FORTRAN GRAPHICS LIBRARY

SPECIAL PROBLEM

Presented to the Department of Computer Science
of the North Texas State University in Partial
Fulfillment of the Requirements

For the degree of

MASTER OF SCIENCE

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TABLE OF CONTENTS

(I) RESEARCH OBJECTIVE

The objective of this work is to help the faculty, staffs and students of NTSU to use the CalComp plotting facility very easily. Therefore, this work is written in such a step by step and self-explanatory way to help the reader to understand and grasp the esential technique of the computer plotting. Each subroutine illustrated in this work has been run and checked by our NTSU computer-CalComp plotting facility; the results of sample programs and illustrated graphs are believed to be very useful to understand each individual subroutine.

Basically, software packages are stored in the magnetic disk of the IBM 360 computer as the standard graphic subroutines. These subroutines were written in FORTRAN IV. The user can write the driving program to call these subroutines and alsc inputs the desire data to the computer for computation. The results of computation will be outputed and stored in the magnetic tape.

(II) BASIC PLOTTING ROUTINES

Many graphic applications require the generation of X-Y graphs to show the relationship between two or more sets of data. Usually these graphs can be produced easily and quickly by a suitably programmed combination of the six subroutines PLOTS, SCALE, AXIS, LINE, SYMBOL and NUMBER.

When plotting requirements cannot be satisfied by using the subroutines mentioned above, the user can call the PLOT subroutine which gives him direct control of pen movement(to any X, Y coordinate position), pen status(up or down).

2.1 PLOTS

It is used to initialize the PLOT subroutine. It must be called before calling any other subroutine. This entry opens the plot output device through the computer's operating system.

The calling sequence has three arguments:

```
CALL PLOTS(IBUF,NLOC,LDEV)
```

IBUF = a large storage area assigned to accumulate the plotter commands produced by PLOT. It should be defined by a DIMENSION statement as an array.

NLOC = the size required for IBUF. This argument's value should be same as the array size declared in the DIMENSION statement for IBUF.

LDEV = the logical output-device number which is assigned by the user. Usually LDEV=6 in NTSU system.

2.2 PLOT

The PLOT entry is used to move the pen in a straight line to a new position, with the pen up or down. It can be used to set a new reference point(origin). The calling sequence has three arguments:

CALL PLOT(XPAGE,YPAGE,±IPEN)

XPAGE = the X-coordinate of the new position to which the pen is to be moved relative to the current origin.

YPAGE = the Y-coordinate of the new position to which the pen is to be moved relative to the current origin.

±IPEN = a signed integer which controls the pen status (up or down), origin definition.

If IPEN = 2, the pen is down before moving, thus drawing a visible line.

If IPEN = 3, the pen is raised before moving.

If IPEN = -2 or -3, a new origin is defined at the position after the movement of the pen is completed. The logical X, Y coordinates of the new pen position are set equal to zero.

The last plotter call in a program IPEN must be 999. It causes the plottape to be closed.

Before the pen is moved, a reference point (an origin) must be defined.

2.3 FACTOR

This entry enables the user to magnify or reduce the size of the entire plot generated.

```
CALL FACTOR(FACT)
```

FACT = the ratio of the desired plot size to the normal plot size. For example, if FACT=0.5, all the distance of subsequent pen movements will be halved.

2.4 WHERE

This entry sets the three real variables to the current pen position coordinates and the current scaling factor(that are used by the PLOT subroutine).

The calling sequence has three arguments:

```
CALL WHERE(RXPAGE,RYPAGE,RFACT)
```

RXPAGE = the present X-coordinate relative to the current origin.

RYPAGE = the present Y-coordinate relative to the current origin.

RFACT = the value last supplied by a call to FACTOR, or 1.0 if FACTOR has not been called.

2.5 SYMBOL

The SYMBOL subroutine is designed to plot annotation at any angle and any size. There are two SYMBOL call formats: (1) the "standard" call, which can be used to draw text such as titles, captions, and legends; and (2) the "special" call, which is used to draw special centered symbols such as a box, octagon, triangle, etc., for plotting data points.

The standard characters that are drawn by SYMBOL include the letters A-Z, digits 0-9, and certain special characters.

The "standard" call is:

```
CALL SYMBOL(XPAGE,YPAGE,HEIGHT,IBCD,ANGLE,+NCHAR)
```

XPAGE,YPAGE = the coordinates, in inches, of the lower left-hand corner (before rotation) of the first character to be produced. The pen is up while moving to this point.

HEIGHT = the height, in inches, of the character to be plotted. The width of character, including spacing, is normally the same as the height.

IBCD = the text to be used as annotation. The character(s) must be left-justified and contiguous in a single variable, an array, or a Hollerith literal.

ANGLE = the angle, at which the annotation is to be plotted. If ANGLE=0.0, the character (s) will be plotted right side up and parallel to the X-axis. If ANGLE=90.0, the character(s) will be plotted parallel to the Y-axis.

+NCHAR = the number of characters to be plotted.

The second form is the "special" call, which produces only a single symbol based on the index value of INTEQ.

CALL SYMBOL(XPAGE,YPAGE,HEIGHT,INTEQ,ANGLE,-ICODE)

XPAGE,YPAGE = the coordinates in inches for the lower left-hand corner of the first character to be produced. If INTEQ is less than 14, XPAGE, YPAGE is the geometric center of the character produced.

HEIGHT = the height (and width), in inches, of the centered symbol to be plotted.

INTEQ = the integer representation of the desired symbol, If INTEQ is 0 through 13, a centered symbol is produced.

ANGLE = the angle, at which the annotation is to be plotted.

-ICODE = a value which determines when the pen is up or down during the move to XPAGE, YPAGE.

When -ICODE is:

-1, the pen is up during the move to XPAGE, YPAGE, after which a single symbol is produced.

-2, the pen is down during the move to XPAGE, YPAGE, after which a single symbol is produced.

Figure 1 shows a table with the integer equivalents for each symbol which are used in the "special" call.

Integer codes are used in special symbol call.

The first 14 symbols are centered symbols.

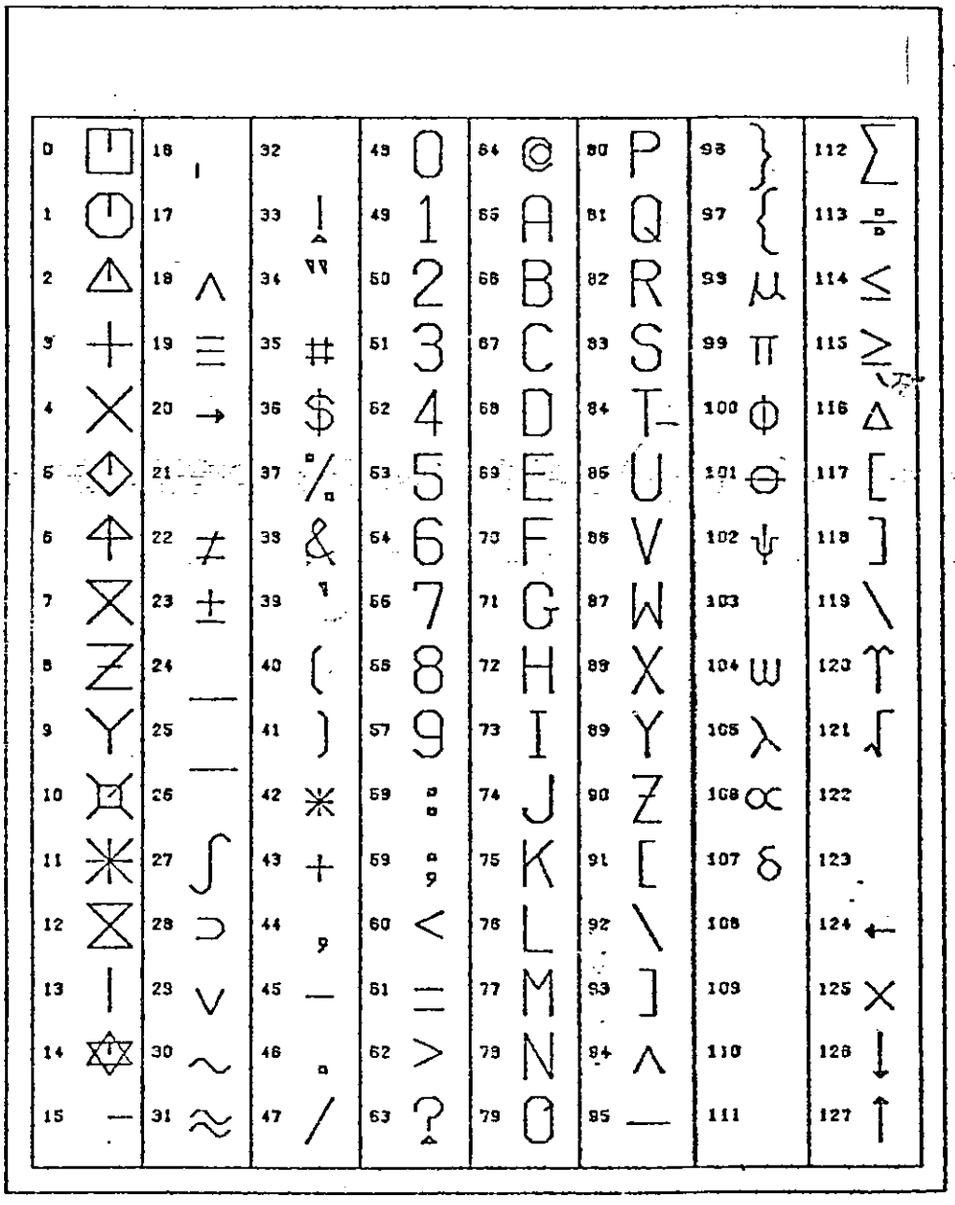


Figure 1

2.6 NUMBER

NUMBER converts a real number to the appropriate fixed-decimal equivalent and plots the converted number. The calling sequence has six arguments:

CALL NUMBER(XPAGE,YPAGE,HEIGHT,FPN,ANGLE,±NDEC)

XPAGE,YPAGE,HEIGHT and ANGLE are the same as those arguments described for subroutine SYMBOL.

FPN = the floating-point number that is to be converted and plotted.

±NDEC = the precision of the conversion of the number FPN.

If NDEC is greater than 0, it specifies the number of digits to the right of the decimal point that are to be converted and plotted, after proper rounding.

For example, the value of FPN is -0.9333421*10**3. If NDEC=3, the plotted number would be -933.342.

If NDEC=0, only the integer portion and a decimal point are presented.

If NDEC=-1, only the integer portion is plotted without decimal point, after rounding.

If NDEC is less than -1, |NDEC|-1 digits are truncated from the integer portion, after rounding.

The magnitude of NDEC should not exceed 9.

2.7 SCALE

The SCALE subroutine is used to examine the data values in an array and to determine a starting value and a scaling factor, such that: (1) the scale annotation drawn by the AXIS subroutine at each division will properly represent the range of real data values in the array; and (2) the data points, when plotted by the LINE subroutine, will fit in a given plotting area. These two values are computed and stored by SCALE at the last two elements of the array.

The scaling factor(DELTAV) is computed to represent the number of data units per inch of axis. The starting value (FIRSTV) will appear as the first annotation on the axis.

DELTAV=(XMAX-XMIN)/S
maximum data value minus minimum data value divided by the length over which the data is to be plotted.

FIRSTV=(XMIN/DELTAV)*DELTAV
the largest integer value less than or equal to the minimum data value divided by the adjusted DELTAV, multiplied by the adjusted DELTAV.

The SCALE subroutine chooses the "optimum" values so that the delta value per inch will be 1, 2, 4, 5 or 8 X 10**N. If the computed DELTAV contains a fractional part, SCALE routine will adjust DELTAV to the next larger whole number delta value.

Examples:

If DELTAV is computed as 6.3, the adjusted DELTAV becomes 8.0.

If DELTAV is computed as 5.0, DELTAV remains 5.0.

If the adjusted DELTAV is 5.0 and XMIN=12.0, then

FIRSTV = (12.0/5.0)*5.0 = (2.4)*5.0
adjusted FIRSTV = 2.0*5.0 = 10.0

If the adjusted DELTAV is 5.0 and XMIN=-12.0, then

FIRSTV= (-12.0/5.0)*5.0 = (-2.4)*5.0
adjusted FIRSTV = -3.0*5.0 = -15.0

If the adjusted DELTAV is 5.0 and XMIN=-10.0, then

FIRSTV = (-10.0/5.0)*5.0 = -2.0*5.0 = -10.0

There are four arguments in the calling sequence:

```
CALL SCALE(ARRAY,AXLEN,NPTS,*INC)
```

ARRAY = the first location of the array of data points.

AXLEN = the length of the axis to which the data is to be scaled.

NPTS = the number of data values to be examined in the array. The FORTRAN DIMENSION statement should specify at least two elements more than the number of values being scanned to allow room for SCALE to store the computed starting value(FIRSTV) and scaling factor(DELTAV) of the array.

*INC = the "step" size used by the SCALE subroutine to scan through the array.

If INC=1, ARRAY(NPTS+1) contains the adjusted starting value(FIRSTV) and ARRAY(NPTS+2) contains

the adjusted incremental value(DELTAV).

If INC is not equal to 1, then the minimum is returned in ARRAY(NPTS*INC+1) and the incremental value in ARRAY(NPTS*INC+INC+1).

SCALE example:

Consider the following data:

```
XARRAY  = location  001  50.0
                    002  30.1-----XMIN
                    003  65.0
                    004  91.2-----XMAX

YARRAY  = location  007  10.5
                    008  15.5
                    009  31.0
                    010  20.0
```

Scaling factor values are returned to the following by the SCALE routine:

005 contains FIRSTX
006 contains DELTAX
011 contains FIRSTY
012 contains DELTAY

To scale the values of XARRAY for a 10 inch axis

```
CALL SCALE(XARRAY,10.0,4,1)
```

DELTAX = (91.2-30.1)/10.0 = 6.11 units/inch

FIRSTX=24.0 will be stored in location 005.
DELTAX=8.0 will be stored in location 006.

To scale the values in YARRAY for a 10 inches axis:

```
CALL SCALE(YARRAY,10.0,4,1)
```

FIRSTV=8.0 will be stored in location 011.
The adjusted DELTAY=4.0 will be stored in location 012.

2.8 AXIS

This subroutine draws any length line at any angle, divides the line into one-inch intervals, annotates the divisions with appropriate scale values, and labels the axis with a centered title. When both X and Y axes are needed, AXIS should be called separately for each one.

There are eight arguments in the calling sequence:

```
CALL AXIS(XPAGE,YPAGE,IBCD,*NCHAR,AXLEN,ANGLE,FIRSTV,
          DELTAV)
```

XPAGE,YPAGE = the coordinates of the starting point of the axis line with respect to the current origin. The entire line and terminal ends should be at least one-half inch from either side of the paper to allow space for the scale annotation and axis title. Usually, both X and Y axes are joined at XPAGE and YPAGE which are equal to zero; but other starting points can be used if desired.

IBCD = the title, which is centered and placed parallel to the axis line. This parameter may be an alphanumeric array or a Hollerith literal. The characters have a fixed height of 0.14 inch.

*NCHAR = the number of characters of the axis title, and determines, by its sign, which side of the line the scale marks and labeling information shall be placed.

If NCHAR is negative, annotation is placed on the counterclockwise side of the axis. This condition is normally desired for the X-axis.

If NCHAR is positive, annotation is placed on the positive side of the axis. This condition is normally desired for the Y-axis.

AXLEN = the length of the axis line, in inches.

ANGLE = the angle of the axis to be drawn. Normally, this value is 0.0 for the X-axis and 90.0 for the Y-axis.

FIRSTV = the starting value of the axis. This value may be either computed and stored by the SCALE subroutine, or supplied by the user.

DELTAV = the increment between data units per inch of axis. This value may be computed by SCALE, or determined by the user.

If scaling is not required, the user must place the appropriate minimum and delta value in the calling sequence. For a one-to-one correspondence of a positive axes, these values should be 0.0(FIRSTV) and 1.0(DELTAV).

AXIS annotes all one-inch-axes intervals with numbers which are greater than .01 and less than 1000. These annotation numbers are FIRSTV, FIRSTV+DELTAV, FIRSTV+2*DELTAV, etc., multiplied by a constant (power of ten) so that all the annotation numbers fall within the range .01-999.99.

2.9 LINE

The LINE subroutine produces a line plot of the pairs of data values in two arrays (X and Y). LINE computes the page coordinates of each plotted point according to the data values in each array and the respective scaling parameters. The data points may be represented by centered symbols and/or connecting lines between points.

The scaling parameters corresponding to FIRSTV and DELTAV must immediately follow each array. If these parameters have not been computed by the SCALE subroutine, they must be supplied by the user.

The calling sequence has six arguments:

```
CALL LINE(XARRAY,YARRAY,NPTS,INC,±LINTYP,INTEQ)
```

XARRAY = array containing the abscissa (X) values and the scaling parameters for the X-array.

YARRAY = the array containing the ordinate (Y) values and the scaling parameters for the Y-array.

NPTS = the number of data points to be plotted in XARRAY and YARRAY. The count does not include the last two locations for the scaling parameters. The number of elements in each array must be the same.

INC = the "step" size to be used to gather the data from both arrays as described previously for the SCALE subroutine.

±LINTYP = a control parameter which describes the type of line to be drawn through the data points.

If LINTYP is zero, the straight lines will connect the points with no symbols.

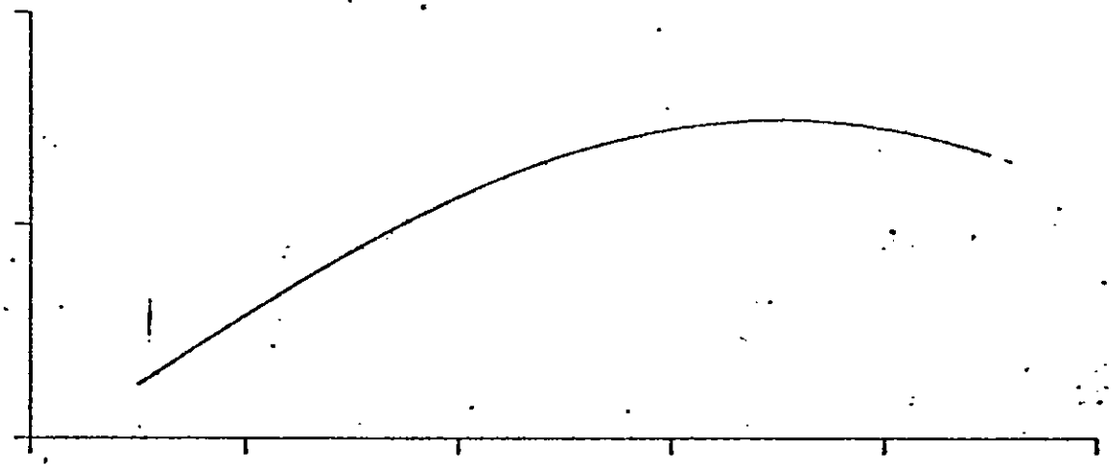
If LINTYP is positive, lines are drawn to connect all data points. If LINTYP = 1, a symbol is placed at every data point; LINTYP = 2 plots a symbol at every other data point; LINTYP = 4 puts a symbol at every fourth data point, etc.

If LINTYP is negative, symbols are plotted without connecting lines.

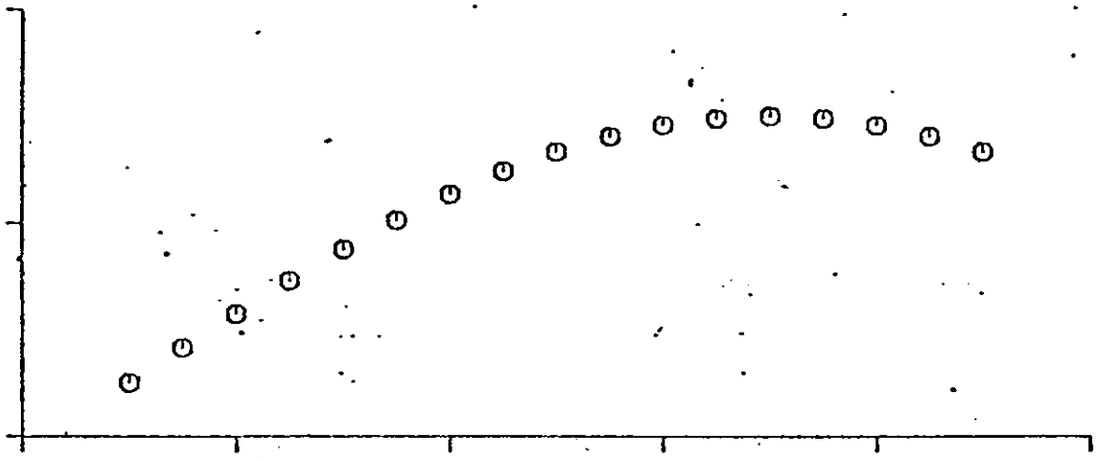
INTEQ = the integer equivalent of the special plotting symbol centered at each data point. This value normally can be 0 through 13, and has meaning only when LINTYP is not zero. Figure 1 lists the symbols that are available.

Figure 2 illustrates the types of lines drawn by various combinations of LINTYP and INTEQ.

A. CALL LINE (XARRAY,YARRAY,33,1,0,0)



B. CALL LINE (XARRAY,YARRAY,33,1,-2,1)



C. CALL LINE (XARRAY,YARRAY,33,1,1,2)

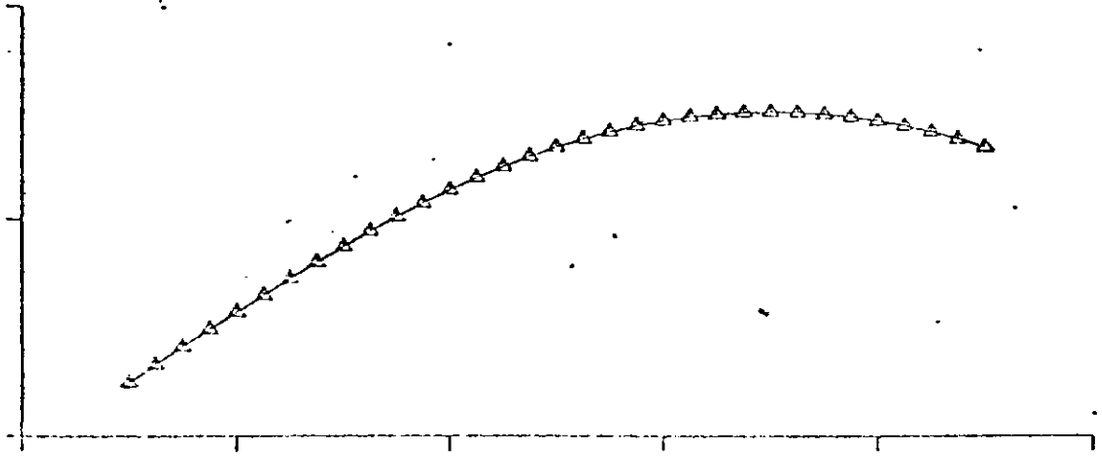


Figure 2.

(III) AN ILLUSTRATIVE SAMPLE PROGRAM

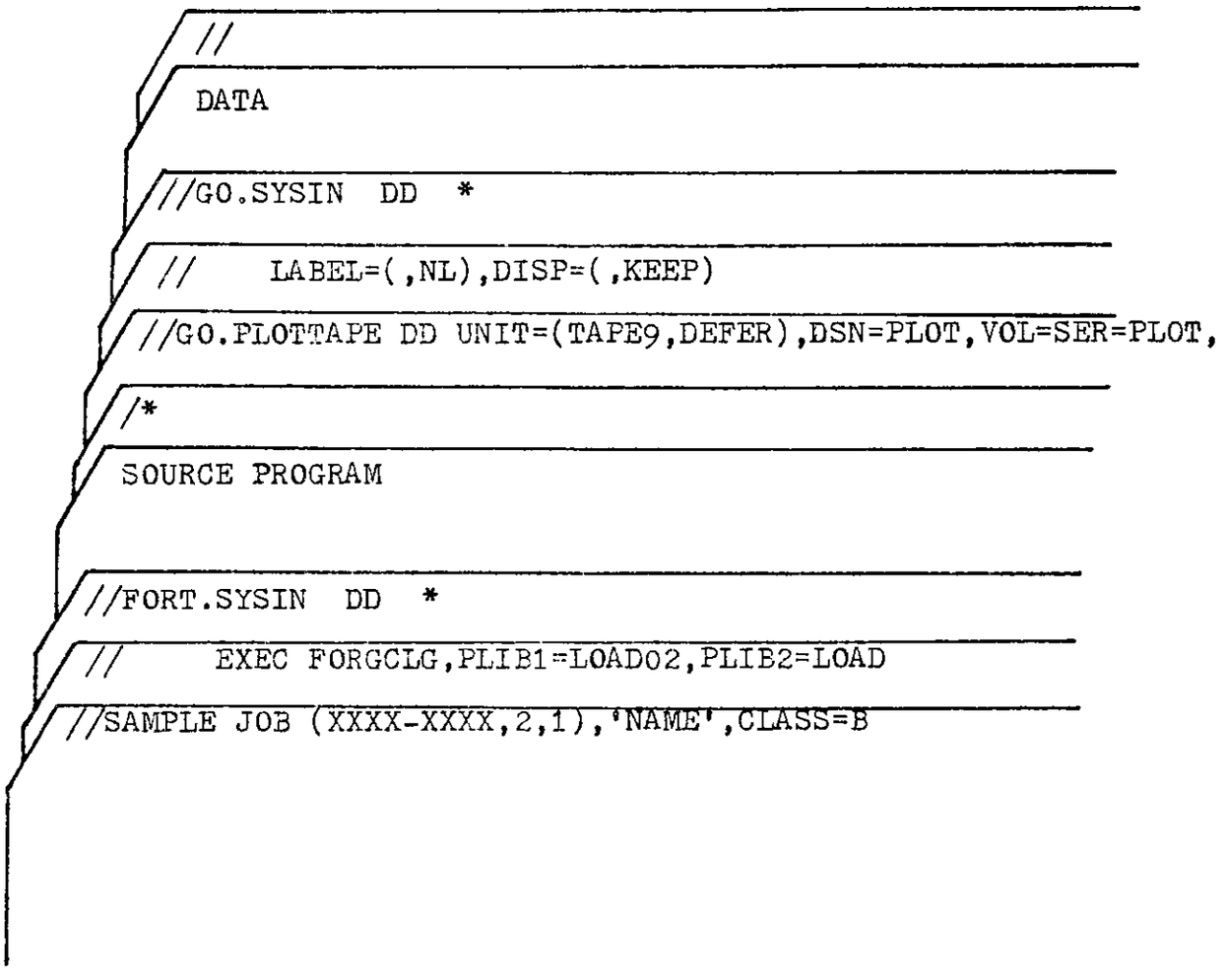
3.1 An Illustrative Sample Program

To illustrate how to use the NTSU CalComp plotter to do computer plotting, let us start with a simple sample program of basic software as shown on the next page.

```
0001            DIMENSION IBUF(1000),XARRAY(13),YARRAY(13)
                C
                C*************************************************************
                C  FUNCTION FUN IS USED TO COMPUTE THE VALUES OF BOTH
                C  XARRAY AND YARRAY ELEMENTS.
                C*************************************************************
0002            FUN(X)=5.0-X**2
                C
                C*************************************************************
                C  TO COMPUTE THE VALUES OF TWO ARRAY ELEMENTS
                C*************************************************************
0003            DO 10 I=1,11
0004            RI=I-1
0005            DX=4.0/(11.0-1.0)
0006            XI=-2.0+RI*DX
0007            XARRAY(I)=XI
0008            YARRAY(I)=FUN(XI)
0009        10  CONTINUE
                C
                C*************************************************************
                C  INITIALIZE THE PLOTTING SOFTWARE
                C*************************************************************
0010            CALL PLOTS(IBUF,1000,6)
                C
                C*************************************************************
                C  SET A NEW ORIGIN
                C*************************************************************
0011            CALL PLOT(3.0,1.5,-3)
                C
                C*************************************************************
                C  SCALE DATA FOR X-AXIS AND Y-AXIS WHICH WILL BE STORED
                C  IN THE LAST TWO LOCATIONS OF XARRAY AND YARRAY
                C*************************************************************
0012            CALL SCALE(XARRAY,6.0,11,1)
0013            CALL SCALE(YARRAY,6.0,11,1)
                C
                C*************************************************************
                C  PLOT SCALED X-AXIS AND Y-AXIS
                C*************************************************************
0014            CALL AXIS(0.0,0.0,6HX-AXIS,-6,6.0,0.0,XARRAY(12),XARRAY(13))
0015            CALL AXIS(0.0,0.0,6HY-AXIS,6,6.0,90.0,YARRAY(12),YARRAY(13))
                C
                C*************************************************************
                C  PLOT ANNOTATION
                C*************************************************************
0016            CALL SYMBOL(2.5,6.0,0.1,8HY=5-X**2,0.0,8)
                C
                C*************************************************************
                C  DRAW A STRAIGHT LINE THROUGH ELEVEN DATA POINTS
                C*************************************************************
0017            CALL LINE(XARRAY,YARRAY,11,1,1,4)
                C
                C*************************************************************
                C  CLOSE PLOT TAPE
                C*************************************************************
0018            CALL PLOT(12.0,0.0,999)
0019            STOP
0020            END
```

3.2 Computer Deck of a Sample Program

The actual computer deck of a sample program shows the control cards, the main driving program and the data of this computer plotting by using the NTSU CalComp plotting facility.



(IV) FUNCTIONAL PLOTTING ROUTINES

4.1 Business Functional Subroutines

Business Functional Subroutines, which are designed for business application, consist of five subroutines arranged alphabetically. The following list briefly summarizes the performance of each subroutine.

AXISB -- draws an axis with business-oriented annotation

AXISC -- draws an axis with calendar-month annotation

BAR -- draws bars for bar-graph plotting

LBAXS -- draws a logarithmic axis with business annotation

SHADE -- draws shading between designated lines.

AXISB

This subroutine draws an annotated axis with business-oriented labeling. The only difference between subroutine AXIS and AXISB is that in AXISB routine power-of-ten labeling is done in words instead of numbers.

This subroutine has eight arguments:

XPAGE,YPAGE,IBCD,±NCHAR,AXLEN,ANGLE,FIRSTV,DELTAV

XPAGE,YPAGE = the coordinates of the starting point of the axis line.

IBCD = the alphabetic title which is centered and placed parallel to the axis line. The characters have a fixed height of 0.14 inch.

±NCHAR = the number of characters in the axis title. The sign will determine which side of the axis line to place scale marks and labeling information.

If NCHAR is greater than zero, all annotation appears on the counter-clockwise side of the axis. This condition is normally desired for the Y-axis.

If NCHAR is less than zero, all annotation appears on the clockwise side of the axis. This condition is normally desired for the X-axis.

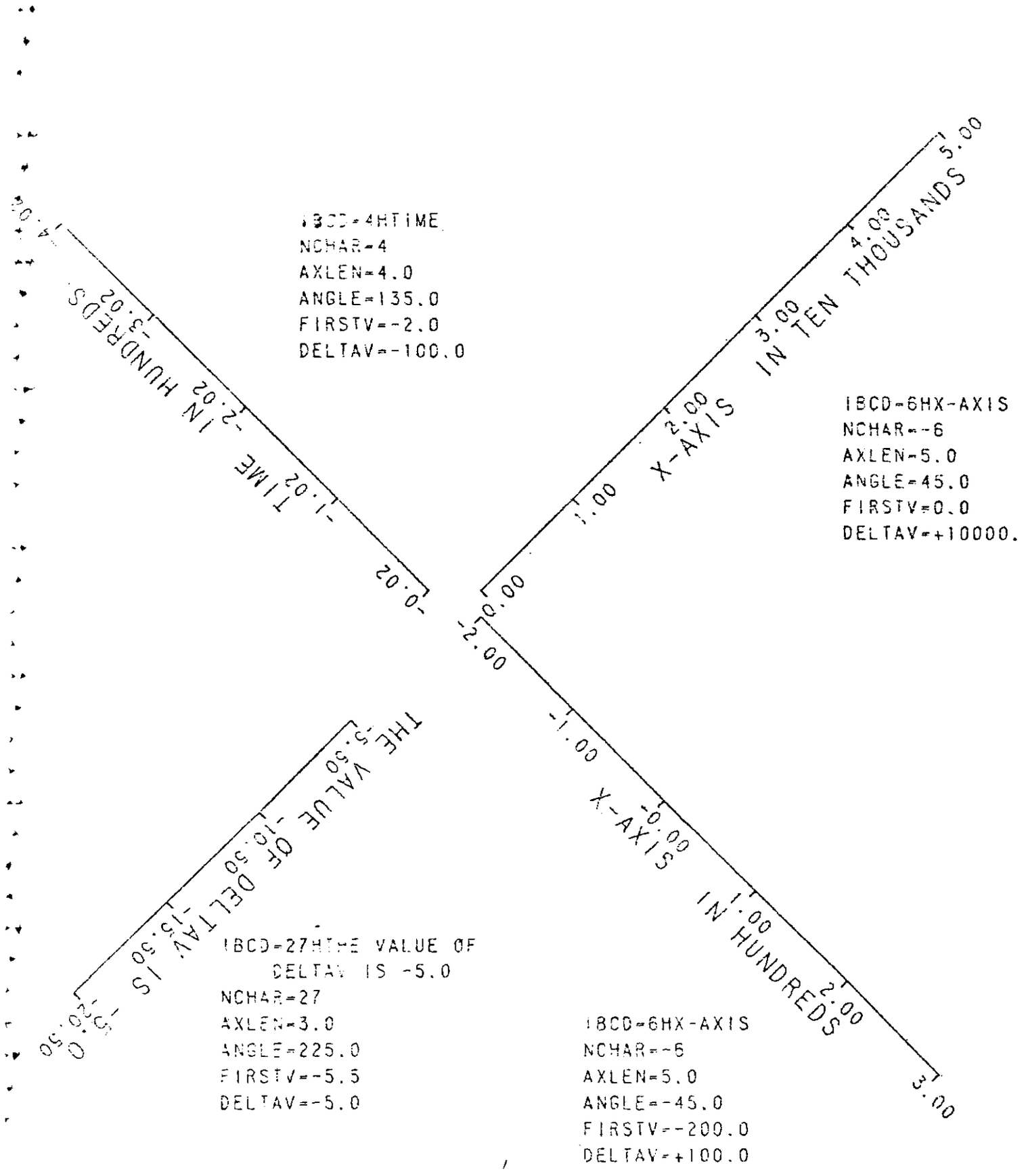
AXLEN = the length of the axis line, in inches.

ANGLE = the angle from which the axis is to be drawn. Normally, this value is 0.0 for the X-axis and 90.0 for the Y-axis.

FIRSTV = the starting value which will appear at the first tick mark on the axis. This value may be either computed and stored by the SCALE subroutine, or determined by the user.

DELTAV = the increment of data value per inch of axis. It is added to each tick mark value for its succeeding one-inch division along the axis. The value of DELTAV may be computed by SCALE, or determined by the user.

AXISB annotates all one-inch-axes intervals with numbers which are greater than 0.01 and less than 1,000. These annotation numbers are FIRSTV, FIRSTV+DELTAV, FIRSTV+2*DELTAV, etc., multiplied by a constant (power of ten) so that all the annotation numbers fall within the range 0.01-999.99. The constant appears after the user's label in words, i.e., (X10**-N), IN HUNDREDS, IN THOUSAND, IN TEN THOUSANDS, IN MILLIONS, or (X10**N).


IBCD=4HTIME
NCHAR=4
AXLEN=4.0
ANGLE=135.0
FIRSTV=-2.0
DELTAV=-100.0
TIME IN HUNDREDS
IBCD=6HX-AXIS
NCHAR=-6
AXLEN=5.0
ANGLE=45.0
FIRSTV=0.0
DELTAV=+10000.
X-AXIS IN TEN THOUSANDS
IBCD=27HTHE VALUE OF
DELTAV IS -5.0
NCHAR=27
AXLEN=3.0
ANGLE=225.0
FIRSTV=-5.5
DELTAV=-5.0
THE VALUE OF DELTAV IS
IBCD=6HX-AXIS
NCHAR=-6
AXLEN=5.0
ANGLE=-45.0
FIRSTV=-200.0
DELTAV=+100.0
X-AXIS IN HUNDREDS

AXISC

This subroutine draws a labeled axis with calendar month annotation.

This subroutine has eight arguments:

XPAGE,YPAGE,IBCD,±NCHAR,AXLEN,ANGLE,FIRSTV,DELTAV

XPAGE,YPAGE = the coordinates of the starting point of the axis line with respect to the current origin. The entire axis line and terminal ends should be at least one-half inch from either side of the paper to allow space for the scale annotation and axis title. Usually, both X and Y axes are joined at the origin of the graphs, where XPAGE and YPAGE equal zero; but other starting points can be used if desired.

IBCD = the title, which is centered parallel to the axis line. The characters have a fixed height of 0.14 inch.

±NCHAR = the number of characters in the axis title. By its sign, it determines which side of the line the scale marks and labeling information shall be placed.

If NCHAR is greater than zero, all annotation appears on the counterclockwise side of the axis. This condition is

normally desired for the Y-axis.

If NCHAR is less than zero, all annotation appears on the clockwise side of the axis. This condition is normally desired for the X-axis.

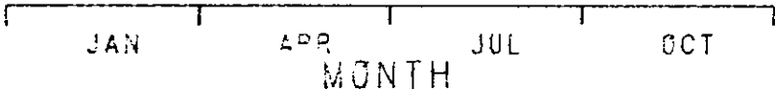
AXLEN = the length of the axis line, in inches.

ANGLE = the angle from which the axis is to be drawn. Normally, for the X-axis this value is 0.0 and for the Y-axis 90.0.

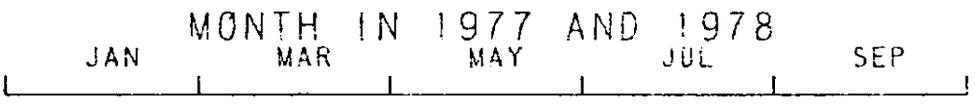
FIRSTV = the value representing the month of a year, to assign annotation for the first tick mark. This value may be computed and stored by the SCALE subroutine, or supplied by the user.

DELTAV = the ratio of months per inch of axis. It is added to each tick mark value for its succeeding one-inch division along the axis line. The value of DELTAV may be computed by routine SCALE, or supplied by the user.

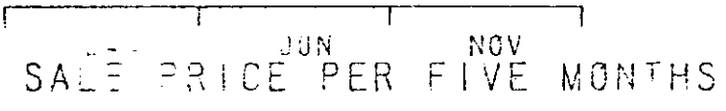
AXISC annotates in calendar months where FIRSTV is the beginning month. 1.0 represents January, 2.0 represents February, etc.. DELTAV corresponds to the number of months between tick marks. This routine can annotate the axes for more than a year of data. Both FIRSTV and DELTAV are real variables and only the integer portion of either is used by AXISC.




```
!BCD=5HMONTH
NCHAR=-5
AXLEN=4.0
ANGLE=0.0
FIRSTV=1.0
DELTAV=3.0
```




```
!BCD=22HMONTH IN 197
  AND 1978
NCHAR=22
AXLEN=5.0
ANGLE=0.0
FIRSTV=1.0
DELTAV=2.0
```




```
!BCD=32HWHOLE SALE PRICE
PER FIVE MONTHS
NCHAR=-32
AXLEN=5.0
ANGLE=0.0
FIRSTV=1.0
DELTAV=5.0
```

BAR

This subroutine draws bars with or without hatching.

This subroutine has eight arguments:

XPAGE,YPAGE,ANGLE,HEIGHT,WIDTH,SH,IHAT,NPI

XPAGE,YPAGE = the coordinates of the lower left-hand corner of the bar.

ANGLE = the angle of the bottom of the bar.

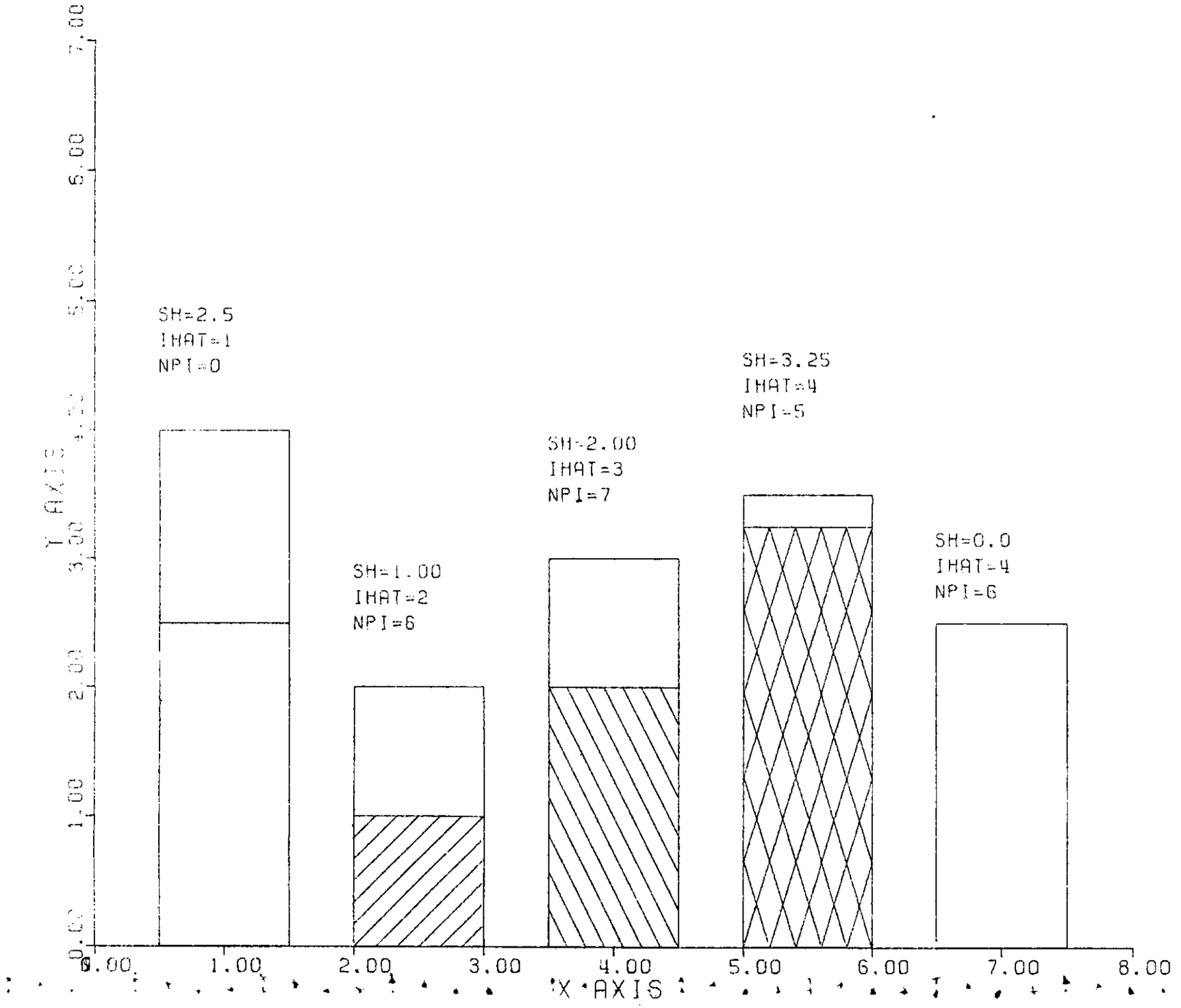
HEIGHT = the height of the main bar.

WIDTH = the width of the main bar.

SH = the height of the intermediate bar which will be hatched according to the IHAT code.

IHAT = 1 draw bar only
= 2 hatch from left to right.
= 3 hatch from right to left.
= 4 hatch both ways.

NPI = the number of lines of hatching per inch.


SH=2.5
IHAT=1
NPI=0
SH=1.00
IHAT=2
NPI=6
SH=2.00
IHAT=3
NPI=7
SH=3.25
IHAT=4
NPI=5
SH=0.0
IHAT=4
NPI=6
Y AXIS
X AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

LBAXS

This subroutine draws a logarithmic axis with business annotation of powers of ten. It differs from LGAXS only by the fact that power-of-ten annotations are done in words in stead of numbers.

This subroutine has eight arguments:

XPAGE,YPAGE,IBCD,±NCHAR,AXLEN,ANGLE,FIRSTV,DELTAV

XPAGE,YPAGE = the coordinates of the starting point of the axis line.

IBCD = the alphabetic title which is centered and placed parallel to the axis line. The characters have a fixed height of 0.14 inch.

±NCHAR = number of characters in the axis title. It's sign will determine which side of the line the scale marks and labeling information should be placed.

If the sign is positive, all annotation will be placed on the positive(counter-clockwise) side of the axis. This condition is normally desired for the Y-axis.

If the sign is negative, all annotation will be placed on the clockwise side of the axis. This condition is normally for the X-axis.

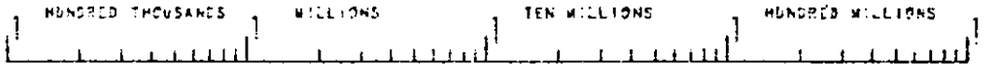
AXLEN = the length of the axis line, in inches.

ANGLE = the angle of the axis will be drawn.

FIRSTV,DELTAV = the scaling factors for both X axis and Y axis, (may be computed by SCALG).

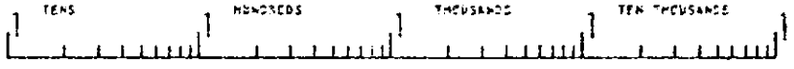
Tick marks are placed along the axis at each power of ten and between each of the nine integer values. The power of ten tick marks are annotated with words (e.g., HUNDREDTHS, BILLIONS) for powers of ten from -14 to +14. The power of ten is annotated in the form 10**N for N less than -14 or N greater than +14. If a log cycle is not less than two inches long, the integer tick marks are annotated.

LBAXS



NCHAR=+5
AXLEN=5.0
ANGLE=0.0
FIRSTV=100000.
DELTAV=0.8

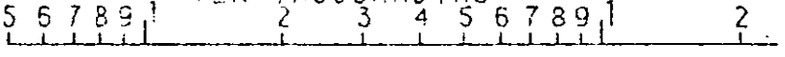
LBAXS



NCHAR=+5
AXLEN=4.0
ANGLE=0.0
FIRSTV=10.0
DELTAV=1.0

LBAXS

TEN THOUSANDTHS



NCHAR=+5
AXLEN=4.0
ANGLE=0.0
FIRSTV=0.00005
DELTAV=0.42

SHADE

This subroutine will shade any polygon formed by two lines defined by any two sets of points. Any number of points can be used with the scaling factors appearing in the last two locations of the arrays.

This subroutine has ten arguments:

XARAY1,YARAY1,XARAY2,YARAY2,D,ANGLE,NPTS1,INC1,NPTS2,INC2

XARAY1,YARAY1 = the array names containing the coordinates of line1. The arrays must be dimensioned with at least NPTS+2 elements.

XARAY2,YARAY2 = the array names containing the coordinates of line 2. The arrays must be dimensioned with at least NPTS+2 elements.

D = the distance between shade lines, in inches.

ANGLE = the angle of inclination of shaded lines, in degrees.

NPTS1 = the number of data points for line 1.

INC1 = the "step" size used to gather the data points in the XARAY1 and YARAY1.

NPTS2 = the number of data points for line 2.

INC2 = the "step" size used to gather the data points in the XARAY2 and YARAY2.

4.2 Drafting Functional Subroutines

Drafting Functional Subroutines consist of five subroutines arranged alphabetically. The following list briefly summarizes the performance of each subroutines.

AROHD -- draws arrowheads

ARROW -- draws lines terminated with an arrow

CNTRL -- draws center lines

DIMEN -- draws annotated dimension lines

LABEL -- draws annotation between specified points.

AROHD

This subroutine draws an arrowhead at the end of a line segment.

This subroutine has seven arguments:

XPAGE,YPAGE,XTIP,YTIP,AHLEN,AHWID,ICODE

XPAGE,YPAGE = the coordinates of the starting point of the line segment.

XTIP,YTIP = the coordinates of the tip of the arrowhead, in inches.

AHLEN = the length of the arrowhead, in inches.

AHWID = the width of the arrowhead, in inches.

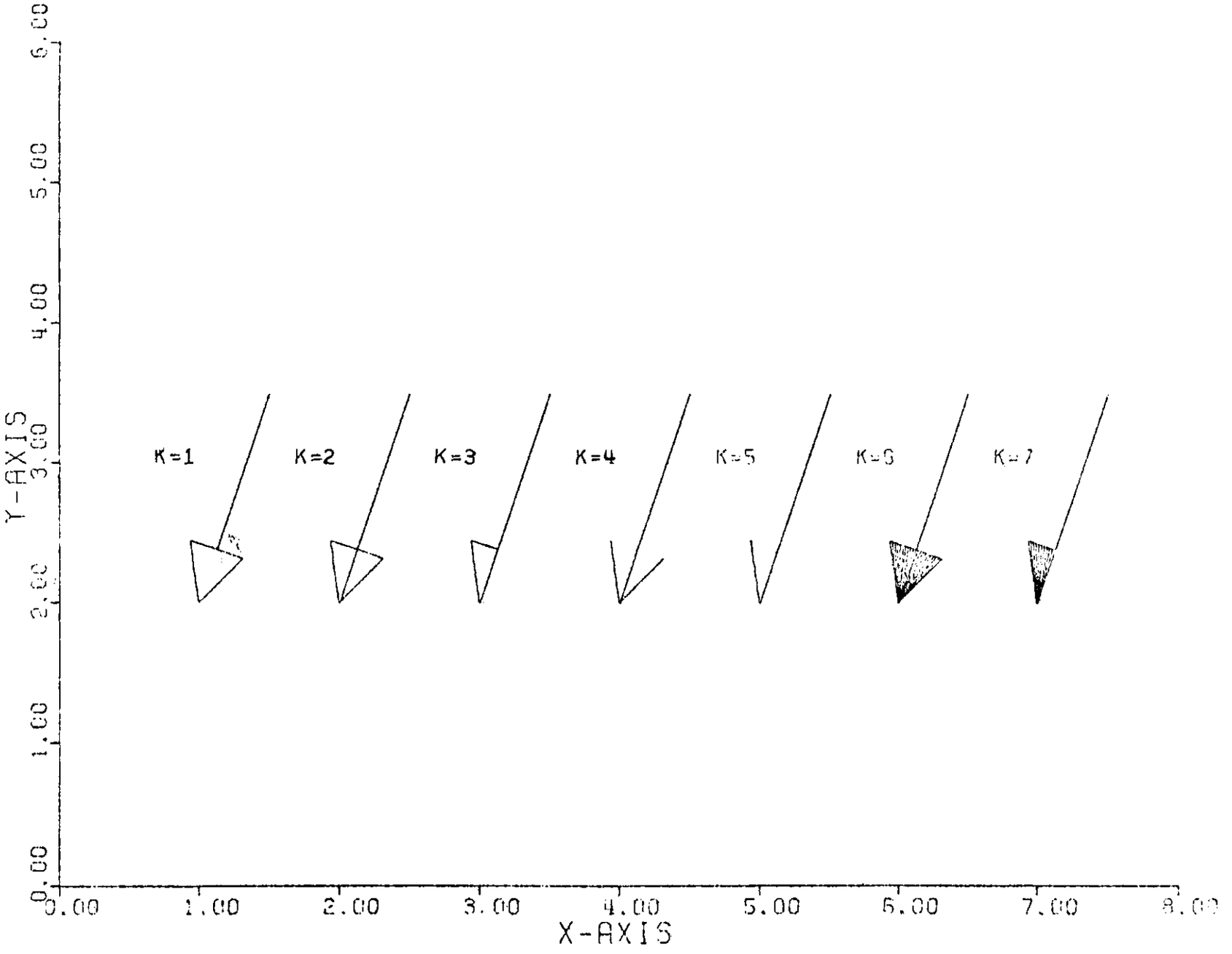
ICODE = a two-digit integer code. The units digit must be between 1 and 7. J represents the tens digit and K represents the units digit.

J=0, no line is drawn from XPAGE, YPAGE to XTIP, YTIP.

J=1, a line is drawn.

J=2, a line is drawn and a second arrowhead pointing in the opposite direction is drawn at XPAGE, and YPAGE.

K=1 through 7 to specify the type of arrowhead desired.


K=1
K=2
K=3
K=4
K=5
K=6
K=7
Y-AXIS
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00

ARROW

This subroutine draws a line through a series of data points and places an arrow on the end of the line.

This subroutine has five arguments:

XARRAY,YARRAY,NPTS,INC,ICODE

XARRAY,YARRAY = the names of the arrays containing the data points to be plotted.

NPTS = the number of data points in each array.

INC = the "step" size used to pick up the data from XARRAY, and YARRAY.

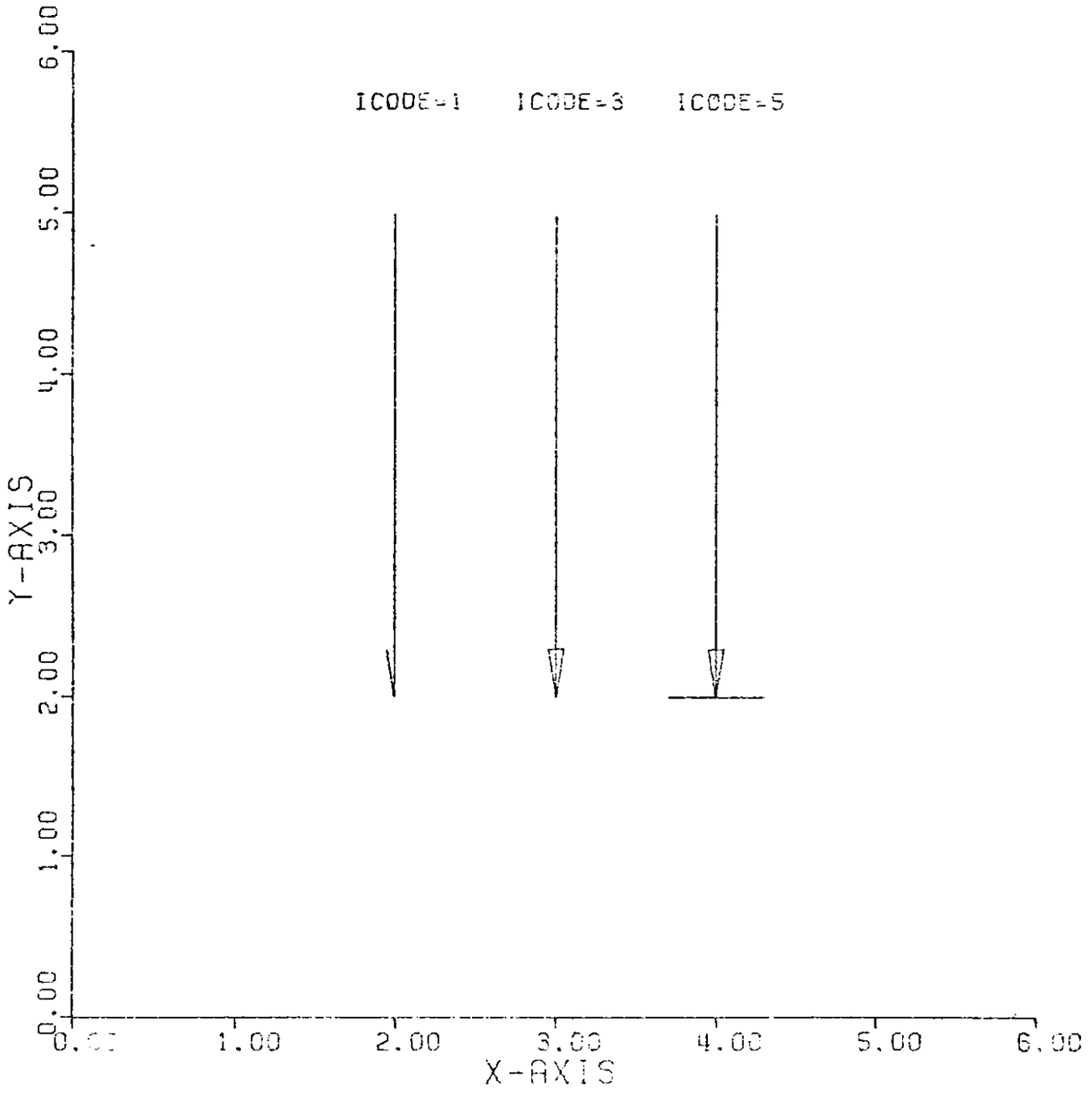
ICODE = the indicator used to specify the type of the arrow.

If ICODE=1, a single wing of an arrow will be drawn.

If ICODE=3, a full arrowhead will be drawn.

If ICODE=5, a full arrowhead with a short line perpendicular to the base of the arrowhead will be drawn.

The X and Y arrays must be dimensioned with at least NPTS+7 elements. The NPTS+1 and NPTS+2 elements in each array must contain the scale factors as described by the SCALE routine.


ICODE=1
ICODE=3
ICODE=5
Y-AXIS
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00

CNTRL

This subroutine draws center lines between a series of data points.

This subroutine has four arguments:

XARRAY,YARRAY,NPTS,INC

XARRAY,YARRAY	=	the name of the arrays containing the data points to be plotted and scaling factors DELTAV and FIRSTV.
NPTS	=	the number of data points in each array.
INC	=	the "step" size to be used to gather the data from XARRAY and YARRAY.

A center line which consists of a long dash, a short dash, and a long dash is drawn from the first to the second data point, then from the second to the third, etc. The dashes are 4/11 and 1/11 of the distance between the points.

DIMEN

This subroutine draws dimension lines with arrowheads at the two ends of the line.

This subroutine has five arguments:

XPAGE,YPAGE,DS,ANGLE,SCALE

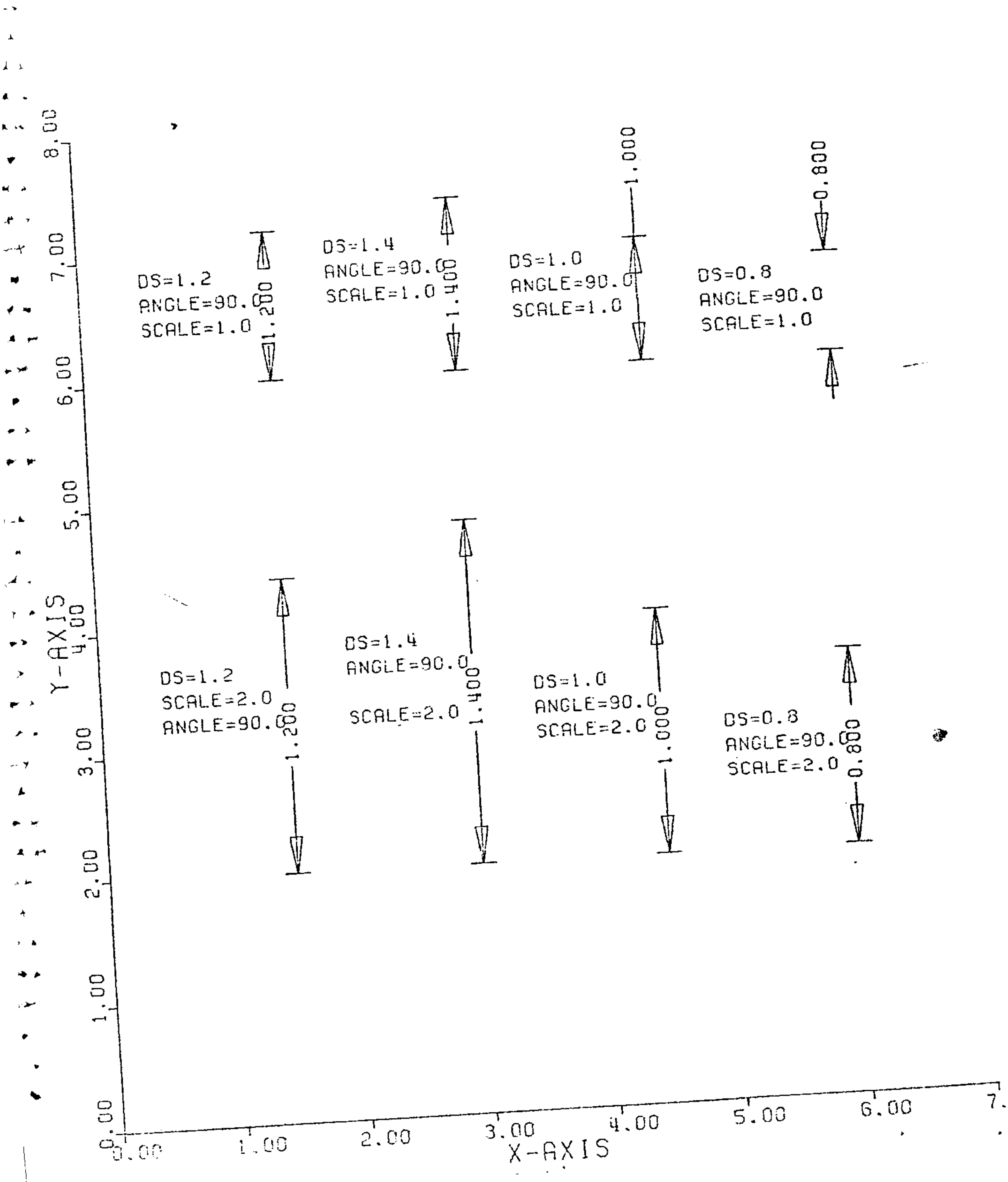
XPAGE,YPAGE = the coordinates of the starting point of the line.

DS = the length of the line in inches.

ANGLE = the angle in degrees, of the dimension line.

SCALE = the scale factor of the length of the dimension line.

The actual length of the dimension line is the product of DS and SCALE. If the resultant line is equal to or greater than 1.2 inches, the annotation of dimension size will be printed in the middle of the dimension line. If the length of the dimension line is between 1.2 and 0.8 inches, the annotation will be placed following the line. If the line is equal to or less than 0.8 inches, the arrowheads will be placed outside along with the annotation.


DS=1.2
ANGLE=90.0
SCALE=1.0
1.200
DS=1.4
ANGLE=90.0
SCALE=1.0
1.400
DS=1.0
ANGLE=90.0
SCALE=1.0
1.000
DS=0.8
ANGLE=90.0
SCALE=1.0
0.800
DS=1.2
SCALE=2.0
ANGLE=90.0
1.200
DS=1.4
ANGLE=90.0
SCALE=2.0
1.400
DS=1.0
ANGLE=90.0
SCALE=2.0
1.000
DS=0.8
ANGLE=90.0
SCALE=2.0
0.800
Y-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.

LABEL

This subroutine is used to plot alphameric characters along a straight line segment which may be at any angle. The size of the characters is adjusted to fall within the specified end points of the line segment.

This subroutine has eleven arguments:

XPAGE1,YPAGE1,XPAGE2,YPAGE2,IBCD,NCHAR,HEIGHT,ISIDE,DST, FPN,NDEC

XPAGE1,YPAGE1 = the coordinates, in inches, of the starting point of the line segment.

XPAGE2,YPAGE2 = the coordinates, in inches, of the ending point of the line segment.

IBCD = the characters to be plotted.

NCHAR = number of characters to be plotted.

HEIGHT = the height of the characters, in inches.

ISIDE = If the units digit of ISIDE=1, the characters are placed on the clockwise side of the line.

If ISIDE=2, the characters are plotted on the counterclockwise side of the line.

If the tens digit of ISIDE=1, a floating-point number(FPN) is plotted along with IBCD.

DST = the distance of IBCD from line segment, in inches.

If ISIDE=±1 or ±11, DST is measured from the line to the top of the characters.

If ISIDE=±2 or ±12, DST is measured from the line to the bottom of the characters.

FPN = the floating-point number that is to be converted and plotted when ISIDE is equal to 11 or 12.

NDEC = the precision of the conversion of the number FPN.

If ISIDE is negative, IBCD will be arranged for readability. If the characters do not fall within the limits of the line, LABEL routine will adjust HEIGHT until it fits.

4.3 Scientific Functional Subroutines

Scientific Functional Subroutines, which are designed for scientific application, consist of eight subroutines arranged alphabetically. The following list briefly summarizes the performance of each subroutine.

CURVX -- plots a function of X over a given range

CURVY -- plots a function of Y over a given range

FLINE -- draws a smooth curve through a set of data points

LGAXS -- draws a logarithmic axis with annotation

LGLIN -- plots data either in log-log or in semi-log mode

POLAR -- plots data points, using polar coordinates

SCALG -- performs scaling for logarithmic plotting

SMOOT -- draws a smooth curve through sequential data points

CURVX

This subroutine plots a function of X over a given range.

This subroutine has ten arguments:

XPAGE1,XPAGE2,C1,E1,C2,E2,C3,E3,C4,E4

XPAGE1,XPAGE2 = the starting and ending values of X.

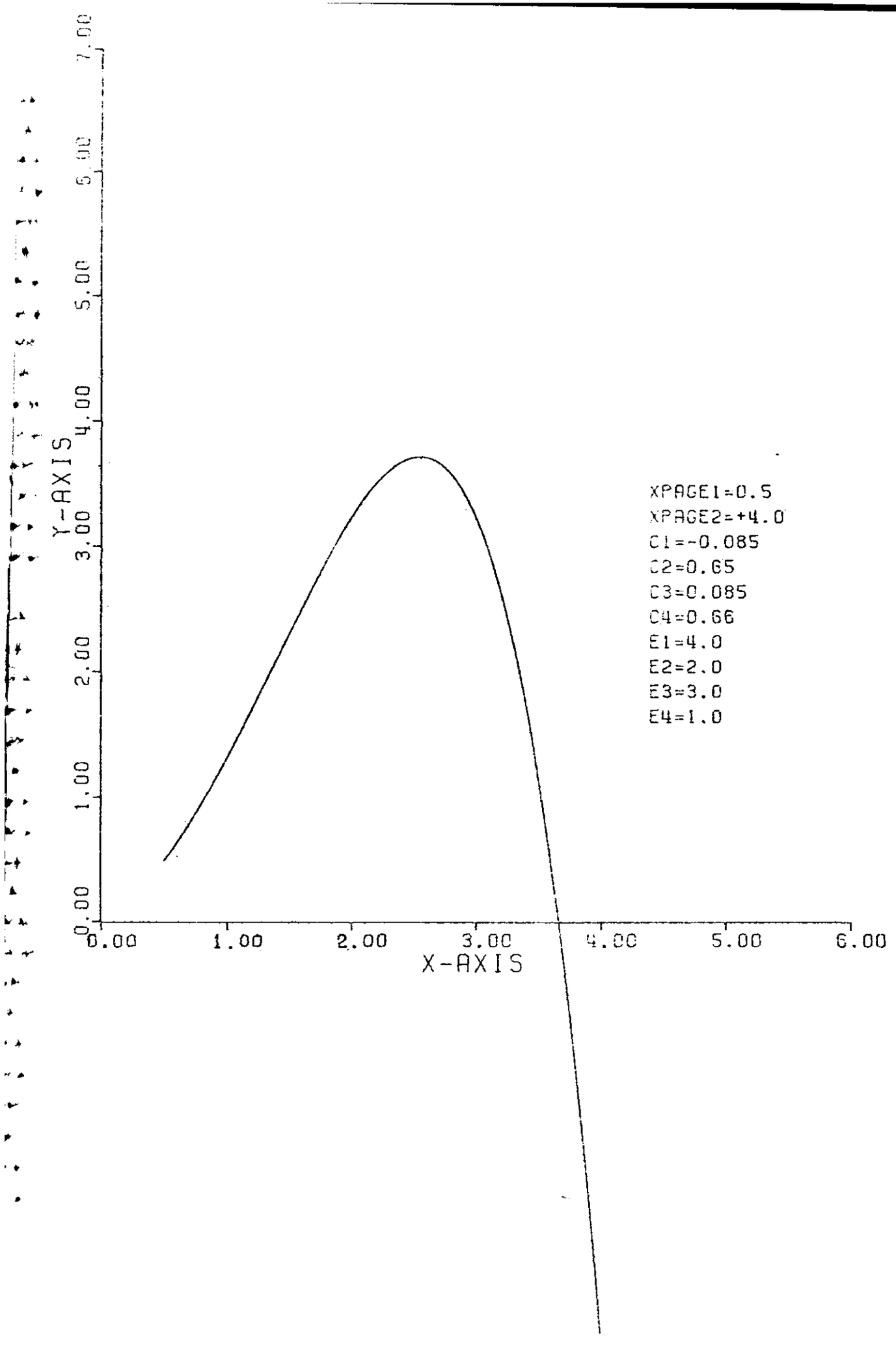
C1,C2,C3,C4 = the coefficients of the polynomial.

E1,E2,E3,E4 = the exponents of the polynomial.

The polynomial plotted is

Y = C1*X**E1+C2*X**E2+C3*X**E3+C4*X**E4

The value of X ranges from XPAGE1 to XPAGE2 in steps of 0.01 inches. Values of X are assumed to be inches. If scaling is required, scaling must be performed before calling this routine. If exponent is zero or negative and X is negative, the errors will be generated by this routine.


Y-AXIS
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
XPAGE1=0.5
XPAGE2=+4.0
C1=-0.085
C2=0.65
C3=0.085
C4=0.66
E1=4.0
E2=2.0
E3=3.0
E4=1.0

CURVY

This subroutine plots a function of Y over a given range.

This subroutine has ten arguments:

XPAGE1,YPAGE2,C1,E1,C2,E2,C3,E3,C4,E4

YPAGE1,YPAGE2 = the starting and ending values of Y.

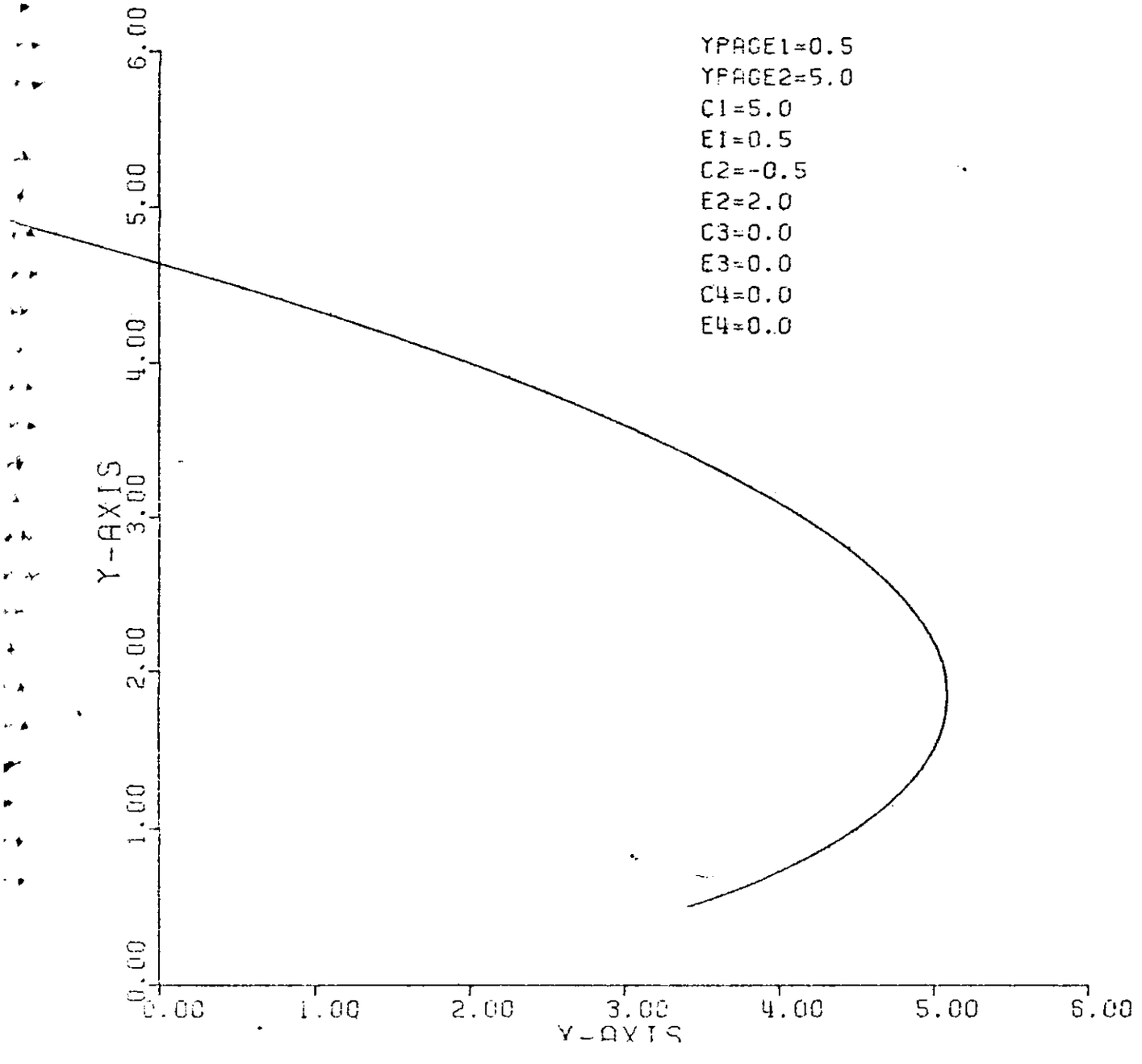
C1,C2,C3,C4 = the coefficients of the polynomial.

E1,E2,E3,E4 = the exponents of the polynomial.

The polynomial plotted is:

X = C1*Y**E1+C2*Y**E2+C3*Y**E3+C4*Y**E4

The value of Y ranges from YPAGE1 to YPAGE2 in steps of 0.01 inches. Values of Y are assumed to be inches. If scaling is required, scaling must be performed before calling this routine. If exponent is zero or negative and Y is negative, errors may be generated by this routine.


YPAGE1=0.5
YPAGE2=5.0
C1=5.0
E1=0.5
C2=-0.5
E2=2.0
C3=0.0
E3=0.0
C4=0.0
E4=0.0
Y-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
X-AXIS

FLINE

This subroutine has the same functions as LINE has except that if NPTS is less than 0 a smooth curve, rather than a straight line, will be drawn between the points. This curve is drawn using a modified spline-fitting technique.

The scaling parameters corresponding to FIRSTV and DELTAV (see SCALE) must immediately follow each array. If these parameters are not computed by the SCALE routine, they must be supplied by the user. If scaling is not required, the user must place the appropriate minimum and delta values in the specified locations of the arrays. For a one-to-one correspondence between array data and plotted data, these values should be 0.0 (FIRSTV) and 1.0 (DELTAV).

This subroutine has six arguments:

XARRAY,YARRAY,±NPTS,INC,±LINTYP,INTEQ

XARRAY = the array containing the abscissa (X) values and the scaling parameters for the X-array.

YARRAY = array containing the ordinate (Y) values and the scaling parameters for the Y-array.

NPTS = the number of data points in XARRAY and YARRAY. It does not include the last two locations for the scaling parameters.

INC = the "step" size used to gather the data from both arrays.

±LINTYP = a parameter which controls the type of line to be drawn through the data points.

If LINTYP = 0, connecting lines are plotted with no symbols.

If LINTYP is greater than 0, connecting lines are drawn and the symbol specified by INTEQ is placed at every LINTYP point, i.e., if LINTYP = 1, a symbol is placed at every data point; LINTYP = 2 puts a symbol at every other data point; LINTYP = 4 places a symbol at every fourth data point, etc.

If LINTYP is less than 0, the symbols are plotted with no connecting lines.

INTEQ = the integer equivalent of the special plotting symbol centered at each data point. This value normally can be 0 through 13, and has meaning only when LINTYP is not zero.

If NPTS is negative, a smooth curve is drawn to connect the points instead of straight lines. If NPTS is positive, this functions exactly like a call to LINE.

LGAXS

This subroutine draws a logarithmic axis with annotation in powers of ten.

This subroutine has eight arguments:

XPAGE,YPAGE,IBCD,±NCHAR,AXLEN,ANGLE,FIRSTV,DELTAV

XPAGE,YPAGE = the coordinates of the starting point of the axis line.

IBCD = the alphabetic title which is centered and placed parallel to the axis line. The characters have a fixed height of 0.14 inch.

±NCHAR = number of characters in the axis title. It's sign will determine which side of the line the scale marks and labeling information should be placed.

If the sign is positive, all annotation will be placed on the positive(counter-clockwise) side of the axis. This condition is normally desired for the Y-axis.

If the sign is negative, all annotation will be placed on the clockwise side of the axis. This condition is normally for the X-axis.

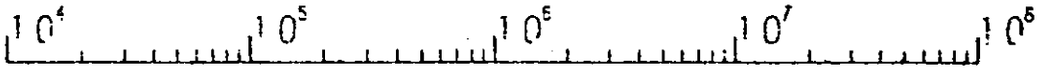
AXLEN = the length of the axis line, in inches.

ANGLE = the angle of the axis will be drawn.

FIRSTV,DELTAV = the scaling factors for both X axis and Y axis, (may be computed by SCALG).

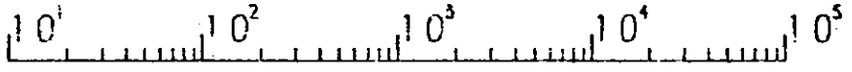
Tick marks are placed on the axis for each power of ten and each of the nine integer values between. The power of ten tick marks are annotated in the form 10**N. If DELTAV is less than or equal to 0.5 log cycles per inch, the integer tick marks are annotated. (This DELTAV implies a log cycle of 2 inches or more).

LGAXS



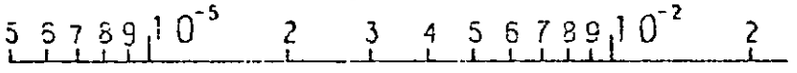
AXLEN=5.0
ANGLE=0.0
FIRSTV=10000.0
DELTAV=0.8

LGAXS



AXLEN=4.0
ANGLE=0.0
FIRSTV=10.0
DELTAV=1.0

LGAXS



AXLEN=4.0
ANGLE=0.0
FIRSTV=0.0005
DELTAV=0.42

LGLIN

This subroutine is used to plot data in log-log or semi-log mode.

This subroutine has seven arguments:

XARRAY,YARRAY,NPTS,INC,±LINTYP,INTEQ,LOGTYP

XARRAY = the array containing the abscissa (X) values and the scaling parameters for the X-array.

YARRAY = the array containing the ordinate (Y) values and the scaling parameters for the Y-array.

NPTS = the number of data points in XARRAY and YARRAY. It does not include the last two locations for the scaling parameters (normally provided by the SCALG routine for logarithmic data and the SCALE routine for linear data). The number of points in each array must be the same.

INC = the "step" size used to gather the data from both arrays as described for the SCALE and SCALG routines.

±LINTYP = a parameter which controls the type of line to be drawn through the data points.

If LINTYP=0, connecting lines are plotted with no symbols.

If LINTYP is greater than 0, connecting lines are drawn and the symbol specified by INTEQ is placed at every LINTYP point, i.e., if LINTYP=1 a symbol is placed at every data point; LINTYP=2 puts a symbol at every other data point; LINTYP=4 places a symbol at every fourth data point, etc.

If LINTYP is less than 0, the symbols are plotted with no connecting lines.

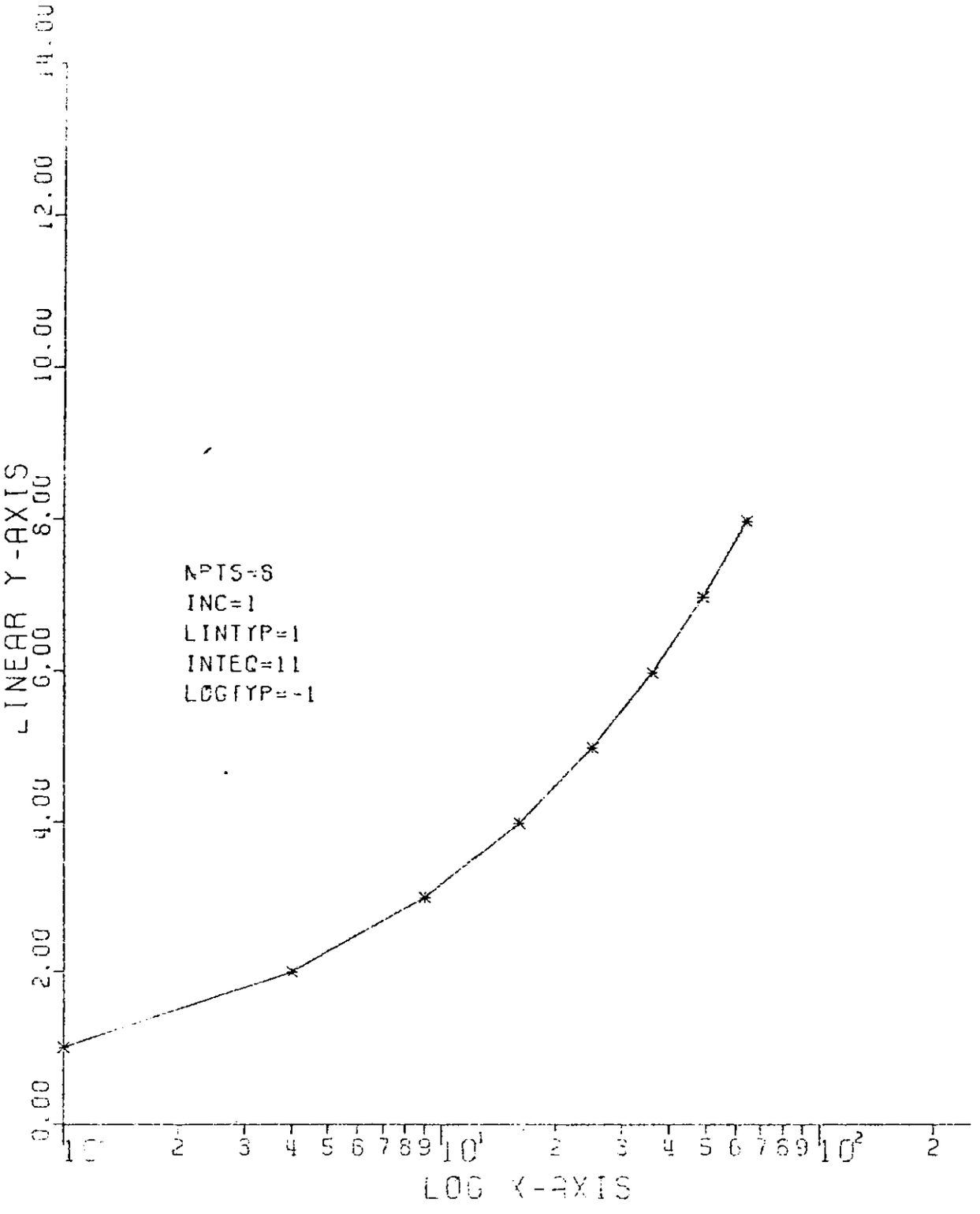
INTEQ = the integer equivalent of the special plotting symbol to be centered at each data point. This value normally can be 0 through 13, and has meaning only when LINTYP is not zero.

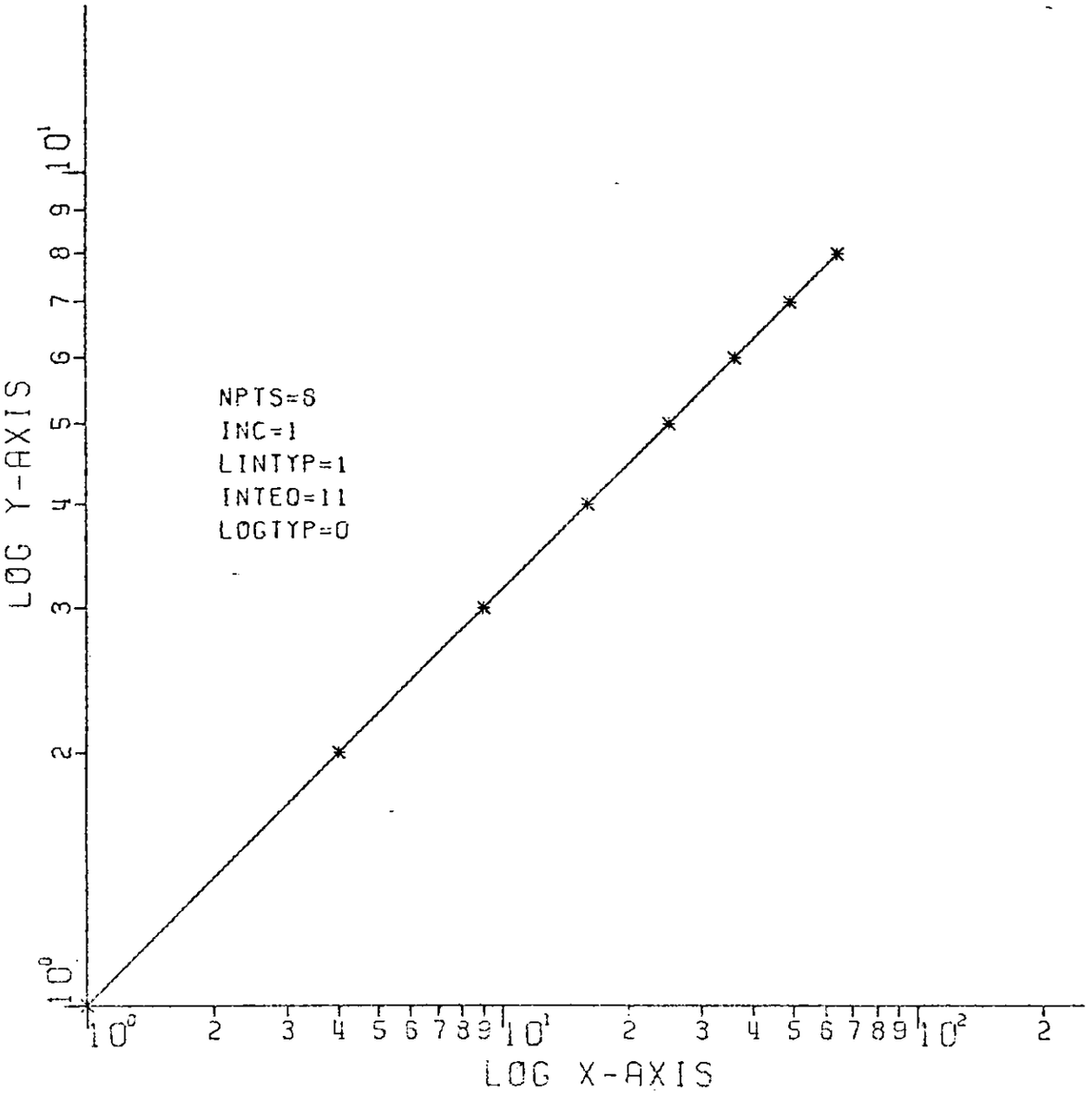
The arguments for LGLIN are identical with those of LINE except for the addition of LOGTYP, which specifies the type of plot desired as follows:

if LOGTYP=-1, a semi-log plot, logarithmic in X and linear in Y is plotted.

if LOGTYP=0, a log-log plot is produced.

if LOGTYP=+1, a semi-log plot, linear in X and logarithmic in Y is produced.


NPTS=8
INC=1
LINTYP=1
INTEQ=11
LOGTYP=-1
LINEAR Y-AXIS
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
LOG X-AXIS
10
2
3
4
5
6
7
8
9
10¹
2
3
4
5
6
7
8
9
10²
2


NPTS=8
INC=1
LINTYP=1
INTEQ=11
LOGTYP=0
LOG Y-AXIS
LOG X-AXIS
10⁰
10¹
10²

POLAR

This subroutine draws lines connecting a series of data points using polar coordinates. POLAR also draws symbols at the data points in polar coordinates.

This subroutine has eight arguments:

XARRAY,ANGRAY,NPTS,INC,LINTYP,INTEQ,RADIUS,DELTAV

XARRAY = the radii to be plotted.

ANGRAY = the angle array (in radians).

NPTS = the number of data points in XARRAY and ANGRAY.

INC = the increment between the data values in the two arrays.

LINTYP = a parameter which controls the type of line to be drawn through the data points.

If LINTYP=0, connecting lines are plotted with no symbols.

If LINTYP is greater than 0, connecting lines are drawn and the symbol specified by INTEQ is placed at every LINTYP point, i.e., if LINTYP=1 a symbol is placed at every data point; LINTYP=2 puts a symbol at every other data point; LINTYP=4 places a symbol at every fourth data point, etc.

If LINTYP is less than 0, the symbols are plotted with no connecting lines.

INTEQ = the integer equivalent of the symbol to be plotted at a data point. See basic routine SYMBOL - the "special" call - for an explanation of integer equivalents.

RADIUS = the magnitude over which the radii array is to be scaled.

DELTAV = the scaling factor. If RADIUS is equal to or less than 0.0, DELTAV is a legitimate scaling factor. If RADIUS is greater than 0.0, DELTAV is computed by the POLAR routine. DELTAV is expressed as units of data per page inch.

SCALG

This subroutine is used to compute scale factors (FIRSTV, DELTAV) for an array of data to be plotted on a logarithmic scale. The scale factors are used by subroutines LGLIN, LGAXS, and LBAXS.

This subroutine has four arguments:

ARRAY,AXLEN,NPTS,INC

ARRAY = the array containing data points to be scanned.

AXLEN = the length of the axis at which the data is to be plotted.

NPTS = the number of data values to be examined in ARRAY. The DIMENSION statement in FORTRAN should specify at least two locations more than the number of values being scanned to allow SCALG to store the computed starting value (FIRSTV) and scaling factor (DELTAV) at the end of the array.

INC = the "step" size used by the SCALG subroutine to scan through the array. Since the array is treated as a single-dimensioned variable in the SCALG subroutine, the increment may be used to pick out values from multi-dimensioned arrays or it may be used to skip data points in an array. INC=1 if every data point is to be used in computing FIRSTV and DELTAV.

If INC=1, ARRAY(NPTS+1) contains the adjusted FIRSTV and ARRAY(NPTS+2) contains the adjusted DELTAV.

If INC is not equal to 1, then the minimum is returned in ARRAY(NPTS*INC+1) and the delta value in ARRAY(NPTS*INC+INC+1).

Example:

ARRAY minimum=12., ARRAY maximum=1147., and AXLEN= 6.25, then

FIRSTV = 10**1 = 10, N = 1

XMAX = 10**4 = 10000, M=4

therefore,

DELTAV = (4-1)/6.25 = 0.48 log cycles per inch.

SMOOT

This subroutine draws a smooth curve through a series of data points. It accomplishes this by using a modified spline-fitting technique. Although the routine receives a single coordinate pair on each call, it will accumulate the points until it has received a sufficient number to compute a pair of cubic parametric equations for a smooth curve. This accumulation of data points requires that the user gives a terminal call to complete the curve. The subroutine operates in one of two modes: Smooth Mode and Plot Mode.

This subroutine has three arguments:

XPAGE,YPAGE,±IPEN

Plot Mode (Initial Mode)

XPAGE,YPAGE = coordinates of the starting point.

If IPEN is greater than 0, the call is treated like CALL PLOT(XPAGE,YPAGE,±IPEN).

If IPEN=0 or -1, Smooth Mode will be initiated.

Smooth Mode

XPAGE,YPAGE = the coordinates of the new pen position.

If IPEN=-2, a smoothed curve is drawn through the data points on the curve.

If IPEN=-3, the pen is up while moving through data points.

If IPEN=2, the pen is down to draw a smooth curve through the data points.

If IPEN=3 , the pen is up to continue the smoothing function.

If IPEN is less than or equal to -24, the call to SMOOT is used for the terminal call. The curve is finished and the subroutine returns to the Plot Mode.

IPEN is greater than 0:

This case is treated as a call to PLOT and the point defined by (XPAGE,YPAGE) will not be considered as a point on the curve. For example IPEN=2 Or 3. Care must be exercised when using a positive IPEN value in the Smooth Mode. Before moving to the point, the pen will be positioned at the point preceeding the point last given. When IPEN is restored to a negative value, the pen will be positioned to the point where it left the smooth curve and the smooth curve continued as though the intervening points (with IPEN greater than 0) had not occurred.

4.4 General Functional Subroutines

General Functional Subroutines, which are designed for plotting a simple geometrical lines and figures, consist of eight subroutines arranged alphabetically. The following list briefly summarize the performance of each subroutine.

CIRCL -- draws a circle, arc or spiral

DASHL -- draws dashed lines connecting a series of data poists

DASHP -- draws a dashed line to a specified point

ELIPS -- draws an ellipse or elliptical arc

FIT -- draws a curve through three points

GRID -- draws a linear grid

POLY -- draws an equilateral polygon

RECT -- draws a rectangle.

CIRCL

This subroutine draws a circle, arc or spiral starting at a given point.

This subroutine has seven arguments:

XPAGE,YPAGE,THO,THF,RO,RF,DI

XPAGE,YPAGE = the coordinates of the starting point of the arc, in inches.

THO = the angle for the start of the arc, in degrees.

THF = the angle for the end of the arc, in degrees.

RO = the radius at the start of the arc, in inches.

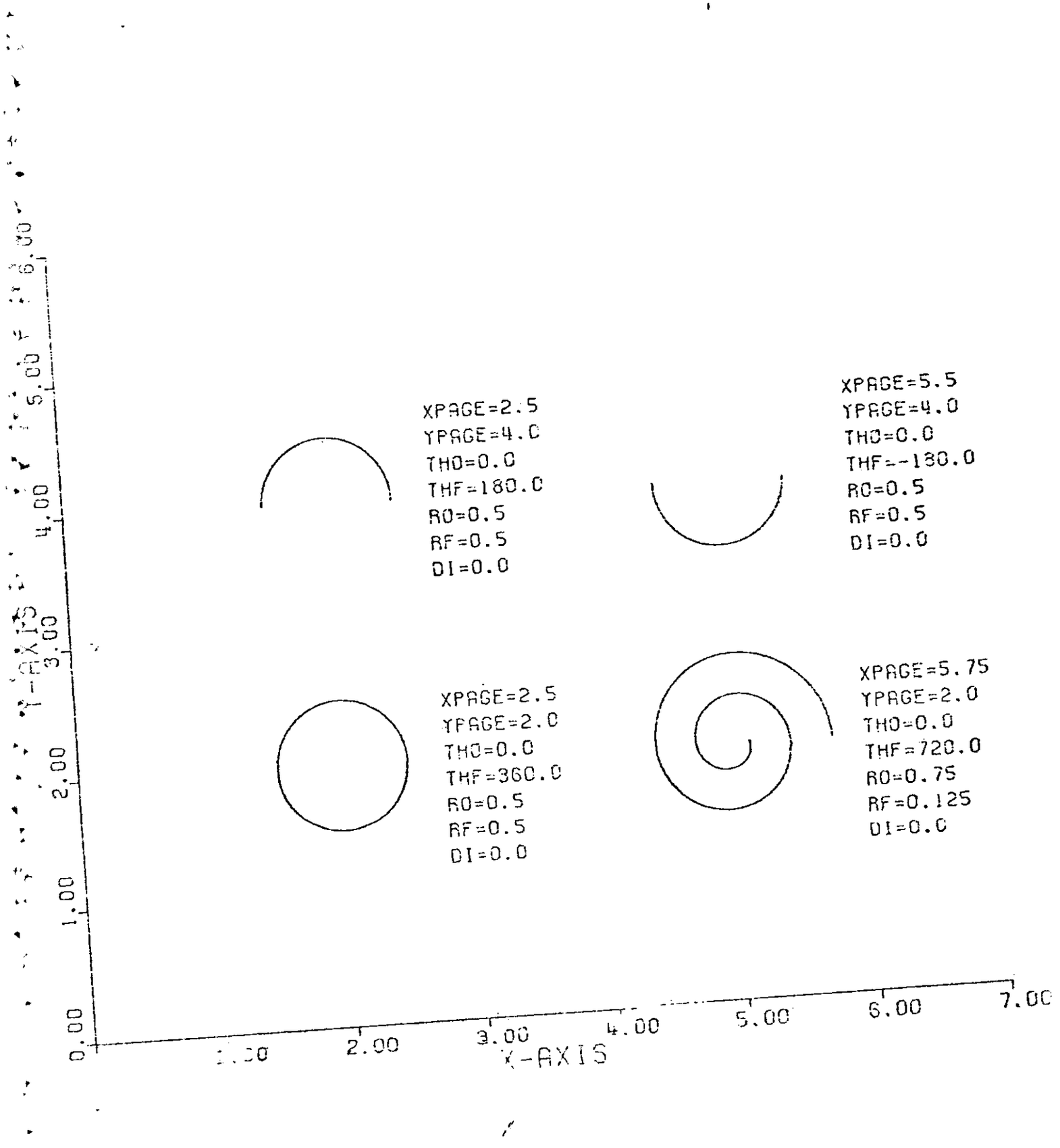
RF = the radius at the end of the arc, in inches.

DI = a code used to specify the type of the line desired.

If DI=0.0, a solid arc is drawn.

If DI=0.5, a dashed arc is drawn.

THO and THF may be positive or negative. If THO is less than THF, the arc is drawn in a counterclockwise direction, and if THO is greater than THF, the arc is drawn in a clockwise direction.


XPAGE=2.5
YPAGE=4.0
THO=0.0
THF=180.0
RO=0.5
RF=0.5
DI=0.0
XPAGE=5.5
YPAGE=4.0
THO=0.0
THF=-180.0
RO=0.5
RF=0.5
DI=0.0
XPAGE=2.5
YPAGE=2.0
THO=0.0
THF=360.0
RO=0.5
RF=0.5
DI=0.0
XPAGE=5.75
YPAGE=2.0
THO=0.0
THF=720.0
RO=0.75
RF=0.125
DI=0.0
Y-AXIS
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00

DASHL

This subroutine draws dashed lines through a series of data points. It differs from routine LINE only by the fact that a dashed line is drawn.

This subroutine has four arguments:

XARRAY,YARRAY,NPTS,INC

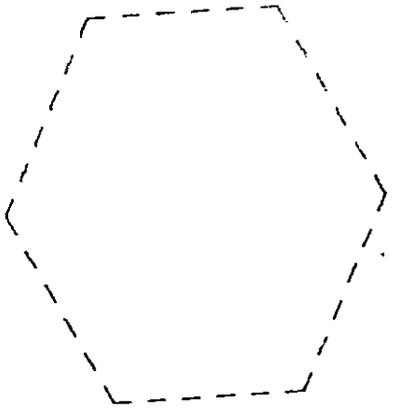
XARRAY = name of the array containing the abscissa values and the scaling parameters for the X array.

YARRAY = name of the array containing the ordinate values and the scaling parameters for the Y array.

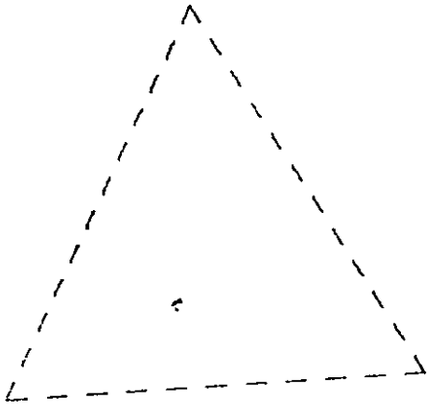
NPTS = the number of data points to be plotted.

INC = increment between elements of the array.

The XARRAY and YARRAY must be dimensioned with at least NPTS+2 elements. The user can supply the values of FIRSTV, DELTAV and store them at the end of the arrays. A dashed line connects sequential points with dashes approximately 0.1 inch long.



NPTS=7
INC=1



NPTS=4
INC=1

DASHP

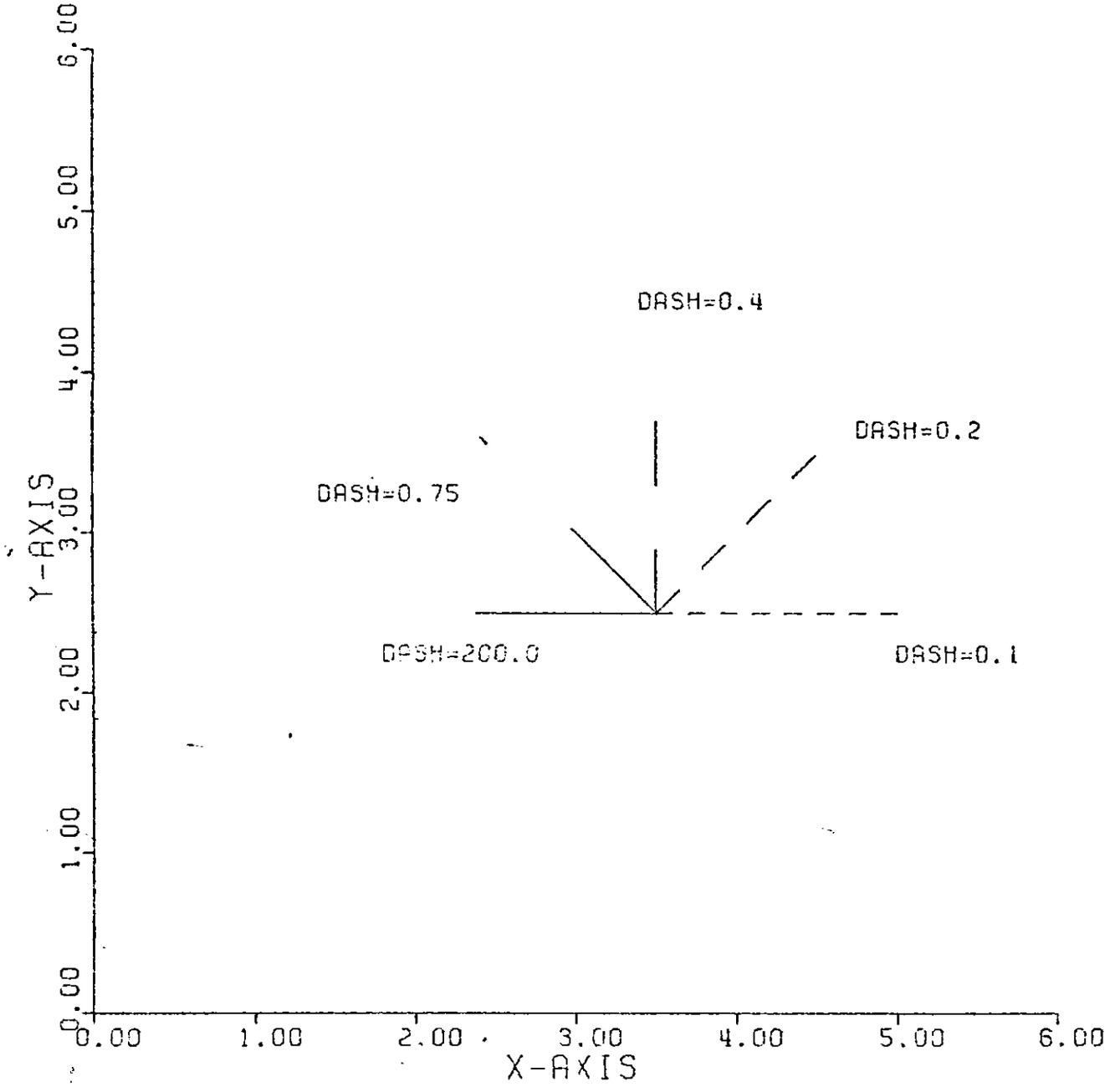
This subroutine draws a dashed line from the current pen position to a specified point.

This subroutine has three arguments:

XPAGE,YPAGE,DASH

XPAGE,YPAGE = the coordinates, in inches, of the point to which the dashed line will be drawn.

DASH = the length, in inches, of the dash line and the space between dashes.


DASH=0.4
DASH=0.2
DASH=0.75
DASH=200.0
DASH=0.1
Y-AXIS
X-AXIS
0.00
1.00
2.00
3.00
4.00
5.00
6.00

ELIPS

This subroutine draws an ellipse or elliptical arc.

This subroutine has eight arguments:

XPAGE,YPAGE,RMAJ,RMIN,ANGLE,THO,THF,IPEN

XPAGE,YPAGE = the coordinates of the starting point of the ellipse or arc, in inches.

RMAJ = the length of the major axis, in inches.

RMIN = the length of the minor axis, in inches.

ANGLE = the angle of the major axis,in degrees.

THO, THF = the beginning and final angles of the arc with respect to the angle of the major axis of the ellipse, in degrees.

IPEN = the code for moving the pen to the starting point of the arc.

If IPEN=2, the pen is down during the move.

If IPEN=3, the pen is up during the move.

THO and THF may be positive or negative. If THO is less than THF, the arc is drawn in a counterclockwise direction; if THO is greater than THF, the arc is drawn in a clockwise direction.

FIT

This subroutine draws a semi-hyperbolic curve through three points.

This subroutine has six arguments:

XPAGE1,YPAGE1,XPAGE2,YPAGE2,XPAGE3,YPAGE3

XPAGE1,XPAGE2,XPAGE3 = the X coordinates of the three points. XPAGE2 should be between XPAGE1 and XPAGE3.

YPAGE1,YPAGE2,YPAGE3 = the Y coordinates of the three points. YPAGE2 should be between YPAGE1 and YPAGE3.

GRID

This subroutine draws a linear grid.

This subroutine has six arguments.

XPAGE,YPAGE,DX,DY,NXSP,NYSP

XPAGE,YPAGE = the coordinates of the starting point on the lower left corner of the grid, in inches.

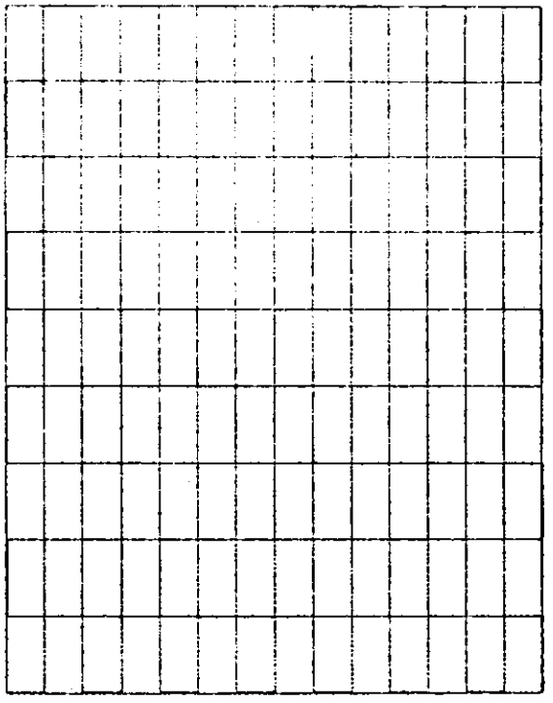
DX = the number of inches between grid lines in the X direction.

DY = the number of inches between grid lines in the Y direction.

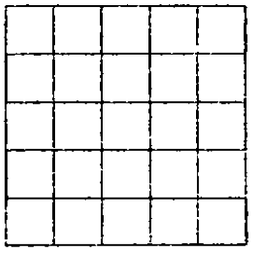
NXSP,NYSP = the number of spaces between lines in the X and Y directions, respectively.

GRID generates a linear gird of any size. The number of lines drawn is NXSP+1 in the X direction and NYSP+1 in the Y direction.

DX=0.2
DY=0.4
NXSP=14
NYSP=9



DX=0.25
DY=0.25
NXSP=5
NYSP=5



DX=0.5
DY=0.5
NXSP=5
NYSP=1

POLY

This subroutine is used to draw equilateral polygons.

This subroutine has five arguments:

XPAGE,YPAGE,SL,±RN,ANGLE

XPAGE,YPAGE = the coordinates of the starting point of the polygon, in inches.

SL = the length of a side of the polygon, in inches.

±RN = if RN is greater than 0, RN is the number of sides of the polygon.

if RN is less than 0, a star is drawn with RN points.

ANGLE = the angle of the first side of the polygon, in degrees.

RECT

This subroutine is used to draw rectangles.

This subroutine has six arguments:

XPAGE,YPAGE,HEIGHT,BASE,ANGLE,IPEN

XPAGE,YPAGE = the coordinates of the starting point of the rectangle base, in inches.

HEIGHT = the height of the rectangle, in inches.

BASE = the base of the rectangle, in inches.

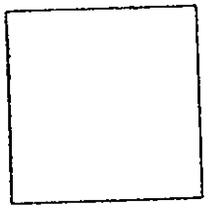
ANGLE = the angle of the base of the rectangle, in degrees.

IPEN = the code for moving the pen to the starting point of the rectangle.

If IPEN=2, the pen is down for the move.

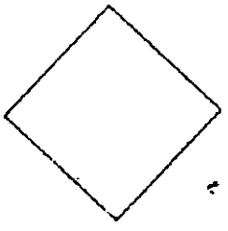
If IPEN=3, the pen is up for the move.

HEIGHT=1.0
BASE=1.0
ANGLE=0.0
IPEN=3

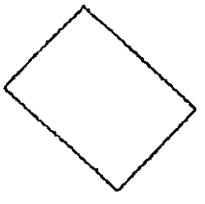


HEIGHT=0.6
BASE=1.4
ANGLE=0.0
IPEN=3

HEIGHT=0.8
BASE=0.8
ANGLE=225.0
IPEN=3



HEIGHT=0.8
BASE=0.6
ANGLE=-135.0
IPEN=3



BIBLIOGRAPHY

1. P. Cress, P. Dirksen, and J. W. Graham, "FORTRAN IV with WATFOR and WATFIV," Prentice-Hall, Inc., New Jersey, 1968.

2. B. L. Wellman, "Introduction to Graphical Analysis and Design," McGraw-Hill Book Company, New York, 1966.

3. H. W. Franke, "Computer Graphics," Phaidon Publishers Inc., 1971.

4. L. Cooper and M. Smith, "Standard Fortran: A Problem-Solving Approach," Houghton Mifflin Company, Boston, 1973.

5. Subroutines of California Computer Products Inc., 1968, pp. 1-31.

6. "Programming CalComp Pen Plotters," California Computer Products, Inc., 1969.

7. C. L. Martin, "Design Graphics," The Macmillan Company, New York, 1968.