UNITED STATES DEPARTMENT OF THE INTERIOR

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JKPLOT - A device-independent plotting system written in BASICA for an IBM PC

by

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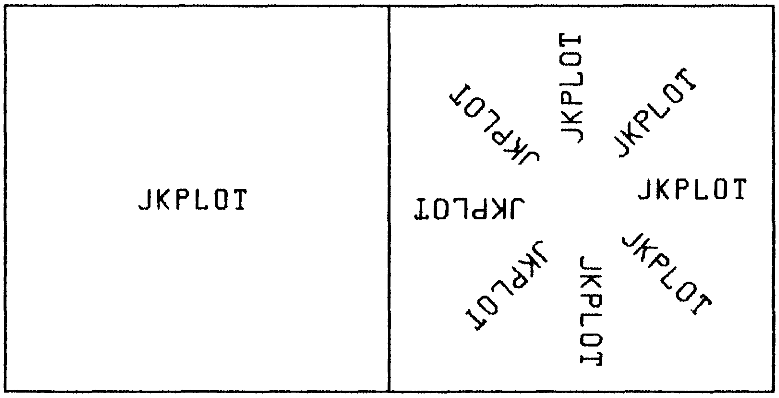

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SECTION I. - INTRODUCTION

The advent of inexpensive personal microcomputers has made sophisticated computation facilities available to individual geologists in their offices, and many mathematical and statistical programs are now available on these computers. Graphics programs that can produce the types of data-display plots that geologists can use for investigating their data have not been made so readily available.

This paper presents JKPLOT, a simple, device-independent plotting system that can provide a base for building plotting facilities tailored to the needs of geologists. The programs were written in BASICA for use on equipment compatible with an IBM personal computer. Assembly language modules were used only when absolutely necessary.

The JKPLOT system was first developed on an Intertec Superbrain in response to a need by project geologists to be able to control plotting devices without the expense of using a mainframe computer. When more sophisticated microcomputers became available the system was transferred to an IBM PC and enhanced to its present state. The computer used for development of the present system is a Columbia MPC 1600-4 with 586 kilobytes of RAM, a 10 megabyte hard disk, a graphics card, 2 serial ports, and 1 parallel port. The operating system is Microsoft MS-DOS Version 2.11; the compiler is IBM Personal Computer BASIC Compiler, Version 1.00; the linker is Microsoft Object Linker Version 2.01 (Large); and the assembler is Microsoft MACRO Assembler, Version 1.25. The original code was checked for compatibility with Microsoft QuickBasic, Version 2.0 and Microsoft Overlay Linker, Version 3.06, and modified versions of those modules that required changes are included. The modifications are discussed in Section IX and Appendix B.

SECTION II. - GENERAL GRAPHICS SOFTWARE CONSIDERATIONS

A. - Types of Graphics Software

Computer graphics software can be classified into three general categories: applications programs, functional software, and basic software. The highest level of software is the application program. A user need only supply data and select among program options to obtain graphics output; no programming is required on the user's part. A typical application program would accept a file of Cartesian (x,y) coordinates of a set of points and make an X-Y plot of the data with axes and titles. Functional software is an intermediate level of software that relieves the user of the task of programming commonly used graphics functions. Functional subroutines are often provided in graphics utility libraries. An example of functional software would be a subroutine that draws a set of axes at a certain location within a plot.

The lowest level of graphics software is called basic software. Basic software accepts only the most primitive plotting commands for controlling a plotter. At this level of programming the type of plotting device being used becomes a factor in the programs because different plotters perform different functions within the plotter hardware itself. Typical basic software provides the capability for drawing a line between two locations and for plotting a symbol at a specified location.

B. - Device Independence

Device independence for computer graphics software means that the programs are applicable on all graphics output devices - pen plotters, ink-jet plotters, storage tube displays, raster CRT displays, dot-matrix printers, etc. Unfortunately the different makes and models of plotting devices do not respond to the same instruction protocols, and even when equivalent instructions (e.g. draw a line) are sent to different devices, the resulting images may be quite different. A line on a low resolution raster CRT is just not the same as a fine line drawn by a pen plotter, and a filled polygon on a color CRT is not the same as a cross-hatched polygon drawn with a pen. The goal of producing exactly the same image on all devices is thus unattainable and can only be approximated.

One approach to the problem of device-independence is to define a graphics processing language with which images can be defined abstractly in terms of a set of well-defined primitives. These abstract images can then be approximated as closely as possible by interpreters which generate display processor code to control the individual devices.

Efforts to design standards for graphics processing have produced two quite sophisticated systems, CORE [1] and GKS [3]. These standards define graphics languages, data structures, and device characteristics for very general purposes. Other earlier languages, usually associated with a particular manufacturer (e.g. CalComp, Tektronix, Hewlett-Packard), had to suffice for the applications programmer while the comprehensive standards were being developed. The JKPLOT system follows the general direction of the most primitive parts of the CalComp system.

C. - Graphics Metafiles

The most elementary way to control a plotting device is for a program to include graphics language statements that cause a primitive (line, symbol, etc.) to be drawn by the plotter immediately upon execution of that statement. Device independence can be obtained by locating the code for interpreting the graphics statements and producing the particular device protocol (display processor code) in a distinct section of the program or in a separate library linked to the program. To change devices the programmer merely replaces the graphics interpreter code (or device driver) for one device with that for another. This method can be called the direct mode of plotter control.

Another method of plotter control is to translate the graphics image into a representation in an intermediate language and store this representation in a file, called an intermediate plot file or graphics metafile. (See Section V for an extended discussion of the JKPLOT metafiles and examples of their use.) An intermediate language interpreter is then used to read this file, translate the intermediate language into display processor code for a particular device, and display the picture. One of the advantages of this method is that a small part of a picture can be changed without the need for regenerating the whole plot. This method can be called the metafile mode of plotter control.

The JKPLOT system can be used in either the direct or metafile mode. All references to the plotting system are accomplished by setting certain parameters and then transferring control to line 30000 using a GOSUB instruction. The particular graphics task is then performed and control is returned to the line following the GOSUB instruction. In the direct mode the device driver for a particular plotter is merged with the application program. When this merged program is executed the plotter instructions are sent directly to the output device. To use the metafile mode the programmer merges a pseudo device driver at line 30000. The pseudo device driver, instead of sending instructions to a plotter, stores the intermediate language instructions in a disk file. Other programs then read these graphics metafiles, manipulate the images, and send the instructions to the plotter.

SECTION III. - THE JKPLOT PLOTTING SYSTEM

A. - General Design Considerations

In order that the system be useful to users who are not sophisticated graphics programmers, design criteria for the plotting system were selected on the basis of simplicity, program transportability, and ease of incorporating program segments into new application programs. File compactness and processing speed were at times sacrificed so that the programming logic would adhere to a straightforward concept of the process of drawing pictures.

The main design criteria are:

i) The programs should be self-contained and require the the incorporation of no commercial software packages.

ii) As much code as possible should be in a high level programming language rather than assembly language, even at the expense of processing speed.

iii) All source code should be in the public domain.

iv) The basic level of software should be device independent in the sense that the same instructions can be used for all plotters.

v) Modifications of the actual device drivers for different devices should require a minimum of programming knowledge.

vi) The capacity for generating device-independent plot files should be provided.

B. - The Basic Plotting System

The unit of measurement for use with the basic plotting system was chosen to be inches. This means that pen position (or pseudo pen position in the case of a CRT) is specified in terms of inches of displacement from a fixed position called the plot origin and that character height is specified in inches. If the user wants to plot a large plot on a CRT screen, the plot can be scaled to fit onto the screen. Different versions of the basic plotting system are required for different plotting devices, but the programs are designed so that drivers can be easily modified for a variety of plotters.

The plotting functions included in the basic system were designed to be compatible with a subset of the elementary plotting commands provided with the CalComp Host Computer Basic Software [4], a software package which is supplied with CalComp pen plotters. Names of variables in the programs were chosen to match as closely as possible those used in the CalComp documentation. The names of the standard subroutines, which are described in detail in the following section, are PLOTS, PLOT, NUMBER, SYMBOL, LINE, FACTOR, and NEWPEN. An additional command, COMMENT, is included to allow a programmer to include information in an intermediate plot file.

All calls to the basic graphics subroutines are accomplished by using the statement GOSUB 30000. The particular function to be accomplished is specified by setting the value of the variable PRM%(1). The values used are 1-PLOTS, 2-PLOT, 3-SYMBOL, 4-NUMBER, 5-LINE, 6-NEWPEN, 7-FACTOR, and 8-COMMENT. This convention is used so that a programmer can write a program using the device driver for one device, the IBM PC screen for instance, and then change the program to send the output to a different device, a Tektronix CRT for instance, by merely replacing the PC driver with the Tektronix driver, which also uses line number 30000 as an entry point for all subroutine calls. Drivers are provided for the PC screen (high resolution, low resolution, enhanced graphics, and Hercules graphics), Tektronix 4014 CRT, Zeta 3600S pen plotter, devices that use the Hewlett Packard GCL (HP 7550A plotter), and Epson and Okidata printers with high or low resolution. A pseudo device driver, CCMAKE.BAS, to write the plot commands to a file for later plotting is also included.

All variables used in the basic plotting system have names beginning with the letters TK or ITK. The user should avoid using variables beginning with these letters in the main body of the program so that permanent plotting parameters are not changed.

C. - The Elementary JKPLOT Instructions

The functions performed by the basic software are described in terms of subroutine calls with arguments. (Note that this description is for informative purposes only; it does not follow the BASICA syntax and cannot be used in a program.) The arguments are listed in parentheses after the subroutine name. In order to call a specific subroutine, the user must assign a value to the variable PRM%(1) indicating which function is to be performed. Then values of the variables listed in parentheses must be assigned and a subroutine transfer made to line 30000 using the GOSUB instruction. When the graphics function has been performed, control of the program returns to the statement immediately following the GOSUB instruction. The subroutines are described in the order of the value of PRM%(1) that specifies that routine.

1: PLOTS(XPAGE,YPAGE). This routine initializes a plot and is called only once (before a call to any other graphics subroutine). Execution of this command opens the plot output device through the computer's operating system, performs scaling calculations, and sets the clipping window. Values of X (the horizontal coordinate) will be clipped at 0 and XPAGE, and values of Y (the vertical coordinate) will be clipped at 0 and YPAGE.

2: PLOT(TKXP,TKYP,TKIP%). This is the basic pen movement command. TKXP and TKYP are coordinates, in inches, from the current reference point (origin), of the position to which the pen is to be moved, and TKIP% is a signed integer which controls the pen status (up or down) and origin definition.

If TKIP% = 2 the pen is down during movement, thus drawing a visible line. If TKIP% = 3 the pen is up during the move.

If TKIP% = -2 or -3, a new origin is established at the terminal position after movement is completed as if TKIP% were positive. In this case the logical X,Y coordinates of the new pen position are set equal to zero, and this position is the reference point for succeeding movements. If TKIP% = 999 the effects are the same as if TKIP% were -3 except that the plot is terminated and the output device is closed.

The values of TKXP, TKYP, TKIP%, and PRM%(1) are not changed by this subroutine call. If only one of the values is to be changed for the next call, the others need not be reassigned.

3: SYMBOL(TKXP, TKYP, TKHT, TKA$ or TKIQ%, TKD, TKCH%). There are two formats for the symbol call: 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, rectangle, etc., for plotting data points. The value of the variable TKCH% indicates whether the call is to the "standard" or the "special" form of the subroutine. A non-negative value of TKCH% indicates a "standard" call for which the fourth parameter should be TKA$, and a negative value of TKCH% indicates a "special" call for which the fourth parameter should be TKIQ%.

For both the "standard" and "special" calls, the pen is first moved to the position specified by TKXP and TKYP. The size of the symbol in inches is specified by TKHT, and TKD specifies the angle, in degrees from the positive horizontal axis, at which the annotation is to be plotted. If TKD = 0 the character(s) will be plotted right side up and parallel to the horizontal axis.

In the "standard" call the text to be plotted is in the character variable TKA$ and may consist of any of the characters listed in Table 1. The number of characters in the string of text need not be specified because the plot driver counts the characters in the variable TKA$. The values of TKXP and TKYP are the location of the lower left corner of the first character to be plotted. If a character not in the acceptable character set is included in TKA$ a question mark is plotted in its place.

A	F	K	P	U	Z	e	j	o	t	y	3	8	*	.	?
B	G	L	Q	V	a	f	k	p	u	z	4	9	+		%
C	H	M	R	W	b	g	l	q	v	0	5	$	-	<	'
D	I	N	S	X	c	h	m	r	w	1	6	(	/	=	"
E	J	O	T	Y	d	i	n	s	x	2	7	)	,	>	

Table 1.--Symbols for standard SYMBOL call

The length of the text in plot inches can be calculated by using the fact that each letter is exactly as wide as it is high. Hence a string of ten characters plotted with a height of 1/4 inches would be 2.5 inches long.

In the "special" call the symbol to be plotted is specified by the value of TKIQ%, which must take a value between 0 and 13. The symbols corresponding to the values of TKIQ% are listed in Table 2. If TKCH% = -1 the pen is up during the move, after which a single symbol is plotted, and if TKCH% is less than -1, the pen is down during the move. The symbol is centered at the position specified by TKXP and TKYP.

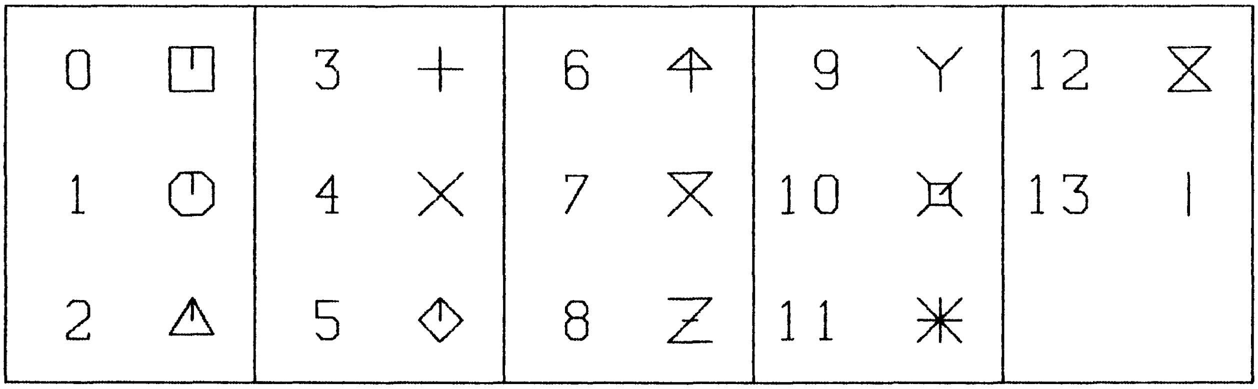


Table 2.--Symbols for special SYMBOL call

4: NUMBER(TKXP, TKYP, TKHT, TKFPN, TKD, TKNDEC%). This routine causes the floating point number in the variable, TKFPN, to be plotted in decimal format. The meanings of the arguments TKXP, TKYP, TKHT, and TKD are the same as those described for the "standard" subroutine SYMBOL. The integer value in TKNDEC% specifies the format and precision of the number to be plotted. If TKNDEC% 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 appropriate rounding. For example if the value in TKFPN is 12.3456 and TKNDEC% is +2, the number plotted would be 12.35. If TKNDEC% = 0 only the number's integer portion and a decimal point are plotted after rounding. If TKNDEC% = -1, only the number's integer portion is plotted, after rounding, and if TKNDEC% is less than -1, -TKNDEC%-1 digits are truncated from the integer portion after rounding. If TKFPN= 143.2 and TKNDEC%= -2 then the number 14 would be plotted.

5: LINE(TKNPTS%, TKLNTP%, TKIQ%, TKHT, TKXARY, TKYARY). The line subroutine produces a line plot of the pairs of data values in the arrays, TKXARY and TKYARY. The coordinates in the two arrays are always in plot inches from the current origin (Note that this is in contrast to the standard CalComp LINE call). The value in TKNPTS% specifies the number of pairs of coordinates in the two arrays.

The value of the integer variable, TKLNTP%, indicates the type of line to draw through the data points, and the magnitude of TKLNTP% specifies the frequency of plotted symbols. For example if TKLNTP% = 4 every fourth data point is used in plotting the line; the other data points are ignored. (Note that this is not exactly the way the CalComp library interprets this parameter.)

The pen is first moved to the position specified by TKXARY(1) and TKYARY(1) in the up position. If TKLNTP% = 0 then the remaining points are connected by straight lines, but no symbols are drawn. If TKLNTP% is not zero, symbols are drawn. The symbol to be drawn is specified by the value of TKIQ% (with the same meaning as in the "special" SYMBOL call), and the size of the symbol is specified by TKHT. If TKLNTP% is negative, no line segments are drawn; only the symbols are plotted - the frequency of the symbols used determined by the magnitude of TKLNTP% as described above. If TKLNTP% is positive, the symbols are drawn and are connected by straight lines.

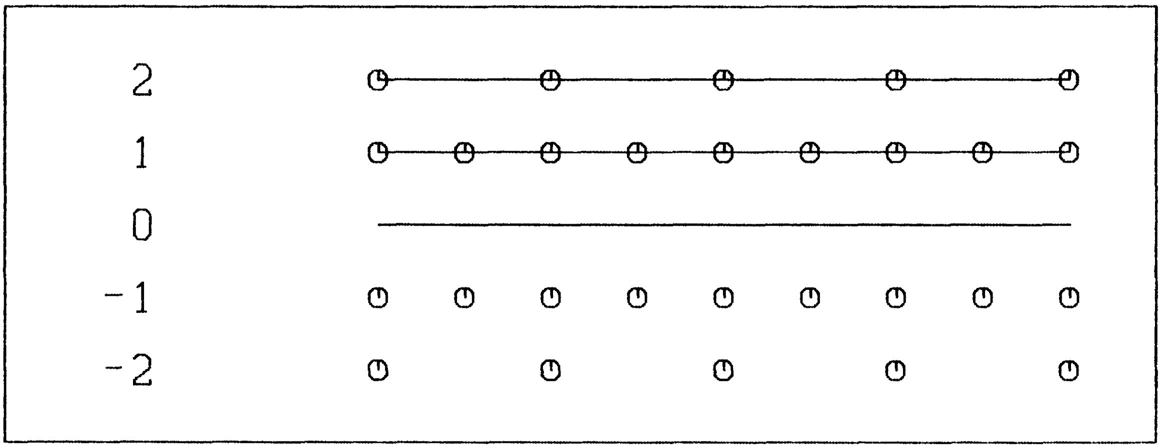


Table 3.--Examples of type of line drawn for selected values of the parameter TKLNTP% shown at left

6: NEWPEN(TKPN%). If the plotter being used has the capability of using more than one pen, this call will specify which pen is to be used in subsequent plotting system calls. The value of TKPN% is initialized to 1 by the initial call to PLOTS.

7: FACTOR(TKRFACT). The factor subroutine causes all subsequent pen movements to be enlarged or reduced by a factor, TKRFACT. If TKRFACT = 2.0 the plotting movements will all be twice normal size, and if TKRFACT = 0.5 the movements will be half normal size. TKRFACT is initialized to 1.0 by the initialization call to PLOTS.

8: COMMENT(TKCMT$). This routine causes no plotting. It is included so that comments can be sent to the plotting system. Some possible uses of this command are to send information about the progress of a plot to the PC screen when the output device is a Tektronix 4014 or to include information about the function being performed in an intermediate plot file being generated.

```
****************************************************************
              SUMMARY OF STANDARD CALLING SEQUENCES
****************************************************************
PLOTS(XPAGE,YPAGE).....................................PRM%(1)=1
     XPAGE,YPAGE    are the dimensions, in inches, of the plot.
PLOT(TKXP,TKYP,TKIP%)..................................PRM%(1)=2
     TKXP,TKYP      are the X,Y coordinates, in inches from the
                    current origin, of a pen movement's terminal
                    position.
     TKIP%          specifies the pen up/down status during
                    movement (up = 3, down = 2).  If negative, a
                    new origin is established at the new
                    position.  If 999 the plot is terminated.
SYMBOL(TKXP,TKYP,TKHT,TKA$ or TKIQ%,TKD,TKCH%).........PRM%(1)=3
NUMBER(TKXP,TKYP,TKHT,TKFPN,TKD,TKNDEC%)...............PRM%(1)=4
     TKXP,TKYP      define the relative origin of the character
                    string (lower left corner of first character
                    for "standard" SYMBOL and NUMBER calls-center
                    of symbol for "special symbol calls).
     TKHT           is the height, in inches, of characters
                    to be plotted.
     TKA$           is the string variable containing the text
                    to be plotted in "standard" SYMBOL call.
     TKIQ%          is the integer equivalent of centered symbol
                    to be plotted in "special" SYMBOL call.
     TKFPN          is the number to be plotted in NUMBER call.
     TKD            is the angle at which the character string
                    is to be plotted.
     TKCH%          indicates whether the SYMBOL call is
                    "standard"(>=0) or "special"(<0).
     TKNDEC%        specifies the number of decimals to be
                    plotted in a NUMBER call.
LINE(TKNPTS%,TKLNTP%,TKIQ%,TKHT,TKXARY,TKYARY).........PRM%(1)=5
     TKXARY,TKYARY  is the array of data coordinates.
     TKNPTS%        is the number of points in the data array.
     TKLNTP%        specifies the type of line to be drawn
                    through the data points [(0)line/no symbols,
                    (>0)line+symbols,(<0)symbols/no line] and the
                    increment between entries in the data array.
     TKIQ%          is the integer equivalent of the centered
                    symbol to be plotted.
     TKHT           is the height of symbols to be plotted.
NEWPEN(TKPN%)..........................................PRM%(1)=6
     TKPN%          is the number of the pen selected.
FACTOR(TKRFACT)........................................PRM%(1)=7
     TKRFACT        is the scale factor that determines the
                    enlargement or reduction of the entire plot.
COMMENT(TKCMT$)........................................PRM%(1)=8
     TKCMT$         is the variable containing the comment.
****************************************************************
```

Table 4.--Summary of standard calling sequences

The CalComp basic plotting system has a subroutine called WHERE with arguments TKRXPAGE and TKRYPAGE. This routine returns the present position of the pen in plot inches from the current reference point. There is no need for such a call in the JKPLOT plotting system because the values of the variables TKRXPAGE and TKRYPAGE are global in the sense that they can be used for calculation anywhere in the calling program. The user must be sure not to modify these values or the results of subsequent plot movement commands will be unpredictable.

D. - Default Scaling

There are two procedures used in default mode for scaling a picture. Because the actual size of a picture produced on the PC screen or Tektronix 4014 terminal depends on the size of the monitor, the term "plot inches" is not meaningful for these devices. Default calculations for these drivers scale the plot to produce the largest aspect-preserving image that can be drawn in the CRT screen. The aspect ratio of a rectangle is the ratio of the width to the height. Without aspect-preservation a square might be drawn as a tall, thin rectangle. For "inch-type" plotters, i.e. devices for which the term "plot inches" is meaningful (HP and Zeta plotters, Epson and Okidata printers), the plot produced is the size specified by the parameters XPAGE and YPAGE unless the plot scaled this way would be too big for the plotter. In this case the user is warned that the plot is too big and is being reduced to a size that will fit on the plotter.

More advanced capabilities of the basic plotting system include plot-coordinate windowing, screen-coordinate viewport/clipping, plot rotation, and plot centering and allow the placement of a number of different plots at different locations within a larger plot. These capabilities will be described in Section VII.

SECTION IV. - STRUCTURE AND USE OF THE JKPLOT DEVICE DRIVERS

A. - Direct vs. Metafile Mode

There are two elementary ways to use the plot drivers described in this paper. The most direct way is to write a program in BASICA, accessing the plotting subroutines by setting the parameters described in Section III-C. The driver for a specific plotting device can then be merged with this program, and when the program is executed, the plot will be drawn on the output device. Another way is to write the same BASICA program but merge the pseudo device driver, named CCMAKE.BAS, into the program. This procedure will produce an intermediate plot file of Calcomp-like commands. The intermediate plot file is an ASCII file containing on each line the name of the plot subroutine to be called along with the parameter values to be set before transfer to the plot subroutines.

Each method of using the plotting system has advantages. The method that sends the output directly to the plotting device has the advantage of immediacy; the product of the program is immediately available for viewing when the program is run. On the other hand, the method that uses the intermediate plot file allows the user to make a number of plots with the same page size and then send them all to the plotter at the same time - a system for overlaying individual plots. The knowledgeable user can also use a standard ASCII file editor to change aspects of a plot by editing the intermediate plot file. Examples of both of these methods will be given in the following section.

B. - Code Modules

Because the plot drivers for different plotters have much code in common, the programs were written in modular form so that the overlapping parts would not have to be repeatedly listed. The device-independent code is named PLTDRV.BAS. This code contains the line to which all graphics calls must transfer (line 30000) and does most of the graphics calculations. The device dependent sections of code all start at line 35000 and contain the code that translates the general graphics functional requirements into the proper protocol for a particular device. This device specification code performs three general functions: (1) device initialization, (2) pen (or pseudo pen) movement, either with pen up or down, and (3) plot termination. It also contains a section that declares the device characteristics.

As mentioned earlier all variables in the plot driver routines start with the letters TK or ITK. The user should be careful not to use variables starting with these letters in an application program. Also, lines 10-100 are reserved for use by the plot driver for driver code that must appear in a program before other executable code. Because the drivers themselves start at lines 30000 and 35000, the user should avoid using line numbers between 10 and 100 or between 30000 and 40000 in an application program.

C. - Direct Mode

To construct a complete device driver for use in the direct plotting mode the user must first load the device independent part of the code, PLTDRV.BAS, and then merge the device specification code. The device driver is then resident in the computer memory and can be saved into a disk file for later merging into an applications program. The names of the device specification subroutines included with this report are listed in Table 5.

When the device-specific code for the high or low resolution PC screen, Tektronix 4014, or Zeta or Hewlett Packard plotters is merged with PLTDRV.BAS, the resulting driver is complete and self contained in the sense that when the applications code is merged with this driver, the program can be executed either through the

PCSPECH.BAS	-high resolution PC screen
PCSPECL.BAS	-low resolution PC screen
EGASPEC.BAS	-enhanced graphics PC screen
HERCSPEC.BAS	-Hercules graphics for PC screen
TKSPEC.BAS	-Tektronix 4014 CRT
HPSPEC.BAS	-Hewlett Packard 7550A plotter
ZETASPEC.BAS	-Zeta 3600X plotter
EPSPECL.BAS	-low resolution EPSON printer plot
EPSPECH.BAS	-high resolution EPSON printer plot
OKSPECL.BAS	-low resolution OKIDATA printer plot
OKSPECH.BAS	-high resolution OKIDATA printer plot

Table 5.--Device specific code for plot drivers

interpreter or after compilation. When programs which use the Tektronix 4014, Zeta, or Hewlett Packard drivers are compiled, the communications object module, IBMCOM.OBJ, must be added to the link list.

When the device independent graphics module, PLTDRV.BAS, is merged with the device dependent code for the printers and the PC screen with enhanced graphics or Hercules graphics, the resulting drivers are not complete. For the printers a bitmap image of the plot must be constructed in the computer memory, a task that requires the use of more memory than is available using only the BASIC language. The code that allocates memory for and stores the printer image was written in assembly language, and the drivers can only be used with compiled programs. The Hercules and enhanced graphics programs for the PC screen require the use of system interrupts which are accomplished via an assembly language module. Different procedures are required for use with Microsoft QuickBasic. Changes in these procedures are discussed in Section IX and Appendix B.

There are two assembly language programs for storing the bitmaps for the printer programs, BITMAP2.ASM and BITMAP8.ASM. BITMAP2.ASM is used for the low resolution plots, and BITMAP8.ASM is used for the high resolution plots. Both of these programs use macros which are stored in files named MAC1.MAC AND MAC2.MAC. The assembly language modules for the hercules and enhanced graphics systems are called HERCASM.ASM and EGAASM.ASM, respectively.

Use of the printer drivers requires that the the applications program be first merged with the device independent code and the device specification code. This program must then be saved in a disk file and compiled. Also, the appropriate BITMAP program must be assembled using a macro assembler. Then the resulting object code must be linked. The linker, however, will not expect such large memory allocation.

To control the linker another assembly language program, LN.ASM, must be assembled into object code. The program, LN.ASM, does not perform any graphics function; its function is solely to control the allocation of memory by the linker. After assembling LN.ASM, the three object modules must be specified for the linker in the order, PROGRAM + LN + BITMAP. The resulting run module is then ready for execution. To compile and link the programs for the Hercules and enhanced graphics systems the compiled modules can be linked without recourse to the link-controlling program, LN.ASM. Table 6 summarizes the capability for interpreted execution, need for assembly language modules, and link lists for the device drivers included with the JKPLOT system.

device	interpreted	assembly	linking
	execution	language	
PCSPECH.BAS	yes		program
PCSPECL.BAS	yes		program
EGASPEC.BAS	no	EGAASM.ASM	program + egaasm
HERCSPEC.BAS	no	HERCASM.ASM	program + hercasm
TKSPEC.BAS	yes		program + ibmcom
HPSPEC.BAS	yes		program + ibmcom
ZETASPEC.BAS	yes		program + ibmcom
EPSPECL.BAS	no	BITMAP2.ASM	program + ln + bitmap2
EPSPECH.BAS	no	BITMAP8.ASM	program + ln + bitmap8
OKSPECL.BAS	no	BITMAP2.ASM	program + ln + bitmap2
OKSPECH.BAS	no	BITMAP8.ASM	program + ln + bitmap8

Table 6.--Summary of information about interpreter execution, need for assembly language modules, and linking procedures

D. - Metafile Mode

To use the plot system in metafile mode, the user first merges the pseudo device driver, CCMAKE.BAS, with the applications program. This program can then be executed through the interpreter or compiled. The result of executing this code is a disk file containing the intermediate language instructions for drawing the plot.

In order to send the plot to a particular device, a program that reads the plot metafile and sends the proper device protocol to the device must be constructed by merging a file-reading program with the appropriate device driver described above. Three such file-reading application programs are supplied on the disk accompanying this report, FILDRV1.BAS, FILDRV2.BAS, and FILDRV3.BAS. The resulting program is essentially an application program for which the application is reading an intermediate plot file. The most elementary file-reading program, FILDRV1.BAS, will read a single plot file and cause a plot to be made using default values for all the plot system parameters. FILDRV2.BAS allows overlaying of up to 10 plots with the same page size and also the selection of a window to plot only a portion of the whole plot. FILDRV3.BAS is a menu-controlled program which exercises many of the more sophisticated capabilities of the JKPLOT system. Use of these drivers is discussed in more detail in Section VIII.

Log files showing the procedures used to merge and compile drivers, applications programs, and metafile-reading drivers using the elementary BASICA compiler are in Appendix A, and changes in the procedures for using Microsoft QuickBasic are discussed in Appendix B.

SECTION V. - EXAMPLES USING THE ELEMENTARY PLOT SYSTEM

For the following examples it will be assumed that the user has constructed a PC screen high resolution driver by merging the programs PLTDRV.BAS and PCSPECH.BAS, saving the merged program in a file named PCDRVH.BAS. It is also assumed that a program, FILPCH1.BAS, for reading an intermediate plot file and drawing the image on the PC screen, has been made by merging the PC driver, PCDRVH.BAS, with the file-reading program, FILDRV1.BAS. For speedy plotting, the program, FILPCH1.BAS, should be compiled. (See Appendices A and B for log files showing procedures for accomplishing these tasks and for using the programs in Examples 1 and 2.)

A. - Example 1

The first example plot is very simple one. The plot consists of a 5 inch by 5 inch square box with the message, EXAMPLE, in .25 inch letters centered in the box. A listing of a BASIC program, EXAMPLE1.BAS, which will produce this plot follows. Comments within the program explain what is being accomplished by the code.

Listing of Program EXAMPLE1.BAS

```
****************************************************************

100 'set output file name
110 OFIL$="EXAMPLE1.PLT"
120 'program to generate example 1
130 'initialize plot with 5 x 5 inch page
140 '5x5 box with the word, example, centered in 1/2 inch letters
150 XPAGE=5:YPAGE=5:PRM%(1)=1:GOSUB 30000
160 'draw the box
170 TKXP=0:TKYP=0:TKIP%=3:PRM%(1)=2:GOSUB 30000 'pen to origin-up
180 TKXP=XPAGE:TKIP%=2:GOSUB 30000               'draw bottom
190 TKYP=XPAGE:GOSUB 30000                       'draw right side
200 TKXP=0:GOSUB 30000                           'draw top
210 TKYP=0:GOSUB 30000                           'draw left side
```

```
220 'set parameters for standard SYMBOL call
230 TKA$="EXAMPLE"
240 TKD=0:TKHT=.5:TKCH%=0
250 'calculate lower left corner of centered message
260 TKYP=2.5-TKHT/2
270 TKXP=2.5-.5*(TKHT*LEN(TKA$))
280 PRM%(1)=3:GOSUB 30000
290 'return pen to origin and terminate plot
300 TKXP=0:TKYP=0:TKIP%=999:PRM%(1)=2:GOSUB 30000
310 END
*****************************************************************
```

The user can merge the particular device driver (in this example, the PC driver) with the program, EXAMPLE1.BAS, by entering the commands LOAD "EXAMPLE1.BAS" and MERGE "PCDRVH.BAS". The program can then be executed by entering the command, RUN.

The PC screen will clear and the picture will be drawn on the screen. When the picture is complete, the computer will sound a short "beep", indicating the completion. The result of running this program is shown in Figure 1.

To remove the picture from the screen, the user must press the <ESCAPE> key, and computer returns to the BASIC system. The reason for the requirement for pressing the <ESCAPE> key without any screen prompt is that the user may want to make a copy of the picture on the printer. If one has the appropriate software, the screen image can be sent to the printer by entering special keyboard entries. Any prompting for the <ESCAPE> key entry would add the prompt message to the picture, and this prompt would be plotted along with the desired picture.

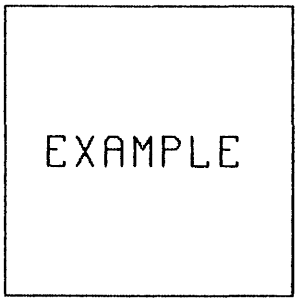


Figure 1.--An elementary example showing the use of the JKPLOT system. (size reduced)

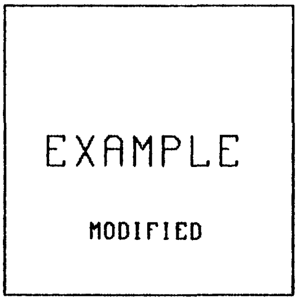


Figure 2.--An example showing the result of modifying the intermediate plot file for Figure 1. (size reduced)

Another way to generate the picture on the PC screen is to append the pseudo device driver, CCMAKE.BAS, to program EXAMPLE1.BAS and then run the program. The user is prompted for an output file name for the intermediate plot file, and the program generates an ASCII file of CalComp-like commands. The user then executes the program, FILPCH1.EXE, which asks for the intermediate plot file name and then plots the image on the PC screen. The ASCII file that is produced by this procedure is named EXAMPLE1.PLT.

```
               Intermediate PLot File, EXAMPLE1.PLT
****************************************************************
PLOTS, 5 , 5
PLOT, 0 , 0 , 3
PLOT, 5 , 0 , 2
PLOT, 5 , 5 , 2
PLOT, 0 , 5 , 2
PLOT, 0 , 0 , 2
SYMBOL, 0 , .75 , 2.25 , .5 , 0 ,EXAMPLE
PLOT, 0 , 0 , 999
****************************************************************
```

A third way to generate the above plot is to use a file editor such as EDLIN to create the intermediate ASCII plot file, EXAMPLE1.PLT, directly. The user then executes the program, FILPCH1.BAS, and the image appears on the screen. If the user understands the construction of the intermediate plot file, many plot modification possibilities are available.

B. - MODIFICATION OF AN INTERMEDIATE PLOT FILE

An intermediate ASCII plot file is just a sequence of CalComp-like instructions that can be read by a program like FILPCH1.BAS. Hence the user can insert plot commands or move images by proper modification of the file. This capability is very valuable if the user has constructed a large, complicated plot and just wants to make a few changes or to add extra documentation without regenerating the whole file.

For example, addition of the line

```
SYMBOL, 0,1.5,1,.25,0,MODIFIED
```

immediately after the SYMBOL call in the intermediate plot file for Example 1 causes the text, "MODIFIED", to appear below the original text in the figure, producing the plot shown in Figure 2.

C. - Example 2

A program, EXAMPLE2.BAS, that demonstrates the use of most of the elementary commands available in the basic plotting software follows.

Listing of the Program, EXAMPLE2.BAS

```
****************************************************************
100 'program to demonstrate use of basic plot system
110 OFIL$="EXAMPLE2.PLT"
120 DIM X(100),Y(100),D$(5),QT$(5)
130 'set page size and initialize plot
140 XPAGE=10:YPAGE=10:PRM%(1)=1:GOSUB 30000
150 'draw outline and four subareas
160 TKXP=0:TKYP=0:TKIP%=3:PRM%(1)=2:GOSUB 30000
170 TKXP=0:TKYP=10:TKIP%=2:GOSUB 30000
180 TKXP=10:TKYP=10:GOSUB 30000
190 TKXP=10:TKYP=0:GOSUB 30000
200 TKXP=0:TKYP=0:GOSUB 30000
210 TKXP=5:TKYP=0:TKIP%=3:GOSUB 30000
220 TKXP=5:TKYP=10:TKIP%=2:GOSUB 30000
230 TKXP=0:TKYP=5:TKIP%=3:GOSUB 30000
240 TKXP=10:TKYP=5:TKIP%=2:GOSUB 30000
250 'comment call for user information use
260 TKCMT$="UPPER LEFT CORNER":PRM%(1)=8:GOSUB 30000
270 'move origin to upper left subarea
280 TKXP=0:TKYP=5:TKIP%=-3:PRM%(1)=2:GOSUB 30000
290 'set parameters for standard SYMBOL call
300 TKA$="Example 2"
310 TKHT=.25:TKXP=2.5-LEN(TKA$)*TKHT/2:TKYP=2.5-TKHT/2
320 TKD=0:TKCH%=1:PRM%(1)=3:GOSUB 30000
330 'show use of FACTOR call
340 TKRFACT=.5:PRM%(1)=7:GOSUB 30000
350 TKA$="Example 2"
360 TKHT=.25:TKXP=2.5-LEN(TKA$)*TKHT/2:TKYP=2.5-TKHT/2
370 TKD=0:TKCH%=1:PRM%(1)=3:GOSUB 30000
380 TKRFACT=1:PRM%(1)=7:GOSUB 30000
390 'comment call for user information use
400 TKCMT$="LOWER LEFT CORNER":PRM%(1)=8:GOSUB 30000
410 'move origin to lower left subarea
420 TKXP=0:TKYP=-5:TKIP%=-3:PRM%(1)=2:GOSUB 30000
430 'draw axis lines
440 TKXP=1:TKYP=1:TKIP%=3:PRM%(1)=2:GOSUB 30000
450 TKXP=4:TKIP%=2:GOSUB 30000
460 TKXP=1:TKIP%=3:GOSUB 30000
470 TKYP=4:TKIP%=2:GOSUB 30000
480 'label axes
490 TKXP=.7:TKYP=1.9:TKD=90:TKHT=.2:TKA$="Y-AXIS"
491 TKCH%=1:PRM%(1)=3:GOSUB 30000
500 TKXP=1.9:TKYP=.4:TKD=0:TKA$="X-AXIS":GOSUB 30000
510 'show use of LINE call
520 TKNPTS%=10:TKHT=.1:TKLNTP%=-1:TKHT=.1:PRM%(1)=5
530 FOR I=1 TO 10:TKXARY(I)=(I-1)/3+1:TKYARY(I)=TKXARY(I)
535 NEXT I:GOSUB 30000
540 TKIQ%=1:TKLNTP%=1
550 FOR I=1 TO 10:TKYARY(I)=SQR(TKXARY(I)):NEXT I:GOSUB 30000
560 TKLNTP%=0
570 FOR I=1 TO 10
```

```
571 T=TKYARY(I):TKYARY(I)=TKXARY(I):TKXARY(I)=T:NEXT I
572 GOSUB 30000
580 'use comment for information
590 TKCMT$="LOWER RIGHT CORNER":PRM%(1)=8:GOSUB 30000
600 'move origin for lower right subarea
610 TKXP=5:TKYP=0:TKIP%=-3:PRM%(1)=2:GOSUB 30000
620 'simple annotated point plotting
630 X(1)=1:Y(1)=4:X(2)=4:Y(2)=3:X(3)=2:Y(3)=1
640 D$(1)="PT-1":D$(2)="PT-2":D$(3)="PT-3"
650 TKIQ%=3:TKD=0:PRM%(1)=3
660 FOR I=1 TO 3:TKHT=.05:TKXP=X(I):TKYP=Y(I):TKIQ%=3
665 TKCH%=-1:GOSUB 30000
670 TKHT=.1:TKXP=X(I)+.15:TKYP=Y(I)-.15:TKA$=D$(I):TKCH%=1
675 GOSUB 30000
680 NEXT I
690 'use comment for information
700 TKCMT$="UPPER RIGHT CORNER":PRM%(1)=8:GOSUB 30000
710 'move origin for upper right subarea
720 TKXP=0:TKYP=5:TKIP%=-3:PRM%(1)=2:GOSUB 30000
730 'show use of angles with SYMBOL call
740 TKHT=.15:TKCH%=1:PRM%(1)=3:TKA$="   EXAMPLE 2"
750 FOR I=0 TO 7:TKD=45*I:TKXP=2.5:TKYP=2.5:GOSUB 30000:NEXT I
760 'move origin back to original position
770 TKXP=-5:TKYP=-5:TKIP%=-3:PRM%(1)=2:GOSUB 30000
780 'end plot
790 TKXP=5:TKYP=0:TKIP%=999:PRM%(1)=2:GOSUB 30000
800 PRINT "DONE":END
****************************************************************
```

The intermediate plot file produced by running the program in metafile mode (by appending the pseudo device driver, CCMAKE.BAS) follows, and Figure 3 shows the resulting plot.

Intermediate Plot File for Example 2

```
****************************************************************
PLOTS, 10 , 10
PLOT, 0 , 0 , 3
PLOT, 0 , 10 , 2
PLOT, 10 , 10 , 2
PLOT, 10 , 0 , 2
PLOT, 0 , 0 , 2
PLOT, 5 , 0 , 3
PLOT, 5 , 10 , 2
PLOT, 0 , 5 , 3
PLOT, 10 , 5 , 2
COMMENT,UPPER LEFT CORNER
PLOT, 0 , 5 ,-3
SYMBOL, 1 , 1.375 , 2.375 , .25 , 0 ,Example 2
FACTOR, .5
SYMBOL, 1 , 1.375 , 2.375 , .25 , 0 ,Example 2
FACTOR, 1
COMMENT,LOWER LEFT CORNER
PLOT, 0 ,-5 ,-3
```

```
PLOT, 1 , 1 , 3
PLOT, 4 , 1 , 2
PLOT, 1 , 1 , 3
PLOT, 1 , 4 , 2
SYMBOL, 1 , .7 , 1.9 , .2 , 90 ,Y-AXIS
SYMBOL, 1 , 1.9 , .4 , .2 , 0 ,X-AXIS
LINE, 10 ,-1 , 0 , .1
 1 , 1
 1.333333 , 1.333333
 1.666667 , 1.666667
 2 , 2
 2.333334 , 2.333334
 2.666667 , 2.666667
 3 , 3
 3.333333 , 3.333333
 3.666667 , 3.666667
 4 , 4
LINE, 10 , 1 , 1 , .1
 1 , 1
 1.333333 , 1.154701
 1.666667 , 1.290995
 2 , 1.414214
 2.333334 , 1.527525
 2.666667 , 1.632993
 3 , 1.732051
 3.333333 , 1.825742
 3.666667 , 1.914854
 4 , 2
LINE, 10 , 0 , 1 , .1
 1 , 1
 1.154701 , 1.333333
 1.290995 , 1.666667
 1.414214 , 2
 1.527525 , 2.333334
 1.632993 , 2.666667
 1.732051 , 3
 1.825742 , 3.333333
 1.914854 , 3.666667
 2 , 4
COMMENT,LOWER RIGHT CORNER
PLOT, 5 , 0 ,-3
SYMBOL,-1 , 1 , 4 , .05 , 3 , 0
SYMBOL, 1 , 1.15 , 3.85 , .1 , 0 ,PT-1
SYMBOL,-1 , 4 , 3 , .05 , 3 , 0
SYMBOL, 1 , 4.15 , 2.85 , .1 , 0 ,PT-2
SYMBOL,-1 , 2 , 1 , .05 , 3 , 0
SYMBOL, 1 , 2.15 , .85 , .1 , 0 ,PT-3
COMMENT,UPPER RIGHT CORNER
PLOT, 0 , 5 ,-3
SYMBOL, 1 , 2.5 , 2.5 , .15 , 0 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 45 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 90 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 135 ,   EXAMPLE 2
```

```
SYMBOL, 1 , 2.5 , 2.5 , .15 , 180 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 225 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 270 ,   EXAMPLE 2
SYMBOL, 1 , 2.5 , 2.5 , .15 , 315 ,   EXAMPLE 2
PLOT,-5 ,-5 ,-3
PLOT, 5 , 0 , 999
*****************************************************************
```

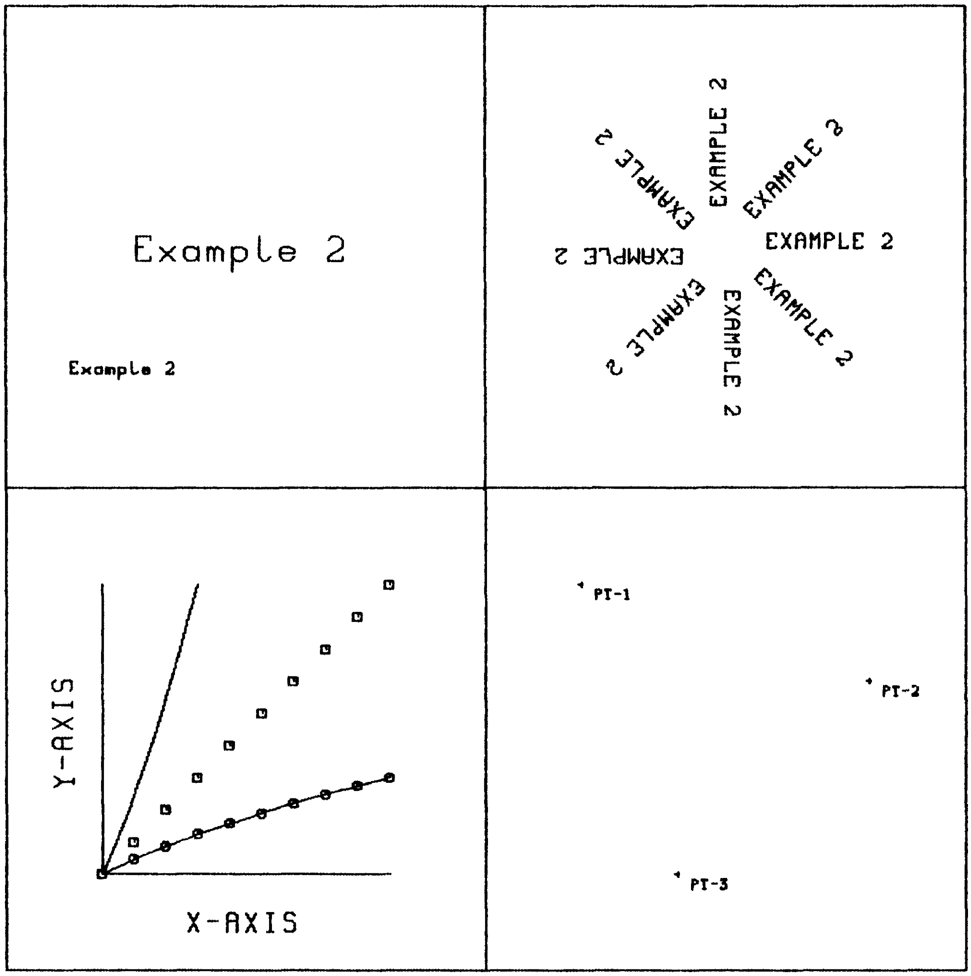


Figure 3.--An example showing the use of most of the elementary commands available in the JKPLOT system.

SECTION VI. - WINDOWING AND ZOOMING BY MODIFYING AN INTERMEDIATE PLOT FILE

Every plot produced by the JKPLOT system has associated with it a page size specified by the values of the variables XPAGE and YPAGE in the initial call to the routine named PLOTS. Any plot instructions that would cause the plotter to draw beyond these page boundaries are clipped at the boundaries. By manipulating the values of XPAGE and YPAGE, the current reference point (or origin), and the current expansion factor (set by the FACTOR command) a user can make the entire plot appear anywhere on the plotting surface or can cause a magnified image of a rectangular subset of the plot to appear at the lower left corner of the plot page. In computer jargon the process of selecting a rectangular subset of the plot to be displayed is call "windowing" and the magnification of an image is called "zooming".

The following intermediate plot file, which produces the plot in Figure 4, will be used as a basis for examples showing how windowing and zooming can be accomplished by simple editing of the file before plotting. More sophisticated methods of accomplishing these same tasks from within an application program are shown by example in the programs FILDRV2.BAS and FILDRV3.BAS and are discussed in Section VIII.

Listing of the intermediate plot file for Figure 4

```
****************************************************************
PLOTS,10,10
COMMENT,----------------------------------------------------
COMMENT, draw outside box
PLOT,0,0,3
PLOT,10,0,2
PLOT,10,10,2
PLOT,0,10,2
PLOT,0,0,2
COMMENT, divide into four quarters
PLOT,5,0,3
PLOT,5,10,2
PLOT,0,5,3
PLOT,10,5,2
COMMENT, center the letters A,B,C,D in quarters
SYMBOL,1,2.25,7.25,.5,0,A
SYMBOL,1,7.25,7.25,.5,0,B
SYMBOL,1,2.25,2.25,.5,0,C
SYMBOL,1,7.25,2.25,.5,0,D
COMMENT, terminate the plot
PLOT,0,0,999
***************************************************************
```

Four examples of windowing and zooming are shown in Figure 5. Each of the examples was produced by replacing the first line (PLOTS,10,10) of the intermediate plot file for Figure 4 with the instructions shown in the middle and right columns of Figure 5. The replacement code for accomplishing the tasks demonstrated on the PC screen is shown in the middle column, and that for accomplishing the same tasks for a pen plotter (Zeta or HP) is shown in the right column. The reason for the necessity of using different replacement code for the PC screen and pen plotters is that the default scaling procedures for screens and "inch-type plotters" is different, as explained in Section III-D.

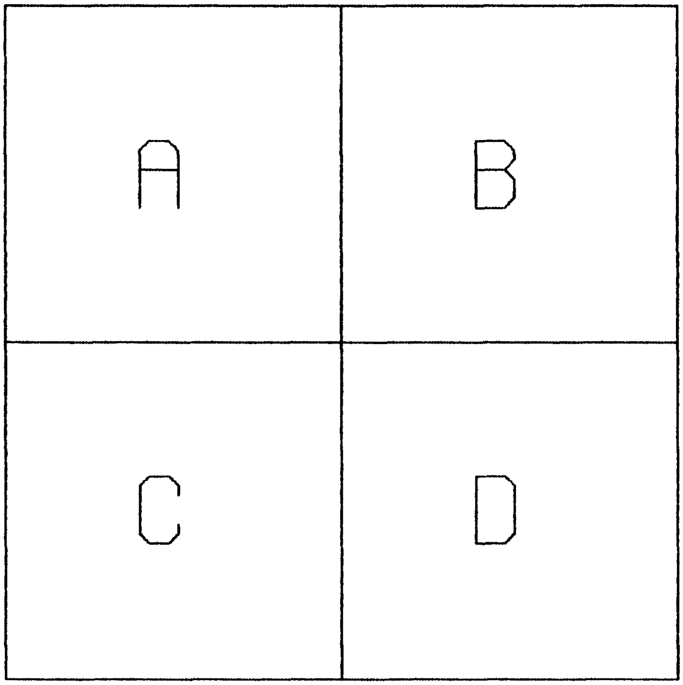


Figure 4.--Plot to be used as a basis for examples of windowing and zooming by modifying an intermediate plot file

SECTION VII. - ADVANCED USES OF THE JKPLOT SYSTEM

The plot driver subroutine, PLTDRV.BAS, was written in terms of plot windows and screen viewports, a standard graphics procedure. In default mode the assignment of these windows and viewports is accomplished automatically, without being visible to the user, when the elementary CalComp-like plot commands are used. The more sophisticated user, however, may wish to specify these values explicitly to obtain more complex plot output than is possible using only the elementary commands.

The reader should be warned that use of these more advanced features requires an understanding of some basic graphics concepts. The drivers are not self-correcting, and erratic results may be obtained when improper specifications are used. Good discussions of the use of windows and viewports are available in Giloi [2] and Hopgood, Duce, Gallop, and Sutcliffe [3].

A string variable of length thirteen, TKST$, is used to record the status of variables within the device drivers. Each of the characters in TKST$ is a flag which can take on the value 0 or 1 indicating the present state of the driver with respect to a particular function. The default value for each of the thirteen flags is 0, indicating that the device driver is to perform the

****

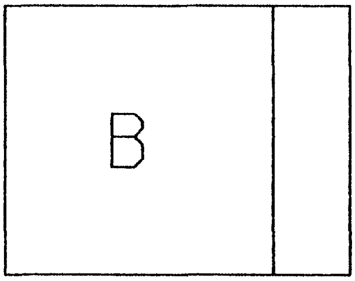
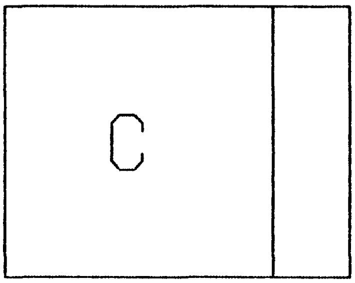
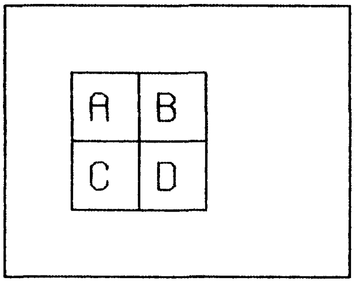
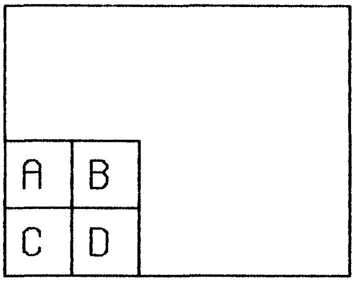
Image after modification	modification for PC screen	modification for Zeta plotter
	PLOTS, 20, 20 COMMENT, ----	PLOTS, 10, 10 FACTOR, .5 COMMENT, -----
	PLOTS, 20, 20 PLOT, 5, 5,-3 COMMENT, -----	PLOTS, 10,10 PLOT, 2.5, 2.5,-3 FACTOR, .5 COMMENT, -----
	PLOTS, 5, 5 COMMENT, -----	PLOTS, 10, 10 PLOT, -10, -10,-3 FACTOR, 2 COMMENT, -----
	PLOTS, 5, 5 PLOT, -5, -5,-3 COMMENT, -----	PLOTS, 10, 10 FACTOR, 2 COMMENT, -----

Figure 5. - Examples of windowing and zooming by modifying an an intermediate plot file. The image resulting on a PC screen is shown in the left column; the replacement code for producing the images on the PC screen is in the middle column; and the replacement code for accomplishing the same task with a pen plotter is in the right column.

corresponding function automatically. A flag value of 1 indicates that a function (such as initialization or setting of windows or viewports) has been performed either by a previous run through the driver or externally in an application program, or that alternative calculations (such as plot centering, plot rotation, or selection of alternate paper sizes) are to be performed within the plot system.

A particular flag is identified by the position of the corresponding character within the variable TKST$. For instance flag 2 is the second character in TKST$ and can be evaluated using the BASICA function MID$(TKST$,2,1). A short description of the function controlled by each flag follows.

Flag 1 is the driver initialization flag. A zero value of this flag indicates that the application program has not yet called any function in the driver, in which case the character generator must be initialized and the output device opened. A programmer may want to manipulate this flag to substitute an alternate character generator for the standard one supplied with the driver.

Flag 2 is the total picture initialization flag. A programmer may want to construct a picture using more than one intermediate plot file, in which case this flag must be set to 1 for all but the first plot. When this flag is 0 the output device is initialized (e.g. the CRT screen is cleared or the parameters for a pen plotter are reset to default values).

Flag 3 controls the assignment of the viewport for the total picture. When multiple plots are included in a picture each plot is assigned its own viewport within the frameport (viewport for the whole picture). If this flag is zero the frameport is set to the whole screen for CRTs and to the minimum of the device limits or the window size for other plotters. (See Section III-D for an explanation of default scaling procedures.) If a programmer sets this flag to 1 in an application program, the total picture viewport must also be set in that program.

Flag 4 is the current window flag. The default window for a plot is the rectangular area specified by the limits O-XPAGE for the horizontal coordinate and O-YPAGE for the vertical coordinate. If flag 4 is O the plot system assigns the default window to the plot being processed. A programmer may wish, however, to select a rectangle within the full window and display only that part of the plot within the selected rectangle. In graphics jargon this process is called "windowing". Flag 4 must be set to 1 if a programmer elects to control "windowing" in an application program.

Flag 5 is the current viewport flag. Each plot within a picture can be assigned its own viewport. If flag 5 is zero, a new plot is assigned the present value of the current viewport, and if the current viewport has not been assigned (the case for the first plot of a picture) it is given the value of the total picture viewport. In other words the default viewports are set equal to the frameport. If a programmer wishes to change the viewport when a new plot is initialized, flag 5 must be set to 1.

Flag 6 controls the graphics mode initialization of the output device. If flag 6 is 0, the plot driver will set the output device to graphics mode. Otherwise this mode initialization must be accomplished in the application program.

Flag 7 determines whether the plot system will adjust the scale factors to preserve the aspect (or shape) of the plot. If a square window and a horizontally long rectangular viewport are selected for a plot, the raw scaling calculations will cause the square to be stretched in the horizontal direction to fill the viewport. For aspect-preserving scale factors, the viewport must be modified to represent the shape of the window. If flag 7 is 0 the viewport will be modified to preserve shape; otherwise the raw scale factors will not be adjusted. The modified viewport is called the clipping port in the JKPLOT system.

If flag 7 is 1, flag 8 has no function; but if flag 7 indicates that the scale factors are to be modified to preserve shape, the actual area for plotting is a subrectangle of the specified viewport. Two reasonable alternatives for placing this subrectangle within the viewport are to center it or to place it in the lower left corner. A 0 value for flag 7 indicates that the subrectangle is to be placed in the lower left corner of the viewport; a value of 1 indicates it is to be centered.

Flag 9 is the rotation flag. If a user wants to plot a tall, thin plot on a device that has a short, wide page shape, the resulting plot will occupy only a small portion of the output page. If the plot is rotated 90 degrees, however, better utilization of the output page will occur. If flag 9 is 0 no rotation will occur; if flag 9 is 1 the plot will be rotated 90 degrees.

Flag 10 is the paper size flag. Some plotters have more that one paper size available (e.g. the Hewlett Packard 7550A). When this flag is 1 the alternate paper size, as specified in the device specification code, is selected.

Flag 11 is reserved for use with applications of 3-dimensional plotting. A 3-dimensional plotting system should provide the capability for locating a 2-dimensional plot in 3-dimensional space and then projecting the resulting image onto a two dimensional image plane. In the JKPLOT plotting system the only reasonable place to trap the 2-dimensional coordinates for this type of transformation is in the plot driver. Flag 11, which is not used now, allows for expansion of the plotting system to include this type of graphics call.

Flag 12 is the endplot flag. If a picture consists of the overlay of more than one subplot, the subplot instruction to terminate plotting must be ignored for all but the last of the subplots. For the last of a sequence of subplots flag 12 must be set to 0; otherwise it should have the value 1.

Flag 13 is the clipping enable flag. When this flag is 0 any instructions that would cause the pen (or pseudo pen) to move beyond the clipping window calculated by the most recent call to PLOTS are clipped at the boundary. In some cases a user might want to override this default setting and move the pen beyond the clipping boundary. Such a situation would occur if the user is sending a number of plots to the Zeta plotter and wants to move the pen a few inches beyond the boundary of the present plot in order to prepare the the beginning of the next plot. A value of 1 for this flag disables the clipping.

The system of thirteen graphics function flags adds great flexibility to the basic plotting system. In default mode, however, all flag manipulations are handled internally by the plotting system; the applications programmer need not be concerned with them.

SECTION VIII. - CAPABILITIES AND USE OF THE THREE FILE-READING PLOT DRIVERS, FILDRV1.BAS, FILDRV2.BAS, AND FILDRV3.BAS

The most elementary file-reading plot program included in this report is FILDRV1.BAS. When this program is executed the user is asked for the name of one intermediate plot file. The program checks to see that the specified file exists and then sends the plot to the plotter. When the plot is finished a beep is sounded and the user must press the <ESCAPE> key to terminate the plot.

Up to ten plot files with the same page size can be plotted using the program, FILDRV2.BAS. The user is prompted the names of up to ten plot files. If fewer than ten files are required the list can be terminated by entering a blank file name. As each file name is entered the program checks to see that the file exists and that the page size of all the files is the same. The user is then asked if a window (subrectangle of the total plot) is to be selected. If the user enters N (for no) the program overlays the plots. If the user enters Y (for yes) to the window selection query, the boundaries of the window must be entered. The program then plots that portion of the total plot within the window, scaled to the default viewport. When the last plot is finished a beep is sounded, and the user must press the <ESCAPE> key to terminate the plot. The program then asks if another plot is to be made. If the answer is N the program ends, and if the answer is Y the user is asked whether the same files are to be used. The user can then enter a new file list and/or a new window and proceed as before.

The more advanced driver, FILDRV3.BAS, is menu driven and allows the user to overlay up to ten plot files, rotate the plot, center the plot, select alternate paper sizes, select windows and viewports, and to define a non-default scaling factor. The user is first asked to insert up to 10 plot file names as in the program FILDRV2.BAS. After the list of files has been entered the menu in Figure 6 (showing numbers used for the PC enhanced graphics screen) appears on the screen. Present selections are shown in upper case in this figure but are in reverse video on the screen.

Because of difficulties using the COLOR command to produce reverse video with the Hercules graphics, this driver will not work with the Hercules driver. Also, an "out of memory" error will occur when a user tries to merge FILDRV3.BAS, PLTDRV.BAS, and ZETASPEC.BAS to make a file-reading plot driver for the Zeta plotter. Enough memory can be made available by removing certain comments from the first two programs. An example in Appendix A shows which comments to remove and how to remove them.

The user selects the function to be performed by pressing the key shown on the menu. The centering, rotation, and paper size selections are toggle type selections requiring no further entries to accomplish the function to be performed. If the user elects to specify a non-default window, viewport, or scale factor further numerical entries are required. In this case the menu is erased and the screen shows the present location of the window, viewport, and clipping boundary. The user is prompted for the numerical entry or entries at the bottom of the screen as shown in Figure 7. The cursor showing the present state of the entry can be moved to the left or right using the numerical keyboard left and right arrow keys respectively. If the user moves the cursor (either to the left or right) beyond the limits of an entry field, the cursor moves to the next field in the chosen direction. If the <RETURN> key is pressed the cursor is moved to the next field to the right. When the cursor is moved to the right of the rightmost field, numerical entry is terminated and the new window, viewport, and clipping port are displayed on the screen. If the user wants to re-enter the values the <ESCAPE> key must be pressed. Depression of any other key accepts the new entries and returns to the main menu.

Interpretation of the window and viewport entries is straightforward, but interpretation of the user-specified scaling entry depends upon which kind of plotter is being used. The window limits are specified in plot inches, and the window must lie within the page limits. The viewport limits are entered in inches if an "inch-type" plotter is being used or in device coordinates for non "inch-type" devices.

```
****************************************************************
                  ***** OPTION SELECTIONS *****
****************************************************************
----------------------------------------------------------------
!PLOT CENTERING        PLOT ROTATION       PAPER SIZE          !
!   L = LOWER LEFT         U = UNROTATED       N=NORMAL        !
!   C = centered           R = rotated         A = alternate   !
----------------------------------------------------------------
!PLOT WINDOW           PLOT VIEWPORT       PLOT SCALING        !
!   B = DEFAULT            S = DEFAULT         F = VIEWPORT FIT !
!   W = select             V = select          I = select (inch)!
----------------------------------------------------------------
!                            WINDOW                            !
!                      ---X---                ---Y---          !
!      Default      0          10          0          10       !
!      Present      0          10          0          10       !
!--------------------------------------------------------------!
!                           VIEWPORT                           !
!                      ---X---                ---Y---          !
!      Device       0          639         0          199      !
!      Present      0          639         0          199      !
!      Clipping     0          478         0          199      !
!--------------------------------------------------------------!
!                       SCALE MULTIPLIER                       !
!       Max:        1      Default:      1       Present:    1 !
!--------------------------------------------------------------!
     ***  SELECT ACTION BY PRESSING KEY (P=PLOT,Q=QUIT)   ***
****************************************************************
```

Figure 6. - Menu for plot modification selections available using FILDRV3.BAS

For non "inch-type" plotters (e.g. screens for which the term "plot inches is not meaningful) a scale factor of 1 indicates that the selected window is scaled to the largest aspect-preserving size that will fit in the selected window. The user can select a scale factor between 0 and 1, reducing the resulting plot by that factor. For example if the scale factor is set to .5, the plot will be one-half as large it would have been under default viewport-filling calculations.

For "inch-type" plotters a viewport larger than the window size can be specified, in which case the scale factor needed to fill the viewport is calculated. For example if the window selected is 5 inches by 5 inches and the viewport is set to 10 inches by 10 inches, the maximum allowed scale factor, which will fill the viewport, is 2. The user can select any value between 0 and the maximum scale factor value. Continuing the above example, if the user selects a scale factor of 1.5, the resulting plot will be 7.5 inches by 7.5 inches.

```
*****************************************************************
************       window       *      viewport     *************
************                    *                   *************
************                    *                   *************
************                    *                   *************
************                    *                   *************
************ ------------------ * ----------------- *************
************ ¦  outlines of   ¦ * ¦  outlines of  ¦ *************
************ ¦ whole plot and ¦ * ¦ screen, view- ¦ *************
************ ¦ window shown   ¦ * ¦ port, and     ¦ *************
************ ¦     here       ¦ * ¦ clipping port ¦ *************
************ ¦                ¦ * ¦  shown here   ¦ *************
************ ------------------ * ¦---------------¦ *************
************                    *                   *************
************                    *                   *************
************                    *                   *************
************                    *                   *************
*****************************************************************
  USER SELECTED VIEWPORT ENTRY
  DEFAULT      0            639         0           199
  PRESENT      0            639         0           199
  INPUT        _________    _________   _________   _________
-----------------------------------------------------------------
            INSERT VIEWPORT (D=DEFAULT, BLANK=PRESENT)
*****************************************************************
```

Figure 7. - Numerical entry screen for FILDRV3.BAS

When the user is satisfied with the plotting parameters shown on the main menu, depression of the "P" key will cause the plot to be sent to the plotter. After the plot is finished the user must depress the <ESCAPE> key to return to the main menu. Depression of the "Q" key when the main menu is displayed returns the user to the plot file selection part of the program.

SECTION IX. - MODIFICATIONS OF THE JKPLOT SYSTEM FOR USE WITH MICROSOFT QUICKBASIC

A. - Printers

The purpose of the assembly language programs, BITMAP8.ASM and BITMAP2.ASM, is to store a bitmap image of the printer output in areas of the computer memory that are not used by BASICA because not enough storage space is made available to the user within that system. The newer Microsoft QuickBasic compiler allows the user to access all of the memory available in the computer, and hence there is no need to use assembly language for this bitmap storage. Two BASIC programs, QKBIT8.BAS and QKBIT2.BAS, which accomplish the same tasks as BITMAP8.ASM and BITMAP2.ASM are included with the JKPLOT system. When the appropriate QKBIT program is merged with the plot drivers for the printers, the user can then proceed to use the drivers just as for the case of using the compiled PC screen driver. The procedure for making a file reading device driver for an Epson printer in high resolution is shown in Appendix B.

B. - PC Screen with enhanced graphics

The SCREEN command available in the BASICA compiler used for development of the JKPLOT system cannot specify the enhanced graphics screen. Access to the EGA screen is available only through the use of system interrupts, which requires the use of assembly language programs. This access is provided by the program, EGAASM.ASM. The QuickBasic compiler allows the specification of the EGA screen and performs the standard graphics functions on that screen, and thus there is no need to use an assembly language program. The program, QKEGASP.BAS (QuickBasic enhanced graphics specifications), is a device specification program very similar to PCSPECH.BAS and can be utilized in device drivers the same way as that program.

C. - PC SCREEN WITH HERCULES GRAPHICS

In Section IV-C, the procedures for compiling and linking the programs HERCSPEC.BAS and HERCASM.ASM with an application program were explained. In that explanation it was noted that use of the link-controlling program, LN.ASM, was not required; however when using these programs with the QuickBasic compiler a link-controlling program is required. The object module for such a program, PREFIX.OBJ, is provided with the QuickBasic compiler and can be used in the same way as the LN.OBJ object module is used when compiling the printer drivers using the BASICA compiler.

SECTION X. - CONCLUSION

The JKPLOT basic plot system provides a simple graphics interface between an IBM PC compatible microcomputer and a variety of plotting devices. The programs are written in an elementary language and are structured to make it easy for a user to modify the system to fit unique needs.

SECTION XI. - REFERENCES

1. ACM/SIGGRAPH Graphics Standards Planning Committee, First report of the CORE definition subgroup, preliminary draft, 1977.

2. Giloi, Wolfgang K., 1978, Interactive computer graphics, data structures, algorithms, languages: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 354 p.

3. Hopgood, F. R. A., Duce, D. A., Gallop, J. R., and Sutcliffe, D. C., 1983, Introduction to the graphics kernel system (GKS): Academic Press, New York, 200 p.

4. Programming CALCOMP Electromechanical Plotters, 1976, California Computer Products, Inc., 32 p.

APPENDIX A

Session Logs Showing Use of the JKPLOT System

System responses are justified to the left margin; user entries are indented ten spaces; comments are immediately preceded by semicolons; and plots are indicated by centered notes delimited by asterisks at each end.

1. Constructing a device driver for the high resolution PC screen.

```
>         BASICA                    ;load basica system

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "PLTDRV.BAS"         ;load the system driver
Ok
          MERGE "PCSPECH.BAS"       ;merge the device specs
Ok
          SAVE "PCDRVH.BAS",A       ;save driver for later use
Ok
          SYSTEM                    ;return to system level
>
```

2. Example 1, direct mode, interpreted

```
>         BASICA                    ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE1.BAS"       ;load applications program
Ok
          MERGE "PCDRVH.BAS"        ;merge the device driver
Ok
          RUN                       ;execute the program

LOADING POINTERS                    ;program is loading
LOADING INCREMENTS                  ;the character generator

        ********** Plot appears on the screen **********

          <ESC>                    ;user must press ESC key
                                   ;unprompted to return to
                                   ;the system
>
```

3. Compiling and running program for Example 1 - direct mode

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE1.BAS"      ;load applications program
Ok
          MERGE "PCDRVH.BAS"       ;merge the device driver
Ok
          SAVE "EX1CMP.BAS",A      ;save in ASCII file
Ok
          SYSTEM                   ;return to system level

>         BASCOM EX1CMP /E/O/S;    ;compile the program

IBM Personal Computer BASIC Compiler
(C) Copyright IBM Corp 1982 Version 1.00
(C) Copyright Microsoft, Inc. 1982

22151 Bytes Available
15682 Bytes Free

0 Warning Error(s)
0 Severe Error(s)

>         LINK EX1CMP;             ;link the program

***** NOTE THAT FOR ALL DRIVERS THAT USE THE COMMUNICATIONS PORT
***** - I.E. THE ZETA, HEWLETT-PACKARD, AND TEKTRONIX 4014
***** DRIVERS - THE COMMUNICATIONS OBJECT MODULE, IBMCOM.OBJ,
***** MUST BE LINKED ALSO.

Microsoft Object Linker V2.01 (Large)
(C) Copyright 1982, 1983 by Microsoft, Inc.

    ****** returns to system after linking is completed *****

>         EX1CMP                   ;execute the program

         ********** Picture appears on screen **********

          <ESC>               ;unprompted user entry of ESC
                              ;key to return to system

>
```

4. Making a file-reading driver for the high resolution PC screen

```
>         BASICA              ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"            ;load the file-reading
                                        ;applications program
Ok
          MERGE "PCDRVH.BAS"            ;merge the device driver
Ok
          SAVE "FILPCH2.BAS",A          ;save source code in file
Ok
          SYSTEM                        ;return to system level
          ;The user should compile this program as in part 3.
```

5. Example 1 using metafile mode and file reading driver

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE1.BAS"      ;load the applications program
Ok
          MERGE "CCMAKE.BAS"       ;merge the pseudo device
driver
Ok
          RUN                      ;execute program through the
                                   ;interpreter

   ********** Metafile EXAMPLE1.PLT is written now **********
Ok
          SYSTEM                   ;return to system level

>         FILPCH                   ;execute the file-reading
                                   ;driver

INSERT NAME OF INPUT FILE NO 1:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          EXAMPLE1.PLT
INSERT NAME OF INPUT FILE NO 2:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          <CR>                  ;carriage return alone indicates
                                ;no more entries desired
DO YOU WANT TO SET A CLIPPING WINDOW: ?
          N
          ********** plot appears on screen **********

          <ESC>                   ;unprompted user entry of ESC
                                  ;key clears the screen

DO YOU WANT ANOTHER PLOT: ?
          N

>
```

6. Making a file-reading plot driver for the EPSON printer in high resolution

```
>         BASICA                     ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"         ;load the file-reading
                                     ;application program
Ok
          MERGE "PLTDRV.BAS"         ;merge the plot system driver
Ok
          MERGE "EPSPECH.BAS"        ;merge the specification for
                                     ;for the EPSON printer in high
                                     ;resolution
Ok
          SAVE "FILEPH2.BAS",A      ;save source code in ASCII file
Ok
          SYSTEM                     ;return to system level

>         BASCOM FILEPH2 /E/O/S;     ;compile the program

IBM Personal Computer BASIC Compiler
(C) Copyright IBM Corp 1982 Version 1.00
(C) Copyright Microsoft, Inc. 1982

22151 Bytes Available
12584 Bytes Free

0 Warning Error(s)
0 Severe Error(s)

>         MASM BITMAP8.ASM;          ;assemble the bitmap program
                                     ;for high resolution plot

The Microsoft MACRO Assembler, Version 1.25
Copyright (C) Microsoft Corp 1981,82,83

47404 Bytes free
```

```
Warning Severe
Errors  Errors
0       0                          ;assembly complete

>         MASM LN.ASM;             ;assemble dummy program for
                                   ;controlling the linker

The Microsoft MACRO Assembler, Version 1.25
Copyright (C) Microsoft Corp 1981,82,83

49722 Bytes free

Warning Severe
Errors  Errors
0       0                          ;assembly complete

>         LINK FILEPH2+LN+BITMAP8;      ;Link object files

Microsoft Object Linker V2.01 (Large)
(C) Copyright 1982, 1983 by Microsoft, Inc.

>         ;execution module, FILEPH2.EXE, has now been made
```

7. Drawing upper left quarter of Example 2 plot (zooming), interpreted metafile mode, using compiled file-reading driver for the EPSON printer in high resolution

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE2.BAS"      ;load the applications program
Ok
          MERGE "CCMAKE.BAS"      ;merge the pseudo device driver
Ok

>         RUN                      ;execute the program through
                                   ;the interpreter
INSERT PLOT FILE NAME:
          EXAMPLE2.PLT             ;output file name was not
                                   ;specified in applications
                                   ;program

UPPER LEFT CORNER                  ;driver is printing comment
LOWER LEFT CORNER                  ;lines on the screen
LOWER RIGHT CORNER
UPPER RIGHT CORNER
```

```
DONE                               ;metafile is now finished
>

>         FILEPH2                  ;execute the file-reading
                                   ;driver for the EPSON printer

INSERT NAME OF INPUT FILE NO 1:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          EXAMPLE 2.PLT            ;enter plot file name
INSERT NAME OF INPUT FILE NO 2:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          <CR>                     ;carriage return alone
                                   ;terminates filename entry
DO YOU WANT TO SET A CLIPPING WINDOW?
          Y

THE PLOT PAGE DIMENSIONS ARE:   10      10

ENTER LOWER AND UPPER X VALUES:
          0,5
ENTER LOWER AND UPPER Y VALUES:
          5,10

CONSTRUCTING BITMAP IMAGE ON COMPUTER MEMORY
          ;the program now constructs the bitmap image of the
          ;picture in the computer memory

UPPER LEFT CORNER             ;comment lines are printed on
LOWER LEFT CORNER             ;the screen as the bitmap is
LOWER RIGHT CORNER            ;being constructed
UPPER RIGHT CORNER

SENDING IMAGE TO PRINTER      ;the printer now begins to receive
                              ;the image

DO YOU WANT ANOTHER PLOT?     ;plot is finished
          N                   ;terminate the program
```

7. Making a file-reading plot driver for Hercules graphics

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"       ;load the file-reading
                                   ;application program
Ok
          MERGE "PLTDRV.BAS"       ;merge the plot system driver
Ok
```

```
          MERGE "HERCSPEC.BAS"      ;merge the specification for
                                   ;for Hercules graphics
Ok
          SAVE "FILHERC2.BAS",A   ;save source code in ASCII file
Ok
          SYSTEM                   ;return to system level

>         BASCOM FILHERC2 /E/O/S;   ;compile the program

IBM Personal Computer BASIC Compiler
(C) Copyright IBM Corp 1982 Version 1.00
(C) Copyright Microsoft, Inc. 1982

22151 Bytes Available
12328 Bytes Free

0 Warning Error(s)
0 Severe Error(s)



>         MASM HERCASM.ASM;        ;assemble the bitmap program
                                   ;for high resolution plot

The Microsoft MACRO Assembler, Version 1.25
Copyright (C) Microsoft Corp 1981,82,83

49694 Bytes free

Warning Severe
Errors  Errors
0       0                          ;assembly complete

>         LINK FILHERC2+HERCASM;      ;Link object files

Microsoft Object Linker V2.01 (Large)
(C) Copyright 1982, 1983 by Microsoft, Inc.

>         ;execution module, FILHERC2.EXE, has now been made
```

8. Making a file-reading plot driver for enhanced graphics

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"       ;load the file-reading
                                   ;application program
Ok
          MERGE "PLTDRV.BAS"       ;merge the plot system driver
```

```
Ok
          MERGE "EGASPEC.BAS"      ;merge the specification for
                                   ;for the enhanced graphics
Ok
          SAVE "FILEGA2.BAS",A    ;save source code in ASCII file
Ok
          SYSTEM                   ;return to system level

>         BASCOM FILEGA2 /E/O/S;   ;compile the program

IBM Personal Computer BASIC Compiler
(C) Copyright IBM Corp 1982 Version 1.00
(C) Copyright Microsoft, Inc. 1982

22151 Bytes Available
12584 Bytes Free

0 Warning Error(s)
0 Severe Error(s)

>         MASM EGAASM.ASM;        ;assemble the bitmap program
                                   ;for high resolution plot

The Microsoft MACRO Assembler, Version 1.25
Copyright (C) Microsoft Corp 1981,82,83

49694 Bytes free

Warning Severe
Errors  Errors
0       0                          ;assembly complete

>         LINK FILEGA2+EGAASM;      ;Link object files

Microsoft Object Linker V2.01 (Large)
(C) Copyright 1982, 1983 by Microsoft, Inc.

>         ;execution module, FILEGA2.EXE, has now been made
```

9. Drawing upper left quarter of Example 2 plot (zooming), interpreted metafile mode, using compiled file-reading driver for the PC screen with enhanced graphics.

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE2.BAS"      ;load the applications program
```

```
Ok
          MERGE "CCMAKE.BAS"      ;merge the pseudo device driver
Ok

>         RUN                      ;execute the program through
                                   ;the interpreter
INSERT PLOT FILE NAME:
          EXAMPLE2.PLT             ;output file name was not
                                   ;specified in applications
                                   ;program

UPPER LEFT CORNER                  ;driver is printing comment
LOWER LEFT CORNER                  ;lines on the screen
LOWER RIGHT CORNER
UPPER RIGHT CORNER

DONE                               ;metafile is now finished
>

>         FILEGA2                  ;execute the file-reading
                                   ;driver for the EPSON printer

INSERT NAME OF INPUT FILE NO 1:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          EXAMPLE 2.PLT            ;enter plot file name
INSERT NAME OF INPUT FILE NO 2:
(BLANK NAME TO PLOT, EXIT TO QUIT PROGRAM WITHOUT PLOTTING)
          <CR>                     ;carriage return alone
                                   ;terminates filename entry
DO YOU WANT TO SET A CLIPPING WINDOW?
          Y

THE PLOT PAGE DIMENSIONS ARE:   10      10

ENTER LOWER AND UPPER X VALUES:
          0,5
ENTER LOWER AND UPPER Y VALUES:
          5,10

CONSTRUCTING BITMAP IMAGE ON COMPUTER MEMORY
          ;the program now constructs the bitmap image of the
          ;picture in the computer memory

UPPER LEFT CORNER             ;comment lines are printed on
LOWER LEFT CORNER             ;the screen as the bitmap is
LOWER RIGHT CORNER            ;being constructed
UPPER RIGHT CORNER

SENDING IMAGE TO PRINTER      ;the printer now begins to receive
                              ;the image

DO YOU WANT ANOTHER PLOT?     ;plot is finished
          N                   ;terminate the program
```

10. Removing comments from FILDRV3.BAS and PLTDRV.BAS to make room in memory for ZETASPEC.BAS to be merged.

```
>BASICA                      ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV3.BAS"      ;load the file reader
Ok
          MERGE "PLTDRV.BAS"      ;merge the device independent
                                  ;code
Ok
          SAVE "TMP.BAS"          ;save for later use
Ok
          MERGE "ZETASPEC.BAS"    ;try to merge the device
                                  ;dependent Zeta code

Out of memory                     ;too much code - must try to
                                  ;make space by removing
                                  ;comments

          LOAD "TMP.BAS"          ;load judiciously saved
                                  ;previous merge
Ok
          DELETE 1-10             ;deleting unneeded comments
Ok
          DELETE 1000-1170
Ok
          DELETE 30005-30090
Ok
          DELETE 30200-30370
Ok
          MERGE "ZETASPEC.BAS"    ;try merge again
Ok
          PRINT FRE(0)            ;see how much space is left
1774
Ok
          SAVE "FILZT3.BAS",A     ;save for compiling
Ok
```

APPENDIX B

Modifications For Microsoft QuickBasic

1. - General

Microsoft QuickBasic is a compiler for the BASIC language, very similar in function to the IBM BASIC compiler used for development of the JKPLOT system. Most of the examples shown in Appendix A can be translated for use with QuickBasic by simply replacing the compiler program name, BASCOM, with the QuickBasic compiler program name, QB. The communications object module is named GWCOM.OBJ in the QuickBasic system and must be substituted for the IBMCOM.OBJ module used when linking drivers for the Zeta, Hewlett-Packard, and Tektronix 4014 drivers. The QuickBasic compiler, however, utilizes much more of the capacity of the computer, and when there is need for interfaces to assembly language programs, changes in the procedures may be necessary. Drivers in the JKPLOT system for which changes are necessary are the printer drivers (Epson and Okidata high and low resolution), the Hercules driver, and the enhanced graphics driver.

Loading, merging, and saving BASIC programs with the interpreter are all accomplished exactly as shown in Appendix A. The QuickBasic system has a file editor that can be used for entering programs, and one might erroneously think that this editor can be used to accomplish the merging previously done with the interpreter. The QuickBasic editor, however, can only insert an external file into the one being edited; it cannot merge BASIC programs in the same way the interpreter does because the order of the program statements after merging with the interpreter is determined by the line numbers in the merged parts. The QuickBasic editor pays no attention to line numbers when inserting or appending programs.

2. - Printer Drivers

The drivers for the Epson and Okidata printers construct a bitmap image of what is to be plotted within the computer memory before sending anything to the printer. Because of the size of the bitmap and the limited use of memory made by the IBM Compiler the bitmap construction programs were written in assembly language. The QuickBasic compiler can access all of available memory - enough to hold the bitmap - and thus there is no need for assembly language when using QuickBasic. Included with the JKPLOT system are two programs, QKBIT8.BAS and QKBIT2.BAS, which take the place of the assembly language programs, BITMAP8.ASM and BITMAP2.ASM. The appropriate QKBIT program must be merged with the BASIC printer driver, and compilation then proceeds in the standard way. The following example shows the procedure for constructin a file reading plot driver for the Epson printer with high resolution.

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"      ;load applications program
Ok
          MERGE "PLTDRV.BAS"       ;merge the device driver
Ok
          MERGE "EPSPECH.BAS"      ;merge the device specs
Ok
          MERGE "QKBIT8.BAS"       ;merge the bitmap construction
                                   ;subroutine
Ok
          SAVE "QFILEPH2.BAS",A      ;save in ASCII file
Ok
          SYSTEM                   ;return to system level

>         QB QFILEPH2 /E/O/S;      ;compile the program

Microsoft QuickBasic Compiler
Version 2.00

(C) Copyright Microsoft Corp. 1982, 1983, 1984, 1985, 1986

948 Lines Compiled
  0 Severe Error(s)

>         LINK QFILQPH2;

Microsoft (R) Overlay Linker   Version 3.06
Copyright (C) Microsoft Corp 1983, 1984, 1985, 1986.
All rights reserved.

    ****** returns to system after linking is completed *****

C>
```

3. - Enhanced Graphics Driver

The QuickBasic compiler allows the specification of the EGA screen and performs the standard graphics functions on that screen., and thus there is no need to use an assembly language program. The program, QKEGASP.BAS (QuickBasic enhanced graphics specifications), is a device specification program very similar to PCSPECH.BAS and can be utilized in device drivers the same way as that program. The following example shows how to compile the BASIC program, EXAMPLE1.BAS, for execution in direct mode.

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "EXAMPLE1.BAS"      ;load applications program
Ok
          MERGE "PLTDRV.BAS"       ;merge the device driver
Ok
          MERGE "QKEGASP.BAS"      ;merge the device specs
Ok
          SAVE "QKEXE1.BAS",A      ;save in ASCII file
Ok
          SYSTEM                   ;return to system level

>         QB QKEXE1 /E/O/S;        ;compile the program

Microsoft QuickBasic Compiler
Version 2.00

(C) Copyright Microsoft Corp. 1982, 1983, 1984, 1985, 1986

642 Lines Compiled
  0 Severe Error(s)

>         LINK QKEXE1;

Microsoft (R) Overlay Linker   Version 3.06
Copyright (C) Microsoft Corp 1983, 1984, 1985, 1986.
All rights reserved.


    ****** returns to system after linking is completed *****

C>
```

4. - Hercules Graphics

The programs and procedures for compiling and using Hercules graphics with QuickBasic are the same as those used with the IBM BASIC compiler except linking. In QuickBasic the linker is more complex, and a special object module, PREFIX.OBJ, is supplied with the system to control the link order when using assembly language programs. The following example shows how to construct a file reading device driver for Hercules graphics using QuickBasic.

```
>         BASICA                   ;load basica

Columbia Data Products BASIC - Version 2.00
Copyright (C) Columbia Data Products, Inc. 1983
Copyright (C) Microsoft 1983
60641 Bytes free
Ok
          LOAD "FILDRV2.BAS"      ;load applications program
Ok
          MERGE "PLTDRV.BAS"       ;merge the device driver
Ok
          MERGE "HERCSPEC.BAS"      ;merge the device specs
Ok
          SAVE "QKFLHERC.BAS",A      ;save in ASCII file
Ok
          SYSTEM                   ;return to system level

>         QB QKFLHERC /E/O/S;        ;compile the program

Microsoft QuickBasic Compiler
Version 2.00

(C) Copyright Microsoft Corp. 1982, 1983, 1984, 1985, 1986

849 Lines Compiled
  0 Severe Error(s)

>         MASM HERCASM.ASM;        ;assemble the bitmap program
                                   ;for high resolution plot

The Microsoft MACRO Assembler, Version 1.25
Copyright (C) Microsoft Corp 1981,82,83

47694 Bytes free

Warning Severe
Errors  Errors
0       0                          ;assembly complete

>         LINK QKFLHERC + PREFIX + HERCASM;

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All rights reserved.

    ****** returns to system after linking is completed *****

C>
```