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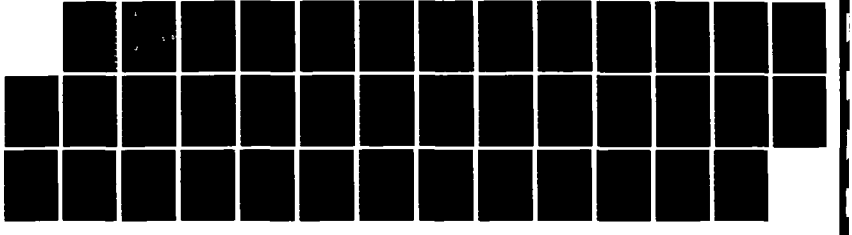

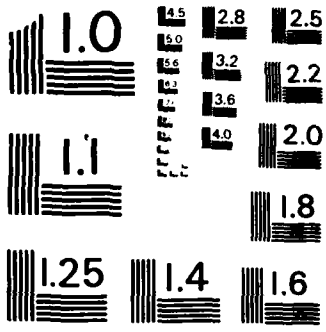

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS - 1963

AD-A169 812

TECHNICAL REPORT RD-DE-86-1

PCVUGRAF PC BASED CODE FOR TEXT CHARTS AND VISUAL AIDS

Miles E. Holloman
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Directed Energy Directorate
Research, Development, and Engineering Center

NOVEMBER 1985

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U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama 35898-5000

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PCVUGRAF is a user friendly charting utility for the MICROCOMPUTER. The code generates presentation quality vu-graphs and charts of various forms.

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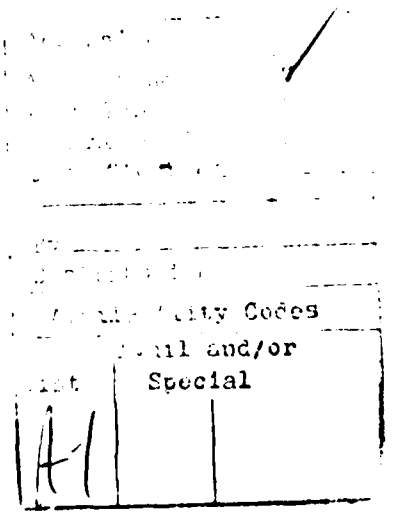

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I. BACKGROUND

The PCVUGRAP program was developed within the US Army Missile Command, Research, Development, and Engineering Center, Directed Energy Directorate, as an expedient tool for the creation of presentation quality text charts. The philosophy that drove the code development was that the tool should be compatible with a minimal microcomputer system, no requirement for excessive computer background or knowledge, allow for the storage of the chart information on disk, and provide sufficient options to allow a reasonable variety of chart types at a presentation quality level. Presentation quality level would be a graphic arts quality at least of the quality of typewriter generated charts, but not necessarily of the professional quality of a graphic arts department. The approach was to develop the code in FORTRAN on a microcomputer equipped with a Hewlett-Packard pen plotter. A number of Hewlett-Packard pen plotters are available; the Model 7475A is used in this discussion as typical of these plotters, compatible with most microcomputers and having exploitable built-in features that would facilitate and simplify the program development.

Alternate approachs to the code development were considered but finally narrowed to two. One approach would be that of a design that would be very user friendly in which it would be assumed the user would have little or no knowledge of a computer. The code in this case would be required to "ask questions" of the user, process the information, store the data on file and finally plot the resulting chart as the built in logic would dictate. From experience it was found that with experienced computer users this approach of having to address multiple menues again and again is an undesirable burden and the preferred approach would be that of minimizing this interaction. Additionally, while it might appear desirable to have a feature to preview the chart on the monitor prior to the plotting, to incorporate this feature would require substantially more complicated coding as well as a hardware requirement to include graphics as a minimum.

The selected approach resulted in a code design that assumed the user to have available a typical editor/word processor program to create a file of information to be processed by the PCVUGRAF program. The only preview of the final chart would then be in the editor/word processor display on the monitor screen. There is a distinct advantage to the elimination of the screen preview in that the plotted chart is now in no way releated to the ability to display the chart on the monitor screen. The chart is not limited by eighty character lines or in the case of graphics screens the ability to represent very small characters in a readable form. Additionally, the typical 25 lines per screen limit of most monitors is also avoided, but at the scarifice of not really knowing what the chart is like until it is plotted. Experience has shown the gains in speed and versitility of this approach outweigh the ability to preview the chart before plotting.

The selected approach allows for various sizes of the lettering but only the font that is built into the plotter being used. For this reason the newer Hewlett-Packard plotters are recommended in that the built-in fonts are more pleasing to the eye than the fonts in the older models.

Within the Directed Energy Directorate the PCVUGRAF program has proven to be a very useful tool for generation of charts and viewgraphs in a cost effective, expedient manner. The ability to store the chart in a disk file allows the chart to be corrected or modified easily and provides a convenient record for future reference.

II. PCVUGRAF HARDWARE/SOFTWARE REQUIREMENTS

PCVUGRAF is written in MICROSOFT FORTRAN and requires the avilability of MICROCOMPATIBLES PLOTMATICS and MICROCOMPATIBLES GRAPHMATICS as a library routine. Machine requirements are that of an IBM PC or IBM PC compatible microcomputer with a minimum of 128K of RAM, a MICROSOFT DISK OPERATING SYSTEM (MS-DOS), a monochrome or graphics monitor and a Hewlett-Packard plotter (Model 7475A is recommended). A line printer is useful to allow viewing of the entire file but is not required. The code has not been checked on all Hewlett-Packard plotters but appears to operate properly on those tested.

Additionally, it is required that an editor/word processor is available. To take full advantage of the PCVUGRAF program this editor should not be limited to 80 character lines, but be capable of up to 100 and 60 characters per line.

III. PCVUGRAF GENERAL DISCUSSION

To generate a chart using PCVUGRAF the user must first create a file with the proper instructions and information for the program to process. This information consists of lines of code containing two single character values the first of which indicates lettering size or special feature and the second indicating the pen or alternate special features to be used in the plotting of this current line of data followed by the text or special information/ instruction for this line of data. The PCVUGRAF program assumes the final chart to have a format consisting of a TITLE section and a BODY section optionally contained within a frame. The TITLE section generally contains one to three lines of text and is automatically horizontally and vertically centered by the program. In this section of the chart the PCVUGRAF code adjusts the letter size to assure that the intended information can be contained within the allotted space. The BODY section of the chart may contain up to 110 lines of text. In this section the code does not automatically horizontally center the text, but allows the user complete control over the layout in this section. The code does however insure the lettering size is adjusted so that all information fits within the bounds in length and height of this section. The code logic is such that the total number of lines of code in this section is determined as is the maximum number of letters in the longest line. From this information the letter size is adjusted so that all information will fit within the bounds of this area accounting for the various sizes of letters. In both the TITLE and BODY sections of the chart leading blanks are counted as blank characters however; the trailing blanks are not included in the total character count. The user will find that complete control in this section sacrifices the code logic that would automatically prevent unpleasent aspect ratios in the lettering. For example, if only one line of text is indicated in the BODY section of the chart the code will attempt to fill the entire BODY with this single line creating very tall lettering. To avoid this problem, experience will indicate the inclusion of blank lines used as spacers or space-savers to adjust the height and width of

the lettering. Figure 1 illustrates the general form of a PCVUGRAF chart and indicates the TITLE and BODY sections enclosed in the two frame options provided in the program. The standard features of affixing the file name and current date are also illustrated in this figure.

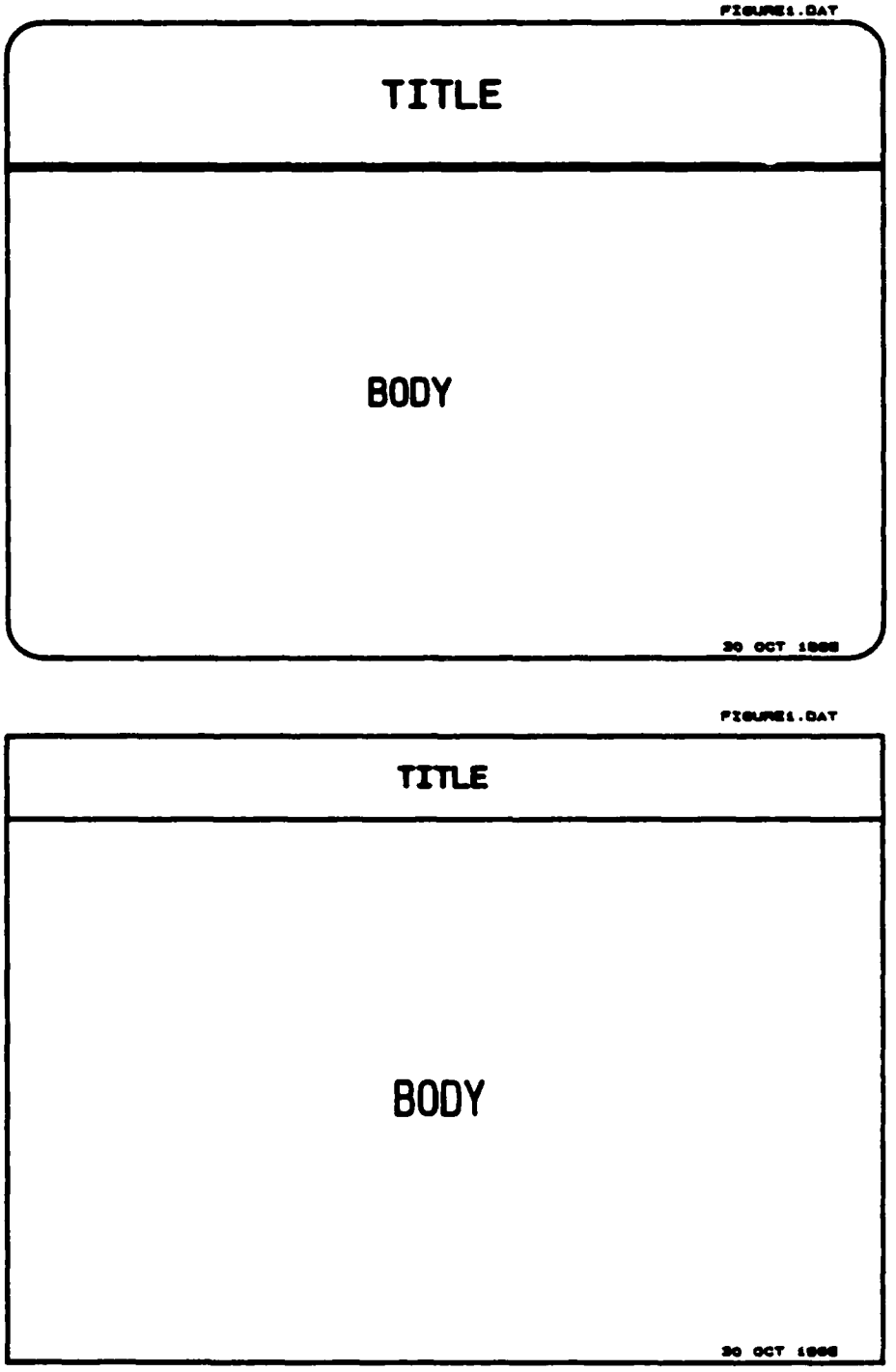


Figure 1. General format of TITLE and BODY of PCVUGRAF.

A. Title Section

The TITLE section of a chart typically contains from one to three lines of text. The instructions for this section are of the form:

SIZE,PEN,TEXT

where

SIZE is a single character representing the relative size of the line of code.

PEN is the desired pen number to be used in plotting the text.

TEXT is the string of characters to be plotted.

NOTE: The program reqires the SIZE character code to be in column 1 of the card image field; PEN character code in column 3 and the TEXT section beginning in column 5. Each of these sections is separated by a comma. The PCVUGRAF program will raise an error message if the format of the input is violated.

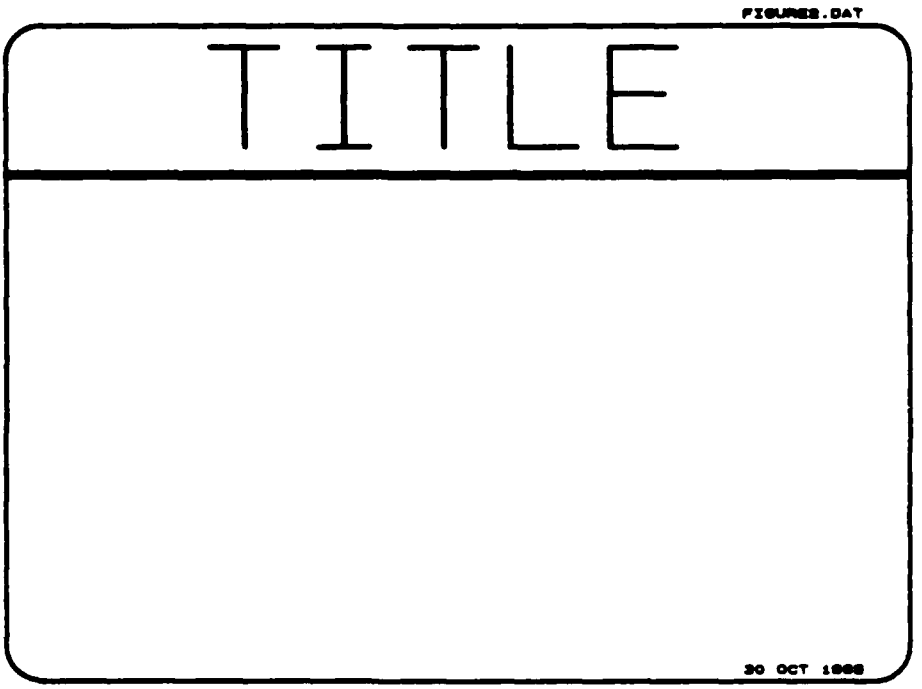
Three options are available for the SIZE parameter to determine the relative size of the lettring in each line. The options are S, M, and L representing lettering in the relative size ratio of 0.64, 0.80, and 1.00. That is, if one line large, L, lettering is used and the next small, S, is used the size of the small lettering will be 0.64 of the large lettering size. These rations are given as relative rather than absolute since the actual letter size will depend on the number of lines of text and the maximum number of letters in the longest line in this section. As previously stated the code automatically centers each line of text in this section. This centering requires the counting of the characters per line and in so doing leading blanks are included in the total, trailing blanks are not. Thus, common practice is to begin the line of TITLE text in the first available postion in the text field to assure proper centering.

The options for PEN are dictated by the plotter. The Model 7475A a six pen plotter will then have six options 1,2,3,4,5 and 6 the actual pen colors or line widths will be dictated by the placement in the plotter carousel.

TEXT represents the actual string of characters to be plotted and is limited to 160 characters. A practical limit is generally less than 50 characters to assure the lettering size to be in keeping with typical titles and the expected appearance of charts of this nature.

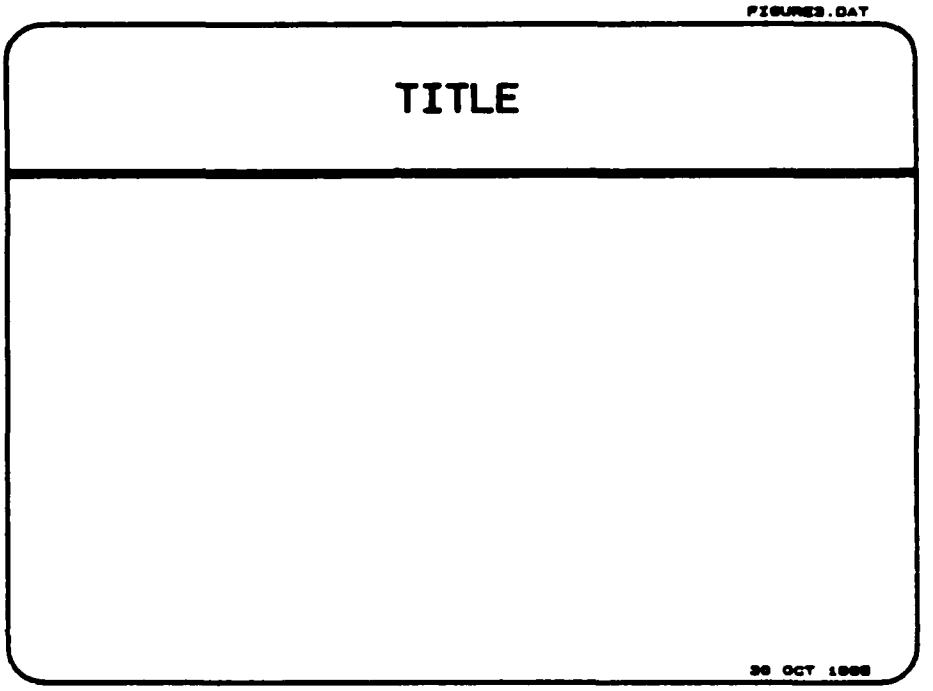
Experience has shown that three lines of text in this section is a practical limit from the appearance of the resulting chart. Additionally, even if only one line of text is desired it is suggested two blank lines be used to assure a more pleasing appearance to the lettering. Figure 2 illustrates typical code to generate the resulting chart contained in Figure 2; note the single line TITLE section and the resulting aspect ratio in this section of the chart. From the code section in Figure 2 it should be noted

that the string of dashes denotes the end of the TITLE section. Figure 2 should be compared with Figure 3 in which additional blank lines have been used to cosmetically improve the appearance of the TITLE section of the chart.




```
L,5,TITLE
---------------
```

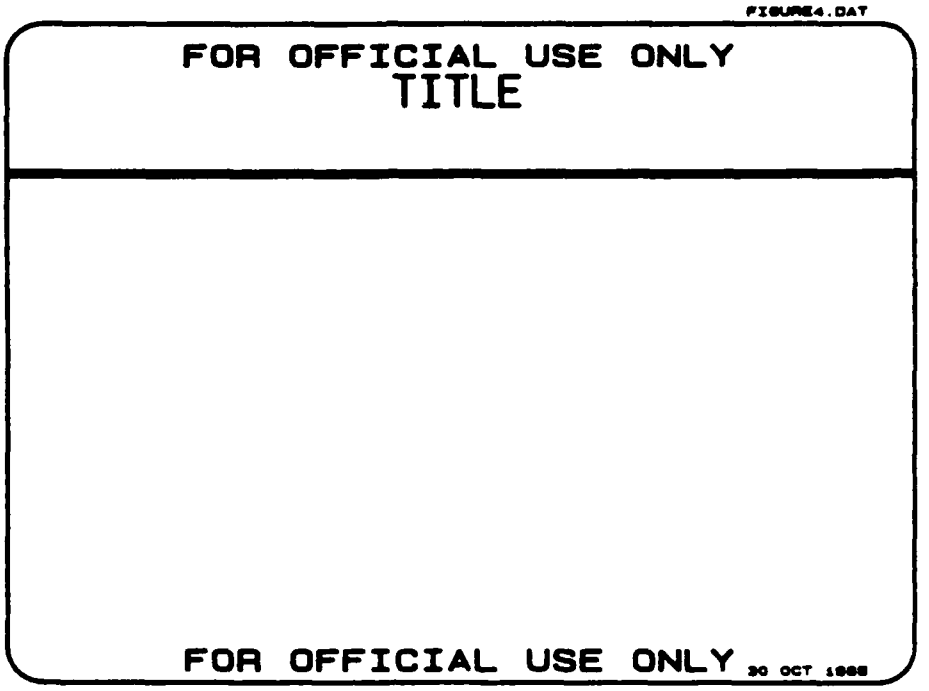
Figure 2. Typical code to generate the resulting chart.




```
L,5,
L,5,TITLE
L,5,
-------------
```

Figure 3. Illustrates additional blank lines used to cosmetically improve appearance of TITLE section.

An additional feature of this section is that of handling of possible classifications placed on charts and viewgraphs. It is common practice to require that restricted information be properly marked. The manner in which this is done is to mark the chart both top and bottom by information such as "FOR OFFICIAL USE ONLY". The PCVUGRAF code will automatically assume that if the first line of coded instruction in the TITLE section requires the small, S, letter size the intent is that the TEXT will be a classification marking to be placed on the first and last lines of the chart. Figure 4 illustrates the code and resulting chart for this option.




```
S,5,FOR OFFICIAL USE ONLY
L,5,TITLE
L,5,
----------
```

Figure 4. Classification marking in TITLE and BODY section.

The final user option for the TITLE section is not specified in the generation of the data file but rather in the running of the PCVUGRAF code. This option, to be discussed in the "RUNNING THE PROGRAM" section determines the number of times the TITLE section is to be overwritten. Each time the TITLE is overwritten the pen is slightly offset to add width and boldness to the lettering thus enhancing the appearance.

B. Body Section

In the data file containing the information to be processed by the PCVUGRAF program the TITLE section is separated from the BODY section by a string of dashes. This deliminiter will not appear in the final plotted chart, but is used within the editor to allow the user to easily see the general form and layout of the chart. In this section of the chart, additional options are

available to allow not only the three letter sizes but also special characters, overlaying, subscripts, superscripts, underlining and the drawing of combinations of horizontal and vertical lines to form enclosures for tables, schedules and high-lights. As in the TITLE sectin the coded instructions are of the form:

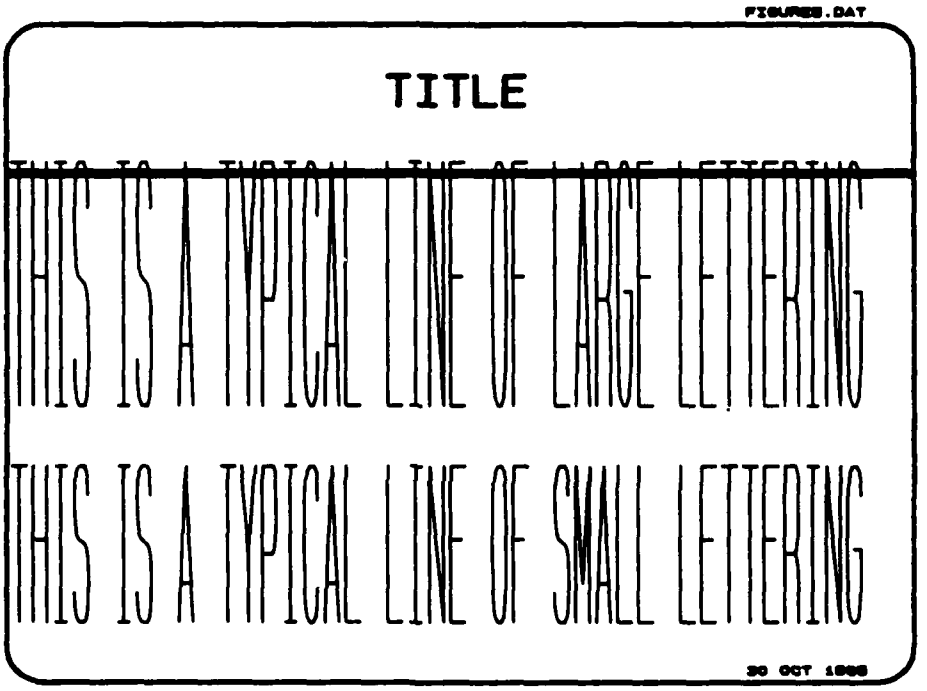
SIZE/OPTION,PEN/OPTION,TEXT/GRAPHICS INSTRUCTION

The above form appears more complicated then the one previously discussed for the TITLE section. The SIZE/OPTION is again a single character that specifies the lettr size, S, M or L but in addition has the options of T, B, O, and C to indicate additional modes of operation. Additional options other than the pen to be used may be specified. Limited graphics instructions as well as text are also available in this section.

The first character in each line of instruction code may be as before S, M or L indicating the relative size of the desired lettering. The relative sizes are as before 0.64, 0.80 and 1.00 with the absolute letter size determined by the number of lines of text and the maximum number of letters in the longest line. For example, typical lines of instructional code may have the form:

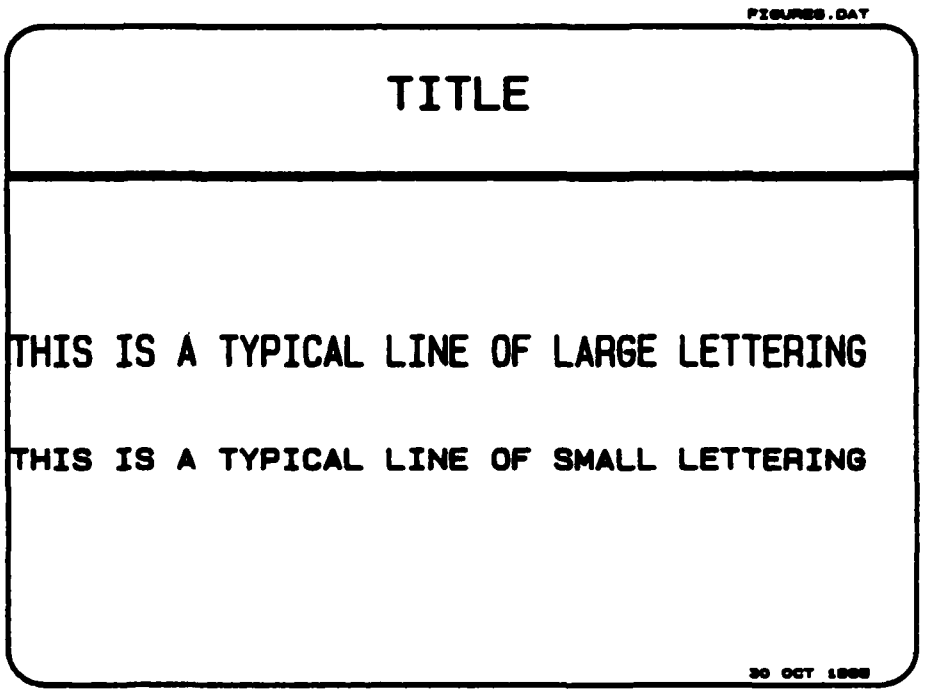
```
L,1,THIS IS A TYPICAL LINE OF LARGE LETTERING
S,2,THIS IS A TYPICAL LINE OF SMALL LETTERING
```

The SIZE character code, L and S in the above example must be located in column 1 of the card image; the PEN character code, 1 and 2 in the above example, must be located in column 3 of the card image and the TEXT section can be located beginning in any column from 5 to 160. These sections of the instructions are separated by commas as in the TITLE section. The PCVUGRAF program does not automatically center text in this section of the chart thus the relative positioning is up to the user. In the above example the "T" in "THIS" would be at the far left boundary of the chart and the final letter "G" in "LETTERING" would be at the far right boundary of the plotting area which might lead to undesirable aspect ratios. Figure 5 illustrates the chart resulting from this coded instruction set and the undesirable appearance. As the examples develop it will become clearer how to avoid these problems, but in general it has been found from experience that a minimum of approximately 12 lines are required in this section, many of which may be blank, to achieve a reasonable aspect ratio to the lettering. Figure 6 illustrates this improvement.




```
S,5,
L,5,TITLE
L,5,
----------
L,5,THIS IS A TYPICAL LINE OF LARGE LETTERING
S,5,THIS IS A TYPICAL LINE OF SMALL LETTERING
```

Figure 5. Coded instruction sets and undersirable appearances.




```
S,5,
L,5,TITLE
L,5,
----------------
L,5,
L,5,
L,5,
L,5,
L,5,THIS IS A TYPICAL LINE OF LARGE LETTERING
L,5,
L,5,
L,5,THIS IS A TYPICAL LINE OF SMALL LETTERING
L,5,
L,5,
L,5,
L,5,
```

Figure 6. Illustrates reasonable aspect ratio to the lettering of a chart.

The additional first character options T, B, 0, and C indicate special features that are applied relative to a line of code beginning with the more familiar S, M or L. That is, a given line of text code plotting using the S, M, or L options, to be referred to as the base line in this discussion, can be modified or enhanced by the use of the T, B, 0 or C options. The option T indicates superscripts and the B indicates a subscript. Superscripts and subscripts are of a smaller lettering size, relative size ratio 0.50, and are located slightly above or below the base line of text. An example of their use is as follows in which leading spaces have been added within the text to better position within the available area.

```
T,5,                          2

L,5,              AREA = PI * R
```

Notice that to exercise the superscript option or subscript option two instruction code lines are required. The "2" to be used as the superscript is located in the column immediately to the right of the "R" in the base line of code.

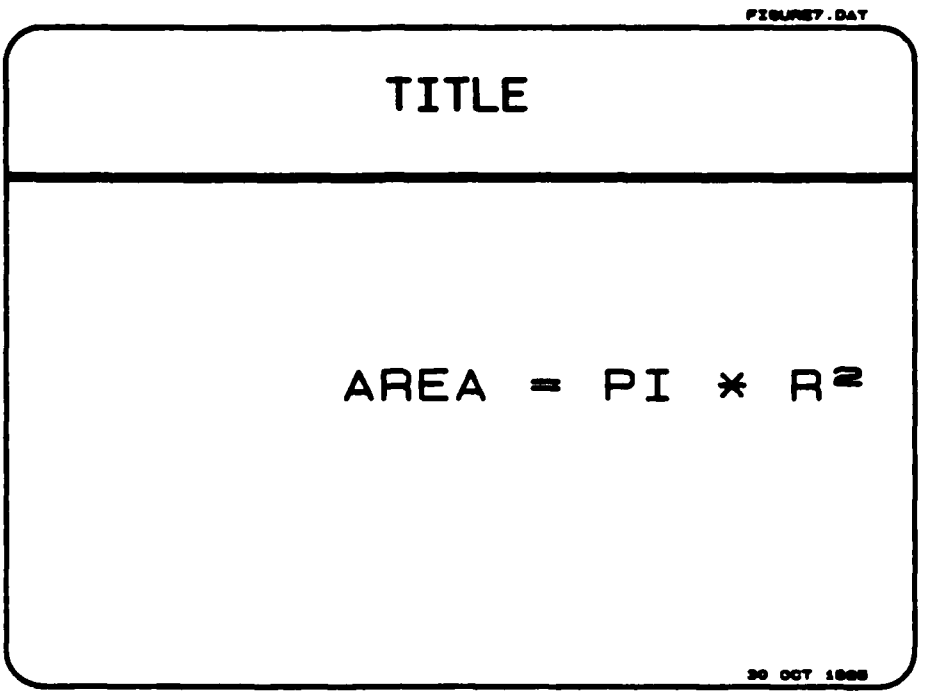
The line of code:

```
L,5,              AREA = PI * R
```

is the base line of code in the example. This feature is illustrated in Figure 7.

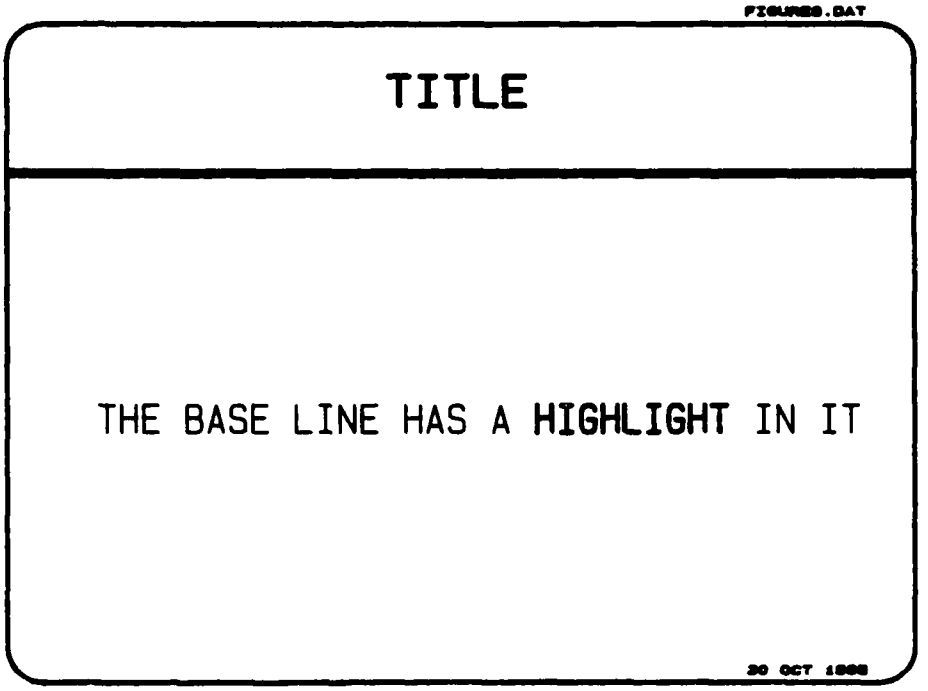
The 0 or overlay option is used to allow the use of different pens to write lettering on a single line of text. This option might be used to highlight a word or phrase within a line by writing over a given word a second time to make it somewhat darker than the surrounding text or to use an alternate pen to insert a highlighted word or phrase within the line. The following example illustrates the instructional code to insert a word written with an alternate pen within the base line of code (see Fig. 8).

```
L,1,     THE BASE LINE HAS A          IN IT

0,5                          HIGHLIGHT
```




```
S,5,
L,5,TITLE
L,5,
---------------
L,5,
L,5,
L,5,
L,5,
L,5,
T,5,                    2
L,5,          AREA = PI * R
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,
```

Figure 7. Superscript options or subscript options.




```
S,5,
L,5,TITLE
L,5,
---------------------------
L,1,
L,1,
L,1,
L,1,
L,1,
L,1,
L,1,
L,1,     THE BASE LINE HAS A           IN IT
0,5,                          HIGHTLIGHT
L,5,
L,5,
L,5,
L,5,
L,5,
```

Figure 8. Instructional code to insert a word written with an alternate pen within the base line of code.

It is assumed the pen number 5 is somehow different from pen number 1 such as being wider or of an alternate color. The overlay, O, option can be used within any letter size, S, M or L and the overlayed text will be sized according to the base line of code directly above it in the above example. Multiple overlays are possible to provide the use of several different colors of pens on a single line as in the following example.

```
L,1,      BLACK PEN #1

O,2,                    RED PEN #2

O,3,                                GREEN PEN #3
```

The special character or C option provides for characters and symbols not normally available within the built-in character set of the plotter. These characters are currently limited to mathematical and typical Greek symbols used in science and engineering. The manner in which the special character option is used is to so signify by the first letter of the instruction code beginning with "C" followed by the pen number to be used. The text section will be interpreted as special character code rather than the normally represented ASCII character. Table 1 lists the special character codes and the corresponding special character. For example the letter "p" is used to indicate the desired use of the greek letter. The special character option is used in a manner similar to the overlay option in that it is assumed by the program the special character is to be inserted or overlayed within a base line of code that preceeds it and thus determines the actual letter size. An example of the use of this option is:

```
T,1,                        2

L,1,          AREA =    * R

C, 1,                   p
```

TABLE 1. Special Character Codes.

CODE	CHARACTER	CODE	CHARACTER
!	√	$	∇
%	±		−
:	∩	<	≤
>	≥	?	Σ
D		I	∞
a	α	b	β
c	↓	d	φ
|	|	g	λ
h	η	l	ω
m	μ	n	ν
o	ρ	p	π
q	γ	r	θ
s	σ	t	τ
v	Δ	w	δ
=	_	@	●

Figure 9 illustrates the resulting chart from this set of instructional code. For those cases in which the special character is not to be inserted within a line of text, but is to be a separate line of text the approach would be to create a blank base line onto which the special character would then be inserted.

C. Pen Option

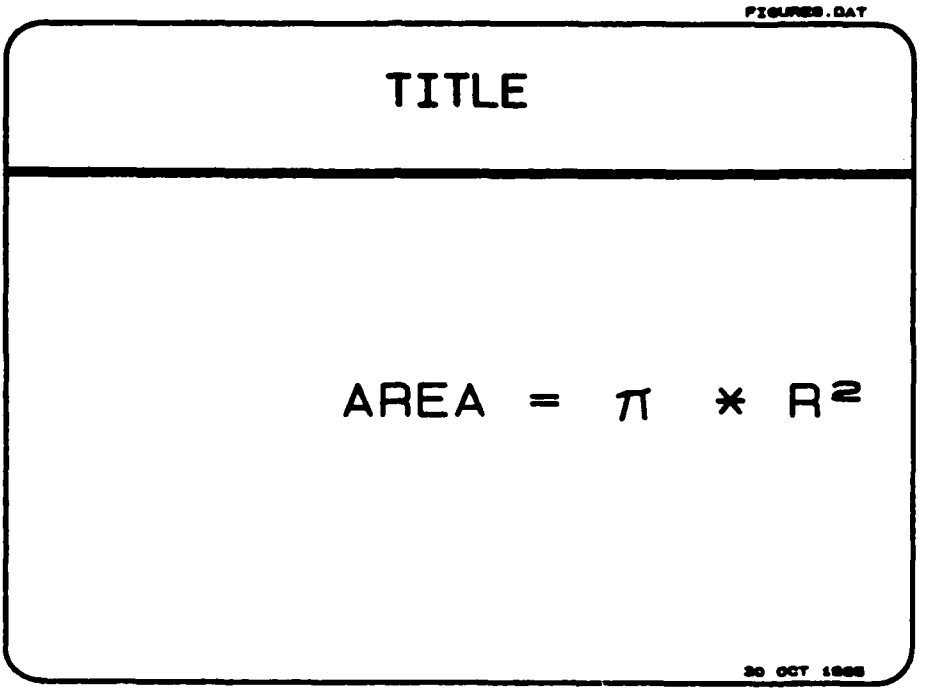
The PEN/OPTION character code not only provides the pen number to be used in plotting the text but also provides two additional options in this section. The underline, U, provides a mechanism to underline a portion of a line of text. This option is used much like the modification and enhancement options previously discussed. An example of its use is:

```
L,5,      THIS IS AN EXAMPLE OF THE UNDERLINE

S,U,                                ---------
```

where the dash character is used to indicate the underlining option, (see Fig. 10).

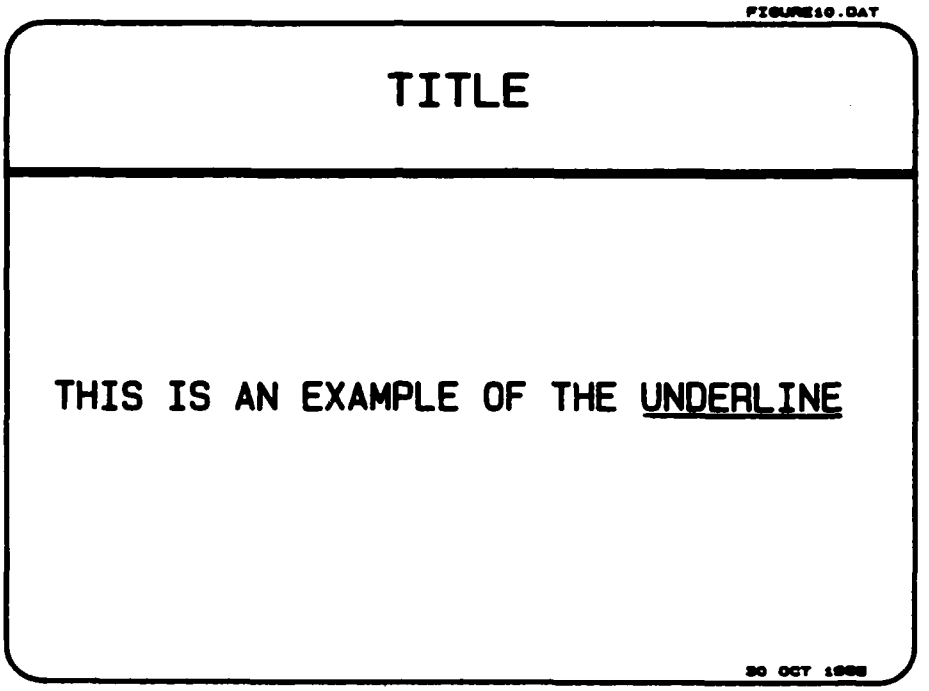
The additional feature the OPTIONS for this character code involve the ability to draw limited graphics. These graphics are limited to horizontal and vertical lines between end points specified by the user. The coding used is to denote the use of this option by specification of "S,G," as the code. The TEXT section of the line of code is replaced by the single character letters T, B, L, R and +. The character T denotes the upper extreme of a vertical line to be drawn between T and B where B denotes the lower extreme. Likewise L and R are the extremes, left and right, of a horizontal line. Placement of these lines within the normal text will allow the text to be separated by horizontal and vertical lines. An example of its use is:

```
S,G, L                    T                    T                    R

L,1,   TECHNICAL AREA          FUNDS AVAILABLE      COST TO DATE

S,G, L                                                              R

M,1,     HARDWARE                $10,000.             $3,000.

S,G, L                                                              R

M, 1,    SOFTWARE                $ 9,000.             $5,000.

S,G, L                    B                    B                    R
```




```
S,5,
L,5,TITLE
L,5,
----------------
L,5,
L,5,
L,5,
L,5,
L,5,
T,5,                    2
L,5,          AREA =   * R
C,5,                   p
L,5,
L,5,
L,5,
L,5,
L,5,
```

Figure 9. Illustrates how a special character option is inserted or overlayed within a base line of code.




```
S,5,
L,5,TITLE
L,5,
----------------
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,    THIS IS AN EXAMPLE OF THE UNDERLINE
S,U,                                ----------
L,5,
L,5,
L,5,
L,5,
L,5,
```

Figure 10. Example of where a dash character is used to indicate the underlining option.

Figure 11 illustrates the resulting chart. The appearance of the chart would be improved if the text was enclosed within a box rather than only the horizontal and vertical lines. The "+" character is used to accomplish this. The "+" locates a corner and requires second graphics characters, L,R or +, to be located on the same horizontal line and another in the same vertical column to complete the definition of the corner. This is best seen by the following example; the previous example is repeated as follows:

```
S,G, +                    T                    T                    +
L,1,   TECHNICAL AREA            FUNDS AVAILABLE      COST TO DATE
S,G, L                                                                R
M,1,     HARDWARE                  $10,000.             $3,000.
S,G, L                                                                R
M,1,     SOFTWARE                  $ 9,000.             $5,000.
S,G, +                    B                    B                    +
```

Figure 12 illustrates the chart resulting from these instructions.

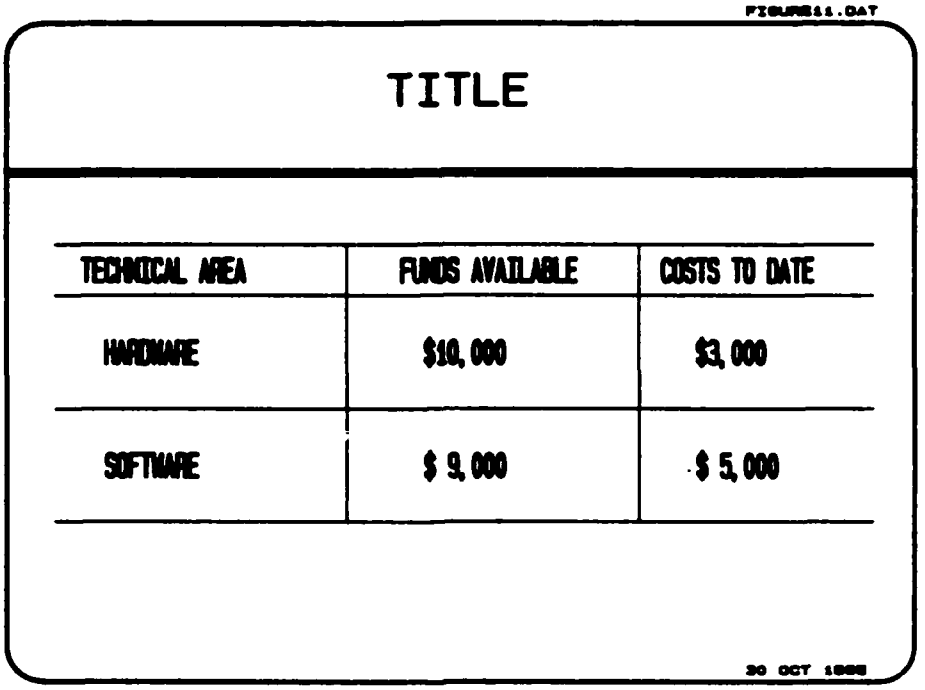
The graphics option requires the use of pairs of symbols to define the beginning and terminating locations of horizontal and vertical lines. These symbols must be properly aligned in the instruction file and failure to do so will cause the program to accomodate the symbol as to providing adequate space to perform the graphics, but will not actually draw the lines unless the pairing is accomplished. That is, the code matches only vertical and horizontal end points, if the end points do not align themselves properly it will be interpreted as single end points of different lines rather than end points of the same line.

FIGURE11.DAT

TITLE

TECHNICAL AREA	FUNDS AVAILABLE	COSTS TO DATE
HARDWARE	$10,000	$3,000
SOFTWARE	$ 9,000	$ 5,000

30 OCT 1988



```
S,5,
L,5,TITLE
L,5,
-- ----------------
L,5,
L,5,
S,G, L                    T                    T                    R
L,5,     TECHNICAL AREA          FUNDS AVAILABLE          COSTS TO DATE
S,G, L                                                                R
L,5,
L,5,      HARDWARE                 $10,000                 $3,000
L,5,
S,G, L                                                                R
L,5,
L,5,      SOFTWARE                 $ 9,000                 $5,000
L,5,
S,G, L                    B                    B                    R
L,5,
L,5,
L,5,
```

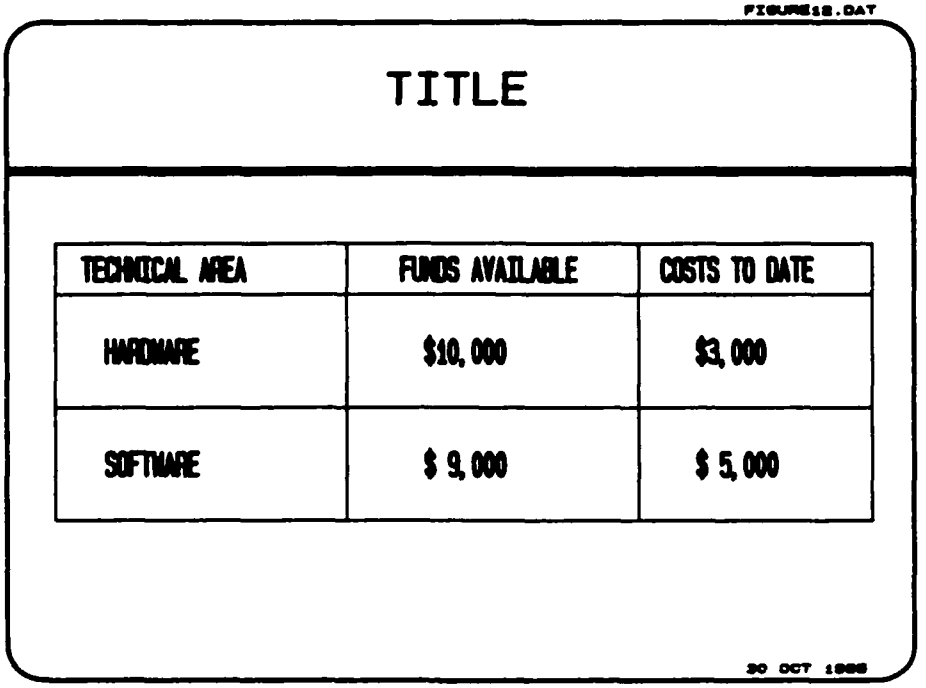
Figure 11. Example of the usage of vertical and horizontal lines.

FIGURE12.DAT

TITLE

TECHNICAL AREA	FUNDS AVAILABLE	COSTS TO DATE
HARDWARE	$10,000	$3,000
SOFTWARE	$ 9,000	$ 5,000

30 OCT 1986



```
S,5,
L,5,TITLE
L,5,
--------------------
L,5,
L,5,
S,G, +                    T                    T                    +
L,5,     TECHNICAL AREA          FUNDS AVAILABLE          COSTS TO DATE
S,G, L                                                                R
L,5,
L,5,      HARDWARE                $10,000                $3,000
L,5,
S,G, L                                                                R
L,5,
L,5,      SOFTWARE                $ 9,000                $5,000
L,5,
S,G, +                    B                    B                    +
L,5,
L,5,
L,5,
```

Figure 12. Illustrates the usage of a box rather than only the horizontal and vertical lines.

Since trailing blanks are not used to determine the maximum line length no convenient means has been discussed to this point to force the placement of short lines of text to the left portion of the chart. A convenient means of accomplishing this is to provide a final line of text in using the graphics option with a "R" in the column to define the right most boundary of the chart. To illustrate this compare Figures 13 and 14 and the corresponding coding used to create them.

An additional option is provided for drawing horizontal lines. This option is of the form:

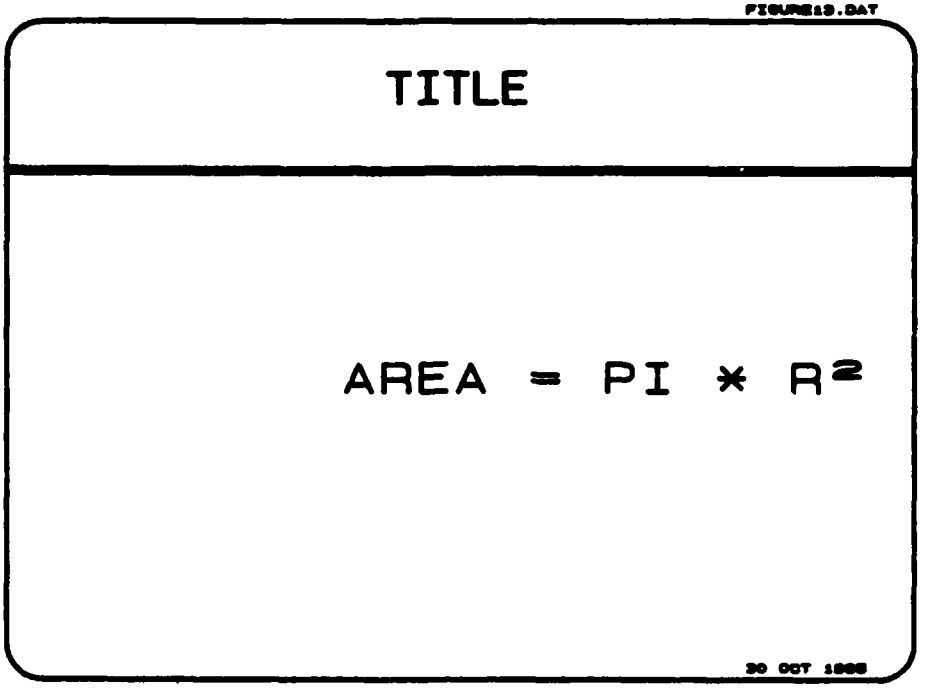
```
L,1,  ----------
```

This command results in drawing a horizontal line between the extremes. If a single hyphen is used it is interpreted as a normal hyphen. Multiple hyphens are interpreted as a continuous line. This option thus makes the normal plotting of a string of hyphens impossible, however, this is provided as a special character feature. The instruction

```
C,1,  ---------
```

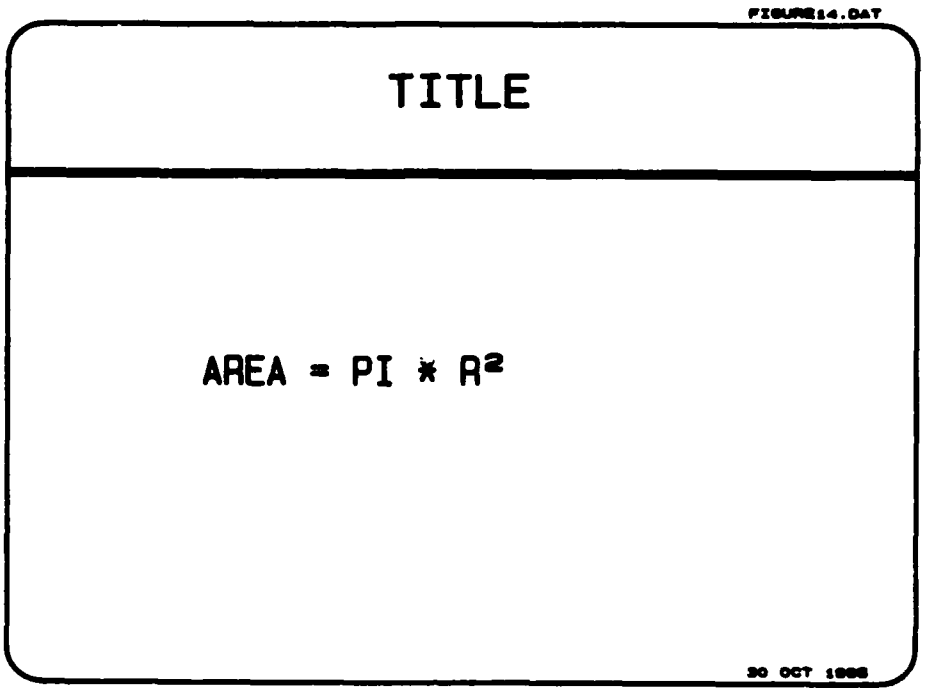
will result in a hypen string. The Appendix contains examples of the use of these two features.

The preceeding discussion has described the options available in the PCVUGRAF program. The user can combine these features to construct charts and viewgraphs of various types and forms. Typical examples of charts and viewgraphs are found in the Appendix section of this report.




```
S,5,
L,5,TITLE
L,5,
---------------
L,5,
L,5,
L,5,
L,5,
L,5,
T,5,                    AREA = PI * R 2
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,
```

Figure 13. Illustrates placement of text in chart without usage of "R" in column to define right most boundary of the chart.




```
S,5,
L,5,TITLE
L,5,
---------------
L,5,
L,5,
L,5,
L,5,
L,5,
T,5,                                  2
L,5,                AREA = PI * R
L,5,
L,5,
L,5,
L,5,
L,5,
L,5,
S,G,                                                    R
```

Figure 14. Illustrates usage of "R" in the column to define right most boundary of the chart.

IV. RUNNING THE PROGRAM

The program is initiated by typing the progam name, PCVUGRAF, immediately following the operating system prompt. The program then prompts the user for two options.

SPECIFY THE OVERWRITE OPTION AND FRAME OPTION

1, 2, 3, 4 1-VUGRAF 2-BOX OR SQUARE 3-NO FRAME

The information is to be input in free field format separated by a comma. Figure 1 illustrates the appearance of the frames available.

The final prompt is for the name of the file containing the instructions for plotting the chart.

Upon completion of the chart the program automatically labels the chart in the upper right corner with the file name and in the lower right portion with the current date.

APPENDIX

TEMPLETS AND GUIDES TO THE MORE USED CHART FORMS

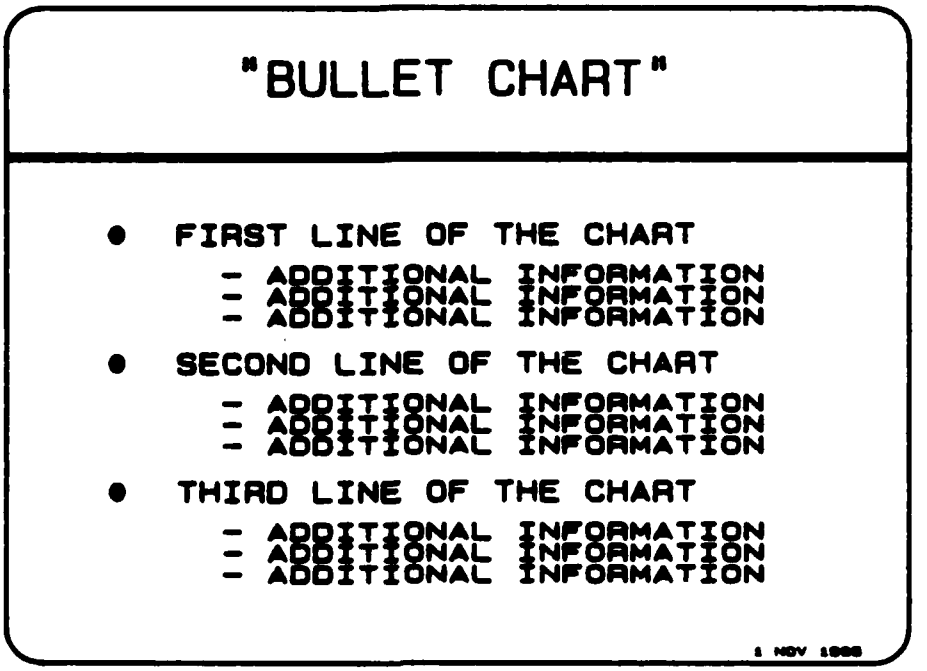
APPENDIX

Three example charts and their respective instruction files are contained in this section to serve as templets and guides to the more used chart forms.

Figure A-1 illustrates a typical "Bullet Chart" in which the special character bullet is used to highlight portions of a chart.

Figure A-2 is a typical schedule chart combining the features of lettering, special characters and graphics. Table A-1 contains the code to generate the chart.

Figure A-3 is a demonstration chart in which most of the options available in PCVUGRAF are exercised for reference. Table A-2 contains the code for the generation of this chart.




```
S,5,
L,5,"BULLET CHART"
M,5,
------------------------
L,5,
L,5,
L,5,      FIRST LINE OF THE CHART
C,5     @
S,%,
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,
L,5,      SECOND LINE OF THE CHART
C,5     @
M,5,
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,
L,5,      THIRD LINE OF THE CHART
C,5     @
M,5,
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,          - ADDITIONAL INFORMATION
M,5,
S,G,                                                    R
```

Figure A-1. Typical bullet chart.

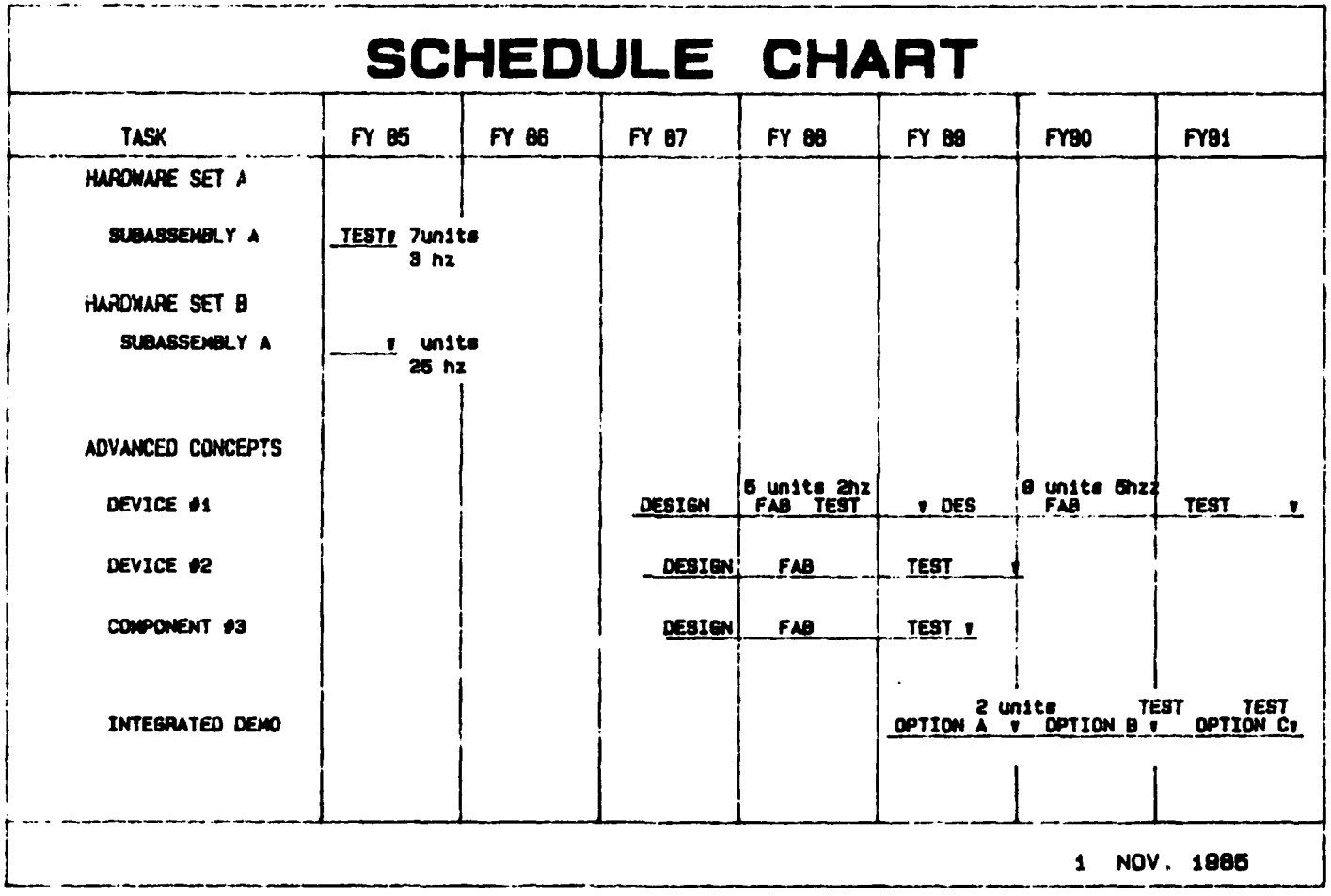


Figure A-2. Typical schedule chart.

TABLE A-1. Codes to Generate a Typical Schedule Chart.

```
S,5
L,5,SCHEDULE CHART
L,5,
------
S,6,+                    T          T          T          T          T          T          T          +
M,1,      TASK              FY 85      FY 86      FY 87      FY 88      FY 89      FY90       FY91
S,6,L                                                                                                R
M,1,    HARDWARE SET A
S,1,
S,6,                                  B
S,1,      SUBASSEMBLY A      TEST  7units
C,1,                            $
S,U,                        ------
S,1,                              3 hz
M,1,
M,1,    HARDWARE SET B
S,1,
S,1,      SUBASSEMBLY A            units
C,1,                            $
S,U,                        ------
S,1,                              25 hz
S,6,                                  T
S,1,
M,1,
M,1,    ADVANCED CONCEPTS
S,1,
S,1,                                                      5 units 2hz            9 units 5hzz
S,1,                                                DESIGN    FAB  TEST      DES      FAB         TEST
O,1,      DEVICE #1
C,1,                                                                    $                                $
S,U,                                                ------------------------------------------------------
S,1,
S,1,
S,1,                                                  DESIGN    FAB        TEST
O,1,      DEVICE #2
C,1,                                                                              $
S,U,                                                ------------------------------
S,1,
S,1,
S,1,                                                  DESIGN    FAB        TEST
O,1,      COMPONENT #3
C,1,                                                                         $
S,U,                                                  ---------------------------
S,1,
S,1,
S,6,                                                                                B          B
S,1,                                                                            2 units      TEST     TEST
S,1,      INTEGRATED DEMO                                                 OPTION A    OPTION B    OPTION C
C,1,                                                                                $          $          $
S,U,                                                                      ------------------------------------
S,1,
S,6,                                                                                T          T
S,1,
S,1,
S,6,+                    B          B          B          B          B          B          B          +
L,1,
```

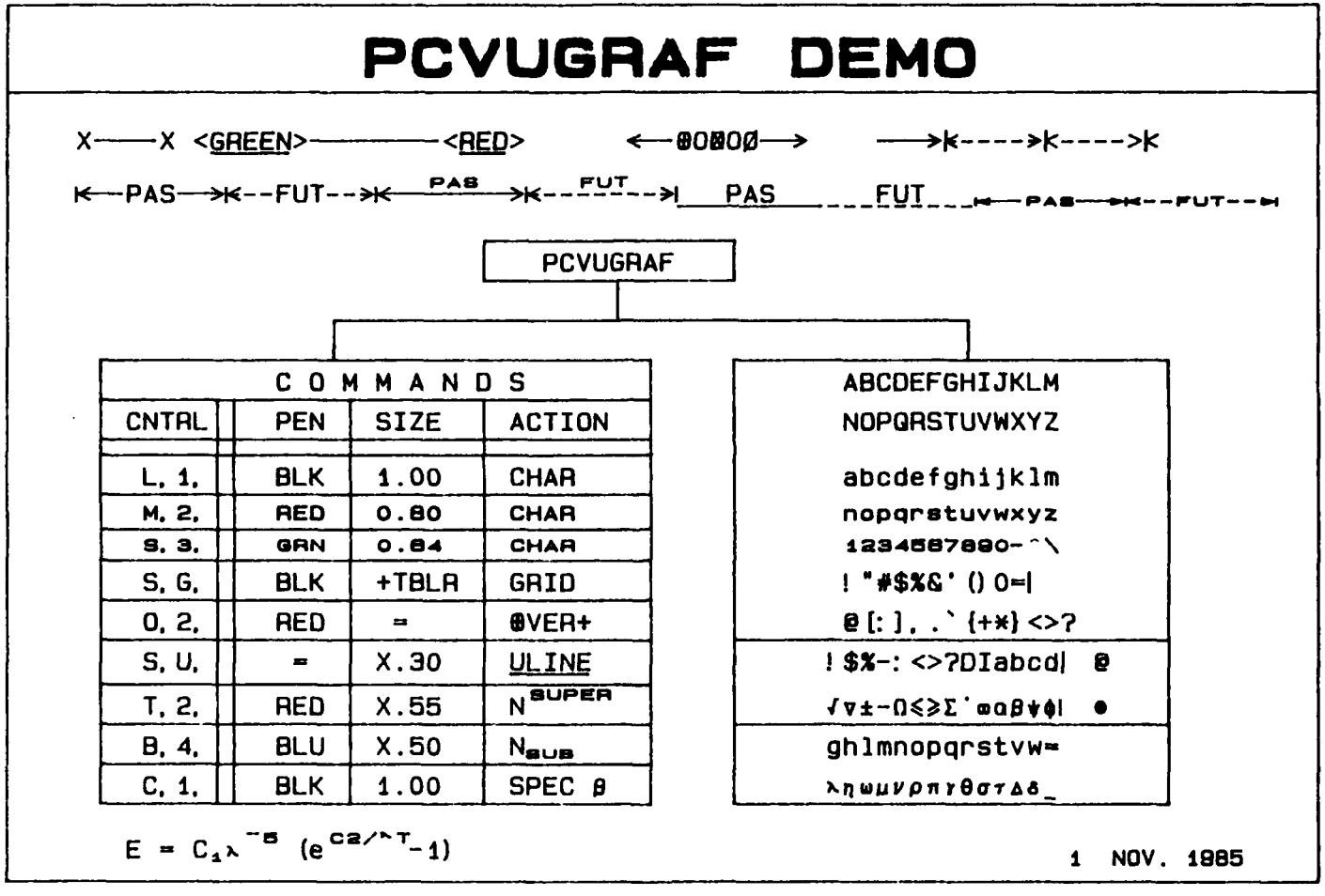


Figure A-3. PCVUGRAF DEMO chart.

TABLE A-2. Codes to Generate a PCVUGRAF DEMO chart.

```
S,5,
L,5,PCVUGRAF DEMO
M,5,
------------
L,1,
L,1,   X----X <     >--------<   >     ---DOOOD---    ----!     !     !
O,1,                                  <  + X /   >     ><    ><    ><
C,1,                                                     -- -- ------
O,3,          GREEN
S,U,          -----
O,2,                        RED
S,U,                        ---
L,1,
T,1,                     PAS     FUT
L,1,   ---PAS---  FUT   --------          PAS     FUT
O,1,   <       ><      ><      ><       >
C,1,            --   ---        ---------
C,1,                                          ==========
S,U,                                    -------
B,1,                                                   ---PAS---   FUT
O,1,                                                   <        ><     >
C,1,                                                              --   --
L,1,
S,6,                          +              +
L,1,                              BG11
S,6,                          +     T        +
S,6,          +                     B                      +
S,6, +        B                 +       +                  B         +
L,1,    C O M M A N D S                      ABCDEFGHIJKLMNOPQRSTUV
S,6, L      TT     T      T        R
L,1,  CNTRL    PEN    SIZE   ACTION                    WXYZ
S,6, L                            R
S,6, L                                R
L,1,  L,1,     BLK    1.00   CHAR                 abcdefghijklmnopqrstuv
S,6, L                                R
M,2,  M,2,     RED    0.80   CHAR                       wxyz
S,6, L                                R
S,3,  S,3,     GRN    0.64   CHAR                  1234567890-^\"
S,6, L                                R
L,1,  S,6,     BLK   +TBLR   GRID                  !"@$%&'()0=[{
S,6, L                                R
L,1,  O,2,     RED     =     OVER                  @[:],.`(+ )<>?
O,2,                          +   +
S,6, L                                R       L                          R
L,1,  S,U,      =    X0.30   ULINE                 $%-:<>?DIabcd @
O,2,
S,U,                          -----
S,6, L                                R
T,2,                          SUPER
L,1,  T,2,     RED   X0.55  N
C,1,                                                $%-:<>?DIabcd @
S,6, L                                R       L                          R
L,1,  B,4,     BLU   X0.50  N                      ghlmnopqrstvw=
B,4,                          SUB
S,6, L                                R
L,1,  C,1,     BLK   1.00    SPEC
C,1,                                                ghlmnopqrstvw=
S,6, +      BB     B      B        +       +                          +
L,1,
T,1,           -5   C2/ T
C,1,                   g
L,1,    E = C     (e     -1)
C,1,          g
B,1,          1
```

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