Basic display support programs for man-machine communications studies

Pulfer, J. K.

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BASIC DISPLAY SUPPORT PROGRAMS FOR MAN-MACHINE COMMUNICATIONS STUDIES

- J. K. PULFER -

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ABSTRACT

Programs developed for the manipulation of graphical information on a digital display are described. The programs are designed to run on a small research computer together with the digital display developed by the Radio and Electrical Engineering Division. The software is used for constructing drawings, entering and manipulating data in graphical form, and for controlling the decision flow in complex interactive programs.

PREFACE

This report is one of a series describing programming support for a digital computer used by the Radio and Electrical Engineering Division. The computer, Model 840A, manufactured by Systems Engineering Laboratories Inc., is being employed as a tool for research in computer usage problems. It is not used for computation or for scientific or business data processing. Specific areas of interest include: man–machine communications using graphical CRT displays, time sharing and multiprogramming problems on small computers, analysis and synthesis of sound including speech and music, three-dimensional graphic construction and manipulation and production of animated films.

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BASIC DISPLAY SUPPORT PROGRAMS FOR MAN–MACHINE COMMUNICATIONS STUDIES

– J.K. Pulfer –

Introduction

This report will describe software developed in this Division for the SEL 840A computer referred to in NRC Report ERB-794, entitled 'Programming support for a small research computer' by J.K. Pulfer and M. Wein.

One of the areas of computer usage being studied is that of man–machine communication and interactive processing using a graphical display. Peripheral equipment which is used consists of high-speed paper-tape readers and punches, teletypes, magnetic tape units and a disc storage unit. There are also a number of digital-to-analog and analog-to-digital channels available.

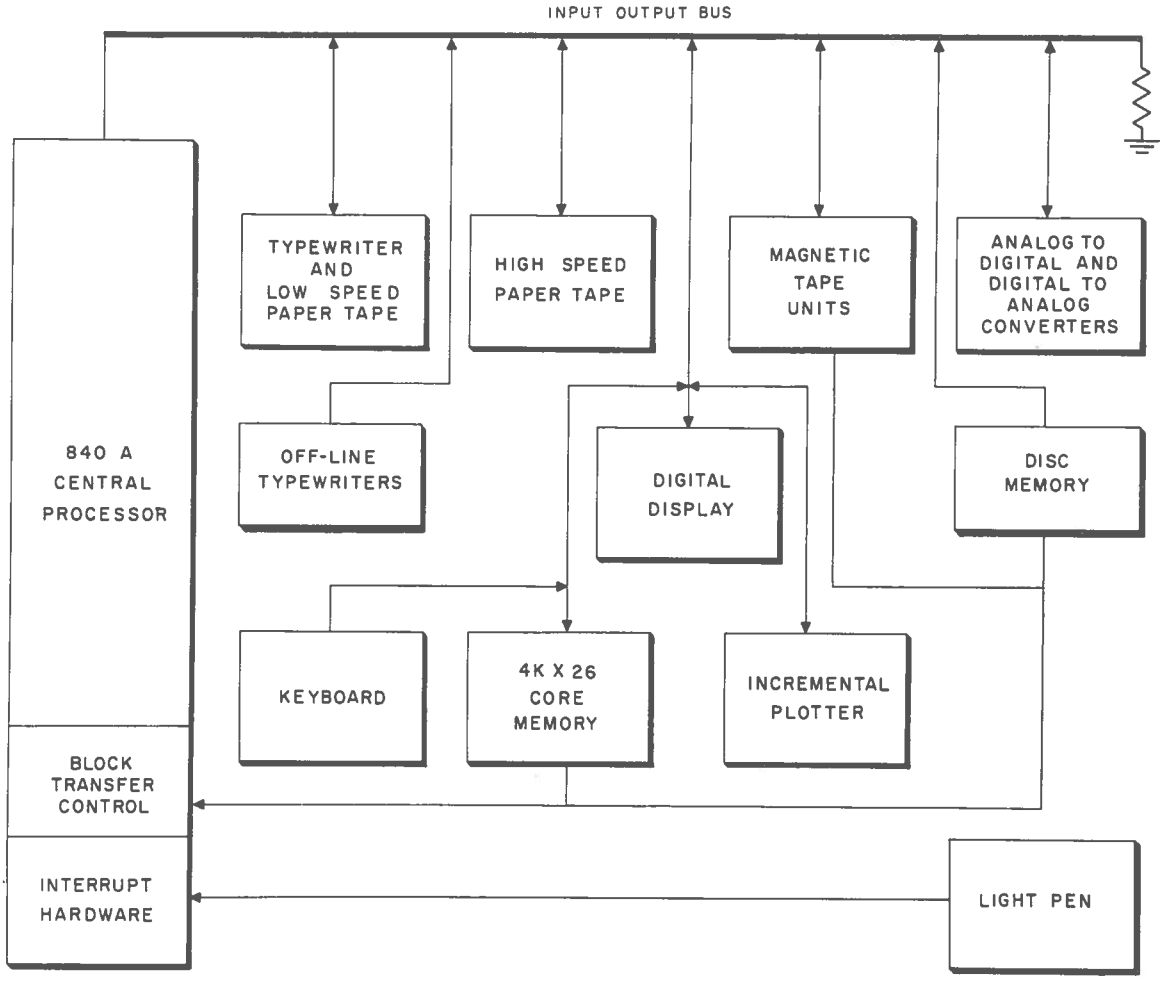

Fig. 1 Simplified block diagram of data systems 840A processor

Figure 1 is a block diagram of the central processor (CPU) and peripheral equipment.

The digital cathode-ray tube display used with the 840A computer has the following pertinent specifications:

(1)	Word length	24 bits
(2)	x and y positioning accuracy	10 bits each
(3)	Intensity	2 bits
(4)	Vector component (Δx and Δy) accuracy	10 bits each
(5)	Vector scale factor	12 bits
(6)	Total Δx and Δy position range (with off-screen hardware blanking)	12 bits each
(7)	Vector speed (depends on commands used)	100 μsec/inch
(8)	Circle capability	yes
(9)	Parabola capability	yes
(10)	Character generator	6-bit truncated ASCII
(11)	Hardware character format with automatic CR/LF (carriage return/line feed)	64 characters/line 8 lines/page
(12)	Buffer core memory	4-K 26-bit words 1.6 μsec cycle time
(13)	Logical element counter	12-bits
(14)	Hardware priority interrupts	Lightpen – (1) Buffer core (1) Executive call (1)
(15)	Auxiliary input devices	binary keyboard absolute shaft position encoders incremental shaft position encoders

A complete description of display commands and data formats is given in NRC Report ERB-788, and a complete and detailed description of the display hardware is given in ERB-797.

The display software to be described in this report will be discussed in terms of design philosophy and potential applications rather than detailed programming. The reader can follow the details for himself by reading the listings in the appendix and by referring to the programming and hardware manuals mentioned in the preceding paragraph.

Display Software

Display software can be arbitrarily divided into the following groups for purposes of description.

(1) *Diagnostic programs* – those programs which allow the user to exercise all the facilities of the display hardware in an orderly way and to check for malfunction.

(2) *Drawing software* – a set of programs which are basic tools for constructing line drawings and free form drawings on the cathode-ray tube. This package makes use of display input hardware such as light pen and shaft position encoders, and services the corresponding interrupts.

(3) *Graphical data manipulation programs* – a software package which can be used to present one- and two-dimensional variables in graphical form on the cathode-ray tube and to manipulate them. Graphical input is also a part of this package.

(4) *Interactive program control routines* – a set of programs which are designed to allow the user seated at the CRT display to control the flow of a program through the routines available to him, depending on his interpretation of the current status of the graphical entity with which he is dealing.

(5) *Storage control software* – a set of programs which allow the user to manipulate files of graphical data without being concerned with their specific size, location in core, or location in disc memory. This report will not cover item 5 since that portion of the graphical software is described in detail in a separate publication entitled Basic Disc Support Programs for Man–Machine Communications Studies (NRC report ERB-796). In addition a large portion of item 3 that deals with the manipulation of three-dimensional line drawings will be described in a separate publication.

Display Diagnostic Program

A diagnostic or exerciser program for the digital display is considerably different from the usual peripheral exerciser. A low probability error in the transfer of digital quantities from core to display which would be completely unacceptable for most peripheral devices in most cases would only cause a flicker on the CRT. Diagnostics for a display should not look for low probability errors, but for gross hardware failures. The diagnostic included with the programs in this report is designed to allow an operator to try each mode of display operation for the particular data formats and data bits which he suspects may be faulty. He is aided by direct observation of display behaviour and by messages on the console typewriter.

Drawing Software

Many of the programs which make use of the graphical display as a communication device between operator and computer deal with line drawings. It is important to have available a set of subroutines which are capable of performing the functions basic to drawing. These routines are the pen, pencil, ink, ruler, eraser, protractor, etc., of the operator.

A programmer who is primarily concerned with routines to construct and manipulate three-dimensional drawings can make use of the drawing software. A second programmer who desires to construct waveforms for computer produced music may use the same set of drawing routines.

The programs and subroutines which are listed in Appendix 2 and described in the following paragraphs are an initial attempt to provide some of the basic drawing functions. Figure 2 illustrates in a schematic way how higher-level programs may depend on basic display programs which, in turn, communicate with the computer hardware.

The first program, SRAK, is a short subroutine (requiring only 8 words of memory) which reads the absolute value of two 10-bit shaft position encoders and returns this information to the calling program combined into one 24-bit word. The format of this shaft position encoder bits within the word is the same as that of the x and y coordinate components of a point-plotting display word.

TRAK is a subroutine which performs the same functions as SRAK, but uses a light pen (photoelectric light detector) and a tracking square on the CRT. The x and y coordinates of the tracking square on the CRT are returned to the calling program in the format of a 24-bit point-plotting display word. The tracking square may be moved about the CRT in any one of three ways. The calling program can specify the position of the square each time the program is called. The light pen can cause the tracking square to move about the face of the display tube using the interrupt routine contained in TRAK. Each time the TRAK subroutine is called the square is displayed twice, and each time the square is detected by the light pen, its position is incremented in a direction tending to center the square under the pen.

A third method is available for moving the tracking square. Each time the TRAK subroutine is called, it checks the x and y components of a word which is available external to the routine. If either x or y or both have been changed since the last call, the position of the square will be incremented in the direction of the detected change. If, for example, the word were to be filled by calling SRAK, then the tracking square would move according to the differential changes in the shaft position encoder values.

SKETCH is a routine for freehand two-dimensional drawing using point plotting only. SKETCH calls TRAK to obtain its input information. The patch traced by the

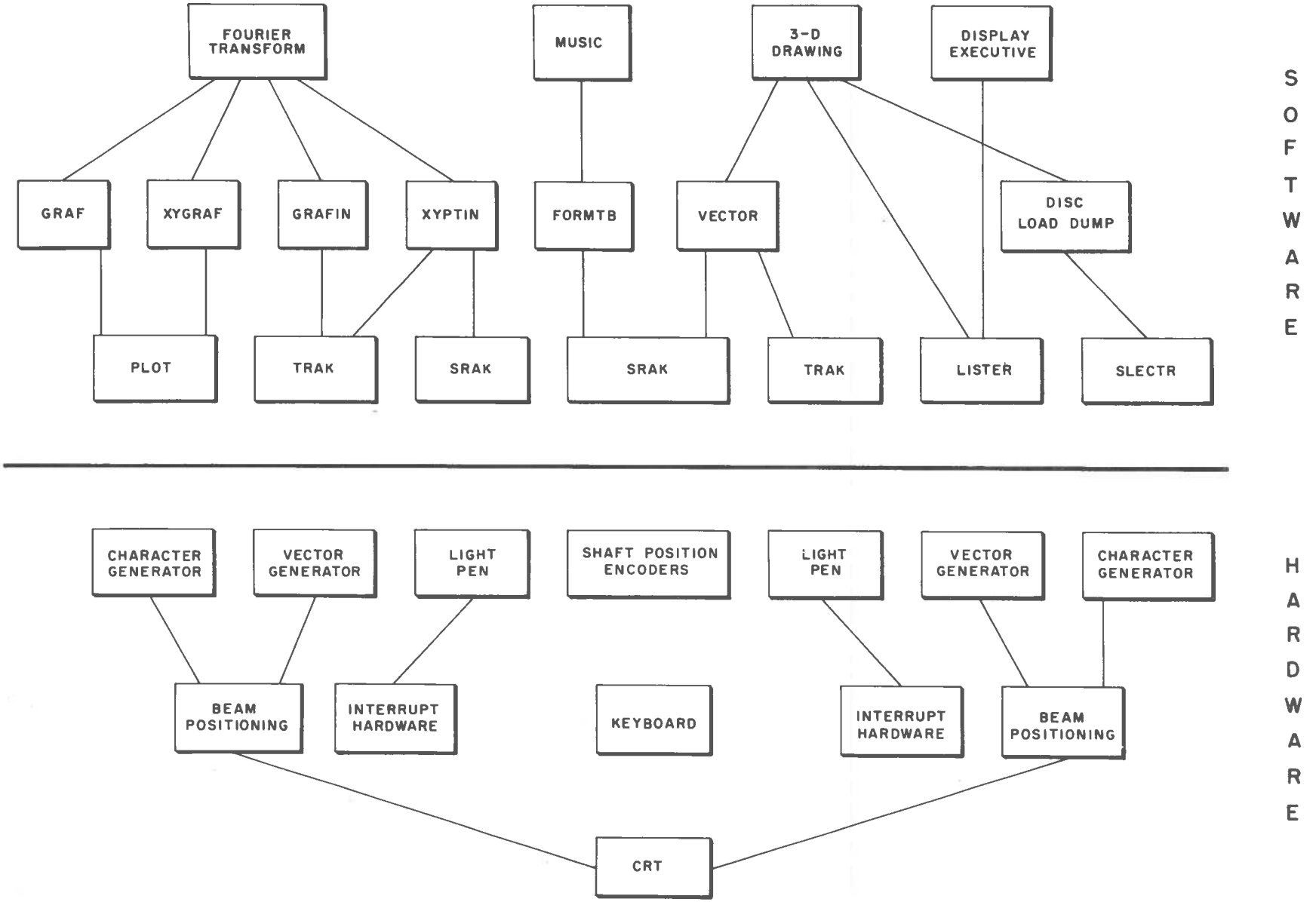

Fig. 2 Schematic illustration of levels of hierarchy of computer hardware and programs

tracking square is converted to a table of x and y values, which are in turn plotted on the CRT face. As more and more lines are added to the picture, the table expands. The functions of *erase*, *draw a line*, and *move the square without drawing a line* are selected by the user by depressing buttons on the display keyboard. SKETCH continually samples the keyboard and performs accordingly. Details of usage and the mechanism of operation can be obtained from the listing (catalog number 1021 Appendix 2).

VECTOR SKETCH is similar to SKETCH in that it constructs a table of display command and data words from the position of the tracking square and the contents of the display keyboard. It differs in that it allows the user to construct drawings with vectors as well as points. When a vector mode is chosen on the keyboard, a vector is drawn between the last point constructed and the current position of the tracking square. When the vector has been drawn to the user's satisfaction, the keyboard button is released and a new line can be added to the picture. Functions available by selecting keyboard buttons include: *add a point*, *add a vector*, *remove points and vectors*, and *erase whole drawing*. A table capable of holding 500 picture elements is included in the program.

VECTOR is a subroutine which performs all the functions of VECTOR SKETCH. In addition, the calling program can specify the position of the tracking square. Exit is controlled by a keyboard selection. VECTOR may also be used as an in-line routine, with entry address available externally to a standard linking loader.

DRAW is an example of an early attempt at graphical manipulation programming. The program branches to VECTOR to allow the user to position points and draw vectors. Exit from VECTOR removes the tracking square and leaves the user one of two choices. He may add points, lines, circular arcs, or parabolic arcs to his picture by appropriate keyboard choice. Alternatively, at any time he may ask for a list of modifying commands to be displayed on the CRT. Upon choosing one of these commands with the light pen he is again presented with his picture, and, by pointing the light pen, any element in the picture may be individually modified. Examples of commands which might be applied to a straight-line element are: LONGER, SHORTER, ROTATE CCW, BLANK, DELETE, MAKE HORIZONTAL, and INCREMENT X COMPONENT. In all, 32 commands are available. There are many obvious weaknesses in DRAW which have prompted changes in later programs. There is no feedback following the choice of a command so that wrong choices are frequently made. Spurious interrupts caused by electrostatic discharges into the light-pen electronics can cause changes to a drawing which are irreversible. No use is made of program directing routines such as LISTER or disc software such as D$STOR. Nevertheless, the program is of interest because it does point out such problems and because of the ability to modify individual picture elements under light-pen control.

Graphical Input and Output Programs

The set of subroutines which are listed in Appendix 3, under the names FORMTB, GRAFIN, XYPTIN, GRAF, and XYGRAF were written to enable the computer programmer to call standard subroutines for graphical input and output on the CRT display.

As an example, a FAST FOURIER TRANSFORM program which calls XYPTIN, GRAF, and XYGRAF , allows the user to create tables of complex numbers as input to the transform routine and to observe immediately various aspects of both the input and transformed functions in graphical form on the display. The programs make use of some of the more basic graphical subroutines such as TRAK and PLOT.

FORMTB is a graphical subroutine which uses the shaft position encoders as input devices. The contents of a table of 2^n points are displayed on the CRT and are continuously modifiable by manipulating the encoders. When the desired contents are achieved, control can be returned to the calling program by lowering a sense switch. The number of points in the table are specified by the calling program. FORMTB was written specifically to allow a user to construct waveforms for computer music programs.

GRAFIN is an early graphical input subroutine which calls TRAK and uses the light pen to draw a single-valued function of the form $y = f(x)$ on the CRT. Table size is fixed at 128 points. There are some operating problems associated with erasures and the tracking square 'bumping into' the maximum or minimum values of x or y. GRAFIN is included mainly for interest, but with the comment that it is neither as flexible nor as easy to use as FORMTB.

XYPTIN is a graphical input routine for filling tables of a dual function of a single variable. An example might be a complex function of a real variable of the form $x + iy = f(z)$ or $x = f_1(z)$, $y = f_2(z)$. When it is called, XYPTIN is given the starting address of each of the two tables to be filled as well as the number of points in the tables. The user is presented with a graph of y versus x with $x = 0$, $y = 0$ at the center of the screen. The absolute value of z is indicated by an octal number in the upper left corner of the screen; x and y are continuously variable and are determined by calls to TRAK. The light pen may therefore be used to position the square at the desired x and y values. z starts at zero and is incremented by pressing display keyboard buttons. The numbers stored in the tables each time z is incremented depend on which button is pressed. The values stored may be:

0,0 at $+z$, 0,0 at $-z$

x,y at $+z$, 0,0 at $-z$

x,y at $+z$, and $-z$

x,y at $+z$, and $-x$, $-y$ at $-z$

Backspace, *erasure*, and *exit to calling program* are also keyboard selectable functions. All points not filled are automatically set to 0,0. XYPTIN is particularly useful for defining symmetrical and asymmetrical input functions for Fourier transform routines. It is more useful for generating discontinuous functions than for continuous ones.

GRAF is a graphical output subroutine for single-valued functions of a single variable. Use is straightforward. The calling program provides the starting address and word count

of the table of values to be displayed. A scale factor which determines the 'vertical gain' of the display is also supplied by the calling program. While the table is displayed on the CRT as a graph, the display parameters may be modified by using the light pen and keyboard. Functions which would correspond to horizontal and vertical position and horizontal and vertical gain on an analog display are available. Return to the calling program is by keyboard selection.

XYGRAF is similar to GRAF with the exception that it displays a dual function of a single variable; i.e., $x = f_1(z)$, $y = f_2(z)$. z is indicated on the display by a bright spot which progresses slowly through the tabular values tracing out the curve for each value of z.

XYGRAF has the same display format as XYPTIN and is useful for displaying the output of a complex FOURIER TRANSFORM routine. Figure 3 is an illustration of the type of display produced by the graphical routines described above.

Interactive Control Routines

One of the basic requirements of an interactive or conversational program is an 'executive' or supervisory routine which accepts a user command and initiates the desired action. In the simple programs described above, commands are given by choosing keyboard functions, or by moving a light pen or shaft position encoders. A level of complexity is soon encountered, however, where the number of commands available to the operator is too large to be selected by any practical keyboard. A much more satisfactory method is to present the operator with a list of choices on the display, and allow him to select with the light pen the command he requires. This approach lends itself naturally to hierarchical structuring of the program. The first list presented should just indicate the broad area of interest. On making his choice, the user can then be given another list with more specific commands. After the second or third choice, commands are so specific that keyboard and light pen are quite practical for input devices.

Figure 4 is an example of a hierarchical structure based on graphical control routines. The first list is at a system executive or supervisory level which gives the user a choice of system support programs from which he chooses *load user programs from disc*. The second list is a number of user programs which are stored as named files on DISC. In this example a three-dimensional drawing program is selected. The third list (the highest level within the user program) offers choices of basic functions such as CLEAR and RESTART. RESTART is chosen, which calls the VECTOR subroutine and presents the user with a tracking square. Pressing a keyboard button selects the desired construction mode as *draw a vector*. Finally, the operator uses the light pen or shaft position encoders to put the vector end point exactly where he wants it in the picture.

The set of programs which will now be described perform some of the functions of presenting the operator with a list of choices and initiating action on the basis of the choice.

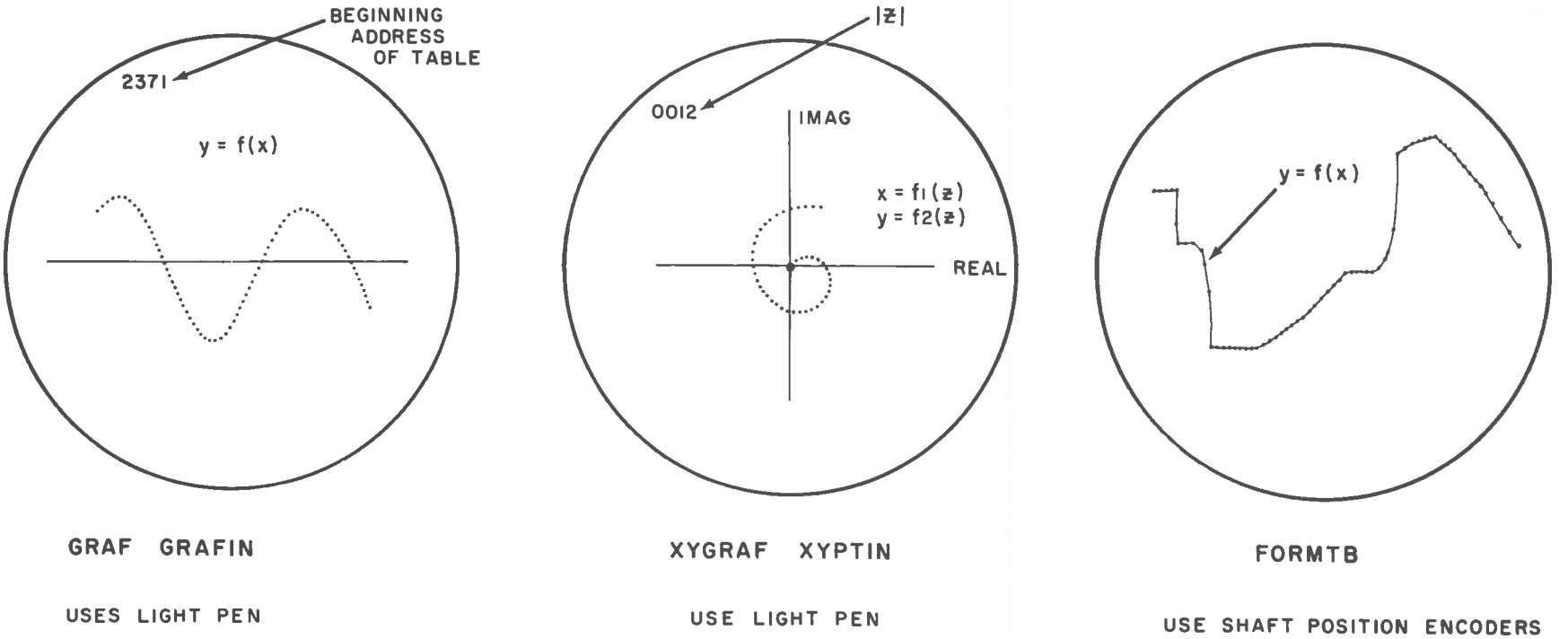

Fig. 3 Typical display formats for some of the graphical subroutines

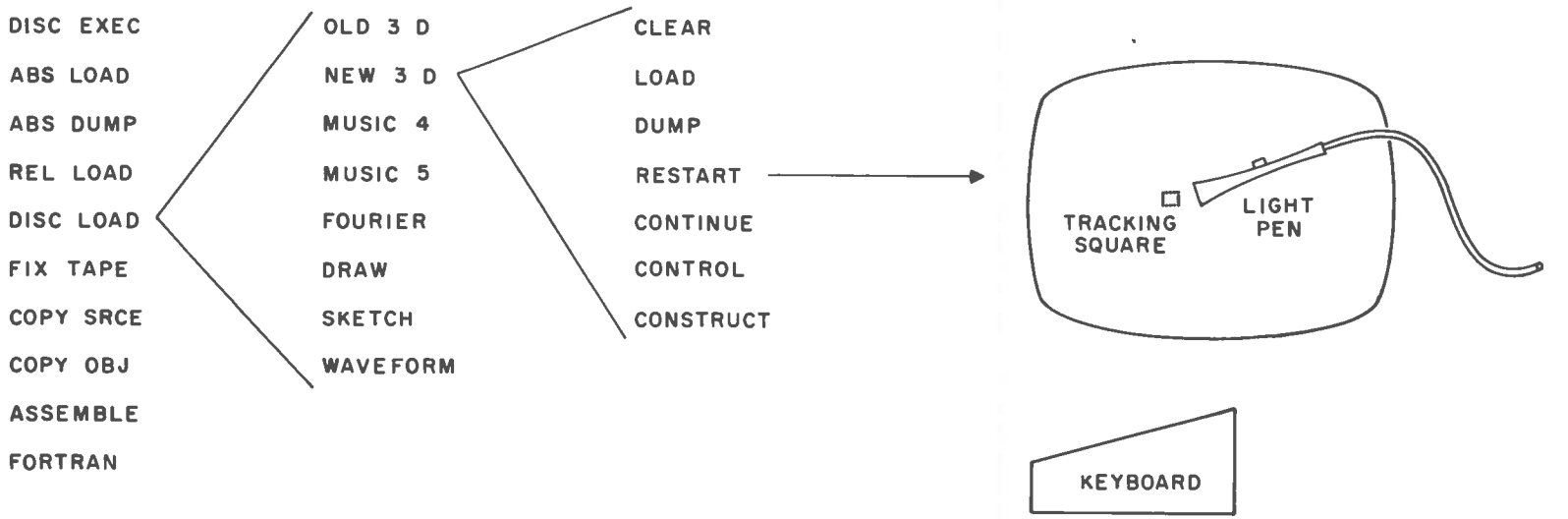

Fig. 4 An example of control of graphical routines using a hierarchy of commands

The simplest routine is POINTR. A call to POINTR results in a display of a list of names which are stored in Table I. If the light pen is pointed at a particular name, an interrupt is requested by the light pen. When the request is granted, program control will be transferred to an interrupt subroutine which changes the interrupt branch instruction to one corresponding to the chosen name. Control is then returned to the program which called POINTR. A subsequent light-pen interrupt will perform the selected function. The tables are external to the subroutine and must be linked by a linking loader. Table size is fixed at 32 names.

DIRECT differs from pointer only in that the addresses and size of the tables are supplied to the subroutine by the calling program. This allows flexible table size and simplifies linking.

SLECTR is considerably different from POINTR and DIRECT even though the display format is the same. A choice of a name by the light pen only causes that name to blink on and off in intensity. When any button on the display keyboard is depressed, control is returned to the calling program with the name selected in the A accumulator.

There is no program branching or jumping as a result of the use of SLECTR. In the interactive programming example described above, SLECTR would be used when loading a named file from disc. In this case the action required is independent of the choice – only the name is changed. The blinking feature of SLECTR provides feedback from the program to the operator – in effect asking him if the name chosen was indeed the one he wanted. This avoids problems caused by accidental interrupts due to electrostatic discharges.

The fourth subroutine used for interactive control is LISTER. LISTER has been made much more general by allowing the calling program to determine the type of action to be taken after a name has been selected. The program will branch to an interrupt routine as does DIRECT if desired. It will also execute any single instruction of which the most common is a branch to some other program – possibly another call to itself with a new list of names. The H version of LISTER adds further flexibility by allowing clearing, presetting, or saving of all volatile registers so that any program may be initiated by LISTER with any desired starting conditions. In the example given above, all steps other than that of loading from disc and the final drawing operation would be done with LISTER. A program which calls LISTER must supply the address of the name table and instruction table, the number of names in the table, and a flag indicating the mode of operation desired.

More details about each of the display support programs may be found in the appendices.

Acknowledgment

Many of the programs described in this report are based on standard system support programming supplied by Systems Engineering Laboratories Inc., the manufacturer of the 840A computer.

The author would like to acknowledge the help of his colleagues in the Data Systems Section during the preparation of this report.

Table of Contents for Program Listings

```
0001                                ********************************
0002                                *
0003                                *     DISPLAY  DIAGNOSTIC
0004                                *
0005  00000  01342100    STRT  SNS   1
0006  00001  01100000*          BRU   STRT
0007  00002  00100055*          LAA   KM1
0008  00003  01200000          SPB   $H$WR
0009  00004  00000000          DAC   $M18
0010  00005  00000010          DAC   8
0011  00006  00100055*          LAA   KM1
0012  00007  01200000          SPB   $H$WR
0013  00010  00000000          DAC   $M1
0014  00011  00000013          DAC   '13
0015  00012  00100055*          LAA   KM1
0016  00013  01200000          SPB   $H$WR
0017  00014  00000000          DAC   $M27
0018  00015  00000010          DAC   8
0019  00016  01310040          CEU   '40,W
0020  00017  00077777          DATA  '77777
0021  00020  00100055*          LAA   KM1
0022  00021  01200000          SPB   $H$WR
0023  00022  00000000          DAC   $M3
0024  00023  00000012          DAC   '12
0025                          CALL  NEXT
0026  00025  01100024*          BRU   *-1
0027  00026  01342100    STR2  SNS   1
0028  00027  01100000*          BRU   STRT
0029  00030  00100055*          LAA   KM1
0030  00031  01200000          SPB   $H$WR
0031  00032  00000000          DAC   $M4
0032  00033  00000012          DAC   '12
0033  00034  01310040          CEU   '40,W
0034  00035  00000000          DAC   0
0035                          CALL  NEXT
0036  00037  01100034*          BRU   *-3
0037  00040  01342100    STR3  SNS   1
0038  00041  01100000*          BRU   STRT
0039  00042  00100055*          LAA   KM1
0040  00043  01200000          SPB   $H$WR
0041  00044  00000000          DAC   $M5
0042  00045  00000014          DAC   '14
0043  00046  01310040          CEU   '40,W
0044  00047  00000251          DAC   '251
0045  00050  05700000          LCS
0046  00051  01710040          AOP   '40,W
0047                          CALL  NEXT
0048  00053  01100046*          BRU   *-5
0049  00054  01100056*          BRU   *&2
0050  00055  77777777    KM1   DATA  -1
0051  00056  01342100          SNS   1
0052  00057  01100000*          BRU   STRT
0053  00060  00100055*          LAA   KM1
0054  00061  01200000          SPB   $H$WR
```

```
0055  00062  00000000          DAC   $M6
0056  00063  00000015          DAC   '15
0057  00064  01310040          CEU   '40,W
0058  00065  00000251          DAC   '251
0059  00066  01750040          MOP   '40,W
0060  00067  20016000          DATA  '20016000
0061  00070  01310040    A3    CEU   '40,W
0062  00071  00001021          DAC   '1021
0063  00072  05700000          LCS
0064  00073  01710040          AOP   '40,W
0065                          CALL  NEXT
0066  00075  01100064*         BRU   A3-4
0067  00076  01342100          SNS   1
0068  00077  01100000*         BRU   STRT
0069  00100  00100055*         LAA   KM1
0070  00101  01200000          SPB   $H$WR
0071  00102  00000000          DAC   $M7
0072  00103  00000013          DAC   '13
0073  00104  01310040    A4    CEU   '40,W
0074  00105  00000251          DAC   '251
0075  00106  01750040          MOP   '40,W
0076  00107  00014000          DAC   '14000
0077  00110  01310040          CEU   '40,W
0078  00111  00001061          DAC   '1061
0079  00112  01750040          MOP   '40,W
0080  00113  37763776          DATA  '37763776
0081  00114  01310040          CEU   '40,W
0082  00115  00000011          DAC   '11
0083  00116  05700000          LCS
0084  00117  01710040          AOP   '40,W
0085                          CALL  NEXT
0086  00121  01100104*         BRU   A4
0087  00122  01342100          SNS   1
0088  00123  01100000*         BRU   STRT
0089  00124  00100055*         LAA   KM1
0090  00125  01200000          SPB   $H$WR
0091  00126  00000000          DAC   $M8
0092  00127  00000015          DAC   '15
0093  00130  01310040          CEU   '40,W
0094  00131  00000251    A5    DAC   '251
0095  00132  01750040          MOP   '40,W
0096  00133  20016000          DATA  '20016000
0097  00134  01310040          CEU   '40,W
0098  00135  00000701          DAC   '701
0099  00136  05700000          LCS
0100  00137  01710040          AOP   '40,W
0101                          CALL  NEXT
0102  00141  01100130*         BRU   A5-1
0103  00142  01342100          SNS   1
0104  00143  01100000*         BRU   STRT
0105  00144  00100055*         LAA   KM1
0106  00145  01200000          SPB   $H$WR
0107  00146  00000000          DAC   $M9
0108  00147  00000015          DAC   '15
```

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0109  00150  01310040          CEU   '40,W
0110  00151  00000251    A6    DAC   '251
0111  00152  01750040          MOP   '40,W
0112  00153  20016000          DATA  '20016000
0113  00154  01310040          CEU   '40,W
0114  00155  00000601          DAC   '601
0115  00156  05700000          LCS
0116  00157  01710040          AOP   '40,W
0117                           CALL  NEXT
0118  00161  01100150*         BRU   A6-1
0119  00162  01342100          SNS   1
0120  00163  01100000*         BRU   STRT
0121  00164  00100055*         LAA   KM1
0122  00165  01200000          SPB   $H$WR
0123  00166  00000000          DAC   $M10
0124  00167  00000016          DAC   '16
0125  00170  01310040    A7    CEU   '40,W
0126  00171  00000631          DAC   '631
0127  00172  05700000          LCS
0128  00173  01710040          AOP   '40,W
0129                           CALL  NEXT
0130  00175  01100170*         BRU   A7
0131  00176  01342100          SNS   1
0132  00177  01100000*         BRU   STRT
0133  00200  00100055*         LAA   KM1
0134  00201  01200000          SPB   $H$WR
0135  00202  00000000          DAC   $M11
0136  00203  00000014          DAC   '14
0137  00204  01310040    A8    CEU   '40,W
0138  00205  00000251          DAC   '251
0139  00206  01750040          MOP   '40,W
0140  00207  20016000          DATA  '20016000
0141  00210  01310040          CEU   '40,W
0142  00211  00001021          DAC   '1021
0143  00212  05700000          LCS
0144  00213  13200224*         LIX   KM4,1
0145  00214  01710040          AOP   '40,W
0146  00215  00000005          TAB
0147  00216  00014017          FLL   12
0148  00217  00000020          ASC
0149  00220  13400214*         IIB   *-4,1
0150                           CALL  NEXT
0151  00222  01100204*         BRU   A8
0152  00223  01100225*         BRU   *&2
0153  00224  77777774    KM4   DATA  -4
0154  00225  01342100          SNS   1
0155  00226  01100000*         BRU   STRT
0156  00227  00100055*         LAA   KM1
0157  00230  01200000          SPB   $H$WR
0158  00231  00000000          DAC   $M12
0159  00232  00000015          DAC   '15
0160  00233  01310040          CEU   '40,W
0161  00234  00000251    A9    DAC   '251
0162  00235  01750040          MOP   '40,W
```

```
0163  00236  20016000          DATA  '20016000
0164  00237  01310040          CEU   '40,W
0165  00240  00041021          DAC   '41021
0166  00241  05700000          LCS
0167  00242  03000366*         MOA   ='30000
0168  00243  13200224*         LIX   KM4,1
0169  00244  01710040          AOP   '40,W
0170  00245  00000005          TAB
0171  00246  00014017          FLL   12
0172  00247  00000020          ASC
0173  00250  13400244*         IIB   *-4,1
0174                           CALL  NEXT
0175  00252  01100233*         BRU   A9-1
0176  00253  01342100          SNS   1
0177  00254  01100000*         BRU   STRT
0178  00255  00100055*         LAA   KM1
0179  00256  01200000          SPB   $H$WR
0180  00257  00000000          DAC   $M13
0181  00260  00000013          DAC   '13
0182  00261  01310040          CEU   '40,W
0183  00262  00000251          DAC   '251
0184  00263  01750040          MOP   '40,W
0185  00264  00014000    A10   DAC   '14000
0186  00265  01310040          CEU   '40,W
0187  00266  00021021          DAC   '21021
0188  00267  05700000          LCS
0189  00270  01710040          AOP   '40,W
0190                           CALL  NEXT
0191  00272  01100261*         BRU   A10-3
0192  00273  01100307*         BRU   *&12
0193  00274  01200000    C011  SPB   $OUT
0194  00275  00000000    NEXT  ZZZ   **
0195  00276  01730043          AIP   '43,W
0196  00277  00022016          LSL   18
0197  00300  02200302*         BAZ   *&2
0198  00301  41100275*         BRU*  NEXT
0199  00302  01400275*         IMS   NEXT
0200  00303  01730043          AIP   '43,W
0201  00304  00022016          LSL   18
0202  00305  02200303*         BAZ   *-2
0203  00306  41100275*         BRU*  NEXT
0204  00307  00100055*         LAA   KM1
0205                           CALL  H$WR
0206  00311  00000000          DAC   $M50
0207  00312  00000014          DAC   '14
0208  00313  01310040          CEU   '40,W
0209  00314  00000076          DATA  '76
0210  00315  01310040          CEU   '40,W
0211  00316  00000256          DATA  '256
0212                           CALL  NEXT
0213  00320  01100313*         BRU   *-5
0214  00321  01342100          SNS   1
0215  00322  01100000*         BRU   STRT
0216  00323  00100055*         LAA   KM1
```

```
0217                                        CALL  H$WR
0218  00325  00000000                       DAC   $M51
0219  00326  00000010                       DAC   8
0220  00327  01730040                       AIP   '40,W
0221  00330  01310040                       CEU   '40,W
0222  00331  00000257                       DAC   '257
0223                                        CALL  NEXT
0224  00333  01100327*                      BRU   *-4
0225  00334  01342100                       SNS   1
0226  00335  01100000*                      BRU   STRT
0227  00336  00100055*                      LAA   KM1
0228                                        CALL  H$WR
0229  00340  00000000                       DAC   $M52
0230  00341  00000015                       DAC   13
0231  00342  01310040                       CEU   '40,W
0232  00343  03000000                       DATA  '3000000
0233  00344  00100365*                      LAA   SPB
0234  00345  00300106                       STA   '106
0235  00346  14300040                       PIE   '40,0
0236  00347  01100351*                      BRU   *&2
0237  00350  00000000              GO       ZZZ
0238  00351  13400352*                      IIB   *&1,1
0239  00352  05700000                       LCS
0240  00353  01310040                       CEU   '40,W
0241  00354  00050001                       DAC   '50001
0242  00355  01710040                       AOP   '40,W
0243  00356  03600357*                      PIR   *&1
0244  00357  00000360*                      DAC   *&1
0245  00360  01310040                       CEU   '40,W
0246  00361  00030000                       DAC   '30000
0247                                        CALL  NEXT
0248  00363  01100360*                      BRU   *-3
0249  00364  01110000                       BRU   '10000
0250  00365  01200350*              SPB      SPB   GO
0251                                        END
      00366  00030000
```

APPENDIX 2

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

Page 1 of 2 Catalog No. 1018

IDENTIFICATION: TRAK, SRAK

AUTHOR: J.K. Pulfer

ACCEPTED: June 1968

PURPOSE:

1. TRAK produces a light pen tracking square on the CRT display which can be positioned by the calling program, and returns its position to the calling program. The square can be moved by using the light pen, or by changing the value of the external location $ENCODE with some other input device such as the shaft position encoders.
2. SRAK loads the absolute position of the shaft position encoders and returns it to the calling program.

COMPUTER CONFIGURATION: 840A with display, and light pen or shaft position encoders.

SUBROUTINES REQUIRED: $ENCODE

STORAGE: TRAK - 156_8 SRAK - 10_8

TIMING:

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USE:

TRAK: Calling sequence

```
CALL TRACK
DATA POSITION
Return Here
```

During Call

If POSITION = all zeros, tracking square will remain at previous position.
If POSITION $\neq$ 0, square will be positioned to a "POSITION" on the CRT.

After Return

The incremental position of the tracking square (caused by either a light pen interrupt or a change in the contents of $ENCODE) will be returned to the calling program.

SRAK: Calling sequence

```
CALL SRAK
DATA POSITION
Return Here
```

The value of X and Y stored in the shaft position encoders will be OR'ed with intensity bits and returned to the calling program in "POSITION"

```
0001                          ******TRAK  A TRACKING SUBRT*********
0002          00000000              NAME  TRAK,TRAA
0003  00000   00000000    TRAA  ZZZ   **
0004  00001   00200131*            LBA   SPBM
0005  00002   00400105              STB   '105
0006  00003   14300020              PIE   '20,0
0007  00004   40100000*            LAA*  TRAA
0008  00005   02200010*            BAZ   STRT
0009  00006   03000156*            MOA   INTN
0010  00007   00300013*            STA   POS
0011  00010   01310040    STRT  CEU   '40,W
0012  00011   00000251              DAC   '251
0013  00012   01750040              MOP   '40,W
0014  00013   20016000    POS   DATA  '20016000
0015  00014   01310040              CEU   '40,W
0016  00015   00000011              DAC   '11
0017  00016   01750040              MOP   '40,W
0018  00017   01014000              DATA  '1014000
0019  00020   01310040              CEU   '40,W
0020  00021   00001061              DAC   '1061
0021  00022   01750040              MOP   '40,W
0022  00023   00006000              DATA  '6000
0023  00024   00100146*            LAA   KMX1
0024  00025   00300150*            STA   XFLG
0025  00026   03300151*            STI   YFLG,0
0026  00027   01750040              MOP   '40,W
0027  00030   20000000              DATA  '20000000
0028  00031   00100152*            LAA   KMY1
0029  00032   00300151*            STA   YFLG
0030  00033   03300150*            STI   XFLG,0
0031  00034   01750040              MOP   '40,W
0032  00035   00002000              DATA  '2000
0033  00036   00100153*            LAA   KPX1
0034  00037   00300150*            STA   XFLG
0035  00040   03300151*            STI   YFLG,0
0036  00041   01750040              MOP   '40,W
0037  00042   60000000              DATA  '60000000
0038  00043   00100155*            LAA   KPY4
0039  00044   00300151*            STA   YFLG
0040  00045   03300150*            STI   XFLG,0
0041  00046   00100147*            LAA   FLAG
0042  00047   00000020              ASC
0043  00050   00300147*            STA   FLAG
0044  00051   03500147*            SMP   FLAG
0045  00052   01100022*            BRU   POS&7
0046  00053   01310040    GO2   CEU   '40,W
0047  00054   00000251              DAC   '251
0048  00055   03300151*            STI   YFLG,0
0049  00056   00100013*            LAA   POS
0050  00057   40300000*            STA*  TRAA
0051  00060   00100000              LAA   $ENCODE
0052  00061   01500126*            CMA   TEM1
0053  00062   01100064*            BRU   *&2
0054  00063   01100124*            BRU   DONE
```

```
0055  00064  00300126*          STA   TEM1
0056  00065  02700154*          MAA   PMSK
0057  00066  00014014           FRL   12
0058  00067  00014015           RSL   12
0059  00070  01500127*          CMA   YPOS
0060  00071  01100076*          BRU   YLES
0061  00072  01100101*          BRU   XTES
0062  00073  00300127*          STA   YPOS
0063  00074  00100155*          LAA   KPY4
0064  00075  01200114*          SPB   EXIT
0065  00076  00300127*  YLES    STA   YPOS
0066  00077  00100152*          LAA   KMY1
0067  00100  01200114*          SPB   EXIT
0068  00101  00000004  XTES    TBA
0069  00102  000140I6           LSL   12
0070  00103  01500130*          CMA   XPOS
0071  00104  01100111*          BRU   XLES
0072  00105  01100124*          BRU   DONE
0073  00106  00300130*          STA   XPOS
0074  00107  00100153*          LAA   KPX1
0075  00110  01200114*          SPB   EXIT
0076  00111  00300130*  XLES    STA   XPOS
0077  00112  00100146*          LAA   KMX1
0078  00113  01100115*          BRU   *&2
0079  00114  00000000  EXIT    ZZZ   **
0080  00115  00300145*          STA   SAVE
0081  00116  00100013*          LAA   POS
0082  00117  02700154*          MAA   PMSK
0083  00120  00500145*          AMA   SAVE
0084  00121  02700154*          MAA   PMSK
0085  00122  03000156*          MOA   INTN
0086  00123  40300000*          STA*  TRAA
0087  00124  01400000*  DONE    IMS   TRAA
0088  00125  41100000*          BRU*  TRAA
0089  00126  00000000  TEM1    DATA  0
0090  00127  00000000  YPOS    ZZZ
0091  00130  00000000  XPOS    ZZZ
0092  00131  01200132*  SPBM    SPB   MOVE
0093  00132  00000000  MOVE    ZZZ   **
0094  00133  00300145*          STA   SAVE
0095  00134  00100013*          LAA   POS
0096  00135  02700154*          MAA   PMSK
0097  00136  00500150*          AMA   XFLG
0098  00137  00500151*          AMA   YFLG
0099  00140  02700154*          MAA   PMSK
0100  00141  03000156*          MOA   INTN
0101  00142  00300013*          STA   POS
0102  00143  00100145*          LAA   SAVE
0103  00144  03600132*          PIR   MOVE
0104  00145  00000000  SAVE    DAC   0
0105  00146  37740000  KMX1    DATA  *37740000
0106  00147  00000000  FLAG    DAC   0
0107  00150  00000000  XFLG    DAC   0
0108  00151  00000000  YFLG    DAC   0
```

```
0109  00152  00003774     KMY1 DATA '3774
0110  00153  00040000     KPX1 DATA '40000
0111  00154  37763777     PMSK DATA '37763777
0112  00155  00000004     KPY4 DATA 4
0113  00156  00014000     INTN DAC  '14000
0114                           END
EOJ
```

```
0001                     ***TRACKING SUBROUTINE
0002                     *
0003                     *  USING SHAFT POSITION
0004                     *
0005                     *  ENCODERS.
0006                     *
0007                     *  CALL SRAK
0008                     *  DATA POSITION
0009                     *
0010                     *
0011        00000000           NAME SRAK,TRAK
0012  00000 00000000     TRAK ZZZ  **
0013  00001 01310040          CEU  '40,W
0014  00002 00000006          DAC  6
0015  00003 01310040          CEU  '40,W
0016  00004 00000006          DAC  6
0017  00005 41770040          MIP* '40,W
0018  00006 40000000*         DAC* TRAK
0019  00007 01400000*          IMS  TRAK
0020  00010 41100000*          BRU* TRAK
0021                           END
EOJ
```

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PROGRAM DESCRIPTION

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IDENTIFICATION: SKETCH - a light pen sketching program

AUTHOR: J.K. Pulfer

ACCEPTED: 30 May 1968

PURPOSE: To allow a user to sketch freehand with a light pen on a CRT display. Only points are used.

COMPUTER CONFIGURATION: 840 A with NRC display

SUBROUTINES REQUIRED: TRAK, TBL

STORAGE: 56_8 + table size

TIMING: depends on size of picture

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USE: Use the light pen and keyboard as follows:

(1) Index finger on keyboard - erase all of picture previously drawn.

(2) Second finger on keyboard - hold down to leave a trail of points, lift to move light pen without leaving points.

(3) Third finger - press and release to brighten picture and remove flicker.

(4) Press and release second finger again before drawing to improve tracking speed.

```
0001                                *SKETCH 3 MAY 30/68**
0002  00000  01100005*                BRU  SKET
0003  00001  00100052*          ERAS  LAA  STRT
0004  00002  00300041*                STA  ADDR
0005  00003  00100053*                LAA  KM1
0006  00004  00300054*                STA  PCNT
0007  00005  13200054*          SKET  LIX  PCNT,1
0008  00006  01100011*                BRU  *&3
0009                                GO    CALL TRAK
0010  00010  20016000           POS   DATA '20016000
0011  00011  01310040                CEU  '40,W
0012  00012  00002251                DAC  '2251
0013  00013  13400040*               IIB  PLOT,1
0014  00014  01730043                AIP  '43,W
0015  00015  02700056*               MAA  ='77
0016  00016  02200026*               BAZ  MOD
0017  00017  00001015                RSL  1
0018  00020  02200001*               BAZ  ERAS
0019  00021  00001015                RSL  1
0020  00022  02200043*               BAZ  CHN1
0021  00023  00001015                RSL  1
0022  00024  02200046*               BAZ  CHN2
0023  00025  01100005*               BRU  SKET
0024  00026  00100010*          MOD  LAA  POS
0025  00027  42600041*               MEA* ADDR
0026  00030  02700055*               MAA  KMX1
0027  00031  02200005*               BAZ  SKET
0028  00032  01400041*          NEWP IMS  ADDR
0029  00033  00100053*               LAA  KM1
0030  00034  03100054*               AAM  PCNT
0031  00035  00100010*               LAA  POS
0032  00036  40300041*               STA* ADDR
0033  00037  01100005*               BRU  SKET
0034  00040  41750040           PLOT MOP* '40,W
0035  00041  10000000           ADDR DAC  $TBL,1
0036  00042  01100007*          DIRT BRU  GO
0037  00043  00100050*          CHN1 LAA  DIR1
0038  00044  00300042*               STA  DIRT
0039  00045  01100005*               BRU  SKET
0040  00046  00100051*          CHN2 LAA  DIR2
0041  00047  01100044*               BRU  *-3
0042  00050  01100007*          DIR1 BRU  GO
0043  00051  01100013*          DIR2 BRU  GO&4
0044  00052  10000000           STRT DAC  $TBL,1
0045  00053  77777777           KM1  DATA -1
0046  00054  77777777           PCNT DATA -1
0047  00055  37403740           KMX1 DATA '37403740
0048                                     END
      00056  00000077
```

```
0001          00000000      NAME TBL,T
0002  00000   20016000   T  DATA '20016000
0003          00001         BSS  2000
0004                        END
```

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PROGRAM DESCRIPTION

Page 1 of 3 Catalog No. 1032

IDENTIFICATION: VECTOR SKETCH - Program
VECTOR - Subroutine

AUTHOR: J.K. Pulfer

ACCEPTED: 2 July 1968

PURPOSE: These two programs--one a stand alone and one a versatile subroutine calling external tables--enable the user to draw line drawings with a light pen on the face of the CRT.

COMPUTER CONFIGURATION: NRC 840 A with display, keyboard and light pen

SUBROUTINES REQUIRED: TRAK (for both)
TRAK, ADR1, ADR2, PCNT, TBL1 and TBL2 for VECTOR

STORAGE: VECTOR SKETCH - 1365_8
VECTOR - 204_8 + subroutines

TIMING: Undefined

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USE:

1. VECTOR SKETCH

VECTOR SKETCH is a self contained drawing program with a table for 500_8 picture elements (vectors or points). USE as follows:

a) Start at lowest address loaded (eras
b) Press and release the keyboard ring finger (3)
c) Move the tracking square to new location
d) Press and release first finger to draw a vector, or
e) Press and release second finger to plot a point
f) Press and release thumb to backspace
g) Flip switch to upper case to erase.

2. VECTOR SUBROUTINE

This subroutine will behave as VECTOR SKETCH if used as a stand-alone program. The table and pointers must be separately loaded.

To Call as a subroutine, proceed as follows:

```
CALL VECTOR
DATA Position and Intensity for tracking square
DATA Exit Flag
NEXT INSTRUCTION
```

If EXIT FLAG IS POSITIVE, Control will stay with the subroutine until the keyboard is placed in upper case after which, control is returned to calling program.

IF EXIT FLAG IS NEGATIVE, two tracking squares will be produced and control will be returned to the calling program after each display of the table.

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USE: (cont'd)

Entry is also possible as follows:

```
BRU  $BVECTR
```

When keyboard is placed in upper case, the program branches to YVECT+1; i.e., to the first instruction of the program in core following VECTOR.

The tables can be initialized by starting the program at its first instruction.

```
0001                                ****VECTOR SKETCH*****
0002                                *   USE KEYBOARD AS FOLLOWS
0003                                *   1.....NEW VECTOR
0004                                *   2.....NEW POINT
0005                                *   3.....TRACKING MODE
0006                                *   4.....NON TRACKING MODE
0007                                *   5.....BACKSPACE
0008                                *   UPPER CASE ....ERASE
0009                                *
0010                                *
0011                                *    THE NUMBERS REFER TO THE FINGERS USED
0012  00000  00100146*   ERAS  LAA   STRT
0013  00001  00300132*         STA   ADDR
0014  00002  00100147*         LAA   STR2
0015  00003  00300130*         STA   ADD2
0016  00004  00100150*         LAA   KM1
0017  00005  00300151*         STA   PCNT
0018  00006  13200151*   SKET  LIX   PCNT,1
0019                      GO    CALL  TRAK
0020  00010  20016000    POS   DATA  '20016000
0021  00011  13400127*         IIB   PLOT,1
0022  00012  01730040          AIP   '40,W
0023  00013  02200031*         BAZ   MOD-1
0024  00014  00001015          RSL   1
0025  00015  02200100*         BAZ   NEWV
0026  00016  00001015          RSL   1
0027  00017  02200112*         BAZ   NEWP
0028  00020  00001015          RSL   1
0029  00021  02200137*         BAZ   CHN1
0030  00022  00001015          RSL   1
0031  00023  02200142*         BAZ   CHN2
0032  00024  00001015          RSL   1
0033  00025  02200067*         BAZ   BACK
0034  00026  00001015          RSL   1
0035  00027  02200000*         BAZ   ERAS
0036  00030  01100006*         BRU   SKET
0037  00031  03300152*         STI   FLAG,0
0038  00032  40100132*   MOD   LAA*  ADDR
0039  00033  01310040          CEU   '40,W
0040  00034  00000251          DAC   '251
0041  00035  01710040          AOP   '40,W
0042  00036  00000005          TAB
0043  00037  02700154*         MAA   XMSK
0044  00040  00014016          LSL   12
0045  00041  00300157*         STA   XOLD
0046  00042  00000004          TBA
0047  00043  02700161*         MAA   YMSK
0048  00044  00300160*         STA   YOLD
0049  00045  00100010*         LAA   POS
0050  00046  00000005          TAB
0051  00047  02700161*         MAA   YMSK
0052  00050  00600160*         SMA   YOLD
0053  00051  02000000          CNS
0054  00052  00300162*         STA   YVCT
```

```
0055  00053  00000004          TBA
0056  00054  02700154*         MAA   XMSK
0057  00055  00014016          LSL   12
0058  00056  00600157*         SMA   XOLD
0059  00057  02000000          CNS
0060  00060  00014015          RSL   12
0061  00061  03000162*         MOA   YVCT
0062  00062  01310040          CEU   '40,W
0063  00063  00001021    MID   DAC   '1021
0064  00064  01710040          AOP   '40,W
0065  00065  00300156*         STA   VECT
0066  00066  01100006*         BRU   SKET
0067  00067  03500152*   BACK  SMP   FLAG
0068  00070  01100006*         BRU   SKET
0069  00071  00100150*         LAA   KM1
0070  00072  00300152*         STA   FLAG
0071  00073  03100132*         AAM   ADDR
0072  00074  03100130*         AAM   ADD2
0073  00075  01400151*         IMS   PCNT
0074  00076  01100006*         BRU   SKET
0075  00077  01100116*         BRU   NEWP&4
0076  00100  03500152*   NEWV  SMP   FLAG
0077  00101  01100006*         BRU   SKET
0078  00102  01400132*         IMS   ADDR
0079  00103  01400130*         IMS   ADD2
0080  00104  00100150*         LAA   KM1
0081  00105  03100151*         AAM   PCNT
0082  00106  00100156*         LAA   VECT
0083  00107  40300132*         STA*  ADDR
0084  00110  00100063*         LAA   MID
0085  00111  40300130*         STA*  ADD2
0086  00112  03500152*   NEWP  SMP   FLAG
0087  00113  01100006*         BRU   SKET
0088  00114  00100150*         LAA   KM1
0089  00115  00300152*         STA   FLAG
0090  00116  01400132*         IMS   ADDR
0091  00117  01400130*         IMS   ADD2
0092  00120  00100150*         LAA   KM1
0093  00121  03100151*         AAM   PCNT
0094  00122  00100010*         LAA   POS
0095  00123  40300132*         STA*  ADDR
0096  00124  00100034*         LAA   MOD&2
0097  00125  40300130*         STA*  ADD2
0098  00126  01100006*         BRU   SKET
0099  00127  41310040    PLOT  CEU*  '40,W
0100  00130  10000664*   ADD2  DAC   TBL2,1
0101  00131  41750040          MOP*  '40,W
0102  00132  10000163*   ADDR  DAC   TBL,1
0103  00133  40100130*         LAA*  ADD2
0104  00134  00600664*         SMA   TBL2
0105  00135  02200011*         BAZ   POS&1
0106  00136  01100007*   DIRT  BRU   GO
0107  00137  00100144*   CHN1  LAA   DIR1
0108  00140  00300136*         STA   DIRT
```

```
0109  00141  01100006*        BRU   SKET
0110  00142  00100145*  CHN2  LAA   DIR2
0111  00143  01100140*        BRU   *-3
0112  00144  01100007*  DIR1  BRU   GO
0113  00145  01100011*  DIR2  BRU   GO&2
0114  00146  10000163*  STRT  DAC   TBL,1
0115  00147  10000664*  STR2  DAC   TBL2,1
0116  00150  77777777   KM1   DATA  -1
0117  00151  77777777   PCNT  DATA  -1
0118  00152  77777777   FLAG  DATA  -1
0119  00153  37003700   KMX1  DATA  '37003700
0120  00154  00003776   XMSK  DATA  '3776
0121  00155  00000000   POS2  DAC   0
0122  00156  00000000   VECT  DAC   0
0123  00157  00000000   XOLD  DAC   0
0124  00160  00000000   YOLD  DAC   0
0125  00161  77760000   YMSK  DATA  '77760000
0126  00162  00000000   YVCT  DATA  0
0127  00163  20016000   TBL   DATA  '20016000
0128         00164            BSS   '500
0129  00664  00000251   TBL2  DATA  '251
0130         00665            BSS   '500
0131                          END
EOJ
```

```
0001            00000014            NAME ERASE,ERAS
0002            00000001            NAME VECTOR,VECT
0003            00000025            NAME BVECTR,BVEC
0004                              *   USE KEYBOARD AS FOLLOWS
0005                              *   1.....NEW VECTOR
0006                              *   2.....NEW POINT
0007                              *   3.....TRACKING MODE
0008                              *   4.....NON TRACKING MODE
0009                              *   5.....BACKSPACE
0010                              *    UPPER CASE...EXIT
0011                              *
0012                              *
0013                              *    THE NUMBERS REFER TO THE FINGERS USED
0014  00000  01100014*              BRU  ERAS
0015  00001  00000000    VECT ZZZ  **  SUBROUTINE ENTRY/EXIT
0016  00002  40100001*              LAA* VECT
0017  00003  00300030*              STA  POS  BRING POSITION
0018  00004  01400001*              IMS  VECT
0019  00005  40100001*              LAA* VECT
0020  00006  00300175*              STA  EFLG     EXIT FLAG
0021  00007  01400001*              IMS  VECT
0022  00010  00100001*              LAA  VECT
0023  00011  03000174*              MOA  BAZ
0024  00012  00300050*              STA  MOD-3   ALTERNATE EXIT
0025  00013  01100025*              BRU  BVEC
0026  00014  00100167*    ERAS LAA  STRT
0027  00015  00300000              STA  $ADR2
0028  00016  00100170*              LAA  STR2
0029  00017  00300000              STA  $ADR1
0030  00020  00100171*              LAA  KM1
0031  00021  00300000              STA  $PCNT
0032  00022  23200176*    SKET LIX  SAVI,2
0033  00023  03500175*              SMP  EFLG
0034  00024  41100001*              BRU* VECT
0035  00025  23300176*    BVEC STI  SAVI,2
0036  00026  23200000              LIX  $PCNT,2
0037                       GO     CALL TRAK
0038  00030  20016000     POS    DATA '20016000
0039  00031  23400150*              IIB  PLOT,2
0040  00032  01730043              AIP  '43,W
0041  00033  02700200*              MAA  SEVN
0042  00034  02200052*              BAZ  MOD-1
0043  00035  00001015              RSL  1
0044  00036  02200121*              BAZ  NEWV
0045  00037  00001015              RSL  1
0046  00040  02200133*              BAZ  NEWP
0047  00041  00001015              RSL  1
0048  00042  02200160*              BAZ  CHN1
0049  00043  00001015              RSL  1
0050  00044  02200163*              BAZ  CHN2
0051  00045  00001015              RSL  1
0052  00046  02200110*              BAZ  BACK
0053  00047  00001015              RSL  1
0054  00050  02200207*              BAZ  YVCT&1
```

```
0055  00051  01100022*        BRU   SKET
0056  00052  03300172*        STI   FLAG,0
0057  00053  40100000  MOD   LAA*  $ADR2
0058  00054  01310040        CEU   '40,W
0059  00055  00000251        DAC   '251
0060  00056  01710040        AOP   '40,W
0061  00057  00000005        TAB
0062  00060  02700177*        MAA   XMSK
0063  00061  00014016        LSL   12
0064  00062  00300203*        STA   XOLD
0065  00063  00000004        TBA
0066  00064  02700205*        MAA   YMSK
0067  00065  00300204*        STA   YOLD
0068  00066  00100030*        LAA   POS
0069  00067  00000005        TAB
0070  00070  02700205*        MAA   YMSK
0071  00071  00600204*        SMA   YOLD
0072  00072  02000000        CNS
0073  00073  00300206*        STA   YVCT
0074  00074  00000004        TBA
0075  00075  02700177*        MAA   XMSK
0076  00076  00014016        LSL   12
0077  00077  00600203*        SMA   XOLD
0078  00100  02000000        CNS
0079  00101  00014015        RSL   12
0080  00102  03000206*        MDA   YVCT
0081  00103  01310040        CEU   '40,W
0082  00104  00001021  MID   DAC   '1021
0083  00105  01710040        AOP   '40,W
0084  00106  00300202*        STA   VCT
0085  00107  01100022*        BRU   SKET
0086  00110  03500172*  BACK  SMP   FLAG
0087  00111  01100022*        BRU   SKET
0088  00112  00100171*        LAA   KM1
0089  00113  00300172*        STA   FLAG
0090  00114  03100000        AAM   $ADR2
0091  00115  03100000        AAM   $ADR1
0092  00116  01400000        IMS   $PCNT
0093  00117  01100022*        BRU   SKET
0094  00120  01100137*        BRU   NEWP&4
0095  00121  03500172*  NEWV  SMP   FLAG
0096  00122  01100022*        BRU   SKET
0097  00123  01400000        IMS   $ADR2
0098  00124  01400000        IMS   $ADR1
0099  00125  00100171*        LAA   KM1
0100  00126  03100000        AAM   $PCNT
0101  00127  00100202*        LAA   VCT
0102  00130  40300000        STA*  $ADR2
0103  00131  00100104*        LAA   MID
0104  00132  40300000        STA*  $ADR1
0105  00133  03500172*  NEWP  SMP   FLAG
0106  00134  01100022*        BRU   SKET
0107  00135  00100171*        LAA   KM1
0108  00136  00300172*        STA   FLAG
```

```
0109  00137  01400000          IMS   $ADR2
0110  00140  01400000          IMS   $ADR1
0111  00141  00100171*         LAA   KM1
0112  00142  03100000          AAM   $PCNT
0113  00143  00100030*         LAA   POS
0114  00144  40300000          STA*  $ADR2
0115  00145  00100055*         LAA   MOD&2
0116  00146  40300000          STA*  $ADR1
0117  00147  01100022*         BRU   SKET
0118  00150  41310040    PLOT  CEU*  '40,W
0119  00151  40000000          DAC*  $ADR1
0120  00152  41750040          MOP*  '40,W
0121  00153  40000000          DAC*  $ADR2
0122  00154  40100000          LAA*  $ADR1
0123  00155  00600000          SMA   $TBL1
0124  00156  02200031*         BAZ   POS&1
0125  00157  01100027*   DIRT  BRU   GO
0126  00160  00100165*  CHN1  LAA   DIR1
0127  00161  00300157*         STA   DIRT
0128  00162  01100022*         BRU   SKET
0129  00163  00100166*  CHN2  LAA   DIR2
0130  00164  01100161*         BRU   *-3
0131  00165  01100027*  DIR1  BRU   GO
0132  00166  01100031*  DIR2  BRU   GO&2
0133  00167  20000000    STRT  DAC   $TBL2,2
0134  00170  20000000    STR2  DAC   $TBL1,2
0135  00171  77777777    KM1   DATA  -1
0136  00172  77777777    FLAG  DATA  -1
0137  00173  37003700    KMX1  DATA  '37003700
0138  00174  02200000    BAZ   BAZ   0
0139  00175  00000000    EFLG  DAC   0
0140  00176  00000000    SAVI  DAC   0
0141  00177  00003776    XMSK  DATA  '3776
0142  00200  00000077    SEVN  DAC   '77
0143  00201  00000000    POS2  DAC   0
0144  00202  00000000    VCT   DAC   0
0145  00203  00000000    XOLD  DAC   0
0146  00204  00000000    YOLD  DAC   0
0147  00205  77760000    YMSK  DATA  '77760000
0148  00206  00000000    YVCT  DATA  0
0149                            END
```

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

Page 1 of 2 Catalog No. 1007

IDENTIFICATION: DRAW

AUTHOR: J.K. Pulfer

ACCEPTED: July 1968

PURPOSE: To allow the user to construct pictures and produce machine-language programs using the vector, circle, and parabola generating functions of the display hardware. Interrupt modification of single picture elements is provided.

COMPUTER CONFIGURATION: 840 A with NRC Display

SUBROUTINES REQUIRED: VECTOR, TRAK, ADR1, ADR2, PCNT, TBL1, TBL2

STORAGE: 1043_8

TIMING: Depends on picture produced

DATA SYSTEMS PROGRAM LIBRARY

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USE: (1) Load program and execute

(2) Construct pts and vectors using VECTOR subroutine
Exit by switching to upper case

(3) To modify the picture elements, go to lower case and press any key. The list of possible modifications should appear. Select the desired type of modification with the light pen. The table should disappear and picture reappear. Select the desired element with the light pen and the modification will take place. Continue to modify as desired. The list is obtained by pressing any key.
To produce new picture elements, go to upper case and continue to (4), or select SKETCH OR TRAK and return to (2) above.

(4) Generate picture elements as follows:

first finger - vectors
second finger - circular arcs
third finger - new points
fourth finger - hyperbolic arcs

```
                       *****************************************
                       *    DRAW
                       *    CALLS BVECTR AND TABLES  ***
00000  01100325*            BRU   INIT
00001  01100315*            BRU   ERAS
00002  14300020             PIE   '20,0
00003  13200023*       LIST LIX   KM32,1
00004  00100025*            LAA   MSK1
00005  01310040             CEU   '40,W
00006  00000251             DAC   '251
00007  01710040             AOP   '40,W
00010  00500024*            AMA   KP64
00011  01310040             CEU   '40,W
00012  00000701             DAC   '701
00013  41750040             MOP*  '40,W
00014  11100066*            BRU   TAL1,1
00015  00200171*            LBA   DDD
00016  00400105             STB   '105
00017  41750040             MOP*  '40,W
00020  11100127*            BRU   TAL2,1
00021  13400005*            IIB   *-12,1
00022  01100003*            BRU   LIST
00023  77777740        KM32 DATA  '-40
00024  00000100        KP64 DATA  '100
00025  00014000        MSK1 DATA  '00014000
00026  02140113             DATA  ''BLAKSKETTRAKDAMMINT ABS RELO    ''
00027  23130524
00030  24220113
00031  04011515
00032  11162440
00033  01022340
00034  22051417
00035  40404040
00036  03172031             DATA  ''COPYBRIGDELEERAS    VERTHORIINCR''
00037  02221107
00040  04051405
00041  05220123
00042  40404040
00043  26052224
00044  10172211
00045  11160322
00046  11160322             DATA  ''INCRDECRDECR90 DNEGAREFL        ''
00047  04050322
00050  04050322
00051  71604004
00052  16050701
00053  22050614
00054  40404040
00055  40404040
00056  22172401             DATA  ''ROTAROTASMALBIGGSHORLONG        ''
00057  22172401
00060  23150114
00061  02110707
00062  23101722
```

```
        00063  14171607
        00064  40404040
        00065  40404040
0030    00066  13404056    TAL1 DATA ''K  .CH .K   .   .DUMPDUMPAD .   .''
        00067  03104056
        00070  13404040
        00071  56404040
        00072  56042515
        00073  20042515
        00074  20010440
        00075  56404040
        00076  56404040
0031    00077  40404056         DATA ''   .HTENTE .E  .   .   .Z  . X .''
        00100  10240516
        00101  24054056
        00102  05404056
        00103  40404056
        00104  40404056
        00105  32404056
        00106  40304056
0032    00107  40314056         DATA '' Y . X . Y .EG .TE .ECT.   .   .''
        00110  40304056
        00111  40314056
        00112  05074056
        00113  24054056
        00114  05032456
        00115  40404056
        00116  40404056
0033    00117  24054014         DATA ''TE LTE RLER.ER .TER.ER .   .   .''
        00120  24054022
        00121  14052256
        00122  05224056
        00123  24052256
        00124  05224056
        00125  40404056
        00126  40404056
0034    00127  00000000    TAL2 DAC  0
0035    00130  01201025*   I    SPB  INI
0036    00131  01201035*   J    SPB  INJ
0037    00132  01200741*   W    SPB  INW
0038    00133  01200677*   K    SPB  INK
0039    00134  01201001*   R    SPB  INR
0040    00135  01200712*   P    SPB  INP
0041    00136  01200773*   M    SPB  INRL
0042    00137  01200361*   O    SPB  INO
0043    00140  01200634*   A    SPB  INA
0044    00141  01200371*   B    SPB  INB
0045    00142  01200404*   D    SPB  IND
0046    00143  01200365*   E    SPB  INE
0047    00144  01200361*   Q    SPB  INO
0048    00145  01200420*   V    SPB  INV
0049    00146  01200412*   H    SPB  INH
0050    00147  01200427*   X    SPB  INX
0051    00150  01200436*   Y    SPB  INY
```

```
0052  00151  01200723*  U      SPB   INU
0053  00152  01200732*  Z37    SPB   INZ7
0054  00153  01200622*  T      SPB   INT
0055  00154  01200454*  N      SPB   INN
0056  00155  01200445*  C      SPB   INC
0057  00156  01200361*  Z      SPB   INO
0058  00157  01200361*  Z33    SPB   INO
0059  00160  01200577*  G      SPB   ING
0060  00161  01200611*  F      SPB   INF
0061  00162  01200763*  Z34    SPB   INSM
0062  00163  01200753*  Z35    SPB   INBI
0063  00164  01200652*  S      SPB   INS
0064  00165  01200641*  L      SPB   INL
0065  00166  01200361*  Z36    SPB   INO
0066  00167  00000022    TBL3   NOP
0067  00170  00000022           NOP
0068  00171  01200172*  DDD    SPB   IDD
0069  00172  00000000    IDD    ZZZ   **
0070  00173  00200207*           LBA   RTRN
0071  00174  00400172*           STB   IDD
0072  00175  10200167*           LBA   TBL3,1
0073  00176  00400105           STB   '105
0074  00177  03600172*           PIR   IDD
0075  00200  01100315*  DRAW   BRU   ERAS
0076  00201  01100325*           BRU   INIT
0077  00202  21100000    STR1   BRU   $TBL1,2
0078  00203  21100000    STR2   BRU   $TBL2,2
0079  00204  77777777    FLAG   DATA  '-1
0080  00205  00000040    KP40   DAC&  '40
0081  00206  77777777    KM1    DATA& '-1
0082  00207  01100325*   RTRN   BRU   INIT
0083  00210  01100352*   BGIN   BRU   GO-1
0084  00211  00000000    FINI   DAC   $PCNT
0085  00212  00000001    KP1    DAC   1
0086  00213  00017601    PUNC   DAC   '17601
0087  00214  00000000    LMSK   DAC   0
0088  00215  00000022    CTBL   NOP
0089  00216  00001021    CA     DATA  '1021
0090  00217  00041021    CB     DATA  '41021
0091  00220  00000000    CC     DAC   0
0092  00221  00000251    CD     DAC   '251
0093  00222  00000000    CE     DAC   0
0094  00223  00000000    CF     DAC   0
0095  00224  00000000    CG     DAC   0
0096  00225  00021021    CH     DATA  '21021
0097  00226  00000000    CI     DAC   0
0098  00227  00000000    CJ     DAC   0
0099  00230  00000000    CK     DAC   0
0100  00231  00000000    CL     DAC   0
0101  00232  00000000    CM     DAC   0
0102  00233  00000000    CN     DAC   0
0103  00234  00000000    CO     DAC   0
0104  00235  00001061    CP     DATA  '1061
0105  00236  00000000    CQ     DAC   0
```

```
0106  00237  00000000  CR    DAC   0
0107  00240  00000000  CS    DAC   0
0108  00241  00000000  CT    DAC   0
0109  00242  00000000  CU    DAC   0
0110  00243  00000000  CV    DAC   0
0111  00244  00000000  CW    DAC   0
0112  00245  00000000  CX    DAC   0
0113  00246  00000000  CY    DAC   0
0114  00247  00000000  CZ    DAC   0
0115  00250  00000000  CZ33  DAC   0
0116  00251  00000000  CZ34  DAC   0
0117  00252  00000000  CZ35  DAC   0
0118  00253  00000000  CZ36  DAC   0
0119  00254  00000000  CZ37  DAC   0
0120  00255  00000022  DTBL  NOP
0121  00256  02010200  DA    DATA  '02010200
0122  00257  02010000  DB    DATA  '02010000
0123  00260  02010200  DC    DATA  '02010200
0124  00261  01015000  DD    DATA  '01015000
0125  00262  00000000  DE    DAC   0
0126  00263  40162203  DF    DATA  '40162203
0127  00264  00000000  DG    DAC   0
0128  00265  00010201  DH    DATA  '00010201
0129  00266  00000000  DI    DAC   0
0130  00267  00000000  DJ    DAC   0
0131  00270  02016001  DK    DATA  '02016001
0132  00271  00000000  DL    DAC   0
0133  00272  00000000  DM    DAC   0
0134  00273  00000000  DN    DAC   0
0135  00274  00000000  DO    DAC   0
0136  00275  10001000  DP    DATA  '10001000
0137  00276  00000000  DQ    DAC   0
0138  00277  00000000  DR    DAC   0
0139  00300  00000000  DS    DAC   0
0140  00301  00000000  DT    DAC   0
0141  00302  00000000  DU    DAC   0
0142  00303  02000200  DV    DATA  '02000200
0143  00304  00000000  DW    DAC   0
0144  00305  00000000  DX    DAC   0
0145  00306  00000000  DY    DAC   0
0146  00307  00000000  DZ    DAC   0
0147  00310  00000000  DZ33  DAC   0
0148  00311  00000000  DZ34  DAC   0
0149  00312  00000000  DZ35  DAC   0
0150  00313  00000000  DZ36  DAC   0
0151  00314  00000000  DZ37  DAC   0
0152  00315  00100202*  ERAS  LAA   STR1
0153  00316  00300000        STA   $ADR1
0154  00317  00100203*        LAA   STR2
0155  00320  00300000        STA   $ADR2
0156  00321  00100206*        LAA   KM1
0157  00322  00300000        STA   $PCNT
0158  00323  00100207*        LAA   RTRN
0159  00324  00300360*        STA   BRNC
```

```
0160  00325  14300020   INIT PIE  '20,0
0161  00326  01730043        AIP  '43,W
0162  00327  02701043*       MAA  ='77
0163  00330  02200003*       BAZ  LIST
0164  00331  10000001        TAI  ,1
0165  00332  00600205*       SMA  KP40
0166  00333  02200342*       BAZ  BFLG
0167  00334  02400336*       BAP  NEW
0168  00335  01100344*       BRU  STRT
0169  00336  10000001   NEW  TAI  ,1
0170  00337  01200477*       SPB  GETN
0171  00340  01200505*       SPB  PUTN
0172  00341  01100344*  RTRX BRU  STRT
0173  00342  00100205*  BFLG LAA  KP40
0174  00343  00300204*       STA  FLAG
0175  00344  00100705*  STRT LAA  KM2C
0176  00345  00300706*       STA  BOX
0177  00346  01400706*       IMS  BOX
0178  00347  01100346*       BRU  *-1
0179  00350  23200000        LIX  $PCNT,2
0180  00351  23400353*       IIB  *&2,2
0181  00352  01100325*       BRU  INIT
0182  00353  41310040   GO   CEU* '40,W
0183  00354  40000000        DAC* $ADR1
0184  00355  41750040        MOP* '40,W
0185  00356  40000000        DAC* $ADR2
0186  00357  01100351*       BRU  GO-2
0187  00360  01100325*  BRNC BRU  INIT
0188  00361  00000000   INO  ZZZ  **  BELL
0189  00362  01750001        MOP  1,W
0190  00363  41600000        DATA '41600000
0191  00364  03600361*       PIR  INO
0192  00365  00000000   INE  ZZZ  **    ERASE  WHOLE PICTURE
0193  00366  00200200*       LBA  DRAW
0194  00367  00400365*       STB  INE
0195  00370  03600365*       PIR  INE
0196  00371  00000000   INB  ZZZ  **        BLANK PT OR CHAR
0197  00372  00300400*       STA  SAV1
0198  00373  00100000        LAA  $KINT
0199  00374  03000403*       MOA  BMSK
0200  00375  00300000        STA  $KINT
0201  00376  00100400*       LAA  SAV1
0202  00377  03600371*       PIR  INB
0203  00400  00000000   SAV1 DAC  0
0204  00401  00000000   SAV2 DAC  0
0205  00402  00000000   SAV3 DAC  0
0206  00403  00016000   BMSK DATA '00016000
0207  00404  00000000   IND  ZZZ  **        DELETE ITEM
0208  00405  01200464*       SPB  GETC
0209  00406  00000003        CLA
0210  00407  00000005        TAB
0211  00410  01200524*       SPB  PUTC
0212  00411  03600404*       PIR  IND
0213  00412  00000000   INH  ZZZ  **      MAKE  HORIZ
```

```
0214  00413  01200464*          SPB   GETC
0215  00414  02700417*          MAA   HMSK
0216  00415  01200530*          SPB   PUTD
0217  00416  03600412*          PIR   INH
0218  00417  77774001    HMSK   DATA  '77774001
0219  00420  00000000    INV    ZZZ   **      MAKE VERT
0220  00421  01200464*          SPB   GETC
0221  00422  02700426*          MAA   VMSK
0222  00423  01200530*          SPB   PUTD
0223  00424  03600420*          PIR   INV
0224  00425  00000022          NOP
0225  00426  40017777    VMSK   DATA  '40017777
0226  00427  00000000    INX    ZZZ   **      INCREMENT X
0227  00430  01200464*          SPB   GETC
0228  00431  00001014          FRL   1
0229  00432  00500707*          AMA   LMSP
0230  00433  00057014          FRL   47
0231  00434  01200530*          SPB   PUTD
0232  00435  03600427*          PIR   INX
0233  00436  00000000    INY    ZZZ   **      INCREMENT Y
0234  00437  01200464*          SPB   GETC
0235  00440  00015014          FRL   13
0236  00441  00500707*          AMA   LMSP
0237  00442  00043014          FRL   35
0238  00443  01200530*          SPB   PUTD
0239  00444  03600436*          PIR   INY
0240  00445  00000000    INC    ZZZ   **      CONJUGATE
0241  00446  01200464*          SPB   GETC
0242  00447  00014014          FRL   12
0243  00450  00000020          ASC
0244  00451  00044014          FRL   36
0245  00452  01200530*          SPB   PUTD
0246  00453  03600445*          PIR   INC
0247  00454  00000000    INN    ZZZ   **      NEGATE
0248  00455  01200464*          SPB   GETC
0249  00456  00000020          ASC
0250  00457  00014014          FRL   12
0251  00460  00000020          ASC
0252  00461  00044014          FRL   36
0253  00462  01200530*          SPB   PUTD
0254  00463  03600454*          PIR   INN
0255  00464  00000000    GETC   ZZZ   **
0256  00465  00300400*          STA   SAV1
0257  00466  00100000          LAA   $ADR1
0258  00467  00500206*          AMA   KM1
0259  00470  00300402*          STA   SAV3
0260  00471  40200402*          LBA*  SAV3
0261  00472  00100000          LAA   $ADR2
0262  00473  00500206*          AMA   KM1
0263  00474  00300401*          STA   SAV2
0264  00475  40100401*          LAA*  SAV2
0265  00476  41100464*          BRU*  GETC
0266  00477  00000000    GETN   ZZZ   **
0267  00500  03500204*          SMP   FLAG
```

```
0268  00501  01100344*          BRU  STRT
0269  00502  10200215*          LBA  CTBL,1
0270  00503  10100255*          LAA& DTBL,1
0271  00504  41100477*          BRU* GETN
0272  00505  00000000  PUTN ZZZ  **   PUT NEW COMM DAT IN PROG
0273  00506  03500204*          SMP  FLAG
0274  00507  41100505*          BRU* PUTN
0275  00510  13300401*          STI  SAV2,1
0276  00511  13200000          LIX  $ADR1,1
0277  00512  10400000          STB  0,1
0278  00513  13200000          LIX  $ADR2,1
0279  00514  10300000          STA  0,1
0280  00515  13200401*          LIX  SAV2,1
0281  00516  01400000          IMS  $ADR1
0282  00517  01400000          IMS  $ADR2
0283  00520  00100206*          LAA  KM1
0284  00521  03100000          AAM  $PCNT
0285  00522  00300204*          STA  FLAG
0286  00523  41100505*          BRU* PUTN
0287  00524  00000000  PUTC ZZZ  **  RESTORE COMM
0288  00525  40400402*          STB* SAV3
0289  00526  00100400*          LAA  SAV1
0290  00527  41100524*          BRU* PUTC
0291  00530  00000000  PUTD ZZZ  **  RESTORE  DATA
0292  00531  40300401*          STA* SAV2
0293  00532  00100400*          LAA  SAV1
0294  00533  41100530*          BRU* PUTD
0295  00534  00000000  CNSY ZZZ  **   CHANGE NO SYSTEM
0296  00535  00000006          IAB
0297  00536  00014017          FLL  12
0298  00537  00014016          LSL  12
0299  00540  02000000          CNS
0300  00541  00000006          IAB
0301  00542  02000000          CNS
0302  00543  00000006          IAB
0303  00544  00014014          FRL  12
0304  00545  00014016          LSL  12
0305  00546  00014014          FRL  12
0306  00547  00000006          IAB
0307  00550  41100534*          BRU* CNSY
0308  00551  00000000  RTAT ZZZ  **
0309  00552  00200710*          LBA  LMSN
0310  00553  00400214*          STB  LMSK
0311  00554  00200707*          LBA  LMSP
0312  00555  03500610*          SMP  RFLG
0313  00556  00400214*          STB  LMSK
0314  00557  02400567*          BAP  FG
0315  00560  00014014          FRL  12
0316  00561  00600214*          SMA  LMSK
0317  00562  02400573*          BAP  CGZ
0318  00563  00000006     DGZ  IAB
0319  00564  00014014          FRL  12
0320  00565  00500214*          AMA  LMSK
0321  00566  01100576*          BRU& EG
```

```
0322  00567  00014014     FG    FRL   12
0323  00570  00500214*          AMA&  LMSK
0324  00571  02400573*          BAP   CGZ
0325  00572  01100563*          BRU   DGZ
0326  00573  00000006     CGZ   IAB
0327  00574  00014014          FRL   12
0328  00575  00600214*          SMA   LMSK
0329  00576  41100551*     EG   BRU*  RTAT
0330  00577  00000000     ING   ZZZ   **
0331  00600  00200206*          LBA   KM1
0332  00601  00400610*          STB   RFLG
0333  00602  01200464*          SPB   GETC
0334  00603  01200534*          SPB   CNSY
0335  00604  01200551*          SPB   RTAT
0336  00605  01200534*          SPB   CNSY
0337  00606  01200530*          SPB   PUTD
0338  00607  03600577*          PIR   ING
0339  00610  00000000     RFLG  DAC   0
0340  00611  00000000     INF   ZZZ   **    ROTATE RIGHT
0341  00612  00200212*          LBA   KP1
0342  00613  00400610*          STB   RFLG
0343  00614  01200464*          SPB   GETC
0344  00615  01200534*          SPB   CNSY
0345  00616  01200551*          SPB   RTAT
0346  00617  01200534*          SPB   CNSY
0347  00620  01200530*          SPB   PUTD
0348  00621  03600611*          PIR   INF
0349  00622  00000000     INT   ZZZ   **    TURN 90 DEG
0350  00623  01200464*          SPB   GETC
0351  00624  00000005          TAB
0352  00625  00000003          CLA
0353  00626  00014017          FLL   12
0354  00627  00400402*          STB   SAV3
0355  00630  03000402*          MOA   SAV3
0356  00631  00000020          ASC
0357  00632  01200530*          SPB   PUTD
0358  00633  03600622*          PIR   INT
0359  00634  00000000     INA   ZZZ   **    ANOTHER
0360  00635  01200464*          SPB   GETC
0361  00636  01200505*          SPB   PUTN
0362  00637  00100400*          LAA   SAV1
0363  00640  03600634*          PIR   INA
0364  00641  00000000     INL   ZZZ   **    MAKE LONGER
0365  00642  01200464*          SPB   GETC
0366  00643  00001014          FRL   1
0367  00644  00500707*          AMA   LMSP
0368  00645  00014014          FRL   12
0369  00646  00500707*          AMA   LMSP
0370  00647  00043014          FRL   35
0371  00650  01200530*          SPB   PUTD
0372  00651  03600641*          PIR   INL
0373  00652  00000000     INS   ZZZ   **    MAKE SHORTER
0374  00653  01200464*          SPB   GETC
0375  00654  00001014          FRL   1
```

```
0376  00655  00300402*          STA   SAV3
0377  00656  02700711*          MAA   MSKS
0378  00657  02200663*          BAZ   *&4
0379  00660  00100402*          LAA   SAV3
0380  00661  00600707*          SMA   LMSP
0381  00662  01100664*          BRU   *&2
0382  00663  00100402*          LAA   SAV3
0383  00664  00014014           FRL   12
0384  00665  00300402*          STA   SAV3
0385  00666  02700711*          MAA   MSKS
0386  00667  02200673*          BAZ   *&4
0387  00670  00100402*          LAA   SAV3
0388  00671  00600707*          SMA   LMSP
0389  00672  01100674*          BRU   *&2
0390  00673  00100402*          LAA   SAV3
0391  00674  00043014           FRL   35
0392  00675  01200530*          SPB   PUTD
0393  00676  03600652*          PIR   INS
0394  00677  00000000    INK    ZZZ   **    ODD
0395  00700  00101042*          LAA   ='4
0396  00701  00300677*          STA   INK
0397  00702  00100210*          LAA   BGIN
0398  00703  03600677*          PIR   INK
0399  00704  00077777    AMSK   DAC   '77777
0400  00705  77777400    KM2C   DATA  '77777400
0401  00706  00000000    BOX    DAC   0
0402  00707  00040000    LMSP   DATA  '40000
0403  00710  77740000    LMSN   DATA  '-40000
0404  00711  77740000    MSKS   DATA  '77740000
0405  00712  00000000    INP    ZZZ   **  PUNCH OUT PROGRAM
0406  00713  00100210*          LAA   BGIN
0407  00714  00300360*          STA   BRNC
0408  00715  00100213*          LAA   PUNC
0409  00716  00300712*          STA   INP
0410  00717  00100210*          LAA   BGIN
0411  00720  02701041*          MAA   ='77777
0412  00721  00200211*          LBA   FINI
0413  00722  03600712*          PIR   INP
0414  00723  00000000    INU    ZZZ   **    DEC X
0415  00724  01200464*          SPB   GETC
0416  00725  00001014           FRL   1
0417  00726  00600707*          SMA   LMSP
0418  00727  00057014           FRL   47
0419  00730  01200530*          SPB   PUTD
0420  00731  03600723*          PIR   INU
0421  00732  00000000    INZ7   ZZZ   **
0422  00733  01200464*          SPB   GETC
0423  00734  00015014           FRL   13
0424  00735  00600707*          SMA   LMSP
0425  00736  00043014           FRL   35
0426  00737  01200530*          SPB   PUTD
0427  00740  03600732*          PIR   INZ7
0428  00741  00000000    INW    ZZZ   **    SEXE
0429  00742  03600743*          PIR   *&1
```

```
0430  00743  00000000          DAC   $BVECTR
0431  00744  00000000  MODF    ZZZ   **
0432  00745  03100751*          AAM   SCAL
0433  00746  01310040          CEU   '40,W
0434  00747  00000011          DAC   '11
0435  00750  01750040          MOP   '40,W
0436  00751  30014000  SCAL    DATA  '30014000
0437  00752  41100744*          BRU*  MODF
0438  00753  00000000  INBI    ZZZ   **      BIGGER
0439  00754  00300400*          STA   SAV1
0440  00755  00100207*          LAA   RTRN
0441  00756  00300753*          STA   INBI
0442  00757  00100707*          LAA   LMSP
0443  00760  01200744*          SPB   MODF
0444  00761  00100400*          LAA   SAV1
0445  00762  03600753*          PIR   INBI
0446  00763  00000000  INSM    ZZZ   **      SMALLER
0447  00764  00300400*          STA   SAV1
0448  00765  00100207*          LAA   RTRN
0449  00766  00300763*          STA   INSM
0450  00767  00100710*          LAA   LMSN
0451  00770  01200744*          SPB   MODF
0452  00771  00100400*          LAA   SAV1
0453  00772  03600763*          PIR   INSM
0454  00773  00000000  INRL    ZZZ   **        RELOAD
0455  00774  00300400*          STA   SAV1
0456  00775  00101040*          LAA   =INIT-2
0457  00776  00300773*          STA   INRL
0458  00777  00100400*          LAA   SAV1
0459  01000  03600773*          PIR   INRL
0460  01001  00000000  INR     ZZZ   **
0461  01002  00101013*          LAA   N35
0462  01003  00301001*          STA   INR
0463  01004  00000022          NOP
0464  01005  00000022          NOP
0465  01006  00100000          LAA   $ADR1
0466  01007  00301016*          STA   GONE&1
0467  01010  00100000          LAA   $ADR2
0468  01011  00301021*          STA   GONE&4
0469  01012  03601001*          PIR   INR
0470  01013  00001014*  N35     DAC   GONE-1
0471  01014  23200000          LIX   $PCNT,2
0472  01015  41300040  GONE    CEU*  '40
0473  01016  20000000          DAC   $TBL1,2
0474  01017  01101015*          BRU   *-2
0475  01020  41740040          MQP*  '40
0476  01021  20000000          DAC   $TBL2,2
0477  01022  01101020*          BRU   *-2
0478  01023  23401015*          IIB   GONE,2
0479  01024  01101014*          BRU   GONE-1
0480  01025  00000000  INI     ZZZ   **    BLANK OUT VECT
0481  01026  01200464*          SPB   GETC
0482  01027  00000006          IAB
0483  01030  03001034*          MOA   DARK
```

```
0484  01031  40300402*          STA*  SAV3
0485  01032  00100400*          LAA   SAV1
0486  01033  03601025*          PIR   INI
0487  01034  00004000     DARK  DAC   '4000
0488  01035  00000000     INJ   ZZZ   **          FIX NEW ELEMENT
0489  01036  03601037*          PIR   *&1
0490  01037  00000000          DAC   $ERASE
0491                             END

      01040  00000323*
      01041  00077777
      01042  00000004
      01043  00000077
```

APPENDIX 3

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

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IDENTIFICATION: FORMTB - Waveform Table Subroutine

AUTHOR: J.K. Pulfer

ACCEPTED: July 9, 1968

PURPOSE: To allow the user to fill a table of 2^n points using the graphical display and the shaft position encoders.

COMPUTER CONFIGURATION: NRC 840A with display + shaft position encoders.

SUBROUTINES REQUIRED: None

STORAGE: 71_8 plus data table

TIMING: N/A

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USE: The calling sequence is

```
CALL FORMTB
DATA M
RETURN HERE
```

where $M=2^n-1$ is the size of the data table and n is an integer between 1 and 9.

If sense switch 1 is set, the table is displayed on the CRT and can be modified by the shaft position encoders. If sense switch 1 is reset, control is returned to the calling program.

```
0001                                * FORM TABLE - A GRAPHICAL
0002                                * INPUT ROUTINE USING THE
0003                                * SHAFT POSITION ENCODERS
0004                                ************************
0005                                *
0006          00000000                    NAME FORM,FORM
0007          00000071                    NAME FORMTB,TUB
0008  00000  00000000    FORM  ZZZ   **
0009  00001  00000003          CLA
0010  00002  10000001          TAI   ,1
0011  00003  00000005          TAB
0012  00004  40100000*         LAA*  FORM
0013  00005  10027032          NOR   23,1
0014  00006  13300031*         STI   KEEP,1
0015  00007  00100031*         LAA   KEEP
0016  00010  00011016          LSL   9
0017  00011  05600000          NEG
0018  00012  03000025*         MOA   SIXT
0019  00013  00300044*         STA   SHIF
0020  00014  40100000*         LAA*  FORM
0021  00015  00300026*         STA   MASK
0022  00016  05600000          NEG
0023  00017  45600000          NEG*
0024  00020  00300023*         STA   COUN
0025  00021  01400000*         IMS   FORM
0026  00022  01100033*         BRU   STAR
0027  00023  00000000    COUN  DAC   0
0028  00024  00000000    ZERO  DAC   0
0029  00025  00000016    SIXT  DAC   '16
0030  00026  00000000    MASK  DAC   0
0031  00027  00003776    PMSK  DAC   '3776
0032  00030  00014000    INT   DAC   '14000
0033  00031  00000000    KEEP  DAC   0
0034  00032  00000000    KOOP  DAC   0
0035  00033  01342100    STAR  SNS   1
0036  00034  01100036*         BRU   *&2
0037  00035  41100000*         BRU*  FORM
0038  00036  13200023*         LIX   COUN,1
0039  00037  23200024*         LIX   ZERO,2
0040  00040  01310040    GO    CEU   '40,W
0041  00041  00000251          DAC   '251
0042  00042  13300031*         STI   KEEP,1
0043  00043  00100031*         LAA   KEEP
0044  00044  00000000    SHIF  ZZZ
0045  00045  23000072*         MOA   TUB&1,2
0046  00046  03000030*         MOA   INT
0047  00047  01710040          AOP   '40,W
0048  00050  01310040          CEU   '40,W
0049  00051  00000006          DAC   '6
0050  00052  01310040          CEU   '40,W
0051  00053  00000006          DAC   '6
0052  00054  01730040          AIP   '40,W
0053  00055  00000005          TAB
0054  00056  02700027*         MAA   PMSK
```

```
0055  00057  00300031*          STA   KEEP
0056  00060  00012017           FLL   10
0057  00061  02700026*          MAA   MASK
0058  00062  00500071*          AMA   TUB
0059  00063  00300032*          STA   KOOP
0060  00064  00100031*          LAA   KEEP
0061  00065  40300032*          STA*  KOOP
0062  00066  23400067*          IIB   *&1,2
0063  00067  13400040*          IIB   GO,1
0064  00070  01100033*          BRU   STAR
0065  00071  00000072*    TUB   DAC   *&1
0066                           END
```

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PROGRAM DESCRIPTION

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IDENTIFICATION: GRAFIN - Subroutine

AUTHOR: J.K. Pulfer

ACCEPTED: 2 July, 1968

PURPOSE: To load a table of values from a curve which is drawn on the CRT face with a light pen.

COMPUTER CONFIGURATION: NRC 840 A, Display, Light Pen, Keyboard

SUBROUTINES REQUIRED: TRAK

STORAGE: 110_8

TIMING:

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USE:
```
CALL GRAFIN
DAC  BLOK
NEXT INSTRUCTION
```
where BLOK is the starting address of the table to be filled.

Sketch the desired curve from left to right on the CRT. The X-axis or y = 0 line is at centre screen vertically. When 128 points have been drawn, control is returned to the calling program.

Values stored in the table have a scale factor such that maximum positive on the screen is stored as 2000_8.

```
0001          00000000          NAME GRAFIN,ENTR
0002  00000  00000000   ENTR ZZZ  **     ENTRY POINY
0003  00001  40100000*  ERAS LAA* ENTR
0004  00002  03000076*       MOA  IND1
0005  00003  00300050*       STA  ADDR
0006  00004  00100103*       LAA  KM1
0007  00005  00300104*       STA  PCNT
0008  00006  00100101*       LAA  K16K
0009  00007  40300050*       STA* ADDR
0010  00010  13200104*  SKET LIX  PCNT,1
0011          0          GO   CALL TRAK
0012  00012  00716000   POS  DATA '716000
0013  00013  13400047*       IIB  PLOT,1
0014  00014  01730043       AIP  '43,W
0015  00015  02700110*       MAA  ='77
0016  00016  02200026*       BAZ  MOD
0017  00017  00001015       RSL  1
0018  00020  02200001*       BAZ  ERAS
0019  00021  00001015       RSL  1
0020  00022  02200052*       BAZ  CHN1
0021  00023  00001015       RSL  1
0022  00024  02200055*       BAZ  CHN2
0023  00025  01100010*       BRU  SKET
0024  00026  40100050*  MOD  LAA* ADDR
0025  00027  02700074*       MAA  XMSK
0026  00030  00300073*       STA  XOLD
0027  00031  00100012*       LAA  POS
0028  00032  02700074*       MAA  XMSK
0029  00033  00600073*       SMA  XOLD
0030  00034  00600107*       SMA  INCR
0031  00035  02300010*       BAN  SKET
0032  00036  00100104*       LAA  PCNT
0033  00037  00600075*       SMA  K128
0034  00040  02200062*       BAZ  FINI
0035  00041  01400050*       IMS  ADDR
0036  00042  00100103*  NEWP LAA  KM1
0037  00043  03100104*       AAM  PCNT
0038  00044  00100012*       LAA  POS
0039  00045  40300050*       STA* ADDR
0040  00046  01100010*       BRU  SKET
0041  00047  41750040   PLOT MOP* '40,W
0042  00050  00000000   ADDR DAC  0
0043  00051  01100011*  DIRT BRU  GO
0044  00052  00100057*  CHN1 LAA  DIR1
0045  00053  00300051*       STA  DIRT
0046  00054  01100010*       BRU  SKET
0047  00055  00100060*  CHN2 LAA  DIR2
0048  00056  01100053*       BRU  *-3
0049  00057  01100011*  DIR1 BRU  GO
0050  00060  01100013*  DIR2 BRU  GO&2
0051  00061  10000106*  STRT DAC  TBL,1
0052  00062  01400000*  FINI IMS  ENTR
0053  00063  13200105*  GEE  LIX  INDM,1
0054  00064  40100050*       LAA* ADDR
```

```
0055  00065  02700077*          MAA   YMSK
0056  00066  00600100*          SMA   DC
0057  00067  40300050*          STA*  ADDR
0058  00070  13400064*          IIB   GEE&1,1
0059  00071  40300050*          STA*  ADDR
0060  00072  41100000*          BRU*  ENTR
0061  00073  00000000    XOLD  DAC   0
0062  00074  37760000    XMSK  DATA  '37760000
0063  00075  77777600    K128  DATA  -128
0064  00076  10000000    IND1  DATA  '10000000
0065  00077  00003777    YMSK  DAC   '3777
0066  00100  00002000    DC    DAC   '2000
0067  00101  00016000    K16K  DATA  '16000
0068  00102  00077777    AMSK  DAC   '77777
0069  00103  77777777    KM1   DATA  -1
0070  00104  77777777    PCNT  DATA  -1
0071  00105  77777601    INDM  DATA  '77777601
0072  00106  00016000    TBL   DATA  '16000
0073  00107  00110000    INCR  DATA  '110000
0074                      END
      00110  00000077
```

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PROGRAM DESCRIPTION

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IDENTIFICATION: XYPTIN - subroutine

AUTHOR: D.H. O'Hara

ACCEPTED: April 1968

PURPOSE: To load into memory coordinates of points plotted with a light pen on the CRT face in an X-Y coordinate system. The number of points plotted is displayed in octal on the CRT. 2^N points may be plotted.

COMPUTER CONFIGURATION: NRC 840A, Display, Light Pen, Keyboard

SUBROUTINES REQUIRED: TRAK, PLOT

STORAGE: 341_8

TIMING:

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USE:

Call XYPTIN
DAC starting address of table for X dimension
DAC starting address of table for Y dimension
DATA no. of points (decimal)
Return point of subroutine

Coordinates are stored in memory in two tables, one for the X dimension and one for Y dimension. For each spot plotted on the CRT face, two points are entered in the tables except for the first point. The value of the dimensions of the second point of each entry is determined by keyboard control. The first plotted point occupies the 0 position in each table; the second plotted point and its "conjugate" occupy positions 1 and N-1; the third occupies 2 and N-2, etc. Position N/2 is empty in the tables.

When the program is operating, the 1st memory location after the table of X dimensions is used by the program (i.e. position N of X table). This location may be the 0 position in the table for Y dimensions.

KEYBOARD COMMANDS

'01 Plot and record dimensions indicated by tracking square: dimensions of "conjugate" point equal 0 (X,Y; 0,0)

'02 Plot and record dimensions at the square: dimension of "conjugate" point same as at the square (X,Y; X,Y)

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'04 Plot and record dimensions at square: X dimension of "conjugate" same amplitude but negative to that of square and Y dimension equal to that of the square (X,Y; -X,Y)

'10 Plot and enter zero amplitude in table for point and conjugate (0,0; 0,0)

'20 N/A

'41 Improve rate at which square will track light pen

'42 Reduce flicker of displayed points

'44 Backspace; erase previous point

'50 Erase all points plotted

'60 Exit subroutine to calling program.

```
0001          00000000          NAME XYPTIN,GRAF
0002  00000   00000000    GRAF  ZZZ  **
0003  00001   40100000*          LAA* GRAF
0004  00002   03000260*          MOA  IND1      ='10000000
0005  00003   00300116*          STA  ADDX      ADDRESS OF REAL
0006  00004   01400000*          IMS  GRAF
0007  00005   40100000*          LAA* GRAF
0008  00006   03000260*          MOA  IND1      ='10000000
0009  00007   00300311*          STA  ADDY      ADDRESS OF IMAG
0010  00010   01400000*          IMS  GRAF
0011  00011   40100000*          LAA* GRAF
0012  00012   00300261*          STA  TOTL
0013  00013   00001015           RSL  1
0014  00014   00300276*          STA  ENPT
0015  00015   01400000*          IMS  GRAF      READY TO EXIT
0016  00016   00100261*          LAA  TOTL        NO. OF POINTS
0017  00017   03100116*          AAM  ADDX
0018  00020   03100311*          AAM  ADDY
0019  00021   05600000           NEG
0020  00022   10000001           TAI  ,1
0021  00023   00000005           TAB
0022  00024   00100116*          LAA  ADDX
0023  00025   00300267*          STA  DCPT
0024  00026   00100340*          LAA  MOP       =0
0025  00027   40300116*          STA* ADDX
0026  00030   40300311*          STA* ADDY
0027  00031   13400027*          IIB  *-2,1
0028  00032   00000004           TBA
0029  00033   03100116*          AAM  ADDX
0030  00034   03100311*          AAM  ADDY
0031  00035   00100262*          LAA  NEG1      =-1
0032  00036   00300263*          STA  INCT      INDEX 1, NEG COUNT
0033  00037   00300264*          STA  LTCH
0034  00040   00000003           CLA
0035  00041   00300266*          STA  NXPT
0036  00042   00100261*          LAA  TOTL
0037  00043   00300270*          STA  COCT      CONJ DIFF
0038  00044   13200263*    BGIN  LIX  INCT,1
0039  00045   23200271*          LIX  IND2,2      PLOT X-Y
0040  00046   41310040           CEU* '40,W
0041  00047   20000332*          DAC  CEU,2
0042  00050   41750040           MOP* '40,W
0043  00051   20000340*          DAC  MOP,2
0044  00052   23400046*          IIB  *-4,2
0045  00053   00200266*          LBA  NXPT      DISPLAY COUNT AT NXT PT
0046  00054   01310040           CEU  '40,W
0047  00055   00000251           DAC  '251
0048  00056   01750040           MOP  '40,W
0049  00057   00017777           DATA '00017777
0050                             CALL PLOT
0051                        GO   CALL TRAK
0052  00062   20016000    POS   DATA '20016000
0053  00063   01310040           CEU  '40,W
0054  00064   00000251           DAC  '251
```

```
0055  00065  13400115*        IIB   SPOT,1
0056  00066  01730043         AIP   '43,W
0057  00067  00000005         TAB
0058  00070  02700273*        MAA   K040      '40
0059  00071  02200110*        BAZ   YES
0060  00072  23200274*        LIX   LHLF,2     LHLF = -5
0061  00073  00000004  CONT   TBA
0062  00074  02700275*        MAA   K037      '37
0063  00075  02200105*        BAZ   RSET
0064  00076  03500264*        SMP   LTCH
0065  00077  01100044*        BRU   BGIN
0066  00100  00200262*        LBA   NEG1
0067  00101  00400264*        STB   LTCH
0068  00102  00001015         RSL   1
0069  00103  62200324*        BAZ*  JOB,2
0070  00104  23400102*        IIB   *-2,2
0071  00105  00200340*  RSET  LBA   MOP       =0
0072  00106  00400264*        STB   LTCH
0073  00107  01100044*        BRU   BGIN
0074  00110  00100276*  YES   LAA   ENPT
0075  00111  00600266*        SMA   NXPT
0076  00112  02200044*        BAZ   BGIN
0077  00113  23200277*        LIX   UHLF,2     -10
0078  00114  01100073*        BRU   CONT
0079  00115  41750040  SPOT  MOP*  '40,W
0080  00116  00000000  ADDX  DAC   0
0081  00117  01100061*  DIRT  BRU   GO
0082  00120  00100300*  SQIN  LAA   DIR1
0083  00121  00300117*        STA   DIRT
0084  00122  01100044*        BRU   BGIN
0085  00123  00100301*  SQOT  LAA   DIR2
0086  00124  01100121*        BRU   *-3
0087  00125  00100266*  BACK  LAA   NXPT
0088  00126  02200044*        BAZ   BGIN
0089  00127  00100262*        LAA   NEG1
0090  00130  03100266*        AAM   NXPT
0091  00131  03100116*        AAM   ADDX
0092  00132  05600000         NEG             (A) & 1
0093  00133  03100263*        AAM   INCT
0094  00134  00500265*        AMA   K001      (A) & 2
0095  00135  03100270*        AAM   COCT
0096  00136  00100116*        LAA   ADDX
0097  00137  00500270*        AMA   COCT
0098  00140  00300305*        STA   SAV1
0099  00141  00100340*        LAA   MOP       0
0100  00142  40300116*        STA*  ADDX      ERASE PT IN TABLE
0101  00143  40300305*        STA*  SAV1      ERASE PT IN TABLE
0102  00144  01100044*        BRU   BGIN
0103  00145  00100341*  ERAS  LAA   NEG3
0104  00146  03100000*        AAM   GRAF
0105  00147  01100001*        BRU   GRAF&1
0106  00150  00100261*  EXIT  LAA   TOTL
0107  00151  00300270*        STA   COCT
0108  00152  00100116*        LAA   ADDX
```

```
0109  00153  00600266*          SMA   NXPT
0110  00154  00300116*          STA   ADDX
0111  00155  40100116*          LAA*  ADDX
0112  00156  42200000*          BAZ*  GRAF
0113  00157  00014014           FRL   12
0114  00160  40100116*          LAA*  ADDX
0115  00161  02700303*          MAA   SAVY      '00003776
0116  00162  00600304*          SMA   TWOK      '20000
0117  00163  40300311*          STA*  ADDY
0118  00164  00000004           TBA
0119  00165  02700303*          MAA   SAVY
0120  00166  00600304*          SMA   TWOK
0121  00167  40300116*          STA*  ADDX
0122  00170  00100116*          LAA   ADDX
0123  00171  00500270*          AMA   COCT
0124  00172  01500267*          CMA   DCPT
0125  00173  01100176*          BRU   *&3
0126  00174  01100214*          BRU   *&16
0127  00175  01100214*          BRU   *&15
0128  00176  00300305*          STA   SAV1
0129  00177  00100311*          LAA   ADDY
0130  00200  00500270*          AMA   COCT
0131  00201  00300306*          STA   SAV2
0132  00202  40100305*          LAA*  SAV1
0133  00203  00014014           FRL   12
0134  00204  40100305*          LAA*  SAV1
0135  00205  02700303*          MAA   SAVY      '00003776
0136  00206  00600304*          SMA   TWOK      '2000
0137  00207  40300306*          STA*  SAV2
0138  00210  00000004           TBA
0139  00211  02700303*          MAA   SAVY
0140  00212  00600304*          SMA   TWOK
0141  00213  40300305*          STA*  SAV1
0142  00214  00100302*          LAA   NEG2
0143  00215  03100270*          AAM   COCT
0144  00216  00100270*          LAA   COCT
0145  00217  42200000*          BAZ*  GRAF
0146  00220  13400155*          IIB   EXIT&5,1
0147  00221  00100062*  PTCO    LAA   POS
0148  00222  00200272*          LBA   CNTR
0149  00223  40300116*  FXUP    STA*  ADDX
0150  00224  00100116*          LAA   ADDX
0151  00225  00500270*          AMA   COCT
0152  00226  00300305*          STA   SAV1
0153  00227  40400305*          STB*  SAV1
0154  00230  00100302*          LAA   NEG2
0155  00231  03100270*          AAM   COCT
0156  00232  01400116*          IMS   ADDX
0157  00233  00100262*          LAA   NEG1
0158  00234  03100263*          AAM   INCT
0159  00235  01400266*          IMS   NXPT
0160  00236  01100044*          BRU   BGIN
0161  00237  00100062*  PTCP    LAA   POS
0162  00240  00000005           TAB
```

```
0163  00241  01100223*          BRU   FXUP
0164  00242  00100272*  POCO    LAA   CNTR
0165  00243  00000005          TAB
0166  00244  01100223*          BRU   FXUP
0167  00245  00100062*  PTCN    LAA   POS
0168  00246  00000005          TAB
0169  00247  02700307*          MAA   MSKY     ='00017777
0170  00250  00300306*          STA   SAV2
0171  00251  00000004          TBA
0172  00252  02700310*          MAA   MSKX     ='37760000
0173  00253  05600000          NEG
0174  00254  03000306*          MOA   SAV2
0175  00255  00000005          TAB
0176  00256  00100062*          LAA   POS
0177  00257  01100223*          BRU   FXUP
0178  00260  10000000  IND1    DATA  '10000000   K
0179  00261  00000200  TOTL    DATA  128         K   NO. OF PTS. IN TABLE
0180  00262  77777777  NEG1    DATA  -1          K
0181  00263  00000000  INCT    DAC   0           V
0182  00264  00000000  LTCH    DAC   0           V, 0 OR -1
0183  00265  00000001  K001    DATA  1           K
0184  00266  00000000  NXPT    DATA  0           V
0185  00267  00000000  DCPT    DATA  0
0186  00270  00000000  COCT    DATA  0           V
0187  00271  77777772  IND2    DATA  -6          K
0188  00272  20016000  CNTR    DATA  '20016000   K
0189  00273  00000040  K040    DATA  '40         K
0190  00274  77777773  LHLF    DATA  -5          K
0191  00275  00000037  K037    DATA  '37         K
0192  00276  00000000  ENPT    DATA  0
0193  00277  77777766  UHLF    DATA  -10         K
0194  00300  01100061*  DIR1    BRU   GO
0195  00301  01100063*  DIR2    BRU   GO&2
0196  00302  77777776  NEG2    DATA  -2          K
0197  00303  00003776  SAVY    DATA  '00003776   K
0198  00304  00002000  TWOK    DATA  '2000       K
0199  00305  00000000  SAV1    DATA  0           TEMP STORE V
0200  00306  00000000  SAV2    DATA  0           TEMP STORE V
0201  00307  00017777  MSKY    DATA  '00017777   K
0202  00310  37760000  MSKX    DATA  '37760000   K
0203  00311  00000000  ADDY    DAC   0           V
0204  00312  00000221*          DAC   PTCO
0205  00313  00000237*          DAC   PTCP
0206  00314  00000245*          DAC   PTCN
0207  00315  00000242*          DAC   POCO
0208  00316  00000044*          DAC   BGIN
0209  00317  00000120*          DAC   SQIN
0210  00320  00000123*          DAC   SQOT
0211  00321  00000125*          DAC   BACK
0212  00322  00000145*          DAC   ERAS
0213  00323  00000150*          DAC   EXIT
0214  00324  00000251  JOB     DAC   '251
0215  00325  00001021          DAC   '1021
0216  00326  00000701          DAC   '701
```

```
0217  00327  00000251          DAC   '251
0218  00330  00001021          DAC   '1021
0219  00331  00000701          DAC   '701
0220  00332  01506000    CEU   DATA  '1506000
0221  00333  34000000          DATA  '34000000
0222  00334  22050114          DATA  ''REAL''
0223  00335  20004150          DATA  '20004150
0224  00336  00003400          DATA  '3400
0225  00337  11150107          DATA  ''IMAG''
0226  00340  00000000    MOP   DATA  0                K
0227  00341  77777775    NEG3  DATA  -3
0228                          END
```

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

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IDENTIFICATION: GRAF - a graphical plotting subroutine

AUTHOR: J.K. Pulfer

ACCEPTED: 2 July 1968

PURPOSE: To plot the contents of a table in computer core memory, in rectangular coordinates

$y = f(x)$

Only the 11 least significant bits in each word are used to form the analog quantity plotted.

COMPUTER CONFIGURATION: 840 A with NRC display

SUBROUTINES REQUIRED: PLOT (cat. no. 1019)

STORAGE: 165_8 + PLOT

TIMING: approx 60 μseconds / point

DATA SYSTEMS PROGRAM LIBRARY

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USE:

```
LBA  SCAL  (fractional scale factor)
CALL GRAF
DAC  starting address of table
DATA XXX
NEXT INSTRUCTION TO BE EXECUTED
```

where XXX contains the table word count.

(1) The numbers in the table are multiplied by SCAL before display. SCAL should be chosen so that the resultant product fills the 11 least significant bits of the word for optimum scaling.

(2) Each of the parameters of the display can be adjusted by using the light pen and placing it on the X axis: right side for increase, left side for decrease.

(3) Parameters to be adjusted are selected by the keyboard as follows:

(a) (first finger) - changes starting address. The address is given in octal in the upper left of the screen.

(b) (second finger) - word count. This is adjustable from 1 to '1777 but must be a sub multiple of '1777.

(c) (first and second fingers) - change vertical position of the X axis. This is normally initialized to centre screen so that both positive and negative points may be plotted.

(d) (third finger) - changes SCAL or vertical gain slowly.

(e) (all three fingers or octal 7) - returns to calling program and also enables the vertical scale factor to be changed rapidly on subsequent calls.

DATA SYSTEMS PROGRAM LIBRARY

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The second listing (labelled INVGRAF) is identical with graf except that the table is displayed with the first location at the centre of the screen instead of the left hand edge. This means that the second half of the table contents are displayed on the left half of the screen. This "INVERTED" display is useful with programs using inverted tables such as the fast Fourier transform.

```
                                 ****************************************
                                 *
                                 *     GRAF - A SUBROUTINE FOR GRAPHICAL
                                 *                 DISPLAY
                                 *
                                 *      USE THE DISPLAY KEYBOARD AS
                                 *                FOLLOWS
                                 *
                                 *    1 .......... RETURN TO CALLING PRGRM
                                 *
                                 *    2 ......... CHANGE STARTING ADDR
                                 *
                                 *    3 .........CHANGE WORD COUNT
                                 *
                                 *    4 ......... CHANGE VERT POSITION
                                 *
                                 *    5 .......... CHANGE VERT GAIN
                                 *
                                 ****************************************
                00000000              NAME GRAF,GRAF
        00000   00000000         GRAF ZZZ  **     GRAPHICAL DISPLAY HANDLER
        00001   40100000*             LAA* GRAF
        00002   03000140*             MOA  INDX
        00003   00300121*             STA  ADDR
        00004   01400000*             IMS  GRAF
        00005   40100000*             LAA* GRAF
        00006   02700137*             MAA  YMSK
        00007   00300142*             STA  WCNT
        00010   01400000*             IMS  GRAF
        00011   00400124*             STB  SCAL
        00012   00200141*             LBA  SPBO
        00013   00400105              STB  '105
        00014   14300020              PIE  '20,0
        00015   00000003              CLA
        00016   00200136*             LBA  XMSK
        00017   01000142*             DIV  WCNT
        00020   02700136*             MAA  XMSK
        00021   00012015              RSL  10
        00022   00300122*             STA  INCR
        00023   01730043         GO   AIP  '43,W
        00024   02700165*             MAA  ='77
        00025   02200027*             BAZ  *&2
        00026   01100036*             BRU  GOT1
        00027   03300135*             STI  BFLG,0
        00030   01100042*             BRU  CEU
        00031   03500135*        GOT2 SMP  BFLG
        00032   01100042*             BRU  CEU
        00033   00100134*             LAA  KM1
        00034   00300135*             STA  BFLG
        00035   41100000*             BRU* GRAF
        00036   10000001         GOT1 TAI  ,1
        00037   02700133*             MAA  KP7
        00040   00600133*             SMA  KP7
        00041   02200031*             BAZ  GOT2
```

```
0055  00042  01310040        CEU   CEU   '40,W
0056  00043  00000251              DAC   '251
0057  00044  00100144*             LAA   INTN
0058  00045  03000137*             MOA   YMSK
0059  00046  01710040              AOP   '40,W
0060  00047  00200121*             LBA   ADDR
0061  00050  01200000              SPB   $PLOT
0062  00051  01310040              CEU   '40,W
0063  00052  00000251              DAC   '251
0064  00053  00100144*             LAA   INTN
0065  00054  00500123*             AMA   DC
0066  00055  01710040              AOP   '40,W
0067  00056  01310040              CEU   '40,W
0068  00057  00001021              DAC   '1021
0069  00060  00100140*             LAA   INDX
0070  00061  01710040              AOP   '40,W
0071  00062  00200134*             LBA   KM1
0072  00063  00400112*             STB   FLAG
0073  00064  01710040              AOP   '40,W
0074  00065  00200130*             LBA   KP1
0075  00066  00400112*             STB   FLAG
0076  00067  00000003              CLA
0077  00070  20000001              TAI   ,2
0078  00071  01310040              CEU   '40,W
0079  00072  00000251              DAC   '251
0080  00073  03300117*             STI   XPOS,0
0081  00074  03300112*             STI   FLAG,0
0082  00075  00200124*        GO2  LBA   SCAL
0083  00076  40700121*             MPY*  ADDR
0084  00077  00500123*             AMA   DC
0085  00100  02700137*             MAA   YMSK
0086  00101  03000144*             MOA   INTN
0087  00102  03000117*             MOA   XPOS
0088  00103  01710040              AOP   '40,W
0089  00104  00300143*             STA   SAV2
0090  00105  00100122*             LAA   INCR
0091  00106  00012016              LSL   10
0092  00107  00500143*             AMA   SAV2
0093  00110  00000021              SAS
0094  00111  01100023*             BRU   GO
0095  00112  00000000        FLAG  DAC   0
0096  00113  02700136*             MAA   XMSK
0097  00114  02200016*             BAZ   GO-5
0098  00115  00300117*             STA   XPOS
0099  00116  23400075*             ITB   GO2,2
0100  00117  00000000        XPOS  DAC   0
0101  00120  00000000        TBL   DAC   0
0102  00121  00000000        ADDR  DAC   0
0103  00122  00000000        INCR  DAC   0
0104  00123  00002000        DC    DAC   '2000
0105  00124  00000000        SCAL  DAC   0
0106  00125  00000000        UNK1  DAC   0
0107  00126  00000000              DAC   0
0108  00127  00000000        UNK2  DAC   0
```

```
0109  00130  00000001     KP1   DAC   1
0110  00131  00000100     KPC   DATA  '100
0111  00132  00000200     KP2C  DATA  '200
0112  00133  00000007     KP7   DAC   7
0113  00134  77777777     KM1   DATA  '-1
0114  00135  00000000     BFLG  DAC   0
0115  00136  37760000     XMSK  DATA  '37760000
0116  00137  00003777     YMSK  DATA  '3777
0117  00140  20000000     INDX  DATA  '20000000
0118  00141  01200145*    SPBO  SPB   INO
0119  00142  00000000     WCNT  DAC   0
0120  00143  00000000     SAV2  DAC   0
0121  00144  00014000     INTN  DATA  '14000
0122  00145  00000000     INO   ZZZ   **    CHANGE CONSTANTS
0123  00146  00300120*          STA   TBL
0124  00147  00100112*          LAA   FLAG
0125  00150  13100120*          AAM   TBL,1
0126  00151  01730043          AIP   '43,W
0127  00152  02700165*          MAA   ='77
0128  00153  00600133*          SMA   KP7
0129  00154  02200157*          BAZ   *&3
0130  00155  00100120*          LAA   TBL
0131  00156  03600145*          PIR   INO
0132  00157  00100124*          LAA   SCAL
0133  00160  00500131*          AMA   KPC
0134  00161  03500112*          SMP   FLAG
0135  00162  00600132*          SMA   KP2C
0136  00163  00300124*          STA   SCAL
0137  00164  01100155*          BRU   *-7
0138                            END
      00165  00000077
```

```
                             ****************************************
                             *
                             *         GRAF - A SUBROUTINE FOR GRAPHICAL
                             *                 DISPLAY
                             *
                             *          USE THE DISPLAY KEYBOARD AS
                             *                FOLLOWS
                             *
                             *        1..........RETURN TO CALLING PRGRM
                             *
                             *        2..........CHANGE STARTING ADDR
                             *
                             *        3..........CHANGE WORD COUNT
                             *
                             *        4..........CHANGE VERT POSITION
                             *
                             *        5..........CHANGE VERT GAIN
                             *
                             ****************************************
              00000000            NAME GRAF,GRAF
     00000    00000000       GRAF ZZZ  **      GRAPHICAL DISPLAY HANDLER
     00001    40100000*           LAA* GRAF
     00002    03000142*           MOA  INDX
     00003    00300123*           STA  ADDR
     00004    01400000*           IMS  GRAF
     00005    40100000*           LAA* GRAF
     00006    02700141*           MAA  YMSK
     00007    00300144*           STA  WCNT
     00010    01400000*           IMS  GRAF
     00011    00400126*           STB  SCAL
     00012    00200143*           LBA  SPBO
     00013    00400105            STB  '105
     00014    14300020            PIE  '20,0
     00015    00000003            CLA
     00016    00200140*           LBA  XMSK
     00017    01000144*           DIV  WCNT
     00020    02700140*           MAA  XMSK
     00021    00012015            RSL  10
     00022    00300124*           STA  INCR
     00023    01730043       GO   AIP  '43,W
     00024    02700167*           MAA  ='77
     00025    02200027*           BAZ  *&2
     00026    01100036*           BRU  GOT1
     00027    03300137*           STI  BFLG,0
     00030    01100042*           BRU  CEU
     00031    03500137*      GOT2 SMP  BFLG
     00032    01100042*           BRU  CEU
     00033    00100136*           LAA  KM1
     00034    00300137*           STA  BFLG
     00035    41100000*           BRU* GRAF
     00036    10000001       GOT1 TAI  ,1
     00037    02700135*           MAA  KP7
     00040    00600135*           SMA  KP7
     00041    02200031*           BAZ  GOT2
```

```
0055  00042  01310040     CEU   CEU   '40,W
0056  00043  00000251           DAC   '251
0057  00044  00100146*          LAA   INTN
0058  00045  03000141*          MOA   YMSK
0059  00046  01710040           AOP   '40,W
0060  00047  00200123*          LBA   ADDR
0061  00050  01200000           SPB   $PLOT
0062  00051  01310040           CEU   '40,W
0063  00052  00000251           DAC   '251
0064  00053  00100146*          LAA   INTN
0065  00054  00500125*          AMA   DC
0066  00055  01710040           AOP   '40,W
0067  00056  01310040           CEU   '40,W
0068  00057  00001021           DAC   '1021
0069  00060  00100142*          LAA   INDX
0070  00061  01710040           AOP   '40,W
0071  00062  00200136*          LBA   KM1
0072  00063  00400114*          STB   FLAG
0073  00064  01710040           AOP   '40,W
0074  00065  00200132*          LBA   KP1
0075  00066  00400114*          STB   FLAG
0076  00067  00000003           CLA
0077  00070  20000001           TAI   ,2
0078  00071  01310040           CEU   '40,W
0079  00072  00000251           DAC   '251
0080  00073  03300121*          STI   XPOS,0
0081  00074  03300114*          STI   FLAG,0
0082  00075  00200126*  GO2     LBA   SCAL
0083  00076  40700123*          MPY*  ADDR
0084  00077  00500125*          AMA   DC
0085  00100  02700141*          MAA   YMSK
0086  00101  03000146*          MOA   INTN
0087  00102  03000121*          MOA   XPOS
0088  00103  00500142*          AMA   INDX
0089  00104  01710040           AOP   '40,W
0090  00105  00600142*          SMA   INDX
0091  00106  00300145*          STA   SAV2
0092  00107  00100124*          LAA   INCR
0093  00110  00012016           LSL   10
0094  00111  00500145*          AMA   SAV2
0095  00112  00000021           SAS
0096  00113  01100023*          BRU   GO
0097  00114  00000000  FLAG     DAC   0
0098  00115  02700140*          MAA   XMSK
0099  00116  02200016*          BAZ   GO-5
0100  00117  00300121*          STA   XPOS
0101  00120  23400075*          IIB   GO2,2
0102  00121  00000000  XPOS     DAC   0
0103  00122  00000000  TBL      DAC   0
0104  00123  00000000  ADDR     DAC   0
0105  00124  00000000  INCR     DAC   0
0106  00125  00002000  DC       DAC   '2000
0107  00126  00000000  SCAL     DAC   0
0108  00127  00000000  UNK1     DAC   0
```

```
0109  00130  00000000          DAC  0
0110  00131  00000000  UNK2    DAC  0
0111  00132  00000001  KP1     DAC  1
0112  00133  00000100  KPC     DATA '100
0113  00134  00000200  KP2C    DATA '200
0114  00135  00000007  KP7     DAC  7
0115  00136  77777777  KM1     DATA '-1
0116  00137  00000000  BFLG    DAC  0
0117  00140  37760000  XMSK    DATA '37760000
0118  00141  00003777  YMSK    DATA '3777
0119  00142  20000000  INDX    DATA '20000000
0120  00143  01200147* SPBO    SPB  INO
0121  00144  00000000  WCNT    DAC  0
0122  00145  00000000  SAV2    DAC  0
0123  00146  00014000  INTN    DATA '14000
0124  00147  00000000  INO     ZZZ  **   CHANGE CONSTANTS
0125  00150  00300122* STA  TBL
0126  00151  00100114* LAA  FLAG
0127  00152  13100122* AAM  TBL,1
0128  00153  01730043  AIP  '43,W
0129  00154  02700167* MAA  ='77
0130  00155  00600135* SMA  KP7
0131  00156  02200161* BAZ  *&3
0132  00157  00100122* LAA  TBL
0133  00160  03600147* PIR  INO
0134  00161  00100126* LAA  SCAL
0135  00162  00500133* AMA  KPC
0136  00163  03500114* SMP  FLAG
0137  00164  00600134* SMA  KP2C
0138  00165  00300126* STA  SCAL
0139  00166  01100157* BRU  *-7
0140                    END
      00167  00000077
```

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

Page 1 of 2 Catalog No. 1020

IDENTIFICATION: XYGRAF subroutine

AUTHOR: J.K. Pulfer

ACCEPTED: 2 July 1968

PURPOSE: To plot on the CRT face points taken from two tables in computer core memory. One table contains the real components and one the imaginary components of the complex function to be plotted. The 11 least significant bits of each word form the number which is displayed.

COMPUTER CONFIGURATION: 840 A with NRC display

SUBROUTINES REQUIRED: None

STORAGE: 115_8

TIMING: approx. 50 μseconds / point plotted

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USE:

```
LBA  SCAL      Scale factor
CALL XYGRAF
DAC  Starting address of REAL TABLE
DAC  Starting Address of IMAGINARY TABLE
DATA Number of points to be plotted
RETURN POINT OF SUBROUTINE
```

(1) Press any key on keyboard to return to calling program

(2) SCAL is the fraction by which all table values will be multiplied.

```
0001          00000027          NAME XYGRAF,GRAF
0002  00000   77777772    KM6   DATA -6
0003  00001   10000000    INDX  DATA '10000000
0004  00002   00000000    WCNT  DAC  0
0005  00003   00000000    ADRX  DAC  0
0006  00004   00000000    ADRY  DAC  0
0007  00005   00000000    SCAL  DAC  0
0008  00006   77777777    FLAG  DATA -1
0009  00007   00003776    MSK   DATA '3776
0010  00010   00004000    INTN  DATA '4000
0011  00011   00010000    INT2  DATA '10000
0012  00012   00000251          DAC  '251
0013  00013   00001021          DAC  '1021
0014  00014   00000701          DAC  '701
0015  00015   00000251          DAC  '251
0016  00016   00001021          DAC  '1021
0017  00017   00000701          DAC  '701
0018  00020   01506000    TBL1  DATA '1506000
0019  00021   34000000          DATA '34000000
0020  00022   22050114          DATA ''REAL''
0021  00023   20004150          DATA '20004150
0022  00024   00003400          DATA '3400
0023  00025   11150107          DATA ''IMAG''
0024  00026   00000000    TBL2  DAC  0
0025  00027   00000000    GRAF  ZZZ  ** ENTYR POINT
0026  00030   40100027*         LAA* GRAF
0027  00031   03000001*         MOA  INDX
0028  00032   00300003*         STA  ADRX
0029  00033   01400027*         IMS  GRAF
0030  00034   40100027*         LAA* GRAF
0031  00035   03000001*         MOA  INDX
0032  00036   00300004*         STA  ADRY
0033  00037   01400027*         IMS  GRAF
0034  00040   40100027*         LAA* GRAF
0035  00041   03100003*         AAM  ADRX
0036  00042   03100004*         AAM  ADRY
0037  00043   05600000          NEG
0038  00044   00300002*         STA  WCNT
0039  00045   01400027*         IMS  GRAF
0040  00046   00400005*         STB  SCAL
0041  00047   13200002*   GO    LIX  WCNT,1
0042  00050   01730043          AIP  '43,W
0043  00051   00022016          LSL  18
0044  00052   02200060*         BAZ  GO1-1
0045  00053   03500006*         SMP  FLAG
0046  00054   01100061*         BRU  GO1
0047  00055   00100002*         LAA  WCNT
0048  00056   00300006*         STA  FLAG
0049  00057   41100027*         BRU* GRAF
0050  00060   03300006*         STI  FLAG,0
0051  00061   23200000*   GO1   LIX  KM6,2
0052  00062   41310040    GO2   CEU* '40,W
0053  00063   20000020*         DAC  TBL1,2
0054  00064   41750040          MOP* '40,W
```

```
0055  00065  20000026*          DAC   TBL2,2
0056  00066  23400062*          IIB   GO2,2
0057  00067  01310040           CEU   '40,W
0058  00070  00000251           DAC   '251
0059  00071  00200005*  GO3     LBA   SCAL
0060  00072  40700004*          MPY*  ADRY
0061  00073  00500020*          AMA   TBL1
0062  00074  02700007*          MAA   MSK
0063  00075  00300026*          STA   TBL2
0064  00076  00200005*          LBA   SCAL
0065  00077  40700003*          MPY*  ADRX
0066  00100  00500020*          AMA   TBL1
0067  00101  02700007*          MAA   MSK
0068  00102  00014016           LSL   12
0069  00103  03000010*          MOA   INTN
0070  00104  03000026*          MOA   TBL2
0071  00105  33400107*          IIB   AOPP,3
0072  00106  01100112*          BRU   BRIT
0073  00107  01710040  AOPP    AOP   '40,W
0074  00110  13400071*          IIB   GO3,1
0075  00111  01100047*          BRU   GO
0076  00112  03000011*  BRIT    MOA   INT2
0077  00113  33200002*          LIX   WCNT,3
0078  00114  33400115*          IIB   *&1,3
0079  00115  01100107*          BRU   AOPP
0080                            END
EOJ
```

APPENDIX 4

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

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IDENTIFICATION: SLECTR (subroutine)

AUTHOR: J.K. Pulfer

ACCEPTED: 26 June 1968

PURPOSE: This is a subroutine which displays a list of 8 character names on the CRT display. When one of the names is selected by light pen, it flashes, and on release of the display keyboard, returns with the first four characters of the name in the "A" accumulator.

COMPUTER CONFIGURATION: SEL 840A with digital display

SUBROUTINES REQUIRED: None

STORAGE: 113_8

TIMING: N/A

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USE: Calling sequence is

```
CALL  SLECTR
DAC   NAMT + XXX
DATA  XXX
RETURN HERE
```

Where NAMT is the first address of the name table
XXX is the number of names in the table

The maximum value of N is 16

```
0001                        *  SELECTOR  ****
0002                        *
0003          00000000           NAME  SLECTR,DIRE
0004  00000  00000000     DIRE  ZZZ   **
0005  00001  40100000*          LAA*  DIRE
0006  00002  03000067*          MUA   INDX
0007  00003  00300074*          STA   INIT
0008  00004  01400000*          IMS   DIRE
0009  00005  40100000*          LAA*  DIRE
0010  00006  05600000           NEG
0011  00007  00300066*          STA   SIZE
0012  00010  01400000*          IMS   DIRE
0013  00011  13300072*          STI   SAVI,1
0014  00012  13200066*    LIST  LIX   SIZE,1
0015  00013  00100074*          LAA   INIT
0016  00014  00300026*          STA   ADR
0017  00015  00100071*          LAA   MSK1
0018  00016  01310040     GO    CEU   '40,W
0019  00017  00004251           DAC   '4251
0020  00020  01200075*          SPB   FLSH
0021  00021  01710040           AOP   '40,W
0022  00022  00500065*          AMA   KM2C
0023  00023  01310040           CEU   '40,W
0024  00024  00000701           DAC   '701
0025  00025  41750040           MOP*  '40,W
0026  00026  00000000     ADR   DAC   0
0027  00027  00200073*          LBA   DDD
0028  00030  00400105           STB   '105
0029  00031  40200026*          LBA*  ADR
0030  00032  00400070*          STB   MSK2
0031  00033  01400026*          IMS   ADR
0032  00034  41750040           MOP*  '40,W
0033  00035  40000026*          DAC*  ADR
0034  00036  01310040           CEU   '40,W
0035  00037  00004251           DAC   '4251
0036  00040  14300020           PIE   '20,0
0037  00041  13400016*          IIB   GO,1
0038  00042  01730043           AIP   '43,W
0039  00043  00022016           LSL   18
0040  00044  02200046*          BAZ   *&2
0041  00045  01100012*          BRU   LIST
0042  00046  01730043           AIP   '43,W
0043  00047  00022016           LSL   18
0044  00050  02200046*          BAZ   *-2
0045  00051  00100060*          LAA   TIN
0046  00052  13200072*          LIX   SAVI,1
0047  00053  41100000*          BRU*  DIRE
0048  00054  00000000     IDD   ZZZ   **
0049  00055  00200070*          LBA   MSK2
0050  00056  00400060*          STB   TIN
0051  00057  03600054*          PIR   IDD
0052  00060  00000000     TIN   DAC   0
0053  00061  00014000     INTN  DAC   '14000
0054  00062  00000000     CNT   DAC   0
```

```
0055  00063  00000040     MSQ   DAC   '40
0056  00064  77763777     DARK  DATA  '77763777
0057  00065  77777600     KM2C  DATA  -128
0058  00066  00000000     SIZE  DAC   0
0059  00067  10000000     INDX  DATA  '10000000
0060  00070  10200000     MSK2  LBA   0,1
0061  00071  20017777     MSK1  DATA  '20017777
0062  00072  00000000     SAVI  DAC   0
0063  00073  01200054*    DDD   SPB   IDD
0064  00074  00000000     INIT  DAC   0
0065  00075  00000075*    FLSH  ZZZ   **
0066  00076  40200026*          LBA*  ADR
0067  00077  00000006           IAB
0068  00100  00600060*          SMA   TIN
0069  00101  02200105*          BAZ   BLNK
0070  00102  00000006           IAB
0071  00103  03000061*          MOA   INTN
0072  00104  41100075*          BRU*  FLSH
0073  00105  01400062*    BLNK  IMS   CNT
0074  00106  00100062*          LAA   CNT
0075  00107  02700063*          MAA   MSQ
0076  00110  02200102*          BAZ   BLNK-3
0077  00111  00000006           IAB
0078  00112  02700064*          MAA   DARK
0079  00113  41100075*          BRU*  FLSH
0080                            END
```

```
                                ** CHAIN LOADING SELECTOR **
                                *
                00000000             NAME SLECTR,DIRE
       00000    00000000        DIRE ZZZ  **
       00001    40100000*            LAA* DIRE
       00002    03000070*            MOA  INDX
       00003    00300075*            STA  INIT
       00004    01400000*            IMS  DIRE
       00005    40100000*            LAA* DIRE
       00006    05600000             NEG
       00007    00300067*            STA  SIZE
       00010    01400000*            IMS  DIRE
       00011    13300073*            STI  SAVI,1
       00012    13200067*       LIST LIX  SIZE,1
       00013    00100075*            LAA  INIT
       00014    00300026*            STA  ADR
       00015    00100072*            LAA  MSK1
       00016    01310040        GO   CEU  '40,W
       00017    00004251             DAC  '4251
       00020    01200076*            SPB  FLSH
       00021    01710040             AOP  '40,W
       00022    00500066*            AMA  KM2C
       00023    01310040             CEU  '40,W
       00024    00000701             DAC  '701
       00025    41750040             MOP* '40,W
       00026    00000000        ADR  DAC  0
       00027    00200074*            LBA  DDD
       00030    00400105             STB  '105
       00031    40200026*            LBA* ADR
       00032    00400071*            STB  MSK2
       00033    01400026*            IMS  ADR
       00034    41750040             MOP* '40,W
       00035    40000026*            DAC* ADR
       00036    01310040             CEU  '40,W
       00037    00004251             DAC  '4251
       00040    14300020             PIE  '20,0
       00041    13400016*            IIB  GO,1
       00042    01730043             AIP  '43,W
       00043    00022016             LSL  18
       00044    02200046*            BAZ  *&2
       00045    01100012*            BRU  LIST
       00046    01730043             AIP  '43,W
       00047    00022016             LSL  18
       00050    02200046*            BAZ  *-2
                                     CALL CHAIN
       00052    00000054*            DAC  LDN
       00053    00000061*            DAC  TIN
       00054    00000016        LDN  DAC  '16
       00055    00000000        IDD  ZZZ  **
       00056    00200071*            LBA  MSK2
       00057    00400061*            STB  TIN
       00060    03600055*            PIR  IDD
       00061    00000000        TIN  DAC  0
       00062    00014000        INTN DAC  '14000
```

```
0055  00063  00000000     CNT   DAC   0
0056  00064  00000040     MSQ   DAC   '40
0057  00065  77763777     DARK  DATA  '77763777
0058  00066  77777600     KM2C  DATA  -128
0059  00067  00000000     SIZE  DAC   0
0060  00070  10000000     INDX  DATA  '10000000
0061  00071  10200000     MSK2  LBA   0,1
0062  00072  20017777     MSK1  DATA  '20017777
0063  00073  00000000     SAVI  DAC   0
0064  00074  01200055*    DDD   SPB   IDD
0065  00075  00000000     INIT  DAC   0
0066  00076  00000076*    FLSH  ZZZ   **
0067  00077  40200026*          LBA*  ADR
0068  00100  00000006           IAB
0069  00101  00600061*          SMA   TIN
0070  00102  02200106*          BAZ   BLNK
0071  00103  00000006           IAB
0072  00104  03000062*          MOA   INTN
0073  00105  41100076*          BRU*  FLSH
0074  00106  01400063*    BLNK  IMS   CNT
0075  00107  00100063*          LAA   CNT
0076  00110  02700064*          MAA   MSQ
0077  00111  02200103*          BAZ   BLNK-3
0078  00112  00000006           IAB
0079  00113  02700065*          MAA   DARK
0080  00114  41100076*          BRU*  FLSH
0081                            END
```

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PROGRAM DESCRIPTION

 Catalog No. 1029

IDENTIFICATION: DIRECT (subroutine)

AUTHOR: J.K. Pulfer

ACCEPTED: 20 October 1967

PURPOSE: To plot a variable length list of calls on the digital display and return with the corresponding interrupt branch vector (see POINTR - Cat. No. 1028).

COMPUTER CONFIGURATION: 840A with NRC display, 16 interrupts, light pen

SUBROUTINES REQUIRED: None

STORAGE: 46_8

TIMING: Depends on list length

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USE:

```
CALL DIRECT
DATA Number of 8 char. labels
DAC  ADR1
DAC  ADR2
NEXT INSTRUCTION
```

where ADR1 is the label field of the $(N/2 + 1)^{th}$ item in the list of words, and ADR2 is the label field of the $(N+1)^{th}$ item in the list of branch vectors.

See the description of POINTR (cat. no. 1028) for a complete description of usage.

ADR1 and ADR2 may be either external or internal addresses.

```
0001          00000000          NAME  DIRECT,DIRE
0002  00000   00000000    DIRE  ZZZ   **
0003  00001   14300020          PIE   '20,0
0004  00002   40100000*         LAA*  DIRE
0005  00003   05600000          NEG
0006  00004   00300045*         STA   SIZE
0007  00005   01400000*         IMS   DIRE
0008  00006   40100000*         LAA*  DIRE
0009  00007   03000046*         MOA   INDX
0010  00010   00300052*         STA   INIT
0011  00011   01400000*         IMS   DIRE
0012  00012   40100000*         LAA*  DIRE
0013  00013   03000047*         MOA   MSK2
0014  00014   00300054*         STA   IDD&1
0015  00015   01400000*         IMS   DIRE
0016  00016   13200045*   LIST  LIX   SIZE,1
0017  00017   00100052*         LAA   INIT
0018  00020   00300032*         STA   ADR
0019  00021   00100050*         LAA   MSK1
0020  00022   01310040    GO    CEU   '40,W
0021  00023   00004251          DAC   '4251
0022  00024   01710040          AOP   '40,W
0023  00025   00500044*         AMA   KM32
0024  00026   00500044*         AMA   KM32
0025  00027   01310040          CEU   '40,W
0026  00030   00000701          DAC   '701
0027  00031   41750040          MOP*  '40,W
0028  00032   00000000    ADR   DAC   0
0029  00033   00200051*         LBA   DDD
0030  00034   00400105          STB   '105
0031  00035   01400032*         IMS   ADR
0032  00036   41750040          MOP*  '40,W
0033  00037   40000032*         DAC*  ADR
0034  00040   01310040          CEU   '40,W
0035  00041   00004251          DAC   '4251
0036  00042   13400022*         IIB   GO,1
0037  00043   01100016*         BRU   LIST
0038  00044   77777740    KM32  DATA  -32
0039  00045   00000000    SIZE  DAC   0
0040  00046   10000000    INDX  DATA  '10000000
0041  00047   10200000    MSK2  LBA   0,1
0042  00050   00017777    MSK1  DATA  '17777
0043  00051   01200053*   DDD   SPB   IDD
0044  00052   00000000    INIT  DAC   0
0045  00053   00000000    IDD   ZZZ   **
0046  00054   00200054*         LBA   *
0047  00055   00400105          STB   '105
0048  00056   03600000*         PIR   DIRE
0049                              END
```

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PROGRAM DESCRIPTION

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IDENTIFICATION: LISTER (versions G, & H)

AUTHOR: J.K. Pulfer

ACCEPTED: 2 July 1968

PURPOSE: These two new versions of LISTER add to and improve the flexibility of the previous program. The H version includes the blinking feature as well as presetting of registers. The G version includes blinking only.

COMPUTER CONFIGURATION:

SUBROUTINES REQUIRED: (H version only -- SAVE, RESTOR, CLEAR, NEW)

STORAGE: LISTER H 162_8

LISTER G 130_8

TIMING:

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USE: LISTER is called as follows:

```
LBA  positive or negative flag
CALL LISTER
DATA N
DAC  ADR 1 + N
DAC  ADR 2 + N
```

where N is the number of 8 char labels in the list and ADR1 and ADR2 may be either external or internal addresses of the first locations of associated label and branch tables.

LISTER will behave as follows:

1) IF the word in B is positive when LISTER is called, behaviour is just the same as for DIRECT (Cat. # 1029). i.e., on selection of a word in the list with the light pen, control will be returned to the calling program and address 105_8 will contain the SPB to the desired interrupt routine (obtained from the branch table).
2) IF the word in B is negative when LISTER is called, then when an item in the list is selected with the light pen, the corresponding instruction in the branch table is immediately executed. Thus, the branch table may contain BRU, SPB or other instructions.

   If the instruction executed is not a branch, then control will be returned to the program which called LISTER after the instruction or routine is executed.

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USE: A choice with the light pen will cause only the chosen name to flash and will execute the chosen instruction when any button on the display keyboard is pressed and released.

In the H version of LISTER, the calling sequence is:

```
LBA  FLAG
CALL LISTER
DATA No. of Labels (N)
DAC  ADR1 + N
DAC  ADR2 + N
```

where FLAG is interpreted by LISTER as follows:

FLAG is positive - behave as DIRECT
FLAG = -1 - behave as ordinary LISTER
FLAG = -2 - save registers on entry and restore before exit
FLAG = -3 - Preset registers from $NEWA, $NEWB, etc. before exit.
FLAG = -4 - Clear all registers before exit.

These choices will allow LISTER to initiate any program with any desired initial conditions.

```
0001                        *    G VERSION OF LISTER *****
0002                        *
0003          00000000           NAME LISTER,DIRE
0004   00000  00000000     DIRE  ZZZ  **
0005   00001  40100000*           LAA* DIRE
0006   00002  05600000           NEG
0007   00003  00300106*           STA  SIZE
0008   00004  01400000*           IMS  DIRE
0009   00005  40100000*           LAA* DIRE
0010   00006  03000107*           MOA  INDX
0011   00007  00300116*           STA  INIT
0012   00010  01400000*           IMS  DIRE
0013   00011  40100000*           LAA* DIRE
0014   00012  03000110*           MOA  MSK2
0015   00013  00300074*           STA  IDD&1
0016   00014  01400000*           IMS  DIRE
0017   00015  00400113*           STB  FLAG
0018   00016  13300114*           STI  SAVI,1
0019   00017  13200106*     LIST  LIX  SIZE,1
0020   00020  00100116*           LAA  INIT
0021   00021  00300035*           STA  ADR
0022   00022  00100111*           LAA  MSK1
0023   00023  03500113*           SMP  FLAG
0024   00024  00100112*           LAA  MSK3
0025   00025  01310040      GO    CEU  '40,W
0026   00026  00004251           DAC  '4251
0027   00027  01200117*           SPB  FLSH
0028   00030  01710040           AOP  '40,W
0029   00031  00500105*           AMA  KM2C
0030   00032  01310040           CEU  '40,W
0031   00033  00000701           DAC  '701
0032   00034  41750040           MOP* '40,W
0033   00035  00000000     ADR   DAC  0
0034   00036  00200115*           LBA  DDD
0035   00037  00400105           STB  '105
0036   00040  01400035*           IMS  ADR
0037   00041  41750040           MOP* '40,W
0038   00042  40000035*           DAC* ADR
0039   00043  01310040           CEU  '40,W
0040   00044  00004251           DAC  '4251
0041   00045  14300020           PIE  '20,0
0042   00046  00000022           NOP
0043   00047  04300020           PID  '20,0
0044   00050  13400025*           IIB  GO,1
0045   00051  01720043           AIP  '43
0046   00052  01100051*           BRU  *-1
0047   00053  02700102*           MAA  M77
0048   00054  02200056*           BAZ  *&2
0049   00055  01100017*           BRU  LIST
0050   00056  01720043           AIP  '43
0051   00057  01100056*           BRU  *-1
0052   00060  02700102*           MAA  M77
0053   00061  02200056*           BAZ  *-3
0054   00062  03500113*           SMP  FLAG
```

```
0055  00063  01100070*          BRU  *&5
0056  00064  00200077*          LBA  TIN
0057  00065  13200114*          LIX  SAVI,1
0058  00066  00400105           STB  '105
0059  00067  41100000*          BRU* DIRE
0060  00070  01600077*  EXEC    EXU  TIN
0061  00071  13200114*          LIX  SAVI,1
0062  00072  41100000*          BRU* DIRE
0063  00073  00000000   IDD     ZZZ  **
0064  00074  00200074*          LBA  *
0065  00075  00400077*          STB  TIN
0066  00076  03600073*          PIR  IDD
0067  00077  00000000   TIN     DAC  0
0068  00100  00014000   INTN    DAC  '14000
0069  00101  00000000   CNT     DAC  0
0070  00102  00000077   M77     DAC  '77
0071  00103  00000040   MSQ     DAC  '40
0072  00104  77763777   DARK    DATA '77763777
0073  00105  77777600   KM2C    DATA -128
0074  00106  00000000   SIZE    DAC  0
0075  00107  10000000   INDX    DATA '10000000
0076  00110  10200000   MSK2    LBA  0,1
0077  00111  00017777   MSK1    DATA '17777
0078  00112  20017777   MSK3    DATA '20017777
0079  00113  00000000   FLAG    DAC  0
0080  00114  00000000   SAVI    DAC  0
0081  00115  01200073*  DDD     SPB  IDD
0082  00116  00000000   INIT    DAC  0
0083  00117  00000117*  FLSH    ZZZ  **
0084  00120  01600074*          EXU  IDD&1
0085  00121  00000006           IAB
0086  00122  00600077*          SMA  TIN
0087  00123  02200127*          BAZ  BLNK
0088  00124  00000006           IAB
0089  00125  03000100*          MOA  INTN
0090  00126  41100117*          BRU* FLSH
0091  00127  01400101*  BLNK    IMS  CNT
0092  00130  00100101*          LAA  CNT
0093  00131  02700103*          MAA  MSQ
0094  00132  02200124*          BAZ  BLNK-3
0095  00133  00000006           IAB
0096  00134  02700104*          MAA  DARK
0097  00135  41100117*          BRU* FLSH
0098                            END
```

```
0001                                ** H VERSION OF LISTER**
0002                                *
0003          00000000              NAME LISTER,DIRE
0004  00000  00000000     DIRE     ZZZ  **
0005                                CALL SAVE
0006  00002  40100000*              LAA* DIRE
0007  00003  05600000               NEG
0008  00004  00300131*              STA  SIZE
0009  00005  01400000*              IMS  DIRE
0010  00006  40100000*              LAA* DIRE
0011  00007  03000132*              MOA  INDX
0012  00010  00300141*              STA  INIT
0013  00011  01400000*              IMS  DIRE
0014  00012  40100000*              LAA* DIRE
0015  00013  03000133*              MOA  MSK2
0016  00014  00300117*              STA  IDD&1
0017  00015  01400000*              IMS  DIRE
0018  00016  00400136*              STB  FLAG
0019  00017  03300125*              STI  FLG,0
0020  00020  01310002               CEU  '2,W
0021  00021  01000000               DATA '1000000
0022  00022  13300137*              STI  SAVI,1
0023  00023  13200131*     LIST     LIX  SIZE,1
0024  00024  00100141*              LAA  INIT
0025  00025  00300041*              STA  ADR
0026  00026  00100134*              LAA  MSK1
0027  00027  03500136*              SMP  FLAG
0028  00030  00100135*              LAA  MSK3
0029  00031  01310040     GO       CEU  '40,W
0030  00032  00004251               DAC  '4251
0031  00033  01200142*              SPB  FLSH
0032  00034  01710040               AOP  '40,W
0033  00035  00500130*              AMA  KM2C
0034  00036  01310040               CEU  '40,W
0035  00037  00000701               DAC  '701
0036  00040  41750040               MOP* '40,W
0037  00041  00000000     ADR      DAC  0
0038  00042  00200140*              LBA  DDD
0039  00043  00400105               STB  '105
0040  00044  01400041*              IMS  ADR
0041  00045  41750040               MOP* '40,W
0042  00046  40000041*              DAC* ADR
0043  00047  01310040               CEU  '40,W
0044  00050  00004251               DAC  '4251
0045  00051  14300020               PIE  '20,0
0046  00052  00000022               NOP
0047  00053  13400031*              IIB  GO,1
0048  00054  01730043               AIP  '43,W
0049  00055  00022016               LSL  18
0050  00056  02200060*              BAZ  *&2
0051  00057  01100023*              BRU  LIST
0052  00060  01730043               AIP  '43,W
0053  00061  00022016               LSL  18
0054  00062  02200060*              BAZ  *-2
```

```
0055  00063  03500136*          SMP   FLAG
0056  00064  01100071*          BRU   *&5
0057  00065  00200122*          LBA   TIN
0058  00066  13200137*          LIX   SAVI,1
0059  00067  00400105           STB   '105
0060  00070  41100000*          BRU*  DIRE
0061  00071  03500125*          SMP   FLG
0062  00072  01100076*          BRU   *&4
0063  00073  13200131*          LIX   SIZE,1
0064  00074  01600117*          EXU   IDD&1
0065  00075  00400122*          STB   TIN
0066  00076  00100136*          LAA   FLAG
0067  00077  05600000           NEG
0068  00100  45600000           NEG*
0069  00101  02200113*          BAZ   EXEC
0070  00102  45600000           NEG*
0071  00103  02200112*          BAZ   REST
0072  00104  45600000           NEG*
0073  00105  02200110*          BAZ   PRES
0074                            CALL  CLEAR
0075  00107  01100113*          BRU   EXEC
0076                      PRES  CALL  PRESET
0077  00111  01100113*          BRU   EXEC
0078                      REST  CALL  RESTOR
0079  00113  01600122*  EXEC    EXU   TIN
0080  00114  13200137*          LIX   SAVI,1
0081  00115  41100000*          BRU*  DIRE
0082  00116  00000000    IDD   ZZZ   **
0083  00117  00200117*          LBA   *
0084  00120  00400122*          STB   TIN
0085  00121  03600116*          PIR   IDD
0086  00122  00000000    TIN   DAC   0
0087  00123  00014000    INTN  DAC   '14000
0088  00124  00000000    CNT   DAC   0
0089  00125  00000000    FLG   DAC   0
0090  00126  00000040    MSQ   DAC   '40
0091  00127  77763777    DARK  DATA  '77763777
0092  00130  77777600    KM2C  DATA  -128
0093  00131  00000000    SIZE  DAC   0
0094  00132  10000000    INDX  DATA  '10000000
0095  00133  10200000    MSK2  LBA   0,1
0096  00134  00017777    MSK1  DATA  '17777
0097  00135  20017777    MSK3  DATA  '20017777
0098  00136  00000000    FLAG  DAC   0
0099  00137  00000000    SAVI  DAC   0
0100  00140  01200116*   DDD   SPB   IDD
0101  00141  00000000    INIT  DAC   0
0102  00142  00000142*   FLSH  ZZZ   **
0103  00143  01600117*          EXU   IDD&1
0104  00144  00000006          IAB
0105  00145  00600122*          SMA   TIN
0106  00146  02200152*          BAZ   BLNK
0107  00147  00000006          IAB
0108  00150  03000123*          MOA   INTN
```

```
0109  00151  41100142*          BRU* FLSH
0110  00152  01400124*  BLNK    IMS  CNT
0111  00153  00100130*          LAA  KM2C
0112  00154  00300125*          STA  FLG
0113  00155  00100124*          LAA  CNT
0114  00156  02700126*          MAA  MSQ
0115  00157  02200147*          BAZ  BLNK-3
0116  00160  00000006           IAB
0117  00161  02700127*          MAA  DARK
0118  00162  41100142*          BRU* FLSH
0119                            END
```

DATA SYSTEMS PROGRAM LIBRARY

PROGRAM DESCRIPTION

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IDENTIFICATION: POINTR (subroutine)

AUTHOR: J.K. Pulfer

ACCEPTED: 20 October 1967

PURPOSE: To list a number of choices on the digital display and when a choice is made with the light pen, to return to the calling program with the corresponding interrupt branch instruction stored in the light pen branch location.

COMPUTER CONFIGURATION: 840A with NRC 840A, 16 interrupts and a light pen

SUBROUTINES REQUIRED: TABLE1 and TABLE2

STORAGE: 31_8

TIMING: approx. 60 scans/second

DATA SYSTEMS PROGRAM LIBRARY

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USE:

```
        CALL POINTR
        NEXT INSTRUCTION
```

The subroutines TABLE1 and TABLE2 should have the following format:

```
        NAME TABLE1,TAL1
        NAME TABLE2,TAL2
        DATA ''LABEL 1LABLE  2LABEL  3LABEL  4''
        DATA ''LABEL 5LABEL  6LABEL  7LABEL  8''
        DATA ''etc. etc.                     ''
        DATA ''etc.                          ''
TAL1    DATA ''LABEL17LABEL 18LABEL 19LABEL 20''
        DATA ''LABEL21LABEL 22LABEL  etc.    ''
        DATA ''etc. etc.                     ''
        DATA ''                       LABEL 32''
        NOP
        SPB  $INT  1
        SPB  $INT  2
        SPB  $INT  3
        etc. etc.
        .
        .
        .
        SPB  $INT 32
TAL2    DAC  0
        END
$
```

DATA SYSTEMS PROGRAM LIBRARY

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DESCRIPTION:

POINTR is a pseudo monitor routine which allows a program user to select the function to be performed when a light pen interrupt is generated.
As an example, suppose the first label in TABLE1 is ROTATE.. (it must be 8 characters),. then the corresponding interrupt routine INT..1 would be selected by pointing the light pen at ROTATE. Then, on returning to the main program, if the light pen were pointed at a picture element, INT..1 would be executed (once or many times depending on whether or not it included a latch) and the desired rotation would be accomplished.

Again -- the list of functions is stored in TABLE1 with each label consisting of 8 characters, and 32 labels in all (some may, of course, be blanks).
The corresponding interrupt branch vectors (store place and branch instructions) are stored in TABLE2

A more general purpose routine in which the table calls and number of elements are brought in the call sequence will also be available as DIRECT.

```
       00000000       NAME POINTR,POIN
00000  00000000  POIN ZZZ  **
00001  14300020       PIE  '20,0
00002  13200026* LIST LIX  KM32,1
00003  00100031*      LAA  INIT
00004  00300016*      STA  ADR
00005  00100027*      LAA  MSK1
00006  01310040  GO   CEU  '40,W
00007  00004251       DAC  '4251
00010  01710040       AOP  '40,W
00011  00500026*      AMA  KM32
00012  00500026*      AMA  KM32
00013  01310040       CEU  '40,W
00014  00000701       DAC  '701
00015  41750040       MOP* '40,W
00016  10000000  ADR  DAC  $TABLE1,1
00017  00200030*      LBA  DDD
00020  00400105       STB  '105
00021  01400016*      IMS  ADR
00022  41750040       MOP* '40,W
00023  40000016*      DAC* ADR
00024  13400006*      IIB  GO,1
00025  01100002*      BRU  LIST
00026  77777740  KM32 DATA -32
00027  00017777  MSK1 DATA '17777
00030  01200032* DDD  SPB  IDD
00031  10000000  INIT DAC  $TABLE1,1
00032  00000000  IDD  ZZZ  **
00033  10200000       LBA  $TABLE2,1
00034  00400105       STB  '105
00035  03600000*      PIR  POIN
                      END
```