XMIN</td>
<td>AMIN - adjusted minimum</td>
</tr>
<tr>
<td>XMAX</td>
<td>AMAX - adjusted maximum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>input</th>
<th>output</th>
</tr>
</thead>
<tbody>
<tr>
<td>XINCR</td>
<td>NMAJOR - number of major tick marks</td>
</tr>
<tr>
<td>NMINOR</td>
<td>NMINOR - number of minor tick marks</td>
</tr>
<tr>
<td>NLEFT</td>
<td>number of digits to the left of the decimal place to represent number on axis</td>
</tr>
<tr>
<td>NRIGHT</td>
<td>number of digits to the right of the decimal place to represent number on axis</td>
</tr>
</tbody>
</table>

These values can be used to create an axis suitable for publication purposes:

C CHMTIC set the # of minor tick marks on the horizontal axis
   CALL CHMTIC(NMINOR)
C CHPREC set the precision for a numeric horizontal axis
   CALL CHPREC(NRIGHT)
C CHAXIS will draw a horizontal axis of length XLEN, with C tick mark labels starting at AMIN to AMAX in increments of C XINCR. Axes attributes (e.g., NHMTIC, NHPREC, etc.) are C determined by the attributes set when CHAXIS is called.
   CALL CHAXIS(AMIN,AMAX,XINCR,XLEN)

3-22
The following is a partial program demonstrating the use of CSCALE to generate publication acceptable axis. The graphics output generated from this example is found in Figure 3-10.

```
PROGRAM CDR7

C---------------------------------------------
C SEMI-LOGARITHMIC LINE CHART (SINGLE DATA SET)
C---------------------------------------------
C SET UP DATA
PARAMETER(NPTS=6)
REAL X(NPTS),Y(NPTS),YTEMP(NPTS)
DATA X/2.2,3.0,4.3,5.1,5.5,6.7/
DATA Y/3.,50.,100.,500.,750.,985./
DATA XORG/2.5/,YORG/2./,XLEN/7./,YLEN/7./,XPAGE/11./,YPAGE/11./

C---------------------------------------------

C RESET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE,XSIZE*1.25)

C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG,YORG)

C---------------------------------------------

C HORIZONTAL AXIS (LINEAR)
CALL CMNMX(X,NPTS,XMIN,XMAX)

C DETERMINE PUBLICATION QUALITY SCALE FACTORS
CALL CSSCALE(XMIN,XMAX,AMIN,AMAX,NMAJOR,NMINOR,XINCR,NLEFT,NRIGHT)

C SET HORIZONTAL AXIS ATTRIBUTES
CALL CHM Tic( NMINOR )
CALL CHPREC(NRIGHT)
CALL CHLAB('F[BLC]REQUENCY, [BUC]H[BLC]Z',1)
CALL CHAXIS(AMIN,AMAX,XINCR,XLEN)

C---------------------------------------------

```

Figure 3-10. Example of axis generation with CSCALE.
3.3.6 Plotting Logarithmic Data

In Subsection 3.3.2, Plotting Linear Data, both the data and the data space progressed in a linear fashion (i.e., the scales increase in a proportional manner in relationship to the axis). A call to JWINDO with the data extremes established a data space encompassing the data to be plotted. Since the underlying graphics package only supplies linear windows, logarithmic data must be transformed onto a linear coordinate system. This is accomplished by converting the logarithmic data by "taking the log of the data", and plotting the resultant array onto the linear data space which has the appropriate range.

A couple of CGL routines are available to aid the user in plotting logarithmic data. First, to determine the minimum and maximum of the logarithmic data, the user can call CMNMX:

```
CALL CMNMX (YARRAY, NPTS, YMIN, YMAX)
```

where:

- input
  - `YARRAY` - represents the array containing the logarithmic data
  - `NPTS` - represents the number of points in `YARRAY`

- output
  - `YMIN` - the returned minimum from `YARRAY`
  - `YMAX` - the returned maximum from `YARRAY`

Next, to determine the "powers of ten" to use as the axis boundaries, the routine `CEXP` can be used.

```
CALL CEXP (YMIN, YMAX, MINEXP, MAXEXP)
```

where:

- input
  - `YMIN` - the minimum from `YARRAY`
  - `YMAX` - the maximum from `YARRAY`

- output
  - `MINEXP` - the returned minimum exponent
  - `MAXEXP` - the returned maximum exponent

The returned values, `MINEXP` and `MAXEXP`, represent the exponents (i.e., the powers of ten) to be used as the axis extremes which will ensure the data will be completely encompassed. Also, from these two values, the number of logarithmic cycles (intervals) can be determined by `MAXEXP-MINEXP`, whereas the number of major tick marks is determined by `(MAXEXP-MINEXP)+1`. 
For example, if CMNMX returns 3.0 and 997.0 as the minimum and maximum of an array, then CEXP would return MINEXP as 0, and MAXEXP as 3 (i.e., $10^0$ to $10^3$, the axis extremes based on the powers of ten to encompass the data).

To draw a logarithmic axis, the routine CHLOG will draw horizontal axis, while CVLOG will draw a vertical axis.

```
C Set the initial power of ten used to label the axis
CALL CHLOGS(MXEXP1)
C Generate a horizontal log axis of length XLEN, with NTICX
C major tick marks, with the minor tick marks labeled as
C denoted by NHLOGI (see CHLOG description in Appendix A).
CALL CHLOG(XLEN,NTICX,NHLOGI)
```

We now can establish a data space corresponding to these extremes. First, a set of logarithmic axes will be positioned and drawn. The following partial program illustrates how to draw logarithmic axes.

```
C-------------------------------------------------------------------
C RESET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE,XSIZE*.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORL,YORL)
C-------------------------------------------------------------------
C HORIZONTAL AXIS (LOG)
CALL CMNMX(X,MXPSTM,XMIN,XMAX)
CALL CEXP(XMIN,XMAX,MXPSTM,MXPST2)
C SET HORIZONTAL AXIS ATTRIBUTES
CALL CSET('NHLOGF',1)
CALL CSET('NHLOGS',MXEXP1)
NTICX=(MXEXP2-MXEXP1)+1
CALL CHLOG(XLEN,NTICX,1)
C-------------------------------------------------------------------
C VERTICAL AXIS (LOGARITHMIC)
CALL CMNMX(Y(1,1),MXPSTM,YMIN,YMAX)
DO 10 I=2,MAXSET
   CALL CMNMX(Y(1,I),MXPSTM,TMIN,TMAX)
   IF(TMIN.LT.YMIN)YMIN=TMIN
10 IF(TMAX.GT.YMAX)YMAX=TMAX
CALL CEXP(YMIN,YMAX,MYEXP1,MYEXP2)
CALL CSET('NVLOGF',1)
CALL CSET('NVLOGS',MYEXP1)
NTICY=(MYEXP2-MYEXP1)+1
CALL CVLOG(YLEN,NTICY,1)
C-------------------------------------------------------------------
```
Figure 3-11. Example of a set of logarithmic axes.
Next, we must determine what the current virtual coordinates are which bound the axes to be used to set the data space and the corresponding virtual coordinate system (see Subsection 3.3.2 for a detailed description)

CALL JCONWV(XORG, YORG, 0., VX1, VY1)

C XORG,YORG - The intersection of the axes
C VX1,VY1 - The virtual coordinates of XORG,YORG

CALL JCONWV(XORG+XLEN, YORG+YLEN, 0., VX2, VY2)

C XLEN,YLEN - The lengths of the axes
C VX2,VY2 - The virtual coordinates of the opposite diagonal of the axes

Next, we set up the data space and viewport:

C Set viewport to data region virtual coordinates
   CALL JVPORT(VX1, VX2, VY1, VY2)
C Set up data region window
C Since X-axis is log, minimum and maximum must be scaled
   CALL JWINDO(REAL(MXEXP1), REAL(MXEXP2),
               REAL(MYEXP1), REAL(MYEXP2))
C Enable clipping to exclude extraneous data
   CALL JWCLIP(.TRUE.)

To complete the chart we open the segment, set the desired plotting attributes, and plot the data. But, we must convert the logarithmic data to correspond to the linear data space [i.e., XTEMP(I)=LOG(X(I))].

DO 1 I=1,NPTS
   XTEMP(I)=LOG(X(I))
   YTEMP(I)=LOG(Y(I))
1
C NOTE: THE ABOVE LOOP ASSUMES THE VALUES IN THE X AND Y ARRAYS ARE GREATER THAN 0.
C
CALL JOPEN
CALL CSYMNO(1)
CALL CLNPLT(XTEMP, YTEMP, NPTS)
CALL JCLOSE

3-28
Figure 3-12. Example of plotting logarithmic data.
3.3.7 Complete Program Plotting Multiple Logarithmic Data Sets

The following is a complete program showing the generation of a logarithmic chart. This program illustrates the use of CMNMX, CEXP, JCONWV, and the mapping of logarithmic data onto a linear scale. The corresponding graphics output can be found in Figure 3-13.

PROGRAM CDR8
C------------------------------------------------------------------
C LOG-LOG LINE CHART (MULTIPLE DATA SETS)
C------------------------------------------------------------------
C SET UP DATA
PARAMETER(MAXPTS=6,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET),YTEMP(MAXPTS),XTEMP(MAXPTS)
DATA X/22.,30.,43.,51.,85.,97. /
DATA (Y(KI,1),KI=1,MAXPTS)/3.0,50.,10. *,50.,75.,98. /
DATA (Y(KI,2),KI=1,MAXPTS)/7.0,90.,10. *,25.,55.,90. /
DATA XORG/2./,YORG/2./,XLEN/7./,YLEN/7./,XPAGE/11./,YPAGE/11./
C------------------------------------------------------------------
C SET UP GRAPHICS AREA
IDEV=0
CALL JBEGIN
CALL CBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C------------------------------------------------------------------
C SET PAGE COORDINATES, AND OPEN A TEMPORARY SEGMENT
CALL JWINDO(0.,XPAGE,0.,YPAGE)
CALL JOPEN
C------------------------------------------------------------------
C SET CHARACTER SIZE, AND OUTPUT TITLE
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
XSIZE=.25
CALL JSIZE(XSIZE,XSIZE*,.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER,BOTTOM)
CALL JMOVE(XPAGE/2.,0.+XSIZE)
CALL JJUST(2,1)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C------------------------------------------------------------------
C RESET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE,XSIZE*,.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG,YORG)
C-----------------------------------------------------------------------
C
C SET UP DATA REGION WINDOW
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
CALL JOPEN
DO 1 KI=1 ,MAXPTS
   XTEMP(KI)=LOG10(X(KI))
   DO 2 KI2=1 ,MAXPTS
      CALL CSYMNO(KI1)
      CALL CLNPAT(KI1)
      DO 3 KI2=1 ,MAXPTS
         YTEMP(KI2)=LOG10(Y(KI2,KI1))
      CALL CLNPLT(XTEMP,YTEMP,MAXPTS)
      CALL JPAUSE( IDEV)
   CALL JCLOSE
   CALL JFRAME
1 CONTINUE
2 CONTINUE
3 CONTINUE
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C HORIZONTAL AXIS (LOG)
   CALL CMNMX(X,MAXPTS,XMIN,XMAX)
   CALL CXEXP(XMIN,XMAX,MXEXP1,MXEXP2)
C-----------------------------------------------------------------------

C SET HORIZONTAL AXIS ATTRIBUTES
   CALL CSET('NHLOGF',1)
   CALL CSET('NHLOGS',MXEXP1)
   NTICX=(MXEXP2-MXEXP1)+1
   CALL CHLOG(XLEN,NTICX,1)
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C VERTICAL AXIS (LOGARITHMIC)
   CALL CMNMX(Y(1,1),MAXPTS,YMIN,YMAX)
   DO :0 I=2 ,MAXSET
      CALL CMNMX(Y(I,1),MAXPTS,TMIN,TMAX)
      IF(TMIN.LT.YMIN) YMIN=TMIN
      IF(TMAX.GT.YMAX) YMAX=TMAX
   CALL CXEXP(YMIN,YMAX,MYEXP1,MYEXP2)
   CALL CSET('NVLOGF',1)
   CALL CSET('NVLOGS',MYEXP1)
   NTICY=(MYEXP2-MYEXP1)+1
   CALL CVLOG(YLEN,NTICY,1)
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SAVE DATA REGION VIRTUAL COORDINATES
   CALL JCONVW(XORG,YORG,0.,VX1,VY1)
   CALL JCONVW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
   CALL JCLOSE
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
   CALL JVPORT(VX1,VX2,VY1,VY2)
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SET UP DATA REGION WINDOW
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
   CALL JWINDO(REAL(MXEXP1),REAL(MXEXP2),REAL(MYEXP1),REAL(MYEXP2))
C-----------------------------------------------------------------------

C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
   CALL JWCLIP(.TRUE.,)
   CALL JOPEN
C-----------------------------------------------------------------------

C PLOT DATA
   CALL JCONVW(XORG,YORG,0.,VX1,VY1)
   CALL JCONVW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
   CALL JCLOSE
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SAVE DATA REGION VIRTUAL COORDINATES
   CALL JCONVW(XORG,YORG,0.,VX1,VY1)
   CALL JCONVW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
   CALL JCLOSE
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
   CALL JVPORT(VX1,VX2,VY1,VY2)
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
C SET UP DATA REGION WINDOW
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
   CALL JWINDO(REAL(MXEXP1),REAL(MXEXP2),REAL(MYEXP1),REAL(MYEXP2))
C-----------------------------------------------------------------------

C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
   CALL JWCLIP(.TRUE.,)
   CALL JOPEN
C-----------------------------------------------------------------------

C PLOT DATA
   CALL JCONVW(XORG,YORG,0.,VX1,VY1)
   CALL JCONVW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
   CALL JCLOSE
C-----------------------------------------------------------------------

3-31
Figure 3-13. Complete logarithmic chart with multiple data sets.
3.3.8 Complete Program Plotting Multiple Semi-Logarithmic Data Sets

Throughout the discussion in Section 3.3.2 through 3.3.7, the reader has been shown how to generate linear and logarithmic charts. The same techniques and principles apply in the generation of semi-logarithmic chart. The following program combines these techniques using the linear method on the horizontal axis, and the logarithmic method on the vertical axis.

```plaintext
PROGRAM CDR7
C-----------------------------------------------------------------------
C SEMI-LOGARITHMIC LINE CHART (SINGLE DATA SET)
C-----------------------------------------------------------------------
C SET UP DATA
PARAMETER(NPTS=6)
REAL X(NPTS),Y(NPTS),YTEMP(NPTS)
DATA X/2.2,3.0,4.3,5.1,5.5,6.7/
DATA Y/35,50,100,500,750,985/
DATA XORG/2.5/,YORG/2.7/,XLEN/7/,YLEN/7/,XPAGE/11.0/,YPAGE/11.0/
C-----------------------------------------------------------------------
C SET UP GRAPhICS AREA
IDEV=0
CALL JBEGI
CALL CBEGI
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------------------------------
C SET PAGE COORDINATES, AND OPEN A TEMPORARY SEGMENT
CALL JWINDO(0.,XPAGE,0.,YPAGE)
CALL JOPEN
C-----------------------------------------------------------------------
C SET CHARACTER SIZE, AND OUTPUT TITLE
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
XSIZE=.25
CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER,BOTTOM)
CALL JMOVE(XPAGE/2.,0.,XSIZE)
CALL JJUST(2,1)
C OUTPUT THE STRING
CALL JHSTRG('P[BLCLOWER LEVEL VS. FREQUENCY')
C-----------------------------------------------------------------------
C RESET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG,YORG)
```
C HORIZONTAL AXIS (LINEAR)
CALL CMNMX(X,NPTS,XMIN,XMAX)
C DETERMINE PUBLICATION QUALITY SCALE FACTORS
CALL CSSCALE(XMIN,XMAX,AMIN,AMAX,NMAJOR,NMINOR,XINCR,NLEFT,NRIGHT)
C SET HORIZONTAL AXIS ATTRIBUTES
CALL CHMHTIC(NMINOR)
CALL CHPRNC(NRIGHT)
CALL CHLAB('F[BLC]REQUENCY, [BUC]H[BLC]Z',1)
CALL CHAXIS(AMIN,AMAX,XINCR,XLEN)

C VERTICAL AXIS (LOGARITHMIC)
CALL CMNMX(Y,NPTS,YMIN,YMAX)
CALL CEXP(YMIN,YMAX,MINEXP,MAXEXP)
CALL CVLAB('P[BLC]OWER LEVEL',1)
CALL CSET('NVLOGF',1)
CALL CSET('NVLOGS',MINEXP)
NTIC=(MAXEXP-MINEXP)+1
CALL CVLOG(YLEN,NTIC,4)

C SAVE DATA REGION VIRTUAL COORDINATES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
CALL JCLOSE

C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
CALL JVPORT(VX1,VX2,VY1,VY2)

C SET UP DATA REGION WINDOW
DO 1 KI=1,NPTS
  1 YTEMP(KI)=LOG10(Y(KI))
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
   CALL JWINDO(AMIN,AMAX,REAL(MINEXP),REAL(MAXEXP))
C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
CALL JWCLIP(.TRUE.,)
CALL JOPEN
C PLOT DATA
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,YTEMP,NPTS)
CALL JPAUSE(IDEV)
CALL JCLOSE
CALL JFRAME

C TERMINATE GRAPHICS
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND

C
STOP
END
Figure 3-14. Complete semi-logarithmic chart.
3.3.9 Plotting Data with Grids without Keys

The Low-Level routines offer a grid capability for both linear and logarithmic scales. This section describes how to generate linear-linear grids, semi-logarithmic grids, and log-log grids. Subsequently, this section will illustrate how to generate any of these grid types without rectangular areas remaining blank (i.e., usually intended for keys). Section 3.3.11 describes grid generation with blank areas.

Two routines are currently available, CGRID and CLGRID. The CGRID routine draws a linear grid over a specified plotting area with optional rectangular or square areas remaining blank. CLGRID enables the user to draw log-log, semi-log, or linear grids with optional blanks for keys.

Three major steps are needed to generate a grid (either linear or logarithmic). The first step is to generate the axes as described in the previous subsections. The grid routine will not label the axes, this must be performed (if desired) by the axis routines. The second step consists of calling the appropriate grid routine (i.e., CGRID or CLGRID) to superimpose a grid onto the axes. The user must ensure that these grid intervals match and align with the axes intervals. The third step is to close the window (representing page coordinates), open a window for the data coordinates, and plot the data.

The only new step is the generation of grids. A grid extends both in the X and Y directions, and may be required to leave a space (hole or area) for a key. Unlike, the axis routines which are handled independently, the call to CGRID (or CLGRID) will draw the complete grid. The user must therefore supply both axes information to the single grid routine.

To generate a linear grid, a call to CGRID is required. This call must be performed in an opened segment, with the window representing page coordinates.
The following is a partial program showing the interaction between axes and linear grids.

```
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JMOVE(XORG,YORG)
CALL CHAXIS(5.,10.,1.,XLEN)
CALL CVAXIS(0.,0.01,0.001,YLEN)
C Based on the axes, determine # of intervals
C X intervals = (XMAX-XMIN)/XINCR
   NOINCX = NINT((10.0-5.0)/1.0)
C X increments= X-axis length/X intervals
   XS = XLEN /REAL(NOINCX)
C Y intervals = (YMAX-YMIN)/YINCR
   NOINCY = NINT((10.0-5.0)/1.0)
C Y increments= Y-axis length/Y intervals
   YS = YLEN /REAL(NOINCY)
C Since no blank areas, then set NBLANK TO 0
   NBLANK=0
C Call linear grid routine
   CALL CGRID(XORG,YORG,XS,YS,NOINCX,NOINCY,BLANK,NBLANK)
```

The resultant figure is shown in Figure 3-15.

Similarly, to generate a semi-log or log-log grid, the same approach applies where a call to CLGRID replaces CGRID. Refer to Appendix A for a complete description of CLGRID, and Appendix B for an example program showing a semi-log grid.
Figure 3-15. Linear grid generated with CGRID.
3.3.10 Plotting Data with Grids and Keys

In order to leave a space in a grid for a key, the key extents (height and width) must be determined. To do so, the attributes of all data sets must be saved. Since saving attributes (i.e., call to CKEYLB) is performed in the data coordinate system, and the grid is usually described in page coordinates, the window must be reset.

The following are the major steps in setting up a grid with a space for the key:

1) generate the axes (page coordinates)
2) draw the data (data coordinates), while saving key related attributes
3) determine key extents, and call the grid routine with key extents (page coordinates)
4) plot the key

Steps 1 and 2 are explained in previous subsections.

Step 3 - Once all the data sets have been plotted (i.e., all of the key related attributes have been saved), then the key extents can be determined. A call to CKEYPL with the variable KPT set to 1, will return the lower-left X and Y coordinates in BPOS(1), BPOS(2), and the upper-right X and Y coordinate in BPOS(3), BPOS(4).

KPT=1
CALL CKEYPL(ISTORE,KEYCHR,CTTL,BPOS,KPT,ICOL,NHPR)
C BPOS(1),BPOS(2) = the lower-left corner (XY coordinate)
C BPOS(3),BPOS(4) = the upper-right corner (XY coordinate)
C Calculate the X and Y extents
   XXTENT=BPOS(3)-BPOS(1)
   YXTENT=BPOS(4)-BPOS(2)

These extents can then be passed to the grid routine to suppress the grid lines through this area.
Step 4 - Now that the user knows the dimensions of the key, the user must determine where to position the key in relationship to the chart. It is preferred for publications that the grid lines stop on grid lines, as opposed to grid lines which dangle (see Figure 3-16). Thus, even though the user determines the extents, the user must further determine the dimensions of the grid lines to suppress. These dimensions are then passed to the grid routine (i.e., either CGRID or CLGRID), and the key should be centered in the grid space requested to be blank.

![Preferred and non-preferred grids with keys](image)

Figure 3-16. Sample grids with keys.
To request blank space in a grid, the variables NBLANK and BLANK are used to inform the grid routine. NBLANK indicates the number of blank areas. BLANK is an array of coordinates (representing the diagonals) of the rectangle to be left.

```
C The number of blank regions
NBLANK=2
C Coordinates of the blank regions
BLANK(1)= {lower-left X coordinate of region 1}
BLANK(2)= {lower-left Y coordinate of region 1}
BLANK(3)= {upper-right X coordinate of region 1}
BLANK(4)= {upper-right Y coordinate of region 1}

C
BLANK(5)= {lower-left X coordinate of region 2}
BLANK(6)= {lower-left Y coordinate of region 2}
BLANK(7)= {upper-right X coordinate of region 2}
BLANK(8)= {upper-right Y coordinate of region 2}
```

Program CDR11 in Appendix B, is a complete program demonstrating these steps.
3.3.11 Line Charts with Variations of Axes

This subsection describes how to generate line charts with axes other than the standard linear/logarithmic vertical and horizontal axes. Examples of non-standard axes include (see Figure 3-17):

- decreasing scales: axes which have a negative increment
- multiple scales: two or more vertical or horizontal axes
- interior axes: axes which are interior to the data space
- disjoint axes: axes which do not intersect

Figure 3-17. Examples of non-standard axes.
Note: shaded areas represent the data space denoted by the axes.
3.3.11.1 Plotting Data with a Decreasing Axis

A decreasing axis is a numeric axis with negative increments. Thus, the values on a horizontal axis decrease from left to right, while the values on a vertical axis decrease from bottom to top (see Figure 3-18).

In order to plot data with decreasing axes (or axis), two major steps must be performed:

1) the generation of the axes; and
2) the plotting of the data to coincide with the axes.

The generation of a decreasing numeric axis is obtained using a call to CHAXIS (for horizontal axes) or CVAXIS (for vertical axes). To generate axes with decreasing values the appropriate arguments must be passed (i.e., the starting value less than the ending value, and a negative increment). Note, a decreasing axis can also be generated using CHAXIC or CVAXIC, with the axis labels having character strings representing the decreasing values.

Since windows (data spaces) in underlying graphics packages are usually increasing in nature, the user must manipulate the decreasing data to conform the increasing window. This entails the usual process of drawing the axes, and setting the window and viewport to match the axes. Then because axis is decreasing to match the data, and the window must be increasing, the data has to be mapped to match the world. For example, if the horizontal axis decreases from 10 to 5, the axis should reflect this decrease, while the corresponding window should be set to 5 to 10. Next, the data set (or sets) coinciding with the decreasing axis must be adjusted to reflect the window in which the data is to be plotted. To aid in this process, the routine CFLIP has been written. The user
passes the data set, the number of points, and the reflection point about which
the data is to be mapped. CFLIP will return the array of points offset from the
reflection point on the reflection point's opposite side. For example, given a
value 8 and a reflection point 5, CFLIP will return a value of 2 (i.e., an equal
distance from the reflection point on the other side). Note, the original value
passed through CFLIP can be obtained by passing the adjusted value with the
same reflection point (i.e., given a value 2 and a reflection point 5, CFLIP will
return a value of 8).

The following is a complete program illustrating a decreasing axis, and the use
of CFLIP to adjust the data. See Figure 3-19 for the resultant chart.

PROGRAM CDR12
C-------------------------------------------------------------
C A LINE CHART WITH A DECREASING AXIS.
C-------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
    PARAMETER (MAXPTS=10,MAXSET=2)
    REAL X(MAXPTS),Y(MAXPTS,MAXSET)
    DATA X(5,5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
    DATA (Y(KI,1),KI=1,10)
    + /001.003,0075,004,.006,.008,.009,.005,.003,.002/
    DATA (Y(KI,2),KI=1,10)
    + /0005,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/
C-------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
    IDEV=0
    CALL CBEGIN
    CALL JBEGIN
    CALL JDINIT(IDEV)
    CALL JDEVOH(IDEV)
C-------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
    CALL CVSPAC(.9,.9.)
    CALL JWINDO(0.,9.,0.,9.)
    CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
    CALL JSIZE(.2,.2*.1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
    CALL JMOVE(4.5,6.0)
    CALL JJUST(2,2)
C OUTPUT THE STRING
    CALL JHSTR('A T[BLC]ITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
    CALL JSIZE(.1,.1*.1.25)

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C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)

C DESCRIBE THE HORIZONTAL AXIS

C Describe the horizontal axis
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(10.,5.,-1.,XLEN)

C Describe the vertical axis
CALL CVPREF(3)

C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(.0,.01,.001,YLEN)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
C NOTE: THE WINDOW OF THE UNDERLYING GRAPHICS PACKAGE MUST BE
C INCREASING IN NATURE. THE RANGE MUST MATCH THE DATA.
CALL JWINDO(5.,10.,0.,0.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)

C FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C REFLECT = (XMAX-XMIN)/2. + XMIN
REFLECT=(10. - 5.)/2. + 5.
CALL CFLIP(X,MAXPTS,REFLECT)
CALL JOPEN

C PLOT FIRST DATA CURVE USING CGL DEFAULTS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,1),MAXPTS)

C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(1,2),MAXPTS)

C IF THE X ARRAY IS TO BE USED AGAIN, THE USER MUST APPLY CFLIP AGAIN.
C IN THIS CASE, THE X ARRAY IS NOT USED AGAIN.
Figure 3-19. Complete program with a decreasing axis.
3.3.11.2 Line Charts with Multiple Scales on an Axis

This subsection describes how to generate line charts with two or more scales on the horizontal or vertical axis. In order to have multiple scales on the same axis, the user must map two windows (with different data extents) onto the same viewport. Thus, the user must set a viewport and window, and plot the appropriate data. Next, the user closes the current segment, resets the window to match the next scale, and plots the data.

The user is referred to previous sections for instructions on generating axes. The following example, however, illustrates the use of mapping two scales (of an axis) onto the same viewport. See Figure 3-20 for the resultant output.

```fortran
PROGRAM CDR13
C------------------------------------------------------------------------
C A LINE CHART WITH MULTIPLE VERTICAL SCALES ON THE SAME AXIS.
C------------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
   PARAMETER (MAXPTS=10,MAXSET=2)
   REAL X(MAXPTS),Y(MAXPTS,MAXSET),BPOS(4)
   PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
   CHARACTER KEYCHR(NCOLS,NLINS)*20
   INTEGER ISORE(15,NLINS),JCOL(NCOLS)
   DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
   DATA JCOL/1/
   DATA (Y(KI,1),KI=1,10) + /0.001,.003,.0075,.004,.006,.008,.009,.005,.003,.002/
   DATA (Y(KI,2),KI=1,10) + /0.0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/
C------------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
   IDEV=0
   CALL CBEGIN
   CALL JBEGIN
   CALL JDINIT(IDEV)
   CALL JDEVON(IDEV)
C------------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
   CALL CVSPAC(9.,9.)
   CALL JWINDO(0.,9.,0.,9.)
   CALL JOPEN
C------------------------------------------------------------------------
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```
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,.5)
CALL JJJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CSIZE=.1
CALL JSIZE(CSIZE,CSIZE*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('W'ING LENGTH',1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)
C-----------------------------------------------------------------------
C DESCRIBE THE VERTICAL AXIS
C NO AXIS LABEL ON INNERMOST VERTICAL AXIS
CALL CVLAB(' ',0)
CALL CVPRE(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
C PLOT FIRST AXIS (DECREASING)
CALL CVAXIS(0.,0.,-0.001,YLEN)
CALL JMOVE(XORG,YORG+YLEN+.75)
CALL JHSTRG('CM')
C PLOT SECOND AXIS (INCREASING)
C POSITION AND DESCRIBE THE OUTMOST VERTICAL AXIS
CALL JMOVE(XORG-CSIZE*7.,YORG)
CALL CVLAB('W'ING WIDTH',1)
CALL CVAXIS(0.,0.01.,0.01,YLEN)
C LABEL FOR OUTMOST VERTICAL AXIS
CALL JMOVE(XORG-CSIZE*7.,YORG+YLEN+.75)
CALL JHSTRG('IN.')
C-----------------------------------------------------------------------
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+YLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
    CALL JWINDO(5.,10.,0.,0.,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
    CALL JVPORT(VX1,VX2,YY1,YY2)
    CALL JOPEN
    CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
C FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C REFLECT = (YMAX-YMIN)/2. + YMIN
    REFLECT = (.01 - 0.)/2. + 0.
    CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C PLOT FIRST DATA CURVE WITH DECREASING AXIS (USING CGL DEFAULTS)
    CALL CSYMNO(1)
    CALL CLNPAT(1)
    CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLCL]CREASING AXIS DATA SET 1')
    CALL CLNPLT(X,Y(I,I),MAXPTS)
C REVERSE DATA AGAIN, TO RETURN DATA TO ORIGINAL VALUES.
    CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
    CALL CSYMNO(2)
    CALL CLNPAT(2)
    CALL CKEYLB(ISTORE,KEYCHR,3,'I[BLC]-CREASING AXIS DATA SET 2')
C PLOT SECOND DATA CURVE WITH INCREASING AXIS.
    CALL CLNPLT(X,Y(I,I),MAXPTS)
    CALL JCLOSE
C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
    CALL JVPORT(-1.,1.,-1.,1.)
    CALL JWINDO(0.,9.,0.,9.)
    BPOS(1)=9.
    BPOS(2)=2.+.5
    CALL JOPEN
    CALL JSIZE(CSIZE,CSIZE*1.25)
    CALL CKEYPL(ISTORE,KEYCHR,'M[BLC]-ULTIPLE AXIS',
                'C[BLC]-OLUMN TITLE',BPOS,JCOL,1)
    CALL JCLOSE
C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
    CALL JPAUSE(IDEV)
    CALL JFRAME
    CALL JDEVOF(IDEV)
    CALL JEND(IDEV)
    CALL JEND
    STOP
END
Figure 3-20. Example of multiple vertical scales on the same axis.
The following example illustrates the use of mapping of two scales (of an axis) onto the opposite side of the chart. See Figure 3-21 for the resultant output.

```
PROGRAM CDR14
C LINE CHART WITH MULTIPLE VERTICAL SCALES (OPPOSITE AXIS)
C
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET),BPOS(4)
PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
CHARACTER KEYCHR(NCOLS,NLINS)*20
INTEGER ISTORE(15,NLINS),JCOL(NCOLS)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10.1/
DATA JCOL/1/
DATA (Y(KI,1),KI=1,10)
+ /'001,'003,'0075,'004,'006,'008,'009,'005,'003,'002/
DATA (Y(KI,2),KI=1,10)
+ /'0015,'004,'007,'0045,'0065,'0078,'0085,'005,'0032,'002/
C
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JINIT(IDEV)
CALL JDEVON(IDEV)
C
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,.5)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG(' A T[B]LITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CSIZE=.1
CALL JSIZE(CSIZE,CSIZE*1.25)
C```

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C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
   XORG=1.25
   YORG=2.
   CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
C XLEN - REPRESENTS THE X-AXIS LENGTH
   XLEN=4.0
   CALL CHAXIS(5.10.,1.,XLEN)
C-----------------------------------------------------------------------
C DESCRIBE THE VERTICAL AXIS
C NO AXIS LABEL ON INNERMOST VERTICAL AXIS
   CALL CVLAB('D[BLCl]ECREASING AXIS',1)
   CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
   YLEN=3.5
C PLOT FIRST AXIS (DECREASING)
   CALL CVAXIS(.01.,0.-.001,YLEN)
C PLOT SECOND AXIS (INCREASING)
C POSITION AND DESCRIBE THE OPPOSITE VERTICAL AXIS
   CALL JMOVE(XORG+XLEN,YORG)
C REQUEST VERTICAL AXIS TICK MARKS TO THE RIGHT OF THE AXIS.
   CALL CVTICJ(2)
C REQUEST VERTICAL AXIS TICK MARK LABELS TO THE RIGHT OF THE AXIS.
   CALL CVLABJ(1)
   CALL CVTICJ(2)
   CALL CVLAB('I[BLCl]NCREASING AXIS',1)
   CALL CVAXIS(.0,.01.,.001,YLEN)
C-----------------------------------------------------------------------
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
   CALL JCONWV(XORG,YORG,0.,VX1,VY1)
   CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
   CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
   CALL JWINDO(5.,10.,.0,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
   CALL JVPORT(VX1,VX2,VY1,VY2)
   CALL JOPEN
   CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
C FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C REFLECT = (YMAX-YMIN)/2. + YMIN
   REFLECT=(.01 - 0.)/2. + 0.
   CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C PLOT FIRST DATA CURVE WITH DECREASING AXIS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLCKECREASING DATA')
CALL CLNPLT(X,Y(1,1),MAXPTS)
C REVERSE DATA AGAIN, TO RETURN DATA TO ORIGINAL VALUES.
CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CKEYLB(ISTORE,KEYCHR,3,'I[BLC][NCREASING DATA')
C PLOT SECOND DATA CURVE WITH INCREASING AXIS.
CALL CLNPLT(X,Y(1,2),MAXPTS)
CALL JCLOSE
C---------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
CALL JVPORT(-1.,1.,-1.,1.)
CALL JWINDO(0.,9.,0.,9.)
BPOS(1)=9.
BPOS(2)=2.+3.5
CALL JOPEN
CALL JSIZE(CSIZE,FSIZE*1.25)
CALL CKEYPL(ISTORE,KEYCHR,'M[BLC][ULTIPLE AXIS',
+ 'D[BLC][ATA TYPE',BPOS,5,3COL,1)
CALL JCLOSE
C---------------------------------------------------------------------
C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOP(DEV)
CALL JDEND(DEV)
CALL JEND
STOP
END
Figure 3-21. Example of multiple vertical scales on opposite axis.
3.3.1 Line Charts with Interior Axes

In order to have interior axes, the user must establish the window and viewport to encompass the axes.

The user is referred to previous sections for instructions of generating axes. The following example, however, illustrates the use of interior axes. See Figure 3-22 for the resultant output.

```
PROGRAM CDR15
C--------------------------------------------------------------------------------
C SIMPLE, YET COMPLETE LOW-LEVEL PROGRAM (WITH A KEY)
C--------------------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER(NUMPT1=13,NUMPT2=3,MAXLAB=20)
REAL X1(NUMPT1),Y1(NUMPT1),BPOS(4)
REAL X2(NUMPT2),Y2(NUMPT2)
PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
CHARACTER KEYCHR(NCOLS,NLINS)*20,CLABS(MAXLAB)*10
INTEGER ISORE(15,NLINS),JCOL(NCOLS)
DATA X1/-8.,-6.,-4.,-2.,0.,2.,4.,6.,8.,10.,12.,14.,16./
DATA JCOL/1/
DATA (Y1(KI),KI=1,NUMPT1)
  +/.079,.068,.035,.021,0.,-.021,.035,.065,.08,.11,
  +-.118,-.12,-.139/
DATA X2/-4.,8.,16./,Y2/.039,-.071,-.145/
C--------------------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C--------------------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C--------------------------------------------------------------------------------
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, TOP)
CALL JMOVE(9./2.,9./.5)
CALL JJUST(2,3)
C OUTPUT THE STRING
CALL JHSTRG('C[BLC]OMPUTATIONS VS[ELC] E[BLC]XPERIMENTS')
```

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C RESET THE CHARACTER SIZE FOR THE AXES
   CSIZE=.1
   CALL JSIZE(CSIZE,CSIZE*1.25)
C-----------------------------------------------------------------------
C BASED AXES DATA ATTRIBUTES (MINIMUM, MAXIMUM, AND INCREMENTS).
   XMIN=-8.
   XMAX=20.
   XINC=4.
   YMIN=-.16
   YMAX=0.12
   YINC=.04
C-----------------------------------------------------------------------
C SET X AND Y AXIS LENGTHS (I.E., XLEN AND YLEN RESPECTIVELY).
   XLEN=4.0
   YLEN=5.5
C POSITION LOWER-LEFT CORNER OF DATA SPACE ON THE PAGE.
   XORG=((9./2.)-1.)-.5*XLEN
   YORG=(9./2.)-.5*YLEN
C NOW, SET XZERO AND YZERO PAGE COORDINATES WHERE AXES 0,0 EXISTS.
C (THIS PROGRAM ASSUMES THAT DATA ENCOMPASSES 0,0 IN X AND Y).
   XZERO=XORG+XLEN*(-XMIN/(XMAX-XMIN))
   YZERO=YORG+YLEN*(-YMIN/(YMAX-YMIN))
C-----------------------------------------------------------------------
C DESCRIBE X-AXIS. MOVE TO X ORIGIN, Y ZERO.
   CALL JMOVE(XORG,YZERO)
   CALL CILAB(XMIN,XMAX,XINC,~,CLABS)
   ICOUNT=NINT((XMAX-XMIN)/XINC)+1
   KI=NINT(ABS(XMIN)/XINC)+1
   CLABS(KI)=' '  
   CALL CHAXIC(XLEN,ICOUNT,CLABS,1,ICOUNT).
   CALL JMOVE(XORG+(5./7.)*XLEN,yZERO-.5)
C DRAW AXIS
C POSITION AND OUTPUT AXIS LABEL
   CALL JHSTRG(' [FONT=9] [BLC] A [FONT=3], DEG')
C-----------------------------------------------------------------------
C DESCRIBE Y-AXIS. MOVE TO X ZERO, Y ORIGIN.
   CALL JMOVE(XZERO,YORG)
C GENERATE Y AXIS LABELS.
   CALL CILAB(YMIN,YMAX,YINC,2,CLABS)
   ICOUNT=NINT((YMAX-YMIN)/YINC)+1
   C BLANK OUT INTERSECTION LABEL (I.E., 0).
   KI=NINT(ABS(YMIN)/YINC)+1
   CLABS(KI)=' '  
   CALL CVAXIC(YLEN,ICOUNT,CLABS,1,ICOUNT).
   CALL JMOVE(XZERO-1.,YORG+(2.5/7.)*YLEN)
C DRAW AXIS.
C POSITION AND OUTPUT AXIS LABEL
   CALL JHSTRG('C[BLC][BSUB]M (0.25C)')
C-----------------------------------------------------------------------
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONV(XORG,YORG,0.,VX1,vy1)
CALL JCONV(XORG+XLEN,YORG+YLEN,0.,VX2,vy2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(XMIN,XMAX,YMIN,YMAX)
C XMIN,XMAX - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C YMIN,YMAX - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,vy1,vy2)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
C PLOT FIRST DATA CURVE USING CGL DEFAULTS
C SET SYMBOL TO 1 (A CIRCLE) FOR EXPERIMENTAL DATA.
CALL CSYMO(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'E[BL]CXPERIMENTA')
CALL CLNPLT(X1,Y1,NUMPT1)
C PLOT SECOND DATA CURVE.
C SET SYMBOL TO SOLID SQUARE (ACTUAL), AND PLOT SYMBOLS ONLY.
CALL CSYMO(902)
CALL CPLTYP(-1)
CALL CKEYLB(ISTORE,KEYCHR,3,'A[BL]CTUAL')
CALL CLNPLT(X2,Y2,NUMPT2)
CALL JCLOSE

C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
CALL JVPORT(-1.,1.,-1.,1.)
CALL JWINDO(0.,9.,0.,9.)
BPOS(1)=9.
BPOS(2)=2.+3.5
CALL JOPEN
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL CKEYPL(ISTORE,KEYCHR,'M[BL]ULTIPLE AXIS',
+ 'D[BL]ATA TYPE',BPOS,5,JCOL,1)
CALL JCLOSE

C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFrame
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Computations vs Experiments

Figure 3-22. Complete program with interior axes.
3.3.11.4 Line Charts with Disjoint Axes

This subsection describes how to generate line charts with a disjoint set of axes. Note, disjoint axes are no publication quality. The crucial element consists of the placement of the axes in relationship to one another and the data space (i.e., placement of the viewport). First the user draws the axes, then offsets the viewport from the axes. The data will be plotted in the window, which in turn is mapped onto the viewport.

The user is referred to previous sections for instructions on generating axes. The following example, however, illustrates the use of interior axes. See Figure 3-23 for the resultant output.

```
PROGRAM CDR16
C---------------------------------------------------------------------
C LINE CHART WITH DISJOINT AXES (BASED ON CDR6)
C---------------------------------------------------------------------
C THE KEY ELEMENTS INVOLVING DISJOINT AXES INCLUDE:
C - THE POSITIONING OF THE AXES (SEE XOFF AND YOFF).
C - THE SETTING OF THE VIEWPORT TO MATCH THE DATA SPACE
C (WHICH DIFFERS FROM THE AXES BOUNDARIES).
C---------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA (Y(KI,1),KI=1,10)
+ /0.001,0.003,0.0075,.004,.006,.008,.009,.005,.003,.002/
DATA (Y(KI,2),KI=1,10)
+ /0.0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/
C---------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C---------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(2.,2*1.25)
C POSITION STRING, AND SETJUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
```
C OUTPUT THE STRING
   CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
   CALL JSIZE(.1,.1*.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
C XOFF - THE DISTANCE TO SHIFT THE X-AXIS DOWN.
   XOFF=.2
   CALL JMOVE(2.,2.-(XOFF))
C DESCRIBE THE HORIZONTAL AXIS
   CALL CHLAB('HORIZONTAL [BUC]AXIS',1)
   CALL CHAXIS(5.,10.,1.,4.)
C DESCRIBE THE VERTICAL AXIS
   CALL CVLAB('VERTICAL [BUC]AXIS',1)
   CALL CVAXIS(0,0,1,001,3.5)
   CALL CVPREC(3)
   YOFF=.2
   CALL JMOVE(2.,2.-YOFF,2.)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
C NOTE: THE VIRTUAL COORDINATES ARE BASED ON DIMENSIONS OF DATA
C SPACE, NOT ON AXIS BOUNDARIES.
   CALL JCONWV(2.,2.,0.,VX1,VY1)
   CALL JCONWV(2.+4.,2.+3.5,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
   CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
   CALL JWINDO(5,10,0,C1)
   CALL JVPORT(VX1,VX2,VY1,VY2)
   CALL JOPEN
C PLOT FIRST DATA CURVE USING CGL DEFAULTS
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,Y(1,1),MAXPTS)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
   CALL CSYMNO(2)
   CALL CLNPAT(2)
   CALL CLNPLT(X,Y(1,2),MAXPTS)
   CALL JCLOSE
C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
   CALL JPAUSE(IODEV)
   CALL JFRAME
   CALL JDEVOF(IODEV)
   CALL JDEND(IODEV)
   CALL JEND
STOP
END
A Title

Figure 3-23. Complete program with disjoint axes.
3.4 **Steps in the Generation of Bar Charts**

This section describes how to generate bar charts, both absolute and additive. In order to generate bar charts, the user must:

- establish page coordinates
- position, describe and draw components (i.e., axes, keys, etc.)
- plot the data (using bars)

3.4.1 **Page Coordinates and Describing Components**

Since the setting up of page coordinates and the generation of chart components is identical to line charts, the user is referred to Section 3.2 for a complete explanation. After the page coordinates have been established, the components need to be positioned and described. As an example, the following partial code positions and describes a set of axes. Instead of a numeric axis, this chart could require a character horizontal axis with tick mark labels rotated at a 45 degree angle.

```plaintext
C NEXT, POSITION THE AXIS AND DESCRIBE ITS CONTENTS.
  CALL JMOVE(XORG,YORG)
C NO HORIZONTAL AXIS LABEL
  CALL CHLAB(' ',0)
C SET HORIZONTAL TICK MARK LABELS ROTATION ANGLE
  CALL CHTROT(45)
  CALL CHAXIC(XLEN,NTICK+2,HTLAB,1,NTICK+2)
C HTLAB IS A CHARACTER ARRAY REPRESENTING MONTHS.
C THE FIRST AND LAST ELEMENTS ARE BLANK TO ENSURE THE
C DATA IS NOT PLOTTED ON THE AXES.
```

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Now, define the vertical axes (in this example, a vertical axis on the left and right of the data area).

```
CALL CVLAB('CRUS (THOUSANDS)', 1)
CALL CVAXIS(0., 10., 5., YLEN)
CALL JMOVE(XORG+XLEN, YORG)
CALL CVLAB('', 0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIS(0., 10., 5., YLEN)
```

Figure 3-24. Horizontal character axis with rotated tick mark labels.
3.4.2 Plotting Absolute Bar Chart Data

When the data is absolute, each data set will have a bar depicting data at each horizontal tick mark. The user must ensure that the width of each bar must be small enough, such that data sets can be clearly distinguished between tick marks. Thus, the cumulative width of each tick mark's data set is

\[ \frac{(X_{\text{MAX}} - X_{\text{MIN}})}{\text{REAL}(\text{NTICK}-1)} \]

where
- \( X_{\text{MAX}} - X_{\text{MIN}} \) represents the length of the axis in terms of the current world coordinate system;
- NTICK-1 represents the number of intervals on the axis.

This would leave a gap before the first tick mark, and after the last tick mark. However, the bars of each tick mark will abut against the bars of another. Thus, we must reduce the width by a reasonable factor (e.g., 2./3.).

\[ \left( \frac{(X_{\text{MAX}} - X_{\text{MIN}})}{\text{REAL}(\text{NTICK}-1)} \right) \times \left( \frac{2}{3} \right) \]

The width of each data set's bars on a single tick mark would be

\[ X_{\text{WID}} = \left( \frac{(X_{\text{MAX}} - X_{\text{MIN}})}{\text{REAL}(\text{NTICK}-1)} \right) \times \left( \frac{2}{3} \right) \]

divided by the number of data sets (i.e., number of bars per tick mark)

\[ X_{\text{BARW}} = \frac{X_{\text{WID}}}{\text{REAL}(\text{NUMSET})} \]

Finally, to plot the data sets we merely setup a loop and perform the appropriate moves and rectangle calls.

```
DO 2 I=1,NUMSET
   CALL JPINDEX(I,48-I))
C XOFF - OFFSET OF THE DATA SET PER TICK MARK ON THE AXIS
   XOFF=-XWID/2. + REAL(I-1)*XBARW
   DO 2 J=1,NUMPTS
      CALL JRECT(REAL(J)+XOFF,0.0,
                     + REAL(J)+XOFF+XBARW,Y(I,J))
```

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3.4.3 Complete Program Plotting Multiple Absolute Bar Chart Data Sets

This section combines the steps presented in Section 3.4.2 into a complete program. This program demonstrates a bar chart with multiple absolute data sets.

```
PROGRAM CDB2
C-------------------------------------------------------------
C ABSOLUTE BARS - MULTIPLE DATA SETS
C-------------------------------------------------------------
C SET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YMAX=11.0,CSIZE=.15)
PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)
C-------------------------------------------------------------
C ALLOCATE STORAGE AND INITIALIZE VARIABLES
PARAMETER(NUMSET=3,NUMPTS=20)
REAL REVCRU(NUMSET,NUMPTS)
CHARACTER MONTHS(0:37)*3,VALUES(3)*2
DATA MONTHS/' ','JAN','FEB','MAR','APR','MAY','JUN',
+ 'JUL','AUG','SEP','OCT','NOV','DEC',
+ 'JAN','FEB','MAR','APR','MAY','JUN',
+ 'JUL','AUG','SEP','OCT','NOV','DEC',
+ 'JUL','AUG','SEP','OCT','NOV','DEC',
' /
DATA VALUES/ '0', '5', '10'/
DO 9 I=1,NUMSET
DO 9 J=1,NUMPTS
9 REVCRU(I,J)=RANF()*.10.
C-------------------------------------------------------------
C INITIALIZE D13000 AND CGL
CALL JBEGIN
CALL CBEGIN
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-------------------------------------------------------------
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL CVSPAC(XWMAX,YMAX)
CALL JWINDO(0.,XWMAX,0.,YMAX)
CALL JOPEN
C-------------------------------------------------------------
CALL JSIZE(CSIZE,CSIZE*.25)
C HORIZONTAL AXIS
CALL JMOVE(XBEG,YBEG)
CALL CHTROT(45)
IMONTH1=8
CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMONTH1-1),?,NUMPTS+2)
```
C YEARS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJJUST(2,3)
CALL JHSTRG('83')
IF(IMONTH1.NE.1)THEN
   DIST=REAL((12-IMONTH1)+2)
   CALL JRMOVE(DIST*XINCR,0.)
   CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')
C-----------------------------------------------------------------------
C VERTICAL AXIS - ON LEFT
CALL JMOVE(XBEG,YBEG)
CALL CVLAB('CREUS ((BLC)THOUSANDS)',1)
CALL CVAXIC(YLEN,2,VALUES,1,1)
C VERTICAL AXIS - ON RIGHT
CALL JMOVE(XBEG+XLEN,YBEG)
CALL CVLAB(' ',0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIC(YLEN,2,VALUES,1,0)
C-----------------------------------------------------------------------
C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2.,YBEG+YLEN+YOFF)
CALL JJJUST(2,1)
CALL JSIZE(1.5*CSIZE,1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')
CALL JRMOVE(0.,-2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE,YBEG+YLEN)
CALL JJJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')
C-----------------------------------------------------------------------
C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG+XLEN,YBEG+YLEN,0.,XV2,YV2)
CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1,XV2,YV1,YV2)
CALL JWINDO(0.,REAL(NUMPTS+1),0.,10.)
C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL JPINTR(1)
C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVIDED BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3). XWIDTH=((NUMPTS+1)/REAL(NUMPTS+2-1))*(2./3.)  

NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH=2/3. XWIDTH= 2./3.

XBARW=XWIDTH/REAL(NUMSET)
DO 2 I=1,NUMSET
   CALL JPINDEX(I,48-I)
   XOFF=-XWIDTH/2. + REAL(I-1)*XBARW
DO 2 J=1,NUMPTS
2   CALL JRECT(REAL(J)+XOFF,0.,REAL(J)+XOFF+XBARW,REVCRU(I,J))

-----------------------------------------------

C TERMINATE DI3000 AND CGL
CALL JCLOSE
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEVT(IDEV)
CALL JEND
STOP
END

REVENUE CRUS
DAILY AVERAGE -- MONTHLY BY MACHINE

Figure 3-25. Bar chart with multiple absolute data sets.
3.4.4 Plotting Additive Bar Chart Data

With additive data sets, the data from subsequent data sets are stacked (or accumulated) per tick mark. For example, Figure 3-26 shows three data sets represented in an additive fashion. The last two data sets are stacked on each other, on top of the first data set.

The establishment of the axis is the same as in Subsection 3.4.1, noting that the vertical axis bounds must represent the largest additive tick mark values. The following code will determine the bar widths, and plot the data in additive fashion. The accumulative width is computed as in the previous section as

\[
XWID = \left( \frac{(XMAX - XMIN)}{\text{REAL}(NTICK-1)} \right) \times \left( \frac{2}{3} \right)
\]

and the midpoint of \(XWID\) is calculated as

\[
XHALF = \frac{XWID}{2}.
\]

Thus, the remaining difference between plotting additive versus absolute is illustrated by the following partial program.

```
C KEEP A RUNNING ACCUMULATION FOR EACH TICK MARK
DO 1 I=1,NUMPTS
1 TOTAL(I)=0.0
C FOR THE NUMBER OF DATA SETS (NUMSET) DO
  C SET THE INTERIOR FILL
  CALL JPINDEX(I,48-I)
C FOR THE NUMBER OF DATA VALUES (NUMPTS) DO
  DO 2 J=1,NUMPTS
C PLOT THE DATA AS BARS
    CALL JRECT(REAL(J)-XHALF,TOTAL(J),
                 REAL(J)+XHALF,TOTAL(J)+Y(I,J))
C ACCUMULATE THE DATA
  2 TOTAL(J)=TOTAL(J)+Y(I,J)
```
3.4.5 Complete Program Plotting Multiple Additive Bar Chart Data Sets

The following is a complete program using the method described Section 3.4.4 to generate bar charts with multiple additive data sets. Figure 3-26 shows the graphics output generated by the following program.

```fortran
PROGRAM CDB3
  C------------------------------------------------------------------
  C ADDITIVE BARS - MULTIPLE DATA SETS
  C------------------------------------------------------------------
  C SET UP PLOT CONSTANTS
  PARAMETER(XWMAX=11.0,YWMAX=11.0,CSIZE=.15)
  PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)
  C------------------------------------------------------------------
  C ALLOCATE STORAGE AND INITIALIZE VARIABLES
  PARAMETER(NUMSET=3,NUMPTS=20)
  REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
  CHARACTER MONTHS(0:37)*3
  DATA MONTHS/'   ', 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',
    + 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
    + 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',
    + 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
    + 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',
    + 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC', ' />
  DO 9 I=1,NUMSET
  DO 9 J=1,NUMPTS
  9 REVCRU(I,J)=RANF()*10.
  C------------------------------------------------------------------
  C INITIALIZE DI3000 AND CGL
  CALL JBEGIN
  CALL CBEGIN
  IDEV=0
  CALL JDINIT(IDEV)
  CALL JDEVON(IDEV)
  C------------------------------------------------------------------
  C SET WINDOW AND VIEWPORT FOR PAGE AREA
  CALL CVSPAC(XWMAX,YWMAX)
  CALL JWINDO(0.,XWMAX,0.,YWMAX)
  CALL JOPEN
  C------------------------------------------------------------------
  CALL JSIZE(CSIZE,CSIZE*1.25)
  C HORIZONTAL AXIS
  CALL JMOVE(XBEG,YBEG)
  CALL CHTROT(45)
  IMONTH1=8
  CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMONTH1-1),1,NUMPTS+2)
```

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C YEARS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJUST(2,3)
CALL JHSTRG('83')
IF(IMonth1.NE.1)THEN
  DIST=REAL(((2-IMonth1)+2)
  CALL JRMOVE(DIST*XINCR,0.)
  CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')

C VERTICAL AXIS - LABEL ON LEFT OF AXIS
CALL JMOVE(XBEG,YBEG)
CALL CVLAB('CRU[BL]CS ([BL]THOUSANDS)',1)
CALL CVAXIS(0.,30.,5.,YLEN)

C VERTICAL AXIS - LABEL ON RIGHT OF AXIS
CALL JMOVE(XBEG+XLEN,YBEG)
CALL CVLAB(' ',0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIS(0.,30.,5.,YLEN)

C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2.,YBEG+YLEN+YOFF)
CALL JJUST(2,1)
CALL JSIZE(1.5*CSIZE,1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')
CALL JRMOVE(0.,-2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE,YBEG+YLEN)
CALL JJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')

C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONVW(XBEG,YBEG,0.,XV1,YV1)
CALL JCONVW(XBEG+XLEN,YBEG+YLEN,0.,XV2,YV2)
CALL JCLOSE

C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1,XV2,YV1,YV2)
CALL JWINDO(0.,REAL(NUMPTS+1),0.,30.)

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C OPEN SEGMENT, AND PLOT BARS
   CALL JOPEN
   CALL JPINTR(1)
C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED
C BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVIDED
C BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3).
C XWIDTH=\((NUMPTS+1)/REAL(NUMPTS+2-1))\*(2./3.)
C NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH=2/3.
     XWIDTH=
     2./3.
   DO 99 I=1,NUMPTS
   99 TOTAL(I)=0.0
   DO 2 I=1,NUMSET
      CALL JPINDEX(I,48-I)
      DO 2 J=1,NUMPTS
         CALL JRECT(REAL(J)-XHALF,TOTAL(J),
       + REAL(J)+XHALF,TOTAL(J)+REVCRU(I,J))
      2 TOTAL(J)=TOTAL(J)+REVCRU(I,J)
C-----------------------------------------------
C TERMINATE DI3000 AND CGL
   CALL JCLOSE
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDENOF(IDEV)
   CALL JEND
   STOP
END
REVENUE CRUS
DAILY AVERAGE – MONTHLY BY MACHINE

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3.4.6 Plotting Both Absolute and Additive Bar Chart Data

Before attempting this section, it is recommended that Sections 3.4.2 and 3.4.4 are read on plotting absolute and additive data sets onto separate charts. The following section explains how to combine the two types onto one chart. There are two steps that should be taken before writing a program.

Step 1: Know the number of data sets. The number of absolute data sets is very important because it directly affects the bar width and the spacing between each tick mark. In this example, there are a total of three data sets, two of which are absolute data sets.

Step 2: Know how to combine the data sets. The first data set will always be plotted as an absolute bar graph because there is no preceding data. The type of the subsequent data sets to be plotted must be indicated by the user as being additive or absolute (i.e., see ID below). In this example, the second data set will be plotted as an additive bar, while the third will be plotted as an absolute bar.

C Allocate storage and initialize variables.

PARAMETER (NUMSET=3, NUMPTS=20)
INTEGER ID(NUMSET)
REAL REVCRU(NUMSET, NUMPTS), TOTAL(NUMPTS)
DATA ID/O, 1, O/

C ID[1] = 0 means an absolute data set
C ID[2] = 1 means an additive data set
C ID[3] = 0 means an absolute data set

C Determine the number of additive data sets.

ICT=0
DO 101 I=2, NUMSET
101 IF(ID(I).EQ.1) ICT=ICT+1

C Note: NUMSET-ICT equals the number of absolute data sets.
C Open segment and plot bars.

CALL JOPEN
CALL JPINTR(1)
The width of the bars at a single tick mark is determined by the length of the axis (in data coordinates) divided by the number of absolute data sets, times (2./3.).

\[ \text{XWIDTH} = \left( \frac{(\text{NUMPTS}+1)}{\text{REAL}(\text{NUMPTS}+2-1)} \right) \times (2./3.) \]

**NOTE:** If the world is from 0 to a value (with an increment of 1, as is typical for bar charts), then \( \text{XWIDTH} = 2./3 \).

Each bar width (XBARW) is the XWIDTH divided by the number of absolute data sets.

\[ \text{XWIDTH} = 2./3, \quad \text{XBARW} = \frac{\text{XWIDTH}}{\text{REAL} \left( \text{NUMSET} - \text{ICT} \right)} \]

DO 99 I=1,NUMPTS

99 TOTAL(I)=0.0

ICT is the current absolute data set counter, and determines the offset (based on which absolute data set).

\[ \text{ICT} = 1 \]

DO 2 I=1,NUMSET

CALL JPINDEX(I,48-I)

XOFF=-XWIDTH/2. + REAL(ICT-1)*XBARW

C If ID[i]=1 (absolute data set), then increment ICT counter.

\[ \text{IF} \left( \text{ID} (I) \right. \text{EQ.1} ) \text{ICT} = \text{ICT} + 1 \]

DO 2 J=1,NUMPTS

DO JRECT(REAL(J)+XOFF,TOTAL(J),REAL(J)+XOFF+XBARW, + TOTAL(J)+REVCRU(I,J))

C Check to see if ID[i+1] = 1 (i.e., an additive data set), then accumulate TOTAL.

\[ \text{IF} \left( \text{ID} (I+1) \right. \text{EQ.1} \right) \text{THEN} \]

TOTAL(J)=TOTAL(J)+REVCRU(I,J)

ELSE

TOTAL(J)=0.

ENDIF

2 CONTINUE

CALL JCLOSE

---

Figure 3-27. Partial program with absolute and additive data sets.

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3.4.7 Complete Program Plotting Multiple Absolute and Additive Bar Chart Data Sets

The following program shows how to generate a bar chart with multiple absolute and additive data sets. This program combines the steps presented in the last section in context. The resultant graphical output is found in Figure 3-27.

```
PROGRAM CDB1

C-----------------------------------------------
C ADDITIVE AND ABSOLUTE BARS - MULTIPLE DATA SETS
C-----------------------------------------------

C SET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YWMAX=11.0,CSIZE=0.15)
PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)

C-----------------------------------------------
C ALLOCATE STORAGE AND INITIALIZE VARIABLES
PARAMETER(NUMSET=3,NUMPTS=20)
INTEGER ID(NUMSET)
REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
CHARACTER MONTHS(0:37)*3
DATA ID/0,1,0/
DATA MONTHS/' ' 'JAN','FEB','MAR','APR','MAY','JUN','
+ 'JUL','AUG','SEP','OCT','NOV','DEC',
+ 'JAN','FEB','MAR','APR','MAY','JUN',
+ 'JUL','AUG','SEP','OCT','NOV','DEC',
+ 'JAN','FEB','MAR','APR','MAY','JUN',
+ 'JUL','AUG','SEP','OCT','NOV','DEC',' ' /
DO 9 I=1,NUMSET
DO 9 J=1,NUMPTS
9 REVCRU(I,J)=RANF(*)*10.

C-----------------------------------------------
C INITIALIZE DI3000 AND CGL
CALL JBEGIN
CALL CBEGIN
IDEV=0
CALL JDINIT(DEV)
CALL JDEVON(DEV)

C-----------------------------------------------
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL CVSPAC(XWMAX,YWMAX)
CALL JWINO(0.,XWMAX,0.,YWMAX)
CALL JOPEN

C-----------------------------------------------
CALL JSIZE(CSIZE,CSIZE*1.25)
C HORIZONTAL AXIS
CALL JMOVE(XBEG,YBEG)
CALL CHTROT(45)
IMONTH1=8
CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMONTH1-1),1,NUMPTS+2)
```
C YEARS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJJUST(2,3)
CALL JHSTRG('83')
IF(IMONTH1.NE.1)THEN
  DIST=REAL((12-IMONTH1)+2)
  CALL JRMOVE(DIST*XINCR,0.)
  CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')
C-----------------------------------------------
C VERTICAL AXIS - ON LEFT OF PLOT
CALL JMOVE(XBEG,YBEG)
CALL CVLAB('CRUS ([BLC]THO[USANDS]','1)
ICT=0
DO 101 I=2,NUMSET
  101 IF (ID(I).EQ.1) ICT=ICT+1
  VMAX=10.*REAL(NUMSET-ICT)
  CALL CVAXIS(0.,VMAX,5.,YLEN)
C VERTICAL AXIS - ON RIGHT OF PLOT
CALL JMOVE(XBEG+XLEN,YBEG)
CALL CVLAB('','0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIS(0.,VMAX,5.,YLEN)
C-----------------------------------------------------------------------
C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2.,YBEG+YLEN+YOFF)
CALL JJJUST(2,1)
CALL JSIZE(1.5*CSIZE,1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')
CALL JRMOVE(0.,-2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE,YBEG+YLEN)
CALL JJJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')
C-----------------------------------------------------------------------
C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG,YBEG,0.,XV1,YV1)
CALL JCONWV(XBEG+XLEN,YBEG+YLEN,0.,XV2,YV2)
CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1,XV2,YV1,YV2)
CALL JWINDO(0.,REAL(NUMPTS+1),0.,VMAX)
C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL JPINTR(1)
C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED
C BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVided
C BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3).
C WIDTH=\((\text{NUMPTS}+1)/\text{REAL(NUMPTS}+2-1)\)*\((2/3)\).
C NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH=2/3.
    XWIDTH= 2./3.
    XBARW=XWIDTH/REAL(NUMSET-ICT)
    DO 99 I=1,NUMPTS
99   TOTAL(I)=0.0
    ICT=1
    DO 2 I=1,NUMSET
        CALL JPINDEX(I,48-I)
        XOFF=-XWIDTH/2. + REAL(ICT-1)*XBARW
        IF(ID(I).EQ.1)ICT=ICT+1
        DO 2 J=1,NUMPTS
            CALL JRECT(REAL(J)+XOFF,TOTAL(J),REAL(J)+XOFF+XBARW,
                       + TOTAL(J)+REVCRU(I,J))
            IF (ID(I+1).EQ.1) THEN
                TOTAL(J)=TOTAL(J)+REVCRU(I,J)
            ELSE
                TOTAL(J)=0.
            END IF
2       CONTINUE
C-----------------------------------------------------------------------
C TERMINATE DI3000 AND CGL
CALL JCLOSE
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Figure 3-28. Complete program with absolute and additive data sets.
3.4.8 Adding a Key to Bar Charts

The necessary steps to generate a bar chart with multiple data sets has been demonstrated. The next evolutionary step is the addition of a key. A key is a list of words or phrases giving an explanation of symbols or abbreviations (Figure 2-4 indicates a key in a XY line chart).

In order to add a key, the following four steps are necessary:

1) declare and allocate key related variables;
2) initialize the key related variables by calling CKEYIN;
3) for each data set to be represented in the key, call CKEYLB. This call should be performed when the data is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active; and
4) finally to plot the key, call CKEYPL. This call should be performed in page coordinates. Thus, the window and viewport may have to be reset.

Step 1 - Declare and allocate variables

A key is a series of entries (lines), where each entry is stored internally as a collection of attributes. The user is required to declare and allocate storage for these attributes. Specifically, two variables are needed, ISTORE (storage array for attributes) and KEYCHR (storage array for line labels). The dimensions of these arrays should be large enough to accommodate the largest number of data sets plotted at one time. See the description of the routine CKEYPL in Appendix A for a more detailed description.

```
PARAMETER (NLINS=4, NCOLS=1)
C NLINS - the maximum number of lines in the key
C NCOLS - the number of columns for an entry
C *20 - the largest character string per entry
C (including mnemonics)
C (Note, in this example 20 is used, could be any value.)

CHARACTER KEYCHR(NCOLS,NLINS)*9
INTEGER ISTORE(15,NLINS)
```
Step 2 - Initialize the key related variables by calling CKEYIN. This initialization can be performed anywhere, at anytime (i.e., the variables passed to CKEYIN will be reset).

- C Set window to match data coordinates, and plot within boundaries of the axes
- CALL JWINDO(0.,REAL(NUMPTS+1),0.,10.)
- C 0.,REAL(NUMPTS+1) - the data coordinate boundaries in the X-direction. Set to NUMPTS, plus an extra point on each end of the scale.
- C 0.,10. - the data coordinate boundaries in the Y-direction
- CALL JVPORT(VX1,VX2,VY1,VY2)
- CALL JOPEN
- CALL CKEYIN(ISTORE, KEYCHR, NLINS, NCOLS, NTLINS)

Step 3 - For each data set to be represented in the key, call CKEYLB. This call should be performed when the data is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active. The key related variables will be assigned values to be plotted when all the key entries have been obtained. This typically requires the plotting of the data (in terms of data coordinates). Note, a "-4" is passed to CKEYLB to indicate a rectangle (instead of a line) is to be used in the key.

- C Plot the first data set
- DO 2 I=1,NUMSET
- CALL JPIDEX(I,48-I)
- CALL CKEYLB(ISTORE, KEYCHR,-4,KEYLAB(I))
- DO 2 J=1,NUMPTS
- CALL JRECT(REAL(J)-XHALF,TOTAL(J),
- REAL(J)+XHALF,TOTAL(J)+REVCRU(I,J))
- 2 TOTAL(J)=TOTAL(J)+REVCRU(I,J)
- CALL JCLOSE

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Step 4 - Finally to plot the key, call CKEYPL. When all the key entries have been made, a call to CKEYPL will plot the key based on the attributes stored in ISTORE and KEYCHR (and a few internal variables). The call to CKEYPL should be performed in page coordinates, and since most data is plotted in data coordinates (where the attributes are saved by CKEYLB), the window and viewport will probably have to be reset.

C Now output the key
C Set the window and viewport for page coordinates
   CALL JVPORT(...)
   CALL JWINDO(...)
   BPOS(1)=XORG+XLEN
   BPOS(2)=YORG+YLEN
   CALL JOPEN
   CALL JSIZE(0.1,0.1*1.25)
   CALL CKEYPL(ISTORE,KEYCHR,'K[BL]EY TITLE',
               + 'C[BL]OLUMN TITLE',BPOS,5,JCOL,1)
   CALL JCLOSE

C Terminate graphics
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
3.4.9 Complete Bar Chart Program with a Key

The following program is used to demonstrate how to embed these four steps into a complete program. The key related statements have been additionally commented for clarity. Figure 3-29 shows the graphics output from the following program.

```
PROGRAM CDB4
C-----------------------------------------
C ADDITIVE BARS - MULTIPLE DATA SETS, WITH A LEGEND.
C-----------------------------------------
C SET UP PLOT CONSTANTS
  PARAMETER(XWMAX=11.0,YWMAX=11.0)
  PARAMETER(XBEG=1.5,YBEG=1.5)
  PARAMETER(XLEN=8.5,YLEN=5.0)
  PARAMETER(CSIZE=.15)
C-----------------------------------------
C ALLOCATE STORAGE AND INITIALIZE VARIABLES
  PARAMETER(NUMSET=3,NUMPTS=20)
  REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
  PARAMETER(NLINES=4,NCOLS=1,NTLINES=1)
  CHARACTER KEYCHR(NCOLS,NLINES)*9,KEYLAB(NLINES)*9
  INTEGER ISTORE(15,NLINES),JCOL(1)
  REAL BPOS(4)
  CHARACTER MONTHS(12)*3,VALUES(3)*2
  DATA MONTHS/ 'JAN','FEB','MAR','APR','MAY','JUN',
               + 'JUL','AUG','SEP','OCT','NOV','DEC'/
  DATA VALUES/ '0','5','10'/
  DATA KEYLAB(1)'-AVAIL+PM'/,KEYLAB(2)'-AVAIL '/
  DATA KEYLAB(3)'-USE '/,KEYLAB(4)'-PROD '/
  DATA JCOL/1/
  DO 9 I=1,NUMSET
  DO 9 J=1,NUMPTS
       9 REVCRU(I,J)=RANF(*3).
C-----------------------------------------
C INITIALIZE DI3000 AND CGL
  CALL JBEGIN
  CALL CBEGIN
  CALL CDEBUG(1)
  IDEV=0
  CALL JDINIT(IDEV)
  CALL JDEVON(IDEV)
C-----------------------------------------
C SET WINDOW AND VIEWPORT FOR PAGE AREA
  CALL JVSPAC(-1.,1.,-1.,1.)
  CALL JWINDO(0.,XWMAX,0.,YWMAX)
  CALL JOPEN
```

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CALL JSIZE(CSIZE, CSIZE*1.25)
C HORIZONTAL AXIS
CALL JMOVE(XBEG, YBEG)
CALL CHLABJ(1)
CALL CHAXIC(XLEN, 2, ', ,0, NUMPTS)
C MONTHS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG, YBEG-2.*CSIZE*1.25)
CALL JJJUST(3,2)
CALL CSETBP(90.)
IMONTH1=8
DO 1 KI=1, NUMPTS
   IMONTH=KI+IMONTH1-1
   IMONTH=MOD(IMONTH, 12)
   IF(IMONTH.EQ.0) IMONTH=12
   CALL JRMOVE(XINCR, 0.)
1 CALL JHSTRG(MONTHS(IMONTH))
CALL CSETBP(0.)
CALL JSETDB(0)
C YEARS
CALL JMOVE(XBEG, YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJJUST(2,3)
CALL CSETBP(0.)
CALL JHSTRG('83')
IF(IMONTH1 .NE. 1) THEN
   DIST=REAL((12-IMONTH1)+2)
   CALL JRMOVE(DIST*XINCR, 0.)
   CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR, 0.)
CALL JHSTRG('85')
C VERTICAL AXIS
CALL JMOVE(XBEG, YBEG)
CALL CVLAB('CRU[BLC]S ([BLC]THOUSANDS)', 1)
CALL CVAXIC(YLEN, 3, VALUES, 1, 3)
CALL JMOVE(XBEG+XLEN, YBEG)
CALL CVLAB(' ', 0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVTICJ(2)
CALL CVAXIC(YLEN, 3, VALUES, 1, 3)
C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2., YBEG+YLEN+YOFF)
CALL JJJUST(2,1)
CALL JSIZE(1.5*CSIZE, 1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRS')
CALL JRMOVE(0., -2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE,YBEG+YLEN)
CALL JJJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')

C-------------------------------------------------------------------
C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG,YBEG,0.,X1,Y1)
CALL JCONWV(XBEG+XLEN,YBEG+YLEN,0.,X2,Y2)
CALL JCLOSE
C-------------------------------------------------------------------

C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(X1,X2,Y1,Y2)
CALL JWINDO(0.,REAL(NUMPTS+1),0.,10.)

C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINES,NCOLS,NTLINES)
CALL JPINTR(1)
XWIDTH=2./3.
XHALF=XWIDTH/2.
DO 99 I=1,NUMPTS
99 TOTAL(I)=0.0
CALL JSIZE(CSIZE,CSIZE*1.25)
DO 2 I=1,NUMSET
   CALL JPIDEX(I,47-(I-1))
   CALL CKEYLB(ISTORE,KEYCHR,-4,KEYLAB(I))
   DO 2 J=1,NUMPTS
      CALL JRECT(REAL(J)-XHALF,TOTAL(J),
      + REAL(J)+XHALF,TOTAL(J)+REVCRU(I,J))
   2 TOTAL(J)=TOTAL(J)+REVCRU(I,J)
CALL JCLOSE
C-------------------------------------------------------------------

C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL JSSETDB(O)
CALL JVPORT(-1.,1.,-773.,773)
CALL JWINDO(0.,10.,0.,7.73)
BPOS(1)=XBEG+XLEN
BPOS(2)=YBEG+YLEN
CALL JOPEN
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL CKLPLN(.08)
CALL CKEYPL(ISTORE,KEYCHR,' ',' ',BPOS,3,JCOL,0)
CALL JCLOSE
C-------------------------------------------------------------------

C TERMINATE DI3000 AND CGL
CALL JPDELETE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END

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Figure 3-29. Complete bar chart with a key.
3.5 Steps in the Generation of Pie Charts

This section discusses how to generate pie charts. The Low-Level routines of the CGL contain no routines for the generation of pie charts. This is because a pie chart consists of a set of sectors (possibly with associated text). Thus, the components of pie charts are so primitive, that little advantage can be obtained by calling any routines other than those supplied by the underlying graphics package.

This section will describe a method of calling the underlying graphics package, and take advantage of some CGL routines to perform supplementary functions (i.e., keys). The major steps in the generation of pie charts consists of:

- setting page coordinates
- determining the placement of the center of the pie
- drawing the pie segments (possibly with segment labels)

3.5.1 Page Coordinates and Describing Components

A convenient approach to aid the user in designing a chart is to establish a coordinate system, referred to here as the page coordinate system, which easily enables the user to arrange and describe the chart components. The page coordinates can be of any dimension and represent any unit. Since publication-quality charts are often requested, the page coordinates described in the document are typically in terms of inches to coincide with the postprocessors (plotters).

A call to JVSPAC will setup the viewspace and viewport. A call to JWINDO defines the viewing window.

\[
\text{CALL JVSPAC}(-1.,1.,-1.,1.)
\]
\[
\text{CALL JWINDO}(0.,10.,0.,10.)
\]

Once the page coordinates have been set, the user can position and describe objects in terms of the page coordinates. For example, the following code will output a graphics string as a title, output a graphics string in the bottom left hand corner of the page as well as the bottom right hand corner of the page (as shown in Figure 3-30).
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
CALL JOPEN
CALL JIWIND(XV,YV,ZV)
CALL JPINDEX(4,0)
CALL JPOLGN(XV,YV,4)
CALL JSIZE(4,4)
CALL JFONT(3)
CALL JJUST(2,2)
CALL JMOVE(5,9.2)
CALL JHSTRG('MATERIALS')
CALL JMOVE(1,.8)
CALL JHSXTN(YEAR,DX,DY)
CALL JPINDEX(6,0)
CALL JRRECT(DX,DY)
CALL JJUST(1,1)
CALL JHSTRG(YEAR)
CALL JMOVE(9.9,.8)
CALL JSIZE(.25,.25)
CALL JFONT(1)
CALL JJUST(3,1)
CALL JHSTRG('PREPARED BY CSC')

C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
MATERIALS

Figure 3-30. Example of page layout for a pie chart.
3.5.2 Plotting Data for Pie Charts

Once the page coordinates have been established, the center of the pie must be decided and the pie segments drawn. In order to get a true circle for the pie, the program should ensure consistent aspect ratios for both the current viewport and current window in which the pie is drawn.

In order to plot the data, the sectors of the pie must be plotted individually. To draw pie segments, the following pie characteristics (see Figure 3-31) must be supplied:

- pie center (i.e., X, Y, 0.0)
- pie radius (RAD1)
- number of pie segments (NUMSEG)
- segment attributes (see JPIDEX)
- segment angles (see variables A0 and A1 of JSECTR)
- segment text attributes (i.e., JSIZE, JFONT, JJUST, etc.)
- segment text position (based on RADIUS and quadrant)

![Figure 3-31. Variables associated with pie chart generation.](image)
The following is a partial program explaining the steps involved in plotting pie chart data.

C-----------------------------'--''-------------------------------
C COMPUTE THE FACTOR FOR CONVERTING DEGREES TO RADIANS.
   DTORAD=ATAN(1.0)/45.
C------------------------------''----------------------------------
C TOTAL THE REGIONAL DATA.
   TOTAL=0.0
   DO 3000 I=1,8
      3 0 0 0 TOTAL = TOTAL+REGION(I)
C-------------------------------''-------------------------------
C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
   CALL JOPEN
C THE FIRST PIE SEGMENT STARTS AT 0.0 DEGREES.
   START=0.
C SET THE TEXT ATTRIBUTES
   CALL JSIZE(.2,.2)
   CALL JFONT(1)
C LOOP FOR ALL PIE SEGMENTS (NUMSEG IS 8)
   DO 5000 I=1,8
C COMPUTE BEGINNING AND ENDING ANGLES
   A0=START
   A1=REGION(I)/TOTAL*360.+START
   START=A1
C SET PIE SEGMENT ATTRIBUTES, AND DRAW SEGMENTS
   CALL JINDEX(I, I+30)
   CALL JSECTR(5.,5.,0.,RAD1,0, A0, A1)
C CALCULATE SEGMENT MIDPOINT, AND ASSOCIATED POSITION OF SEGMENT TEXT
   AMID=(A1-A0)/2.+A0
   ARAD=AMID*DTORAD
   C1=COS(ARAD)
   S1=SIN(ARAD)
C MOVE AND DRAW A LINE FROM THE PIE SEGMENT TO THE TEXT
   CALL JMOVE(5.+RAD2*C1,5.+RAD2*S1)
   CALL JDRAW(5.+RAD3*C1,5.+RAD3*S1)
C DETERMINE THE PIE SEGMENT TEXT JUSTIFICATION (BASED ON ANGLE)
   IF (AMID.LT. 45. .OR. AMID.GE. 315.) CALL JJJUST(1,2)
   IF (AMID.GT. 45. .AND. AMID.LT. 135.) CALL JJJUST(2,1)
   IF (AMID.GE. 135. .AND. AMID.LT. 225.) CALL JJJUST(3,2)
   IF (AMID.GE. 225. .AND. AMID.LT. 315.) CALL JJJUST(2,3)
C POSITION TEXT AND DRAW TEXT
   CALL JMOVE(5.+RAD4*C1,5.+RAD4*S1)
5000 CALL JHSTRG(LABEL(I))

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Figure 3-32. Plotting pie data.
3.5.3 Complete Program Plotting a Pie Chart

The previous subsections walked through the steps and described a method of generating a pie chart. The following is a complete program using the method previously described in context. The corresponding graphics output can be found in Figure 3-33.

```plaintext
PROGRAM CDP1
C-----------------------------------------------
C BASIC PIE CHART
C-----------------------------------------------
C INITIALIZE DATA
    REAL OFFSET,RAD1,RAD2,RAD3,RAD4
    REAL XV(4),YV(4),ZV(4),REGION(8)
    CHARACTER*14 LABEL(8)
    CHARACTER*4 YEAR
C-----------------------------------------------
C INITIALIZE DATA
    DATA OFFSET,RAD1,RAD2,RAD3,RAD4 / .25,2.,2.35,2.85,2.95/
    DATA REGION(1),REGION(2),REGION(3),REGION(4)/21.,6.,24.,28./
    DATA REGION(5),REGION(6),REGION(7),REGION(8)/4.,13.,18.,32./
C
    DATA YEAR / '1988'/
C
    DATA LABEL(1)/'N[BLC]ICKEL'/
    DATA LABEL(2)/'M[BLC]AGNESIUM'/
    DATA LABEL(3)/'A[BLC]UMINUM'/
    DATA LABEL(4)/'G[BLC]OLD'/
    DATA LABEL(5)/'I[BLC]RON'/
    DATA LABEL(6)/'S[BLC]ILVER'/
    DATA LABEL(7)/'C[BLC]OPPER'/
    DATA LABEL(8)/'L[BLC]EAD'/
C-----------------------------------------------
C INITIALIZE DI-3000
    CALL JBEGIN
C WRITE TO THE DEVICE IDEV
    IDEV=0
    CALL JDMIN(DDEV)
    CALL JDEVOV(DDEV)
C-----------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
    CALL JVSPAC(-1.,1.,-1.,1.)
    CALL JWINDO(0.,10.,0.,10.)
C-----------------------------------------------
C FILL POLYGONS BY DEFAULT.
    CALL JDPINT(1)
```
C-- --------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
    CALL JOPEN
    CALL JWIN(XV,YV,2V)
    CALL JPINDEX(4,0)
    CALL JPINDEX(XV,YV,4)
    CALL JSIZE(.4,.4)
    CALL JFONT(3)
    CALL JJUST(2,2)
    CALL JMOVE(5.9,2)
    CALL JHSTRG('MATERIALS')
    CALL JMOVE(.1,.8)
    CALL JHSXTH(YEAR,DX,DY)
    CALL JPINDEX(6,0)
    CALL JRECT(DX,DY)
    CALL JJUST(1,1)
    CALL JHSTRG(YEAR)
    CALL JMOVE(9.9,.8)
    CALL JSIZE(.25,.25)
    CALL JFONT(1)
    CALL JJUST(3,1)
    CALL JHSTRG('PREPARED BY CSC')
C-- --------------------------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
    CALL JCLOSE
C-- --------------------------------------------------------------
C COMPUTE THE FACTOR FOR CONVERTING DEGREES TO RADIANS.
    DTORAD=ATAN(1.0)/45.
C-- --------------------------------------------------------------
C TOTAL THE REGIONAL DATA.
    TOTAL=0.0
    DO 3000 I=1,8
3000 TOTAL=TOTAL+REGION(I)
C-- --------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
    CALL JOPEN
    START=0.
    CALL JSIZE(.2,.2)
    CALL JFONT(1)
    DO 5000 I=1,8
      AO=START
      A1=REGION(I)/TOTAL*360.+START
      START=A1
      CALL JPINDEX(I,I+30)
      CALL JSECTR(.5,.5,.0,.RAD1,0,A0,A1)
C
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AMID=(A1-A0)/2.+A0
ARAD=AMID*PTORAD
C1=COS(ARAD)
S1=SIN(ARAD)
CALL JMOVE(5.+RAD2*C1,5.+RAD2*S1)
CALL JDRAW(5.+RAD3*C1,5.+RAD3*S1)

C
IF (AMID.LT.45. .OR. AMID .GE. 315.) CALL JJUST(1,2)
IF (AMID .GT. 45. .AND. AMID .LT. 135.) CALL JJUST(2,1)
IF (AMID .GE. 135. .AND. AMID .LT. 225.) CALL JJUST(3,2)
IF (AMID .GE. 225. .AND. AMID .LT. 315.) CALL JJUST(2,3)

C
CALL JMOVE(5.+RAD4*C1,5.+RAD4*S1)
5000 CALL JHSTRG(LABEL(I))
C---------------------------------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
C---------------------------------------------------------------------
C PAUSE TO VIEW CHART.
CALL JPAUSE(IDEV)
C---------------------------------------------------------------------
C TERMINATE DI-3000; ALL DEVICES ARE DESELECTED AND TERMINATED.
CALL JEND
STOP
END
Figure 3-33. Complete pie chart program.
3.5.4 Steps in Plotting a Pie Chart with a Key

In context, a simple pie chart has been demonstrated. The next evolutionary step is the addition of a key. A key is a list of words or phrases giving an explanation of symbols or abbreviations (Figure 2-6 indicates a key in a pie chart).

In order to add a key, four steps are necessary:

1) declare and allocate key related variables;
2) initialize the key related variables by calling CKEYIN;
3) for each data set to be represented in the key, call CKEYLB. This call should be performed when the pie segment is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active;
4) finally to plot the key, call CKEYPL. This call should be performed in page coordinates.

**Step 1 - Declare and allocate variables**

A key is a series of entries (lines), where each entry is stored internally as a collection of attributes. The user is required to declare and allocate storage for these attributes. Specifically, two variables are needed, ISTORE (storage array for attributes) and KEYCHR (storage array for line labels). The dimensions of these arrays should be large enough to accommodate the largest number of data sets plotted at one time. See the description of the routine CKEYPL in Appendix A for a more detailed description.

```
PARAMETER(NLINS=8)
C NLINS  - the maximum number of lines in the key
C *9    - the largest character string per entry
C       (including mnemonics)
C (Note, in this example 20 is used, could be any value.)
CHARACTER KEYCHR(1,NLINS)*9
INTEGER   ISTORE(15,NLINS)
```

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**Step 2** - Initialize the key related variables by calling CKEYIN. This initialization can be performed anywhere, at anytime (i.e., the variables passed to CKEYIN will be reset).

```c
C Set window to match page coordinates
CALL JWINDO(0.,10.,0.,10.)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)

Step 3 - For each data set to be represented in the key, call CKEYLB. This call should be performed when the data is to be drawn, since this routine will save off various DI-3000 and CGL attributes currently active. The key related variables will be assigned values to be plotted when all the key entries have been obtained. This typically requires the plotting of the data (in terms of data coordinates).

```c
C Plot the pie segments
DO 1 I=1,NUMSEG
  C Set pie segment attributes
  CALL JPIDEX(I,I+30)
  CALL JSECTR(...)
  CALL CKEYLB(ISTORE,KEYCHR,-4,LABEL(I))
1 CONTINUE
```
Step 4 - Finally to plot the key, call CKEYPL. When all the key entries have been made, a call to CKEYPL will plot the key based on the attributes stored in ISTORE and KEYCHR (and a few internal variables).

C Now output the key
C Set the key position.
   BPOS(1)=...
   BPOS(2)=...
C Plot the key
   CALL CKEYPL(ISTORE, KEYCHR, ' ', ' ', BPOS, 5, 1, 0)
   CALL JCLOSE

C Terminate graphics
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JEND(IDEV)
   CALL JEND
3.5.5 Complete Program Plotting a Pie Chart with a Key

The following program is used to demonstrate how to embed these four steps into a complete program. Figure 3-34 shows the graphics output from the following program.

```
PROGRAM CDP3
C-------------------------------------------------------------
C BASIC PIE CHART WITH A LEGEND
C-------------------------------------------------------------
C INITIALIZE DATA
REAL OFFSET,RAD1,RAD2,RAD3,RAD4
REAL BPOS(4)
REAL XV(4),YV(4),ZV(4),REGION(8)
CHARACTER*14 LABEL(8)
CHARACTER*4 YEAR
C
CHARACTER KEYCHR(1,8)*15
INTEGER ISTORE (15,8)
DATA OFFSET,RAD1,RAD2,RAD3,RAD4 /-.5,4.,4.7,5.7,5.9/
DATA REGION(1),REGION(2),REGION(3),REGION(4)/2.1,.6,2.4,2.8/
DATA REGION(5),REGION(6),REGION(7),REGION(8)/.4,1.3,1.8,3.2/
C
DATA YEAR /'1988'/
C
DATA LABEL(1)/'N(BLC)ICKEL'/
DATA LABEL(2)/'M(BLC)AGNESIUM'/
DATA LABEL(3)/'A(BLC)LUMINUM'/
DATA LABEL(4)/'I(BLC)RON'/
DATA LABEL(5)/'T(BLC)IN'/
DATA LABEL(6)/'C(BLC)OPPER'/
DATA LABEL(7)/'G(BLC)OLD'/
DATA LABEL(8)/'Z(BLC)INC'/
C-------------------------------------------------------------
C INITIALIZE DI-3000
CALL JBEGIN
CALL CBEGIN
C-------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-------------------------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
CALL JVSPAC(-1.,1.,-1.,1.)
CALL JWINDO(0.,10.,0.,10.)
C-------------------------------------------------------------
```

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C FILL POLYGONS BY DEFAULT.
CALL JDPINT(1)

C OPEN A TEMPORARY SEGMENT FOR BORDERS.
CALL JOPEN
CALL JIWIND(XV,YV,ZV)
CALL JPINDEX(4,0)
CALL JPOLGN(XV,YV,4)
CALL JSIZE(.6,.6)
CALL JFONT(5)
CALL JJUST(2,2)
CALL JMOVE(5,.9,1)
CALL JHSTRG('CGL PIE GRAPH')
CALL JMOVE(.1,.5)
CALL JHSXTN(YEAR,DX,DY)
CALL JPINDEX(6,0)
CALL JRRECT(DX, DY)
CALL JJUST(1,1)
CALL JHSTRG(YEAR)
CALL JMOVE(9.9,.5)
CALL JSIZE(.25,.25)
CALL JFONT(1)
CALL JJUST(3,1)
CALL JHSTRG('PREPARED BY CSC')

C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE

C DESIGN THE PIE TO BE 50% SMALLER
RAD1=RAD1-(RAD1*.50)
RAD2=RAD2-(RAD2*.50)
RAD3=RAD3-(RAD3*.50)
RAD4=RAD4-(RAD4*.50)

C COMPUTE THE FACTOR FOR CONVERTING DEGREES TO RADIANS.
DTORAD=ATAN(1.0)/45.

C TOTAL THE REGIONAL DATA.
TOTAL=0.0
DO 3000 I=1,8
3000 TOTAL = TOTAL+REGION(I)

C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,8,1,1)
START=5.
CALL JSIZE(.3,.3)
CALL JFONT(1)
DO 5000 I=1,8
   A0=START
   A1=REGION(I)/TOTAL*360.+START
   CALL JPIDEX(I,I+30)
   CALL JSECTR(3.,5.,3.,RAD1,0,A0,A1)
C
   START=A1
   AMID=(A1-A0)/2.+A0
   ARAD=AMID*DTORAD
   C1=COS(ARAD)
   S1=SIN(ARAD)
   5000 CALL CKEYLB(ISTORE,KEYCHR,-4,LABEL(I))
       BPOS(1)=9.5
       BPOS(2)=8.
       CALL CKEYPL(ISTORE,KEYCHR,' ',' ',BPOS,5,1,0)
C--------------------------------------------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
   CALL JCLOSE
C--------------------------------------------------------------------------------
C PAUSE FOR OPERATOR ACTION.
   CALL JPAUSE(IDEV)
C--------------------------------------------------------------------------------
C TERMINATE DI-3000; ALL DEVICES ARE DESELECTED AND TERMINATED.
   CALL JEND
   STOP
   END
Figure 3-34. Pie chart with a key.
3.5.6 **Plotting a Pie Chart with Exploded Segments**

In order to plot an exploded pie chart, all steps are the same as in the previous examples, except for the positioning of each segment. For pie charts with non-exploded segments, the origin of the pie segments are fixed. The only change needed to generate pie charts with exploded pie segments, is to vary the origin of the pie segments.

For **non-exploded** segments

\[
\begin{align*}
X0 &= \text{a fixed value} \\
Y0 &= \text{a fixed value} \\
\text{DO } 1 & \text{ I=1, NUMSEG} \\
& \text{CALL JSECTR(X0, Y0, ...)} \\
1 & \text{ CONTINUE}
\end{align*}
\]

For **exploded** segments

\[
\begin{align*}
\text{DO } 1 & \text{ I=1, NUMSEG} \\
& \text{X0} = \text{a changing value} \\
& \text{Y0} = \text{a changing value} \\
& \text{CALL JSECTR(X0, Y0, ...)} \\
1 & \text{ CONTINUE}
\end{align*}
\]

A complete pie chart program follows, illustrating a pie chart with exploded segments. The corresponding graphics output can be found in Figure 3-35.

```
PROGRAM CDP2
C---------------------------------------------------------------
C EXPLODED PIE CHART
C---------------------------------------------------------------
C INITIALIZE DATA
REAL OFFSET, RAD1, RAD2, RAD3, RAD4
REAL XV(4), YV(4), ZV(4), REGION(8)
CHARACTER*14 LABEL(8)
CHARACTER*4 YEAR
C
DATA OFFSET, RAD1, RAD2, RAD3, RAD4 / .25, 2., 2.35, 2.85, 2.95/
DATA REGION(1), REGION(2), REGION(3), REGION(4)/21., 6., 24., 28./
DATA REGION(5), REGION(6), REGION(7), REGION(8)/4., 13., 18., 32./
C
DATA YEAR / '1988'/
C
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```
DATA LABEL(1) /'N(BLC)ICKEL'/
DATA LABEL(2) /'M(BLC)AGNESIUM'/
DATA LABEL(3) /'A(BLC)LUMINUM'/
DATA LABEL(4) /'G(BLC)OLD'/
DATA LABEL(5) /'I(BLC)RON'/
DATA LABEL(6) /'S(BLC)ILVER'/
DATA LABEL(7) /'C(BLC)OPPER'/
DATA LABEL(8) /'L(BLC)EAD'/

C----------------------------------------------------------------------
C INITIALIZE DI-3000
   CALL CBEGIN
   CALL JBEGIN
C----------------------------------------------------------------------
C WRITE TO A DEVICE IDEV
   IDEV=0
   CALL JDINIT(IDEV)
   CALL JDEVON(IDEV)
C----------------------------------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
   CALL JVSPAC(-1.,1.,-1.,1.)
   CALL JWINDO(0.,10.,0.,10.)
C----------------------------------------------------------------------
C FILL POLYGONS BY DEFAULT
   CALL JDPMINT(1)
C----------------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
   CALL JOPEN
   CALL JIWIND(XV,YV,2V)
   CALL JPDEX(4,0)
   CALL JPOLGN(XV,YV,4)
   CALL JSIZE(.5,.5)
   CALL JFONT(3)
   CALL JJUST(2,2)
   CALL JMOVE(5.,9.2)
   CALL JHSTRG('MATERIALS')
   CALL JMOVE(.1,.8)
   CALL JHSXTN(YEAR,DX,DY)
   CALL JPDEX(6,0)
   CALL JRECT(DX,DY)
   CALL JJUST(1,1)
   CALL JHSTRG(YEAR)
   CALL JMOVE(9.9,.8)
   CALL JSIZE(.25,.25)
   CALL JFONT(1)
   CALL JJUST(3,1)
   CALL JHSTRG('PREPARED BY CSC')
C----------------------------------------------------------------------
C CLOSE TEMPORARY SEGMENT
   CALL JCLOSE
C----------------------------------------------------------------------
C COMPUTE THE FACTOR FOR CONVERTING DEGREES TO RADIANS.
   DTORAD=ATAN(1.0)/45.

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C TOTAL THE REGIONAL DATA.
TOTAL=0.0
DO 3000 I=1,8
3000 TOTAL = TOTAL+REGION(I)
C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
CALL JSOEN
START=5.
CALL JSIZE(.15,.15)
CALL JFONT(1)
DO 5000 I=1,8
AO=START
A1=REGION(I)/TOTAL*360.+START
START=A1
AMID=(A1-A0)/2.+A0
ARAD=AMID*DTORAD
C1=COS(ARAD)
S1=SIN(ARAD)
CALL JPIDEX(I,I+30)
C
XO=OFFSET*C1+5.
Y0=OFFSET*S1+5.
C
CALL JSCTR(X0,Y0,0.,RAD1,0,A0,A1)
C
CALL JMOVE(RAD2*C1+5.,RAD2*S1+5.)
C
IF (AMID.LT.45. .OR. AMID .GE. 315.) CALL JJUST(1,2)
IF (AMID .GT. 45. .AND. AMID .LT. 135.) CALL JJUST(2,1)
IF (AMID .GE. 135. .AND. AMID .LT. 225.) CALL JJUST(3,2)
IF (AMID .GE. 225. .AND. AMID .LT. 315.) CALL JJUST(2,3)
C
CALL JMOVE(RAD4*C1+5.,RAD4*S1+5.)
5000 CALL JHSTRG(LABEL(I))
C CLOSE TE TEMPORARY SEGMENT.
CALL JCLOSE
C
C PAUSE TO VIEW CHART.
CALL JPAUSE(IDEV)
C
C TERMINATE DI-3000; ALL DEVICES ARE DESELECTED AND TERMINATED.
CALL JEND
STOP
END
Figure 3-35. Pie chart with exploded segments.
3.6 Steps in the Generation of Composite Charts

The previous subsections described how to generate the various chart types offered by the Common Graphics Library (CGL). The following sections describe how to create a composite chart (i.e., multiple charts on a single display area).

3.6.1 Arranging Composite Charts

Multiple charts can be displayed on a single frame by opening and closing several windows and viewports, and plotting the axes and data corresponding to each chart. Although many charts can be displayed on a page, the user should keep in mind the readability of the resultant chart. When plotting the composite chart, it is recommended one chart be done at a time, and each be done in its own segment. The following is a skeleton program showing the major elements involved in the generation of composite charts.

```fortran
PROGRAM ...
  ...
  CALL CBEGIN
  CALL CVSPAC(...)
  ...

  (Repeat this section of code for every chart.)
  CALL JWINDO(...) (page coordinates)
  CALL JOPEN
  CALL CHAXIS(...)
  CALL CVAXIS(...)
    {save the axes' diagonals virtual values}
  CALL JCONWV(...)
  CALL JCLOSE
  ...

  CALL JWINDO(...) (data coordinates)
  CALL JVPORT(...) {set viewport based on JCONWV}
  CALL JOPEN
  CALL CLNPLT(...) {plot data}
  CALL JCLOSE

  ...

  CALL JDEVOF(...)
  CALL JDEND(...)
  CALL JEND
STOP
END
```

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In the preceding skeleton program, a window is opened to draw the axes (i.e., page related components), and then a window is opened to draw the data. These steps (indicated above between the dashed lines) should be repeated for each chart.

3.6.2 Complete Program Plotting a Composite Chart

The following program shows how to generate a composite chart. The resultant graphical output is found in Figure 3-36.

```plaintext
PROGRAM CDC1
C----------------------------------------------
C COMPOSITE CHART (I.E., TWO CHARTS ON ONE PAGE)
C----------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=10,MAXSET=4)
REAL X(MAXPTS,MAXSET),Y(MAXPTS,MAXSET)
DATA (X(KI,1),KI=1,10) + /0.,1.,2.,3.,4.,5.,6.,7.,8.,9/
DATA(X(KI,1),KI=1,10) + /1.,15.,3.,35.,45.,55.,65.,75.,85.,1.,2/
DATA(X(KI,1),KI=1,10) + /0.,1.,2.,3.,4.,5.,6.,7.,8.,9/
DATA(X(KI,4),KI=1,10) + /1.,2.,4.,6.,7.,8.,9,1.,1,1,1,2/
DATA (Y(KI,1),KI=1,10) + /0.,2.,4.,6.,7.,10.,12.,15.,18.,21.,24./
DATA (Y(KI,2),KI=1,10) + /1.,3.,5.,7.,9,11.,13.,16.,20.,22.,23./
DATA (Y(KI,3),KI=1,10) + /0.,.005,.01,.015,.02,.025,.029,.03,.035,.04/
DATA (Y(KI,4),KI=1,10) + /-.005,-.01,-.015,-.02,-.025,-.03,-.03,-.04,-.05,-.065,-.08/
C----------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C----------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
XS=.2
YS=6.0
CALL CVSPAC(10.,10.)
CALL J4RGET(2, VX3, VX4, VY3, VY4)
CALL JWINDOW(0.,10.,0.,10.)
CALL JOPEN
```
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(XS,XS*1.25)

C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)
CALL JMOVE(5.0,10.0)
CALL JJUST(2,3)

C OUTPUT THE STRING
CALL JHSTRG('A TITLE')

C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(XS,XS*1.25)

C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.0
CALL JMOVE(XORG,YORG)

C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('C [SUB] L','1')
CALL CHTICJ(1)

C XLEN-REPRESENTS THE X-AXIS LENGTH
XLEN=6.0
CALL CHPREC(1)
CALL CHAXIS(-.2,1.2,.2,XLEN)

C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('[FON=9][BLC] A[FONT=3]. DEG','1')
CALL CVPREC(3)
CALL CVTICJ(1)

C YLEN-REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVPREC(-1)
CALL CVJUST(1)
CALL CVAXIS(-4.,24.,4.,YLEN)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C-----------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(-.2,1.2,-4.,24.)

C -2,1.2 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C -4,24. - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN

C PLOT FIRST DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,1),MAXPTS)

C SET SYMBOL NUMBER TO 902, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(1,2),MAXPTS)
CALL JCLOSE

3-111
C WORK ON SECOND GRAPH
   CALL JWINDO(0.,10.,0.,10.)
   CALL JVPORT(VX3,VX4,VY3,VY4)
   CALL JOPEN
   CALL JSIZE(XS,XS*1.25)
   CALL JMOVE(XORG,YS)

C YLEN-REPRESENTS THE Y-AXIS LENGTH
   CALL CVLAB('C[SUB][BLC]M',1)
   CALL CVPREC(2)
   CALL CVAXIS(-.08,.04,.04,YLEN)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
   CALL JCONWV(XORG,YS,0.,0.,VX1,VY1)
   CALL JCONWV(XORG+XLEN,YS+3.5,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
   CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES AND PLOT WITHIN BOUNDARIES
   CALL JWINDO(-.2,1.2,-.08,-.04)
   CALL JVPORT(VX1,VX2,VY1,VY2)
   CALL JOPEN

C PLOT THIRD DATA CURVE
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,Y(1,3),MAXPTS)

C PLOT FOURTH SET OF DATA POINTS
   CALL CSYMNO(2)
   CALL CLNPAT(2)
   CALL CLNPLT(X,Y(1,4),MAXPTS)
   CALL JCLOSE

C TERMINATE GRAPHICS
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JEND(IDEV)
   CALL JEND
   STOP
   END
Figure 3-36. Example of a composite chart.
4. ADDITIONAL CAPABILITIES

This section describes capabilities and methodologies useful in generating and debugging programs using the Low-Level graphics programs. Currently, this section contains error detection and debugging capabilities. This section will be expanded to include additional capabilities as they are developed.

4.1 Error Detection and Debugging Capabilities

A fundamental premise of the Low-Level routines states that correct usage of the routines will generate a chart as described by this document. Correct usage consists of a proper sequence of calls with a proper set of routine arguments.

4.1.1 Error Detection

The error detection mechanism implemented in the Low-Level routines is passive; that is as errors are detected, error messages are written to a specified destination. The error mechanism requires no calls to initiate, as error detection is automatically performed. However, there is no means of error inquiry, nor any means of user-definable error recovery.

The errors detected by the Low-Level routines are classified as non-fatal and fatal. Non-fatal errors are considered tolerable in that the Low-Level routines can make suitable adjustments and continue processing. Fatal errors are those which are so severe that error recovery cannot occur, and the program terminates. All errors and their types are included in Appendix A under the routine which can generate them.

An example of a non-fatal error is to pass a value out of range for a subroutine argument. An appropriate error message will be written indicating that the information cannot be used. Typically, errors due to invalid values will result in the arguments being set to their defaults (see Appendix A for defaults).

Figure 4-1 shows an example of the error detection and reporting features, along with the corresponding graphics output. Note, as shown by the following example, the default destination of the error messages is the output device (often overwriting the graphics output). Refer to Section 4.1.3 for changing the destination of output.
The following program illustrates the Low-Level error detection mechanism.

```plaintext
PROGRAM COD1

C AN EXAMPLE SHOWING A SIMPLE CGL ERROR.
C
C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=5)
REAL X(MAXPTS), Y(MAXPTS)
DATA X/5.5, 6.5, 7.5, 8.5, 9.5/ , Y/0.001, 0.0075, 0.006, 0.009, 0.002/
C
C WRITE TO THE METAFILE
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9., 9.)
CALL JWINDO(0., 9., 0., 9.)
CALL JOPEN
CALL JSIZE(.2, .2*1.25)
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.1, .1*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)
CALL JMOVE(4.5, 6.0)
CALL JJUST(2, 2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1, .1*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG, YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS', 1)
CALL CHTICJ(-1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5., 10., 1., XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXIS', 1)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(.0, .01, .01, YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG, YORG, 0., VX1, VY1)
CALL JCONWV(XORG+XLEN, YORG+YLEN, 0., VX2, VY2)
CALL JCLOSE
```

4-2
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN
C BOUNDARIES OF THE AXES (BY SAVE VIRTUAL COORDINATES)
   CALL JWINDO(5,10,0,01)
C 5, 10 - REPRESENTS THE DATA BOUNDARIES IN THE X-DIRECTION
C 0, 01 - REPRESENTS THE DATA BOUNDARIES IN THE Y-DIRECTION
   CALL JVPORT(VX1,VX2,VY1,VY2)
   CALL JOPEN
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,Y,MAXPTS)
   CALL JCLOSE

CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END

CHTICJ: IMPROPER ENTRY GIVEN FOR POSITIONING
OF TICKMARKS. VALUE MUST BE 0, 1, 2, OR 3. DEFAULT VALUE OF 1 IS USED.

A Title

Figure 4-1. Low-Level error detection mechanism.
4.1.2 Debugging Capabilities

The Low-Level routine CDEBUG provides a method for recording the calls to and the arguments of the Low-Level routines. This enables the user to validate the sequence of Low-Level calls, along with their arguments. There are two debug levels: 0 (OFF) or 1 (ON). Initially, the debug level is OFF (i.e., the default), but can be turned ON or OFF at any time. The user can control the amount and content of debugging output by setting the level to include or exclude sections of code to be monitored. To enable Low-Level debugging, the user can enter

```
CALL CDEBUG(1)
```

To disable Low-Level debugging, the user can enter

```
CALL CDEBUG(0)
```

When the debugging level is ON and a Low-Level routine is entered, the following message(s) will be written:

```
routine name: ENTER
argument_1 : argument type VALUE= value
argument_2(1) : argument type VALUE= value
argument_3(EQ) : argument type VALUE= value
```

where the lower-case strings will be replaced by actual values (see the following example). Note, when an argument is an array, then a one in parentheses will follow the argument (see argument_2 above), and the first value of the array will be displayed. If an argument may vary in type depending on the context (e.g., INTEGER in one case, and REAL in another), then an "EQ" in parentheses will follow the argument (see argument_3 above), and the corresponding value of all applicable types will be displayed (see the following example).

Similarly, when the debugging level is ON and a Low-Level routine is exited, the following message(s) will be written:

```
routine name: EXIT
```

where routine_name will be replaced with an actual routine name (see the following example). This information validates the sequence of Low-Level calls, along with the values and types of the corresponding arguments.

4-5 PRECEDING PAGE BLANK NOT FILMED
The following partial program illustrates the debugging capability along with some sample output. This program is similar to the previous program; a call to CDEBUG should be noted.

```
PROGRAM CDD2

C --- AN EXAMPLE SHOWING A DEBUGGING CAPABILITIES.
C

C ALLOCATE AND INITIALIZE DATA
  PARAMETER(MAXPTS=5)
  REAL X(MAXPTS),Y(MAXPTS)
  DATA X/5.5,6.5,7.5,8.5,9.5/,Y/.001,.0075,.006,.009,.002/

C --- WRITE TO THE METAFILE
  IDEV=0
  CALL CBEGIN
  CALL JBEGIN
  CALL JDINIT(IDEV)
  CALL JDEVON(IDEV)

C --- DEBUGGING TURNED ON FOR USER-CALLABLE ROUTINES.
  CALL CDEBUG(1)

C

C ---

C ---

  CALL JWINDO(5.,10.,0.,.01)
  C 5,10 - REPRESENTS THE DATA BOUNDARIES IN THE X-DIRECTION
  C 0.,.01 - REPRESENTS THE DATA BOUNDARIES IN THE Y-DIRECTION
  CALL JVPORT(VX1,VX2,VY1,VY2)
  CALL JOPEN

C --- PLOT DATA CURVE
  CALL CSYMNO(1)
  CALL CLNPAT(1)
  CALL CLNPLT(X,Y,MAXPTS)
  CALL JCLOSE

C

C ---

  CALL JPAUSE(IDEV)
  CALL JFRAME
  CALL JDEVOF(IDEV)
  CALL JDEND(IDEV)
  CALL JEND
  STOP
  END
```

4-6
The following output reflects the debug messages written to the default destination TAPE77 (logical unit 77).

CDEBUG: ENTER
  IDBLVL : INTEGER VALUE = 1
CDEBUG: EXIT
  IDBLVL : REAL VALUE = 1
CVSPAC: ENTER
  WIDTH : REAL VALUE = 9.
  HEIGHT : REAL VALUE = 9.
CVSPAC: EXIT
CHLAB: ENTER
  CHARA(1) : CHAR(*) VALUE = H[BLClA[BLClXIS
  NLINE : INTEGER VALUE = 1
CSTRIP: ENTER
  STRING : CHAR(*) VALUE = H[BLClA[BLClXIS
CSTRIP: EXIT
CHLAB: EXIT
CHAXIS: ENTER
  HZMIN : REAL VALUE = 5.0
  HZMAX : REAL VALUE = 10.0
  TINCR : REAL VALUE = 1.0
  HLONG : REAL VALUE = 4.0
CGTSTR: ENTER
  VALUE(EQ) : REAL VALUE = 0.0
  NDEC : INTEGER VALUE = -1
CSTRIP: ENTER
  STRING : CHAR(*) VALUE = 5
CSTRIP: EXIT
...CHAXIS: EXIT
CVLAB: ENTER
  CHARA(1) : CHAR(*) VALUE = V[BLClA[BLClXIS
  NLINE : INTEGER VALUE = 1
CSTRIP: ENTER
  STRING : CHAR(*) VALUE = V[BLClA[BLClXIS
CSTRIP: EXIT
CVLAB: EXIT

CLNPLT: ENTER
  X(1) : REAL VALUE = 5.5
  Y(1) : REAL VALUE = .001
  N : INTEGER VALUE = 5
CPNTPT: ENTER
  A : REAL VALUE = 5.5
  B : REAL VALUE = .001
CPNTPT: EXIT
A Title

Figure 4-2. Low-Level debug capability.

4-8
4.1.3 **Destination of Output**

The routine CFILES enables the user to control the output destination of error and debug processing. Error messages, both fatal and non-fatal, are written by default to output device (i.e., the current display device). This is often undesirable as it will overwrite graphics output. To redirect **Low-Level error messages** the user can call

```
ICODE=1
CALL CFILES(ICODE, logical unit, filename)
```

The above call will inform the Low-Level routines to redirect the subsequent Low-Level error messages, indicated by the first argument, to the logical unit with the associated filename. If the file is not already open, CFILES will open the file with the appropriate filename and logical unit number as indicated.

Debug messages, when turned on by CDEBUG, have the default destination of file TAPE77 associated with the logical unit 77. To redirect **Low-Level debug messages** the user can call

```
ICODE=2
CALL CFILES(ICODE, logical unit, filename)
```

The above call will inform the Low-Level routines to redirect the subsequent Low-Level debug messages, indicated by the first argument, to the logical unit with the associated filename. If the file is not already open, CFILES will open the file with the appropriate filename and logical unit number as indicated.

It is often advantageous to redirect output from several processes into a single output destination. This will provide the user with a single collection of information in the order in which the appropriate processes were executed (i.e., Low-Level error messages, Low-Level debug messages, underlying graphics package messages, and user generated messages).
The following partial program illustrates the changing of the error and debugging destination. This program is similar to the previous program; two calls to CFILES should be noted.

```
PROGRAM CDD3

C AN EXAMPLE SHOWING A ERROR AND DEBUGGING REDIRECTION.

C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=5)
REAL X(MAXPTS), Y(MAXPTS)
DATA X/5.5, 6.5, 7.5, 8.5, 9.5/, Y/.001, .0075, .006, .009, .002/

C WRITE TO THE METAFILE
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JINIT(IDEV)
CALL JEVON(IDEV)

C WRITE CGL ERROR MESSAGES TO UNIT 80, FILE 'TAPE80'.
CALL CFILES(1,80,'TAPE80')

C WRITE CGL DEBUG MESSAGES TO UNIT 80, FILE 'TAPE80'.
CALL CFILES(2,80,'TAPE80')

C DEBUGGING TURNED ON FOR USER-CALLABLE Routines.
CALL CDEBUG(1)

C PLOT DATA CURVE
CALL CSYMN0(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y,MAXPTS)
CALL JCLOSE

CALL JPAUSE(IDEV)
CALL JFRAME
CALL JEVOP(IDEV)
CALL JEND(IDEV)
CALL JEND
STOP
END
```
Note, this example redirects both error and debugging messages and combines them in the same file for ease of debugging. The user could also write to the same unit, possibly delimiting sections of this file to examine carefully.

CDEBUG: ENTER
IDBLVL : INTEGER VALUE = 1
CDEBUG: EXIT
IDBLVL : REAL VALUE = 1
CVSPAC: ENTER
WIDTH : REAL VALUE = 9.
HEIGHT : REAL VALUE = 9.
CVSPAC: EXIT
CHLAB: ENTER
CHARA(1) : CHAR*(*) VALUE = HORIZONTAL BUCIXIS
NLINE : INTEGER VALUE = 1
CSTTRIP: ENTER
STRING : CHAR*(*) VALUE = HORIZONTAL BUCIXIS
CSTTRIP: EXIT
CHLAB: EXIT
CHTICJ: ENTER
IV : INTEGER VALUE = -1
CHTICJ: EXIT
CHAXIS: ENTER
HZMIN : REAL VALUE = 5.
HZMAX : REAL VALUE = 10.
TINCR : REAL VALUE = 1.
HLONG : REAL VALUE = 4.
CGTSTR: ENTER
VALUE(EQ) : REAL VALUE = 0.
NDEC : INTEGER VALUE = -1
CGTSTR: EXIT
STRING : CHAR*(*) VALUE = 5

CLNPLT: ENTER
X(1) : REAL VALUE = 5.5
Y(1) : REAL VALUE = .001
N : INTEGER VALUE = 5
CPNTPT: ENTER
A : REAL VALUE = 5.5
B : REAL VALUE = .001
CPNTPT: EXIT
5. INTERFACING WITH OTHER GRAPHICS PACKAGES

This section describes how to interface the CGL (focusing on the Low-Level routines) with other graphical packages. This section will identify what requirements are necessary to interface with the CGL, and how to interface. The description of interfacing will consist of a generalized method, followed by a specific example (i.e., interfacing with the CGL LEZ routines).

Why interface with the CGL? The Low-Level routines of the CGL provide primitive graphical entities (i.e., NASA symbols, NASA line patterns), and compound graphical entities (i.e., axes, grids, plotting an array, etc.). Because these entities are part of a chart and are basic in nature, there are fewer graphical and computational inherent limitations than with a higher-level graphics package.

These limitations may be graphical or computational. For example, the LEZ routines have a limited number of points which can comprise a data set representing a curve. This limit exists because the LEZ routines must store this information internally. The Low-Level routines display a set of data directly supplied by the user, thus the maximum is limited by the size of the array the user can allocate. Similarly, the Low-Level routines may be used to augment the graphical capabilities of a limited package. For example, the LEZ routines only produce a single set of X and Y axes, whereas the Low-Level routines can be called repeatedly to generate several additional axes.

5.1 Requirements for Interfacing with the CGL

In order to interface with the CGL, it is assumed that a program (i.e., possibly FORTRAN, C, etc.) will invoke the CGL and generate graphics output (i.e., either interactively, or to a metafile). Thus, the appropriate software tools (i.e., device drivers, metafile translators, etc.) are assumed prerequisites when needed.

All computer programs require system resources (i.e., I/O units, field length, device interaction, etc.), and thus must be coordinated. Since the CGL resides on top of a general purpose graphics package, that package must be available and be able to be invoked. If an additional graphics package is to be invoked, then it will either:

- use the same underlying graphics package; or
- require the use of another primitive graphics package.
When using a different underlying graphics package (e.g., using CGL with DI-3000, and another package, possibly GKS), the graphical resources (e.g., graphics devices, metafiles, etc.) are in contention. Typically, these resources are non-sharable simultaneously. However, it may be possible to perform the graphical operations from one package, display the results, terminate that package, then subsequently use the second package to generate graphics on the same display device. This is only possible if both packages can access the same device, and the transition between the two graphics packages can be coordinated. This is typically not the case, as termination and initialization of graphics packages often clear the display device. As an alternative approach, generate the plots separately, then if the metafile translator recognizes the file representation (i.e., metafile, SAVPLT, etc.) combine the chart appropriately.

When using the same underlying graphics package (e.g., using CGL with DI-3000, and the LEZ with DI-3000) the graphics resources are also in contention, but are typically sharable. The following subsections will work with this premise.

5.2 Interfacing with a Generalized High-Level Graphics Package

Sections 3.1 through 3.2 describe the characteristics of the underlying graphics package, and how to interface the CGL with such fundamental packages. This section will describe the general method of interfacing the Low-Level routines with high-level graphics packages.

As indicated in Section 3, most underlying graphics packages operate on similar concepts. These concepts, as illustrated in Figure 5-1, consist of the establishment (i.e., initialization and termination) of the graphics package and the graphics devices, in addition to providing an appropriate graphical context necessary to use the Low-Level routines.

The majority of the Low-Level routines must be called at a point when graphical output can be generated. When interfacing with the underlying graphics package such as DI-3000, this context is referred to as an opened segment. However, high-level graphics packages, such as LEZ and CONTOUR, already incorporate parts of the graphical environment into its structure, such as initialization/termination, or the opening/closing of segments.

To coordinate the interface of the Low-Level routines with a high-level graphics package, the user must ensure that an appropriate graphical environment has been established. Since the Low-Level routines are designed to operate with an
underlying graphics package, it is convenient to allow the high-level package to establish the graphical environment. This may consist of initializing the graphics package and appropriate devices, and generating graphical output (possibly pausing and clearing the display devices). Then, the user can inquire about attributes in the current graphical environment, and invoke the Low-Level routines. Note, the user should ensure that any attribute changed by the CGL will not affect subsequent use of the high-level package.

![Diagram of function subroutine]

**Figure 5-1.** DI-3000 skeleton program.
5.3 Interfacing with the CGL LEZ Routines

The CGL LEZ routines provide a high-level abstract user interface incorporating the establishment of the graphical environment. The Low-Level routines must be called after the user has ensured the graphical environment has been established. Thus the Low-Level routines are used to augment the existing graphics package capabilities by being called in an appropriate context.

The LEZ routines are described in the LEZ User’s Guide [G-12]; Figure 5-2 shows an LEZ skeleton program. Based on this skeleton, the user should interface the Low-Level routines near LEZSHW (i.e., roughly where the high-level graphics package generates graphics).

The critical environmental attributes to be considered include the window and viewport extents, primitive attributes (i.e., color, character sizes, etc.), and whether the segment is opened.

<table>
<thead>
<tr>
<th>Function</th>
<th>Subroutine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initialize system</td>
<td></td>
</tr>
<tr>
<td>Initialize graphics device(s)</td>
<td></td>
</tr>
<tr>
<td>Select graphics device(s)</td>
<td>LEZINI</td>
</tr>
<tr>
<td>Set defaults (LEZ/DI-3000)</td>
<td></td>
</tr>
<tr>
<td>Establish chart as linear/logarithmic</td>
<td>LEZLIN/LEZLOG</td>
</tr>
<tr>
<td>Display current chart</td>
<td>LEZSHW</td>
</tr>
<tr>
<td>Deselect graphics device(s)</td>
<td></td>
</tr>
<tr>
<td>Terminate graphics device(s)</td>
<td></td>
</tr>
<tr>
<td>Terminate system</td>
<td>LEZTRM</td>
</tr>
</tbody>
</table>

Figure 5-2. LEZ skeleton program.
The values of the *window* can be set to match the *page coordinate area*, in which the user can invoke the Low-Level routines to draw a chart component (i.e., axis, etc.). Or, the window can be set to match the *data coordinate area*, in which the user can display data. In either case, the window will be mapped onto the current viewport, and in turn the viewport will determine where the graphical output will be displayed in the viewspace (i.e., on the display device). For a complete description of mapping see the DI-3000 User's Guide [G-5].

In the following example program, the Low-Level routines are used to draw additional axes (i.e., a top and right axis - see Figure 5-3). Since the axes are components described in terms of page coordinates, the corresponding window and viewport are initially set to the LEZ default values as documented in the LEZ User's Guide [G-12].

Next, the length and origin of the axes are obtained by calling the LEZ inquiry routine LEZGET. These values are in terms of the page coordinate system common to both LEZ and the Low-Level by the previous calls to the window and viewport.

The graphical segment is then opened, and the Low-Level routines are called to generate the axes. Note, the axes are displayed prior to calling LEZSHW, and thus before the chart generated by LEZSHW. Since LEZSHW is called next, any environmental attributes altered by the Low-Level routines (either DI-3000 or CGL) must be restored. Next, the segment is closed, completing the augmentation using the Low-Level routines. Finally, LEZSHW is called to complete the chart generation. The LEZTRM routine is called to deselect and terminate the graphics device(s), and terminate the system.

The following program illustrates the interfacing of the Low-Level routines with a high-level package (i.e., the LEZ routines).

```plaintext
PROGRAM CDLL1
C------------------------------------------------------------------------
C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LEZ ROUTINES.
C------------------------------------------------------------------------
CHARACTER TITLE*80, IAXLBL*80, DAXLBL*80
REAL FREQ(100), POWER(100), IndMin, IndMax
DATA (POWER(I),I=1,76)/
          + 7066.0770323, 313987.5856597, 23005.34014683, 25971.13637497,
          ...
```

5-5
C----------------------------------------
C CONVERT DATA TO BE REPRESENTED AS LOGARITHMIC
DO 1 I=1,100
   FREQ(I)=LOG10(REAL(I))
   POWER(I)=LOG10(POWER(I))
C----------------------------------------
C INITIALIZE GRAPHICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
   IDEV=0
   CALL LEZINI(IDEV)
C----------------------------------------
C SET LEZ ATTRIBUTES
   NVALS=100
   TITLE='POWER LEVEL VS. FREQUENCY'
   IAXLBL='FREQUENCY'
   DAXLBL='POWER LEVEL'
   INDMIN=LOG10(1.)
   INDMAX=LOG10(100.0)
   DEPMIN=LOG10(65.0)
   DEPMAX=LOG10(290000.0)
   IAXTYP=3
   IHLOGI=0
   IVLOGI=0
   INDHV=1
   LINAPP=1
C----------------------------------------
C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
   CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
         +DEPMIN,DEPMAX,IAXTYP,IHLOGI,IVLOGI,INDHV,LINAPP)
C----------------------------------------
C OUTPUT A NOTE ON THE DISPLAY DEVICE
   CALL LEZNOT('CDLL1',7.,0.,3,1,0)
C----------------------------------------
C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
   CALL JWINDO(0.,7.,0.,7.)
   CALL JVPORT(-1.,1.,-1.,1.)
C GET CURRENT LEZ AXES VALUES
   CALL LEZGET('XORIGIN',XOR,NVALS,MVALS)
   CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
   CALL LEZGET('YORIGIN',YOR,NVALS,MVALS)
   CALL LEZGET('VAXLEN',YLEN,NVALS,MVALS)
   CALL JOPEN
C HORIZONTAL AXIS
   CALL JMOVE(XOR,YOR+YLEN)
C SEE INDMIN,INDMAX ABOVE FOR THE FOLLOWING VALUES
   CALL CEXP(1.,100.,MINH,MAXH)
   NTICH=(MAXH-MINH)+1
   CALL CHLABJ(1)
   CALL CHLOGF(MINH)
   CALL CHLOGF(1)
   CALL CHLOGF(XLEN,NTICH,0)

5-6
C RESTORE VALUES FOR LEZ ROUTINES
CALL CHLABJ(0)

C VERTICAL AXIS
CALL JMOVE(XOR+XLEN,YOR)
C SEE DEPMIN, DEPMAX ABOVE FOR THE FOLLOWING VALUES
CALL CEXP(65.0, 2900000.0, MINV, MAXV)
NTICV=(MAXV-MINV)+1
CALL CVLABJ(1)
CALL CVLOGS(MINV)
CALL CVLOGF(1)
CALL CVLOG(YLEN,NTICV,0)
C RESTORE VALUES FOR LEZ ROUTINES
CALL CVLABJ(0)
CALL JCLOSE

C GENERATE GRAPHICS OUTPUT FOR THE LEZ ROUTINES
CALL LEZSHW
C TERMINATE ALL GRAPHICS
CALL LEZTRM

C-------------------------------
STOP
END

Figure 5-3. Interfacing the Low-Level routines with a high-level package.
In the previous example, the Low-Level routines are called prior to LEZSHW. The Low-Level routines could have been called after LEZSHW with a few minor adjustments. A call to LEZSHW displays the LEZ graphics output, and by default pauses for the viewer. Subsequently, the user hits any key to continue, causing the display device to be cleared (i.e., a frame advance).

Thus, if the Low-Level routines are called after LEZSHW, the use must suppress both the pause and the clear performed by LEZSHW, and invoke these operations appropriately after performing the desired Low-Level operations.

The following program is identical to the previous, except now the calls to the Low-Level routines are made after LEZSHW. Note, the calls to LEZOPT prior to LEZSHW suppress the pause and clear operations. These operations are now performed after the calls to the Low-Level routines by calls to the underlying graphics package (i.e., JPAUSE and JFRAME).

```
PROGRAM CDLL2
C-----------------------------------------------------------------------
C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LE2 ROUTINES.
C-----------------------------------------------------------------------
CHARACTER TITLE*80, IAXLBL*80, DAXLBL*80
REAL FREQ(100), POWER(100), INDMIN, INDMAX
DATA (POWER(I), I=1, 76)/
+ 7066.0770323, 313987.5856597, 23005.34014683, 25971.13674854,
+ 1075.542233512, 2304.552081512, 3938.878376374, 2372.668800947,
+ 990.5827153465, 1139.692923046, 539.1035104119, 186.2399260743,
+ 185.9121866205, 6922.275564162, 47871.80671708, 101610.8109471,
+ 90151.05656181, 32565.81919631, 3126.25985372, 5378.883275207,
+ 19139.27829711, 26311.51279586, 18051.10302768, 7595.925085295,
+ 2769.064915013, 1114.906853713, 472.3435990609, 336.5553643497,
+ 224.6112529072, 292.8078714839, 913.1650006148, 1111.290988571,
+ 763.2538952391, 1036.75027208, 2318.840862193, 1815.115702427,
+ 1546.468077257, 30998.79018191, 90446.3960755, 99542.65318885,
+ 46517.56984878, 8264.407149583, 477.4873134733, 82.183079214,
+ 67.7501808438, 136.6466583528, 197.6147132091, 229.3505457034,
+ 643.2165902202, 1824.921600301, 5246.01888617, 9355.942325839,
+ 8240.202957789, 4042.516486596, 1615.454279283, 876.7523693048,
+ 780.321551955, 869.2308712535, 806.9102907816, 1417.485863451,
+ 13314.08582872, 42705.82833591, 56933.22987118, 34522.64829539,
+ 8369.70034301, 423.4410260173, 1721.308093883, 3815.02155281/
```
DATA (POWER(I),I=77,100)/
+ 3096.896818539, 1130.33337685, 351.6629052997, 323.9146852672,
+ 496.8216394068, 716.3789266813, 707.1830537755, 395.452882063,
+ 185.9595078555, 349.7278623283, 579.1256929328, 427.7957796537,
+ 339.4866401359, 404.7726592585, 3303.494231505, 44732.3344563,
+ 168132.2764905, 259620.2781873, 179647.069922, 51634.19154093,
+ 4701.338454798, 220.74733211, 377.2257021375, 552.6383507909/

C CONVERT DATA TO BE REPRESENTED AS LOGARITHMIC
DO 1 I=1,100
   FREQ(I)=LOG10(REAL(I))
   POWER(I)=LOG10(POWER(I))
1  C INITIALIZE GRAPHICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
   IDEV=0
   CALL LEZINI(IDEV)

C SET LEZ ATTRIBUTES
   NVALS=100
   TITLE='POWER LEVEL VS. FREQUENCY'
   IAXLBL='FREQUENCY'
   DAXLBL='POWER LEVEL'
   INDMIN=LOG10(1.)
   INDMAX=LOG10(100.0)
   DEPMIN=LOG10(65.0)
   DEPMAX=LOG10(290000.0)
   IAXTYP=3
   IHLOGI=0
   IVLOGI=0
   INDHV=1
   LINAPP=1

C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
   CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
   +DEPMIN,DEPMAX,IAXTYP,IHLOGI,IVLOGI,INDHV,LINAPP)

C OUTPUT A NOTE ON THE DISPLAY DEVICE
   CALL LEZNOT('CDLL2',7.,0.,3,1,0)

C SUPPRESS THE LEZ DEFAULTS OF PAUSE AND CLEAR
   CALL LEZOPT('PAUSE',.FALSE.)
   CALL LEZOPT('CLEAR',.FALSE.)

C GENERATE GRAPHICS OUTPUT FOR THE LEZ ROUTINES
   CALL LEZSHW

C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
   CALL JWINDO(0.,7.,0.,7.)
   CALL JVPOR(-1.,1.,-1.,1.)
C GET CURRENT LEZ AXES VALUES
   CALL LEZGET('XORIGIN',XOR,NVALS,MVALS)
   CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
   CALL LEZGET('YORIGIN',YOR,NVALS,MVALS)
   CALL LEZGET('VAXLEN',YLEN,NVALS,MVALS)
   CALL JOPEN

C HORIZONTAL AXIS
   CALL JMOVE(XOR,YOR+YLE)
C SEE INDMIN,INDMAX ABOVE FOR THE FOLLOWING VALUES
   CALL CEXP(1.,100.,MINH,MAXH)
   NTICH=(MAXH-MINH)+1
   CALL CHLABJ(1)
   CALL CHLOGS(MINH)
   CALL CHLOGF(1)
   CALL CHLOG(XLEN,NTICH,0)
C RESTORE VALUES FOR LEZ ROUTINES
   CALL CHLABJ(0)

C---------------------------------------------------------------------
C VERTICAL AXIS
   CALL JMOVE(XOR+XLEN,YOR)
C SEE DEPMIN,DEPMAX ABOVE FOR THE FOLLOWING VALUES
   CALL CEXP(65.0,290000.0,MINV,MAXV)
   NTICV=(MAXV-MINV)+1
   CALL CVLABJ(1)
   CALL CVLOGS(MINV)
   CALL CVLOGF(1)
   CALL CVLOG(YLEN,NTICV,0)
C RESTORE VALUES FOR LEZ ROUTINES
   CALL CVLABJ(0)
   CALL JCLOSE

C---------------------------------------------------------------------
C NOW PAUSE AND CLEAR
   IF(IDEV.GE.1)CALL JPAUSE(1)
   CALL JFRAME

C---------------------------------------------------------------------
C TERMINATE ALL GRAPHICS
   CALL LEZTRM

C---------------------------------------------------------------------
STOP
END
Figure 5-4. Interfacing the Low-Level routines with a high-level package.
6. POSTPROCESSING CONSIDERATIONS

This section gives basic information needed to postprocess plots generated by the Low-Level routines. This section also describes what postprocessing capabilities are available, and what information is necessary in order to interface with the postprocessors.

Most large-scale, general-purpose graphics packages provide the ability to generate and manipulate graphical information in an external file. Thus the user can generate interactive plots, and save the equivalent graphical representation on a file for later use. However, the ability to postprocess depends on a translator to convert the external file information into appropriate instructions to drive the physical device. Thus the translator can take the same external file and plot (or display) it on several different display devices.

For example, the Low-Level routines use DI-3000 as its underlying graphics package, and thus generates external files, called metafiles, which can be postprocessed using the Metafile Translator. Thus, DI-3000 provides a device independent method of generating plots which can be displayed on several different devices (interactive or hardcopy) without the need of major code modifications.

6.1 Postprocessors

A postprocessor is a separate program that reads a metafile, performs various operations on the file, and formats the data to a file that can be used to drive the specified graphics plotting device.

The Metafile Translator is a plot postprocessor which is useful for previewing and editing of metafiles. The Metafile Translator is documented in the Metafile User's Guide [6]. The Metafile Translator instructions allow more flexibility in how the metafile may be displayed.

A special form of the Metafile Translator is the PLOT control statement which is available on the ACD central computers (CDC/NOS). The PLOT statement is documented in the ACD static plotter device driver manual [7].
6.2 DI-3000 Concepts as Related to Static Plotters

Certain postprocessing limitations exist and may need to be addressed. First, the availability of the devices is installation dependent, and the supported device drivers may further restrict this accessibility. Second, each device has inherent limitations (such as color, selective erase, and so forth), and these device dependent characteristics can have a major impact on the resultant output. Most notably, special considerations are needed to ensure that proper sizing or scaling is consistent between the constructed image and the plotted image. Specific information for devices are given in the device driver manuals [7].

The plotters vary in the quality and types of plots that are generated. The pen plotter provides smooth lines but limits the available colors. The pen plotter will also allow for varying the thickness of a line. The electrostatic plotters offer limited line thickness and also may not generate smooth curves because of the pixel resolution. This non-smooth problem is usually eliminated by generating larger plots and then having them reduced.

6.3 Distortion and Scaling

The user can request that a metafile be generated by calling the appropriate underlying graphics package routines (as mentioned in Section 1.2.2, and as shown in several examples in Section 3). In order to postprocess this metafile, the user should know the dimensions used to draw the image. The user is responsible for requesting the appropriate dimensions of the plotter, typically by matching the metafile’s aspect ratio. All of the plotters regard a metafile’s aspect ratio as its height to width (determined by the 
viewspace). Proper information will ensure:

- a compatible aspect ratio between the page size and the device coordinate system. For example, a plot generated in a 7 by 7-inch page size should be plotted in an area of equal (square) aspect ratio to avoid distortion.

- the scaling to be performed from the world coordinate to device is consistent (e.g., a 7 by 7-inch plot is sent to a plotting device and will be plotted on a 7 by 7-inch region).
The page size is set by a call to CVSPAC, which ensures that the Low-Level routines of the CGL will establish the largest viewspace corresponding to the desired page size, and thereby a consistent relationship between the page size and the underlying virtual coordinates. However, the user must ensure that the postprocessor aspect ratio coincides with the viewspace. The NGS software defaults to plot in the largest possible square on a given device. This ratio may be changed to meet specific needs. Since each plotter uses a different frame size, the physical dimensions of the square varies between devices. The COMMON GRAPHICS LIBRARY offers routines which support commonly used aspect ratios, such as page size, and also allows the user the capability of setting an aspect ratio to meet specific requirements.

Since there are no default world coordinates in the Low-Level routines, the user must establish them; preferably through CVSPAC. For example, a call to CVSPAC with the values (7.,7.), would establish a world coordinate system of a 7 by 7-unit region (e.g., possibly inches). This implies the aspect ratio is 1. To avoid distortion, the user should select a plotter aspect ratio of 1. For example:

```
PLOT.CAL,11 (HEIGHT=7., WIDTH=7.)
or
PLOT.CAL,11 (HEIGHT=11., WIDTH=11.)
```

The first plot instruction will plot the image on the CalComp 11" plotter in a 7 by 7-inch region (matching identically with the image area). The second plot instruction will plot the image in an 11 by 11-inch region (proportionally enlarging all objects).

6.4 Visual Characteristics

Because of the variations in plotter characteristics, the user should try to use only enough colors to specifically address the plots needs. If monochrome copies are to be made, then line patterns and fill patterns should be clear enough so that the contents of the chart are distinguished easily by the reader. Care should also be taken to ensure that text is properly positioned on the page and is of sufficient size that it is legible. The text should be bold enough so that it may be copied by a photocopy device without losing any portion of a character. Viewgraphs should contain characters large and bold enough to be seen across a dark room. All of these items require planning in the design of a plot. Fortunately for the user, there are usually consistent requirements. Once the appropriate technique is selected, most plots will conform to standards, thus resulting in little or no change to the user's plot program.
APPENDIX A

Description of the Low-Level Routines

The Low-Level routines are described in detail on the following pages. The following information is provided for each routine:

Subroutine Name: The subroutines are listed in alphabetical order.

Purpose: A brief description of what the routine is used for.

Use: The structure of how to call the routine. Also a list of the parameters for that routine with a description of what they are and the types of values they accept.

Restrictions: A list of restrictions on the values passed to the parameters or on the use of that routine.

Notes: Any further information that the user might have need to know.

Errors: A list of errors which may be produced by the routine. The error message will indicate the routine which reported the error, and a brief description of the cause of the error. Typically, the message will be followed by the method of recovery the routine used (i.e., routine not executed, the default value used, etc.).
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CARRow - Draw a Line between 2 Pts (with an Arrow Head at an End)

LANGUAGE: FORTRAN 77

PURPOSE: To draw a line between two points starting at the point \((AX,AY)\) and ending at the point \((BX,BY)\). An arrow head of ITYPE is drawn at point \((AX,AY)\). The final pen position is set to point \((BX,BY)\).

USE: CALL CARRow(AX,AY,BX,BY,ALNGTH,ITYPE)

**AX,AY** - Starting coordinates of the line.  
  type: REAL

**BX,BY** - Ending coordinates of the line.  
  type: REAL

**ALNGTH** - Length of the arrow head.  
  range: greater than 0.  
  type: REAL

**ITYPE** - Type of arrow head.  
  range: 0 to 5.  
  type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, polygon attributes.
2) CGL attributes: None.

RESTRICTIONS:
1) AX,AY cannot equal BX,BY.
2) Segment must be open.

ERRORS:

CARRow: THE RANGE OF ALNGTH IS .GT. 0
ATTEMPTED TO PASS IN ALNGTH = alnqth
THIS ROUTINE IS NOT EXECUTED.

CARRow: THE RANGE OF ITYPE IS 0 TO 5 (INTEGER).
ATTEMPTED TO PASS IN ITYPE = itype
THIS ROUTINE IS NOT EXECUTED.

CARRow: BOTH (BX=AX) AND (BY=AY) CAN’T BE TRUE.
THE ROUTINE IS NOT EXECUTED.

NOTE: Arrowheads set to ITYPE of 3,4,5 are drawn as polygons, and therefore can be solid filled.
CBEGIN - Initialize Values used by the CGL

LANGUAGE: FORTRAN 77

PURPOSE: Initialize values used by the CGL.

USE: CALL CBEGIN

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: None.
2) CGL attributes: None.

RESTRICTIONS: 1) Must be called prior to using other CGL routines. If this routine is not called, uninitialized variables may cause unpredictable results. The invocation of this routine is functionally independent of DI-3000, and can thus be called anywhere, anytime. However, subsequent invocations will reset any user defined CGL attributes.

ERRORS: none.

EXAMPLE: PROGRAM MAIN
          
          
          C Initialize DI-3000
          CALL JBEGIN
          CALL JDINIT(IDEV)
          CALL JDEVON(IDEV)
          C Initialize COMMON GRAPHICS LIBRARY (CGL)
          CALL CBEGIN
CDEBUG - Change The Low-Level Debug Level.

----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Change the Low-Level debug level.

USE: CALL CDEBUG(IDBLVL)

WHERE: IDBLVL - The debug level.
  0 - Debugging turned OFF. (default)
  1 - Debugging turned ON for
      user-callable routines.
  2 - Debugging turned ON for
      user-callable and internal routines.

type: INTEGER

ASSOCIATED ATTRIBUTES:
  1) DI-3000 attributes: none.
  2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
  CDEBUG: INVALID ARGUMENT IN CDEBUG.
  IDBLVL SHOULD BE AN INTEGER 0,1 OR 2.
  IDBLVL NOT CHANGED, CURRENT VALUE = idblvl

NOTES: See CFILES for the file name and associated logical
       unit where the debugging information is written.
CDREXP - Convert FORTRAN to Standard Scientific Notation

LANGUAGE: FORTRAN 77

PURPOSE: This routine converts the FORTRAN exponent notation to standard scientific notation. If a REAL zero value is input as '0.0' it will be returned as '0.0'. Thus, the routine only reformats a value, as opposed to recomputing it.

This routine also puts in the DI-3000 graphics art precision text notation for the superscripts of an exponent (if one is needed). If no exponent is needed, the number is returned as specified by NDIGIT on the call statement.

USE: CALL CDREXP(CNMIN,NUMIN,NDIGIT,CNMOUT,NUMOUT)

where: CNMIN - Character array containing FORTRAN notation exponent. type:CHARACTER
NUMIN - Number of characters in CNMIN type:INTEGER
NDIGIT - Number of digits to precede (to the left of) the decimal point. type:INTEGER
CNMOUT - Character array containing scientific notation exponent. type:CHARACTER (returned)
NUMOUT - Number of characters in CNMOUT. type:INTEGER (returned)

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes:
   NRLINT - REAL to INTEGER conversion flag
       .TRUE. - REAL value is plotted as an INTEGER
       .FALSE. - REAL value is plotted as a REAL (default)
       Type:logical

RESTRICTIONS: 1) The maximum number of characters for CNMIN is 18. The maximum number of characters for CNMOUT is 34. CNMOUT will contain DI-3000 text mnemonics to represent superscripts.

ERRORS:
CDREXP: NUMIN IS NOT OF INTEGER TYPE.
       ATTEMPTED TO PASS IN NUMIN = numin
       THIS ROUTINE IS NOT EXECUTED.

CDREXP: NDIGIT IS NOT OF INTEGER TYPE.
       ATTEMPTED TO PASS IN NDIGIT = ndigit

A - 8
THIS ROUTINE IS NOT EXECUTED.

EXAMPLE:

CALL CDREXP('??',2,2,CNMOUT,NUMOUT)
(* CNMOUT WILL = '????????', AND NUMOUT WILL = ???. *)
CELIPS - Plot an Arc of an Ellipse Centered at Current Point

LANGUAGE: FORTRAN 77

PURPOSE: To plot an arc of an ellipse centered at current point. Since the arc may not be a closed line segment, the DI-3000 polygon is not used (i.e., not solid filled).

USE: CALL CELIPS(A,B,ALPHA,THETAO,THETAF)

A - Length of the semi-major axis (world coordinates).
    type: REAL

B - Length of the semi-minor axis (world coordinates).
    type: REAL

ALPHA - Angle of orientation of the major axis. This angle is measured from the horizontal to the major axis. Counter-clockwise is defined as positive direction.
    type: REAL

THETAO - Starting angle between radius vector and major axis.
    type: REAL

THETAE - Final angle between radius vector and major axis.
    type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes.
2) CGL attributes: None.

RESTRICTIONS: 1) If THETAO=THETAF, then no ellipse is generated.
2) Segment must be open.

NOTES: Since the arc may not be a closed line segment, the DI-3000 polygon is not used (i.e., not solid filled).

ERRORS: none.
Figure illustrating ellipses.
CERROR - To Set the Error Level for the Low-Level Routines

LANGUAGE: FORTRAN 77

PURPOSE: To set the error level for the Low-Level routines.

USE: CALL CERROR(IERLVL)

WHERE: IERLVL - The error level.
   0 - Erroring checking disabled.
   1 - Erroring checking enabled for Low-Level ("C"-level) routines.
      (default)
   2 - Erroring checking enabled for level 1 and all internal routines.
      type: INTEGER

ERRORS:
CERROR:INVALID ARGUMENT IN CERROR.
IERLVL SHOULD BE AN INTEGER 0, 1, OR 2.
IERLVL NOT CHANGED, CURRENT VALUE = ierlvl

NOTES: Error level 2 (internal routines) is not intended for users,
but for internal debugging of the CGL.
CEXP - Determine the Exponent for Log Base 10 Min/Max Values

-------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Determine the exponent for log base 10 of a minimum and maximum value. The resultant exponent for the minimum value will be such that: VMIN >= 10.**MINEXP. The resultant exponent for the maximum value will be such that: VMAX <= 10.**MAXEXP.

EXAMPLE:

<table>
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<th>VALUE</th>
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<th>MAXEXP</th>
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<tr>
<td>.01</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>.05</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>.1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>.5</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>1.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>9.5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15.0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>100.0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>105.0</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

USE: CALL CEXP(VMIN, VMAX, MINEXP, MAXEXP)

where:

VMIN - Minimum value
type: REAL

VMAX - Maximum value
type: REAL

MINEXP - Log 10 exponent for VMIN (returned)
type: INTEGER

MAXEXP - Log 10 exponent for VMAX (returned)
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) VMIN and VMAX must be greater than zero.

ERRORS:

CEXP: INVALID VALUE FOR VMIN OR VMAX.
VMIN, VMAX = vmin, vmax
VALID RANGE IS REAL GREATER THAN ZERO.
MINEXP, MAXEXP RETURNED AS ZERO.
CFILES - Change The Output Destination Of Various Processes.

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Change the output destination of various processes.
This routine opens a file, denoted by the logical unit LUN and file name of CFILE.

USE: CALL CFILES(ICODE,LUN,CFILE)

WHERE: ICODE  - Specifies the process to be changed.
            1 - Error processing.
            2 - Debug processing.
            3 - Internal processing (LEZLIN/LEZLOG).
            type: INTEGER

LUN  - Output logical unit.
      Must be an integer greater than 0.
      Logical units are MACHINE DEPENDENT.
      type: INTEGER

CFILE  - Output file descriptor.
        CFILE declared internally as size of 20.
        Valid file names are MACHINE DEPENDENT.
        type: CHARACTER

NOTES: The files are opened with:
        "OPEN(UNIT=LUN,FILE=CFILE,STATUS=UNKNOWN")
        All other file attributes use MACHINE defaults.
        Both LUN and CFILE must be valid before files are processed.

ERRORS:

CFILES: INVALID ARGUMENT IN CFILES.
        ICODE MUST BE AN INTEGER 1, 2, OR 3.
        NO CHANGE HAS BEEN MADE.

CFILES: INVALID ARGUMENT IN CFILES.
        LUN SHOULD BE AN INTEGER GREATER THAN 0.
        NO CHANGE HAS BEEN MADE.

CFILES: INVALID ARGUMENT IN CFILES.
        CFILE IS INVALID.
        NO CHANGE HAS BEEN MADE.

CFILES: LUN=lun WAS ASSIGNED TO "fn".
        REASSIGNED TO "jfile".

CFILES: ERROR DURING OPEN.
        ICODE,LUN,CFILE= icode,lun,"cfile".
        FILE NOT PROCESSED.
CFILES: ERROR DURING INQUIRE.
ICODE, LUN, CFILE = icode, lun, "cfile".
FILE NOT PROCESSED.
CFLIP - Offset an Array about a Reflection Point (2D)

LANGUAGE: FORTRAN 77

PURPOSE: Subroutine to offset an array about a reflection point. Specifically, offset each element of array A, by an equal distance (of that element), on the opposite side of a point of reflection (REFLEC).

USE: CALL CFLIP(A,N,REFLEC)

Where: A - The array to be examined and transformed. Type: REAL
       N - Number of elements in array A. Type: INTEGER
       REFLEC - Point about which to invert data. Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) N must be 2 or greater.

Discussion:
This routine was written to map elements of an array into the corresponding mirror image. One purpose of this would be to plot data in decreasing order.

Example:
Given a minimum and maximum of 100 to 200, the elements of an array must be adjusted in order to plot them on an axis decreasing from 200 to 100.

Plot data in a world represented by 200...100.

The input required would consist of the array to be adjusted, the size of the array, and in this example, the point of reflection (150). More specifically, 100+((200-100)/2.), or more generally, MINIMUM+((MAXIMUM-MINIMUM)/2.).

This presupposes that the world coordinate system will be inverted by mapping MAXIMUM...MINIMUM, to MINIMUM...MAXIMUM (as shown above).

Thus, given an array A to be plotted from 200 to 100,
CALL JWINDOW(100,200,YMIN,YMAX)
CALL CFLIP(A,N,REFLEC)
<plot data>
Note: to return data to original values, apply CFLIP to the adjusted data ("unflip").
(i.e., flip(flip(A)) == A).

A detailed example can be found in Appendix B of the CGL Low-Level User's Guide.

ERRORS:

CFLIP: N IS NOT OF INTEGER TYPE.
ATTEMPTED TO PASS N = n
THIS ROUTINE IS NOT EXECUTED.
CGRID - Draw a Linear Grid (with or without Blank Areas)

LANGUAGE: FORTRAN 77

PURPOSE: Draw a linear grid over a specified plotting area with a rectangular or square area(s) remaining blank.

USE: CALL CGRID (X,Y,XS,YS,NOINCX,NOINCY,BLANK,NBLANK)

where

X,Y - The lower left corner of grid in world coordinate units.
    type: REAL

XS - The increment in world coordinate units between vertical grid lines.
    range: greater than 0, but less than 4000.
    type: REAL

YS - The increment in world coordinate units between horizontal grid lines.
    range: greater than 0, but less than 4000.
    type: REAL

NOINCX - The number of increments along the X-axis.
    range: greater than 0.
    type: INTEGER

NOINCY - The number of increments along the Y-axis.
    range: greater than 0.
    type: INTEGER

BLANK - An array containing the coordinates of the rectangular or square blank area(s).
The user is responsible for supplying an array containing the corner points of the blank areas, and the corresponding number of blank areas.
    type: REAL

The first blank area:
BLANK(1) contains X lower left coordinate
BLANK(2) contains Y lower left coordinate
BLANK(3) contains X upper right coordinate
BLANK(4) contains Y upper right coordinate

For the second blank area:
BLANK(5) contains X lower left coordinate
BLANK(6) contains Y lower left coordinate
BLANK(7) contains X upper right coordinate
BLANK(8) contains Y upper right coordinate

NBLANK - An INTEGER specifying the number of blank areas to be drawn. A maximum of 10 blank areas are allowed.
range: 0 to 10. If NBLANK is 0, then a dummy variable should be passed for BLANK.
    type: INTEGER
NOTES:
To draw a box around the areas, the user is required to make the following calls immediately before or after the call to "CGRID":
CALL JRECT(BLANK(1,1),BLANK(2,1),BLANK(3,1),BLANK(4,1))
For the 2nd box -
CALL JRECT(BLANK(1,2),BLANK(2,2),BLANK(3,2),BLANK(4,2))
For the N'th box -
CALL JRECT(BLANK(1,n),BLANK(2,n),BLANK(3,n),BLANK(4,n))

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes.
2) CGL attributes: none.

RESTRICTIONS:
1) The maximum number of boxes is limited to 10.
2) NOINCX and NOINCY are limited to 4000.
3) Segment must be open.

ERRORS:
CGRID: XS MUST BE .GT. 0, BUT LESS THAN maxinc.
ATTEMPTED TO PASS IN XS = xs
THIS ROUTINE IS NOT EXECUTED.
CGRID: YS MUST BE .GT. 0, BUT LESS THAN maxinc.
ATTEMPTED TO PASS IN YS = ys
THIS ROUTINE IS NOT EXECUTED.
CGRID: NOINCX EXPECTED INTEGER TYPE.
ATTEMPTED TO PASS IN NOINCX = noincx
THIS ROUTINE IS NOT EXECUTED.
CGRID: NOINCY EXPECTED INTEGER TYPE.
ATTEMPTED TO PASS IN NOINCY = noincy
THIS ROUTINE IS NOT EXECUTED.
CGRID: NBLANK EXPECTED INTEGER BETWEEN 0 AND maxbox
ATTEMPTED TO PASS IN NBLANK = nblank
THIS ROUTINE IS NOT EXECUTED.
CALL CGRID(X, Y, XS, YS, NOINCX, NOINCY, BLANK, NBLNK)

X, Y       WORLD COORDINATES OF LOWER LEFT PT
XS       INCREMENT BETWEEN X-AXIS GRID LINES
YS       INCREMENT BETWEEN Y-AXIS GRID LINES
NOINCX   NUMBER OF INCREMENTS ALONG X-AXIS
NOINCY   NUMBER OF INCREMENTS ALONG Y-AXIS
BLANK    COORDINATE ARRAY OF THE BLANK AREAS
NBLNK    NUMBER OF BLANK AREAS
CGTEXP - Convert Exponential Value to a Character String

---------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: This routine converts an exponential value to a character string and returns the number of characters. This is needed when plotting exponential values, as the actual value to be plotted is converted to display code using a FORTRAN 77 internal write.

USE: CALL CGTEXP(VALUE,NDEC,CHRNUM,NUM)

where: VALUE - Numeric value to be converted.
    type: REAL
NDEC - Number of significant digits.
    type: INTEGER
CHRNUM - Character string containing the numeric value (returned).
    type: CHARACTER
NUM - Number of characters in CHRNUM. up to 18. (returned).
    type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes:
   NRLINT - REAL to INTEGER conversion flag
     .TRUE. - REAL value is plotted as an INTEGER
     .FALSE. - REAL value is plotted as a REAL (default)
     Type: logical

RESTRICTIONS: 1) Up to 13 significant digits are allowed including the decimal point.

ERRORS:
CGTEXP: NDEC EXPECTED INTEGER TYPE.
ATTEMPTED TO PASS IN NDEC= ndec
THIS ROUTINE IS NOT EXECUTED.
CGTSTR - Convert a Numeric Value to a Character Value

LANGUAGE: FORTRAN 77

PURPOSE: This routine converts a numeric value to a character value and returns the number of numeric characters or digits.

USE: CALL CGTSTR(VALUE,NDEC,CHRNUM,NUM)

WHERE: VALUE - Numeric value to be converted. Type may be either INTEGER or REAL based on NDEC.

NDEC - If the sign of NDEC is positive (i.e., the value of NDEC is 0 or more), then the value NDEC specifies the number of digits to the right of the decimal point. If the sign is negative, then the value NDEC specifies the minimum number of digits.

CHRNUM - Character string containing the numeric value (returned).

NUM - Number of characters in CHRNUM. Maximum of 13. (returned).

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes:
   NRLINT - REAL to INTEGER conversion flag
   .TRUE. - REAL value is plotted as an INTEGER
   .FALSE. - REAL value is plotted as a REAL (default)

RESTRICTIONS: 1) Up to 13 significant digits are allowed, including the decimal point.

ERRORS:
CGTSTR: NDEC EXPECTED INTEGER TYPE.
ATTEMPTED TO PASS IN NDEC= ndec
THIS ROUTINE IS NOT EXECUTED.

NOTES: A value of 0.0 will be represented as "0" regardless of NDEC (i.e., regardless of type, or precision).
CHAXIC - Draw a Horizontal Axis with Character Labels

LANGUAGE: FORTRAN 77

PURPOSE: To draw a horizontal axis with character labels. This routine retrieves attributes (DI-3000 and CGL) when the subroutine is invoked. These axis characteristics remain in force until SUBROUTINE CHAXIC is reinvoked. If a horizontal axis label is desired, SUBROUTINE CHLAB must be invoked prior to this routine.

USE: CALL CHAXIC(XLEN,NTIC,CHARA,NLINES,NLABS)

XLEN - Length of axis (in world coordinates).
   range: greater than 0.
type: REAL

NTIC - Number of tick marks (end tick marks inclusive). If NTIC is negative, the major and minor tick marks will be suppressed, but the tick mark labels will be retained.
   range: IABS(NTIC) must be greater than 1.
type: INTEGER

CHARA - Tick mark labels, dimensioned:
   CHARA(NLINES, NLABS),
type: CHARACTER

NLINES - Number of lines in the tick mark labels.
   Range: must be greater than or equal to 0.
type: INTEGER

NLABS - Number of labels for the tick marks.
   Range: must be greater than or equal to 0.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, polygon attributes.
2) CGL attributes:

   NHBTIC - Position of horizontal axis label in relation to horizontal tick marks.
       0 - labels centered at tick marks. (default)
       1 - labels centered between tick marks.
type: INTEGER

   NHJUST - Determines if horizontal axis label is written horizontally or vertically.
       0 - vertical (default).
       1 - horizontal.
type: INTEGER

   NHLABJ - Position of axis label in relation to horizontal axis. (above or below)
       0 - horizontal axis label is below axis. (default)
       1 - horizontal axis label is above axis.
**NHMTIC** - Number of minor tick marks between major tick marks for the horizontal axis. (default=0)

Range: INTEGERS greater or equal to 0.

**TYPE: INTEGER**

**NHTICJ** - A value to indicate positioning of tick marks for horizontal axis.

0 - tick marks are not positioned about the axis.
1 - tick marks positioned right of the axis.
2 - tick marks positioned to the left of the axis.
3 - tick marks positioned on both sides of axis.

Default: 1

**Type: INTEGER**

**NHTROT** - Angle of rotation for horizontal axis tick mark labels.

**Type: INTEGER**

**Restrictions:**

1) XLEN must be positive.
2) Segment must be open.
3) An absolute minimum of two major tick marks.
4) Axis label can only be horizontal.

**Errors:**

**CHAXIC:**

XLEN EXPECTED VALUE .GT. 0

ATTEMPTED TO PASS XLEN= xlen
THIS ROUTINE IS NOT EXECUTED.

**CHAXIC:**

NTIC EXPECTED INTEGER .GT. 1

ATTEMPTED TO PASS NTIC= ntic
THIS ROUTINE IS NOT EXECUTED.

**CHAXIC:**

N LINES EXPECTED INTEGER .GE. 0

ATTEMPTED TO PASS NLINES= nlines
THIS ROUTINE IS NOT EXECUTED.

**CHAXIC:**

N LABS EXPECTED INTEGER .GE. 0

ATTEMPTED TO PASS NLABS= nlabs
THIS ROUTINE IS NOT EXECUTED.

**CHAXIC:**

TICK MARK ROTATION (NHTROT) ONLY APPLY TO ONE TICK MARK LINE (NLINES).
NO ROTATION PERFORMED.

**NH=0**

**HORIZONTAL CHARACTER AXIS**

---

START  MIDDLE  END

HORIZONTAL AXIS LABEL
CHAXIS - Draw a Horizontal Axis with Numeric Labels

---

**LANGUAGE:** FORTRAN 77

**PURPOSE:** This routine plots a horizontal numeric axis. The numeric values input are calculated, converted to characters, then a call to the CHAXIC routine is made to do the actual plotting. The attributes used by CHAXIC and CHLAB should be considered prior to calling this routine.

**USE:**

```fortran
CALL CHAXIS(HZMIN, HZMAX, TINCR, HLONG)
```

where:
- **HZMIN** - Minimum value used for tick marks
  type: REAL
- **HZMAX** - Maximum value used for tick marks
  type: REAL
- **TINCR** - Increment value of tick marks
  type: REAL
- **HLONG** - Length of axis in current world coordinates
  type: REAL

**ASSOCIATED ATTRIBUTES:**

1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:

- **NHHTIC** - Position of horizontal axis label in relation to horizontal tick marks.
  - 0 - labels centered at tick marks. (default)
  - 1 - labels centered between tick marks.
  type: INTEGER

- **NHJUST** - Determines if horizontal axis label is written horizontally or vertically.
  - 0 - vertical (default)
  - 1 - horizontal.
  Type: INTEGER

- **NHLABJ** - Position of axis label in relation to horizontal axis. (above or below)
  - 0 - horizontal axis label is below axis. (default)
  - 1 - horizontal axis label is above axis.
  type: INTEGER

- **NHMTIC** - Number of minor tick marks between major tick marks for the horizontal axis. (default=0)
  Range: INTEGERS greater or equal to 0.
  TYPE: INTEGER

- **NHPREC** - Number of digits to the right of the decimal point in the tick mark labels of the horizontal axis.
  - < 0 - plot as an INTEGER (no decimal point)
= 0 - decimal point only
> 0 - plot as a REAL. Value represents the number of digits to the right of the decimal point
Default: -1
Type: INTEGER

NHTICJ - A value to indicate positioning of tick marks for horizontal axis.
0 - tick marks are not positioned about the axis.
1 - tick marks positioned right of the axis.
2 - tick marks positioned to the left of axis.
3 - tick marks positioned on both sides of axis.
Default: 1
Type: INTEGER

NHTROT - Angle of rotation for horizontal axis tick mark labels.
Type: INTEGER

RESTRICTIONS: 1) Tick mark labels always occur at the major tick marks (regardless of attribute settings).
2) If HZMIN is greater than HZMAX, then TINCR must be negative. HZMIN and HZMAX cannot be equal.
3) Segment must be open.

ERRORS: none.

NOTES: If HZMIN is greater than HZMAX, then axis labels will be output in decreasing order.

A Title
CHBTIC - Set Position of Horizontal Axis Label Tick Marks

LANGUAGE: FORTRAN 77

PURPOSE: Set position of horizontal axis label tick marks.

USE: CALL CHBTIC(IV)

where: IV
Position of horizontal axis label in relation to the horizontal tick marks.
0 - labels centered at tick marks.(default)
1 - labels centered between tick marks.
Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CHBTIC: INVALID VALUE FOR IV.
THE RANGE OF nhbtic IS 0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.
CHEXP - Compute Minimum and Maximum Exponents

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: To determine the minimum and maximum value of the input data for computing the horizontal axis labels.

USE: CALL CHEXP(XMIN,XMAX,XBEG,XEND)

XMIN - Minimum data value.
XMAX - Maximum data value.
XBEG - First tick mark label (returned).
XEND - Last tick mark label (returned).

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS: none.
CHLAB - Describe Text and Attributes of Horizontal Axis Label

LANGUAGE: FORTRAN 77

PURPOSE: To describe the text and associated attributes of the horizontal axis label. This routine retrieves attributes (DI-3000 and CGL) when the subroutine is invoked. These label characteristics remain in force until SUBROUTINE CHLAB is reinvoked.

USE: CALL CHLAB(CHARA,NLINE)

CHARA(NLINE) - Array of characters for axis.
   type: CHARACTER
NLINE - Number of lines in label.
   range: integer 0 to 5.
   type: INTEGER

Associated Attributes:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes: none.

RESTRICTIONS:
1) The number of lines per axis label is limited to 0.
2) The number of characters per line is limited to 256.
3) All lines in axis label are single spaced.
4) Segment must be open.
5) Horizontal axis label can only be horizontal text.

NOTES: if NLINE is less than or equal to 0, then all horizontal axis label attributes are reinitialized. If NLINE is greater than 5, then only the first 5 array elements are used.

ERRORS:
CHLAB: NLINE MUST BE .GE. 0
ATTEMPTED TO PASS NLINE= nline
THIS ROUTINE IS NOT EXECUTED.
CHLABJ - Set Position of Axis Label Relative to Horizontal Axis

LANGUAGE: FORTRAN 77

PURPOSE: Set position of horizontal axis label relative to horizontal axis.

USE: CALL CHLABJ(IV)

where: IV
Position of axis label in relation to horizontal axis. (above or below)
0 = horizontal axis label is below axis. (default)
1 = horizontal axis label is above axis.
Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

NOTES: Attribute CHTICJ controls the horizontal axis tick mark positioning (i.e., above, below, etc.). The attribute CHLABJ controls the positioning of the tick mark labels.

RESTRICTIONS: none.

ERRORS:
CHLABJ: INVALID ARGUMENT.
THE RANGE OF "NHLABJ" IS 0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.

HORIZONTAL LINE 1

CALL CHLABJ(0)

HORIZONTAL LINE 1

CALL CHLABJ(1)
CHLOG - Draw a Horizontal Log Axis

PURPOSE:
To draw a horizontal log axis.
This routine retrieves attributes (DI-3000 and CGL) when
this subroutine is invoked.
These characteristics remain in force until subroutine
CHLOG is reinvoked.
If a horizontal axis label is desired, subroutine CHLAB
must be invoked prior to this routine.

USE:
CALL CHLOG(XLEN,NTIC,NHLOGI)

XLEN - Length of axis (in world coordinates),
range: greater than 0.
type: REAL

NTIC - Number of tick marks (end tick marks inclusive)
(i.e., number intervals over XLEN axis).
If ntic is negative, the major
tick marks will be suppressed, but the
numeric tick mark label will be retained.
range: IAABS(NTIC) must be greater than 1.
type: INTEGER

NHLOGI - Tick mark labels type.
The following are the various types:
0 - No small tick marks.
1 - 1,2,3,4,5,6,7,8,9,1
2 - 1,2,4,6,8,1
3 - 1,3,5,7,9,1
4 - 1,5,1
5 - 1,1
6 - 2,3,4,5,6,7,8,9
7 - 2,4,6,8
8 - 3,5,7,9
9 - 5

If NHLOGI is positive then labels
and small log tick marks are drawn.
If NHLOGI is negative then only small log
tick marks are drawn.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:

NHLABJ - Position of axis label in relation to
horizontal axis. (above or below)
0 - horizontal axis label is below axis,(default)
1 - horizontal axis label is above axis.
type: INTEGER

NHLOGF - Determine if horizontal axis will have
major tick marks as 10 raised to a power.
-1 - major tick mark labels decrease
0 - no major tick mark labels (default)
1 - major tick mark labels increase
TYPE: INTEGER

NHLOGS - The initial power for the horizontal log
axis labels. (i.e., 10 raised to this power)
(default=0) Range: any valid INTEGER.
Type: INTEGER

NLABP - The size of the minor tick marks as a percentage
of the size of the major tick marks. (Default=2/3)
Range: REAL values greater than 0.
Type: REAL

RESTRICTIONS: 1) XLEN must be positive.
2) Only whole log cycles starting at minor tick mark
one are generated.
3) An absolute minimum of two major tick marks.
4) Segment must be open.

ERRORS:
CHLOG: XLEN EXPECTED TO BE .GT. 0
ATTEMPTED TO PASS XLEN= xlen
THIS ROUTINE IS NOT EXECUTED.

CHLOG: NTIC EXPECTED TO BE AN INTEGER.
ATTEMPTED TO PASS NTIC= ntic
THIS ROUTINE IS NOT EXECUTED.

CHLOG: NHLOGI EXPECTED TO BE AN INTEGER.
ATTEMPTED TO PASS NHLOGI= nhlogi
THIS ROUTINE IS NOT EXECUTED.
1) TO SET AXIS LABEL
   CALL CHLAB(CHARA,NLINE)
   CHARA  ARRAY OF CHARACTERS FOR THE AXIS
   NLINE  NUMBER OF LINES IN THE AXIS LABEL

2) TO DRAW AXIS AND LABEL
   CALL CHLOG(XLEN,NTIC,NLOGI)
   XLEN   LENGTH OF THE AXIS
   NTIC   NUMBER OF MAJOR TIC MARKS
   NLOGI  TIC MARK LABEL TYPE
      0  - NO MINOR TIC MARKS
      1  - 1,2,3,4,5,6,7,8,9,1
      2  - 1,2,4,6,8,1
      3  - 1,3,5,7,9,1
      4  - 1,5,1
      5  - 1,1
      6  - 2,3,4,5,6,7,8,9
      7  - 2,4,6,8
      8  - 3,5,7,9
      9  - 5
CHLOGF - Set Horizontal Axis Power of 10

LANGUAGE: FORTRAN 77

PURPOSE: Set horizontal axis power of 10

USE: CALL CHLOGF(IV)

where: IV -
Determine if horizontal axis will have major tick marks as 10 raised to a power.
-1  - Major tick mark labels decrease
0   - No major tick mark labels (default)
1   - Major tick mark labels increase

Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CHLOGF: INVALID VALUE FOR IV.
THE RANGE OF "NHLOGF" IS -1,0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.

CALL CHLOGF(1)
CHLOGS - Set the Initial Power for the Horizontal Log Axis Labels

LANGUAGE: FORTRAN 77

PURPOSE: Set the initial power for the horizontal log axis labels.

USE: CALL CHLOGS(IV)

where: IV
The initial power for the horizontal log axis labels (i.e., 10 raised to this power) (default = 0)
Range: any valid integer
Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: None.

ERRORS:
CHLOGS: INVALID VALUE FOR IV.
THE RANGE OF "NHLOGS" IS ANY INTEGER.
ILLEGAL VALUE IS IV
THE DEFAULT VALUE IS USED.

CALL CHLOGS(3)
CHMTIC - Set the # of Horizontal Minor Tick Marks between Major

LANGUAGE: FORTRAN 77

PURPOSE: Set the number of horizontal minor tick marks between major tick marks.

USE: CALL CHMTIC(IV)

where:  IV -
Number of minor tick marks between major tick marks for the horizontal axis. (default = 0)
Range: Integers greater or equal to zero.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: None.

ERRORS:
CHMTIC: IV MUST BE AN INTEGER .GE. 0
ATTEMPTED TO PASS IV = iv
THE DEFAULT VALUE IS USED.

CALL CHMTIC(7)
CHNMBR - Draw a Numeric Value using DI-3000 Text Attributes

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: This routine draws a numeric value using current text attributes.

USE: CALL CHNMBR(VALUE,NDEC)

where: VALUE - Value to be plotted real or integer.
  type: REAL
  NDEC - Integer specifying number of digits to the right of the decimal point.
  type: INTEGER
  NDEC = 0 - Decimal point, number digits to the right.
  NDEC < 0 - No decimal point, minimum # of digits in integer value.

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: text attributes.
2) CGL attributes: none.

RESTRICTIONS: 1) The number is restricted to a maximum of 12 significant digits.
2) Segment must be open.

ERRORS:
CHNMBR: NDEC MUST BE AN INTEGER .GT. 0
ATTEMPTED TO PASS NDEC= ndec
THIS ROUTINE IS NOT EXECUTED.
CHPREC - Set Horizontal Numeric Axis Tick Mark Label Precision

---

LANGUAGE: FORTRAN 77

PURPOSE: Set horizontal numeric axis tick mark label precision

USE: CALL CHPREC(IV)

Where:

IV - Number of digits to the right of the decimal point in the tick mark labels of the horizontal axis

> 0 - Plot as a real. IV represents the number of digits to the right of the decimal point
< 0 - Display as integer (no decimal point)
= 0 - No trailing digits.
Default: -1

Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: None.

ERRORS:

CHPREC: IV MUST BE AN INTEGER.
ATTEMPTED TO PASS IV= iV
THE DEFAULT VALUE IS USED.
CHTICJ - Set the Tick Mark Position Relative to the Horizontal Axis

LANGUAGE: FORTRAN 77

PURPOSE: Set the tick mark positioning relative to the horizontal axis.

USE: CALL CHTICJ(IV)

WHERE: IV -
    is a value to indicate positioning of tick marks
    0 -- No tick marks.
    1 -- Tick marks positioned above the axis.
    2 -- Tick marks positioned below the axis.
    3 -- Tick marks positioned above and below the axis.

TYPE: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

NOTES: Attribute CHTICJ controls the horizontal axis tick mark positioning (i.e., above, below, etc.). The attribute CHLABJ controls the positioning of the tick mark labels.

RESTRICTIONS: none.

ERRORS:
CHTICJ: IMPROPER ENTRY GIVEN FOR POSITIONING OF TICK MARKS. VALUE MUST BE 0, 1, 2, OR 3. DEFAULT VALUE IS USED.

---

NO TICK MARKS
CALL CHTICJ(0)

TICK MARKS ABOVE THE AXIS
CALL CHTICJ(1)

TICK MARKS BELOW THE AXIS
CALL CHTICJ(2)

TICK MARKS ABOVE AND BELOW THE AXIS
CALL CHTICJ(3)

HORIZONTAL LINE
CALL CHFROT(0)
CHTROT - Set Angle of Rotation of Horizontal Axis Tick Mark Labels

---------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set angle of rotation of horizontal axis tick mark label

USE: CALL CHTROT(IV)

WHERE: IV - Rotation angle

TYPE: Integer

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) Angles are entered in as integer values.

ERRORS:
CHTROT: IV MUST BE AN INTEGER.
ATTEMPTED TO PASS IV= iv
THE DEFAULT VALUE IS USED

HORIZONTAL LINE 1
CALL CHTROT(0)

HORIZONTAL LINE 1
CALL CHTROT(45)
CKEYIN - Initialize Key Related Variables

---------------------------------------------------------------------

LANGUAGE FORTRAN 77

PURPOSE: Initialize key related variables (i.e., ISTORE and KEYCHR). This routine will reset all key related variables to their defaults. Thus existing keys using these variables will be overwritten. To plot a key, use the following sequence of calls to the CGL:

Initialization - CALL CKEYIN(...)
before constructing the label for the first line in the first key.

Label - CALL CKEYLB(...)
for each line to save off current line information to be plotted by a call to CKEYPL.

Plot key - CALL CKEYPL(...)
once all lines have been created, send the key box coordinates and plot the key.

Note: If the same key variables are used for more than one plot, all values are valid until another call is made to CKEYIN.

USE: CALL CKEYIN(ISTORE,KEYCHR,LINES,NCOL,NTLINS)

where:

ISTORE - Storage array for attributes used by the CGL. Must be dimensioned:
INTEGER(15,LINES)
type:INTEGER (returned)

KEYCHR - Storage array for line labels.
Line labels may have more than one column. If so each column must be specified using a delimiter. The storage array must be able to handle the longest label(s) for any line. Must be dimensioned:
CHARACTER*?? KEYCHR(NCOL,LINE).
(where ?? is the largest expected character length of all the labels).
type:CHARACTER (returned)

LINES - Number of lines to be keyed.
range: greater than 0.
type:INTEGER

NCOL - Number of columns in the key.
range: greater than 0.
type:INTEGER

NTLINS - Number of lines to key column titles (in CCTLS) to be stored
in COMMON CKEYDT as NLINS.  
range: greater than or equal to 0.  
type: INTEGER

ASSOCIATED ATTRIBUTES:
  1) DI-3000 attributes: none.
  2) CGL attributes: none.

RESTRICTIONS: 1) Only one key may be built at a time per ISTORE and KEYCHR.

ERRORS:

  CKEYIN: LINES MUST BE AN INTEGER .GT. 0.  
          ATTEMPTED TO PASS LINES = lines  
          THIS ROUTINE IS NOT EXECUTED.

  CKEYIN: NCOL MUST BE AN INTEGER .GT. 0.  
          ATTEMPTED TO PASS NCOL= ncol  
          THIS ROUTINE IS NOT EXECUTED.

  CKEYIN: NTLINS MUST BE AN INTEGER .GE. 0.  
          ATTEMPTED TO PASS NTLINS= ntlins  
          THIS ROUTINE IS NOT EXECUTED.
CKEYLB - Label the Key

LANGUAGE: FORTRAN 77

PURPOSE: This routine labels the key for a given line using current attributes.

USE: CALL CKEYLB(ISTORE,KEYCHR,ICODE,LABEL)

where: ISTORE - Storage array for line and symbol attributes. (See CKEYIN)
   type: INTEGER (returned)

   KEYCHR - Storage array for line labels.
   type: CHARACTER (returned) (See CKEYIN)

   ICODE - Code deciding what is to be used in key.
   type: INTEGER
   = 1 - CGL line only
   = 2 - CGL marker only
   = 3 - CGL marker and line
   = -1 - DI-3000 line only
   = -2 - DI-3000 marker only
   = -3 - DI-3000 marker and line
   = -4 - Rectangle

   LABEL - Text string for this line.
   type: CHARACTER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) Storage area arrays should be initialized using subroutine CKEYIN. Only one key may be built at a time per ISTORE and KEYCHR.
2) DI-3000 markers are device dependent, therefore the height and width are not selectable by the user. Any key using DI-3000 markers are only approximate. CGL markers and line patterns are preferred. approximate (i.e., CGL markers are recommended).
3) CKEYLB should be invoked just before or after the call to have the line and/or symbol plotted, in order to retain the current attributes.

ERRORS:
ATTEMPTED TO PASS ICODE= icode
THIS ROUTINE IS NOT EXECUTED.
CKEYPL - Plot the Key

---

**LANGUAGE:** FORTRAN 77

**PURPOSE:** To plot the key within the user's box dimensions for the CGL routines. This routine uses the variables ISTORE and KEYCHR initialized by CKEYIN and set by CKEYLB.

**USE:**

```fortran
CALL CKEYPL(ISTORE,KEYCHR,CTTL,CCTLS,BPOS,KPT,JCOL,NHDR)
```

where:

- `ISTORE` - Storage array for line and symbol attributes (see CKEYIN).
  - type: INTEGER

  A description of ISTORE's content:

  - location: description
    - `01-10` : DI-3000 current internal environment
    - `1` : the current color (J1IGET(5)).
    - `2` : the current intensity.
    - `3` : the current line style.
    - `4` : the current line width.
    - `5` : the current pen.
    - `6` : the current polygon edge style.
    - `7` : the current polygon interior style.
    - `8` : the current polygon color index.
    - `9` : the current polygon intensity index.
    - `10` : the current marker symbol.
    - `11-15` : additional attributes used by CGL.
    - `11` : CGL marker symbol number.
    - `12` : marker symbol size.
    - `13` : plot type.
    - `14` : line pattern type.
    - `15` : magnification factor.

- `KEYCHR` - Character array (See CKEYIN) key lines.
  - type: CHARACTER

- `CTTL` - Character variable contains key title.
  - type: CHARACTER

- `CCTLS` - Character array (NCOL,NTLINS) for column titles. See CKEYIN for description of NCOL and NTLINS.
  - type: CHARACTER

- `BPOS` - Storage array for key box coordinates.
  - REAL BPOS(4) (user supplied)
  - type: REAL (returned)

  positions for key box:
  - `BPOS(1)` : X coordinate for specified box corner.
  - `BPOS(2)` : Y coordinate for specified box corner.
BPOS(3): X coordinate for box center point.
BPOS(4): Y coordinate for box center point.

KPT - Type of box coordinates input.
   type: INTEGER (returned)
   1 - Center point given in BPOS(3), BPOS(4)
   2 - Lower left corner in BPOS(1), BPOS(2)
   3 - Lower right corner in BPOS(1), BPOS(2)
   4 - Upper left corner in BPOS(1), BPOS(2)
   5 - Upper right corner in BPOS(1), BPOS(2)

   box for key:
   *-------------------*
   |                  |
   |                  |
   |                  |
   |                  |
   |                    BPOS(3) |
   |                    BPOS(4) |
   |                  |
   |                  |
   |                  |
   |                  |
   |                  |
   BPOS(1) -
   BPOS(2) *-------------------*

NOTE: ****
If the center point is supplied (KPT=1)
the box's two diagonal points will be
determined by the key's dimensions, and output
in BPOS(1), BPOS(2) and BPOS(3), BPOS(4) without
plotting the key.

JCOL - Array containing the justification codes
   INTEGER JCOL(LCOL)
   type: INTEGER
   for each column.
   1 = left justification
   2 = center justification
   3 = right justification

NHDR - Code specifying if a key title is given
   type: INTEGER
   0 = no header
   1 = header given in CTTL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:
   NKLPLN - Key line pattern length (in inches). (Default=1.)
   Range: REAL values greater than 0.
   Type: REAL

   NPBCOL - Distance (in inches) between columns and between
title and the identification column in the key.
   (Default=.25)
   Range: REAL values greater than 0.
   Type: REAL

   NPBLIN - Distance between lines in the key (in inches).
Range : REAL values greater than 0.
Type: REAL

NPDKEY - Margins for the 4 sides of the key (in inches).
( Default=.188)
Range : REAL values greater than or equal to 0.
Type: REAL

NSYMSZ - Size of symbol.
Range : REAL values greater than zero.
Type: REAL

RESTRICTIONS:
1) Associated attributes must be described in terms of the current
world coordinates. The attributes associated with height, width,
and length, are converted and stored in virtual coordinates.
2) The DI-3000 marker is device dependent, therefore only an
approximation of its size is used in CKEYPL's calculations.
Since the DI-3000 marker cannot be scaled, then if CKEYPL is
required to rescale, the resultant key output will probably be
in error. Thus, the use of DI-3000 marker in conjunction with
CKEYPL is left to the user's discretion.
3) Segment must be open.

ERRORS:
CKEYPL: NHDR MUST BE 0 OR 1.
ATTEMPTED TO PASS NHDR= nhdr
THIS ROUTINE IS NOT EXECUTED.

CKEYPL: INVALID VALUE FOR KPT.'
THE RANGE OF "KPT" [1,5] (INTEGER).'
ILLEGAL VALUE IS ',KPT
NO DEFAULT VALUE CAN BE ASSIGNED.',
THE ROUTINE IS NOT EXECUTED.'

NOTE: ****
If the center point is supplied (KPT=1)
the box's two diagonal points will be
determined by the key's dimensions, and output
in BPOS(1),BPOS(2) and BPOS(3),BPOS(4) without
plotting the key.
EXAMPLE: See appendix B for an example of generating a key in context. The partial program below shows the dimensions of variables, and the interrelationship among routines, in key generation.

```plaintext
PROGRAM CKEYPL1
PARAMETER(NCOLS=1, NTLINS=1, NLINS=3, NPTS=10)
INTEGER ISTORE(15, NLINS)
CHARACTER KEYCHR(NCOLS, NLINS)*15, KEYLAB(NLINS)*15
REAL BPOS(4)
DATA ICODE/3, 1, 2/, BPOS/3., 6., 0., 0./
DATA KEYLAB/'LINE AND MARKER', 'LINE ONLY', 'MARKER ONLY'/

CALL JBEGIN
CALL CBEGIN
CALL CVSPAC(...)
CALL JWINDO(...)
CALL JOPEN

CALL CKEYIN(ISTORE, KEYCHR, NCOLS, NTLINS, NLINS)
DO 10 I=1, NLINS
  CALL CSET(...)
  CALL CKEYLB(ISTORE, KEYCHR, ICODE, KEYLAB)
  CALL CLNPLT(...)
  CALL CKEYPL(ISTORE, KEYCHR, CTTL, CCTLS, BPOS, KPT, JCOL, NHDR)
10
```

A - 47
CKEYPL1: EMBEDDED KEY INVOCATIONS.
CKEYTC - Set Key Text to Normal or Color of Key Symbol

LANGUAGE: FORTRAN 77

PURPOSE: Set key text to normal or color of key symbol.

USE: CALL CKEYTC(LV)

WHERE: LV -
   Flag to set key text to normal or color
   .TRUE. - Key text is normal (default).
   .FALSE. - Key text is same color as symbol

TYPE: Logical

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS: none.
CKLPLN - Set Key Line Pattern Length

LANGUAGE: FORTRAN 77

PURPOSE: Set key line pattern length

USE: CALL CKLPLN(RV)

where: RV
       Key line pattern length (world coordinates).
       (default = 1.)
       Range: Real values greater than zero.
       Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CKLPLN: RV MUST BE .GT. 0.
ATTEMPTED TO PASS RV= rv.
THE DEFAULT VALUE IS USED.

Key of functions

\[ y = \sin(x) \quad y = \cos(x) \]

Key Line Pattern Length

Trigonometric values
CLABP - Set the Size of the Minor Tick Marks as a % of Major

LANGUAGE: FORTRAN 77

PURPOSE: Set the size of the minor tick marks as a % of major.

USE: Call CLABP(RV)

Where: RV -
The size of the minor tick marks as a percentage of the size of the major tick marks.
(Default=2/3)
Range: Real values greater than zero.
Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CLABP: INVALID VALUE FOR RV.
THE RANGE OF "NLABP" IS .GT. ZERO (REAL).
ILLEGAL VALUE IS RV
THE DEFAULT VALUE IS USED.
CLEAF - Set Interleave Factor

--------------------------------------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set interleave factor. Currently, this attribute is
         only used by CLNPLT.

USE: CALL CLEAF(IV)

where: IV
       Interleaf Factor
       1 - values are stored sequentially (default)
       2 - values stored in every other location
       N - values stored in every N'th location

RANGE: INTEGER values greater than zero
Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CLEAF: INVALID VALUE FOR IV.
      THE RANGE OF "NLEAF" IS .GT. ZERO (INTEGER).
      ILLEGAL VALUE IS IV
      THE DEFAULT VALUE IS USED.

EXAMPLE: given:
        REAL A(10)
        DATA A/1.,2.,3.,4.,5.,6.,7.,8.,9.,10./
        then
call CLEAF(1) will allow CLNPLT to access {1., ..., 10.}
call CLEAF(2) ==> {1., 3., 5., 7., 9.}
call CLEAF(3) ==> {1., 4., 7., 10.}
call CLEAF(IV) ==> {1st, 1+iv position, 1+2*iv, etc.}
PURPOSE:
To draw a log-log, semi-log (in either axis) or linear grid with rectangular or square area(s) remaining blank.

USE:
CALL CLGRID (XSC,YSC,IXC,IYC,XGS,YGS,XGI,YGI, 
BLANK,NBLANK)

XSC  log - Number of units per log cycle for X.  
     lin - Total X axis length.  
     type:REAL

YSC  log - Number of units per log cycle for Y.  
     lin - Total Y axis length.  
     type:REAL

IXC  log - Number of log cycles along X axis.  
     lin - -1 must be loaded.  
     type:INTEGER

IYC  log - Number of log cycles along Y axis.  
     lin - -1 must be loaded.  
     type:INTEGER

XGS  log - Starting grid line for X (1.0 To 9.0).  
     This also controls ending grid line.  
     lin - 0. must be loaded.  
     type:REAL

YGS  log - Starting grid line for Y (1.0 to 9.0).  
     This also controls ending grid line.  
     lin - 0. must be loaded.  
     type:REAL

XGI  log - Interval between secondary grid lines in each cycle.  Interval is doubled above 6 primary grid lines for each cycle.  Each integer grid line must also be an interval line.  If not, interval is modified so this condition will be satisfied.  
     1.0 no secondary grid lines  
     .5 one secondary grid line  
     .25 three secondary grid lines  
     -XGI use tick marks not full grid lines  
     +XGI use full grid lines  
     type:REAL

lin - Interval between grid lines for entire axis.  
     -XGI use tick marks not full grid lines  
     +XGI use full grid lines  
     type:REAL

YGI  log - Interval between secondary grid lines in each cycle.  This interval is doubled above 6 primary grid lines per cycle.  Each integer grid line must also be an
interval line. If not, interval is modified so this condition will be met.
1.0 no secondary grid lines
.5 one secondary grid line
.25 three secondary grid lines
-YGI use tick marks not full grid lines
+YGI use full grid lines

lin  - Interval between grid lines for entire axis.
-YGI use tick marks not full grid lines
+YGI use full grid lines
type: REAL

BLANK  An array containing the coordinates of the rectangular or square blank area(s).
For the first blank area
BLANK(1) - X lower left coordinate
BLANK(2) - Y lower left coordinate
BLANK(3) - X upper right coordinate
BLANK(4) - Y upper right coordinate
For the second blank area
BLANK(5) - X lower left coordinate
BLANK(6) - Y lower left coordinate
BLANK(7) - X upper right coordinate
BLANK(8) - Y upper right coordinate
type: REAL

NBLANK  An integer specifying the number of blank areas. A maximum of 10 blank areas are allowed.
range: 0 to 10. If NBLANK is 0, then a dummy variable should be passed for BLANK.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:
   NLABP  - The size of the minor tick marks as a percentage of the size of the major tick marks. (Default=2/3)
   Range : REAL values greater than 0.
   Type: REAL

NOTES:
(1) Major tick mark lengths -
   Horizontal axis : current character height.
   Vertical axis : current character width.

(2) Minor tick mark lengths -
   Major tick mark length*NLABP
   (where NLABP is desired percentage of major tick mark).

RESTRICTIONS:
1) Segment must be opened.
2) The routine will first move the pen to
X=0 and Y=0. Only perpendicular axes are allowed (no skewed grids).

**METHOD:**
For log-grids the cycle size, number of cycles and choice of grid lines within each cycle are specified independently for each axis. For a log cycle, starting grid lines and interval between lines are specified. This interval is used until primary grid lines over six are encountered. Then the interval is doubled.

For a linear grid, the axis length and interval between lines are specified.
For both linear and log grids, user may choose between full grid lines or 0.25-unit abbreviated grid lines independently for each axis.

**OTHER CODING INFORMATION**
If repeat interval .GT. one after doubled, it will be set to one. If it is one, the repeat interval lines will coincide with the integer grid lines.

**ERRORS:**

- **CLGRID:** IXC MUST BE AN INTEGER.
  ATTEMPTED TO PASS IXC= ixc
  THIS ROUTINE IS NOT EXECUTED.

- **CLGRID:** IYC MUST BE AN INTEGER.
  ATTEMPTED TO PASS IYC= iyc
  THIS ROUTINE IS NOT EXECUTED.

- **CLGRID:** NBLANK MUST BE AN INTEGER .ge. 0 .AND. .LE. 10.
  ATTEMPTED TO PASS NBLANK= nblank
  THIS ROUTINE IS NOT EXECUTED.
CLNPAT - Set Line Pattern for NASA Standard Line Patterns

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set line pattern for NASA standard line patterns.

USE: CALL CLNPAT(NLNPAT)

NLNPAT Line pattern for NASA standard line patterns
1 Solid line (default)
2 - 8 NASA dashed patterns
range: Integer values from 1 to 8,
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3600 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CLNPAT: INVALID VALUE FOR IV.
THE RANGE OF "NLNPAT" IS 1 TO 8 (INTEGER).
ILLEGAL VALUE IS IV
THE DEFAULT VALUE IS USED.

LINE PATTERNS

1

2

3

4

5

6

7

8

A - 56
CLNPLT - Draw a Line between and/or Draw NASA Standard Symbol

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: To draw a line between and/or draw NASA standard symbol or to draw continuous dashed line with a symbol at the end of a line.

The characteristics of the line and/or symbols are set by defining the appropriate CGL attributes.

USE:

CALL CLNPLT(X,Y,N)

- X - X array to plotted (X world coordinates).
  type: REAL

- Y - Y array to plotted (Y world coordinates).
  type: REAL

- N - Number of points to be plotted.
  type: INTEGER

ASSOCIATED ATTRIBUTES:

1) DI-3000 attributes: line and polygon attributes.
2) CGL attributes:

- NLEAF - Interleave factor for line plots (CLNPLT).
  1 values are stored sequentially (Default)
  2 values stored in every other location.
  Range: INTEGER values greater than 0.
  Type: INTEGER

- NPLTYP - Code for line plot type (CLNPLT).
  Magnitude specifies the alternate points for symbol
  positive for line and symbol plot
  negative for symbol only
  0 for line plot with specified symbol at end
  1 for symbol for each data point and line between
    (default = 1)
  -2 for symbol for every other data point
  -n for symbol for every other n'th data point
  Range: any INTEGER value.
  Type: INTEGER

- NSYMNO - The Type of symbol to be drawn:

  NSYMNO = 0 no symbol
  1 circle
  2 square (default)
  3 diamond
  4 triangle
  5 right triangle
  6 quadrant
  7 dog house
  8 fan
long diamond
house
circle with plus
square with plus
diamond with plus
triangle with plus
right triangle with plus
quadrant with plus
dog house with plus
fan with plus
long diamond with plus
house with plus
dot
plus sign

If a flag is desired, add 100, 200,..., 900 to NSYMNO, such that:
1 - symbol
101 - symbol + upper right line
201 - symbol + upper left line
301 - symbol + lower left line
401 - symbol + lower right line
501 - symbol + upper right flag
601 - symbol + upper left flag
701 - symbol + lower left flag
801 - symbol + lower right flag
901 - symbol is solid filled
Range : 0 to 22,100 to 122,...,900 to 922.
Type:INTEGER

NSYMNO - Size of symbol.
Range : REAL values greater than zero.
Type:REAL

NLNPAT - Line pattern for NASA standard line patterns.
1 solid line (Default)
2 - 8 NASA dashed patterns
Range : INTEGER values between 1 and 8 (inclusive).
Type:INTEGER

NMAGFL - Magnification factor of line pattern (CLNPLT).
Each element of the selected line pattern is multiplied by the value NMAGFL. (Default = 1.0)
Range : REAL values greater than 0.
Type:REAL

NOTE: To draw a line only (i.e., no symbols, nor spaces for symbols) set NSYMNO to 0.

RESTRICTIONS: 1) Segment must be opened.
2) The latest world coordinate system (See DI-3000's JWINDO) should be related to the values in the X and Y arrays.
ERRORS:

CLNPLT: N MUST BE AN INTEGER .GT. 0.
ATTEMPTED TO PASS N= n
THIS ROUTINE IS NOT EXECUTED.

CLNPLT: NLEAF MUST BE AN INTEGER .GT. 0.
ATTEMPTED TO PASS NLEAF= nleaf
THIS ROUTINE IS NOT EXECUTED.

Xyzabc branch
Resource utilization

Resource

Batch
Simulation
Remote
Interactive
Other

Mid-range

Other

CRU's

Fiscal year

A - 59
CMAGFL - Set Magnification Factor of Line Pattern

 LANGUAGE: FORTRAN 77

 PURPOSE: Set magnification factor of line pattern.

 USE: CALL CMAGFL(NMAGFL)

 where: NMAGFL
 Magnification factor of line pattern. Each element of the selected line pattern is multiplied by the value of NMAGFL. (Def = 1.)
 Range: Real values greater than zero.
 type: REAL

 ASSOCIATED ATTRIBUTES:
 1) DI-3000 attributes: none.
 2) CGL attributes: none.

 RESTRICTIONS: none.

 ERRORS:
 CMAGFL: INVALID VALUE FOR NMAGFL.
 THE RANGE OF NMAGFL IS .GT. 0 (REAL).
 ILLEGAL VALUE IS nmagfl
 THE DEFAULT VALUE IS USED.
CMNMX - Find the Minimum and Maximum of an Array

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Subroutine to find the minimum and maximum of an array.

USE: CALL CMNMX(A,N,XMIN,XMAX)

Where: A - The array to be examined.
       Type: REAL
       N - Number of elements in array A.
       Type: INTEGER
       XMIN, XMAX - Minimum and maximum values found.
       (returned) Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) N must be 2 or greater.

ERRORS:
CMNMX: N MUST BE INTEGER .GT. 0.
       ATTEMPTED TO PASS N = n
       THIS ROUTINE IS NOT EXECUTED.
CNASA - Draw NASA Logo

LANGUAGES: FORTRAN 77 (ANSI)

PURPOSE: To draw the NASA LOGO. The policy governing the use of the NASA LOGO is documented in the NASA LANGLEY RESEARCH CENTER Management Manual (NMI 1020, Ie paragraph 13.b).

USE: CALL CNASA (THETA,HEIGHT,ICOLOR)

where -

THETA : Angle (degrees) of inclination of the logo about the current position. See the note below for a further explanation.
type: REAL

HEIGHT : Height of the logo (world coordinates). Range: greater than 0.
type: REAL

ICOLOR : Integer value showing color of NASA LOGO polygon fill.
0 - black
1 - red
2 - normal
3 - complement of normal
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

Notes: The angle of inclination (THETA) is applied relative to the NASA logo as indicated by the current text justification (JJUST). For example, a current text justification of 2,2 (center,center) will rotate the NASA logo about the logo's center-center location. The following figure provides a summary of the text justification.

```
1,3--------2,3--------3,3
 . 
1,2 NA 2,2 SA 3,2
 . 1,1--------2,1--------3,1
```

RESTRICTIONS: 1) Segment must be opened.
2) HEIGHT must be greater than zero.
3) The ratio of HEIGHT to width is 1:3.76.
4) Each logo letter is a polygon with about 244 points. Therefore, the user must ensure that the device driver can support polygons with that many points.
This figure illustrates justification of the NASA Logo about a point.
This figure illustrates rotation of the NASA Logo about a point
CNOTE - Output a Graphics String Rotated by an Angle

---

LANGUAGE: FORTRAN 77

PURPOSE: To output a graphics string STR, rotated about the X-axis by ANGLE degrees. The string is output in the precision determined by PREC.

USE: CALL CNOTE(STR, ANGLE, PREC)

where:

- STR - Graphics string to be output.
  type: CHARACTER(*)
- ANGLE - Angle of rotation (degrees).
  type: REAL
- PREC - Type of graphics precision.
  Range:
  1 - string precision text.
  2 - character precision text.
  3 - stroke precision text.
  4 - graphics art precision text.
  5 - di-textpro precision text.
  Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes:
   NTCOL - Text color.
   Range: 0 or greater (see underlying package).
   Type: INTEGER

RESTRICTIONS: Segment must be open.

ERRORS:

CNOTE: PREC MUST BE AN INTEGER 1 TO 5.
ATTEMPTED TO PASS PREC = prec
THIS ROUTINE IS NOT EXECUTED.

NOTE: 1) The current character attributes are used (except JBASE and JPLANE).
2) The vectors for JBASE and JPLANE may be altered.
CPBCOL - Set Distance Between Columns in the Key

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set distance between columns.

USE:

CALL CPBCOL(RV)

where: RV -
Distance (in inches) between columns and between title
and the identification column in the key.(Default=.25)
Range: REAL values greater than zero.
Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:

CPBCOL: INVALID VALUE FOR RV.
THE RANGE OF "NPBCOL" IS .GT. ZERO (REAL).
ILLEGAL VALUE IS rv
THE DEFAULT VALUE IS USED.

A - 66
CPBLIN - Set Horizontal Distance Between Lines in the Key

---

**LANGUAGE:** FORTRAN 77

**PURPOSE:** Set horizontal distance between lines in the key.

**USE:**

```fortran
CALL CPBLIN(RV)
```

where: RV - Distance between lines (in inches).
      (Default = .081) 
      Range: REAL values greater than zero 
      Type: REAL

**ASSOCIATED ATTRIBUTES:**
1) DI-3000 attributes: none.
2) CGL attributes: none.

**RESTRICTIONS:** none.

**ERRORS:**

CPBLIN: INVALID VALUE FOR RV.
       THE RANGE OF "NPBLIN" IS .GT. 0. (REAL).
       ILLEGAL VALUE IS rv
       THE DEFAULT VALUE IS USED.

---

[Diagram of a key with lines labeled Abcde, Fghij, Kimmo, and Pqrs]
CPBXVL - Return X World Coordinates for X Inches

 LANGUAGE: FORTRAN 77

 PURPOSE: Determine amount of DI-3000 X world coordinates for a given length in X inches.

 USE: VAL = CPBXVL(XINCH)

 where: XINCH - Value in inches.
 type: REAL

 ASSOCIATED ATTRIBUTES:
 1) DI-3000 attributes: none.
 2) CGL attributes: none.

 RESTRICTIONS: CVSPAC or CVPORT must be called prior to this routine.

 ERRORS: none.
CPBYVL - Return Y World Coordinates for Y Inches

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Determine amount of DI-3000 Y world coordinates for a given length in Y inches.

USE: VAL = CPBYVL(YINCH)

where: YINCH - Value in inches.
      type: REAL

ASSOCIATED ATTRIBUTES:
  1) DI-3000 attributes: none.
  2) CGL attributes: none.

RESTRICTIONS: CVSPAC or CVPORT must be called prior to this routine.

ERRORS: none.
CPDKEY - Set Margins for the Four Sides of the Key

LANGUAGE: FORTRAN 77

PURPOSE: Set margins for the four sides of the key.

USE: CALL CPDKEY(RV)

where: RV -
Margins for the four sides of the key.
(Default = .188)
Range: Real values greater than or equal to 0.
Type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CPDKEY: INVALID VALUE FOR RV.
THE RANGE OF "NPDKEY" IS .GT. 0. (REAL).
ILLEGAL VALUE IS RV
THE DEFAULT VALUE IS USED.
CPLGRD - Draw a Polar Grid

---------------------------------------------------------
LANGUAGE: FORTRAN

PURPOSE: To draw a polar grid, which consists of a pair of intersecting axes, concentric circles, and tick marks on the outer circles. The tick marks can also be extended to the origin, thus forming radii.

USE: CALL CPLGRD(X,Y,R,TMAJ,TICDEG)
where:
X,Y - The coordinates of the center of the polar grid.
  type: REAL
R - Length of the radius of the grid.
  range: greater than 0.
  type: REAL
TMAJ - Length along the axis separating concentric circles.
  + label axis
  - axis not labeled
  range: not equal to 0.
  type: REAL
TICDEG - The number of degrees between tick marks.
  + tick mark only
  - tick mark extended to grid origin
  type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes.
2) CGL attributes: none.

RESTRICTIONS: - A segment must be open.
  - X, Y, and R are in world coordinates.

ERRORS:
CPLGRD: R MUST BE .GT. 0.
  ATTEMPTED TO PASS R= r
  THIS ROUTINE IS NOT EXECUTED.
CPLGRD: TMAJ CANNOT .EQ. 0.
  ATTEMPTED TO PASS TMAJ= tmaj
  THIS ROUTINE IS NOT EXECUTED.
CPLTST - Send a Message to the Plotter Operator

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: This routine is used to send a message to the plot operator. It is intended for use with static plotters operated by the ACD support personnel.

USE: CALL CPLTST (MESSAGE)

MESSAGE - is the message for the operator. Type: character(*)

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: Only the first 80 characters are used.

ERRORS: none.
**CPLTYP - Set Code for Plot Type**

**LANGUAGE:** FORTRAN 77

**PURPOSE:** Set code for plot type.

**USE:** CALL CPLTYP(IV)

**WHERE:** IV - Code for plot type.

Magnitude specifies the alternate points for symbol:
- Positive for line and symbol;
- Negative for symbol only.
- 0 For line plot with the specified symbol at end;
- 1 For symbol for each data point and line between; (default = 1)
- -2 For symbol for every other data point;
- -N For symbol for every other N'th data point.

**RANGE:** Any INTEGER value.

**TYPE:** INTEGER

**ASSOCIATED ATTRIBUTES:**
1) DI-3000 attributes: none.
2) CGL attributes: none.

**RESTRICTIONS:** none.

**NOTES:** Attribute CLEAF determines which elements are selected, CPLTYP determines which selected elements will be represented by a symbol.

**ERRORS:**
- CPLTYP: INVALID VALUE FOR IV.
- THE RANGE OF "NPLTYP" IS ANY INTEGER.
- ILLEGAL VALUE IS iv
- THE DEFAULT VALUE IS USED.

```
-2 0 1 2
    o o o o o
 __________

1 2
 △-----△-----△-----△-----△
```

A - 74
CPNTPT - Draw a NASA Symbol at the Specified Location

-------------------------------------------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Draws a NASA point symbol at the specified location. The type and size of the symbol are specified by setting the associated attributes listed below.

USE: CALL CPNTPT(XO,YO)

where: XO - Center of symbol X world coordinates.
       type: REAL

       YO - Center of symbol Y world coordinates.
       type: REAL

ASSOCIATED ATTRIBUTES:

1) DI-3000 attributes: polygon attributes.
2) CGL attributes:

   NSYMNO - The Type of symbol to be drawn:

   NSYMNO =  0   no symbol
             1   circle
             2   square (default)
             3   diamond
             4   triangle
             5   right triangle
             6   quadrant
             7   dog house
             8   fan
             9   long diamond
            10   house
            11   circle with plus
            12   square with plus
            13   diamond with plus
            14   triangle with plus
            15   right triangle with plus
            16   quadrant with plus
            17   dog house with plus
            18   fan with plus
            19   long diamond with plus
            20   house with plus
            21   dot
            22   plus sign

   If a flag is desired, add 100, 200,..., 900 to NSYMNO, such that:

   1 - symbol
   101 - symbol + upper right line
   201 - symbol + upper left line
   301 - symbol + lower left line
   401 - symbol + lower right line
   501 - symbol + upper right flag
   601 - symbol + upper left flag

A - 75
701 - symbol + lower left flag
801 - symbol + lower right flag
901 - symbol is solid filled

Range : 0 to 22, 100 to 122, ..., 900 to 922.
Type: INTEGER

NSYMSZ - Size of symbol.
Range : REAL values greater than zero.
Type: REAL

REstrictions: 1) Segment must be open.
               2) CPNTPT will set the current position (CP) to XO, YO.

errors: none.

NASA SYMBOLS

<table>
<thead>
<tr>
<th>ISYM</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

If a flag is wanted, add 100, 200, ..., 900 to ISYM

<table>
<thead>
<tr>
<th>ISYM</th>
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<tbody>
<tr>
<td>1</td>
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<td>901</td>
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</tbody>
</table>

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CREXP - Return the Integer Value between '[BSUP]' And '[ESUP]'.

-----------------------------

LANGUAGE:FORTRAN 77

PURPOSE:To read a string "CEXP" and return an integer "IVAL" between "[BSUP]" and "[ESUP]".

USE:CALL CREXP(CEXP,IVAL)

where:CEXP - Character string to be scanned.
   type:CHARACTER(*)
IVAL - Integer value returned.
   type:INTEGER

ASSOCIATED ATTRIBUTES:
   1) DI-3000 attributes: none.
   2) CGL attributes: none.

RESTRICTIONS: The string CEXP must contain "[BSUP]IVAL[ESUP]".
                IVAL is limited to two digits.

ERRORS: none.
CRLINT - Set Real to Integer Conversion Flag

LANGUAGE: FORTRAN 77

PURPOSE: Set real to integer conversion flag for any numeric text to be displayed via the CGL.

USE:

CALL CRLINT(LV)

where: LV -
Real to integer conversion flag
.TRUE. - Real is plotted as integer
.FALSE. - Real is plotted as a real (default)

The numeric value is not changed. Conversion is done to the character string containing the printed number. Hence, the number is not rounded. If rounding is preferred, it should be done by the user prior to calling the conversion routines.

type:LOGICAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS: none.
CScale - To Determine Publication Quality Axis Attributes

Language: FORTRAN 77

Purpose: Determine publication quality axis attributes. Specifically, the data min and max are passed to this routine, which returns an adjusted minimum and maximum, the number of major and minor tick marks, and the appropriate number of decimal places to the left and right of the decimal point. These values will provide publication-quality labels when used on an axis.

Use:

CALL CScale(DMIN, DMAX, AMIN, AMAX, NMAJOR, NMINOR, XINCR, NLEFT, NRIGHT)

Where:

DMIN - Data minimum. (input)
   type: REAL

DMAX - Data maximum.
   type: REAL (input)

AMIN - Adjusted data minimum.
   type: REAL (returned)

AMAX - Adjusted data maximum.
   type: REAL (returned)

NMAJOR - Number of major tick marks
   type: INTEGER (returned)

NMINOR - Number of minor tick marks
   type: INTEGER (returned)

XINCR - The step value between min and max.
   XINCR set to (AMAX-AMIN)/NMAJOR-1.
   type: REAL (returned)

NLEFT - Number of digits to the left of the decimal point.
   type: INTEGER (returned)

NRIGHT - Number of digits to the right of the decimal point.
   type: INTEGER (returned)

Associated Attributes:

1) DI-3000 attributes: none.
2) CGL attributes: none.

Restrictions: none.

Errors: none.
CSET - Set Common Graphics Library (CGL) Attributes

LANGUAGE: FORTRAN 77

PURPOSE: This routine allows the user to set CGL attributes from a single routine. The use of a single routine frees the user from finding and calling different routines, but at the expense of additional field length. If the user desires to call the specific routine, thus reducing the field length, then the routine is generally denoted as C### for the attribute N###.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Routine</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHBTIC</td>
<td>CHBTIC</td>
</tr>
<tr>
<td>N.........</td>
<td>C.......</td>
</tr>
<tr>
<td>NVMTIC</td>
<td>CVMTIC</td>
</tr>
</tbody>
</table>

USE: CALL CSET (ATTRIBUTE,VALUE)

where: ATTRIBUTE - option selection.
       type: character
       VALUE - option value.
       type: determined by option

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes:
   NHBTIC - Position of horizontal axis label in relation to horizontal tick marks.
            0 - labels centered at tick marks. (default)
            1 - labels centered between tick marks.
            type: INTEGER
   
   NHLABJ - Position of axis label in relation to horizontal axis. (above or below)
            0 - horizontal axis label is below axis. (default)
            1 - horizontal axis label is above axis.
            type: INTEGER
   
   NHLOGF - Determine if horizontal axis will have major tick marks as 10 raised to a power.
           -1 - major tick mark labels decrease
            0 - no major tick mark labels (default)
            1 - major tick mark labels increase
            TYPE: INTEGER
   
   NHLOGS - The initial power for the horizontal log axis labels. (i.e., 10 raised to this power)
            (default=0)
            Range : any valid INTEGER.
            Type: INTEGER
NHMTIC - Number of minor tick marks between major tick marks for the horizontal axis. (default=0)
Range : INTEGERS greater or equal to 0.
TYPE: INTEGER

NHPREC - Number of digits to the right of the decimal point in the tick mark labels of the horizontal axis.
  < 0  - plot as an INTEGER (no decimal point)
  = 0  - decimal point only
  > 0  - plot as a REAL. Value represents the number of digits to the right of the decimal point
Default: -1
Type: INTEGER

NHTICJ - A value to indicate positioning of tick marks for horizontal axis.
  0  - tick marks are not positioned about the axis.
  1  - tick marks positioned right of the axis.
  2  - tick marks positioned to the left of axis.
  3  - tick marks positioned on both sides of axis.
Default: 1
Type: INTEGER

NKLPLN - Key line pattern length (in inches). (Default=1.)
Range : REAL values greater than 0.
Type: REAL

NLABP - The size of the minor tick marks as a percentage of the size of the major tick marks. (Default=2/3)
Range : REAL values greater than 0.
Type: REAL

NLEAF - Interleave factor for line plots (CLNPLT).
  1  values are stored sequentially (Default)
  2  values stored in every other location.
Range : INTEGER values greater than 0.
Type: INTEGER

NLNPAT - Line pattern for NASA standard line patterns.
  1  solid line (Default)
  2  - 8 NASA dashed patterns
Range : INTEGER values between 1 and 8 (inclusive).
Type: INTEGER

NMAGFL - Magnification factor of line pattern (CLNPLT).
Each element of the selected line pattern is multiplied by the value NMAGFL. (Default = 1.0)
Range : REAL values greater then 0.
Type: REAL

NPBCOL - Distance (in inches) between columns and between title and the identification column in the key.
(_Default=.25)
Range : REAL values greater than 0.
Type: REAL

NPBLIN - Distance between lines in the key (in inches).
( Default=.081)
Range : REAL values greater than 0.
Type: REAL

NPDKY - Margins for the 4 sides of the key (in inches).
( Default=.188)
Range : REAL values greater than or equal to 0.
Type: REAL

NPLTYP - Code for line plot type (CLNPLT).
Magnitude specifies the alternate points for symbol
positive for line and symbol plot
negative for symbol only
  0 for line plot with specified symbol at end
  1 for symbol for each data point and line between
  (default = 1)
-2 for symbol for every other data point
-n for symbol for every other n'th data point
Range : any INTEGER value.
Type: INTEGER

NRLINT - REAL to INTEGER conversion flag
.TRUE. - REAL value is plotted as an INTEGER
.FALSE. - REAL value is plotted as a REAL (default)
Type: logical

NSYMSZ - Size of symbol.
Range : REAL values greater than zero.
Type: REAL

NTPREC - Text precision.
Range : 1 - string precision text.
        2 - character precision text.
        3 - stroke precision text.
        4 - graphics art precision text.
        5 - DI-TEXTPRO precision text.
Type: INTEGER

NTCOL - Text color.
Range : 0 or greater (see underlying package).
Type: INTEGER

NVBTIC - Position of vertical axis label in relation to vertical tick marks.
  0 - labels centered at tick marks. (default)
  1 - labels centered between tick marks.
Type: INTEGER

NVJUST - Determines if vertical axis label is written horizontally or vertically.
NVLABJ - Position of axis label in relation to vertical axis. (left or right)
  0 - vertical axis label is left of axis. (default)
  1 - vertical axis label is right of axis.
  Type: INTEGER

NVLOGF - Determine if vertical log axis will have major marks as 10 raised to a power.
  -1 - no major tick mark labels
  0 - major tick mark labels (default)
  1 - major tick mark labels increase
  Type: INTEGER

NVLOGS - The initial power for the vertical log axis labels.
  Range: any valid INTEGER (10 raised to this power).
  (default 0)
  Type: INTEGER

NVMTIC - Number of minor tick marks between major tick marks for the vertical axis. (default=0)
  Range: INTEGER values greater than or equal to 0
  Type: INTEGER

NVPREC - Number of digits to the right of the decimal point in the tick mark labels of the vertical axis.
  < 0 - display as a REAL. value represents the number of digits to the right of the decimal point.
  = 0 - decimal point only
  > 0 - display as INTEGER (no decimal point)
  default: -1
  Type: INTEGER

NVTCIJ - A value to indicate positioning of tick marks for vertical axis.
  0 - tick marks are not positioned about the axis.
  1 - tick marks positioned right of the axis.
  2 - tick marks positioned to the left of axis.
  3 - tick marks positioned on both sides of axis.
  default: 1
  Type: INTEGER

RESTRICTIONS: 1) Segment must be open.

ERRORS: Errors from the routines which set the attributes.

EXAMPLE:
  CALL CSET('NLEAF',nleaf_val) or CALL CLEAF(nleaf-real)
  CALL CSET('NLNPAT',nlnpat_val) or CALL CLNPAT(nlnpat-val)
CALL CSET('NSYMSZ',nsymsz_val) or CALL CSYMSZ(nysmsz-val)
CALL CSET('NPLTYP',npltyp_val) or CALL CPLTYP(npltyp-val)
CSETBP - Set the Base/Plane Vectors for an Angle of Rotation

LANGUAGE: FORTRAN 77

PURPOSE: Set the base/plane vectors for an angle of rotation.

USE: CALL CSETBP(ANGLE)

where

ANGLE - Angle of rotation (degrees).
  type: REAL

NOTE: This routine will set JBASE and JPLANE, and
  not restore these values.

ASSOCIATED ATTRIBUTES:
  1) DI-3000 attributes: none.
  2) CGL attributes: none.

RESTRICTIONS: Segment must be open.

ERRORS: none.
CSTRG - Output Graphics Text

LANGUAGE: FORTRAN 77

PURPOSE: Output graphics text.

USE: CALL CSTRG(STR)

where: STR - Graphics text string to be displayed.
       Type: CHARACTER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: text attributes.
2) CGL attributes:
   NTCOL - Text color.
       Range: 0 or greater (see underlying package).
       Type: INTEGER

   NTPREC - Text precision.
       Range: 1 - string precision text.
       2 - character precision text.
       3 - stroke precision text.
       4 - graphics art precision text.
       5 - DI-TEXTPRO precision text.
       Type: INTEGER

RESTRICTIONS: Segment must be open.
       DI-TEXTPRO must be part of the load process if
       NTPREC equals 5.

ERRORS: none.
CSTRIP - Find indices for first and last non-blank character

------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Find indices for the first and last non-blank character (i.e., IBEG and IEND respectively).

USE: CALL CSTRIP(STRING, IBEG, IEND)

STRING - Character string.
          Type: CHARACTER

IBEG - First non-blank character position.
       (returned)
       Type: CHARACTER

IEND - Last non-blank character position.
       (returned)
       Type: CHARACTER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: A blank character string will result in IBEG and IEND set to one.

ERRORS: none.

EXAMPLE: given CHARACTER*5 C1, C2, C3
          DATA C1/'1 3 5'/, C2/' 234 '/, C3/' /

then

CALL CSTRIP(C1, IBEG, IEND) ==> IBEG=1, IEND=5
CALL CSTRIP(C2, IBEG, IEND) ==> IBEG=2, IEND=4
CALL CSTRIP(C3, IBEG, IEND) ==> IBEG=1, IEND=1
CSYMNO - Set the Type of Symbol

LANGUAGE: FORTRAN 77

PURPOSE: Set the type of symbol

USE: CALL CSYMNO(NSYMNO)

where: NSYMNO -

0  no symbol
1  circle
2  square (default)
3  diamond
4  triangle
5  right triangle
6  quadrant
7  dog house
8  fan
9  long diamond
10 house
11 circle with plus
12 square with plus
13 diamond with plus
14 triangle with plus
15 right triangle with plus
16 quadrant with plus
17 dog house with plus
18 fan with plus
19 long diamond with plus
20 house with plus
21 dot
22 plus sign

If a flag is desired, add 100, 200,...,900 to NSYMNO, such that:

1  - Symbol
101 - Symbol + upper right line
201 - Symbol + upper left line
301 - Symbol + lower left line
401 - Symbol + lower right line
501 - Symbol + upper right flag
601 - Symbol + upper left flag
701 - Symbol + lower left flag
801 - Symbol + lower right flag
901 - Symbol is solid filled

range : 0 to 22,100 to 122,...,900 to 922.

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.
RESTRICTIONS: none.

ERRORS:

CSYMNO: IV MUST BE AN INTEGER .GE.0.
ATTEMPTED TO PASS IV= iv
THE DEFAULT VALUE IS USED.

NASA SYMBOLS

\[
\begin{array}{cccccccc}
1 & \bigcirc & 2 & \Box & 3 & \Diamond & 4 & \triangle & 5 & \triangle
\
6 & \triangle & 7 & \Box & 8 & \Diamond & 9 & \triangle & 10 & \triangle
\
11 & + & 12 & \Box & 13 & \Diamond & 14 & \triangle & 15 & \triangle
\
16 & + & 17 & \Box & 18 & \Diamond & 19 & \triangle & 20 & \triangle
\
21 & & 22 & +
\end{array}
\]

IF A FLAG IS WANTED, ADD 100, 200, ..., 900 TO ISYM

\[
\begin{array}{cccccccc}
1 & \bigcirc & 101 & \bigcirc & 201 & \bigcirc & 301 & \bigcirc & 401 & \bigcirc
\
501 & \bigcirc & 601 & \bigcirc & 701 & \bigcirc & 801 & \bigcirc & 901 & \bullet
\end{array}
\]
CSYMSZ - Set Size of Symbol

LANGUAGE: FORTRAN 77

PURPOSE: Set size of symbol

USE: CALL CSYMSZ(NSYMSZ)

where: NSYMSZ - Size of symbol
To set the symbol size in terms of current page coordinates.
range: Real values greater than zero
type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTION: Segment must be open.

ERRORS:
CSYMSZ: INVALID VALUE FOR RV.
THE RANGE OF "NSYMSZ" IS .GT. ZERO (REAL).
ILLEGAL VALUE IS rv
THE DEFAULT VALUE IS USED.
CTCOL - Set Text Color for CGL Graphics Text

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set text color for all subsequent CGL graphical text.

USE: CALL CTCOL(IV)

WHERE: IV -
Text color (for all subsequent text).
range: 0 or greater (see underlying graphics package).
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CTCOL: INVALID VALUE FOR IV.
THE RANGE OF "NTCOL" IS ANY INTEGER.
ILLEGAL VALUE IS IV
THE DEFAULT VALUE IS USED.
CTODX - Convert Degrees to a Vector Related Value

--------------------------------------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: To convert degrees to a vector related value.
Conversion formula: value = TAN(XDEG in radians)
Example: JBASE(DX,1.),0.), where DX=CTODX(XDEG).

USE: VALUE=CTODX(XDEG)

where:
XDEG - Angle(in degrees) to be converted.
type: REAL

NOTE: The sign of the resultant value of CTODX is the same as the sign of XDEG.
If the TAN result is 0, then CTODX is 0.

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS: none.
CTPREC - Set Text Precision for CGL Graphical Text

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set text precision for all subsequent CGL graphical text.

USE: CALL CTPREC(IV)

WHERE: IV -
Text precision.
range : 1 - String precision text.
2 - Character precision text.
3 - Stroke precision text.
4 - Graphics art precision text.
5 - DI-TEXTPRO precision text.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) DI-TEXTPRO must be loaded prior to execution if type 5 is (to be) selected.

NOTES: Call CSETBP(ANGLE1 for text to be written at an angle of rotation (see CSETBP description).

ERRORS:
CTPREC: INVALID VALUE FOR IV.
THE RANGE OF "NTPREC" IS ANY INTEGER.
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.
CVAXIC - Draw a Vertical Axis with Character Labels

LANGUAGE: FORTRAN 77

PURPOSE: To draw a vertical axis with character labels. This routine retrieves attributes (DI-3000 and CGL) when the subroutine is invoked. These axis characteristics remain in force until SUBROUTINE CVAXIC is reinvoked. If a vertical axis label is desired, SUBROUTINE CVLAB must be invoked prior to this routine.

USE: CALL CVAXIC(XLEN,NTIC,CHARA,NLINES,NLABS)

XLEN - Length of axis (in world coordinates).
   range: greater than 0.
   type: REAL

NTIC - Number of tick marks (end tick marks inclusive).
   If NTIC is negative, the major and minor tick marks will be suppressed, but the tick mark labels will be retained.
   range: IABS(NTIC) must be greater than 1.
   type: INTEGER

CHARA - Tick mark labels, dimensioned
   type: CHARACTER

NLINES - Number of lines in the tick mark labels.
   range: must be greater than or equal to 0.
   type: INTEGER

NLABS - Number of labels for the tick marks.
   range: must be greater than or equal to 0.
   type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:
   NVBTIC - Position of vertical axis label in relation to vertical tick marks.
      0 - labels centered at tick marks. (default)
      1 - labels centered between tick marks.
   Type: INTEGER

   NVJUST - Determines if vertical axis label is written horizontally or vertically.
      0 - vertical (default).
      1 - horizontal.
   Type: INTEGER

   NVLABJ - Position of axis label in relation to vertical axis. (left or right)
0 - vertical axis label is left of axis. (default)
1 - vertical axis label is right of axis.
Type: INTEGER

NVMTIC - Number of minor tick marks between major tick marks for the vertical axis. (default=0)
Range: INTEGER values greater than or equal to 0
Type: INTEGER

NVTICJ - A value to indicate positioning of tick marks for vertical axis.
0 - tick marks are not positioned about the axis.
1 - tick marks positioned right of the axis.
2 - tick marks positioned to the left of axis.
3 - tick marks positioned on both sides of axis.
default: 1
Type: INTEGER

NVTROT - Angle of rotation for vertical axis tick mark labels.
Type: INTEGER

RESTRICTIONS: 1) XLEN must be positive.
2) An absolute minimum of two major tick marks.
3) Segment must be open.

ERRORS:

CVAXIC: NTIC MUST BE AN INTEGER .GT. 1.
ATTEMPTED TO PASS NTIC= ntic
THIS ROUTINE IS NOT EXECUTED.

CVAXIC: NLLINES MUST BE AN INTEGER .GE. 0.
ATTEMPTED TO PASS NLLINES= nlines
THIS ROUTINE IS NOT EXECUTED.

CVAXIC: NLLABS MUST BE AN INTEGER .GE. 0
ATTEMPTED TO PASS NLLABS= nlabs
THIS ROUTINE IS NOT EXECUTED.

CVAXIC: INVALID VALUE FOR XLEN.
THE RANGE OF "XLEN" IS .GT. ZERO.
THE ROUTINE IS NOT EXECUTED.

CVAXIC: TICK MARK ROTATION (NVTROT) ONLY APPLY TO ONE TICK MARK LINE (NLLINES).
NO ROTATION PERFORMED.
CVAXIS - Draw a Vertical Axis with Numeric Labels

LANGUAGE: FORTRAN 77

PURPOSE: This routine plots a vertical axis. The numeric values are calculated, converted to labels, then CVAXIC routine is called to do the actual plotting. The attributes for CVAXIC are the same and actually do not affect this routine, but will affect the actual plot.

USE: CALL CVAXIS(VTMIN,VTMAX,TINCR,VLONG)

where: VTMIN - Minimum value used for tick marks (Type: REAL)
VTMAX - Maximum value used for tick marks (Type: REAL)
TINCR - Increment value of tick marks (Type: REAL)
VLONG - Length of axis in current world coordinates (Type: REAL)

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:
   NVBTIC - Position of vertical axis label in relation to vertical tick marks.
       0 - labels centered at tick marks. (default)
       1 - labels centered between tick marks.
Type: INTEGER

   NVJUST - Determines if vertical axis label is written horizontally or vertically.
       0 - vertical (default).
       1 - horizontal.
Type: INTEGER

   NVLABJ - Position of axis label in relation to vertical axis. (left or right)
       0 - vertical axis label is left of axis. (default)
       1 - vertical axis label is right of axis.
Type: INTEGER

   NVMTIC - Number of minor tick marks between major tick marks for the vertical axis. (default=0)
Range: INTEGER values greater than or equal to 0
Type: INTEGER

   NVPREC - Number of digits to the right of the decimal point in the tick mark labels of the vertical axis. < 0 - display as a REAL value represents the
number of digits to the right of the
decimal point.

= 0 - decimal point only
> 0 - display as INTEGER (no decimal point)
default: -1
Type: INTEGER

NVICJ - A value to indicate positioning of tick marks for vertical axis.
0 - tick marks are not positioned about the axis,
1 - tick marks positioned right of the axis,
2 - tick marks positioned to the left of axis,
3 - tick marks positioned on both sides of axis.
default: 1
Type: INTEGER

NVROT - Angle of rotation for vertical axis tick mark labels.
Type: INTEGER

RESTRICTIONS: 1) Tick mark labels always occur at the major tick marks (regardless of attribute settings).
2) If VTMIN is greater than VTMAX, then TINCR must be negative. VTMIN and VTMAX cannot be equal.
3) Segment must be open.

ERRORS: none.

NOTES: If VTMIN is greater than VTMAX, then axis labels will be output in decreasing order.
CVBTIC - Set Position of Vertical Axis Label Tick Marks

LANGUAGE: FORTRAN 77

PURPOSE: Set position of vertical axis label tick marks.

USE: CALL CVBTIC(IV)

WHERE: IV - Position of vertical axis label in relation to vertical tick marks.
0 - Labels centered at tick marks. (default)
1 - Labels centered between tick marks.

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CVBTIC: INVALID VALUE FOR IV.
THE RANGE OF "NVBTIC" IS 0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.

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CVJUST - Set Position of Vertical Axis Label (Horizontal/Vertical)

LANGUAGE: FORTRAN 77

PURPOSE: Set position of vertical axis label (horizontal/vertical)

USE: CALL CVJUST(IV)

where: IV -
  Determines if vertical axis label is written horizontally or vertically.
  0 - vertical (default)
  1 - horizontal.
  type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CVJUST: INVALID VALUE FOR IV.
THE RANGE OF "NVJUST" IS 0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.
CVLAB - Describe the Text and Attributes of Vertical Axis Label

------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: To describe the text and associated attributes of the vertical axis label. This routine retrieves attributes (DI-3000 and CGL) when the subroutine is invoked. These label characteristics remain in force until SUBROUTINE CVAXIC is reinvoked.

USE: CALL CVLAB(CHARA,NLINE)

CHARA(NLINE) - Array of characters for axis.  
type: CHARACTER

NLINE - Number of lines in label.  
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:
   NVJUST - Determines if vertical axis label is written horizontally or vertically.
   0 - vertical (default).
   1 - horizontal.
   Type: INTEGER

RESTRICTIONS:
1) Maximum number of lines per axis label is limited to 5.
2) The number of characters per line is limited to 256.
3) All lines in axis label are single spaced.
4) Segment must be open.

ERRORS:
CVLAB: NLINE MUST BE AN INTEGER .GE. 0. 
ATTEMPTED TO PASS NLINE = nline 
THIS ROUTINE IS NOT EXECUTED.

Note: If NLINE is less than or equal to 0, then all vertical axis label attributes are reinitialized.
CVLABJ - Set Position of Axis Label Relative to Vertical Axis

Purpose: Set position of axis label relative to vertical axis.

Use: CALL CVLABJ(IV)

Where:  IV - Position of axis label in relation to vertical axis. (left or right)
        0 - Vertical axis label is left of axis. (default)
        1 - Vertical axis label is right of axis.

Type: INTEGER

Associated Attributes:
1) DI-3000 attributes: none.
2) CGL attributes: none.

Restrictions: none.

Notes: Attribute CVTICJ controls the vertical axis tick mark positioning (i.e., above, below, etc.). The attribute CVLABJ controls the positioning of the tick mark labels.

Errors:
CVLABJ: INVALID VALUE FOR IV.
THE RANGE OF "NVLABJ" IS 0,1 (INTEGER).
ILLEGAL VALUE IS iv
THE DEFAULT VALUE IS USED.

---

CALL CVLABJ(0)  CALL CVLABJ(1)
CVLOG - Draw a Vertical Log Axis

PURPOSE:
To draw a vertical log axis. This routine retrieves attributes (DI-3000 and CGL) when the subroutine is invoked. These characteristics remain in force until subroutine CVLOG is reinvoked. If a vertical axis label is desired, subroutine CVLAB must be invoked prior to this routine.

USE:
CALL CVLOG(XLEN,NTIC,NVLOGI)

XLEN - Length of axis (in world coordinates).
range: greater than 0.
type: REAL

NTIC - Number of tick marks (end tick marks inclusive; i.e., number of cycles-1 on XLEN).
If NTIC is negative, the major tick marks will be suppressed, but the numeric tick mark labels will be retained.
range: IABS(NTIC) must be greater than 1.
type: INTEGER

NVLOGI - Tick mark label type.
The following are the various types:
0 - No small tick marks.
1 - 1,2,3,4,5,6,7,8,9,1
2 - 1,2,4,6,8,1
3 - 1,3,5,7,9,1
4 - 1,5,1
5 - 1,1
6 - 2,3,4,5,6,7,8,9
7 - 2,4,6,8
8 - 3,5,7,9
9 - 5

If NVLOGI is positive then labels and small log tick marks are drawn.
if NVLOGI is negative then only small log tick marks are drawn.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: line attributes, text attributes.
2) CGL attributes:

NLABP - The size of the minor tick marks as a percentage of the size of the major tick marks. (Default=2/3)
Range : REAL values greater than 0.
Type: REAL

NVLABJ - Position of axis label in relation to vertical axis. (left or right)
0 - vertical axis label is left of axis. (default)
1 - vertical axis label is right of axis.
Type: INTEGER

NVLOGF - Determine if vertical log axis will have
major marks as 10 raised to a power.
-1 - no major tick mark labels
0 - major tick mark labels (default)
1 - major tick mark labels increase
Type: INTEGER

NVLOGS - The initial power for the vertical log
axis labels.
Range: any valid INTEGER (10 raised to this power).
(default 0)
Type: INTEGER

RESTRICTIONS: 1) XLEN must be positive.
2) An absolute minimum of two major tick marks.
3) Segment must be open.

ERRORS:
CVLOG: XLEN MUST BE .GT. 0.
ATTEMPTED TO PASS XLEN = xlen.
THIS ROUTINE IS NOT EXECUTED.

CVLOG: NTIC MUST BE AN INTEGER .GT. 1.
ATTEMPTED TO PASS NTIC = ntic.
THIS ROUTINE IS NOT EXECUTED.

CVLOG: INVALID VALUE FOR XLEN.
THE RANGE OF "XLEN" IS .GT. ZERO.
THE ROUTINE IS NOT EXECUTED.

CVLOG: INVALID VALUE FOR NVLOGI.
THE RANGE OF "NVLOGI" IS -9 TO 9.
THE ROUTINE IS NOT EXECUTED.
VERTICAL LOG AXIS

1) TO SET AXIS LABEL
   CALL CVLABS(CHARA, NLINE)
   CHARA  ARRAY OF CHARACTERS FOR THE AXIS
   NLINE  NUMBER OF LINES IN THE AXIS LABEL

2) TO DRAW AXIS AND LABEL
   CALL CVLOG(XLEN, NTIC, NLOGI)
   XLEN  LENGTH OF THE AXIS
   NTIC  NUMBER OF MAJOR TIC MARKS
   NLOGI TIC MARK LABEL TYPE
         0 - NO MINOR TIC MARKS
         1 - 1, 2, 3, 4, 5, 6, 7, 8, 9, 1
         2 - 1, 2, 4, 6, 8, 1
         3 - 1, 3, 5, 7, 9, 1
         4 - 1, 5, 1
         5 - 1, 1
         6 - 2, 3, 4, 5, 6, 7, 8, 9
         7 - 2, 4, 6, 8
         8 - 3, 5, 7, 9
         9 - 5
CVLOGF - Set Vertical Log Axis Raised to a Power of 10

-----------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set vertical log axis raised to a power of 10

USE: CALL CVLOGF(IV)

where: IV -
  Determine if vertical log axis will have major marks as 10 raised to a power.
  - 1 - Major tick mark labels decrease
  0 - No major tick mark labels (default)
  1 - Major tick mark labels increase
    type: INTEGER

ASSOCIATED ATTRIBUTES:
  1) DI-3000 attributes: none.
  2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
  CVLOGF: INVALID VALUE FOR IV.
  THE RANGE OF "NVLOGF" IS -1,0,1 (INTEGER).
  ILLEGAL VALUE IS iv.
  THE DEFAULT VALUE IS USED.
CVLOGS - Set the Initial Power of the Vertical Log Axis Label

-----------------------------------------------

LANGUAGE: FORTRAN 77
PURPOSE: Set the initial power of the vertical LOG axis label
USE: CALL CVLOGS(IV)

where: IV -
The initial power for the vertical log axis labels (i.e., 10 raised to this power).
range: Any valid integer
(default 0)
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CVLOGS: INVALID VALUE FOR IV.
THE RANGE OF "NVLOGS" IS ANY INTEGER.
ILLEGAL VALUE IS iv.
THE DEFAULT VALUE IS USED.
CVMTIC - Set the Number of Vertical Minor Tick Marks between Major

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set the number of vertical minor tick marks between major tick marks.

USE: CALL CVMTIC(IV)

where: IV -
Number of minor tick marks between major tick marks for the vertical axis. (default = 0)
range: Integer values greater or equal to 0.
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CVMTIC: INVALID VALUE FOR IV.
THE RANGE OF "NVMTIC" IS .GE. ZERO (INTEGER).
ILLEGAL VALUE IS iv.
THE DEFAULT VALUE IS USED.
CVPORT - Define a Viewport into the Virtual Coordinates by DI-3000

---------------------------------------------------------------
LANGUAGE: FORTRAN 77

PURPOSE: This subroutine uses "relative" inches to define virtual coordinates used by DI-3000 based upon the values contained in the COMMON BLOCK CFRSIZ. Routine CVSPAC defines the maximum relative inches (minimum is always zero). This is used to map the virtual coordinates to device coordinates.

USE: CALL CVPORT(XLCOR,YLCOR,XUCOR,YUCOR)

XLCOR - X value of the lower boundary of the viewport (inches). (default = 0 inches) range: 0 or greater. type: REAL

XUCOR - X value of the right boundary of the viewport (inches). (default = height) range: cannot exceed width in CVSPAC. type: REAL

YLCOR - Y value of the left boundary of the viewport (inches). (default = 0 inches) range: 0 or greater. type: REAL

YUCOR - Y value of the upper boundary of the viewport (inches). (default = width) range: cannot exceed height in CVSPAC. type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) Subroutine CVSPAC must be called prior to CVPORT.
2) Segment must NOT be open.

ERRORS:

CVPORT: XLCOR MUST BE .GE. 0.
ATTEMPTED TO PASS XLCOR= x1cor.
THIS ROUTINE IS NOT EXECUTED.

CVPORT: YLCOR MUST BE .GE. 0.
ATTEMPTED TO PASS YLCOR= y1cor.
THIS ROUTINE IS NOT EXECUTED.
CVPREC - Set Vertical Numeric Axis Tick Mark Label Precision

-----------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Set vertical numeric axis tick mark label precision.

USE: CALL CVPREC(IV)

Where: IV - Number of digits to the right of the decimal point in the tick mark labels of the vertical axis.

< 0 - Plot as an integer

= 0 - Decimal point only

> 0 - Plot as a real. IV represents the number of digits to the right of the decimal point.

default: -1
type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS:
CVPREC: INVALID VALUE FOR IV.
ATTEMPTED TO PASS IV= iv.
THE DEFAULT VALUE IS USED.
CVSPAC - Establish DI-3000 Boundaries for an Entire Frame

---------------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Establishes DI-3000 boundaries for an entire frame which correspond to the values used on the plot card. This routine should be called for plotting regions that are rectangular rather than square. If this routine is not invoked then the default frame will be an 11" by 11" square. This routine can only be called once, and must be called prior to opening the first segment.

This routine will establish a coordinate system based on the values in the X-direction of 0 to width, and values in the Y-direction of 0 to height. These coordinates are referred to as "inches" or "relative inches".

USE:

CALL CVSPAC(WIDTH,HEIGHT)

WIDTH - Width of the frame. Should be same as or proportional to the value used on the plot card used to call the device driver for the static plotters. (default = 11.)
range: greater than 0.
type: REAL

HEIGHT - Height of the frame. Should be same as or proportional to the value used on the plot card used to call the device driver for the static plotters. (default = 11.)
range: greater than 0.
type: REAL

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) WIDTH and HEIGHT must be greater than 0.
2) Must be called prior to opening the first segment.

ERRORS:

CVSPAC: HEIGHT MUST BE .GE. 0.
ATTEMPTED TO PASS HEIGHT= height.
THIS ROUTINE IS NOT EXECUTED.

CVSPAC: WIDTH MUST BE .GE. 0.
ATTEMPTED TO PASS WIDTH= width.
THIS ROUTINE IS NOT EXECUTED.
CVTICJ - Set the Tick Mark Position Relative to the Vertical Axis

LANGUAGE: FORTRAN 77

PURPOSE: Set the tick mark position relative to the vertical axis.

USE: CALL CVTICJ(IV)

WHERE: IV - is a value to indicate positioning of tick marks.
   0 - No tick marks on the axis.
   1 - Tick marks positioned right of the axis. (default)
   2 - Tick marks positioned to the left of axis.
   3 - Tick marks positioned on both sides of axis.

Type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

NOTES: Attribute CVTICJ controls the vertical axis tick mark positioning (i.e., above, below, etc.). The attribute CVLABJ controls the positioning of the tick mark labels.

ERRORS: CVTICJ: IV MUST BE A 0, 1, 2, 3.
ATTEMPTED TO PASS IV= iv.
THE DEFAULT VALUE IS USED.
CVTROT - Set Angle of Rotation for Vertical Axis Tick Mark Labels

LANGUAGE: FORTRAN 77

PURPOSE: Set angle of rotation for vertical axis tick mark labels.

USE: CALL CVTROT(IV)

WHERE: IV - Rotation angle.
       type: INTEGER.

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: 1) Angles are entered in as integer values.

ERRORS:
CVTROT: INVALID VALUE FOR IV.
ATTEMPTED TO PASS IV= iv.
THE DEFAULT VALUE IS USED.

CALL CVTROT(0)

CALL CVTROT(45)
CXCALC - Return Equivalent Delta X Value for a Given Delta Y

-----------------------------------------

LANGUAGE: FORTRAN 77

PURPOSE: Return the equivalent delta X value for a given delta Y (in world coordinates).

USE: 

\[ x\_value = \text{CXCALC}(YVAL) \]

where : YVAL - Y distance in world coordinates.

\[ \text{type: REAL} \]

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS: none.

ERRORS: none.
CYCALC - Return Equivalent Delta Y Value for a Given Delta X

Language: FORTRAN 77

Purpose: Return the equivalent delta Y value for a given delta X (in world coordinates).

Use:

\[ y\_value = \text{CYCALC}(XVAL) \]

where: XVAL - X distance in world coordinates
type: REAL

Associated Attributes:
1) DI-3000 attributes: none.
2) CGL attributes: none.

Restrictions: none.

Errors: none.
C1NMBR - Draw a Numeric Value Using Text Precision

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: This routine draws a numeric value using current text attributes. Low quality text precision is used.

USE: CALL C1NMBR(VALUE,NDEC)

where: VALUE - Value to be plotted real or integer.

        type:REAL

        NDEC - Integer specifying number of digits to the right of the decimal point.

        NDEC = 0 - Decimal point, number digits to the right.

        NDEC < 0 - No decimal point, min number of digits in integer value.

        type:INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS:
1) The number is restricted to a maximum of 12 significant digits.
2) Segment must be open.

ERRORS:
C1NMBR: NDEC MUST BE AN INTEGER.
ATTEMPTED TO PASS NDEC= ndec
THIS ROUTINE IS NOT EXECUTED.
C2NMBR - Draw a Numeric Value Using Character Precision

LANGUAGE: FORTRAN 77

PURPOSE: This routine draws a numeric value using current text attributes. Character precision is used.

USE: CALL C2NMBR(VALUE,NDEC)

where: VALUE - Value to be plotted real or integer.
      type: REAL

NDEC - Integer specifying number of digits to the right of the decimal point.

NDEC = 0 - Decimal point, number digits to the right.
NDEC < 0 - No decimal point, min number of digits in integer value.
      type: INTEGER

ASSOCIATED ATTRIBUTES:
1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS:
1) The number is restricted to a maximum of 12 significant digits.
2) Segment must be open.

ERRORS:
C2NMBR: NDEC MUST BE AN INTEGER.
      ATTEMPTED TO PASS NDEC= ndec
      THIS ROUTINE IS NOT EXECUTED.
C3NMBR - Draw a Numeric Value Using Stroke Precision

-----------------------------

LANGUAGE: FORTRAN 77

PURPOSE: This routine draws a numeric value using current text attributes. Stroke precision is used.

USE:

CALL C3NMBR(VALUE,NDEC)

where:

VALUE - Value to be plotted real or integer.
  type: REAL

NDEC - Integer specifying number of digits to the right of the decimal point.
  NDEC = 0 - Decimal point, number digits to the right.
  NDEC < 0 - No decimal point, min number of digits in integer value.
  type: INTEGER

ASSOCIATED ATTRIBUTES:

1) DI-3000 attributes: none.
2) CGL attributes: none.

RESTRICTIONS:
1) The number is restricted to a maximum of 12 significant digits.
2) Segment must be open.

ERRORS:

C3NMBR: NDEC MUST BE AN INTEGER.
ATTEMPTED TO PASS NDEC= NDEC.
THIS ROUTINE IS NOT EXECUTED.
APPENDIX B

CHARTS AND TEST CASES OF THE LOW-LEVEL Routines

In this appendix, the output generated by the sample programs will appear before the programs. All output will be labeled with the program's title and a short description of each figure.

BAR CHARTS:
- CDB1 - Additive and absolute bars - multiple data sets B - 3
- CDB2 - Absolute bars - multiple data sets B - 7
- CDB3 - Additive bars - multiple data sets B - 11
- CDB4 - Additive bars - multiple data sets, with a legend B - 15

COMPOSITE CHART:
- CDC1 - Composite chart (i.e., two charts on one page) B - 19

PIE CHARTS:
- CDP1 - Basic pie chart B - 23
- CDP2 - Exploded pie chart B - 27
- CDP3 - Basic pie chart with a legend B - 31

LINE CHARTS:
- CDR1 - Simple program to demonstrate symbols and polygon fill patterns B - 35
- CDR2 - Simple program to demonstrate symbols and polygon symbol sizes B - 37
- CDR3 - Simple program to demonstrate how to generate a set of axes B - 39
- CDR4 - Basic line chart B - 41
- CDR5 - Complete line chart B - 44
- CDR6 - Complete line chart with a legend B - 47
- CDR7 - Semi-logarithmic line chart (single data set) B - 50
- CDR8 - Log-log line chart (multiple data sets) B - 53
- CDR9 - Line chart with a grid (without a legend) B - 56
- CDR10 - Semi-log line chart with a grid (single data set) B - 59
- CDR11 - Complete low-level program (with a key) and a grid B - 62
- CDR12 - Line chart with a decreasing axis B - 66
- CDR13 - Line chart with multiple vertical scales on the same axis B - 69
- CDR14 - Line chart with multiple vertical scales (opposite axis) B - 73
- CDR15 - Simple, yet complete low-level program (with a key) B - 77
CDR16 - Line chart with disjoint axes (based on CDR4)

DEBUG PROGRAMS:
- CDD1 - Example showing a simple CGL error
- CDD2 - Example showing debugging capabilities
- CDD3 - Example showing an error and debugging redirection

COMBINATION OF HIGH AND LOW LEVEL PROGRAMS:
- CDLL1 - Program interfacing the low-level routines with the LEZ Routines
- CDLL2 - Program interfacing the low-level routines with the LEZ Routines
- CDLL3 - Program interfacing the low-level routines with the LEZ Routines (This program is CDLL1 modified to CALL CLGRID(log-log).
- CDLL4 - Program interfacing the low-level routines with the LEZ Routines (This program is CDLL3 modified to CALL CLGRID(semi-log).)
REVENUE C-RUS
DAILY AVERAGE - MONTHLY BY MACHINE

Figure CDB1. Additive and absolute bars - multiple data sets.
PROGRAM CDB1

C ADDITIVE AND ABSOLUTE BARS - MULTIPLE DATA SETS
C
C SET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YWMAX=11.0,CSIZE=.15)
PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)
C
C ALLOCATE STORAGE AND INITIALIZE VARIABLES
PARAMETER(NUMSET=3,NUMPTS=20)
INTEGER ID(NUMSET)
REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
CHARACTER MONTHS(0:37)*3
DATA ID/0,1,0/
DATA MONTHS/
  'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',
  'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
  'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',
  'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
  'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
/
DO 9 I=1,NUMSET
DO 9 J=1,NUMPTS
9  REVCRU(I,J)=RANF(*)*10.
C
C INITIALIZE DI3000 AND CGL
CALL JBEGIN
CALL CBEGIN
IDEV=0
CALL JDINIT(IDEV)
CALL JDEIVN(IDEV)
C
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL CVSPAC(XWMAX,YWMAX)
CALL JWINDO(0.,XWMAX,0.,YWMAX)
CALL JOPEN
C
C CALL JSIZE(CSIZE,CSIZE*1.25)
C
C HORIZONTAL AXIS
CALL JMOVE(XBEG,YBEG)
CALL CHTROT(45)
IMONTH1=8
CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMONTH1-1),1,NUMPTS+2)
C
C YEARS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+3.*CSIZE+(CSIZE*1.25)))
CALL JJJUST(2,3)
CALL JHSTRG('83')
IF(IMONTH1.NE.1) THEN
  DIST=REAL((12-IMONTH1)+2)
  CALL JRMOVE(DIST*XINCR,0.)
  CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')
C VERTICAL AXIS - ON LEFT OF PLOT
CALL JMOVE(XBEG,YBEG)
CALL CVLAB('CRU[BLCLS ([BLCLS]THOUSANDS)',1)
ICT=0
DO '01 I=2,NUMSET  
101 IF (ID(I).EQ.1) ICT=ICT+1  
VMAX=10.*REAL(NUMSET-ICT)  
CALL CVAXIS(0.,VMAX,5.,YLEN)
C VERTICAL AXIS - ON RIGHT OF PLOT
CALL JMOVE(XBEG+XLEN,YBEG)
CALL CVLAB('',0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIS(0.,VMAX,5.,YLEN)
C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+~.*CSIZE)  
CALL JMOVE(XBEG+XLEN/2.,YBEG+YLEN+YOFF)
CALL JJUST(2,1)
CALL JSIZE(1.5*CSIZE,1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')  
CALL JRMOVE(0.,-2.*CSIZE*1.25)  
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')  
CALL JMOVE(XBEG+XLEN,YBEG+YLEN)
CALL JJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')
C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG,YBEG,0.,XV1,YV1)  
CALL JCONWV(XBEG+XLEN,YBEG+YLEN,XV2,YV2)
CALL JCLOSE
C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1,XV2,YV1,YV2)  
CALL JWINDO(O.,REAL(NUMPTS+1),O.,VMAX)
CALL JOPEN  
C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN  
CALL JPINTR(1)
C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED  
C BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVIDED  
C BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3).  
C XWIDTH=((NUMPTS+1)/REAL(NUMPTS+2-1))*(2./3.)  
C NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH=2/3.  
XWIDTH=2./3.
XBARW=XWIDTH/REAL(NUMSET-ICT)  
DO 99 I=1,NUMPTS  
99 TOTAL(I)=0.0  
ICT=1  
DO 2 I=1,NUMSET  
2 CALL JPINDEX(I,48-I)  
XOFF=-XWIDTH/2. + REAL(ICT-1)*XBARW  
IF(ID(I).EQ.1)ICT=ICT+1
DO 2 J=1,NUMPTS
  CALL JRECT(REAL(J)+XOFF,TOTAL(J),REAL(J)+XOFF+XBARW,
            TOTAL(J)+REVCRU(I,J))
  IF (ID(I+1).EQ.1) THEN
    TOTAL(J)=TOTAL(J)+REVCRU(I,J)
  ELSE
    TOTAL(J)=0.
  END IF
2 CONTINUE
C-----------------------------------------------------------------------
C TERMINATE DI3000 AND CGL
  CALL JCLOSE
  CALL JFRAME
  CALL JDEVOP(IDEV)
  CALL JDEND(IDEV)
  CALL JEND
STOP
END
REVENUE CRUS
DAILY AVERAGE – MONTHLY BY MACHINE

Figure CDB2. Absolute bars - multiple data sets.
PROGRAM CDB2

CABSOLUTE BARS - MULTIPLE DATA SETS

CSET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YMAX=11.0,CSIZE=.15)
PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)

CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JMOVE(XBEG,YBEG)
CALL CHTROT(45)
IMONTH=8
CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMONTH-1),1,NUMPTS+2)

XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JHSTRG('83')
IF(IMONTH.NE.1)THEN
  DIST=REAL((12-IMONTH)+2)
  CALL JRMOVE(DIST*XINCR,0.)
  CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')
C VERTICAL AXIS - ON LEFT
CALL JMOVE(XBEG,YBEG)
CALL CVLAB('CRU([BLC]S ([BLC]THOUSANDS)',1)
CALL CVAXIC(YLEN, VALUES, 1, 3)

C VERTICAL AXIS - ON RIGHT
CALL JMOVE(XBEG+XLEN,YBEG)
CALL CVLAB(' ',0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVTICJ(2)
CALL CVAXIC(YLEN, VALUES, 1, 3)

C DRAW MISC. TEXT OVER PLOT
YOFF=(2.*CSIZE+5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2.,YBEG+YLEN+YOFF)
CALL JJUST(2,1)
CALL JSIZE(1.5*CSIZE,1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')
CALL JRMOVE(O.,-2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE,YBEG+YLEN)
CALL JJJUST(1,3)
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL JHSTRG('CY 175')

C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG,YBEG,O.,XV1,YV1)
CALL JCONWV(XBEG+XLEN,YBEG+YLEN,O.,XV2,YV2)
CALL JCLOSE

C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1,XV2,YV1,YV2)
CALL JWINDO(O.,REAL(NUMPTS+1),O.,10.)

C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL JPINTR(1)

C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED
C BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVIDED
C BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3).
C XWIDTH=((NUMPTS+1)/REAL NUMPTS+2-1)*(2/3).
C NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH=2/3.

XWIDTH= 2/3.
XBARW=XWIDTH/REAL(NUMSET)
DO 2 I=1,NUMSET
CALL JPINDEX(I,48-I)
XOFF=-XWIDTH/2. + REAL(I-1)*XBARW
DO 2 J=1,NUMPTS
2 CALL JRECT(REAL(J)+XOFF,0.,REAL(J)+XOFF+XBARW,REVCRU(I,J))

C TERMINATE DI3000 AND CGL
CALL JCLOSE
CALL JFRAME
CALL JDEVOF(1DEV)
CALL JDEND(1DEV)
CALL JEND
REVENUE CRUS
DAILY AVERAGE – MONTHLY BY MACHINE

Figure CDB3. Additive bars - multiple data sets.
PROGRAM CDB3
C-----------------------------------------------
C ADDITIVE BARS - MULTIPLE DATA SETS
C-----------------------------------------------
C SET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YWMAX=11.0,CSIZE=.15)
PARAMETER(XBEG=1.5,YBEG=1.5,XLEN=8.5,YLEN=5.0)
C-----------------------------------------------
C ALLOCATE STORAGE AND INITIALIZE VARIABLES
PARAMETER(NUMSET=3,NUMPTS=20)
REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
CHARACTER MONTHS(0:37)*3
DATA MONTHS/
  ', 'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
+  'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
+  'JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN', 'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
+  'JUL', 'AUG', 'SEP', 'OCT', 'NOV', 'DEC',
/ 
DO 9 I=1,NUMSET
DO 9 J=1,NUMPTS
9 REVCRU(I,J)=RANF()*.10.
C-----------------------------------------------
C INITIALIZE DI3000 AND CGL
CALL JBEGIN
CALL CBEGIN
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL CVSPAC(XWMAX,YWMAX)
CALL JWINDO(0.,XWMAX,0.,YWMAX)
CALL JOPEN
C-----------------------------------------------
CALL JSIZE(CSIZE,CSIZE*1.25)
C HORIZONTAL AXIS
CALL JMOVE(XBEG,YBEG)
CALL CHTROT(45)
IMonth1=8
CALL CHAXIC(XLEN,NUMPTS+2,MONTHS(IMonth1-1),1,NUMPTS+2)
C YEARS
XINCR=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJUST(2,3)
CALL JHSTRG('83')
IF(IMonth1.NE.1)THEN
  DIST=REAL((12-IMonth1)+2)
  CALL JRMOVE(DIST*XINCR,0.)
  CALL JHSTRG('84')
ENDIF
CALL JRMOVE(12.*XINCR,0.)
CALL JHSTRG('85')
C-----------------------------------------------
C VERTICAL AXIS - LABEL ON LEFT OF AXIS
CALL JMOVE(XBEG, YBEG)
CALL CVLAB('CRU[BLC]S ([BLC]THOUSANDS)', 1)
CALL CVAXIS(0., 30., 5., YLEN)
C VERTICAL AXIS - LABEL ON RIGHT OF AXIS
CALL JMOVE(XBEG+XLEN, YBEG)
CALL CVLAB('CRU[BLC]S ([BLC]THOUSANDS)', 1)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVAXIS(0., 30., 5., YLEN)

C DRAW MISC. TEXT OVER PLOT
YOFF = (2.*CSIZE + 5.*CSIZE)
CALL JMOVE(XBEG+XLEN/2., YBEG+YLEN+YOFF)
CALL JJUST(2, 1)
CALL JSIZE(1.5*CSIZE, 1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRUS')
CALL JRMOVE(0., -2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG+CSIZE, YBEG+YLEN)
CALL JJJUST(1, 3)
CALL JSIZE(CSIZE, CSIZE*1.25)
CALL JHSTRG('CY 175')

C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG+XLEN, YBEG+YLEN, 0., XV2, W2)
CALL JCLOSE
CALL JCONWV(XBEG, YBEG, 0., XV1, YVI)

C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(XV1, XV2, YV1, YV2)
CALL JWINDO(0., REAL(NUMPTS+1), 0., 30.)

C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL JPINTR(1)
C THE WIDTH OF BARS AT A SINGLE TICK MARK IS DETERMINED
C BY THE LENGTH OF THE AXIS (IN DATA COORDINATES) DIVIDED
C BY THE NUMBER OF INTERVALS TIMES A FRACTION (2/3).
C XWIDTH = ((NUMPTS+1)/REAL(NUMPTS+2-1))*(2./3.)
C NOTE IF THE WORLD IS FROM 0 TO A VALUE, THEN XWIDTH = 2/3.
  XWIDTH =
  2./3.
  XHALF = XWIDTH/2.
DO 99 I = 1, NUMPTS
  99 TOTAL(I) = 0.0
DO 2 I = 1, NUMSET
    CALL JFIDEX(I, 48-I)
    DO 2 J = 1, NUMPTS
        CALL JRECT(REAL(J)-XHALF, TOTAL(J),
                  REAL(J)+XHALF, TOTAL(J)+REVCRU(I, J))
    2 TOTAL(J) = TOTAL(J)+REVCRU(I, J)

C TERMINATE DI3000 AND CGL
CALL JCLOSE
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
REVENUE CRUS
DAILY AVERAGE – MONTHLY BY MACHINE

Figure CDB4. Additive bars - multiple data sets, with a legend.
PROGRAM CDB4

C-------------------------------
C ADDITIVE BARS - MULTIPLE DATA SETS, WITH A LEGEND.
C-------------------------------
C SET UP PLOT CONSTANTS
PARAMETER(XWMAX=11.0,YWMAX=11.0)
PARAMETER(XBEG=1.5,YBEG=1.5)
PARAMETER(XLEN=8.5,YLEN=5.0)
PARAMETER(CSIZE=.15)

C ALLOCATE STORAGE AND INITIALIZE VARIABLES
PARAMETER(NUMSET=3,NUMPTS=20)
REAL REVCRU(NUMSET,NUMPTS),TOTAL(NUMPTS)
PARAMETER(NLINES=4,NCOLS=1,NTLINES=1)
CHARACTER KEYCHR(NCOLS,NLINES)*9,KEYLAB(NLINES)*9
INTEGER ISTORE(15,NLINES),JCOL(1)
REAL BPOS(4)
CHARACTER MONTHS(12)*3,VALUES(3)*2
DATA MONTHS/'JAN','FEB','MAR','APR','MAY','JUN',
   + 'JUL','AUG','SEP','OCT','NOV','DEC'/
DATA VALUES/' 0',' 5','10'/
DATA KEYLAB(1)'/-AVAIL+PM',/KEYLAB(2)'/-AVAIL /
DATA KEYLAB(3)'/-USE ',/KEYLAB(4)'/-PROD '
DATA JCOL/1/
DO 9 I=1,NUMSET
   DO 9 J=1,NUMPTS
9 REVCRU(I,J)=RANF()*3.

C-------------------------------
C INITIALIZE D13000 AND CGL
CALL JBEGN
CALL CBEGIN
CALL CDEBUG(1)
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C-------------------------------
C SET WINDOW AND VIEWPORT FOR PAGE AREA
CALL JVSPAC(-1.,1.,-1.,1.)
CALL JWINDO(0.,XWMAX,0.,YWMAX)
CALL JOPEN

C-------------------------------
CALL JSIZE(CSIZE,CSIZE*1.25)

C HORIZONTAL AXIS
CALL JMOVE(XBEG,YBEG)
CALL CHLABJ(1)
CALL CHAXIC(XLEN,2,' ',0,NUMPTS)

C MONTHS
XINC=XLEN/REAL(NUMPTS+2-1)
CALL JMOVE(XBEG,YBEG-2.*CSIZE*1.25)
CALL JJUST(3,2)
CALL CSETBP(90.)
IMONTH1=8
DO 1 KI=1,NUMPTS
   IMONTH=KI+IMONTH1-1

B - 16
IMONTH = MOD(IMONTH, 12)
IF (IMONTH .EQ. 0) IMONTH = 12
CALL JMOVE(XINCR, 0.)
CALL JHSTRG(MONTHS(IMONTH))
CALL CSETBP(0.)
CALL JSETDB(0)

C YEARS
CALL JMOVE(XBEG, YBEG - ((CSIZE*1.25)+(3.*CSIZE)+(CSIZE*1.25)))
CALL JJJUST(2, 3)
CALL CSETBP(0.)
CALL JHSTRG('83')
IF (IMONTH .NE. 1) THEN
  DIST = REAL((12 - IMONTH1) + 2)
  CALL JMOVE(DIST * XINCR, 0.)
  CALL JHSTRG('84')
ENDIF
CALL JMOVE(12.*XINCR, 0.)
CALL JHSTRG('85')

C VERTICAL AXIS
CALL JMOVE(XBEG, YBEG)
CALL CVLAB('CRU\[BLC\]S (\[BLC\]THOUSANDS)', 1)
CALL CVAXIC(YLEN, 3, VALUES, 1, 3)
CALL JMOVE(XBEG + XLEN, YBEG)
CALL CVLAB('', 0)
CALL CVJUST(0)
CALL CVLABJ(1)
CALL CVTICJ(2)
CALL CVAXIC(YLEN, 3, VALUES, 1, 3)
CALL JMOVE(XBEG + XLEN, YBEG)
CALL CVJUST(0)
CALL JSIZE(1.5*CSIZE, 1.5*CSIZE*1.25)
CALL JHSTRG('REVENUE CRU\[BLC\]S')
CALL JMOVE(0., -2.*CSIZE*1.25)
CALL JHSTRG('DAILY AVERAGE - MONTHLY BY MACHINE')
CALL JMOVE(XBEG + CSIZE, YBEG + YLEN)
CALL JJJUST(1, 3)
CALL JSIZE(CSIZE, CSIZE*1.25)
CALL JHSTRG('CY 175')

C SAVE OFF VIRTUAL COORDINATES OF DATA AREA (FROM AXES)
CALL JCONWV(XBEG, YBEG, 0., XI, YI)
CALL JCONWV(XBEG + XLEN, YBEG + YLEN, 0., X2, Y2)
CALL JCLOSE

C SET WINDOW AND VIEWPORT FOR DATA AREA
CALL JVPORT(X1, X2, Y1, Y2)
CALL JWINDO(0., REAL(NUMPTS+1), 0., 10.)
C OPEN SEGMENT, AND PLOT BARS
CALL JOPEN
CALL CKEYIN(ISTORE, KEYCHR, NNLINES, NCOLS, NTLINES)
CALL JPINTR(1)
XWIDTH=2./3.
XHALF=XWIDTH/2.
DO 99 I=1,NUMPTS
99 TOTAL(I)=0.0
CALL JSIZE(CSIZE,CSIZE*1.25)
DO 2 I=1,NUMSET
   CALL JINDEX(I,47-(I-1))
   CALL CKEYLB(ISTORE,KEYCHR,-4,KEYLAB(I))
   DO 2 J=1,NUMPTS
      CALL JRECT(REAL(J)-XHALF,TOTAL(J),
         REAL(J)+XHALF,TOTAL(J)+REVCRU(I,J))
   2 TOTAL(J)=TOTAL(J)+REVCRU(I,J)
CALL JCLOSE
C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE AREA
   CALL JSETDB(0)
   CALL JVPORT(-1.,1.,-0.773,.773)
   CALL JWINDOW(0.,10.,0.,7.73)
   BPOS(1)=YBEG+YLEN
   BPOS(2)=YBEG+YLEN
   CALL JOPEN
   CALL JSIZE(CSIZE,CSIZE*1.25)
   CALL CKEYPL(ISTORE,KEYCHR,'I','BPOS,3,JCOL,0)
   CALL JCLOSE
C-----------------------------------------------------------------------
C TERMINATE DI3000 AND CGL
   CALL JPFAUSE(IDEV)
   CALL JFRAME
   CALL JDEVP(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
STOP
END
Figure CDC1. Composite chart (i.e., two charts on one page).
PROGRAM CDC1

C---------------------------------------------------------------------
C COMPOSITE CHART (IE, TWO CHARTS ON ONE PAGE)
C---------------------------------------------------------------------

C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=10, MAXSET=4)
REAL X(MAXPTS, MAXSET), Y(MAXPTS, MAXSET)
DATA (X(KI,1), KI=1, 10)
+ /0., 1., 2., 3., 4., 5., 6., 7., 8., 9/
DATA (X(KI,2), KI=1, 10)
+ /1., 15., 3., 35., 45., 55., 65., 75., 85., 1.2/
DATA (X(KI,3), KI=1, 10)
+ /0., 1., 2., 3., 4., 5., 6., 7., 8., 9/
DATA (X(KI,4), KI=1, 10)
+ /1., 2., 4., 6., 7., 8., 9., 1., 1.1, 1.2/
DATA (Y(KI,1), KI=1, 10)
+ /0., 2., 4., 7., 10., 12., 15., 18., 21., 24./
DATA (Y(KI,2), KI=1, 10)
+ /1., 3., 5., 8., 11., 13., 16.5., 20., 22., 23./
DATA (Y(KI,3), KI=1, 10)
+ /0., .005, .01, .015, .02, .025, .029, .03, .035, .04/
DATA (Y(KI,4), KI=1, 10)
+ /-.005, -.01, -.015, -.02, -.025, -.03, -.035, -.05, -.065, -.08/
C---------------------------------------------------------------------

C WRITE TO THE DEVICE IDev
IDev=0
CALL CBEGIN
CALL JBEGIN
CALL JDevon(IDev)
CALL JEINIT(IDev)
C---------------------------------------------------------------------

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
XS=.2
YS=6.0
CALL CVSPAC(10., 10.)
CALL JTarget(2, VX3, VX4, VY3, VY4)
CALL JWindo(0., 0., 0., 0.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(XS, XS*1.25)
C POSITION TEXT, AND SET TTEXT JUSTIFICATION (CENTER, CENTER)
CALL JMove(5.0, 10.0)
CALL JJust(2, 3)
C OUTPUT THE STRING
CALL JHstrg('A Title')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(XS, XS*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
Xorg=2.
Yorg=2.0
CALL JMove(Xorg, Yorg)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHlab('C[BSUB]L', 1)
CALL CHTICJ(1)
B - 20
C XLEN-REPRESENTS THE X-AXIS LENGTH
XLEN=6.0
CALL CHPREC(1)
CALL CHAXIS(-.2,1.2,.2,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('[FONT=9][BLC]A[FONT=3],DEG',1)
CALL CVPREC(3)
CALL CVTICJ(1)
C YLEN-REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVPREC(-1)
CALL CVJUST(1)
CALL CVAXIS(-4.,24.,0.,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C---------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(-.2,1.2,-4.,24.)
C -.2,1.2 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C -4.,24. - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
C PLOT FIRST DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,1),MAXPTS)
C SET SYMBOL NUMBER TO 902, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(1,2),MAXPTS)
CALL JCLOSE
C---------------------------------------------------------------------
C WORK ON SECOND GRAPH
CALL JWINDO(0.,10.,0.,10.)
CALL JVPORT(VX3,VX4,VY3,VY4)
CALL JOPEN
CALL JSIZE(XS,XS*1.25)
CALL JMOVE(XORG,YS)
C YLEN-REPRESENTS THE Y-AXIS LENGTH
CALL CVLAB('C[BSUB][BLC]M',1)
CALL CVPREC(2)
CALL CVAXIS(-.08,.04,.04,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YS,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YS+3.5,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C---------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(-.2,.12, -.08,.04)
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN

C PLOT THIRD DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,3),MAXPTS)

C PLOT FOURTH SET OF DATA POINTS
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(1,4),MAXPTS)
CALL JCLOSE

C--------------------------------------------
C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Figure CDP1. Basic pie chart.
PROGRAM CDP1
C-----------------------------------------------
C BASIC PIE CHART
C-----------------------------------------------
C INITIALIZE DATA
REAL OFFSET,RAD1,RAD2,RAD3,RAD4
REAL XV(4),YV(4),ZV(4),REGION(8)
CHARACTER*14 LABEL(8)
CHARACTER*4 YEAR
C-----------------------------------------------
C INITIALIZE DATA
DATA OFFSET,RAD1,RAD2,RAD3,RAD4 ,/.25,2.,2.35,2.85,2.95/
DATA REGION(1),REGION(2),REGION(3),REGION(4)/21.,6.,24.,28./
DATA REGION(5),REGION(6),REGION(7),REGION(8)/4.,13.,18.,32./
C
DATA YEAR /'1988'/
C
DATA LABEL(1)://'N[BLK]ICKEL'/
DATA LABEL(2)://'M[BLK]AGNESIUM'/
DATA LABEL(3)://'A[BLK]LUMINUM'/
DATA LABEL(4)://'G[BLK]OLD'/
DATA LABEL(5)://'I[BLK]RON'/
DATA LABEL(6)://'S[BLK]ILVER'/
DATA LABEL(7)://'C[BLK]OPPER'/
DATA LABEL(8)://'L[BLK]EAD'/
C-----------------------------------------------
C INITIALIZE DI-3000
CALL JBEGIN
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
CALL JVSPAC(-1.,1.,-1.,1.)
CALL JWINDO(0.,10.,0.,10.)
C-----------------------------------------------
C FILL POLYGONS BY DEFAULT.
CALL JDPINT(1)
C-----------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
CALL JOPEN
CALL JIWIND(XV,YV,ZV)
CALL JPIDEX(4,0)
CALL JPOLGN(XV,YV,4)
CALL JSIZE(.4,.4)
CALL JFONT(3)
CALL JJJUST(2,2)
CALL JMOVE(5.,9.2)
CALL JHSXTN(YEAR,DX,DY)
CALL JPIDEX(6,0)
CALL JRRECT(DX,DY)
CALL JJUST(1,1)
CALL JHSTRG('PREPARED BY CSC')

C----------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
CALL JOPEN
START=0.
DO 5000 I=1,8
AO=START
A1=REGION(I)/TOTAL*360.+START
START=A1
CALL JPIDEX(I,I+30)
CALL JSECTR(.5,.5,.0,.RA1,0,1,A0,1)
C
AMID=(A1-A0)/2.+A0
ARAD=AMID*DTORAD
C1=COS(ARAD)
S1=SIN(ARAD)
CALL JMOVE(.5.+RAD2*C1,.5.+RAD2*S1)
CALL JDRAW(.5.+RAD3*C1,.5.+RAD3*S1)
C
IF (AMID.LT.45. .OR. AMID .GE. 315.) CALL JJUST(1,2)
IF (AMID .GT. 45. .AND. AMID .LT. 135.) CALL JJUST(2,1)
IF (AMID .GE. 135. .AND. AMID .LT. 225.) CALL JJUST(3,2)
IF (AMID .GE. 225. .AND. AMID .LT. 315.) CALL JJUST(2,3)
C
5000 CALL JHSTRG('LABEL(I)')

C----------------------------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
C
C PAUSE TO VIEW CHART.
CALL JPAUSE(1,2)
C
C TERMINATE DI-3000; ALL DEVICES ARE Deselected AND TERMINATED.
CALL JEND
Figure CDP2. Exploded pie chart.
PROGRAM CDP2
C-----------------------------------------------------------------------------------------------------------------
C EXPLODED PIE CHART
C-----------------------------------------------------------------------------------------------------------------
C INITIALIZE DATA
REAL OFFSET,RAD1,RAD2,RAD3,RAD4
REAL XV(4),YV(4),ZV(4),REGION(8)
CHARACTER*14 LABEL(8)
CHARACTER*4 YEAR
C
DATA OFFSET,RAD1,RAD2,RAD3,RAD4 / .25,2.,2.35,2.85,2.95/
DATA REGION(1),REGION(2),REGION(3),REGION(4)/21.,6.,24.,28./
DATA REGION(5),REGION(6),REGION(7),REGION(8)/4.,13.,18.,32./
C
DATA YEAR / '1988' /
C
DATA LABEL(1) / 'N[BLCIICKEL' /
DATA LABEL(2) / 'M[BLCIAGNESIUM' /
DATA LABEL(3) / 'A[BLC]LUMINUM' /
DATA LABEL(4) / 'G[BLC]OLD' /
DATA LABEL(5) / 'I[BLC]RON' /
DATA LABEL(6) / 'S[BLC]ILVER' /
DATA LABEL(7) / 'C[BLC]OPPER' /
DATA LABEL(8) / 'L[BLC]EAD' /
C-----------------------------------------------------------------------------------------------------------------
C INITIALIZE DI-3000
CALL CBEGIN
CALL JBEGIN
C-----------------------------------------------------------------------------------------------------------------
C WRITE TO A DEVICE IDEV
IDEV=0
CALL JINIT(IDEV)
CALL JDEVon(IDEV)
C-----------------------------------------------------------------------------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
CALL JVSPAC(-1.,1.,-1.,1.)
CALL JWINDO(0.,10.,0.,10.)
C-----------------------------------------------------------------------------------------------------------------
C FILL POLYGONS BY DEFAULT
CALL JDPINT(1)
C-----------------------------------------------------------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
CALL JOPEN
CALL JIWIND(XV,YV,ZV)
CALL JPINDEX(4,0)
CALL JPOLGN(XV,YV,4)
CALL JSIZE(.5,.5)
CALL JFONT(3)
CALL JJUST(2,2)
CALL JMOVE(5.,9.2)
CALL JHSTRG('MATER1ALS')
CALL JMOVE(.1,.8)
CALL JHSXTN(YEAR,DX,DY)
CALL JPINDEX(6,0)
CALL JRRECT(DX,DY)  
CALL JJJUST(1,1)  
CALL JHSTRG(YEAR)  
CALL JMOVE(9.9,.8)  
CALL JSIZE(.25,.25)  
CALL JFONT(1)  
CALL JJJUST(3,1)  
CALL JHSTRG('PREPARED BY CSC')
C----------------------------------------------------------------
C OPEN A TEMPORARY SEGMENT
CALL JOPEN
START=5.
CALL JSIZE(.15,.15)  
CALL JFONT(1)
DO 5000 I=1,8
AO=START
A1=REGION(I)/TOTAL*360.+START
START=A1
AMID=(A1-A0)/2.+A0
ARAD=AMID*DTORAD
C1=COS(ARAD)
S1=SIN(ARAD)
CALL JPINDEX(I,I+30)
C X0=OFFSET*C1+5.
Y0=OFFSET*S1+5.
C CALL JSECTR(X0,Y0,0.,RAD1,0,A0,A1)
C CALL JMOVE(RAD2*C1+5.,RAD2*S1+5.)
C IF (AMID.LT.45. .OR. AMID .GE. 315.) CALL JJJUST(1,2)
IF (AMID .GT. 45. .AND. AMID .LT. 135.) CALL JJJUST(2,1)
IF (AMID .GE. 135. .AND. AMID .LT. 225.) CALL JJJUST(3,2)
IF (AMID .GE. 225. .AND. AMID .LT. 315.) CALL JJJUST(2,3)
C CALL JMOVE(RAD4*C1+5.,RAD4*S1+5.)
5000 CALL JHSTRG(LABEL(I))
C----------------------------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
C----------------------------------------------------------------
C PAUSE TO VIEW CHART.
CALL JPAUSE(IDEV)

C-----------------------------------------------

C TERMINATE DI-3000; ALL DEVICES ARE DESELECTED AND TERMINATED.
CALL JEND
STOP
END
Figure CDP3. Basic pie chart with a legend.
PROGRAM CDP3

C---------------------------------------------
C BASIC PIE CHART WITH A LEGEND
C---------------------------------------------

C INITIALIZE DATA
REAL OFFSET,RAD1,RAD2,RAD3,RAD4
REAL BPOS(4)
REAL XV(4),YV(4),ZV(4),REGION(8)
CHARACTER*14 LABEL(8)
CHARACTER*4 YEAR

C
CHARACTER KEYCHR(1,8)*15
INTEGER ISTORE (15,8)
DATA OFFSET,RAD1,RAD2,RAD3,RAD4 / .5,4.,4.7,5.7,5.9/
DATA REGION(1),REGION(2),REGION(3),REGION(4)/2.1,6.2,4.2.8/
DATA REGION(5),REGION(6),REGION(7),REGION(8)/.4,1.3,1.8,3.2/

C
DATA YEAR / '1988' /

C
DATA LABEL(1) / 'N[BLK]ICKEL' /
DATA LABEL(2) / 'M[BLK]AGNESIUM' /
DATA LABEL(3) / 'A[BLK]LUMINUM' /
DATA LABEL(4) / 'I[BLK]RON' /
DATA LABEL(5) / 'T[BLK]IN' /
DATA LABEL(6) / 'C[BLK]OPPER' /
DATA LABEL(7) / 'G[BLK]OLD' /
DATA LABEL(8) / 'Z[BLK]INC' /

C---------------------------------------------
C INITIALIZE DI-3000
CALL JBEG
CALL CBEGIN

C---------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C---------------------------------------------
C DEFINE THE VIEWSPACE AND WINDOW OF SAME ASPECT RATIO
CALL JVSPAC(-1.,1.,-1.,1.)
CALL JWINDO(0.,10.,0.,10.)

C---------------------------------------------
C FILL POLYGONS BY DEFAULT.
CALL JDPINT(1)

C---------------------------------------------
C OPEN A TEMPORARY SEGMENT FOR BORDERS.
CALL JOPEN
CALL JIWIND(XV,YV,ZV)
CALL JPIDEX(4,0)
CALL JPOLGN(XV,YV,4)
CALL JSIZE(.6,.6)
CALL JFONT(5)
CALL JJUST(2,2)
CALL JMOVE(5.,9.1)
CALL JHSTRG('CGL PIE GRAPH')
CALL JMOVE(.1,.5)
CALL JHSXTN(YEAR,DX,DY)
CALL JPIDERX(6,0)
CALL JRECT(DX,DY)
CALL JJUST(1,1)
CALL JHSTRG(YEAR)
CALL JMOVE(9.9,.5)
CALL JSIZE(.25,.25)
CALL JFONT(1)
CALL JJUST(3,1)
CALL JHSTRG('PREPARED BY CSC')

C-----------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
C-----------------------------------------------

C DESIGN THE PIE TO BE 50% SMALLER
RAD1=RAD1-(RAD1*.50)
RAD2=RAD2-(RAD2*.50)
RAD3=RAD3-(RAD3*.50)
RAD4=RAD4-(RAD4*.50)

C-----------------------------------------------
C COMPUTE THE FACTOR FOR CONVERTING DEGREES TO RADIANS.
DTORAD=ATAN(1.0)/45.
C-----------------------------------------------

C TOTAL THE REGIONAL DATA.
TOTAL=0.0
DO 3000 I=1,8
     3000 TOTAL=TOTAL+REGION(I)
C-----------------------------------------------

C OPEN A TEMPORARY SEGMENT FOR THE PIE CHART SECTORS AND LABELS.
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,8,1,1)
START=5.
CALL JSIZE(.3,.3)
CALL JFONT(1)
DO 5000 I=1,8
     A0=START
     A1=REGION(I)/TOTAL*360.+START
     CALL JPIDERX(I,I+30)
     CALL JSECTR(3.,5.,3.,RAD1,0,A0,A1)
C
     START=A1
     AMID=(A1-A0)/2.+A0
     ARAD=AMID*DTORAD
     C1=COS(ARAD)
     S1=SIN(ARAD)
     CALL CKEYLB(ISTORE,KEYCHR,-4,LABEL(I))
     BPOS(1)=9.5
     BPOS(2)=8.
     CALL CKEYPL(ISTORE,KEYCHR,' ',' ',BPOS,5,1,0)
C-----------------------------------------------
C CLOSE THE TEMPORARY SEGMENT.
CALL JCLOSE
C-----------------------------------------------
C PAUSE FOR OPERATOR ACTION.
   CALL JPAUSE<IDEV>
C-----------------------------------------------
C TERMINATE DI-3000; ALL DEVICES ARE DESELECTED AND TERMINATED.
   CALL JEND
   STOP
   END
Figure CDR1. Simple program to demonstrate symbols and polygon fill patterns.
PROGRAM CDB1
C--------------------------------------------------------------------------
C SIMPLE PROGRAM TO DEMONSTRATE SYMBOLS AND POLYGON FILL PATTERNS
C--------------------------------------------------------------------------
C INITIALIZE DI-3000
   CALL JBEGIN
C--------------------------------------------------------------------------
C THIS MUST BE THE FIRST CGL CALL TO INITIALIZE THE CGL
   CALL CBEGIN
C--------------------------------------------------------------------------
C WRITE TO THE IDEV DEVICE
   IDEV=0
   CALL JDINIT(IDEV)
   CALL JDEVON(IDEV)
C--------------------------------------------------------------------------
C SET UP THE VIEWING WINDOW
   CALL JWINDO(0.,11.,0.,11.)
C--------------------------------------------------------------------------
C OPEN CURRENT SEGMENT
   CALL JOPEN
C--------------------------------------------------------------------------
C SET THE CURRENT POLYGON AND SET THE CURRENT SIZE OF SYMBOLS
   CALL JPINTR(1)
   CALL CSYMNZ(.5)
C--------------------------------------------------------------------------
C A LOOP WHICH PRINTS NASA POINT SYMBOLS WITHIN CURRENT SEGMENT
   DO 1 I=1,10
      CALL JPINDEX(1,48-I)
      CALL CSYMNO(I)
   1 CALL CFNTPT(REAL(I),1.)
C--------------------------------------------------------------------------
C ENDS ALL GRAPGICS AND CLOSES CURRENT SEGMENT
   CALL JPAUSE(IDEV)
   CALL JCLOSE
   CALL JFRAME
   CALL JDEVOP(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
   STOP
END
Figure CDR2. Simple program to demonstrate symbols and polygon symbol sizes.
PROGRAM CDR2

C--------------------------------------------------
C SIMPLE PROGRAM TO DEMONSTRATE SYMBOLS AND POLYGON SYMBOL SIZES
C--------------------------------------------------
C INITIALIZE DI-3000 AND SET UP CURRENT IDEV DEVICE
   IDEV=0
   CALL JBEGIN
   CALL JDINIT(IDEV)
   CALL JDEVON(IDEV)
C--------------------------------------------------
C INITIALIZE CGL ATTRIBUTES TO DEFAULTS AND SET CURRENT WINDOW
   CALL CBEGIN
   CALL JWINDO(0.,11.,0.,11.)
C--------------------------------------------------
C OPEN CURRENT SEGMENT
   CALL JOPEN
C--------------------------------------------------
C OUTPUT SYMBOL (WITH DEFAULT SYMBOL NUMBER AND SYMBOL SIZE)
   CALL CPNTPT(1.,1.)
C--------------------------------------------------
C CHANGE SYMBOL NUMBER TO 3, SYMBOL SIZE TO .5, AND DISPLAY
   CALL CSYMNO(3)
   CALL CSYMSZ(.5)
   CALL CPNTPT(2.,1.)
C--------------------------------------------------
C RESET CGL ATTRIBUTES BACK TO DEFAULTS
   CALL CBEGIN
   CALL CPNTPT(3.,1.)
C--------------------------------------------------
C END ALL GRAPhICS AND CLOSE CURRENT SEGMENT
   CALL JPAUSE(IDEV)
   CALL JCLOSE
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JEND(IDEV)
   CALL JEND
   STOP
END
Figure CDR3. Simple program to demonstrate how to generate a set of axes.
PROGRAM CDR3
C--------------------------------------------------
C SIMPLE PROGRAM TO DEMONSTRATE HOW TO GENERATE A SET OF AXES
C--------------------------------------------------
C INITIALIZE CGL AND DI-3000
CALL CBEGIN
CALL JBEGIN
C--------------------------------------------------
C WRITE TO THE IDEV DEVICE
IDEV=0
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C--------------------------------------------------
C SET UP WINDOW AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDOW(0.,9.,0.,9.)
C--------------------------------------------------
C OPEN CURRENT SEGMENT
CALL JOPEN
C--------------------------------------------------
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.2,.2*.125)
C--------------------------------------------------
C POSITION STRING AND SET JUSTIFICATION (CENTER, CENTER)
CALL JMOVE(4.5,8.75)
CALL JJUST(2,2)
C--------------------------------------------------
C OUTPUT THE STRING
CALL JHSTRG('A T[BLC]ITLE')
C--------------------------------------------------
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*.125)
C--------------------------------------------------
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(2,2.)
C--------------------------------------------------
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('H[BLC]ORIZONTAL A[BLC]XIS',1)
CALL CHAXIS(5.,10.,1.,4.)
C--------------------------------------------------
C DESCRIBE THE VERTICAL AXIS
CALL CVPLOT(3)
CALL CVAXIS(0.,0.,.001,3.5)
C--------------------------------------------------
C END ALL GRAPHICS AND CLOSE CURRENT SEGMENT
CALL JPAUSE(IDEV)
CALL JCLOSE
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JEND(IDEV)
CALL JEND
STOP
END
A Title

Figure CDR4. Basic line chart.
PROGRAM CDR4

C BASIC LINE CHART

C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=1)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA Y(Y(KI,1),KI=1,10)
+ /0.001,0.003,0.0075,0.004,0.006,0.008,0.009,0.005,0.003,0.002/

C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN

C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(-2,0.2*1.e25)

C POSITION STRING, AND SET JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)

C OUTPUT THE STRING
CALL JHSTRG('A T[BLC]ITLE')

C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*1.25)

C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(2.,2.)

C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('H[BLC]ORIZON[AL [BUC]AXIS',1)
CALL CHAXIS(5.,10.,1.,4.)

C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('V[BLC]ERTICAL [BUC]AXIS',1)
CALL CVAXIS(.0,.01,.001,3.5)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(2.,2.,.0,VX1, Vy1)
CALL JCONWV(2.+4.,2.+3.5,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,0.01)
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN

C PLOT FIRST DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,1),MAXPTS)
CALL JCLOSE

C---------------------------------
C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JEND(IDEV)
CALL JEND
STOP
END
Figure CDR5. Complete line chart.
PROGRAM CDR5

C COMPLETE LINE CHART

C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA (Y(KI,1),KI=1,10)
+ /0.001,.003,.0075,.004,.006,.008,.009,.005,.003,.002/
DATA (Y(KI,2),KI=1,10)
+ /0.0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/

C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.2,.2*.125)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*.1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
  XORG=2.
  YORG=2.
  CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXES',1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
  XLEN=4.0
  CALL CHAXIS(5.,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXES',1)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
  YLEN=3.5
  CALL CVAXIS(.0,.01,.001,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWW(XORG,YORG,0.,VX1,VY1)
CALL JCONWW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

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C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
   CALL JWINO(5.,10.,.0,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
   CALL JVPORT(VX1,VX2,VY1,VY2)
   CALL JOPEN
C PLOT FIRST DATA CURVE
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,Y(1,1),MAXPTS)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
   CALL CSYMNO(2)
   CALL CLNPAT(2)
   CALL CLNPLT(X,Y(1,2),MAXPTS)
   CALL JCLOSE
C---------------------------------------------------------------
C TERMINATE GRAPHICS
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
   STOP
   END
Figure CDR6. Complete line chart with a legend.
PROGRAM CDR6

C-------------------------------'--------------------------------
C COMPLETE LINE CHART WITH A LEGEND
C-------------------------------'--------------------------------

C ALLOCATE AND INITIALIZE DATA

PARAMETER (MAXPTS=10, MAXSET=2)
REAL X(MAXPTS), Y(MAXPTS, MAXSET), BPOS(4)
PARAMETER (NLINS=2, NCOLS=1, NTLINS=1)
CHARACTER KEYCHR(NCOLS, NLINS)*20
INTEGER ISTORE(15, NLINS), JCOL(NCOLS)
DATA X/5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0/
DATA JCOL/1/
DATA (Y(KI,1), KI=1, 10)
+ / .001, .003, .0075, .004, .006, .008, .009, .005, .003, .002/
DATA (Y(KI,2), KI=1, 10)
+ / .0015, .004, .007, .0045, .0065, .0078, .0085, .0055, .0032, .002/

C WRITE TO THE DEVICE IDEV

IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE

CALL CVSPAC(9., 9.)
CALL JWINDO(0., 9., 0., 9.)
CALL JOPEN
CALL JSIZE(.2, .2*1.25)
CALL JMOVE(4.5, 6.0)
CALL JJUST(2, 2)

C OUTPUT THE STRING

CALL JHSTRG('A TITLE')

C RESET THE CHARACTER SIZE FOR THE AXES

CALL JSIZE(.1, .1*1.25)

C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)

CALL JMOVE(4.5, 6.0)
CALL JJUST(2, 2)

C OUTPUT THE STRING

CALL JHSTRG('A TITLE')

C SET THE LOWER-LEFT INTERSECTION OF THE AXES

XORG=2.
YORG=2.

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES

CALL JCONWW(XORG, YORG, 0., VX1, VY1)
CALL JCOMWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
    CALL JWINDO(5.,10.,0.,0.01)
    CALL JVPORT(VX1,VX2,VY1,VY2)
    CALL JOPEN
    CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
    
C PLOT FIRST DATA CURVE
    CALL CSYMNO(1)
    CALL CLNPAT(1)
    CALL CKEYLB(ISTORE,KEYCHR,3,'DATA SET 1')
    CALL CLNPLT(X,Y(I,I),MAXPTS)
    
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
    CALL CSYMNO(2)
    CALL CLNPAT(2)
    CALL CKEYLB(ISTORE,KEYCHR,3,'DATA SET 2')
    CALL CLNPLT(X,Y(I,2),MAXPTS)
    CALL JCLOSE

C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
    CALL JVPORT(-1.,1.,-1.,1.)
    CALL JWINDO(0.9,0.9,0.9,0.9)
    BPOS(1)=9.
    BPOS(2)=2.3.5
    CALL JOPEN
    CALL JSIZE(.1,.1*1.25)
    CALL CKEYPL(ISTORE,KEYCHR,'KEY TITLE','COLUMN TITLE',
                          BPOS,5,JCOL,1)
    CALL JCLOSE

C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
    CALL JPAUSE(IDEV)
    CALL JFRAME
    CALL JDEVOF(IDEV)
    CALL JDEND(IDEV)
    CALL JEND
    STOP
    END
Figure CDR7. Semi-logarithmic line chart (single data set).
PROGRAM CDR7

C SEMI-LOGARITHMIC LINE CHART (SINGLE DATA SET)

C SET UP DATA
PARAMETER(NPTS=6)
REAL X(NPTS),Y(NPTS),YTEMP(NPTS)
DATA X/2.2,3.0,4.3,5.1,5.5,6.7/
DATA Y/3.5,50.1,100.,500.,750.,985./
DATA XORG/2.5,10.,YORG/2.0,XLEN/7.,YLEN/7.,XPAGE/11.,YPAGE/11./

C SET UP GRAPHICS AREA
IDEV=0
CALL JBEGIN
CALL CBEGIN
CALL JINIT(IDEV)
CALL JDEVON(IDEV)

C SET PAGE COORDINATES, AND OPEN A TEMPORARY SEGMENT
CALL JWINDO(0.,XPAGE,0.,YPAGE)
CALL JOPEN

C SET CHARACTER SIZE, AND OUTPUT TITLE
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
XSIZE=.25
CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER,BOTTOM)
CALL JMOVE(XPAGE/2.,.0,+.XSIZE)
CALL JJUST(2,1)

C OUTPUT THE STRING
CALL JHSTRG('P[BLC]OWER LEVEL VS. FREQUENCY')

C RESET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG,YORG)

C HORIZONTAL AXIS (LINEAR)
CALL CMNXM(X,NPTS,XMIN,XMAX)
C DETERMINE PUBLICATION QUALITY SCALE FACTORS
CALL CSSCALE(XMIN,XMAX,AMIN,AMAX,NMAJOR,NMINOR,XINCR,NLEFT,NRIGHT)
C SET HORIZONTAL AXIS ATTRIBUTES
CALL CHMTC(NMINOR)
CALL CHPREC(NRIGHT)
CALL CHLAB('P[BLC]ERVEY, [BUC]H[BLC]Z',1)
CALL CHAXIS(AMIN,AMAX,XINCR,XLEN)

C VERTICAL AXIS (LOGARITHMIC)
CALL CMNXM(Y,NPTS,YMIN,YMAX)
CALL CEXP(YMIN,YMAX,MINEXP,MAXEXP)
CALL CVLAB('P[BLC]OWER LEVEL',1)
CALL CSET('NVLOGP',1)
CALL CSET('NVLOGS',MINEXP)
NTIC=(MAXEXP-MINEXP)+1
CALL CVLOG(YLEN,NTIC,4)

C------------------------------------------------------------------------

C SAVE DATA REGION VIRTUAL COORDINATES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
CALL JCLOSE

C------------------------------------------------------------------------

C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
CALL JVPORT(VX1,VX2,VY1,VY2)

C------------------------------------------------------------------------

C SET UP DATA REGION WINDOW
   DO 1 KI=1,NPTS
      YTEMP(KI)=LOG10(Y(KI))
   C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
      CALL JWINDO(AMIN,AMAX,REAL(MINEXP),REAL(MAXEXP))

C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
   CALL JWCLIP(.TRUE.)
   CALL JOPEN

C PLOT DATA
   CALL CSYMPN(1)
   CALL CLNPAT(1)
   CALL CLNPNT(X,YTEMP,NPTS)
   CALL JPAUSE(IDEV)
   CALL JCLOSE
   CALL JFRAME

C------------------------------------------------------------------------

C TERMINATE GRAPHICS
   CALL JDEVF(IDEV)
   CALL JDENF(IDEV)
   CALL JEND

C------------------------------------------------------------------------

STOP
END
Figure CDR8.  Log-log line chart (multiple data sets).
PROGRAM CDR8

C LOG-LOG LINE CHART (MULTIPLE DATA SETS)

C SET UP DATA
PARAMETER(MAXPTS=6, MAXSET=2)
REAL X(MAXPTS), Y(MAXPTS, MAXSET), YTEMP(MAXPTS), XTEMP(MAXPTS)
DATA X/22., 30., 43., 51., 85., 97./
DATA Y(1,1)/3.0, 50., 10., 25., 90./
DATA Y(1,2)/7.0, 90., 10., 25., 90./
DATA XORG/2., YORG/2., XLEN/7., YLEN/7., XPAGE/11., YPAGE/11./

C SET UP GRAPHICS AREA
IDEV=0
CALL JBEGIN
CALL CBEGIN
CALL JINIT(IDEV)
CALL JDEVON(IDEV)

C SET PAGE COORDINATES, AND OPEN A TEMPORARY SEGMENT
CALL JWINDO(0., XPAGE, 0., YPAGE)
CALL JOPEN

C SET CHARACTER SIZE, AND OUTPUT TITLE
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
XSIZE=.25
CALL JSIZE(XSIZE, XSIZE*1.25)

C SET THE CHARACTER SIZE FOR THE AXES
XSIZE=.2
CALL JSIZE(XSIZE, XSIZE*1.25)

C OUTPUT THE STRING
CALL JHSTRG('A T[BLC]ITLE')

C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
CALL JMOVE(XORG, YORG)

C HORIZONTAL AXIS (LOG)
CALL CMNMX(X, MAXPTS, XMIN, XMAX)
CALL CEXP(XMIN, XMAX, MXEXP1, MXEXP2)

C SET HORIZONTAL AXIS ATTRIBUTES
CALL CSET('NHLOGF', 1)
CALL CSET('NHLOGS', MXEXP1)
NTICK=(MXEXP2-MXEXP1)+1
CALL CHLOG(XLEN, NTICK, 1)

C VERTICAL AXIS (LOGARITHMIC)
CALL CMNMX(Y(1,1), MAXPTS, YMIN, YMAX)
DO 10 I=2, MAXSET
   CALL CMNMX(Y(I,1), MAXPTS, TMIN, TMAX)
   IF(TMIN.LT.YMIN) YMIN=TMIN

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IP(TMAX,GT,YMAX)YMAX=TMAX
CALL CEXP(YMIN,YMAX,MYEXP1,MYEXP2)
CALL CSET('NVLOGF',1)
CALL CSET('NVLOGS',MYEXP1)
NTICY=(MYEXP2-MYEXP1)+1
CALL CVLOG(YLEN,NTICY,1)

C------------------------------------------------------------------------
C SAVE DATA REGION VIRTUAL COORDINATES
CALL JCONMV(XORG,YORG,0.,VX1,VY1)
CALL JCONMV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
CALL JCLOSE

C------------------------------------------------------------------------
C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
CALL JVPORT(VX1,VX2,VY1,VY2)

C------------------------------------------------------------------------
C SET UP DATA REGION WINDOW
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
CALL JXWD0(REAL(MXEXP1),REAL(MXEXP2),REAL(MYEXP1),REAL(MYEXP2))
C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
CALL JWCLIP(.TRUE.)
CALL JOPEN

C PLOT DATA
DO 1 KI=1,MAXPTS
  XTEMP(KI)=LOG10(X(KI))
DO 2 KI=1,MAXPTS
  CALL CSYMNO(KI)
  CALL CLNPAT(KI)
  DO 3 KI2=1,MAXPTS
    YTEMP(KI2)=LOG10(Y(KI2,KI1))
2    CALL CLNPPLT(XTEMP,YTEMP,MAXPTS)
    CALL JPAUSE(IDEV)
    CALL JCLOSE
    CALL JFRAME
3    CALL JCLOSE
    CALL JFRAME
1  CONTINUE

C------------------------------------------------------------------------
C TERMINATE GRAPHICS
CALL JDEVOP(IDEV)
CALL JDEND(IDEV)
CALL JEND

C------------------------------------------------------------------------
STOP
END
A Title

Figure CDR9. Line chart with a grid (without a legend).
PROGRAM CDR9
C-----------------------------------------------------------------------
C LINE CHART WITH A GRID (WITHOUT A LEGEND)
C-----------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA (Y(KI,1),KI=1,10)
+ / .001,.003,.0075,.004,.006,.008,.009,.005,.003,.002/
DATA (Y(KI,2),KI=1,10)
+ / .0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0032,.002/
C-----------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(.9,.9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JSIZE(.2,.2*1.25)
CALL JWINDO(0.,9.,0.,9.)
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL [BUC]AXIS',1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('V[BLK]ERTICAL [BUC]AXIS',1)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(0.,01.,001,YLEN)
C CALL GRID ROUTINE TO REQUEST GRID LINES TO BE OUTPUT OVER DATA AREA.
NOINCX=NINT((10.-5.)/1.)
NOINCY=NINT((.01-.0)/.001)
XS=XLEN/REAL(NOINCX)
YS=YLEN/REAL(NOINCY)
NBLANK=0
CALL CGRID(XORG,YORG,XS,YS,NOINCX,NOINCY,BLMK,NBLANK)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN

C PLOT FIRST DATA CURVE USING CGL DEFAULTS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(1,1),MAXPTS)

C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(1,2),MAXPTS)
CALL JCLOSE

C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
CALL JPAUSE(1DEV)
CALL JFRAME
CALL JDEVOF(1DEV)
CALL JDEND(1DEV)
CALL JEND
STOP
END
Figure CDR10. Semi-log line chart with a grid (single data set).
PROGRAM CDR10

C SEMI-LOG LINE CHART WITH A GRID (SINGLE DATA SET)

C SET UP DATA
PARAMETER(NPTS=6)
REAL X(NPTS),Y(NPTS),YTEMP(NPTS),BLANK(4)
DATA X/2.2,3.0,4.3,5.1,5.5,6.7/,BLANK/0.,0.,0.,0./
DATA Y/3.,50.,10.,50.,75.,98./
DATA XORG/2.5/,YORG/2.5/,XLEN/7.,YLEN/7.,XPAGE/11.,YPAGE/11./

C SET UP GRAPHICS AREA
IDEV=0
CALL JBEGIN
CALL CBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C SET PAGE COORDINATES, AND OPEN A TEMPORARY SEGMENT
CALL JWINDO(0.,XPAGE,0.,YPAGE)
CALL JOPEN

C SET CHARACTER SIZE, AND OUTPUT TITLE
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
   XSIZE=.25
   CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER,BOTTOM)
   CALL JMOVE(XPAGE/2.,0.+XSIZE)
   CALL JJJUST(2,1)
C OUTPUT THE STRING
   CALL JHSTRG('P[BLC]OWER LEVEL VS. FREQUENCY')

C RESET THE CHARACTER SIZE FOR THE AXES
   XSIZE=.2
   CALL JSIZE(XSIZE,XSIZE*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
   CALL JMOVE(XORG,YORG)

C HORIZONTAL AXIS (LINEAR)
   CALL CMNMX(X,NPTS,XMIN,XMAX)
C DETERMINE PUBLICATION QUALITY SCALE FACTORS
   CALL CSSCALE(XMIN,XMAX,AMIN,AMAX,NMAJOR,NMINOR,XINCR,NLEFT,NRIGHT)
C SET HORIZONTAL AXIS ATTRIBUTES
   CALL CMHTIC(NMINOR)
   CALL CHPRIC(NRIGHT)
   CALL CHLAB('P[BLC]EQUENCY, [BUC]H[BLC]Z',1)
   CALL CHAXIS(AMIN,AMAX,XINCR,XLEN)

C VERTICAL AXIS (LOGARITHMIC)
   CALL CMNMX(Y,NPTS,YMIN,YMAX)
   CALL CEXP(YMIN,YMAX,MINEXP,MAXEXP)
   CALL CVLAB('P[BLC]OWER LEVEL',1)
   CALL CSET('NVLOGF',1)
   CALL CSET('NVLOGS',MINEXP)


```

NTIC=(MAXEXP-MINEXP)+1
CALL CVLOG(YLEN,NTIC,1)

C-----------------------------------------------

C GENERATE A GRID
XSC=XLEN
YSC=YLEN/REAL(NTIC-1)
IXC=-1
IYC=NTIC-1
XGS=0.
YGS=1.
XGI=XLEN/REAL(NMAJOR-1)
YGI=1.
NBLANK=1
CALL CLGRID(XSC,YSC,IXC,IYC,XGS,YGS,XGI,YGI,BLANK,NBLANK)

C-----------------------------------------------

C SAVE DATA REGION VIRTUAL COORDINATES
CALL JCONWV(XORG,YORG,0.,,VX1,vy1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,,VX2,vy2)
CALL JCLOSE

C-----------------------------------------------

C SET VIEWPORT TO DATA REGION VIRTUAL COORDINATES
CALL JVPORT(VX1,VX2,vy1,vy2)

C-----------------------------------------------

C SET UP DATA REGION WINDOW
   DO 1 KI=1,NPTS
1   YTEMP(KI)=LOG10(Y(KI))
C X-AXIS IS LOG, MIN AND MAX MUST BE SCALED.
   CALL JWINDO(AMIN,AMAX,REAL(MINEXP),REAL(MAXEXP))
C ENABLE CLIPPING TO EXCLUDE EXTRANEOUS DATA
   CALL JWCLIP(.TRUE.)
   CALL JOPEN
C PLOT DATA
   CALL CSYMNO(1)
   CALL CLNPAT(1)
   CALL CLNPLT(X,YTEMP,NPTS)
   CALL JPAUSE(IDEV)
   CALL JCLOSE
   CALL JFRAME

C-----------------------------------------------

C TERMINATE GRAPHICS
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND

C-----------------------------------------------

STOP
END
```

```
Figure CDR11. Complete low-level program (with a key) and a grid.
PROGRAM CDR11

C-----------------------------------------------------------------------
C COMPLETE LOW-LEVEL PROGRAM (WITH A KEY) AND A GRID
C-----------------------------------------------------------------------

C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET),BPOS(4),BLANK(4)
PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
CHARACTER KEYCHR(NCOLS,NLINS)*20
INTEGER ISTORE(15,NLINS),JCOL(NCOLS)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA JCOL/1/
DATA (Y(KI,1),KI=1,10)
+ / .001,.003,.0075,.004,.006,.008,.009,.005,.004,.005/
DATA (Y(KI,2),KI=1,10)
+ / .0015,.004,.007,.0045,.0065,.0078,.0085,.0055,.0015,.006/

C-----------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDEVON(IDEV)
CALL JDINIT(IDEV)

C-----------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*.125)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,0.5)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CSIZE=.1
CALL JSIZE(CSIZE,CSIZE*.125)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS',1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=5.0
CALL CHTICJ(0)
CALL CHAXIS(5.,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXIS',1)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=5.0

B - 63
CALL CVAXIS(.0,.01,.001,YLEN)

C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,.0,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)

C PLOT FIRST DATA CURVE USING CGL DEFAULTS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'DATA SET 1')
CALL CLNPLT(X,Y(1,1),MAXPTS)

C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CKEYLB(ISTORE,KEYCHR,3,'DATA SET 2')
CALL CLNPLT(X,Y(1,2),MAXPTS)
CALL JCLOSE

C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND AND GRID WITH A HOLE.
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
CALL JVPORT(-1.,1.,-1.,1.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JSIZE(CSIZE,CSIZE*1.25)

C FIRST CALL CKEYPL WITH KPT SET TO 3 TO OBTAIN KEY EXTENTS.
KPT=1
BPOS(1)=2.0
BPOS(2)=2.0
BPOS(3)=3.0
BPOS(4)=3.0
CALL CKEYPL(ISTORE,KEYCHR,'KEY TITLE','COLUMN TITLE',
+ BPOS,KPT,JCOL,1)
XXTENT=BPOS(3)-BPOS(1)
YXTENT=BPOS(4)-BPOS(2)
WRITE(77,*'(XXTENT,YXTENT=',XXTENT,YXTENT'+BPOS,KPT,JCOL,1)

C NOW BASED ON EXTENTS AND AXES, DETERMINE WHERE TO PLACE HOLE FOR KEY.
C SET BPOS AND KPT ACCORDINGLY.
XL=XLEN/5.
YL=YLEN/10.
BPOS(1)=(XORG+XLEN)-((XL*3.0-XXTENT)/2.)
BPOS(2)=YORG+((YL*3.0-YXTENT)/2.)
KPT=3
CALL CKEYPL(ISTORE,KEYCHR,'KEY TITLE','COLUMN TITLE',
+ BPOS,KPT,JCOL,1)
C NOW GENERATE GRID WITH APPROPRIATE HOLE.

NOINCX=NINT((10.-5.)/1.)
NOINCY=NINT((.01-.0)/.001)
XS=XLEN/REAL(NOINCX)
YS=YLEN/REAL(NOINCY)
NBLANK=1
BLANK(1)=XORG+XL*2.
BLANK(3)=XORG+XLEN
BLANK(2)=YORG
BLANK(4)=YORG+YL*3.
CALL CGRID(XORG,YORG,XS,YS,NOINCX,NOINCY,BLANK,NBLANK)
CALL JCLOSE

C TERMINE GRAPHCICS
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Figure CDR12. Line chart with a decreasing axis.
PROGRAM CDR12
C-----------------------------------------------------------------------
C A LINE CHART WITH A DECREASING AXIS.
C-----------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10, MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA (Y(KI,1),KI=1,10) + /9.001,0.003,0.0075,0.004,0.006,0.008,0.009,0.005,0.003,0.002/
DATA (Y(KI,2),KI=1,10) + /9.0015,0.004,0.007,0.0045,0.0065,0.0078,0.0085,0.0055,0.0032,0.002/
C-----------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(.9,.9.)
CALL JWINDO(.0,.9,.0,.9.)
CALL JOPEN
CALL JSIZE(.2,.2*.125)
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(.45,.6)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A T[BLC]ITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=.4
CALL CHAXIS(.1,.5,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(.0,.01,.001,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,.0,.VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,.0,.VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
C NOTE: THE WINDOW OF THE UNDERLYING GRAPHICS PACKAGE MUST BE
C INCREASING IN NATURE. THE RANGE MUST MATCH THE DATA.
C
CALL JWINDO(5.,10.,.0,.01)
C
5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
C
CALL JVPORT(VX1,VX2,VY1,VY2)
C
FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C
RELECT = (XMAX-XMIN)/2. + XMIN
C
REFLECT=(10. - 5.)/2. + 5.
C
CALL CFLIP(X,MAXPTS,REFLECT)
C
CALL JOPEN
C
PLOT FIRST DATA CURVE USING CGL DEFAULTS
C
CALL CSYMNO(1)
C
CALL CLNPAT(1)
C
CALL CLNPLT(X,Y(1,1),MAXPTS)
C
SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
C
CALL CSYMNO(2)
C
CALL CLNPAT(2)
C
CALL CLNPLT(X,Y(1,2),MAXPTS)
C
CALL JCLOSE
C
IF THE X ARRAY IS TO BE USED AGAIN, THE USER MUST APPLY CFLIP AGAIN.
C
IN THIS CASE, THE X ARRAY IS NOT USED AGAIN.
C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
C
CALL JPAUSE(IDEV)
C
CALL JFRAME
C
CALL JDEVOF(IDEV)
C
CALL JDEND(IDEV)
C
CALL JEND
STOP
END
Figure CDR13. Line chart with multiple vertical scales on the same axis.
PROGRAM CDR13

C A LINE CHART WITH MULTIPLE VERTICAL SCALES ON THE SAME AXIS.

C ALLOCATE AND INITIALIZE DATA

PARAMETER (MAXPTS=10, MAXSET=2)
REAL X(MAXPTS), Y(MAXPTS, MAXSET), BPOS(4)
PARAMETER (NLINS=2, NCOLS=1, NTLINS=1)
CHARACTER KEYCHR(NCOLS, NLINS)*20
INTEGER ISTORE(15, NLINS), JCOL(NCOLS)
DATA X/5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0/
DATA JCOL/1/
DATA (Y(KI, 1), KI=1, 10)
+ / .001, .003, .0075, .004, .006, .008, .009, .005, .003, .002/
DATA (Y(KI, 2), KI=1, 10)
+ / .0015, .004, .007, .0045, .0065, .0078, .0089, .0055, .0032, .002/

C WRITE TO THE DEVICE IDEV

IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JINIT(IDEV)
CALL JDEVON(IDEV)

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE

CALL CVSPAC(9., 9.)
CALL JWINDO(0., 9., 0., 9.)
CALL JOPEN

C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)

CSIZE=2
CALL JSIZE(CSIZE, CSIZE*1.25)

C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER, CENTER)

CALL JMOVE(4.5, .5)
CALL JJUST(2, 2)

C OUTPUT THE STRING

CALL JHSTRG('A T[BLC]ITLE')

C RESET THE CHARACTER SIZE FOR THE AXES

CSIZE=1
CALL JSIZE(CSIZE, CSIZE*1.25)

C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES

XORG=2.
YORG=2.
CALL JMOVE(XORG, YORG)

C DESCRIBE THE HORIZONTAL AXIS

CALL CHLAB('W[BLC]ING LENGTH', 1)

C XLEN - REPRESENTS THE X-AXIS LENGTH

XLEN=4.0
CALL CHAXIS(5., 10., 1., XLEN)

C DESCRIBE THE VERTICAL AXIS

C NO AXIS LABEL ON INNERMOST VERTICAL AXIS

CALL CVLAB( ' ', 0)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
 YLEN=3.5
C PLOT FIRST AXIS (DECREASING)
 CALL CVAXIS(.01,.0,.001,YLEN)
 CALL JMOVE(XORG,YORG+YLEN+.75)
 CALL JHSTRG('[BLC]CM')
C PLOT SECOND AXIS (INCREASING)
C POSITION AND DESCRIBE THE OUTMOST VERTICAL AXIS
 CALL JMOVE(XORG-CSIZE*7.,YORG)
 CALL CVLAB('W[BLC]ING WIDTH',1)
 CALL CVAXIS(.0,.01,.001,YLEN)
C LABEL FOR OUTMOST VERTICAL AXIS
 CALL JMOVE(XORG-CSIZE*7. ,YORG+YLEN+.75)
 CALL JHSTRG('[BLC]N.')
C-----------------------------------------------------------------------
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
 CALL JCONWV(XORG,YORG,0.,VX1,VY1)
 CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
 CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
 CALL JWINDO(5.,10.,.0,.01)
 C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
 C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
 CALL JVPORT(VX1,VX2,VY1,VY2)
 CALL JOPEN
 CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
C FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C REFLECT = (YMAX-YMIN)/2. + YMIN
 REFLECT= (.01 -.0)/2. + 0.
 CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C PLOT FIRST DATA CURVE WITH DECREASING AXIS (USING CGL DEFAULTS)
 CALL CSYMNO(1)
 CALL CLNPAT(1)
 CALL CKEYLB(ISTORE,KEYCHR,3,'D[BLC]ECREASING AXIS DATA SET 1')
 CALL CLNPLT(X,Y(1,1),MAXPTS)
C REVERSE DATA AGAIN, TO RETURN DATA TO ORIGINAL VALUES.
 CALL CFLIP(Y(1,1),MAXPTS,REFLECT)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
 CALL CSYMNO(2)
 CALL CLNPAT(2)
 CALL CKEYLB(ISTORE,KEYCHR,3,'I[BLC]NCREASING AXIS DATA SET 2')
C PLOT SECOND DATA CURVE WITH INCREASING AXIS.
 CALL CLNPLT(X,Y(1,1),MAXPTS)
 CALL JCLOSE
C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
 CALL JVPORT(-1.,1.,-1.,1.)
 CALL JWINDO(0.,9.,0.,9.)
 BPOS(1)=9.
BPOS(2)=2.+3.5
CALL JOPEN
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL CKEYPL(ISTORE,KEYCHR,'MULTIPLE AXIS',
          'COLUMN TITLE',BPOS,5,JCOL,1)
CALL JCLOSE

C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
CALL JPAPER(IDEV)
CALL JFRAME
CALL JEXIT(IDEV)
CALL JEND(IDEV)
CALL JEND
STOP
END
Figure CDR14. Line chart with multiple vertical scales (opposite axis).
PROGRAM CDRI4

C------------------------------------------
C LINE CHART WITH MULTIPLE VERTICAL SCALES (OPPOSITE AXIS)
C------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET),BPOS(4)
PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
CHARACTER KEYCHR(NCOLS,NLINS)*20
INTEGER ISTORE(15,NLINS),JCOL(NCOLS)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10.0/
DATA JCOL/1 /
DATA (Y(KI,1),KI=1,10) + / .001, .003, .0075, .004, .006, .008, .009, .005, .003, .002/
DATA (Y(KI,2),KI=1,10) + / .0015, .004, .007, .0045, .0065, .0078, .0085, .0055, .0032, .002/
C------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
C------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C------------------------------------------
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*1.25)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(4.5,.5)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CSIZE=.1
CALL JSIZE(CSIZE,CSIZE*1.25)
C------------------------------------------
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=1.25
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS',1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)
C------------------------------------------
C DESCRIBE THE VERTICAL AXIS
C NO AXIS LABEL ON INNERMOST VERTICAL AXIS
CALL CVLAB('DCREASING AXIS',1)
CALL CVPREC(3)

C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5

C PLOT FIRST AXIS (DECREASING)
CALL CVAXIS(.01,.0,-.001,YLEN)

C PLOT SECOND AXIS (INCREASING)
C POSITION AND DESCRIBE THE OPPOSITE VERTICAL AXIS
CALL JMOVE(XORG+XLEN,YORG)

C REQUEST VERTICAL AXIS TICK MARKS TO THE RIGHT OF THE AXIS.
C CALL CVTICJ(2)

C REQUEST VERTICAL AXIS TICK MARK LABELS TO THE RIGHT OF THE AXIS.
CALL CVLABJ(1)
CALL CVTICJ(2)
CALL CVLAB('INCREASING AXIS',1)
CALL CVAXIS(.0,.0,.001,YLEN)

-- Save virtual coordinates of axes boundaries
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)

C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,.01)
C 5,10 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C 0,.01 - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)

C FLIP THE DATA ABOUT A REFLECTION POINT (I.E., MIRROR IMAGE).
C REFLECT = (YMAX-YMIN)/2. + YMIN
   REFLECT=(.01 - 0.)/2. + 0.
   CALL CFLIP(Y(1,1),MAXPTS,REFLECT)

C PLOT FIRST DATA CURVE WITH DECREASING AXIS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'DECREASING DATA')
CALL CLNPLT(X,Y(1,1),MAXPTS)

C REVERSE DATA AGAIN, TO RETURN DATA TO ORIGINAL VALUES.
CALL CFLIP(Y(1,1),MAXPTS,REFLECT)

C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CKEYLB(ISTORE,KEYCHR,3,'INCREASING DATA')

C PLOT SECOND DATA CURVE WITH INCREASING AXIS.
CALL CLNPLT(X,Y(1,2),MAXPTS)

CALL JCLOSE

C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
CALL JVPORT(-1.,1.,-1.,1.)
CALL JWINDO(0.,9.,0.,9.)
BPOS(1)=9.
BPOS(2)=2.+3.5
CALL JOPEN
CALL JSIZE(CSIZE,CSIZE*1.25)
CALL CKEYPL(ISTORE,KEYCHR,'MULTIPLE AXIS',
                    'DATA TYPE',BPOS,5,JCOL,1)
CALL JCLOSE

C-----------------------------------------------
C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFrame
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Figure CDR15. Simple, yet complete low-level program (with a key).

Computations vs Experiments

Multiple axis

Data type

- Experimental
- Actual
PROGRAM CDR15

C---------------------
C SIMPLE, YET COMPLETE LOW-LEVEL PROGRAM (WITH A KEY)
C--------------------------------------------------

C ALLOCATE AND INITIALIZE DATA
PARAMETER(NUMPT1=13,NUMPT2=3,MAXLAB=20)
REAL X1(NUMPT1), Y1(NUMPT1), BPOS(4)
REAL X2(NUMPT2), Y2(NUMPT2)
PARAMETER (NLINS=2,NCOLS=1,NTLINS=1)
CHARACTER KEYCHR(NCOLS,NLINS)*20,CLABS(MAXLAB)*10
INTEGER ISTORE(15,NLINS), JCOL(NCOLS)
DATA X1/-8.,-6.,-4.,-2.,0.,2.,4.,6.,8.,10.,12.,14.,16. /
DATA JCOL/1/
DATA (Y1(KI),KI=1,NUMPT1) 
+ / .079,.068,.035,.021,0. -.021, -.035,.065,.08, -.11, 
+ -.118,-.12,-.139/
DATA X2/-4.,8.,16./,Y2/.039,.071,-.145/

C---------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGI N
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)

C---------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINO(0.,9.,0.,9.)
CALL JOPEN

C---------------------
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CSIZE=.2
CALL JSIZE(CSIZE,CSIZE*1.25)

C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,TOP)
CALL JMOVE(9./2.,9.,-.5)
CALL JJUST(2,3)

C OUTPUT THE STRING
CALL JHSTRG('C[BLC]OMPUTATIONS VS[ELC] E[BLC]XPERIMENTS')

C RESET THE CHARACTER SIZE FOR THE AXES
CSIZE=.1
CALL JSIZE(CSIZE,CSIZE*1.25)

C---------------------
C BASED AXES DATA ATTRIBUTES (MINIMUM, MAXIMUM, AND INCREMENTS).
XMIN=-8.
XMAX=20.
XINC=4.
YMIN=-.16
YMAX=0.12
YINC=.04

C---------------------
C SET X AND Y AXIS LENGTHS (I.E., XLEN AND YLEN RESPECTIVELY).
XLEN=4.0
YLEN=5.5

C POSITION LOWER-LEFT CORNER OF DATA SPACE ON THE PAGE.
XORG=((9./2.)-1.)-.5*XLEN
YORG=(9./2.)-.5*YLEN
C NOW, SET XZERO AND YZERO PAGE COORDINATES WHERE AXES 0,0 EXISTS.
C (THIS PROGRAM ASSUMES THAT DATA ENCOMPASSES 0,0 IN X AND Y).
XZERO=XORG+XLEN*(-XMIN/(XMAX-XMIN))
YZERO=YORG+YLEN*(-YMIN/(YMAX-YMIN))
C-----------------------------------------------------------------------
C DESCRIBE X-AXIS. MOVE TO X ORIGIN, Y ZERO.
CALL JMOVE(XORG,YZERO)
C GENERATE X AXIS LABELS.
CALL CILAB(XMIN,XMAX,XINC,0,CLABS)
ICOUNT=NINT((XMAX-XMIN)/XINC)+1
C BLANK OUT INTERSECTION LABEL (I.E., 0).
KI=NINT(ABS(XMIN)/XINC)+1
CLABS(KI)=" 
C DRAW AXIS
CALL CHAXIC(XLEN,ICOUNT,CLABS,CLABS)
C POSITION AND OUTPUT AXIS LABEL
CALL JMOVE(XORG+(5./7.)*XLEN,YZERO-.5)
CALL JHSTRG('[FONT=9][BLC]A[FONT=3l,DEG')
C-----------------------------------------------------------------------
C DESCRIBE Y-AXIS. MOVE TO X ZERO, Y ORIGIN.
CALL JMOVE(XZERO,YORG)
C GENERATE Y AXIS LABELS.
CALL CILAB(YMIN,YMAX,YINC,2,CLABS)
ICOUNT=NINT((YMAX-YMIN)/YINC)+1
C BLANK OUT INTERSECTION LABEL (I.E., 0).
KI=NINT(ABS(YMIN)/YINC)+1
CLABS(KI)=" 
C DRAW AXIS.
CALL CVAXIC(YLEN,ICOUNT,CLABS,1,ICOUNT)
C POSITION AND OUTPUT AXIS LABEL
CALL JMOVE(XZERO-1.5,YORG+(2.5/7.)*YLEN)
CALL JHSTRG('[BLC][BSUB]M (0.25C)')
C-----------------------------------------------------------------------
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(XMIN,XMAX,YMIN,YMAX)
C XMIN,XMAX - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE X-DIRECTION
C YMIN,YMAX - REPRESENTS THE DATA COORDINATE BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
CALL CKEYIN(ISTORE,KEYCHR,NLINS,NCOLS,NTLINS)
C PLOT FIRST DATA CURVE USING CGL DEFAULTS
C SET SYMBOL TO 1 (A CIRCLE) FOR EXPERIMENTAL DATA.
CALL CSYMNO(1)
CALL CKEYLB(ISTORE,KEYCHR,3,'E[BLC]XPERIMENTAL')
CALL CLNPLT(X1,Y1,NUMPT1)
C PLOT SECOND DATA CURVE.
C SET SYMBOL TO SOLID SQUARE (ACTUAL), AND PLOT SYMBOLS ONLY.
   CALL CSYMP(902)
   CALL CPLTYP(-1)
   CALL CKEYLB(ISTORE, KEYCHR, 3, 'A [BLK]CTUAL')
   CALL CKNPLT(X2,Y2,NUMP2)
   CALL JCLOSE
C-----------------------------------------------------------------------
C NOW OUTPUT LEGEND
C SET WINDOW AND VIEWPORT FOR PAGE COORDINATES
   CALL JVPORT(-1.,1.,-1.,1.)
   CALL JWINDO(0.,9.,0.,9.)
   BPOS(1)=9.
   BPOS(2)=2.+3.5
   CALL JOPEN
   CALL JSIZE(CSIZE,CSIZE*1.25)
   CALL CKEYPL(ISTORE, KEYCHR, 'M [BLK]ULTIPLE AXIS',
               '+ [BLK]DATA TYPE', BPOS, 5, JCOL, 1)
   CALL JCLOSE
C-----------------------------------------------------------------------
C TERMINATE GRAPHICS
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JEND
   STOP
END
Figure CDR16. Line chart with disjoint axes (based on CDR4).
PROGRAM CDR16
C------------------------------------------------------------------
C LINE CHART WITH DISJOINT AXES (BASED ON CDR6)
C------------------------------------------------------------------
C THE KEY ELEMENTS INVOLVING DISJOINT AXES INCLUDE:
C  - THE POSITIONING OF THE AXES (SEE XOFF AND YOFF),
C  - THE SETTING OF THE VIEWPORT TO MATCH THE DATA SPACE
C  (WHICH DIFFERS FROM THE AXES BOUNDARIES).
C------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER (MAXPTS=10,MAXSET=2)
REAL X(MAXPTS),Y(MAXPTS,MAXSET)
DATA X/5.5,6.0,6.5,7.0,7.5,8.0,8.5,9.0,9.5,10./
DATA (Y(KI,1),KI=1,10)
+ / .001, .003, .0075, .008, .009, .005, .003, .002/ 
DATA (Y(KI,2),KI=1,10)
+ / .0015, .004, .007, .0045, .0065, .0078, .0085, .0055, .0032, .002/
C------------------------------------------------------------------
C WRITE TO THE DEVICE IDEV
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
CALL JSIZE(.1,.1*.25)
C POSITION STRING, AND SET JUSTIFICATION (CENTER,CENTER)
CALL JMOVE(.4,.5,.6,.0)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
C XOFF - THE DISTANCE TO SHIFT THE X-AXIS DOWN.
XOFF=.2
CALL JMOVE(2.,2.-(XOFF))
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS',1)
CALL CHAXIS(5.,10.,1.,.4.)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXIS',1)
CALL CVAXIS(0.,.001,.001,3.5)
C YOFF - THE DISTANCE TO SHIFT THE Y-AXIS LEFT.
YOFF=.2
CALL JMOVE(2.-YOFF,2.)
CALL CVAXIS(0.,.001,.001,3.5)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
C NOTE: THE VIRTUAL COORDINATES ARE BASED ON DIMENSIONS OF DATA
SPACE, NOT ON AXIS BOUNDARIES.
CALL JCONWV(2.,2.,0.,VX1,VY1)
CALL JCONWV(2.+4.,2.+3.5,0.,VX2,VY2)
C CLOSE CURRENT WORLD COORDINATES (PAGE COORDINATES)
CALL JCLOSE
C---------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN BOUNDARIES
C OF THE AXES (BY SAVED VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,0.01)
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
C PLOT FIRST DATA CURVE USING CGL DEFAULTS
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y(I,I),MAXPTS)
C SET SYMBOL NUMBER TO 2, AND PLOT SECOND DATA CURVE
CALL CSYMNO(2)
CALL CLNPAT(2)
CALL CLNPLT(X,Y(I,2),MAXPTS)
CALL JCLOSE
C---------
C TERMINATE GRAPHICS
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
CHTICJ: IMPROPER ENTRY GIVEN FOR POSITIONING OF TICKMARKS. VALUE MUST BE 0, 1, 2, OR 3. DEFAULT VALUE OF 1 IS USED.

Figure CDD1. Example showing a simple CGL error.
PROGRAM CDD1
C AN EXAMPLE SHOWING A SIMPLE CGL ERROR.
C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=5)
REAL X(MAXPTS),Y(MAXPTS)
DATA X/5.5,6.5,7.5,8.5,9.5/,Y/.001,.0075,.006,.009,.002/
C WRITE TO THE METAFILE
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVS PAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JSIZE(.2,.2*.1/.25)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(.1,.1*.1/1.25)
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL [BUC]AXIS',1)
CALL CHTICJ(-1)
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('V[BUC]ERTICAL [BUC]AXIS',1)
CALL CVPREC(3)
YLEN=3.5
CALL CVAXIS(.0,.01,.01,YLEN)
C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWW(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
CALL JCLOSE
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN
C BOUNDARIES OF THE AXES (BY SAVE VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,0.01)
C 5,10 - REPRESENTS THE DATA BOUNDARIES IN THE X-DIRECTION
C 0.01 - represents the data boundaries in the y-direction
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
C plot data curve
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y,MAXPTS)
CALL JCLOSE
C---------------------------------------------------------------
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEND(IDEV)
CALL JEND
STOP
END
Figure CDD2. Example showing debugging capabilities.
PROGRAM CDD2

C AN EXAMPLE SHOWING A DEBUGGING CAPABILITIES.

C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=5)
REAL X(MAXPTS),Y(MAXPTS)
DATA X/5.5,6.5,7.5,8.5,9.5/,Y/.001,.0075,.006,.009,.002/

C WRITE TO THE METAFILE
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JJOIN(T(IDEV)
CALL JDEVON(IDEV)

C DEBUGGING TURNED ON FOR USER-CALLABLE ROUTINES.
CALL CDEBUG(1)

C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JSIZE(.2,.2*1.25)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
CALL JHSTRG('A T[BLClTLE')
CALL JSIZE(.1,.1*1.25)
CALL JMOUE(XORG,YORG)
CALL CHLAB('H[BLClORIZONTAL [BUC]A[BLClXIS',1)
CALL CHAXIS(S.,10.,1.,XLEN)
CALL CVLAB('V[BLClERTICAL [BUC]A[BLClXIS',1)
CALL CVAXIS(.0,.01,.01,YLEN)
CALL JCONVW(XORG,YORG,0.,VX1,vy1)
CALL JCONW(YORG+XLEN,YORG+YLEN,0.,VX2,vy2)
CALL JCLOSE

C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN
C BOUNDARIES OF THE AXES (BY SAVE VIRTUAL COORDINATES)
CALL JWINDO(5.10.,0.,01)
C 5,10 - REPRESENTS THE DATA BOUNDARIES IN THE X-DIRECTION
C 0.,01 - REPRESENTS THE DATA BOUNDARIES IN THE Y-DIRECTION
CALL JWPORT(VX1,VX2,VY1,VY2)
CALL JOPEN
C PLOT DATA CURVE
   CALL CSYMO(1)
   CALL CLNPAT(1)
   CALL CLNPIL(TX,Y,MAXPTS)
   CALL JCLOSE
C---------------------------------------------------------------
   CALL JPAUSE(IDEV)
   CALL JFRAME
   CALL JDEVOF(IDEV)
   CALL JDEND(IDEV)
   CALL JEND
   STOP
   END
Figure CDD3. Example showing an error and debugging redirection.
PROGRAM CDD3
C-----------------------------------------------------------------------
C AN EXAMPLE SHOWING A ERROR AND DEBUGGING REDIRECTION.
C-----------------------------------------------------------------------
C ALLOCATE AND INITIALIZE DATA
PARAMETER(MAXPTS=5)
REAL X(MAXPTS),Y(MAXPTS)
DATA X/5.5,6.5,7.5,8.5,9.5/,Y/0.001,0.0075,0.006,0.009,0.002/
C-----------------------------------------------------------------------
C WRITE TO THE METAFILE
IDEV=0
CALL CBEGIN
CALL JBEGIN
CALL JDINIT(IDEV)
CALL JDEVON(IDEV)
C-----------------------------------------------------------------------
C WRITE CGL ERROR MESSAGES TO UNIT 80, FILE 'TAPE80'.
C-----------------------------------------------------------------------
C WRITE CGL DEBUG MESSAGES TO UNIT 80, FILE 'TAPE80'.
C-----------------------------------------------------------------------
C DEBUGGING TURNED ON FOR USER-CALLABLE ROUTINES.
CALL CDEBUG(1)
C-----------------------------------------------------------------------
C ESTABLISH THE PAGE COORDINATES AND VIEWSPACE
CALL CVSPAC(9.,9.)
CALL JWINDO(0.,9.,0.,9.)
CALL JOPEN
CALL JSIZE(-2,.2*1.25)
CALL JMOVE(4.5,6.0)
CALL JJUST(2,2)
C SET THE CHARACTER SIZE (IN TERMS OF PAGE COORDINATES)
C POSITION TEXT, AND SET TEXT JUSTIFICATION (CENTER,CENTER)
C OUTPUT THE STRING
CALL JHSTRG('A TITLE')
C RESET THE CHARACTER SIZE FOR THE AXES
CALL JSIZE(1.*1.25)
C POSITION THE LOWER-LEFT INTERSECTION OF THE AXES
XORG=2.
YORG=2.
CALL JMOVE(XORG,YORG)
C DESCRIBE THE HORIZONTAL AXIS
CALL CHLAB('HORIZONTAL AXIS',1)
CALL CHTICJ(-1)
C XLEN - REPRESENTS THE X-AXIS LENGTH
XLEN=4.0
CALL CHAXIS(5.,10.,1.,XLEN)
C DESCRIBE THE VERTICAL AXIS
CALL CVLAB('VERTICAL AXIS',1)
CALL CVPREC(3)
C YLEN - REPRESENTS THE Y-AXIS LENGTH
YLEN=3.5
CALL CVAXIS(.0,.01,.01,YLEN)

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C SAVE VIRTUAL COORDINATES OF AXES BOUNDARIES
CALL JCONWV(XORG,YORG,0.,VX1,VY1)
CALL JCONWV(XORG+XLEN,YORG+YLEN,0.,VX2,VY2)
CALL JCLOSE

C-----------------------------------------------------------------------
C SET WINDOW TO MATCH DATA COORDINATES, AND PLOT WITHIN
C BOUNDARIES OF THE AXES (BY SAVE VIRTUAL COORDINATES)
CALL JWINDO(5.,10.,0.,0.01)
C 5,10 - REPRESENTS THE DATA BOUNDARIES IN THE X-DIRECTION
C 0.,01 - REPRESENTS THE DATA BOUNDARIES IN THE Y-DIRECTION
CALL JVPORT(VX1,VX2,VY1,VY2)
CALL JOPEN

C PLOT DATA CURVE
CALL CSYMNO(1)
CALL CLNPAT(1)
CALL CLNPLT(X,Y,MAXPTS)
CALL JCLOSE

C-----------------------------------------------------------------------
CALL JPAUSE(IDEV)
CALL JFRAME
CALL JDEVOF(IDEV)
CALL JDEVD(IDEV)
CALL JEND
STOP
END
Figure CDLL1. Program interfacing the low-level routines with the LEZ Routines.
PROGRAM CDL1

C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LEZ ROUTINES.

C

CHARACTER TITLE*80,IAXLBL*80,DAXLBL*80
REAL FREQ(100),POWER(100),INDMIN,INDMAX

DATA (POWER(I),I=1,76)/
+ 7066.0770323, 313987.5856597, 23314.47811626, 16222.72126064,
+ 6533.280733426, 5567.484820724, 5931.92717933, 3010.185764845,
+ 1075.54223512, 2304.552081512, 3938.878376374, 2372.668800947,
+ 990.5827153465, 539.1035104119, 185.921866205, 6922.275564162,
+ 90151.05656181, 32565.81919631, 19139.27829711, 26311.51279586,
+ 2769.064915013, 1118.2538952391, 763.2538952391, 1036.757022708,
+ 763.2538952391, 1036.757022708, 2318.840862193, 1815.115702427,
+ 1546.468077257, 30998.79018191, 90446.399670755, 99542.65318885,
+ 46517.56984878, 8264.407149631, 477.4873134733, 82.183079214,
+ 67.7501808438, 136.6466583528, 197.6147132091, 229.3505457034,
+ 643.2165902202, 1824.921660301, 5246.01888617, 9355.942325835,
+ 8240.202957789, 4042.516486596, 1615.454279283, 876.7523693048,
+ 780.321551955, 869.2380712535, 806.9102907816, 1417.485863451,
+ 13314.08558278, 42705.34014683, 25971.13637417, 32565.81919631,
+ 8369.70034301, 423.4410260173, 7218.840862193, 1815.115702427,
+ 90446.399670755, 477.4873134733, 82.183079214,
+ 3096.896818539, 1130.33337685, 351.6629052997, 323.9146852672,
+ 496.8216394068, 716.3789266813, 707.1830537755, 395.4528826033,
+ 185.9595078555, 349.7278623283, 579.1256929328, 427.7957796537,
+ 339.4866401359, 404.7726592585, 3303.494231505, 44732.334563,
+ 168132.27829711, 259620.2781873, 4701328454798, 220.74733211679.
C CONVET DATA TO BE REPRESENTED AS LOGARITHMIC

DO 1 I=1,100
FREQ(I)=LOG10(REAL(I))
1 POWER(I)=LOG10(POWER(I))

C INITIALIZE GRAPHICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
IDEV=0
CALL LEZINI(IDEV)

C SET LEZ ATTRIBUTES
NVALS=100
TITLE='P[BLC]OWER LEVEL VS. FREQUENCY'
IAXLBL='F[BLC]REQUENCY, [ELC]H[BLC]Z'
DAXLBL='P[BLC]OWER LEVEL'
INDMIN=LOG10(1.),
INDMAX=LOG10(100.0)
DEPMIN=LOG10(65.0)
DEPMAX=LOG10(290000.0)
IAXTYP=3
IHLOGI=0
IVLOGI=0
INDHV=1
LINAPP=1

C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
   CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
   +DEPMIN,DEPMAX,IAXTYP,IVLOGI,INDHV,INDAPP)

C OUTPUT A NOTE ON THE DISPLAY DEVICE
   CALL LEZNOT('CDLL1',7.,0.,3,1,0)

C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
   CALL JWINDO(0.,7.,0.,7.)
   CALL JVPORT(-1.,1.,-1.,1.)

C GET CURRENT LEZ AXES VALUES
   CALL LEZGET('XORIGIN',XOR,NVALS,MVALS)
   CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
   CALL LEZGET('YORIGIN',YOR,NVALS,MVALS)
   CALL LEZGET('VAXLEN',YLEN,NVALS,MVALS)
   CALL JOPEN
   CALL JMOVE(XOR,YOR+YLEN)
   CALL CEXP(1.,100.,MINH,MAXH)
   NTICH=(MAXH-MINH)+1
   CALL CHLABJ(1)
   CALL CHLOGS(MINH)
   CALL CHLOGF(1)
   CALL CHLOG(XLEN,NTICH,0)

C RESTORE VALUES FOR LEZ ROUTINES
   CALL CHLABJ(0)

C--------

C VERTICAL AXIS
   CALL JMOVE(XOR+XLEN,YOR)
   CALL CEXP(65.0,290000.0,MINV,MAXV)
   NTICV=(MAXV-MINV)+1
   CALL CVLABJ(1)
   CALL CVLOGS(MINV)
   CALL CVLOGF(1)
   CALL CVLOG(YLEN,NTICV,0)

C RESTORE VALUES FOR LEZ ROUTINES
   CALL CVLABJ(0)
   CALL JCLOSE

C--------

C GENERATE GRAPHICS OUTPUT FOR THE LEZ ROUTINES
   CALL LEZSHW

C TERMINATE ALL GRAPhICS
   CALL LEZTRM

C--------

STOP
END
Figure CDLL2. Program interfacing the low-level routines with the LEZ Routines.
PROGRAM CDLL2

C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LEZ ROUTINES.

C

CHARACTER TITLE*80, IAXLBL*80, DAXLBL*80
REAL FREQ(100), POWER(100), INDMIN, INDMAX

DATA (POWER(I),I=1,76)/
+ 7066.0770323, 313987.8556597, 23005.34014683, 25971.13637497,
+ 23314.47811626, 16222.72126064, 11123.46224798, 8573.673551723,
+ 6533.28073426, 6567.484820724, 5931.92717933, 3100.185764845,
+ 1075.54233512, 2304.552081512, 9398.87376374, 2372.668800947,
+ 990.5827153465, 1139.692923046, 539.1035104119, 186.2399260743,
+ 185.9121866205, 7922.275564162, 47871.80671708, 101610.8109471,
+ 90151.05656181, 32565.81919631, 3126.25985372, 5378.8832752072,
+ 19139.27829711, 26311.51279586, 18051.10302768, 7595.925085295,
+ 2769.664915013, 1114.906853713, 472.3435990609, 336.5553643497,
+ 224.6112590727, 292.8078714839, 913.1650061489, 1111.290988571,
+ 763.2538952391, 1036.757022708, 2318.840862193, 1815.115702427,
+ 1546.486077257, 30998.79018191, 90446.399607555, 99542.65318885,
+ 46517.56984878, 8264.407149583, 477.4873134733, 82.183079214,
+ 67.7501808384, 136.6466583528, 197.6147132091, 229.3505457034,
+ 643.2165902202, 1824.921600301, 5246.01888617, 9355.942325835,
+ 8240.202957789, 4042.516486596, 1615.454279283, 876.7532693048,
+ 780.321551955, 869.2380712535, 806.9102907816, 1417.485863451,
+ 13314.08558278, 42705.82833591, 56933.22987158, 3452.64829539,
+ 8369.70034301, 423.4410260173, 1721.308093883, 3815.021552281/

DATA (POWER(I),I=77,100)/
+ 3096.896818539, 1130.33337685, 496.8216394068, 716.7389266813, 707.1830537755,
+ 395.452882063, 185.995078555, 349.7278623283, 579.1256929328, 427.7957796537,
+ 339.4866401359, 404.7726592585, 3303.494231505, 47871.80671708, 1815.115702427,
+ 168132.2764905, 259620.2781873, 179647.069922, 51634.19154093,
+ 47017.38454798, 220.74733211, 377.2257021375, 552.6383507909/}

C CONVERT DATA TO BE REPRESENTED AS LOGARITHMIC

DO 1 I=1,100
FREQ(I)=LOG10(REAL(I))
1 POWER(I)=LOG10(Power(I))

C INITIALIZE GRAPHICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
IDEV=0
CALL LEZINII(IDEV)

C SET LEZ ATTRIBUTES

NVALS=100
TITLE='P[BLC]OWER LEVEL VS. FREQUENCY'
IAXLBL='F[BLC]REQUENCY, [ELC]H[BLC]Z'
DAXLBL='P[BLC]OWER LEVEL'
INDMIN=LOG10(1.)
INDMAX=LOG10(100.0)
DEPMIN=LOG10(65.0)
DEPMAX=LOG10(29000.0)
IAXTP=3
IHLOGI=0
IVLOGI=0
INDHV=1
LINAPP=1

C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
+DEPMIN,DEPMAX,IAXTYP,IVLOGI,INDHV,LINAPP)

C OUTPUT A NOTE ON THE DISPLAY DEVICE
CALL LEZNOT('CDLL2',7.,0.,3,1,0)

C SUPPRESS THE LEZ DEFAULTS OF PAUSE AND CLEAR
CALL LEZOPT('PAUSE',.FALSE.)
CALL LEZOPT('CLEAR',.FALSE.)

C GENERATE GRAPHICS OUTPUT FOR THE LEZ ROUTINES
CALL LEZSHW

C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
CALL JWIND0(0.,7.,0.,7.)
CALL JVPORT(-1.,1.,-1.,1.)

C GET CURRENT LEZ AXES VALUES
CALL LEZGET('XORIGIN',XOR,NVALS,WALS)
CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
CALL LEZGET('YORIGIN',YOR,NVALS,MVALS)
CALL LEZGET('VAXLEN',YLEN,NVALS,MVALS)

C HORIZONTAL AXIS
CALL JMOVE(XOR,YOR+YLEN)
C SEE INDMIN,INDMAX ABOVE FOR THE FOLLOWING VALUES
CALL CEXP(1.,100.,MINH,MAXH)
NTICH=(MAXH-MIH)+1
CALL CHLABJ(1)
CALL CHLOGS(MIH)
CALL CHLOGF(1)
CALL CHLOG(XLEN,NTICH,0)

C RESTORE VALUES FOR LEZ ROUTINES
CALL CHLABJ(0)

C VERTICAL AXIS
CALL JMOVE(XOR+XLEN,YOR)
C SEE DEPMIN,DEPMAX ABOVE FOR THE FOLLOWING VALUES
CALL CEXP(65.0,290000.0,MINV,MAXV)
NTICV=(MAXV-MINV)+1
CALL CVLABJ(1)
CALL CVLOGS(MINV)
CALL CVLOGF(1)
CALL CVLOG(YLEN,NTICV,0)

C RESTORE VALUES FOR LEZ ROUTINES
CALL CVLABJ(0)
CALL JCLOSE

C NOW PAUSE AND CLEAR
IF(IDEV.GE.1)CALL JPAUSE(1)
CALL JFRAME
C TERMINATE ALL GRAPHICS
   CALL LEZTRM
C-----------------------------------------------
   STOP
   END
Figure CDLL3. Program interfacing the low-level routines with the LEZ Routines (this program is CDLL1 modified to CALL CLGRID(log-log)).
PROGRAM CDLL3

C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LEZ ROUTINES.
C NOTE: THIS PROGRAM IS CDLL1 MODIFIED TO CALL CGRID (LOG-LOG).

CHARACTER TITLE*80, IAXLBL*80, DAXLBL*80
REAL FREQ(100), POWER(100), INDMIN, INDMAX, BLANK(4)
DATA BLANK/0., 0., 0., 0./
DATA (POWER(I), I=1,76)/
+ 7066.0770323, 313987.5856597, 23005.34014683, 25971.13637497,
+ 23314.47811626, 16222.72126064, 11123.46224798, 8573.673551723,
+ 6533.28073426, 6567.484820724, 5931.92717933, 3100.185764845,
+ 1075.542233512, 2304.552081512, 3938.878376374, 2372.668800947,
+ 990.5827153465, 1139.692923046, 539.1035104119, 186.2399260743,
+ 185.9121866205, 6922.275561462, 47871.8067107, 101610.8109471,
+ 9015.06561815, 32565.8191631, 3126.25985372, 5378.83275207,
+ 19139.27829711, 26311.51279586, 18051.1032768, 7595.929085295,
+ 2769.064915013, 1114.906853713, 472.3435990609, 336.5536343497,
+ 224.6112529072, 292.8078714839, 913.165006148, 1111.290988571,
+ 763.2538952391, 1036.757022708, 2318.840862193, 1815.115702427,
+ 1546.468077257, 30998.79018191, 90446.39960755, 99542.65318885,
+ 46517.56984878, 8264.407149583, 477.4873134733, 82.183079214,
+ 67.7501884348, 136.6466583528, 197.6147132091, 229.3505457034,
+ 643.2165902202, 1824.921600301, 5246.018888617, 9355.942325835,
+ 8240.202957789, 4042.516486596, 1615.454279283, 876.7523693048,
+ 780.32151955, 869.2380712535, 806.9102907816, 1417.4856363451,
+ 13314.80558278, 42705.82833591, 5693.322987158, 3452.68295359,
+ 8369.70034301, 423.4410260173, 1721.308093883, 3815.021552281/
DATA (POWER(I), I=77,100)/
+ 3096.896818539, 11123.46224798, 8573.673551723, 323.9146852672,
+ 496.8216394068, 716.3789266813, 707.1830537755, 395.452882063,
+ 185.9121866205, 349.7278623283, 579.1256929328, 427.7957796537,
+ 339.4866401359, 404.7726592585, 3303.494231505, 47871.8067107,
+ 168132.2764905, 259620.2781873, 5391035104119, 186.2399260743,
+ 47205.82833591, 220.74733211, 1615.454279283, 876.7523693048,
+ 780.32151955, 869.2380712535, 806.9102907816, 1417.4856363451,
+ 13314.80558278, 42705.82833591, 5693.322987158, 3452.68295359,
+ 8369.70034301, 423.4410260173, 1721.308093883, 3815.021552281/
C CONVVERT DATA TO BE REPRESENTED AS LOGARITHMIC
DO 1 I=1,100
  FREQ(I)=LOG10(REAL(I))
  POWER(I)=LOG10(Power(I))
1 C INITIALIZE GRAPICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
   IDEV=0
   CALL LEZINI(IDEV)
C SET LEZ ATTRIBUTES
   NVALS=100
   TITLE='POWER LEVEL VS. FREQUENCY'
   IAXLBL='FREQUENCY, [ELC]H[BLC]Z'
   DAXLBL='POWER LEVEL'
   INDMIN=LOG10(1.)
   INDMAX=LOG10(100.0)
   DEPMIN=LOG10(65.0)
   DEPMAX=LOG10(290000.0)
IAXTYP=3
IHLOGI=0
IVLOGI=0
INDHV=1
LINAPP=1

C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
+DEPMIN,DEPMAX,IAXTYP,IHLXI,IVLOGI,INDHV,LINAPP)

C OUTPUT A NOTE ON THE DISPLAY DEVICE
CALL LEZNOT('CDL3',7.,0.,3,1,0)

C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
CALL JWINDO(0.,7.,0.,7.)
CALL JVPORT(-1.,1.,-1.,1.)

C GET CURRENT LEZ AXES VALUES
CALL LEZGET('XORIGIN',XOR,NVALS,MVALS)
CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
CALL LEZGET('YORIGIN',YOR,NVALS,WALS)
CALL LEZGET('VAXLEN',YLEN,NVALS,MVALS)
CALL JOPEN

C HORIZONTAL AXIS
C SEE INDMIN,INDMAX ABOVE FOR THE FOLLOWING VALUES
CALL CEXP(1.,100.,MINH,MAXH)
NTICH=(MAXH-MINH)+1
CALL CHLABJ(1)
CALL CHLOGS(MINH)
CALL CHLOGF(1)
CALL CHLOG(XLEN,NTICH,0)

C RESTORE VALUES FOR LEZ ROUTINES
CALL CHLABJ(0)

C VERTICAL AXIS
C SEE DEPMIN,DEPMAX ABOVE FOR THE FOLLOWING VALUES
CALL CEXP(65.0,290000.0,MINV,MAXV)
NTICV=(MAXV-MINV)+1
CALL CVLABJ(1)
CALL CVLOGS(MINV)
CALL CVLOGF(1)
CALL CVLOG(YLEN,NTICV,0)

C RESTORE VALUES FOR LEZ ROUTINES
CALL CVLABJ(0)

C CALL CLGRID
CALL JMOVE(XOR,YOR)
IXC=NTICH-1
IYC=NTICV-1
XSC=XLEN/REAL(IXC)
YSC=YLEN/REAL(IYC)
XGS=1.
YGS=1.
XGI=1.
YGI=1.
NBLANK=1
CALL CLGRID(XSC,YSC,IXC,IYC,XGS,YGS,XGI,YGI,BLANK,NBLANK)
CALL JCLOSE

C Generate graphics output for the LEZ routines
CALL LEZSHW

C Terminate all graphics
CALL LEZTRM

C---------------------------------------------
STOP
END
Figure CDLL4. Program interfacing the low-level routines with the LEZ Routines (this program is CDLL3 modified to CALL CLGRID(semi-log)).
PROGRAM CDLL4

C PROGRAM INTERFACING THE LOW-LEVEL ROUTINES WITH THE LEZ ROUTINES.
C NOTE: THIS PROGRAM IS CDLL3 MODIFIED TO CALL CLGRID (SEMI-LOG).

C-----------------------------------------------------------------------
CHARACTER TITLE*80, IAXLBL*80, DAXLBL*80
REAL FREQ(100), POWER(100), INDMIN, INDMAX, BLANK(4)
DATA BLANK/0.,0.,0.,0./
DATA (POWER(I), I=1,100)
+ 7066.0770323, 31398.5856597, 23005.34014683, 25971.13637497,
+ 23314.47811626, 16222.72126064, 11123.46224798, 8573.673551723,
+ 6533.280733426, 6567.484820724, 3938.878376374, 2372.668800947,
+ 990.5827153465, 1139.692923046, 990.5827153465, 101610.8109471,
+ 90151.05684161, 32565.81919631, 3126.25985372, 5378.83275207,
+ 19139.27829711, 26311.51279586, 1114.906853713, 18051.10302768,
+ 2769.064915013, 292.8078714839, 913.1650006148, 1111.29098571,
+ 763.2538952391, 1036.757022708, 2318.840862193, 1815.115702427,
+ 1546.468077257, 30998.7901891, 90446.39960755, 99542.65318885,
+ 46517.56984878, 8264.407149583, 477.487313473, 82.183079214,
+ 67.750188438, 136.6466858328, 197.6147132091, 229.3505457034,
+ 643.2165902202, 1824.921600301, 5246.01888617, 9355.94235835,
+ 8240.20257789, 4042.51648696, 1615.454279283, 876.7523693048,
+ 780.32151955, 869.2380712535, 806.910297816, 1417.485863451,
+ 13314.08558278, 42705.82833591, 56933.22987158, 8369.70034301,
+ 8369.70034301, 423.4410260173, 1721.3080938833, 3815.021552281/
DATA (POWER(I), I=77,100)
+ 3096.896818539, 1130.33337685, 351.6629052997, 323.9146852672,
+ 496.8216394068, 716.3789266813, 707.1830537755, 395.452882063,
+ 185.9595078555, 349.7278623283, 579.1256929328, 427.7957796537,
+ 339.4866401359, 404.7726592585, 3303.494231505, 168132.2764905,
+ 168132.2764905, 259620.2781873, 179647.069922, 51634.19154093,
+ 4701.338454798, 220.74733211, 377.2257021375, 552.6383507909/
C-----------------------------------------------------------------------

C CONVET DATA TO BE REPRESENTED AS LOGARITHMIC
DO 1 I=1,100
FREQ(I)=LOG10(REAL(I))
1 POWER(I)=LOG10(POWER(I))
C-----------------------------------------------------------------------

C INITIALIZE GRAPHICS PACKAGE, THEN INITIALIZE AND SELECT DISPLAY DEVICE.
IDEV=0
CALL LEZINI(IDEV)
C-----------------------------------------------------------------------

C SET LEZ ATTRIBUTES
NVALS=100
TITLE='P[BLC]OWER LEVEL VS. FREQUENCY'
IAXLBL='P[BLC]REQUENCY, [ELC]H[BLC]Z'
DAXLBL='P[BLC]OWER LEVEL'
INDMIN=LOG10(1.)
INDMAX=LOG10(100.0)
DEPMIN=LOG10(65.0)
DEPMAX=LOG10(290000.0)

B - 105
IAXTYP=3
IHLOGI=0
IVLOGI=0
INDHV=1
LINAPP=1

C CALL LEZLOG (SET LEZ LOG ATTRIBUTES)
   CALL LEZLOG(FREQ,POWER,NVALS,TITLE,IAXLBL,DAXLBL,INDMIN,INDMAX,
               +DEPMIN,DEPMAX,IAXTYP,IHLOGI,IVLOGI,INDHV,LINAPP)

C CALL LEZNOT ('CDLSE4',7.,0.,3,1,0)
C USE LOW-LEVEL ROUTINES TO ADD EXTRA AXES.
C SET WINDOW AND VIEWPORT TO MATCH LEZ'S DEFAULTS.
   CALL JWINDO(0.,7.,0.,7.)
   CALL JVPORT(-1.,1.,-1.,1.)

C GET CURRENT LEZ AXES VALUES
   CALL LEZGET('XORIGIN',XOR,NVALS,MVALS)
   CALL LEZGET('HAXLEN',XLEN,NVALS,MVALS)
   CALL LEZGET('YORIGIN',YOR,NVALS,MVALS)
   CALL JOPEN

C HORIZONTAL AXIS
   CALL JMMOVE(XOR,YOR+YLEN)
   C SEE INDMIN,INDMAX ABOVE FOR THE FOLLOWING VALUES
   CALL CEXP(1.,100.,MINH,MAXH)
   NTICH=(MAXH-MINH)+1
   CALL CHLABJ(1)
   CALL CHLOGS(MINH)
   CALL CHLOGF(1)
   CALL CHLOG(XLEN,NTICH,0)

C RESTORE VALUES FOR LEZ ROUTINES
   CALL CHLABJ(0)

C VERTICAL AXIS
   CALL JMMOVE(XOR+XLEN,YOR)
   C SEE DEPMIN,DEPMAX ABOVE FOR THE FOLLOWING VALUES
   CALL CEXP(65.0,290000.0,MINV,MAXV)
   NTICV=(MAXV-MINV)+1
   CALL CVLABJ(1)
   CALL CVLOGS(MINV)
   CALL CVLOGF(1)
   CALL CVLOG(YLEN,NTICV,0)

C RESTORE VALUES FOR LEZ ROUTINES
   CALL CVLABJ(0)

C CALL CLGRID
   CALL JMMOVE(XOR,YOR)
   IXC=-1
   IYC=NTICV-1
   XSC=XLEN
   YSC=YLEN/REAL(IYC)
   XGS=0.
   YGS=1.
XGI=XLEN/REAL(NTICH-1)
YGI=1.
NBLANK=1
CALL CLGRID(XSC,YSC,IXC,IYC,XGS,YGS,XGI,YGI,BLANK,NBLANK)
CALL JCLOSE

C---------------------------------------------------------------------
C GENERATE GRAPHICS OUTPUT FOR THE LEZ ROUTINES
CALL LEZSHW
C TERMINATE ALL GRAPHICS
CALL LEZTRM
C---------------------------------------------------------------------
STOP
END
Appendix C

A List of DI-3000 Routines

This appendix provides a list of DI-3000 routines, and a one line description of their purpose. The contents of this appendix was obtained from PVI's DI-3000 User's Guide [G-5].

Chapter 3 Functional Descriptions Chapter 3

3.18 DI-3000 SUBROUTINE SUMMARY

Listed below are all the DI-3000 subroutines grouped by function. Some subroutines appear in more than one place to show all their functional groupings. The functions of these subroutines have been discussed in the preceding sections of Chapter 3. Each individual subroutine is completely described in Appendix A of this User's Guide. Subroutines marked [E] are part of DI-3000 Extended; those marked [M] are part of the Metafile System. Both are options to DI-3000 and may not be available at all installations.

3.18.1 SYSTEM AND DEVICE CONTROL

<table>
<thead>
<tr>
<th>Subroutine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JBEGIN</td>
<td>Initialize DI-3000</td>
</tr>
<tr>
<td>JEND</td>
<td>Terminate DI-3000</td>
</tr>
<tr>
<td>JDINIT</td>
<td>Initialize a device</td>
</tr>
<tr>
<td>JDEVON</td>
<td>Select a device</td>
</tr>
<tr>
<td>JDEVOF</td>
<td>Deselect a device</td>
</tr>
<tr>
<td>JEND</td>
<td>Terminate a device</td>
</tr>
</tbody>
</table>

3.18.2 DRAWING PRIMITIVES

<table>
<thead>
<tr>
<th>Subroutine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JMOVE</td>
<td>Invoke an absolute, 2D move</td>
</tr>
<tr>
<td>JRMOVE</td>
<td>Invoke a relative, 2D move</td>
</tr>
<tr>
<td>J3MOVE</td>
<td>Invoke an absolute, 3D move</td>
</tr>
<tr>
<td>JR3MOV</td>
<td>Invoke a relative, 3D move</td>
</tr>
<tr>
<td>JDRAW</td>
<td>Invoke an absolute, 2D draw</td>
</tr>
<tr>
<td>JRDRAW</td>
<td>Invoke a relative, 2D draw</td>
</tr>
<tr>
<td>J3DRAW</td>
<td>Invoke an absolute, 3D draw</td>
</tr>
<tr>
<td>JR3DRA</td>
<td>Invoke a relative, 3D draw</td>
</tr>
<tr>
<td>JPOLY</td>
<td>Draw an absolute, 2D polyline</td>
</tr>
<tr>
<td>JRPOLY</td>
<td>Draw a relative, 2D polyline</td>
</tr>
<tr>
<td>J3POLY</td>
<td>Draw an absolute, 3D polyline</td>
</tr>
<tr>
<td>JR3PLY</td>
<td>Draw a relative, 3D polyline</td>
</tr>
<tr>
<td>JMARK</td>
<td>Draw an absolute, 2D marker</td>
</tr>
<tr>
<td>JRMARK</td>
<td>Draw a relative, 2D marker</td>
</tr>
<tr>
<td>J3MARK</td>
<td>Draw an absolute, 3D marker</td>
</tr>
<tr>
<td>JR3MRK</td>
<td>Draw a relative, 3D marker</td>
</tr>
<tr>
<td>JFMARK</td>
<td>Draw an absolute, 2D polymarker</td>
</tr>
<tr>
<td>JPRMRK</td>
<td>Draw a relative, 2D polymarker</td>
</tr>
<tr>
<td>J3PRMK</td>
<td>Draw an absolute, 3D polymarker</td>
</tr>
<tr>
<td>JPR3MR</td>
<td>Draw a relative, 3D polymarker</td>
</tr>
<tr>
<td>JPOLGN</td>
<td>Draw an absolute, 2D polygon</td>
</tr>
<tr>
<td>JRPLGN</td>
<td>Draw a relative, 2D polygon</td>
</tr>
<tr>
<td>J3PLGN</td>
<td>Draw an absolute, 3D polygon</td>
</tr>
<tr>
<td>JR3PGN</td>
<td>Draw a relative, 3D polygon</td>
</tr>
<tr>
<td>JRECT</td>
<td>Draw an absolute rectangle</td>
</tr>
<tr>
<td>JRRECT</td>
<td>Draw a relative rectangle</td>
</tr>
<tr>
<td>J3CIRCL</td>
<td>Draw a circle</td>
</tr>
<tr>
<td>JCIRCL</td>
<td>Draw a circle</td>
</tr>
<tr>
<td>J3SECTR</td>
<td>Draw a sector</td>
</tr>
<tr>
<td>JSECTR</td>
<td>Draw a sector</td>
</tr>
<tr>
<td>JARC</td>
<td>Draw an arc</td>
</tr>
<tr>
<td>JF2PLN</td>
<td>Generate a &quot;smoothed&quot; polyline</td>
</tr>
</tbody>
</table>

3.18.3 PRIMITIVE ATTRIBUTES

<table>
<thead>
<tr>
<th>Subroutine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JCOLOR</td>
<td>Set the current color</td>
</tr>
<tr>
<td>JDCOLR</td>
<td>Set the default color</td>
</tr>
<tr>
<td>JINTEN</td>
<td>Set the current intensity</td>
</tr>
<tr>
<td>JDINTE</td>
<td>Set the default intensity</td>
</tr>
</tbody>
</table>

C - 1
3.18.4 TEXT
PRIMITIVES AND
ATTRIBUTES

Text output primitives:

J1TEXT  Output string precision text (FORTRAN 66)
J1STRG  Output string precision text (FORTRAN 77)
J2TEXT  Output character precision text (FORTRAN 66)
J2STRG  Output character precision text (FORTRAN 77)
J3TEXT  Output stroke precision text (FORTRAN 66)
J3STRG  Output stroke precision text (FORTRAN 77)
JHTEXT  Output graphic arts precision text (FORTRAN 66)
JHSTRG  Output graphic arts precision text (FORTRAN 77)

Text attributes:

JPATH   Set the current character path
JDPATH  Set the default character path
JFONT   Set the current character font
JDFONT  Set the default character font
JJUST   Set the current text justification
JDJUST  Set the default text justification
JSIZE   Set the current character size
JDSIZE  Set the default character size
JGAP    Set the current character gap
JDGAP   Set the default character gap
JBASE   Set the current character base line
JDBASE  Set the default character base line
JPLANE  Set the current character plane
JDPLAN  Set the default character plane
JCESUB  Set the current size and position of subscripts.
JDESUB  Set the default size and position of subscripts
JCESUP  Set the current size and position of superscripts
JDESUP  Set the default size and position of superscripts
JCEFLG  Set the current sentinel character flags (FORTRAN 66)
Chapter 3

Functional Descriptions

Chapter 3

3.18.5 SEGMENTS

AND SEGMENT

ATTRIBUTES

Segment creation:

JOPEN Open a temporary segment
JCLOSE Close a temporary segment
JROPE[N] Open a retained segment
JRCELSE Close a retained segment

Segment attributes:

JTYP[E] Define a global image transformation type
JVISBI[E] Set the visibility of a retained segment
JVDIR[E] Set the default visibility of subsequent retained segments
JVSAI[E] Set the visibility of all retained segments on all devices
JHILI[E] Set the highlighting of a retained segment
JHILIE Set the default highlighting of subsequent retained segments
JDETEC[E] Set the detectability and PICK priority of a retained segment
JDEITE[E] Set the default detectability and PICK priority of subsequent retained segments
JSGPRI[E] Set the segment priority of a retained segment
JDSGPRI[E] Set the default segment priority for subsequently created segments
JPKID[E] Set the PICK-ID of subsequent primitives within a retained segment
JDPKID[E] Set the default PICK-ID of subsequent primitives within a retained segment

Segment operations:

JRENAM[E] Rename a retained segment
JPURGE[E] Delete a retained segment
JCLEAR[E] Delete all retained segments
JSASSO[E] Associate a retained segment with a specific device
JSDASS[E] Disassociate a retained segment from a specific device
JSAAL[E] Associate or disassociate all segments with a specific device

JDEFLG Set the default sentinel character flags (FORTRAN 66)
JSEFL Set the current sentinel character flags (FORTRAN 77)
JSEFL Set the default sentinel character flags (FORTRAN 77)

Text positioning and text inquiry:

JCRLF Generate a carriage return/line feed
JMARGN Set the character margin
JEXTNT Return the string extent, stroke precision (FORTRAN 66)
JSTXTN Return the string extent, stroke precision (FORTRAN 77)
JHXTNT Return the string extent, graphic arts precision (FORTRAN 66)
JHSXTN Return the string extent, graphic arts precision (FORTRAN 77)
JIQTXT Return the hardware text character size

3.18.5 SEGMENTS

AND SEGMENT

ATTRIBUTES

Segment creation:

JOPEN Open a temporary segment
JCLOSE Close a temporary segment
JROPE[N] Open a retained segment
JRCELSE Close a retained segment

Segment attributes:

JTYP[E] Define a global image transformation type
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JVDIR[E] Set the default visibility of subsequent retained segments
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JDSGPRI[E] Set the default segment priority for subsequently created segments
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Segment operations:

JRENAM[E] Rename a retained segment
JPURGE[E] Delete a retained segment
JCLEAR[E] Delete all retained segments
JSASSO[E] Associate a retained segment with a specific device
JSDASS[E] Disassociate a retained segment from a specific device
JSAAL[E] Associate or disassociate all segments with a specific device

C - 3
### Functional Descriptions

#### 3.18.6 Shielding Regions

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSHLDW</td>
<td>Define a shielding region in world coordinates</td>
</tr>
<tr>
<td>JSHLDV</td>
<td>Define a shielding region in virtual coordinates</td>
</tr>
<tr>
<td>JSHCLP</td>
<td>Enable or disable shielding within a shielding region</td>
</tr>
<tr>
<td>JSCALL</td>
<td>Enable or disable shielding within all shielding regions</td>
</tr>
<tr>
<td>JIQSHL</td>
<td>Determine if a shielding region has been defined and return the shielding status and coordinates</td>
</tr>
<tr>
<td>JIQNSH</td>
<td>List the identifiers of all currently defined shielding regions</td>
</tr>
<tr>
<td>JSHPRG</td>
<td>Delete a shielding region</td>
</tr>
<tr>
<td>JSPALL</td>
<td>Delete all shielding regions</td>
</tr>
</tbody>
</table>

#### 3.18.7 Viewing Transformations

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JWINDO</td>
<td>Define the viewing window</td>
</tr>
<tr>
<td>JVUPRT</td>
<td>Define the viewport</td>
</tr>
<tr>
<td>JNORML</td>
<td>Define the viewplane normal</td>
</tr>
<tr>
<td>JVPLN</td>
<td>Define the viewplane distance</td>
</tr>
<tr>
<td>JUPVEC</td>
<td>Define the viewup vector</td>
</tr>
<tr>
<td>JPARAL</td>
<td>Set the projection to parallel</td>
</tr>
<tr>
<td>JPAROB</td>
<td>Set the projection to parallel oblique</td>
</tr>
<tr>
<td>JPERSP</td>
<td>Set the projection to perspective</td>
</tr>
<tr>
<td>JPEROB</td>
<td>Set the projection to perspective oblique</td>
</tr>
<tr>
<td>JCVIEW</td>
<td>Define a viewing transformation in world Cartesian coordinates</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>JSVIEW</td>
<td>Define a viewing transformation in world spherical coordinates</td>
</tr>
<tr>
<td>JHITHR</td>
<td>Set the hither plane distance</td>
</tr>
<tr>
<td>JYON</td>
<td>Set the yon plane distance</td>
</tr>
<tr>
<td>JWCLIP</td>
<td>Turn window clipping on or off</td>
</tr>
<tr>
<td>JHCLIP</td>
<td>Turn hither clipping on or off</td>
</tr>
<tr>
<td>JYCLIP</td>
<td>Turn yon clipping on or off</td>
</tr>
<tr>
<td>JVSPAC</td>
<td>Redefine the dimensions of the virtual coordinates</td>
</tr>
<tr>
<td>JRIGHT</td>
<td>Change the &quot;handedness&quot; of the world coordinate system</td>
</tr>
<tr>
<td>JRESET</td>
<td>Reset the viewing transformation to default</td>
</tr>
<tr>
<td>JVSAVE</td>
<td>Save the current viewing parameters into an array</td>
</tr>
<tr>
<td>JVLOAD</td>
<td>Replace the current viewing parameters from a previously saved array</td>
</tr>
</tbody>
</table>
3.18.8 INPUT FUNCTIONS

JENAB  Associate a physical input device with a virtual input function on a specific display device
JDISA  Disassociate a physical input device from a virtual input function on a specific display device
JBUITN  Request BUTTON input
JLOCAT  Request LOCATOR input
JVALUE  Request VALUATOR input
KEYBD  Request KEYBOARD input (FORTRAN 66)
JKEYBS  Request KEYBOARD input (FORTRAN 77)
JSTROK  Request STROKE input
JPICK] Request PICK input
JSPICK Request a software simulation of PICK
JPAPK  Define the size of the PICK aperture
JCONPK  Continue a PICK function
JEPSEG  Establish a PICK list of retained segments
JPECHO  Set the echo position for subsequent input functions
JELSEG  Associate the image transformation with a LOCATOR input echo
JEVSEG  Associate the image transformation with a VALUATOR input echo

3.18.9 IMAGE TRANSFORMATIONS

JTYP[E]  Define a global image transformation type
JT2TRA  Set a 2D translation image transformation for a retained segment
JT2ALL Set a complete image transformation for a retained segment
JELSEG  Associate the image transformation with a LOCATOR input echo
JEVSEG  Associate the image transformation with a VALUATOR input echo
JIQ2TR Return the 2D translation components of an image transformation
JIE2AI Return all 2D components of an image transformation

3.18.10 MODELING TRANSFORMATIONS

TRANS Define a modeling transformation matrix
BUILD Build on an existing modeling transformation matrix
MODEL Select a modeling matrix for subsequent primitives
MOBON Enable or disable the current modeling matrix
JCONCT Concatenate two existing transformation matrices

3.18.11 DEVICE TRANSFORMATIONS

DEVWN Define the device window
DEVVP Define the device viewport

3.18.12 SYSTEM AND DEVICE INQUIRY

JCP  Return the current position in world coordinates
JIQDDL Return the release level of the device driver
JIQDIM Return the release level of DI-3000
JIQDIM Return the maximum dimensions of the display device in meters
### Chapter 3 Functional Descriptions

- **JIQERR**: Return the most recent error number detected
- **JIWIND**: Return the window location in 3D, untransformed world coordinates
- **JI1GET**: Return a single INTEGER value (e.g., a current attribute value)
- **JI3RGET**: Return three floating point values (e.g., the view reference point)
- **JI4RGET**: Return four floating point values (e.g., the viewport borders)
- **JI6GET**: Return a four-by-four floating point matrix defining a transformation
- **JASPEK**: Return the aspect ratio of a physical device
- **JIQTXT**: Return the hardware text character size
- **JIQDEV**: Return an INTEGER characteristic of a device (e.g., the number of colors supported)
- **JISGMT[E]**: Return an array of information on a particular retained segment
- **JIQ2TR[E]**: Return the 2D translation components of an image transformation
- **JIQ2AI[E]**: Return all 2D components of an image transformation

#### 3.18.13 METAFILE SYSTEM
- **JDINIT**: Initialize the Metafile Driver
- **JDEVON**: Select the Metafile Driver
- **JDEVOF**: Deselect the Metafile Driver
- **JEND**: Terminate the Metafile Driver
- **JMFDAT[M]**: Write a data record to the metafile
- **JMFFMT[M]**: Set the metafile format
- **JIQFMT[M]**: Inquire capability of system to determine input file format
- **JMTEXT[M]**: Write a picture title to the metafile (FORTRAN 66)
- **JMSTRG[M]**: Write a picture title to the metafile (FORTRAN 77)
- **JMGET[M]**: Return the current item code from the metafile
- **JMREAD[M]**: Return the current item from the metafile
- **JMINTR[M]**: Translate the metafile item into a DI-3000 action

#### 3.18.14 ERROR PROCESSING AND DEBUGGING
- **JSETER**: Set the error fatality level
- **JSETDB**: Set the debugging commentary level
- **JFILES**: Set the logical unit number of the error log or debug file
- **JFTOPN**: Set the logical unit number and/or file name of the error log or debug file (FORTRAN 66)
- **JFSOPN**: Set the logical unit number and/or file name of the error log or debug file (FORTRAN 77)

#### 3.18.15 SPECIAL DEVICE FUNCTIONS
- **JPAUSE**: Request a pause action
- **JDD3D**: Use 3D virtual coordinates at the device dependent level
- **JBACKG**: Set the background color
- **JCOLTBL**: Download a color table of device dependent color indices
- **JESCAP**: Invoke an output escape function
- **JIESCP**: Invoke an input escape function
- **JINESC**: Inquire a physical device on the availability of escape functions
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>JBEAM</td>
<td>Explicitly position the drawing beam on a device</td>
</tr>
<tr>
<td>JFILES</td>
<td>Set the logical unit number for several internal files</td>
</tr>
<tr>
<td>JFTOPN</td>
<td>Set the logical unit number and/or name for several internal files (FORTRAN 66)</td>
</tr>
<tr>
<td>JFSOPN</td>
<td>Set the logical unit number and/or name for several internal files (FORTRAN 77)</td>
</tr>
<tr>
<td>JCONVW</td>
<td>Convert virtual coordinates to world coordinates</td>
</tr>
<tr>
<td>JCONWV</td>
<td>Convert world coordinates to virtual coordinates</td>
</tr>
<tr>
<td>JFRAME</td>
<td>Clear the display surface and redraw all retained segments</td>
</tr>
<tr>
<td>JUPDAT</td>
<td>Flush the internal buffers to ensure that the picture is current</td>
</tr>
</tbody>
</table>
Appendix D

How to Access and Execute the Common Graphics Library

This appendix explains how to access and execute the CGL on several computer systems. It contains the following sections:

1.0 Accessing the Common Graphics Library on NOS
   1.1 Manual Load Sequence
   1.2 Batch CCL Procedure

2.0 Accessing the Common Graphics Library on PRIMOS
   2.1 Load Sequence Using Unshared Versions of DI-3000
   2.2 Load Sequence Using Shared Version of DI-3000

3.0 Accessing the Common Graphics Library on VAX

Any FORTRAN 77 code will be able to access the CGL routines which currently use the DI-3000 based CGL. The CGL does not contain any PVI software; therefore, the device drivers, DI-3000 library, extended library, and any other DI-3000 based software must be loaded with the CGL. The user should consider the CGL as an extension of their graphics program. Because NOS and PRIME are ACD supported systems, procedures for these machines are given in this section. As the CGL is moved onto other ACD supported systems, this section will be expanded.
1.0 Accessing The Common Graphics Library On NOS

The CGL is available as a user library under the user number UN=LIBRARY. It may be accessed and loaded manually in a job stream or terminal session. There are also Cyber Control Language (CCL) procedures to facilitate both batch and interactive operation of the CGL.

1.1 Manual Load Sequence

Metafile Driver LOAD/EXECUTE Sequence (NOS)

ATTACH,DI3000,DIERFN,MFNODE,SSDUMMY,DD4014/UN=LIBRARY.
ATTACH,DICOMLB/UN=LIBRARY.
LDSET,LIB=DI3000/DICOMLB,MAP=N.
LOAD,MFNODE,SSDUMMY,DD4014.
LGO.

NGS LOAD/EXECUTE Sequence

ATTACH,DI3000,DIERFN,MFDUMMY,SSDUMMY,DD=DD4014/UN=LIBRARY.
ATTACH,DICOMLB/UN=LIBRARY.
LDSET,LIB=DI3000/DICOMLB,MAP=N.
LOAD,MFDUMMY,SSDUMMY,DD.
LGO.
1.2 Batch CCL Procedure

There are two batch procedures to run the CGL. The first procedure uses the standard NOS load sequence and is called CGLGO. The second, called CGLCGO, uses the capsule loader version of DI-3000. Their usage is given below:

GET,CGLGO/UN=PVINFO.
CGLGO,DRIVER,MF,SS,ACCOUNT.

Where: DRIVER - the device driver to be loaded.
MF - the metafile (omit if none is desired)
MFNODE - if one is desired.
SS - use the extended version of DI-3000
ACCOUNT - ACCOUNT other than LIBRARY (not recommended unless a special driver is used.)

GET,CGLCGO/UN=PVINFO.
CGLCGO,LGO,DRIVER,MF,SS,ACCOUNT.

Where: LGO - the relocatables of the user's program.
DRIVER - the device driver to be loaded.
MF - the metafile (omit if none is desired)
MFNODE - if one is desired.
SS - use the extended version of DI-3000
ACCOUNT - ACCOUNT other than LIBRARY (not recommended unless a special device driver is used).
2.0 Accessing The Common Graphics Library On PRIMOS

The CGL is available as a user library on the PRIME network. The CGL pathname is:

PVI.INFO>CGL>DICOM.LIB

and it is located on the M machine. The user can use the load sequences below to build CPL files to create and execute a SEG file for a CGL application program. These sequences can also be performed manually.

The following assumptions hold for all the load sequences in this section:

1) application program resides on a file named TEST.F77.
2) all programs compiled using F77 compiler (i.e., F77 TEST).
3) target device is Tektronix 4014.

2.1 Load Sequence Using Unshared Versions of DI-3000

SEG -LOAD
ST 177774 (OPTIONAL)
LO TEST
LO PVI.INFO>CGL>DICOM.LIB
LI DIBASIC
LI DD4014
LI VAPPLB
LI Q

To execute:

SEG TEST
2.2 Load Sequence Using Shared Version of DI-3000

SEG -LOAD
ST 177774 (OPTIONAL)
LO TEST
LO PVL.INFO>CGL>DICOM.LIB
LI D13.SHR
LI VAPPLB
LI
Q

To execute:

SEG TEST

All conventions for using the shared version of DI-3000 (WHOAMI, metafiles, etc.) remain unchanged. See Section 7.1.4.2 of the Graphics Mini-Manual (Central Scientific Computing Complex Document G-1) for complete details.
3.0 Accessing The Common Graphics Library On Vax

Several VAX machines on the field have the CGL available to the users. The load sequence below can be used either in a .COM file or entered interactively.

The following assumptions hold for the given load sequence:

1) application program resides on a file of the form XXX.FOR.
2) all programs are compiled by executing the command FOR XXX, where XXX is the XXX.FOR file from 1).
3) the target device is a Tektronix 410X series terminal.

The load sequence is:

```
LINK 'P1' -
Dxxx:[CGL directory]DICOM.OLB/LIBRARY -
Dyyy:[D13000 directory]DILIB.OLB/LIBRARY -
Dyyy:[D13000 directory]DDR405.OBJ -
Dyyy:[D13000 directory]MFNODE.OBJ -
Dyyy:[D13000 directory]DIMFLIB.OLB/LIBRARY -
Dyyy:[D13000 directory]UTILLIB.OLB/LIBRARY -
```

where:

- 'P1' - XXX from 1) and 2) above
- Dxxx - disk where the CGL directory resides
- Dyyy - disk where the D13000 directory resides
- CGL directory - pathname to the CGL files
- D13000 directory - pathname to the D13000 files
- DICOM.OLB - CGL code (executables)
- DILIB.OLB - D13000 code
- DDR405.OBJ - device driver
- MFNODE - metatile device driver
- DIMFLIB.OLB - library containing I/O routines for the Metafile device driver
- UTILLIB.OLB - library containing utility routines for D13000

These two files need not be included in the load sequence if the metafile is not used.
NOTE: Since there is no centralized control over the different VAX machines on the field, the exact pathnames and filenames may be different from machine to machine. The system administrator for the user's machine should be contacted for specific directory and file information.
List of References

The following list of references are denoted by:

G-x refers to the ACD document series.

G-1 GRAPHICS MINI MANUAL (September 1985)


G-3 Langley Graphics System (January 1983)


G-6 Metafile System User's Guide

G-7 GRAFMAKER User's Guide, Precision Visuals Incorporated (PVI)

G-10 Device Driver Guides


NMI 1020.1E NASA Langley Research Center Management Manual (Paragraph 13b)
The intent of this report is to introduce and instruct the users how to use the Low-Level routines of the Common Graphics Library (CGL). The Low-Level routines form an application-independent graphics package enabling the user community to construct and design scientific charts conforming to the publication and/or viewgraph process. The Low-Level routines allow the user to design unique or unusual report-quality charts from a set of graphics utilities. The features of these routines can be used stand-alone or in conjunction with other packages to enhance or augment their capabilities. This library is written in ANSI FORTRAN 77, and currently uses a CORE-based underlying graphics package, and is therefore machine-independent, providing support for centralized and/or distributed computer systems.