NASA CONTRACTOR
REPORT

NASA CR-149965

(NASA-CR-149965) SIGMA 2 GRAPHIC DISPLAY SOFTWARE PROGRAM DESCRIPTION (M&S Computing, Inc., Huntsville, Ala.) 107 p HC $5.50 CSCL 09B G3/61

N76-30846

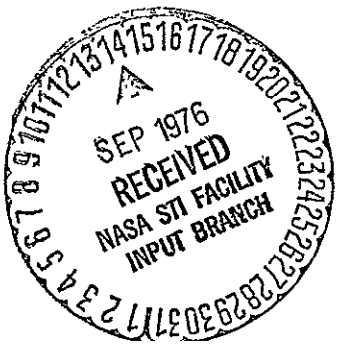
Unclas 50392

SIGMA 2 GRAPHIC DISPLAY SOFTWARE PROGRAM DESCRIPTION

By B. T. Johnson

M&S Computing, Inc.
P. O. Box 5183
Huntsville, Alabama 35805

January 19, 1973



Prepared for
NASA - GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-149965		

4 TITLE AND SUBTITLE	5. REPORT DATE
SIGMA 2 GRAPHIC DISPLAY SOFTWARE PROGRAM DESCRIPTION	January 19, 1973
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT #
B. T. Johnston	73-0003
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
M&S Computing, Inc. P.O. Box 5183 Huntsville, AL 35805	11. CONTRACT OR GRANT NO. NAS8-25621
12 SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT & PERIOD COVERED
National Aeronautics and Space Administration Marshall Space Flight Center, Alabama 35812	Contractor Report
	14. SPONSORING AGENCY CODE EC45

15. SUPPLEMENTARY NOTES

Electronics Development Division, Electronics and Control Laboratory
Design Techniques Branch

16. ABSTRACT

Under the direction of NASA contract NAS8-25621, M&S Computing has implemented a general purpose, user oriented graphic support package. This document contains a comprehensive description of the two software components comprising the graphic support package: Display Librarian and Display Controller. These programs have been implemented in FORTRAN on the XDS Sigma 2 Computer Facility at Marshall Space Flight Center. This facility consists of an XDS Sigma 2 general purpose computer coupled to a Computek Display Terminal.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
	Unclassified-Unlimited COR: John M. Gould EC01 R.M. Aden for F.B. Moore Director, E&C Lab

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	95	NTIS

TABLE OF CONTENTS

1. INTRODUCTION

This document describes the graphic display software package developed by M&S Computing, Inc. for the Astrionics Laboratory Technology Division's computer facility. This facility consists of an XDS SIGMA 2 computer and a Computek/400 CRT Display System.

Since the primary user of this facility will be an engineer rather than a computer specialist, the Computek Display provides an ideal method for efficient user oriented, two-way communication between the engineer and the system. This communication is achieved through the use of the graphic display software which provides the interface between the application programs operating in the Sigma 2 computer and the Computek display unit through which the user communicates with the system. Figure 1-1 presents the general flow of communication between the application program, the user at the display and the Display Controller.

The graphic display software is defined in detail in Sections 2 and 3 of this document and, in order to facilitate program maintenance or modification, detail program flowcharts are included in Appendices A and B; however, a brief description will be given here in order to provide a general introduction to the functions performed by the software package. The display software consists of two distinct components interacting to form a highly flexible graphics capability. The two software components are:

- The Display Librarian (Section 2), an off-line Sigma 2 program which performats the application oriented displays and from them creates a Display Library to be accessed by the Display Controller during real time operation. Detailed flowcharts of the Display Librarian are included in Appendix A.

- The Display Controller (Section 3), residing in the Sigma 2 computer, which coordinates all communication between the operator at the graphics terminal and the application program executing within the Sigma 2 computer. Detailed flowcharts of the Display Controller are contained in Appendix B.

COMMUNICATION FLOW

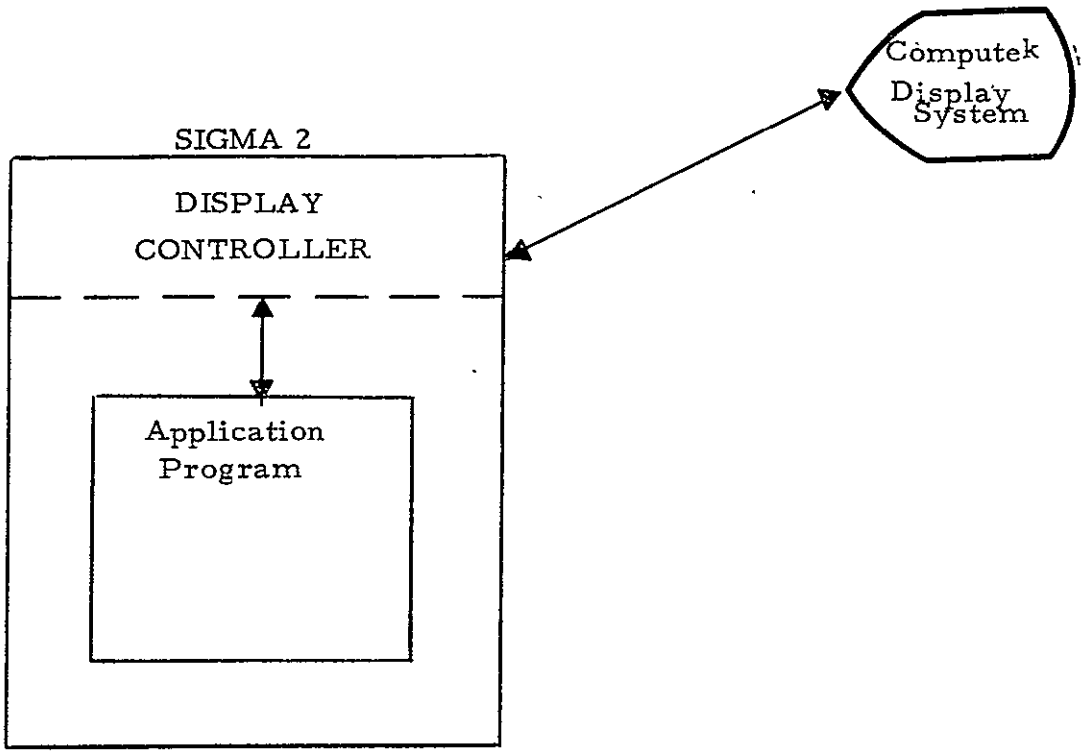


Figure 1-1

2. DISPLAY LIBRARIAN

To minimize the on-line core and time requirements necessary to create each individual application program oriented display and to provide a completely general graphics capability, all displays are preformatted by an off-line Display Librarian. The Librarian accepts card images of the text and control information defining each display and creates a "book" of displays.

The display book resides on disk and contains a display chapter for each display within the book. A display index is generated by the Librarian defining the location of each display chapter within the display book. Each display chapter is further sub-divided into four "pages":

- Text Page
- Pen Page
- Keyboard Page
- Fill Page

The text page of each display chapter contains display text information in an expanded format consisting of embedded graphic control commands. The text page exists in a format which is ready for immediate generation on the display screen and requires no editing, scanning, or unpacking in real time. The pen, keyboard and fill pages of each chapter provide the control information needed by the real time Display Controller to respond to tablet pen and keyboard inputs and application program fill-in requests.

Figure 2-1 presents the process by which the display book is generated and the organization of the display chapters and the display index on disk. In addition to creating the display book, the Display Librarian creates a printed listing of the text page of each display which represents the picture that will be seen on the display screen.

2.1 Display Assembly and Generation

In order to create the preformatted display book, it is necessary for the Display Librarian to perform extensive error checking on the users' input data prior to creating the display chapter on disk to insure that the data can be correctly displayed and operated on during real-time operations. The Librarian can therefore serve as a display assembler and aid the user in defining his displays. During the processing of a display, records that contain errors are listed along with messages describing the errors. Each display must be completely free of errors before it is added to the display book on disk.

DISPLAY GENERATION

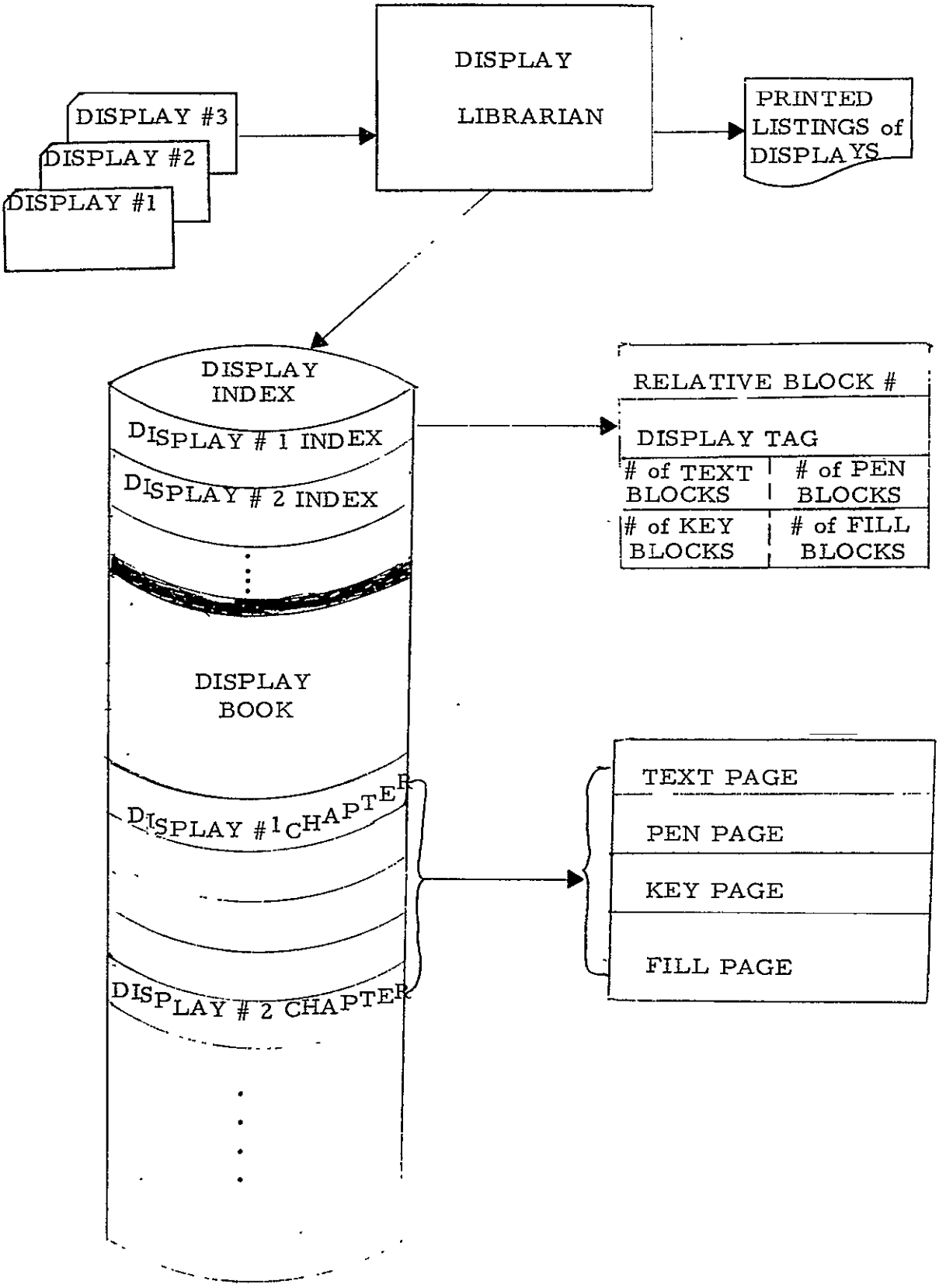


Figure 2-1

Once the users' input data is free of errors, the Display Librarian creates an entry in the display index for this display and generates a display chapter consisting of four "pages": the text page, the pen page, the keyboard page, and the fill page.

2.1.1 Display Index

The Display Index is a separate file on disk that defines the location of each display chapter within the display book file. The display index is segmented into 90-word blocks and the format of the index is presented in Figure 2-2.

The relative block number of the display chapter is the relative block number within the display book file and the block number of the first text page block. The blocks within a display chapter are organized sequentially in the order: text blocks, pen blocks, key blocks, and fill blocks. If any of the blocks are not required for a display, the appropriate display index entry is set to zero. The display name is an integer between 1 and 9999 defined by the users' input card.

The Display Controller reads the display index file sequentially, locates the appropriate display chapter index by virtue of the display name, and then uses the relative block number of the display chapter to access the display within the display book file.

2.1.2 Display Book

The display book is a randomly organized file on disk consisting of a display chapter for each display within the book. The display chapters are further sub-divided into four "pages": the text page, the pen page, the keyboard page, and the fill page. Each display chapter will always contain a text page and may contain any or all of the other three pages. The pages are segmented into 90-word blocks.

2.1.2.1 Text Page

The text page contains the information that is to be displayed to the operator. This information consists of embedded graphic orders, character control orders, alphanumeric information and special symbols that have meaning to the operator and the Display Controller. The "#" symbol defined by the user input indicates locations where an application program may fill-in tabular data. The "#" symbol is replaced by a blank within the text page when a display is presented to eliminate the need to refresh the entire display picture when an application sends data to the screen. The data is displayed in the format initially defined by the "#" symbols.

DISPLAY INDEX FORMAT

16 bit word

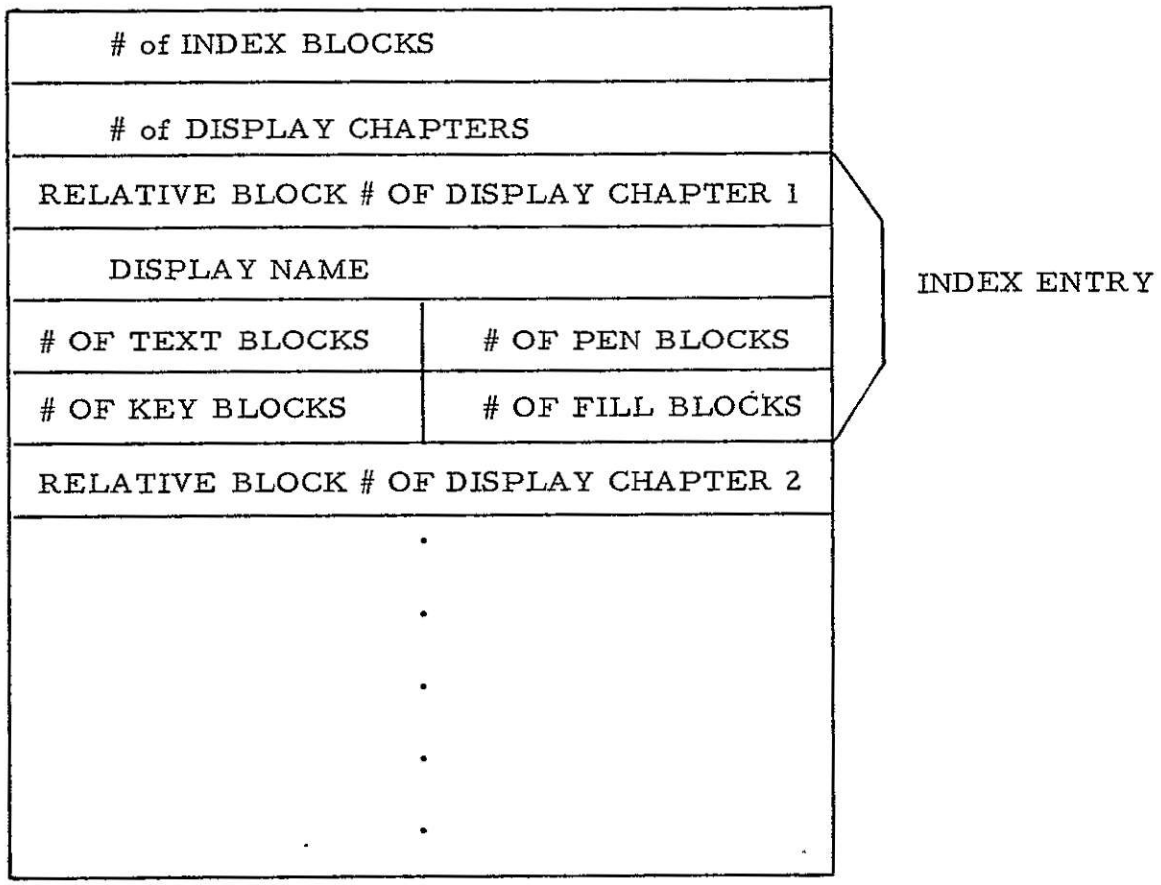


Figure 2-2

The "|" symbol is replaced by an underline (_) character within the text page and display picture. The pen option areas are defined to the Librarian as the area between the two enclosing symbols "<" and ">". The characters within the symbols are displayed on the display picture and comprise one pen option area.

In addition, four character sizes are supported by the Display Librarian and character control orders are defined within the text page to display the different sizes. Any combination of the character sizes may be defined for a display and the Librarian will insure the correct spacing both horizontally and vertically. Since the line printer supports only one character size, a method of representing the various sizes on the printed listing of the display was devised as follows:

- Character size 1 - 1 column x 1 line
- Character size 2 - 2 columns x 2 lines
- Character size 3 - 3 columns x 3 lines
- Character size 4 - 4 columns x 4 lines

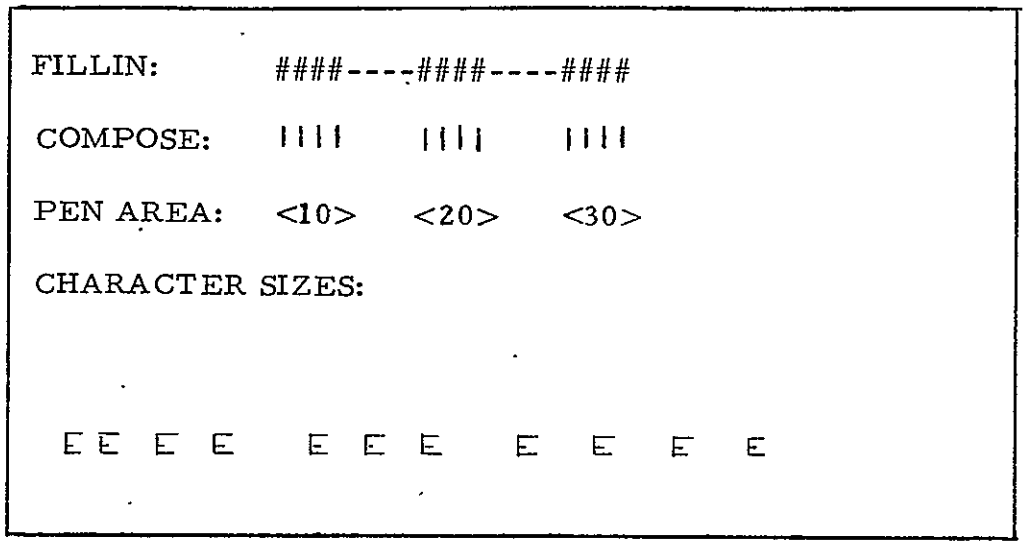
Figure 2-3 illustrates the differences between the display printout and the display picture with respect to the special symbols and the character sizes. Figures 2-4 through 2-6 present the general format of the three basic display configurations. Many different variations of each type of display format may exist in the book; each one is suited to different user requirements.

2.1.2.2 Pen Page

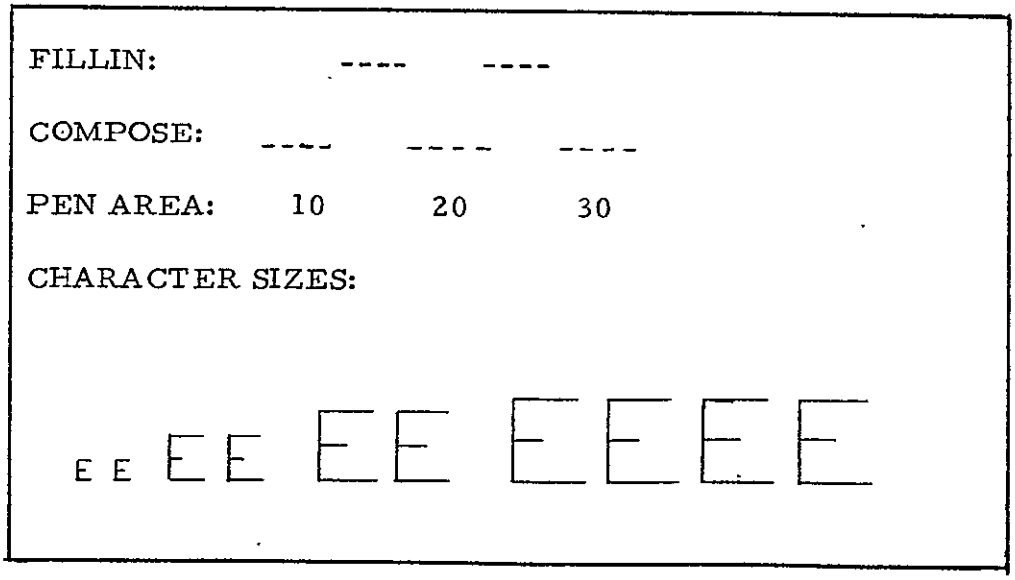
The pen page of the display chapter contains the control information necessary to define the areas of the display text that may be selected with the graphics tablet pen. The format of the pen page is depicted in Figure 2-7. Each pen entry is 6 words in length consisting of:

- The character size and the number of characters within the pen field.
- The next display to be presented to the user when this pen field option is selected with the tablet pen.
- An optional 4-character application program name to be given control when this pen field is selected.
- The X, Y coordinate of the first character within the pen field.

DISPLAY PRINT-OUT VS. DISPLAY PICTURE



DISPLAY PRINT-OUT

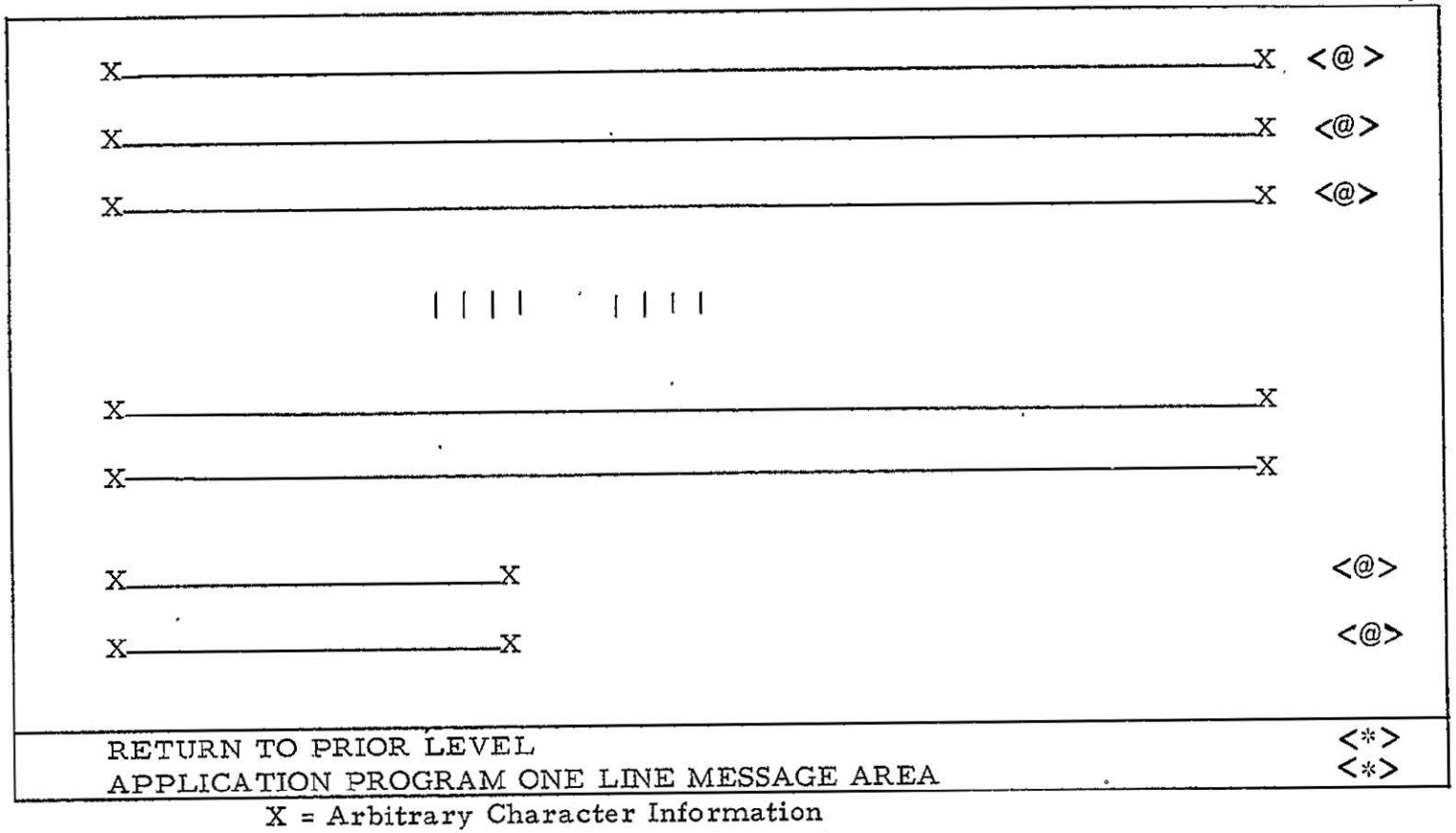


DISPLAY PICTURE

Figure 2-3

TYPICAL CONTROL DISPLAY FORMAT

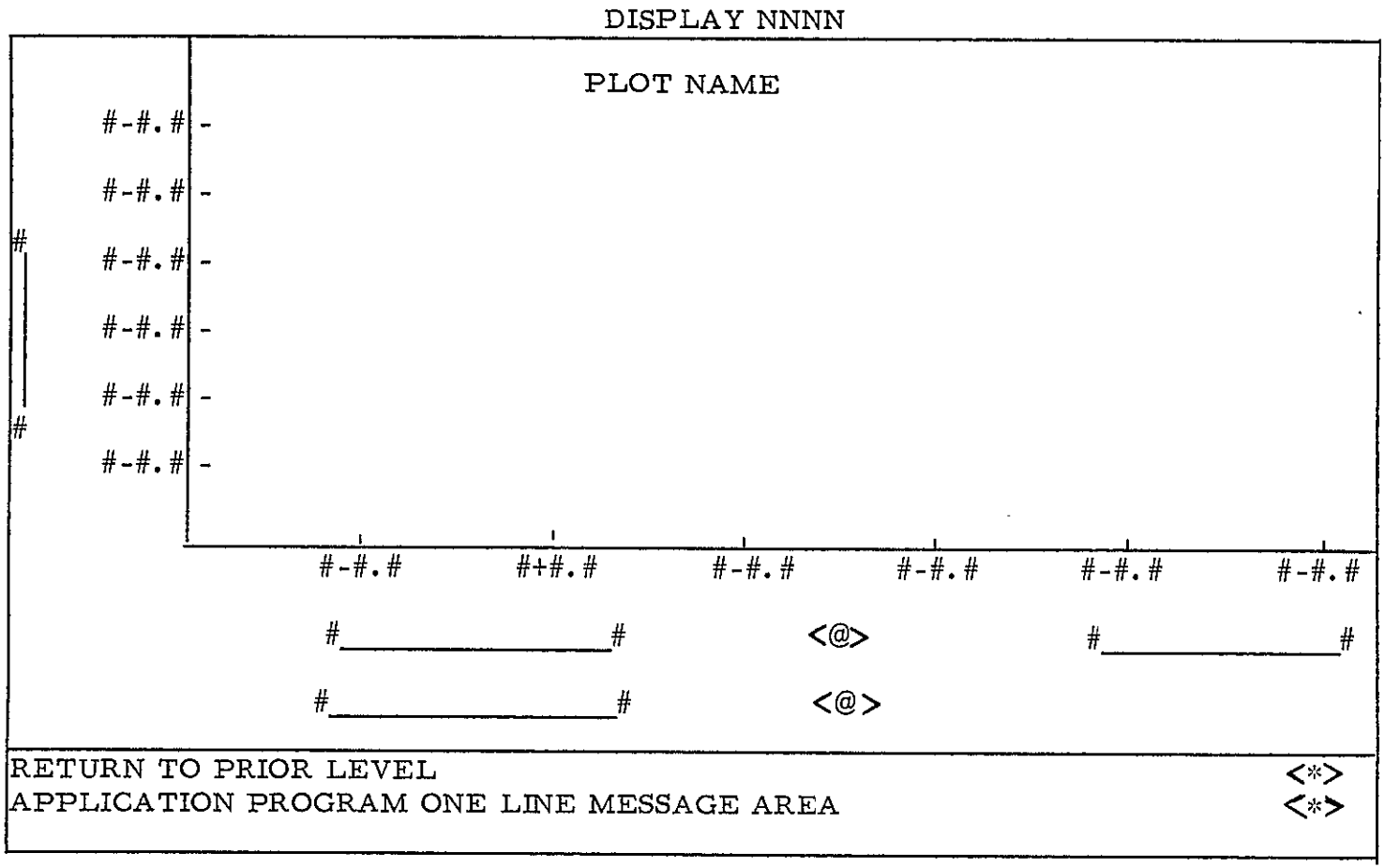
DISPLAY NNNN



X = Arbitrary Character Information

Figure 2-4

TYPICAL PLOT DISPLAY FORMAT



Message Area

Figure 2-5

TYPICAL IMAGE DESIGN DISPLAY FORMAT

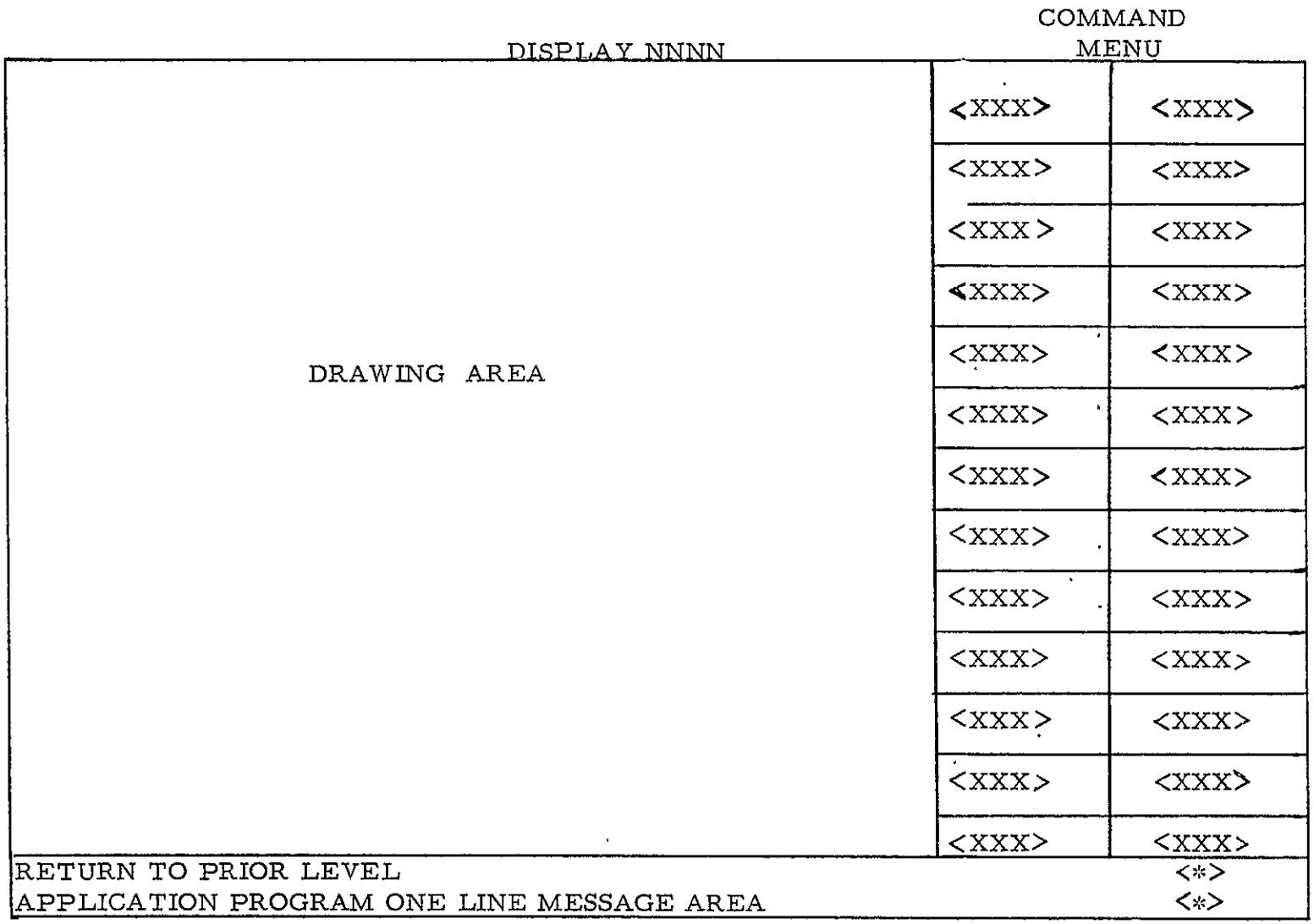


Figure 2-6

PEN PAGE FORMAT

(16 bit word)

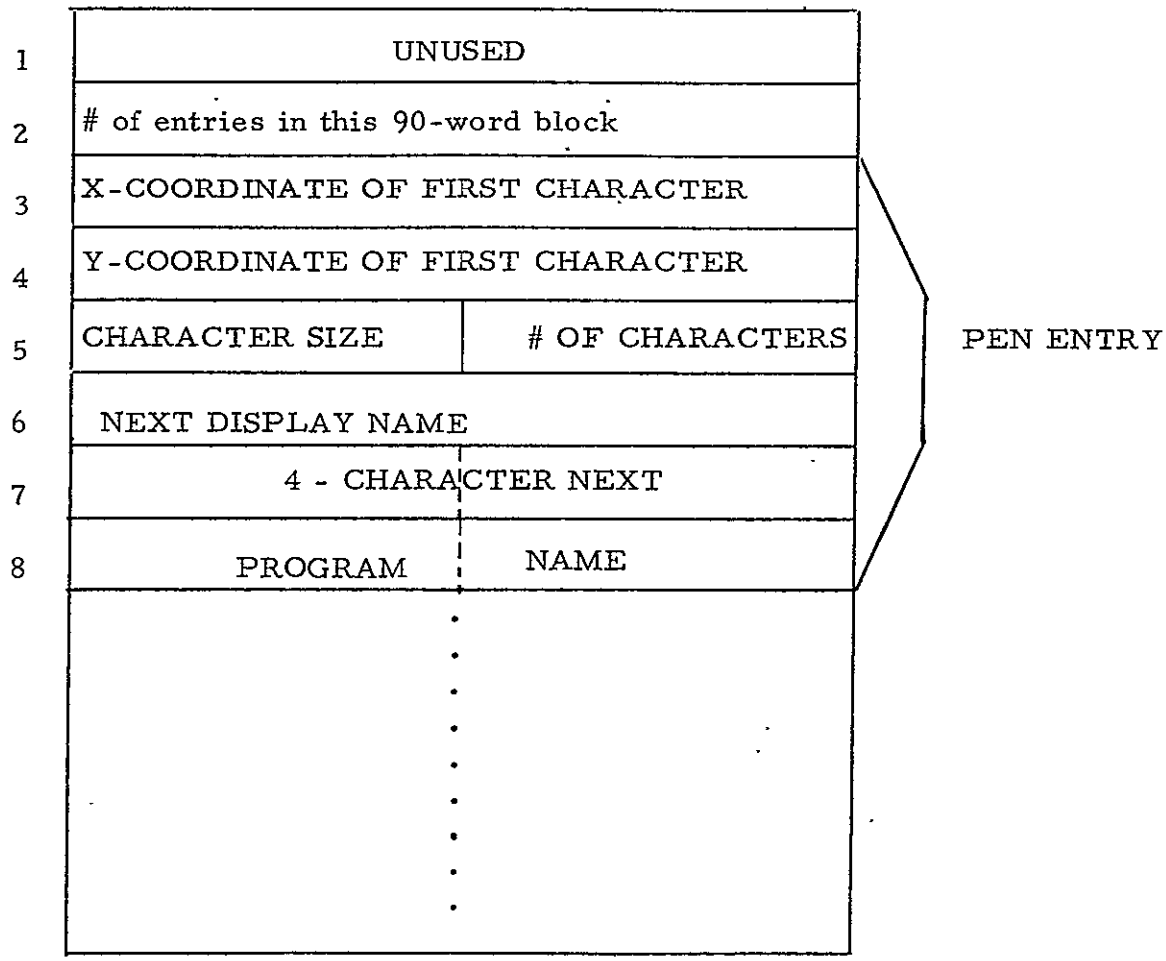


Figure 2-7

The Display Controller determines the dimensions of the pen field from the starting X, Y coordinates of the first character, the character size and the number of characters in the field. When the tablet pen input is received, its coordinates are checked against the dimensions of each pen field within the pen page to determine which option was selected. On finding the selected option, the next display and next program associated with the pen field are displayed and executed, respectively.

2.1.2.3 Keyboard Page

The Computek keyboard permits the user to enter alphanumeric characters into computer storage for transmission to the application program. The cursor keys on the Computek keyboard control the compose field where the data will be placed. As each character is entered, it is displayed to the operator in one of the character slots indicated by the underline(_) character for verification and editing. After entering the data, the user presses the transmission key to pass the data to the application program associated with the compose field.

The keyboard page contains the following control information for each compose field within the display text (see Figure 2-8):

- The total number of characters within the compose field.
- The number of sub-fields within the compose field and the definition of each sub-field as to character size, number of characters, X, Y coordinate of the first character within the sub-field and the relative character number within the total compose field.
- The next display name to be presented to the operator.
- The next program name to receive the compose data.
- The control data to allow the Display Controller to legality check and format the data for the application program.

2.1.2.4 Fill Page

All areas of the display text that are available for application program tabular data output must be predefined to the Display Librarian by the special symbol "#". The Librarian constructs a fill page entry for each of these areas defining their location within the display text. Each fill entry is delimited by either a non-# symbol or a new display line. The format of the fill page is depicted in Figure 2-9.

KEYBOARD PAGE FORMAT

(16 Bit Words)

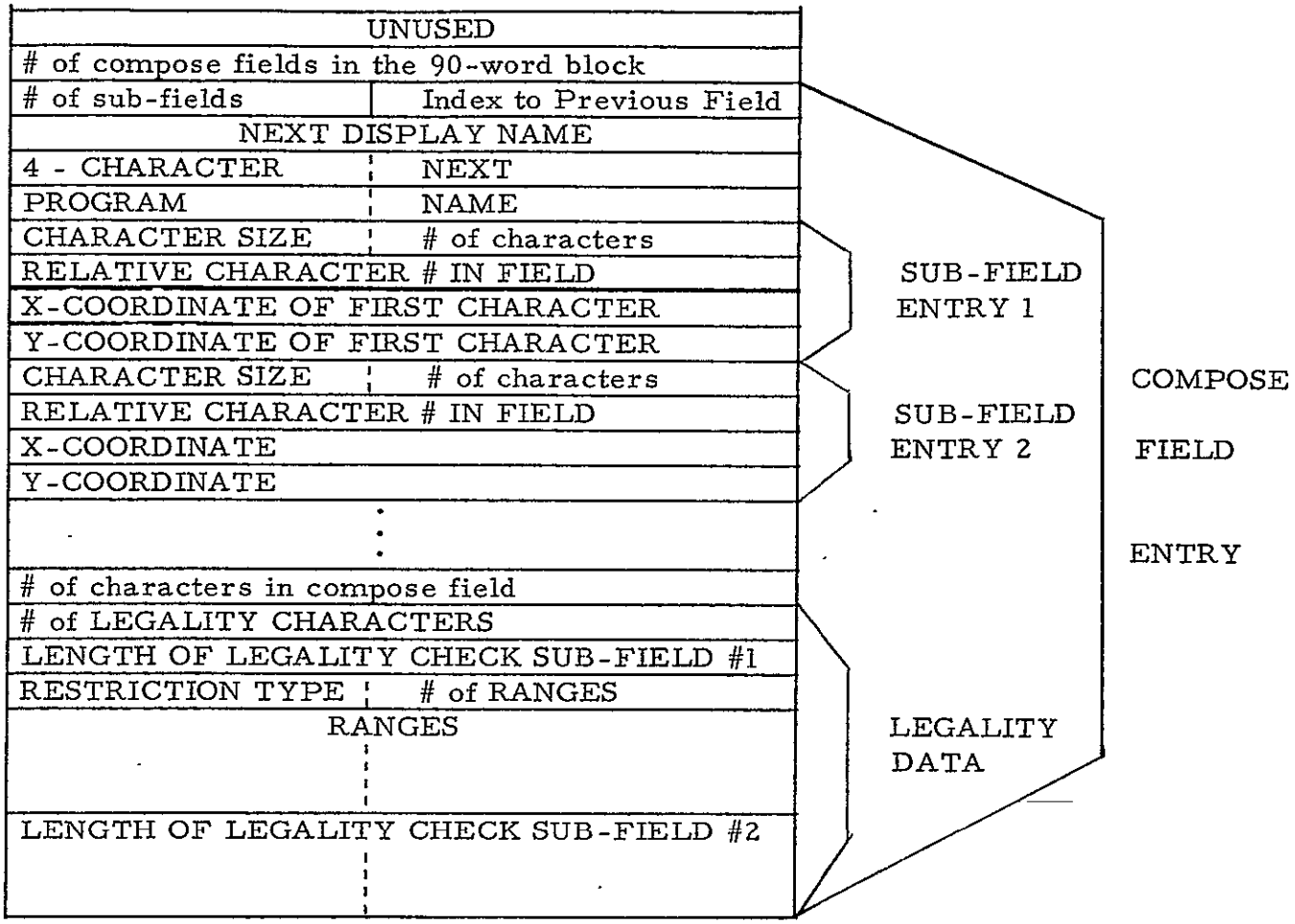


Figure 2-8

FILL PAGE FORMAT

(16 bit words)

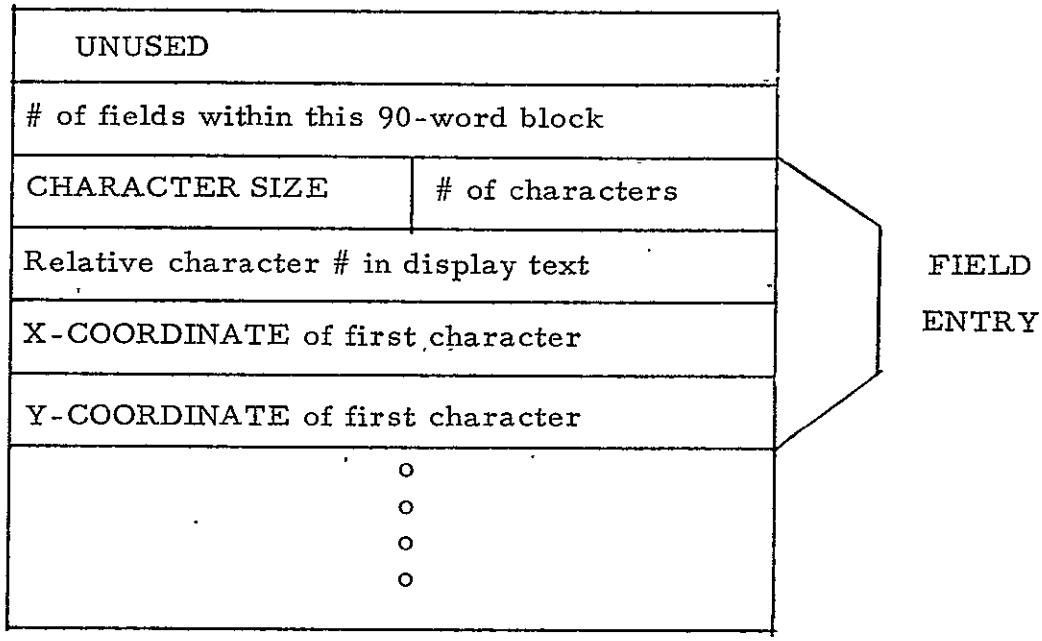


Figure 2-9

2.2 Input Requirements

The pages which make up the display chapter on disk are generated from the user's input data. The following subsections give the necessary display data formatting details required to enable the application programmer to design his displays.

2.2.1 Control Records

Two control records are defined to allow the user to override the standard input and output assignments. These records are not required for the generation of a display and their presence in the users' input data set is therefore optional. The standard input and output assignments to the Display Librarian are:

- Input - source deck from the card reader
- Output - printed listing of the displays

2.2.1.1 Input Option Card (I)

I$\not\emptyset$U - Column 1 contains the identifier "I" followed by a blank in column 2. Column 3 contains the logical unit number of the tape drive on which the input tape is mounted.

The INPUT OPTION card is used to designate that the data records defining the displays are to be input from tape. The tape must be in 80-character card image format. If the INPUT OPTION card is omitted, the Librarian will assume that the data records are to be read from the card reader.

2.2.1.2 Output Option Card (O)

O$\not\emptyset$S, P, L, U - Column 1 contains the identifier "O" followed by a blank in column 2. The first option must be entered in column 3 and additional options must be separated by commas. The options are:

S - list the source cards.

P - print the formatted display(s) on the line printer.

L - create a new display library from the display(s).

U - update an existing display library by adding and/or deleting displays.

The OUTPUT OPTION card selects the type of output desired by the user. It may contain one or more of the options described above. If the OUTPUT OPTION card is not included in the input deck, the Librarian will assume the "P" option.

When the "L" or "U" option is selected, displays will be written to the display library only if no errors are detected in the source card input. All errors will result in error messages being printed, regardless of the output options selected.

2.2.2 Data Records

The data records are used by the Librarian to create the pre-formatted displays. Each data record requires an identifier in column 1 of the record and may require special placement with regard to the other data records. For example, the first record of each display must be a NAME (N) card and the last must be an END (E) card.

The following is a list of the data records allowed by the Librarian:

- NAME card
- PEN card
- COMPOSE card
- LEGALITY card
- LINE card
- TEXT card
- END card
- DELETE card

2.2.2.1 Name Card (N)

N␣XXXX - Column 1 contains the identifier "N" followed by a blank in column 2. Columns 3 through 6 contain the Display Name Tag.

The NAME card must be the first card of each display. The display name tag can be any four digit numbers in the range of 0001 through 9999.

2.2.2.2 Pen Card (P)

P␣XXXX,YYYY - Column 1 contains the identifier "P" followed by a blank in column 2. Columns 3 through 6 contain the display name. The next display name may be any legal display name tag or "SAME" or "PREV". The next program name (YYYY) on the PEN card is optional. If present it is separated from the next display name by a comma and is one to four alphabetic characters.

PEN cards are required only if there are pen fields defined within the text data for the display. The next display name and the next program name designate the next display and the next program to be displayed and executed, respectively, when the associated pen field of the display is selected by the tablet pen. "SAME" or "PREV" in the next display name field indicates that the same or previous display is to be presented when the pen field is selected.

The PEN cards must appear in the input deck in the same order as the associated pen fields in the display text. Pen fields within the display text are defined as the characters between the special symbols "<" and ">". A pen field may be comprised of any number of characters within a text line but may not be defined across text lines.

2.2.2.3 Compose Card (C)

C␣VV,WW,XXXX,YYYY - Column 1 contains the identifier "C" followed by a blank in column 2. The four required data fields begin in column 3 and are separated by commas. The fields are: VV = one or two digits defining the number of compose subfields; WW = one or two digits defining the number of compose characters within the compose field; XXXX = Next Display Name; and YYYY = Next Program Name.

COMPOSE cards are required only if there are compose fields defined within the text data for the display. The next display name and the next program name specify the next display and the next program to be displayed and executed, respectively, when the associated compose field is filled by keyboard data. "SAME" or "PREV" can be used for the next display name.

The COMPOSE cards must appear in the input deck in the same order as the associated compose fields appear in the text data. A compose field may contain any number of subfields where a compose subfield is defined by a contiguous string of "|" characters within one text line. An example of one compose field made up of four compose sub-fields is defined below with the COMPOSE card defining the field.

COMPOSE Card: C␣4, 12, 0001, COMP

COMPOSE Field: |||| ␣␣␣␣ ||
||| ␣␣␣␣ |||

2.2.2.4 Legality Card (X)

X␣(L1T1R1)(L2T2R2).....(LNTNRN) - Column 1 contains the identifier "X" followed by a blank in column 2. The legality data begins in column 3. "L" is the length of the legality subfield, where a legality subfield is that data enclosed by parenthesis in the format example above. "T" is the type of restriction data and can be any of the following:

"O" = octal,
"B" = binary,
"D" = decimal,
"A" = alphabetic
"X" = no checking
"S" = special characters such as ␣ " # ' () * = - + . , ? | < and > .
"R" = is the restriction data and can be explicit magnitudes, magnitude ranges, or combinations of both.

An additional example of the LEGALITY card format is shown below to illustrate how the legality data for a typical compose field might be specified:

Compose field: |||||| ␣␣␣␣ ||||| ␣␣␣ |||
AAAABB CCCCC DDD

Where:

A = Decimal Display Name Tag
B = Binary ID Code
C = Octal Unit Address Code
D = Alphabetic End Key

LEGALITY Card: X␣(4D0001-0005, 0010)(2B), (5O10077)(3AEND)

The first subfield of this LEGALITY card specifies that the first 4 character positions of the compose field must be decimal characters (D) in the range of 0001 through 0005 or the explicit decimal character sequence 0010. The second subfield, (2B), must be 2 characters of valid binary data (B) of any possible combination of 00, 01, 10, 11. The third subfield, (5O10077), may only be the 5 character octal (O) number 10077. The fourth subfield, (3AEND), must be the 3 alphabetic (A) characters END.

LEGALITY cards are optional. If included in the input deck, a LEGALITY card must immediately follow the COMPOSE card to which it applies. If no LEGALITY card is input with a COMPOSE card, no legality checking will be performed by the Display Controller on the keyboard data input to this compose field.

LEGALITY cards can require more than 71 card columns for data. To accommodate this, a continuation card is allowed and indicated by a non-blank character in column 72 of the LEGALITY card. Column 72 is not interpreted as a data character and is used only to signify that there is a continuation card for this record. The LEGALITY continuation card contains the identifier "X" in column 1 followed by a blank in column 2 with the continued legality data beginning in column 3.

2.2.2.5 Line Card (L)

There are two types of line format specifications allowed. The first specifies a line vector to be included in the display and is defined in terms of display screen coordinates:

L␣C,IIII,JJJJ,KKKK,LLLL - Column 1 contains the identifier "L" followed by a blank in column 2. Column 3 contains the character "C" followed by a comma in column 4. The four line specification data fields begin in column 5 and can be one to four digit numbers in the range of 0 through 1023. They are: "From" X ordinate, "From" Y ordinate, "To" X ordinate, and "To" Y ordinate.

The second line format specification specifies a Text Underline to be included in the display and is specified in terms of text character position and line number.

L␣L,MM,NN,OO,PP - Column 1 contains the identifier "L" followed by a blank in column 2. Column 3 contains an "L" followed by a comma in column 4. The four line specification data

fields begin in column 5 and can be a one or two digit number in the range of 1 through 85 for the character position, and 1 through 38 for the line numbers. They are: "From" text character position, "From" text line number, "To" text character position, and "To" text line number.

2.2.2.6 Text Card (T)

T⍽JJJJ ....JJJ -	Column 1 contains the identifier "T" followed by a blank in column 2. The text characters are punched in columns 3 through 71.

TEXT cards contain the data that is to appear on the display. They also contain data areas defined on the display as pen fields contained within the > and < characters; compose fields and subfields defined by the | characters, task fill-in fields defined by # characters; and character size commands defined by "%" characters followed by a number from one to four specifying which character size. All TEXT records must follow the previously defined data cards and must be in the order that the text is to appear on the display. A TEXT record can contain a maximum of eighty-five character size 1 text characters. To accommodate this, a TEXT continuation card is allowed and is indicated by a non-blank character in column 72 of the TEXT card. The TEXT continuation card contains the identifier "T" in column 1 followed by a blank in column 2 and followed by the continued data beginning in column 3.

Four character sizes are supported and indicated in the display text by the characters %N, where N is a number between 1 and 4. The default character size is character size 1 and the display text will be generated at this size unless otherwise specified. Any combination of the character sizes can be defined for a display and the Librarian will handle the vertical and horizontal spacing. The maximum number of characters and lines allowed on the display for each character size are as follows:

- Character size 1 = 85 characters x 38 lines
- Character size 2 = 42 characters x 19 lines
- Character size 3 = 28 characters x 12 lines
- Character size 4 = 21 characters x 9 lines

The number of characters and lines will vary according to the combination of character sizes input. The vertical spacing is determined by the largest character size within each text character line.

2.2.2.7 End Card (E)

END Contains the identifier "E" in column 1 followed by the characters N and D in columns 2 and 3. This card indicates end of the input data for a display and must be the last card input for each display.

2.2.2.8 Delete Card (D)

D␣XXXX - Column 1 contains the identifier "D" followed by a blank in column 2. The display name tag of the display to be deleted from the display library is contained in columns 3 through 6. This card is functional only if the update option "U" has been specified on the Output Option card (Section 2.2.1.2).

2.2.3 Display Input Deck Setup

The input deck setup depicted in Figure 2-10 details the input data set required for one display. Input data sets for any number of displays can be stacked contiguously and processed in a single row. The EOD card indicates end of run.

The DELETE card is a special case and the input data set required to delete a display from the display library is comprised of only the DELETE card itself.

DISPLAY INPUT DECK SETUP

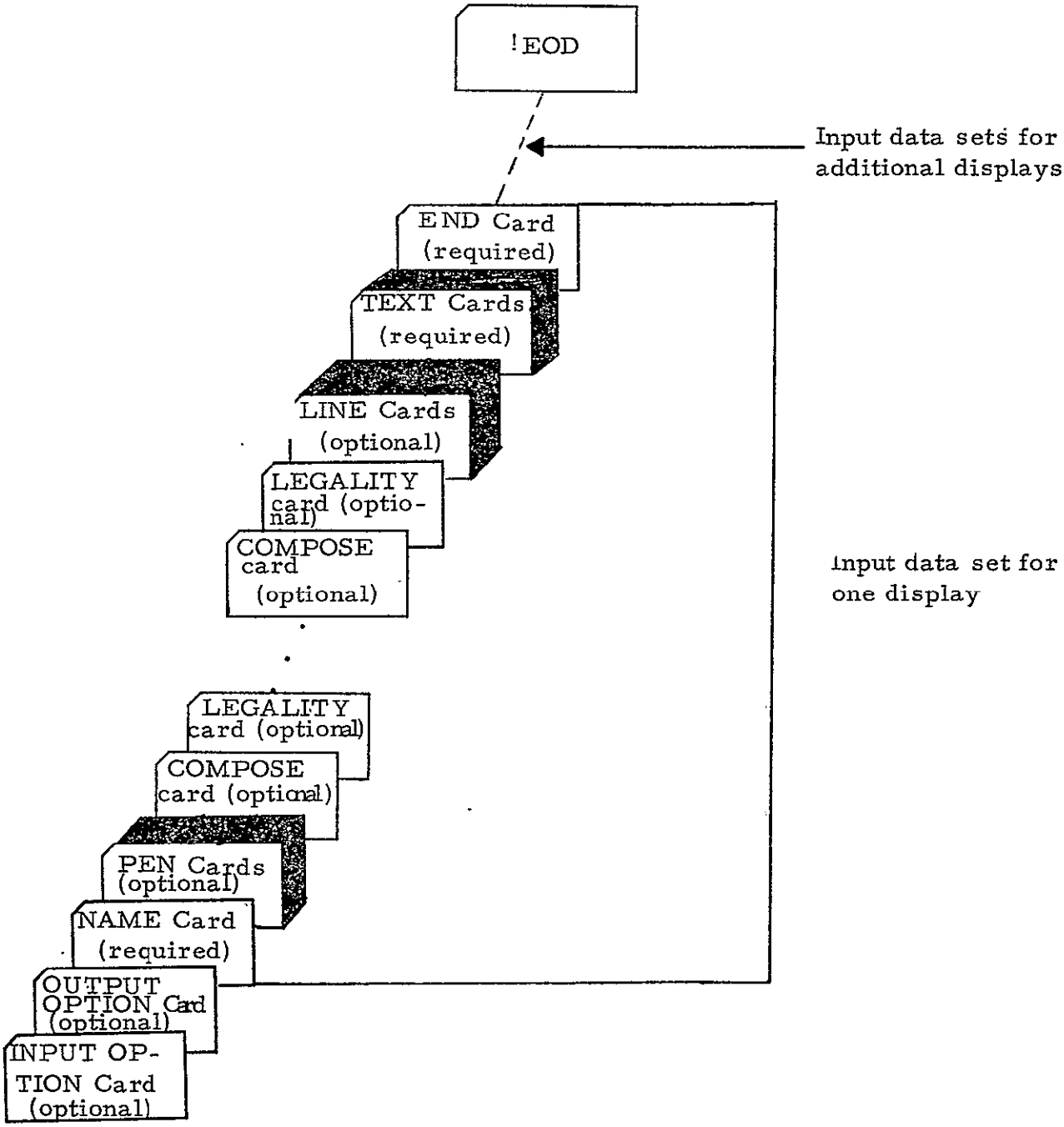


Figure 2-10

3. DISPLAY CONTROLLER

The Display Controller software package coordinates all communication between the operator at the graphics terminal and the application program executing within the Sigma 2 computer. The Display Controller performs the following functions:

- o Displays the proper text in response to the operator's actions.
- o Validates keyboard inputs.
- o Passes control information to the application program.
- o Displays application program output information to the operator.

The programmed book of tutorial displays can provide the user with any desired level of control over the execution of his program. The display book, along with the use of the tablet pen and the alphanumeric keyboard, will lead the user through the functions of initializing and executing the program, and monitoring the progress and results of the job. Each user option will be carefully spelled out in the display text, and all user inputs will be verified before they are accepted by the display processor. Should error conditions occur (due to incorrect input, hardware failure, or application program failure), error messages will be presented to the user with instructions as to the recovery action that should be taken.

3.1 Operator Input Interface

Figure 3-1 illustrates the Display Controller interface with the display unit and the Sigma 2 application program. The control information pages for a display chapter remain in memory as long as that display's text is being presented to the operator. When the operator uses the graphic tablet pen or the keyboard, the Display Controller uses these pages to determine the NEXT PROGRAM and the NEXT DISPLAY and passes this information to the application program through the parameter list shown in Figure 3-2. When the chapter for the next display is retrieved from the display book on disk, the display text processor merges the display text with any application program data and presents the combined image on the display screen. The new tablet pen and keyboard pages remain in memory to identify the next operator action.

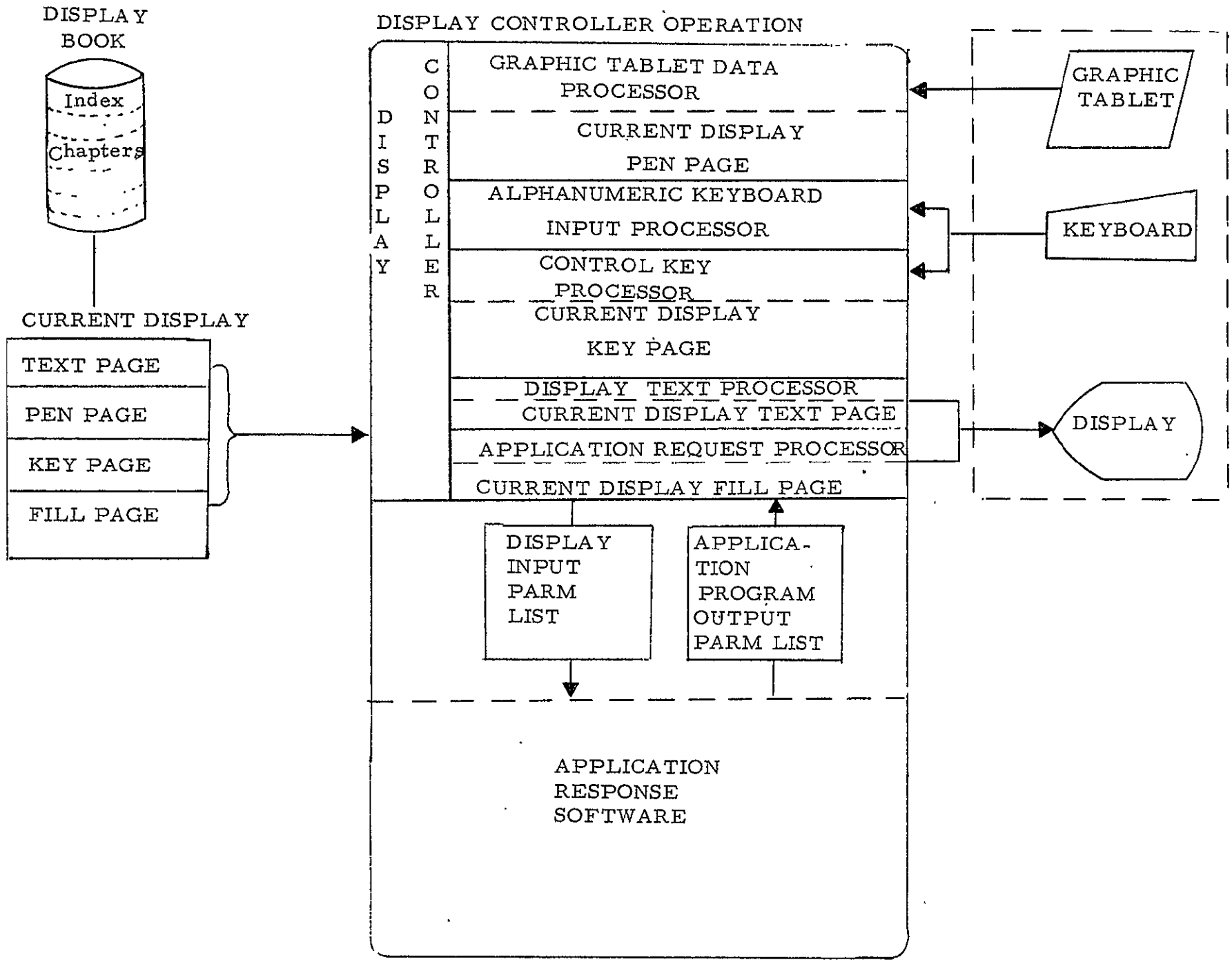
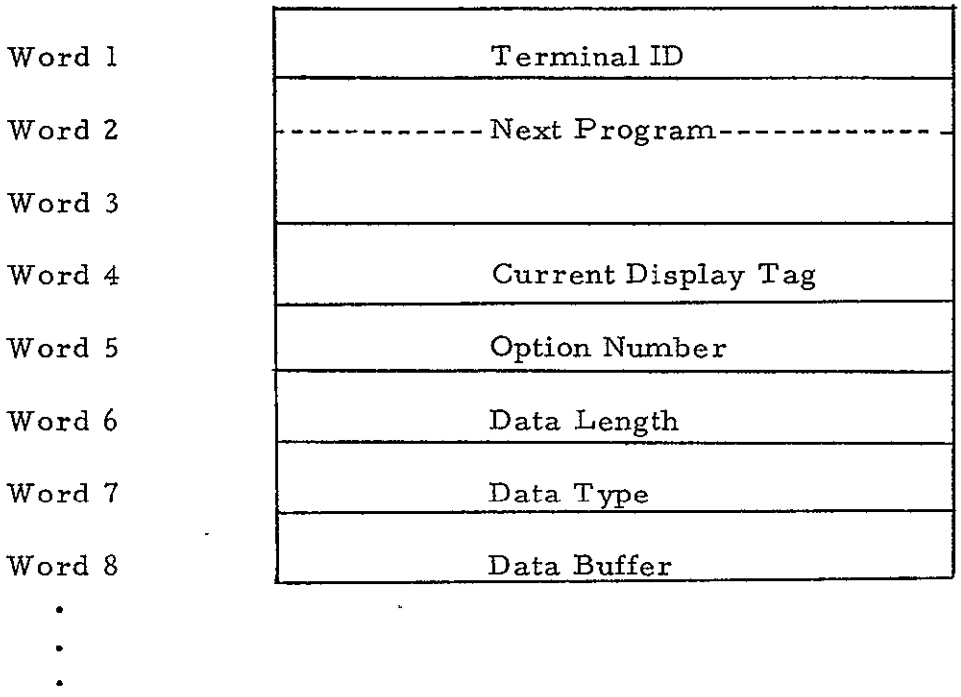

DISPLAY BOOK
Index
Chapters
CURRENT DISPLAY
TEXT PAGE
PEN PAGE
KEY PAGE
FILL PAGE
DISPLAY CONTROLLER OPERATION
DISPLAY CONTROLLER
GRAPHIC TABLET DATA PROCESSOR
CURRENT DISPLAY PEN PAGE
ALPHANUMERIC KEYBOARD INPUT PROCESSOR
CONTROL KEY PROCESSOR
CURRENT DISPLAY KEY PAGE
DISPLAY TEXT PROCESSOR
CURRENT DISPLAY TEXT PAGE
APPLICATION REQUEST PROCESSOR
CURRENT DISPLAY FILL PAGE
DISPLAY INPUT PARM LIST
APPLICATION PROGRAM OUTPUT PARM LIST
APPLICATION RESPONSE SOFTWARE
GRAPHIC TABLET
KEYBOARD
DISPLAY

Figure 3-1

SIGMA 2 DISPLAY CONTROLLER INPUT DATA PARAMETER LIST



TERMINAL ID: This value identifies the user terminal to the application program for multi-terminal systems.

NEXT PROGRAM: This field contains the four character program name associated with the operator's action.

CURRENT DISPLAY: This field contains the display tag for the display presented as a result of the operator's action.

OPTION NUMBER: This field contains the number of the compose field or tablet pen option associated with this transmission.

DATA LENGTH: This field contains the count of the number of characters of data being sent to the application program.

DATA TYPE: This field contains the code that identifies the type of processing required.

CODE	DESCRIPTION
00	This request was initiated by a tablet pen option select.

Figure 3-2

SIGMA 2 DISPLAY CONTROLLER INPUT DATA PARAMETER LIST
(continued)

CODE	DESCRIPTION
01	This request was initiated by the transfer of compose field character data.
02	This request was initiated by the transmission of tablet pen image design data.
03	This request was initiated by the transmission of image design character data.

DATA BUFFER: This field contains the character data defined by the DATA LENGTH and DATA TYPE fields.

Figure 3-2
(continued)

3.1.1 Tablet Pen Support

The graphics tablet pen may be used to provide control information, input data, or pen image design data to an application program. The Display Controller supports the operator's use of the graphics tablet pen by monitoring the position proximity and pressure of the tablet pen. When the tablet pen is within proximity of the tablet surface, the Display Controller moves the display screen cursor to the X, Y location corresponding to the tablet pen. If the operator applies pressure to the tablet pen, the Display Controller processes the tablet data as either pen option select data or pen image design data.

3.1.1.1 Pen Option Select Data

The tablet pen may be used to select a pen option thus initiating the NEXT PROGRAM, NEXT DISPLAY process. The Display Controller maintains a history of the tablet pen data entered with pen pressure applied. If the history indicates that the operator drew an 'X', the pen option process is executed.

3.1.1.2 Pen Image Design Data

A second use of the tablet pen is the entry of data points for image design. Tablet pen data, entered with pen pressure applied in a form other than an 'X', is assumed to be image design data and is passed to the application program.

3.1.2 Alphanumeric Keyboard Support

The alphanumeric keyboard may be used to provide control information and input character data to an application program. The Display Controller receives all keyboard entries and stores them in predefined compose fields within the display text. The operator is able to see the message as he types in each character. When the operator has completed his input and verified its contents, he must use a specially defined control key (Return Key, Section 3.1.3.1) to initiate the processing of the input data.

3.1.3 Control Key Support

The control key processing provided by the Display Controller consists of support for six program-interpretable keys on the alphanumeric keyboard. These keys may be used in the process of pen option selection and compose field data entry.

3.1.3.1 Return Key

The Return key may be used by the display operator to select a compose field for data entry. Each use of the Return key causes the Display Controller to position the cursor to the first character of the next compose field. The Return key must be used by the operator to initiate the processing of the input data. When the character data for a compose field has been entered and verified, the operator uses the Return key to have the Display Controller accept the data.

The Display Controller makes legality checks on all keyboard inputs against the data within the key page of the current display chapter. The legality data could, for example, instruct that only octal digits be accepted. Each character entered would be tested to determine if it was within the range of zero to seven. If an error occurs, a data message is presented to the operator instructing him to re-enter the correct data.

After the input data has passed all legality checks, the Display Controller transmits the data to the application program according to the list given in Figure 3-2.

3.1.3.2 Line Feed Key

The Line Feed key may be used in place of drawing an 'X' with the tablet pen to select a pen option. The option select corresponds to the position of the display cursor at the time the Line Feed key is depressed.

3.1.3.3 Tab Key

The Tab key may be used to position the display cursor at a pen option select area. Each use of the Tab key causes the Display Controller to move the display cursor from its current position to that of the next pen option in sequence.

3.1.3.4 Page Key

The Page key may be used to cause the Display Controller to generate a fresh copy of the current display. The initial text for the current display tag is presented and all compose field, plot, or tabular data is cleared.

3.1.3.5 Backspace/Space Keys

The Backspace and Space key cause the Display Controller to re-position the display cursor backward or forward by the character size

of the current compose field. The process supports the movement from one subfield to another as appropriate.

3.2 Application Program Output Interface

Figure 3-3 details the application program output request parameter list. The capabilities provided by these requests allow the application program to display large blocks of data in a graphic form or to display selective, but representative, data in a tabular format. A technique is also provided to allow the application program to notify the operator of a detected error or irregularity in the system's operation (See Section 3.2.3).

3.2.1 Tabular Output

All areas of a display text that are available for application program tabular data output must be predefined in the text page of the display chapter. When the Display Controller receives input data that is associated with the current display, it merges the data with the display text, overlaying each successive tabular space with the next input character. The overlay process is terminated when the last character of input data has been received from the application software or when the last tabular space in the display text has been overlaid.

The application program input areas for any display may be predefined on the display book by the user to suit his special needs and to present his input data in an easy-to-read format. For example, if the input areas in a display text are defined in a column format, the programmer's data will automatically be presented in a column format when his data is merged with the predefined display text.

Before an application program can present tabular data to the operator, the display tag associated with the display currently being presented to the operator must agree with the display tag associated with the program's tabular data. If the displays are not the same, the Display Controller sends back an error code to the application program to indicate the error and the request will be ignored. Normally this error indication can be interpreted as the operator's lack of interest in the data being presented and should not require corrective action by the program presenting the data. However, if the program deems its data to be critical or of particular interest to the operator, a special capability is provided to allow the program to present a single line message or to make a "New Display" request (See Section 3.2.2 and 3.2.3). These features insure that the user can be made aware of all critical display requirements, yet leave him in complete control of display operations. The format of the tabular output data is depicted in Figure 3-4.

APPLICATION PROGRAM OUTPUT REQUEST PARAMETER LIST

Word 1	Request Code
Word 2	Return Code
Word 3	Current Display Tag
Word 4	Next Display Tag
Word 5	Next Program
Word 6	Data Length/Control Word
Word 7	Data Buffer
Word 8	Terminal ID

REQUEST CODE: The following request codes have been defined to support the capabilities presented in this document:

CODE	REQUEST
01	Tabular Output
02	New Display Request
03	Message (single line)
04	Character Plot
05	Vector Plot
06	Design Data Acquisition
07	Display Screen Erase

RETURN CODE: This field will be set by the Display Controller to one of the following codes at the completion of the application program's request:

CODE	INDICATES
00	Successful completion
-1	Invalid Request Code
-2	Display tag does not correspond to current Display

Figure 3-3

APPLICATION PROGRAM OUTPUT REQUEST PARAMETER LIST
(continued)

Other codes must be interpreted in relation to the Request Code as follows:

REQUEST CODE	RETURN CODE	INDICATES
01	01	No tabular output area defined in Display
	02	All available tabular output spaces have been used
03	01	Message Line full
04	01	More than 160 characters in a single request
05	01	Invalid plot type

CURRENT DISPLAY TAG: The value of this field must correspond to the display tag of the display being presented to the operator. By way of exception, this field may contain a value of zero for a New Display request, '02' for a message request, '03' if the request may appear on any display.

NEXT DISPLAY TAG: This field is used on New Display requests and Message requests to indicate the display to be presented if the message is responded to by the operator. An entry of zero indicates no new display.

NEXT PROGRAM: This field is used on New Display requests and Message requests to specify the name of the program to be executed if the message is responded to by the operator. If the name is less than 4 characters, it must be left-justified and padded with blanks. An entry of zero indicates no program is to be executed. This field is used on Design Data Acquisition requests to define the program to receive tablet pen points processed by the Display Controller.

DATA LENGTH: The number of characters of data associated with the calling program's request. For a Display Screen Erase request (07), the value of this field must be a 1 for the primary screen

Figure 3-3
(continued)

APPLICATION PROGRAM OUTPUT REQUEST PARAMETER LIST
(continued)

	or a 2 for the secondary screen.
DATA BUFFER:	The format of the data passed through the Display Controller to the display screen will be dependent on the type of request specified.

CODE	REQUIRES
01	EBCDIC data as described in Figure 3-4
02	No data
03	EBCDIC data, limited to 85 characters
04	EBCDIC data as described in Figure 3-5
05	Data as described in Figure 3-6
06	No data
07	No data

TERMINAL ID:	This value identifies the user terminal to the Display Controller for multi-terminal systems.

Figure 3-3
(continued)

TABULAR OUTPUT REQUEST DATA FORMAT

Word 1	Reserved for future use	
Word 2	Char 1	Char 2
Word 3	Char 3	Char 4
Word 4	Char 5	Char 6
	. . .	
Word (n+1)/2	Char N	

Figure 3-4

3.2.2 New Display Request

If the application program must provide more than a single line description of an error condition, the message may be predefined as the text of a display and referenced directly by its display tag through the use of the 'New Display' request. The Next Display and Next Program supplied by the application program in the parameter list (Figure 3-3) are assigned to the pen symbol of the Message line. The Display Controller automatically provides a one line message specifying to the operator that a new display is pending. When the operator responds to the request by selecting the pen symbol, the appropriate display is presented and the program specified is executed.

3.2.3 Message Line

As each display is preformatted and entered in the display book, the last line of the display text is reserved for communication between the application program and the display console. Any program may use this special line to display a short message to the operator. A predefined pen option sensitive symbol is associated with the message line and available as a real time operator/program communication device. The application program may wish to be notified if the display operator responds to the message by selecting the pen option. In this case, the program sending the message must supply in the parameter list (Figure 3-3) the name of the program to be executed. An entry of zero indicates no program is to be executed.

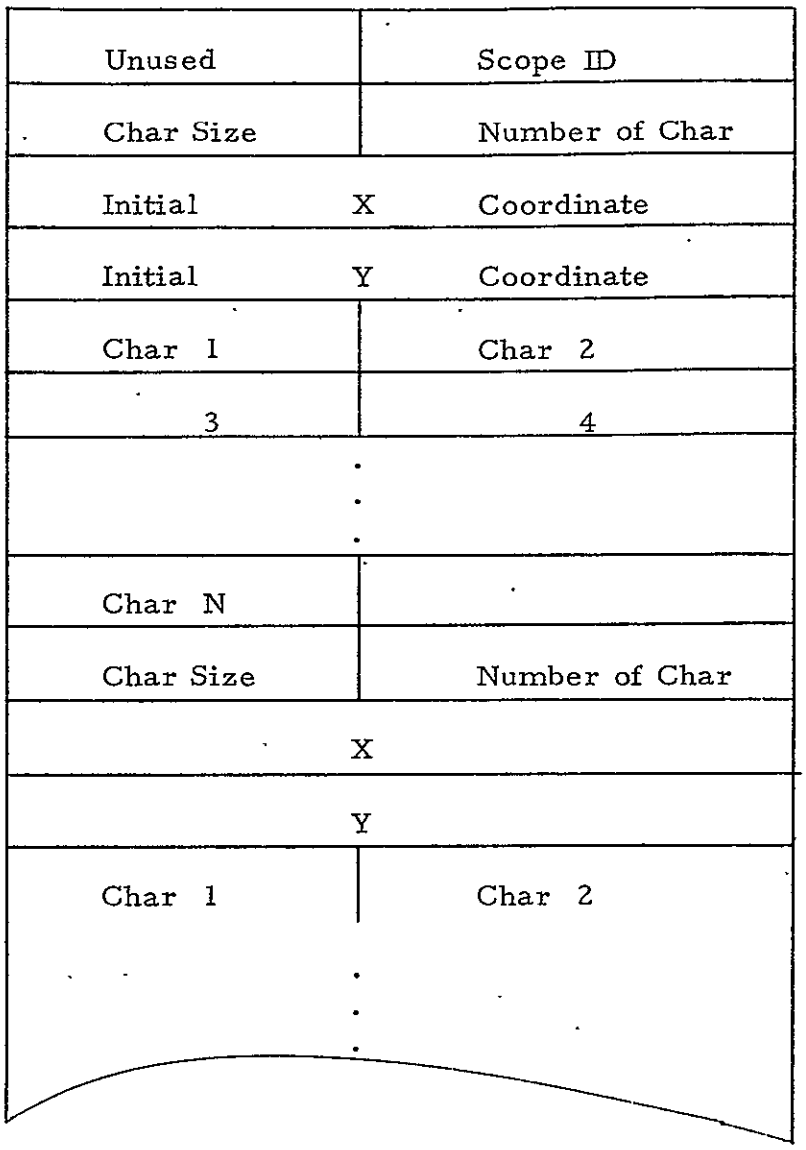
3.2.4 Graphics Support

The visibility into certain application program operations can be enormously enhanced by sending output data to the console operator in a plotted or graphic rather than tabular format. In addition, many real-time applications require the user and the computer to form an interactive partnership for the construction of graphic images and/or designs which can be accepted, rejected, acknowledged, or modified by the user. The remainder of this section describes the software available to provide these capabilities.

3.2.4.1 Character Plots

The character plot request allows the application program to form and present messages to the display operator. The length, format, and position of these messages are not limited to those of the predefined tabular output areas, and are controlled by the application request (Figure 3-5).

CHARACTER PLOT REQUEST DATA FORMAT



SCOPE ID: Must be 1 or 2 for primary or secondary screen respectively

CHAR SIZE: May be 1, 2, 3, or 4

Figure 3-5

3.2.4.2 Vector Plots

The Display Controller's software supports a vector plot capability that gives the user the opportunity to view a large amount of output data from an application program in an easy to interpret format. Four plot types are recognized by the Display Controller: solid line, dotted line, dashed line, and dashed-dotted line. Figure 3-6 defines the format for an application program request for each of these plot types.

3.3 Display Controller Program

This section outlines the structure of the Display Controller software package. The organization of the programs into overlay tasks corresponds to a functional layout of the Display Controller Program modules as illustrated in Table 3-1.

The Display Controller Program consists of four overlay task segments. Segment 0, the root segment, contains the program modules that must remain in core throughout the execution of the display software. Included in the root segment are all modules that communicate directly with the display terminal and tablet. Segment 1 contains a program to initialize the task COMMON data area.

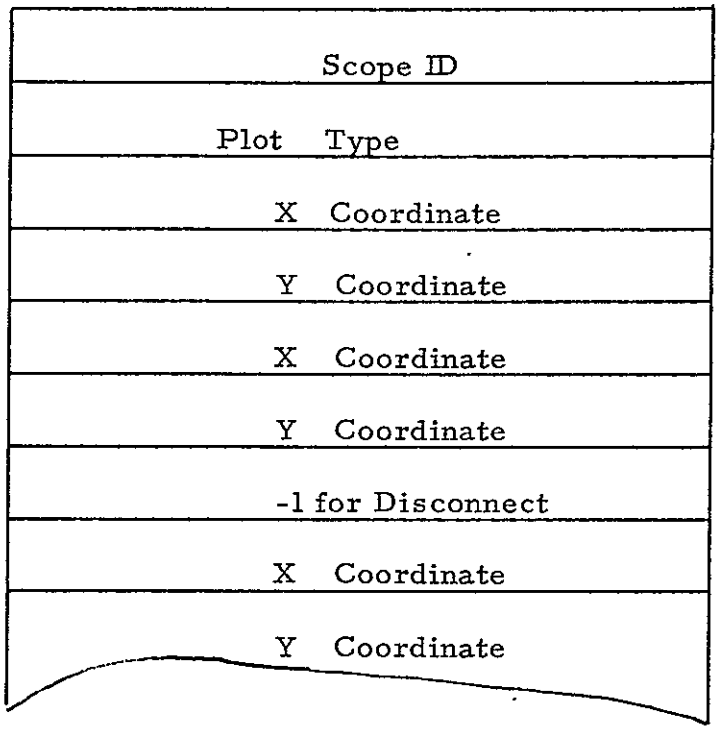
Segment 2 is the overlay task that contains the program modules to process the operator keyboard and tablet inputs. This overlay task alternates with Segment 3. Segment 3 contains the program modules that process the application program output requests. Table 3-1 lists the program modules that comprise each overlay segment within the Display Controller.

The primary functions of the Display Controller include task initialization, communication with the display terminal and tablet, and interface with the Display Book. The program modules in Segments 0 and 1 complete these requirements by providing the software necessary to effect all input and output through the RBM service monitor M:IOEX.

Once keyboard or tablet pen data has been accepted by the display driver segment, segment 2 program modules are loaded into core. This software performs the support role of interpreting and recording the display operator inputs. All compose field, pen data, pen option, and new display logic is included in segment 2.

As part of the process of transmitting input data to the application program, segment 3 is loaded into core. This segment contains the programs that process the application program output parameter list.

VECTOR PLOT REQUEST DATA FORMAT



SCOPE ID: Must be 1 or 2 for primary or secondary screen respectively.

PLOT TYPE: May be:

01	SOLID
02	DOT
03	DASHED
04	DASHED/DOT

The interpretation and use of the X, Y pairs depend upon the Plot Type selected. For solid line plots, the cursor is moved to the position X_1, Y_1 and a line is drawn to X_2, Y_2. The next line is drawn to X_3, Y_3, etc. A value of -1, disconnect, forces the chain to be broken and restarted at point Xn, Yn. Note that the disconnect is valid only for solid plots. For single points plots, a dot is drawn at each X, Y pair. For dash plots, a line is started at pair Xn, Yn and drawn to pair Xn+1, Yn+1. For dash/dot plots, the sequence of drawing a dash is alternated with that for drawing a dot. Thus three X, Y pairs are used for each dash/dot. A line is drawn from Xn, Yn to Xn+1, Yn+1 and then a dot is drawn at Xn+2, Yn+2.

Figure 3-6

DISPLAY CONTROLLER OVERLAY SEGMENTS

Segment 0	Flowchart Index
Foreground Initialize	B-4
Display Input Driver	B-5
Graphics Input	B-6
Process Input Request	B-7
Process Error	B-8
Display Book Read	B-9
Display Terminal Output	B-10
Segment 1	
COMMON Initialize	B-11
Segment 2	
New Display Process	B-12
Find Display Chapter	B-13
Get/Put Display History	B-14
Pen Data Process	B-15
Key Data Process	B-16
Transmit Key Process	B-17
Legality Check	B-18
Return Key Process	B-19
Compose Key Process	B-20
Key Position Verify	B-21
Backspace Key Process	B-22
Tab Key Process	B-23
Segment 3	
Display Request Process	B-24
Fill Request	B-25
Message Request/New Display Request	B-26
Character Plot Request	B-27
Vector Plot Request	B-28
Type 1 Vector Process	B-29
Type 2, 3, 4, Vector Process	B-30
Image Design Request/Display Erase Request	B-31
Request Process Utilities	B-32

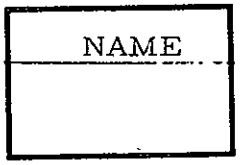
Table 3-1

APPENDIX A

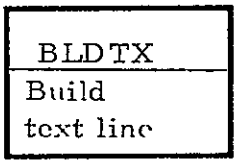
DISPLAY LIBRARIAN PROGRAM FLOWCHARTS

This Appendix presents the detail flowcharts of the Display Librarian Program. The flowcharts should provide sufficient explanation of the Librarian listing.

The "Picture-on-a-Page" technique has been utilized, which allows the reader to study the flowcharts to the depth he desires. Each page is a complete representation of the area presented. Those functions that are expanded in more depth on subsequent sheets are identified with subroutine nomenclature blocks



For example, on page A - 6 the block



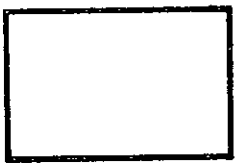
indicates that activity defined by the block is discussed in more detail on a separate page with the title BLDTX.

Page A2 is an index to the flowcharts. Page A3 describes the flowchart symbol convention adhered to by these flowcharts and by the flowcharts in Appendix B.

APPENDIX A
DISPLAY LIBRARIAN PROGRAM FLOWCHARTS

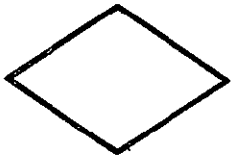
FLOWCHART SYMBOL CONVENTION

Subroutine Terminal Points

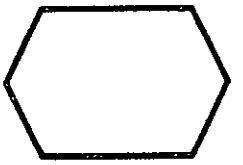


Process

Subroutine Call



Decision



I/O Operation

On Page Connector

DISPLAY LIBRARIAN-GENERAL FLOW

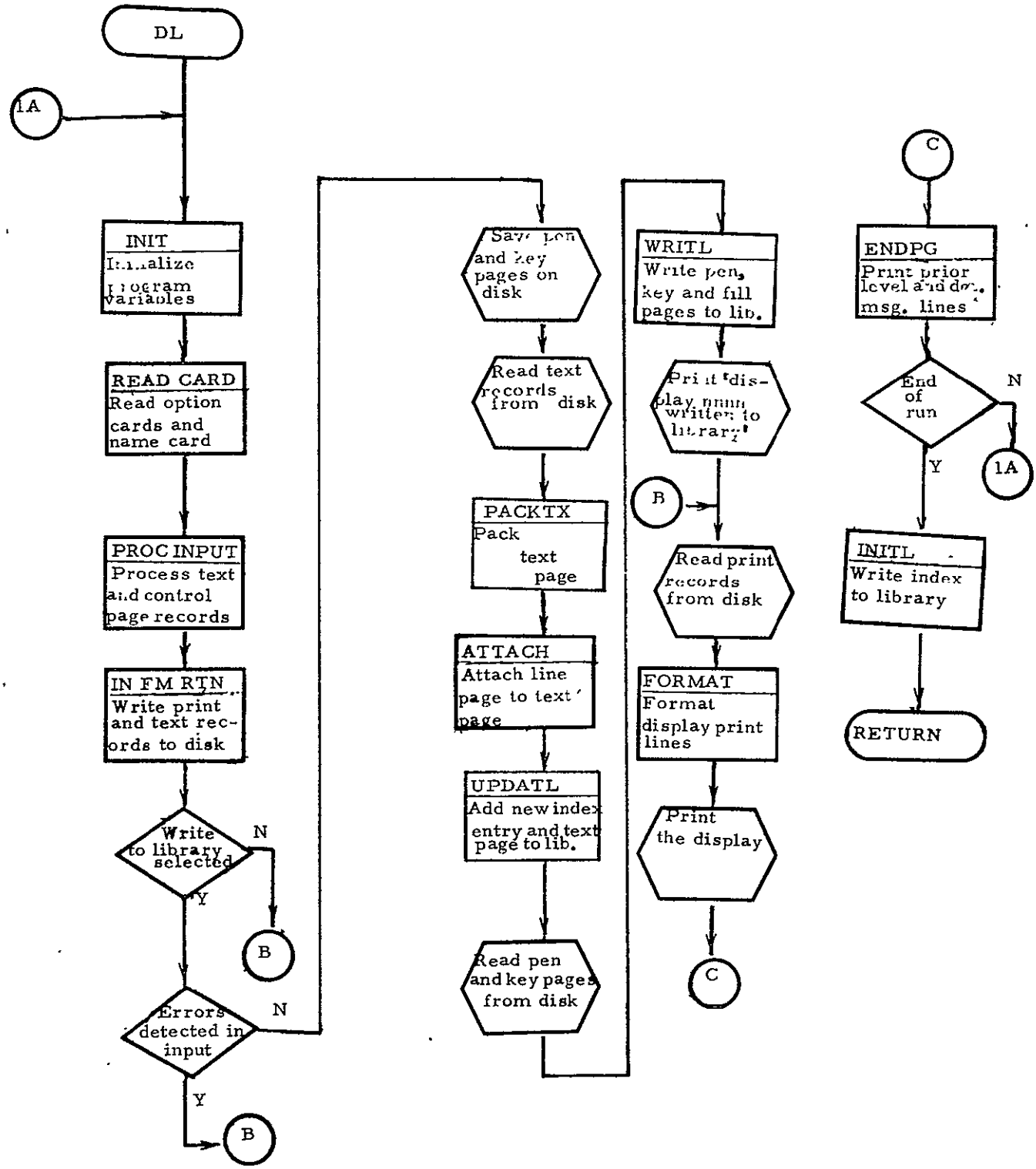


Figure A-1

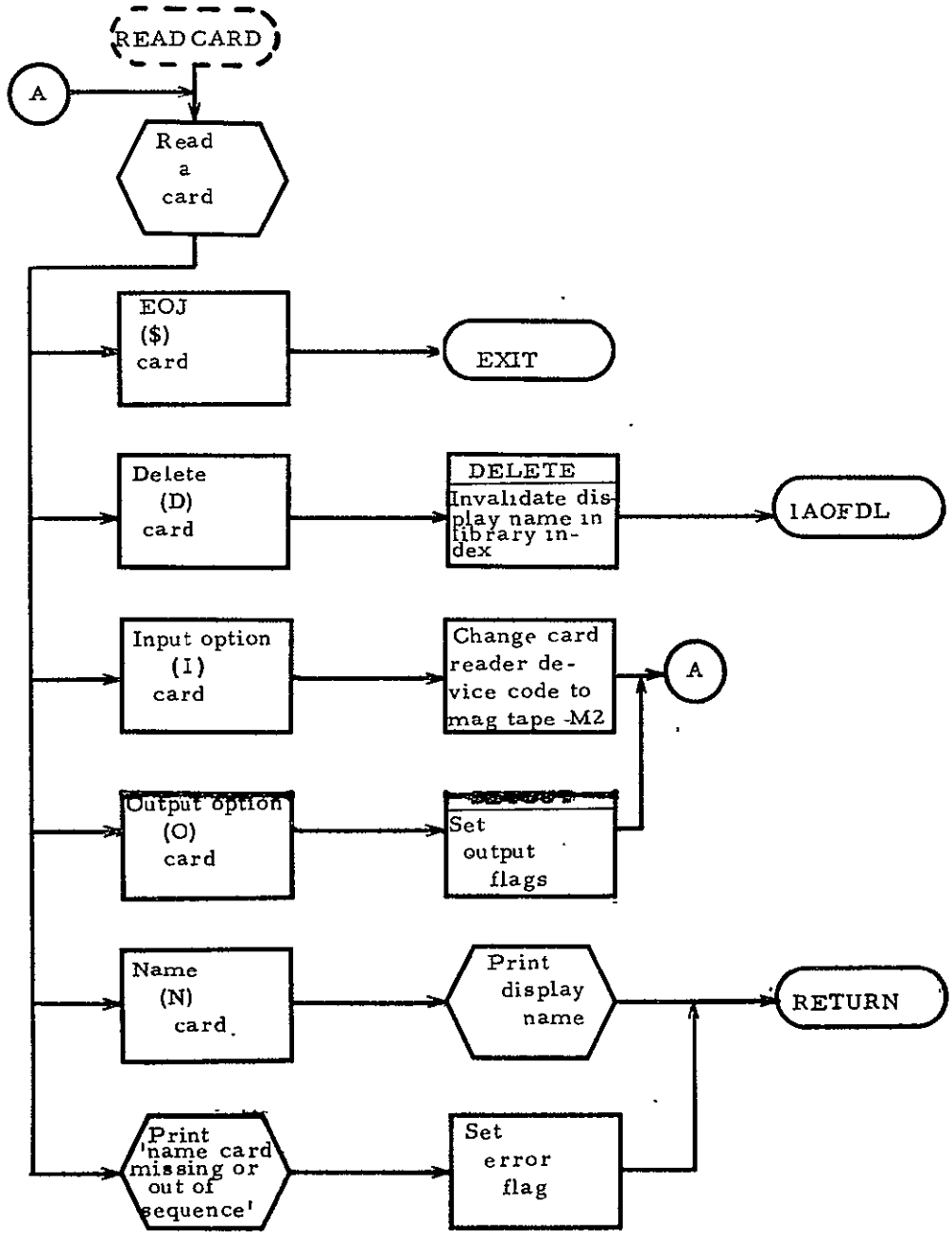


Figure A-1
(continued)

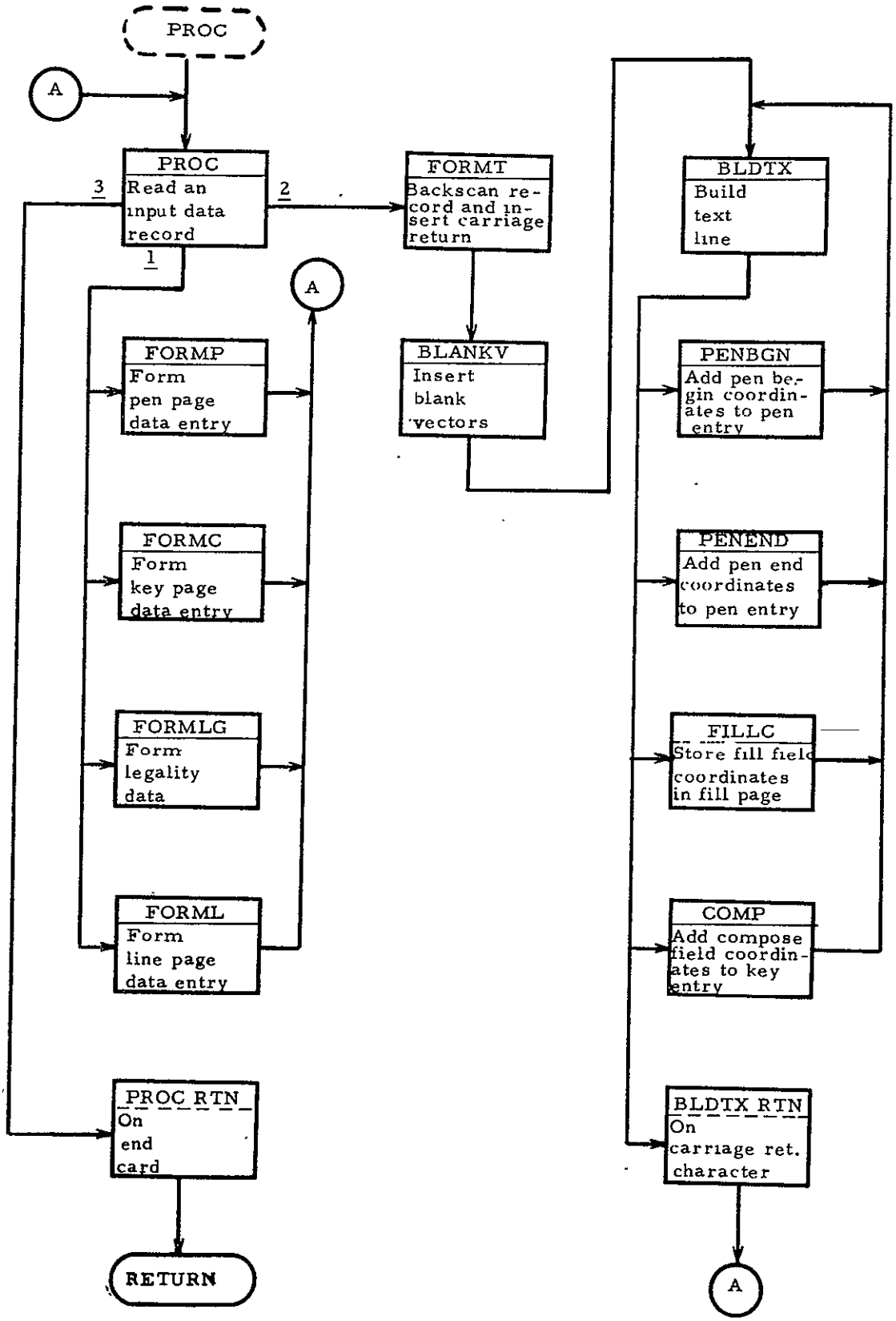


Figure A-1
(continued)

DELETE DISPLAY

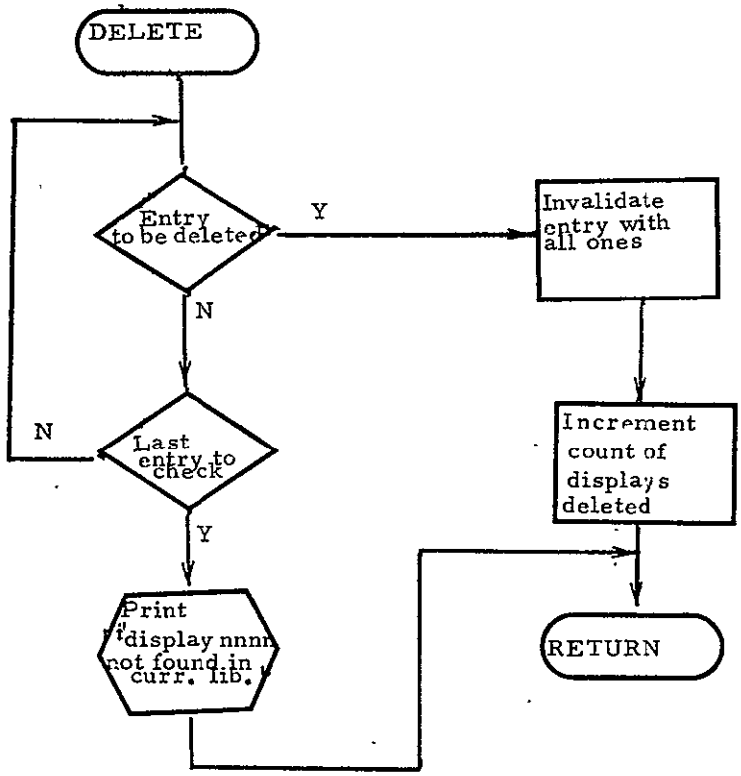


Figure A-2

SET OUTPUT OPTIONS

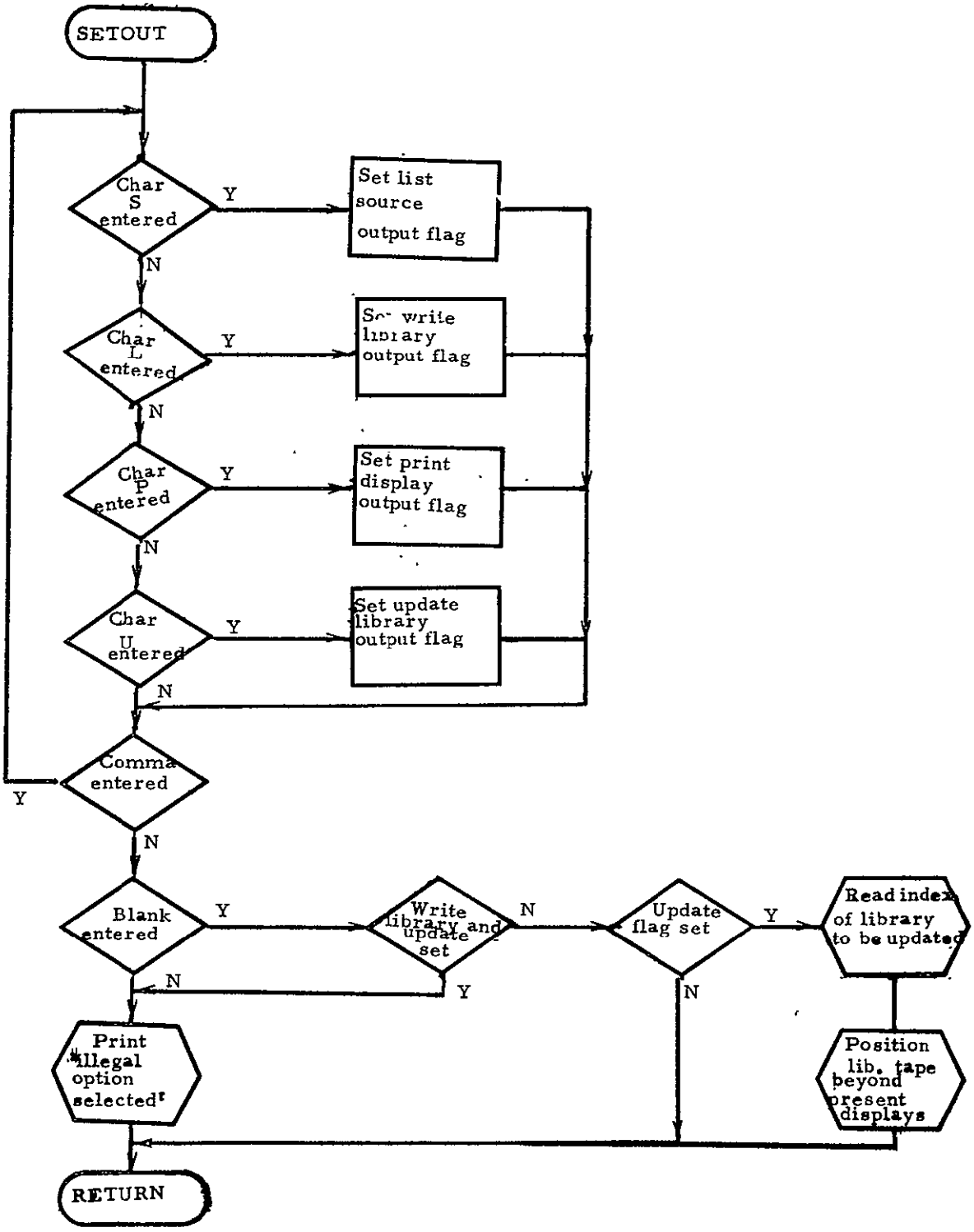


Figure A-3

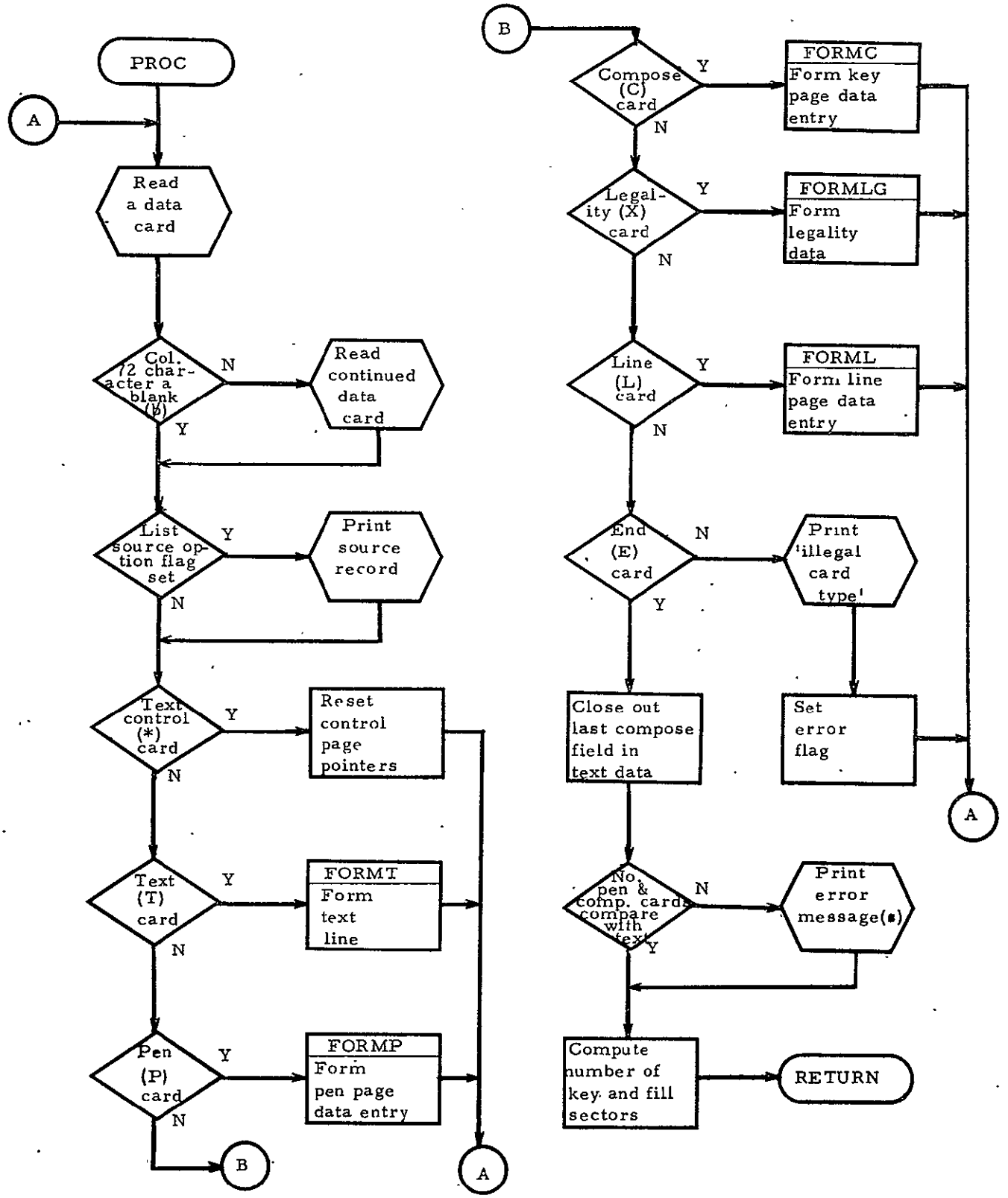


Figure A-4

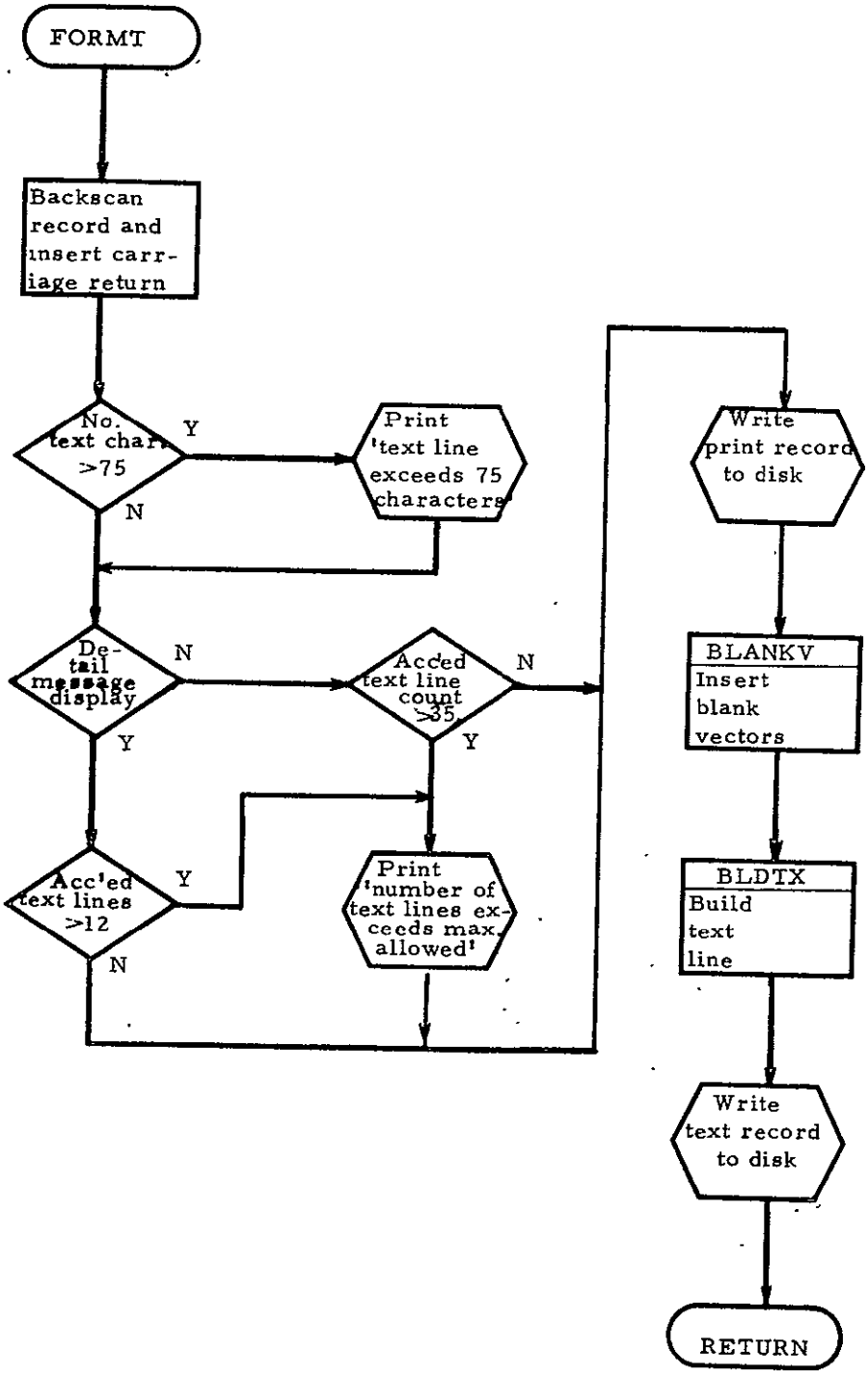

FORMT
Backscan record and insert carr-iage return
No. text char. >75
Y
N
Print 'text line exceeds 75 characters'
De-tail message display
N
Y
Acced text line count >35
N
Y
Acc'ed text lines >12
Y
N
Print 'number of text lines ex-ceeds max. allowed'
Write print record to disk
BLANKV
Insert blank vectors
BLDTX
Build text line
Write text record to disk
RETURN

Figure A-5

INSERT BLANK VECTORS

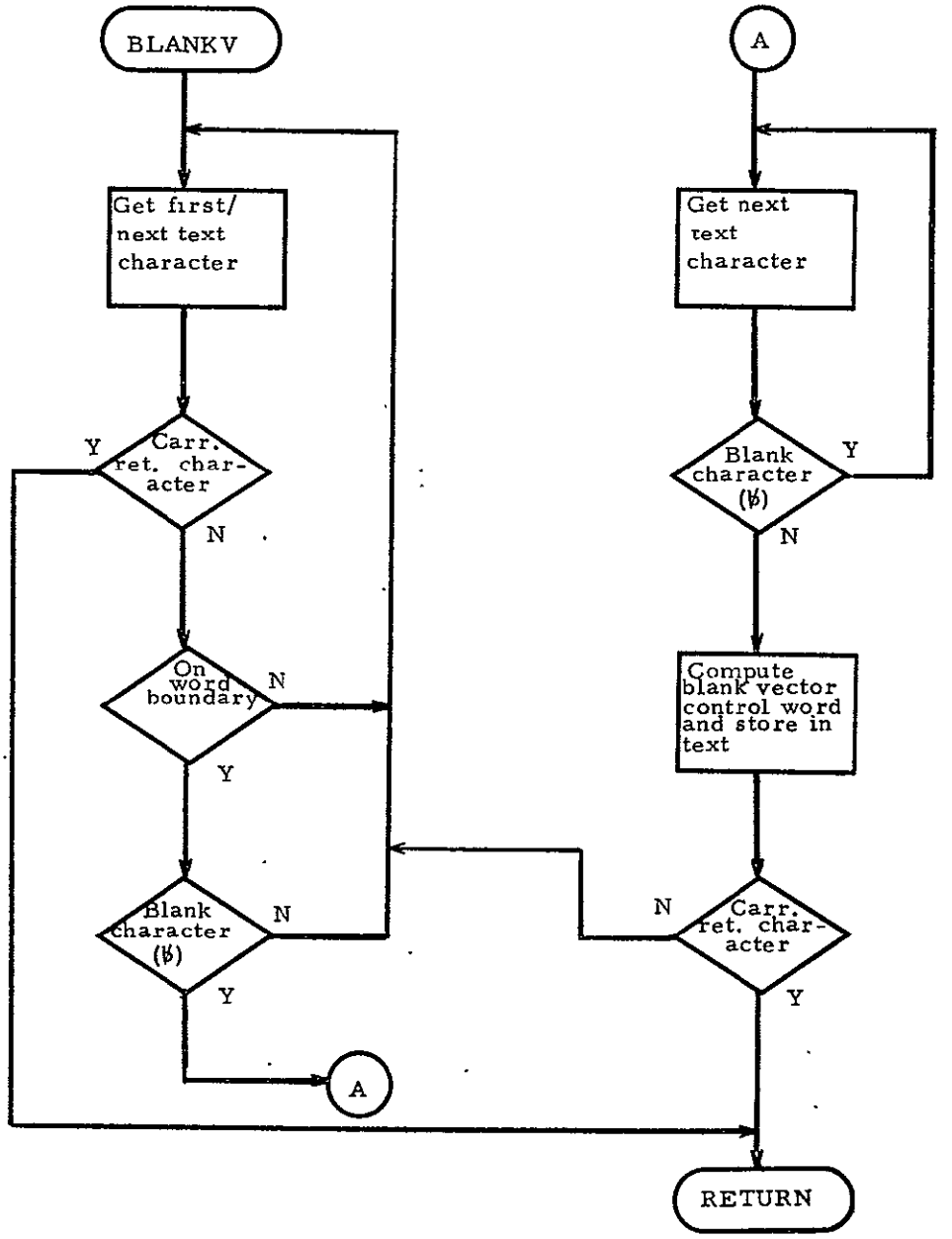


Figure A-6

BUILD TEXT LINE

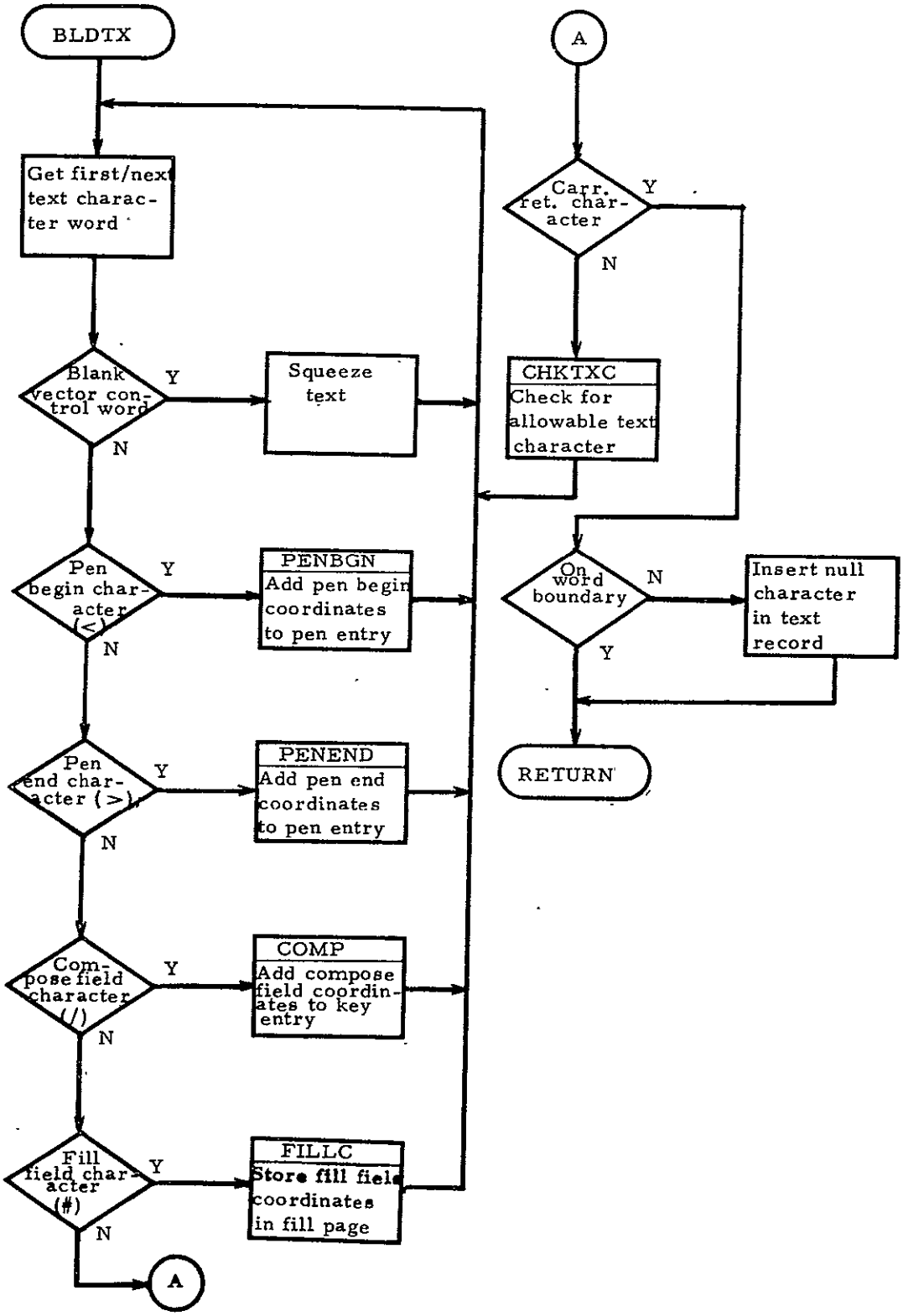


Figure A-7

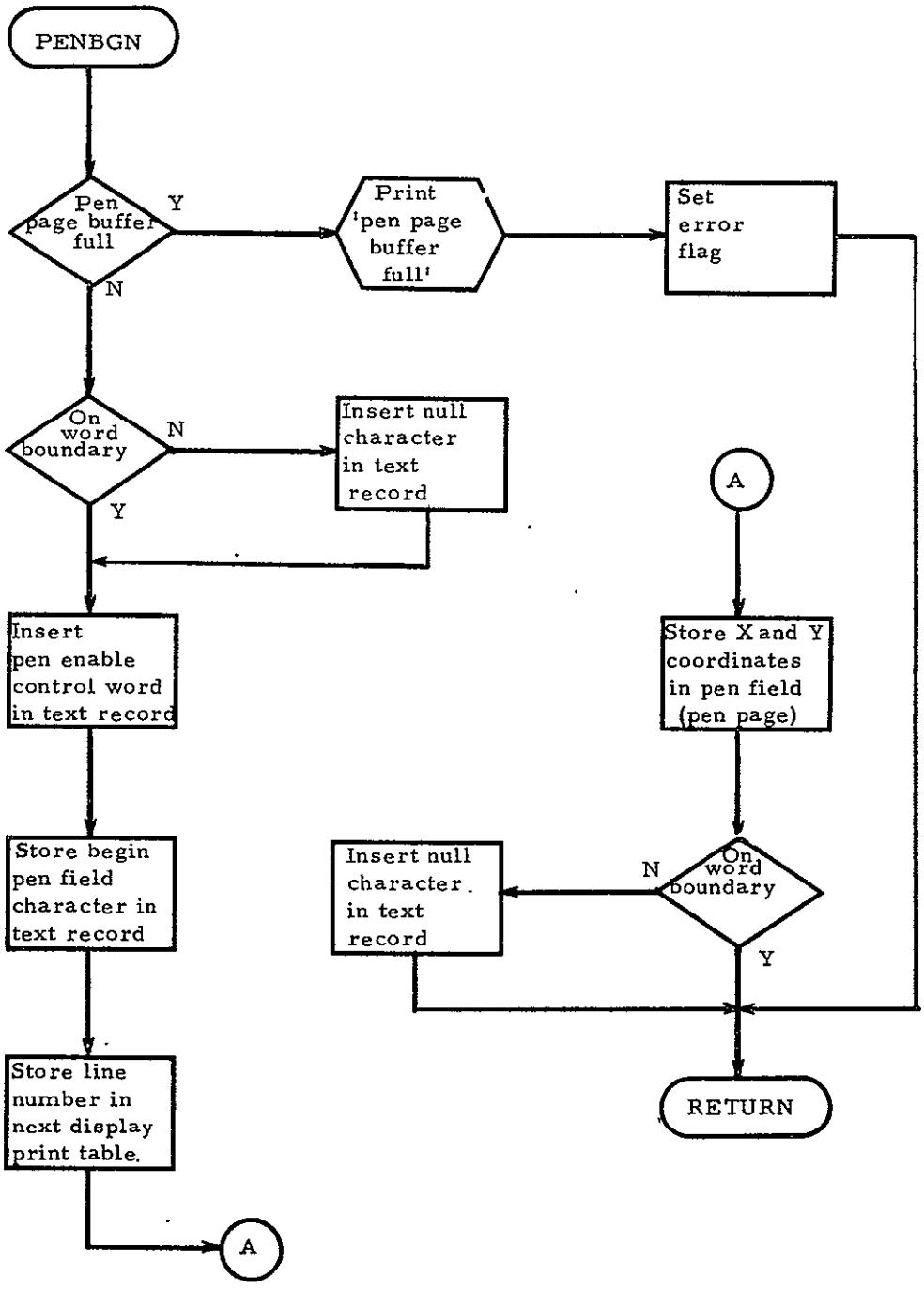


Figure A-8

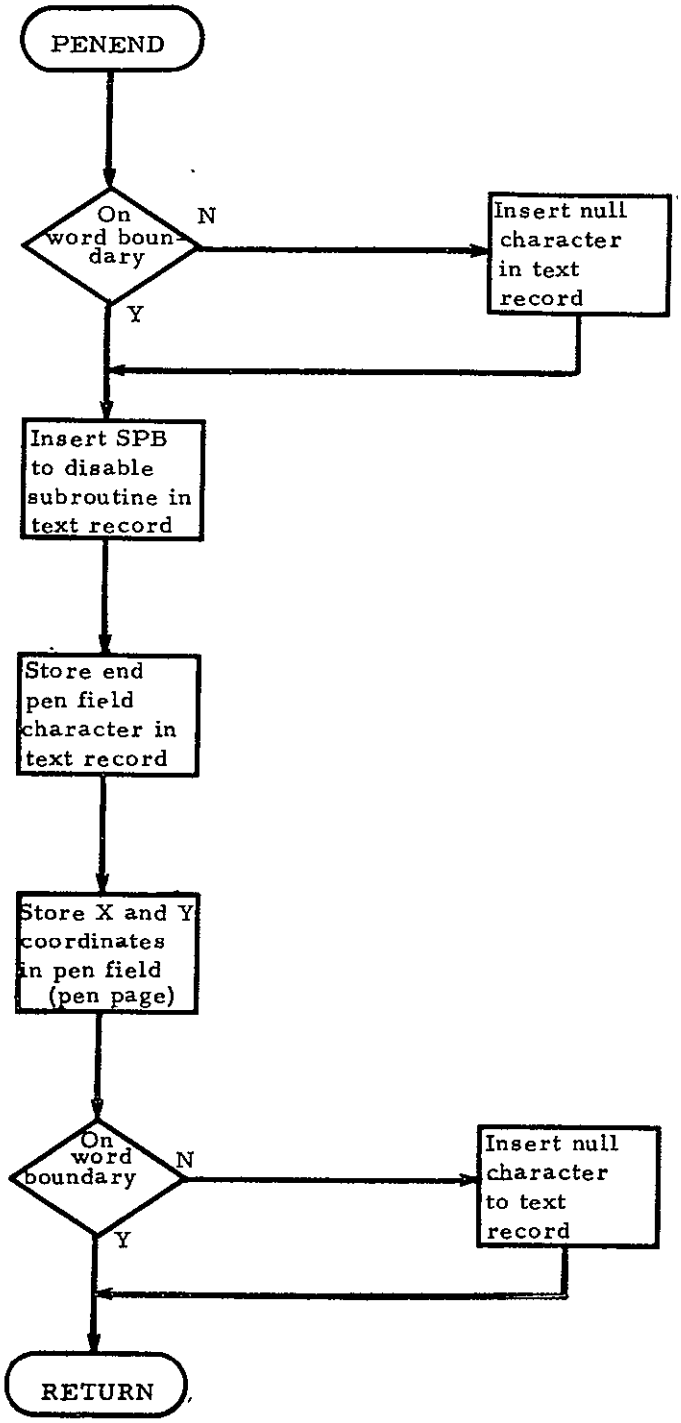

PENEND
On word boundary
N
Y
Insert null character in text record
Insert SPB to disable subroutine in text record
Store end pen field character in text record
Store X and Y coordinates in pen field (pen page)
On word boundary
N
Y
Insert null character to text record
RETURN

Figure A-9

CONSTRUCT FILL FIELD

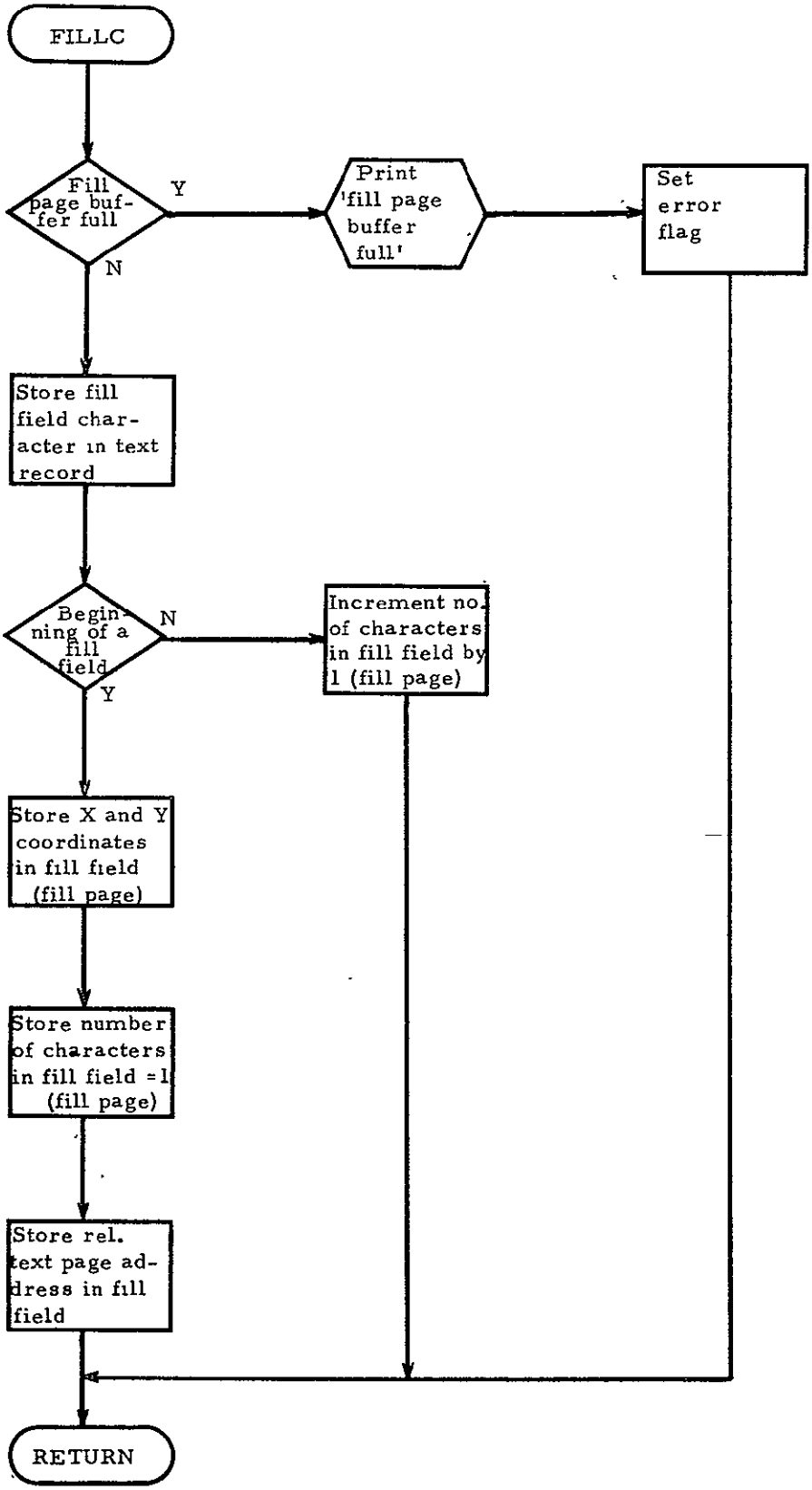


Figure A-10

COMPLETE COMPOSE FIELD

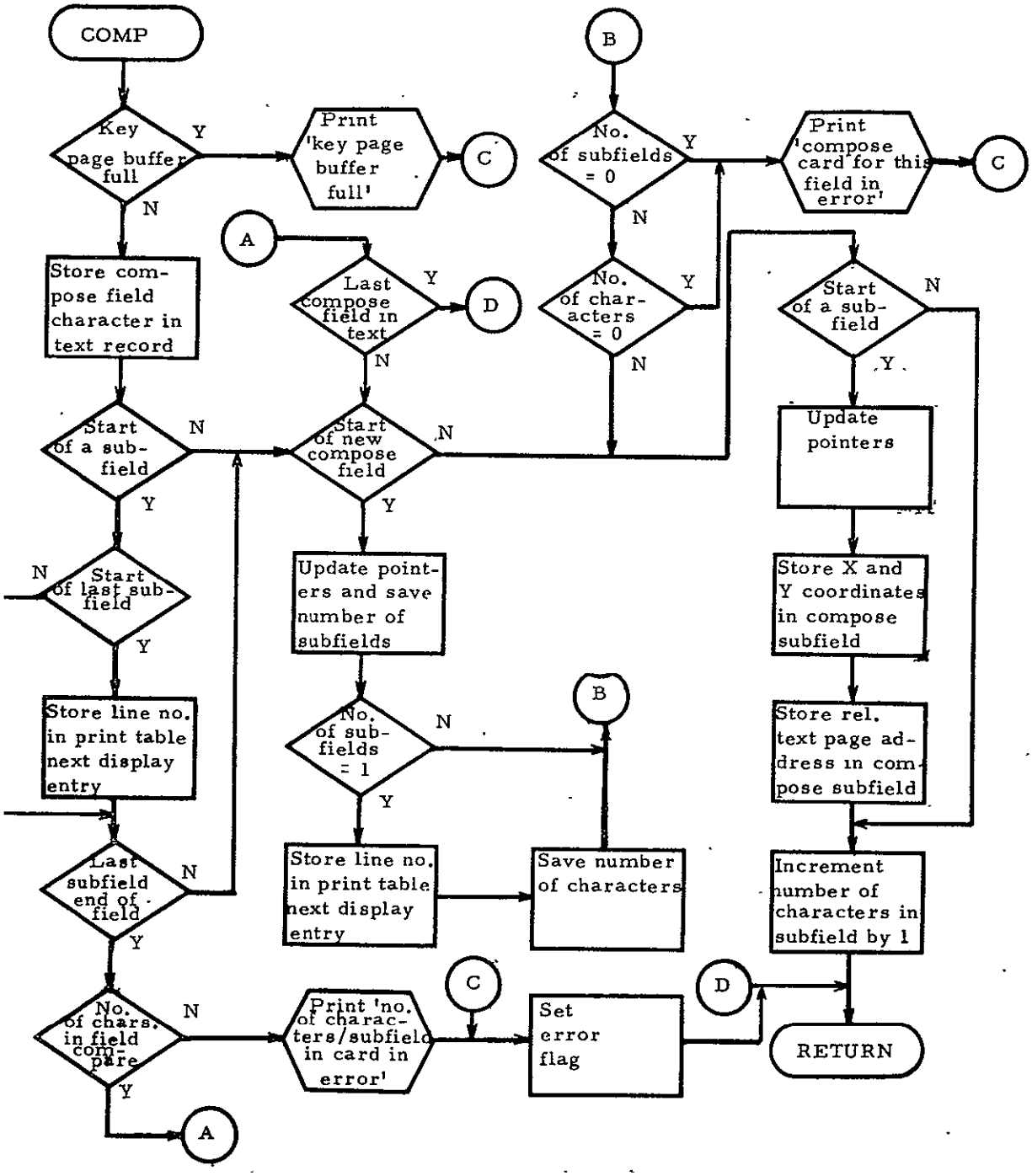


Figure A-11

CHECK TEXT DATA

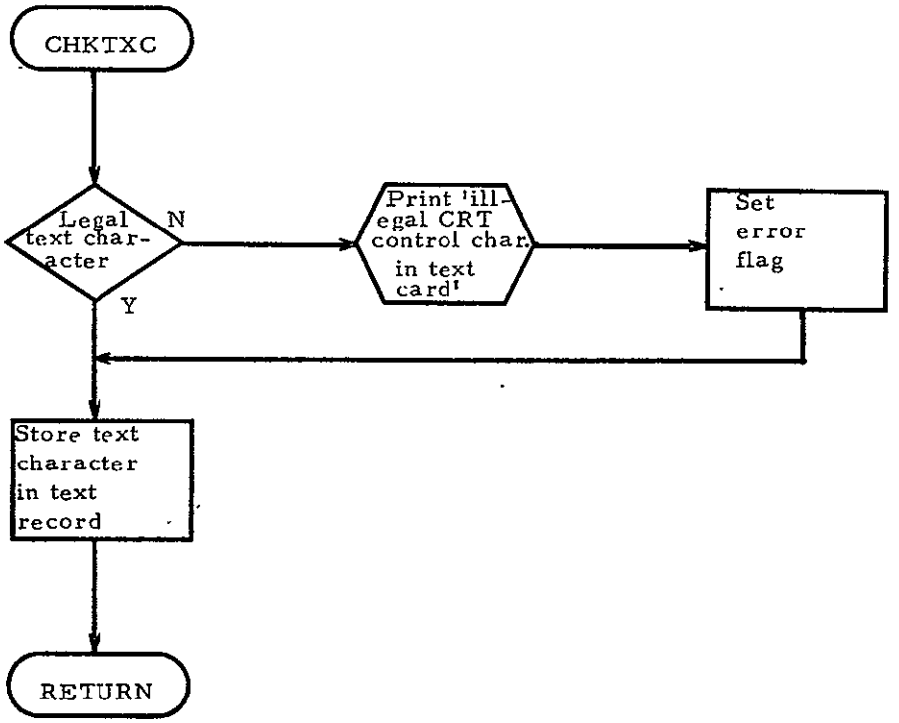


Figure A-12

FORM PEN FIELD

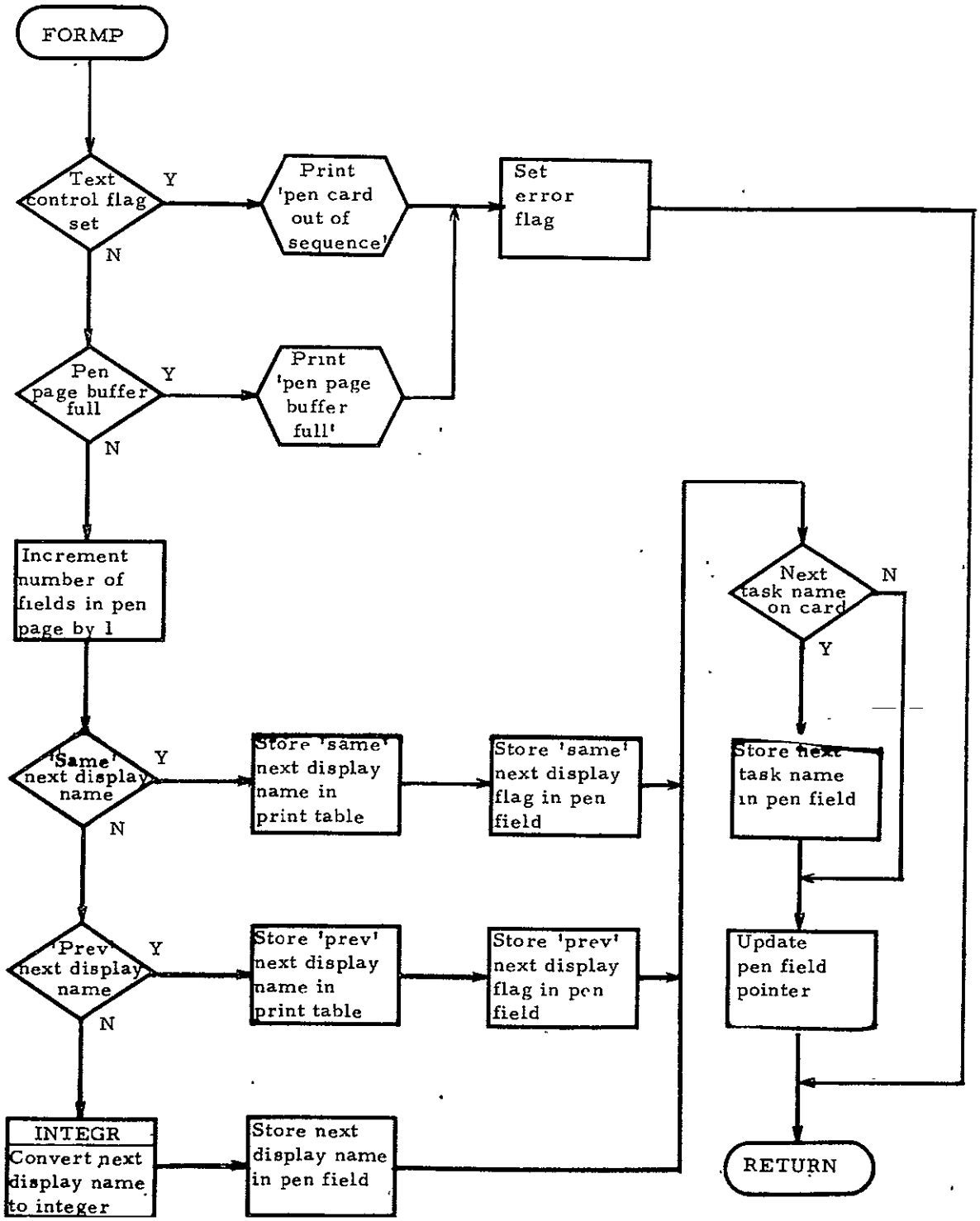


Figure A-13

FORM COMPOSE FIELD

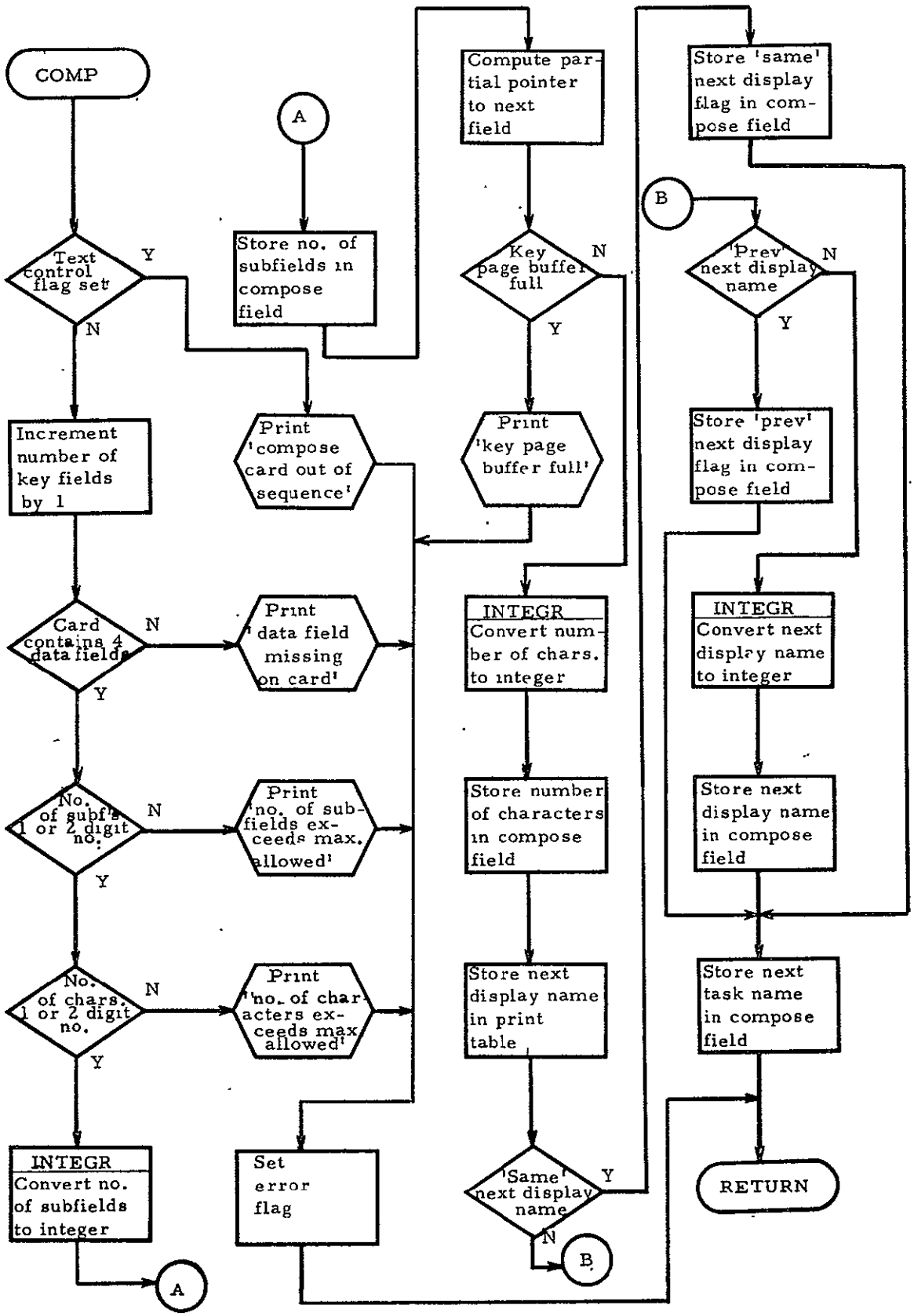


Figure A-14

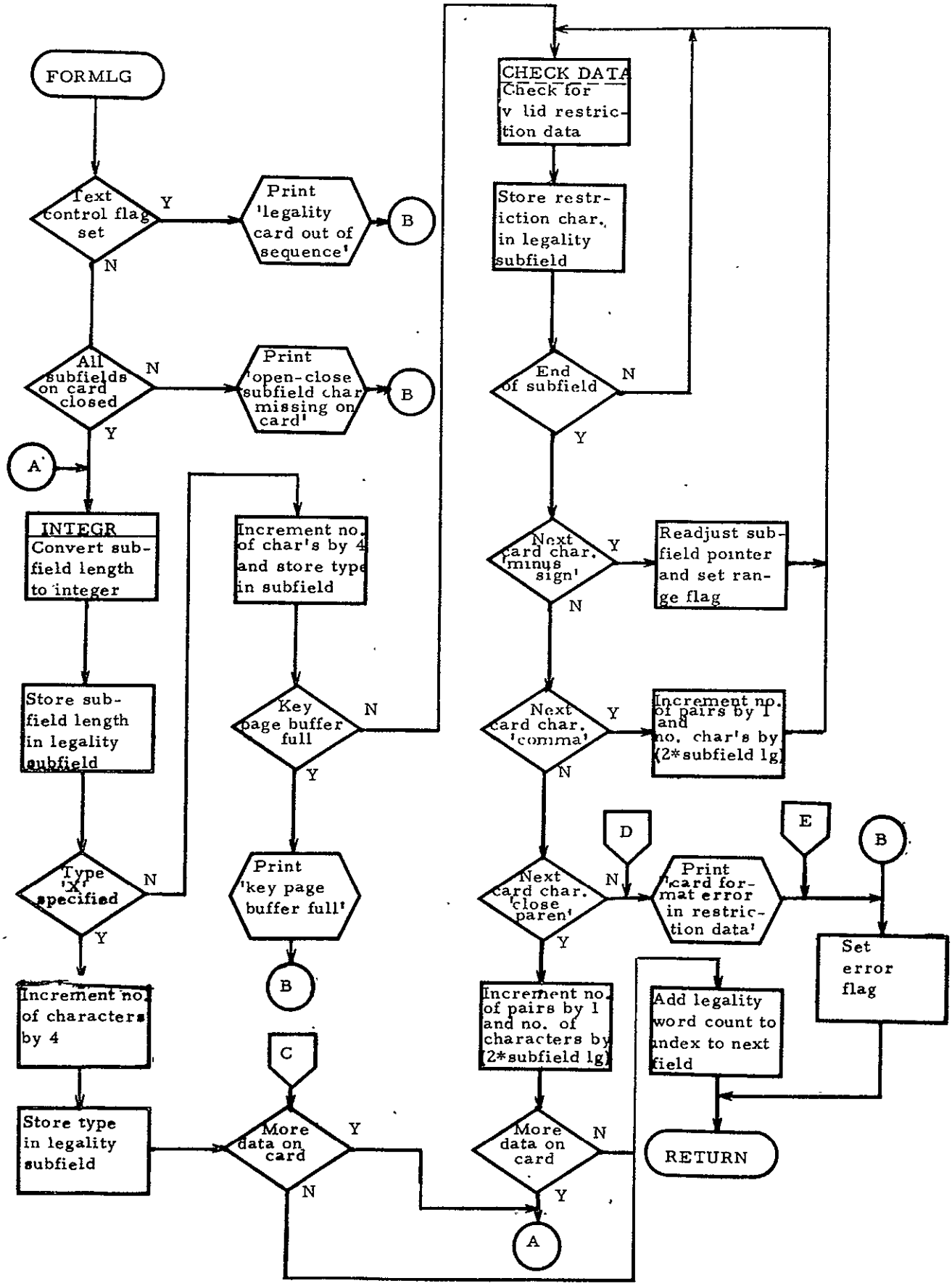

FORMLG
Text control flag set
Y
N
Print 'legality card out of sequence'
B
All subfields on card closed
N
Y
Print 'open-close subfield char missing on card'
B
A
INTEGR
Convert subfield length to integer
Store subfield length in legality subfield
Type 'X' specified
N
Y
Increment no. of characters by 4
Store type in legality subfield
Increment no. of char's by 4 and store type in subfield
Key page buffer full
N
Y
Print 'key page buffer full'
B
C
More data on card
Y
N
CHECK DATA
Check for valid restriction data
Store restriction char. in legality subfield
End of subfield
N
Y
Next card char. 'minus sign'
Y
N
Readjust subfield pointer and set range flag
Next card char. 'comma'
Y
N
Increment no. of pairs by 1 and no. char's by (2*subfield lg)
D
Next card char. 'close paren'
N
Y
Print 'card format error in restriction data'
E
B
Set error flag
Increment no. of pairs by 1 and no. of characters by (2*subfield lg)
Add legality word count to index to next field
More data on card
N
Y
RETURN
A

Figure A-15

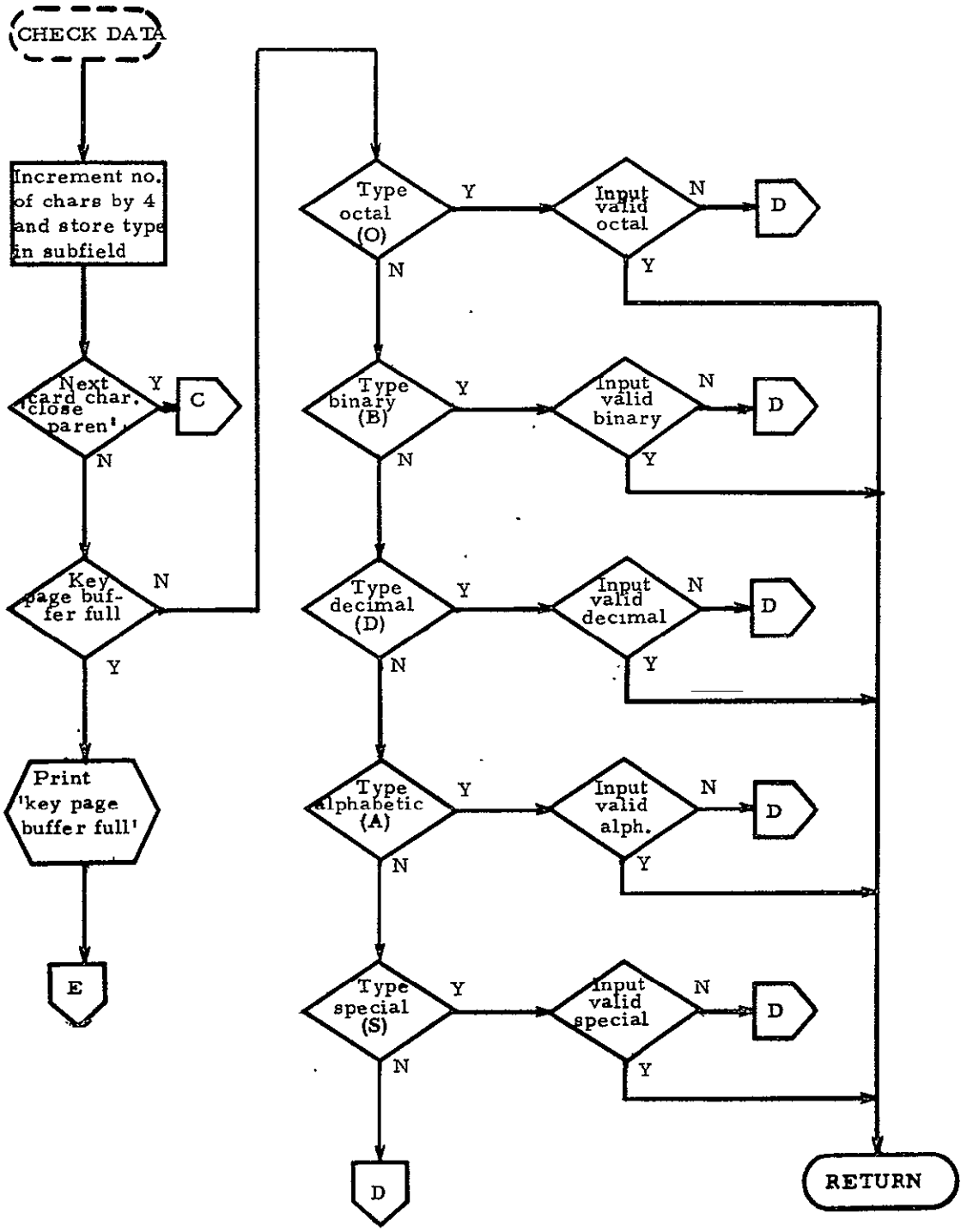


Figure A-15
(continued)

FORM LINE PAGE DATA

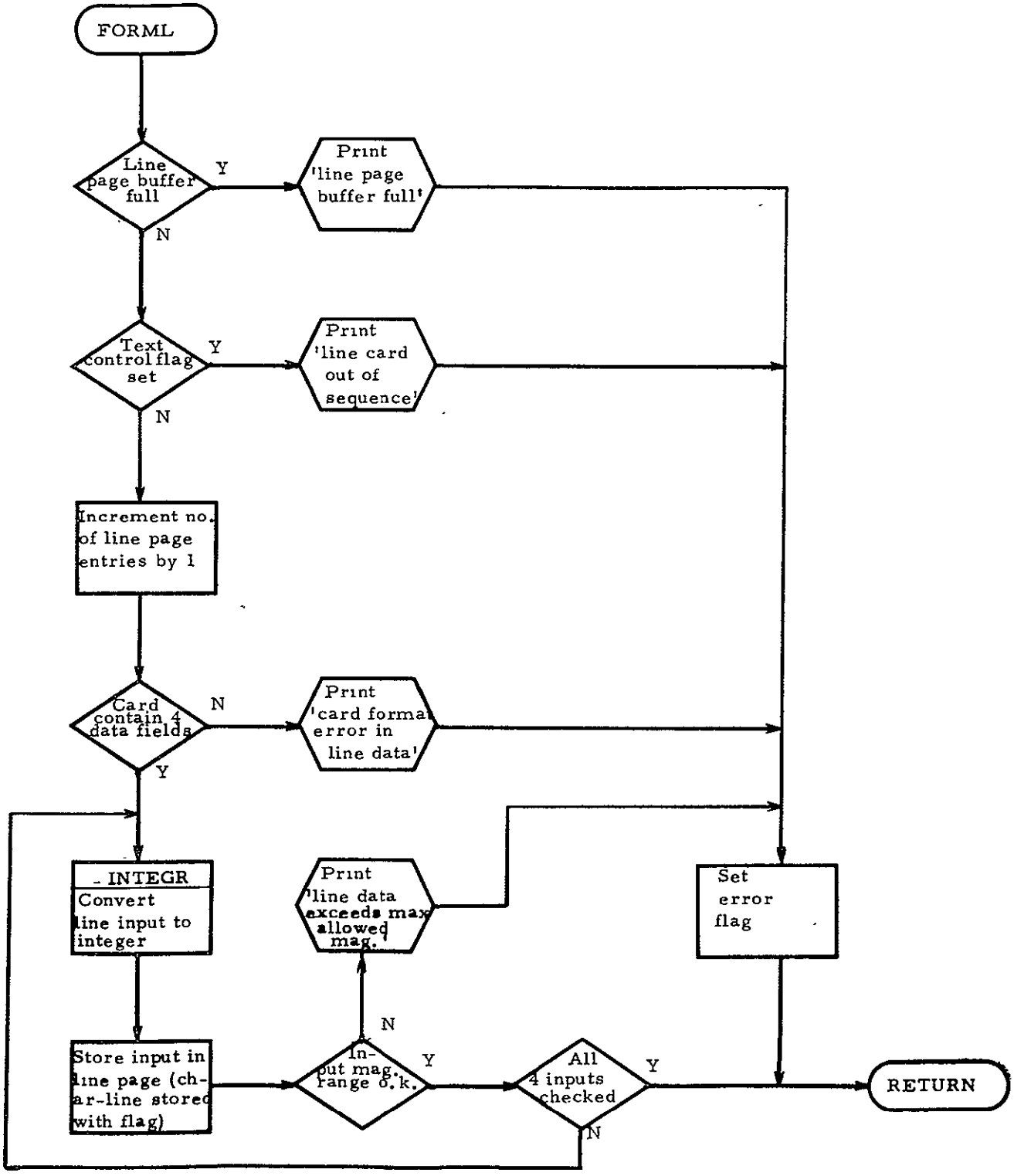
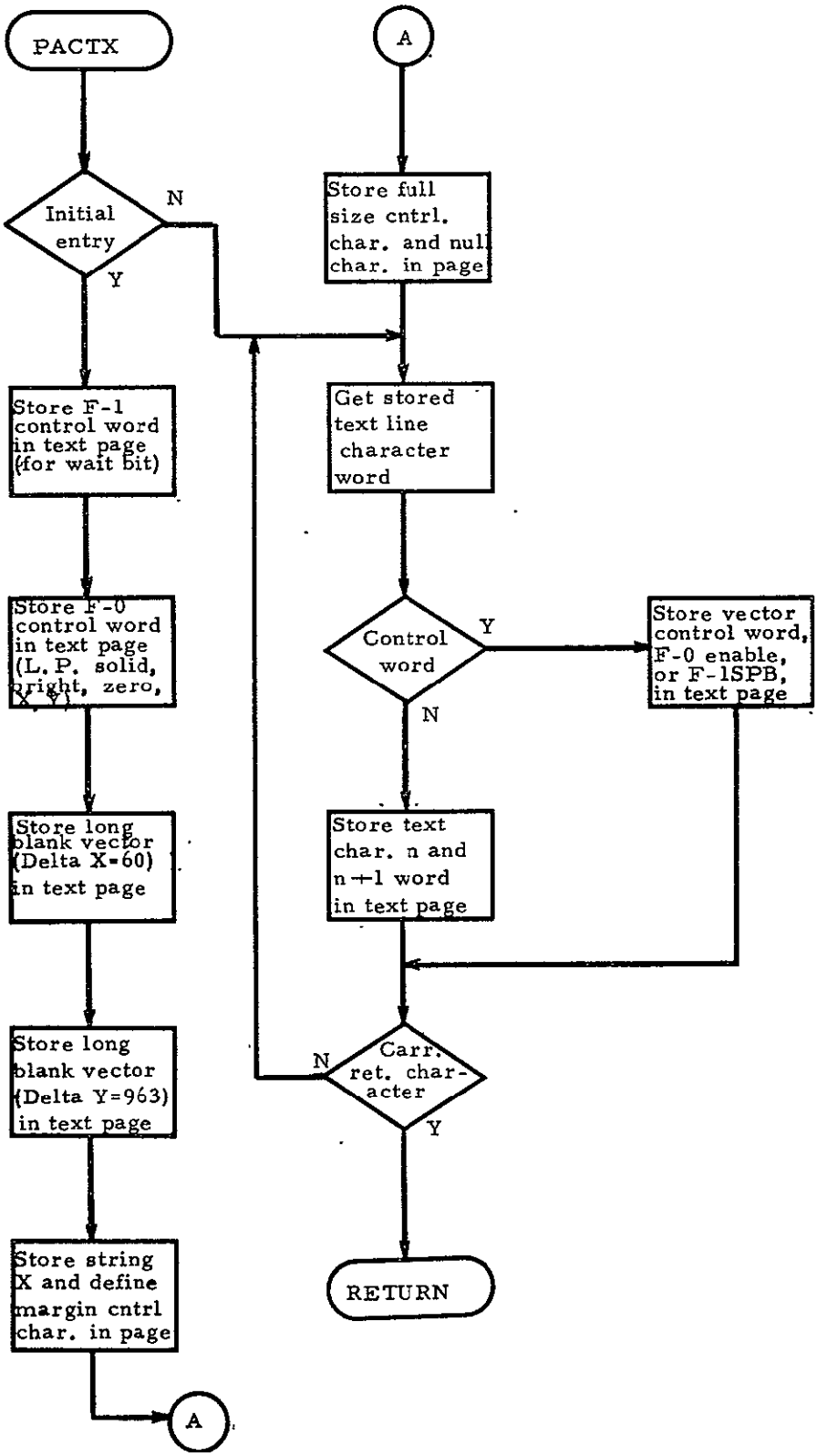


Figure A-16



ORIGINAL PAGE IS
OF POOR QUALITY

Figure A-17

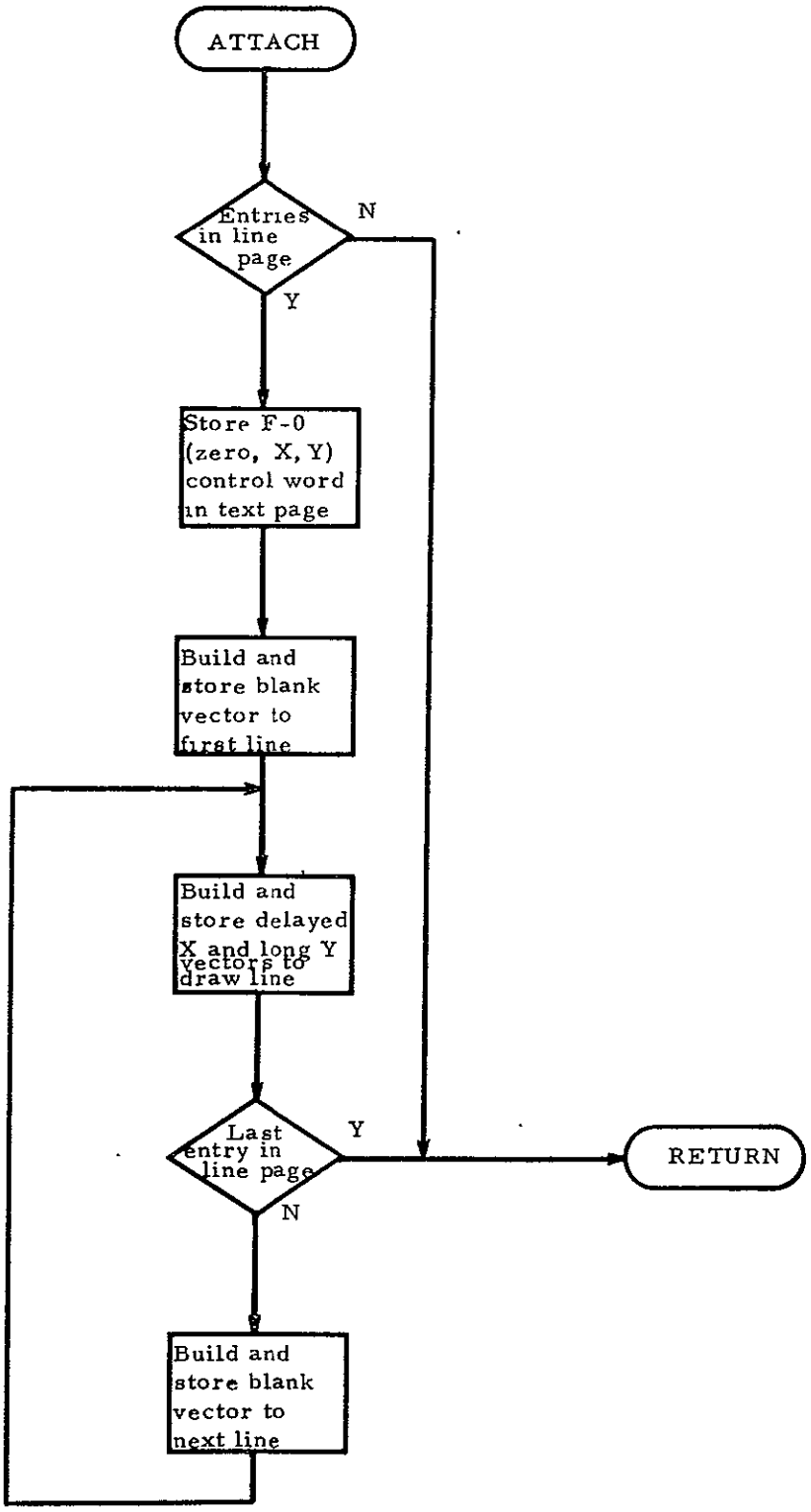

ATTACH
Entries in line page
N
Y
Store F-0 (zero, X, Y) control word in text page
Build and store blank vector to first line
Build and store delayed X and long Y vectors to draw line
Last entry in line page
Y
N
RETURN
Build and store blank vector to next line

Figure A-18

INITIALIZE DISPLAY LIBRARY TAPE

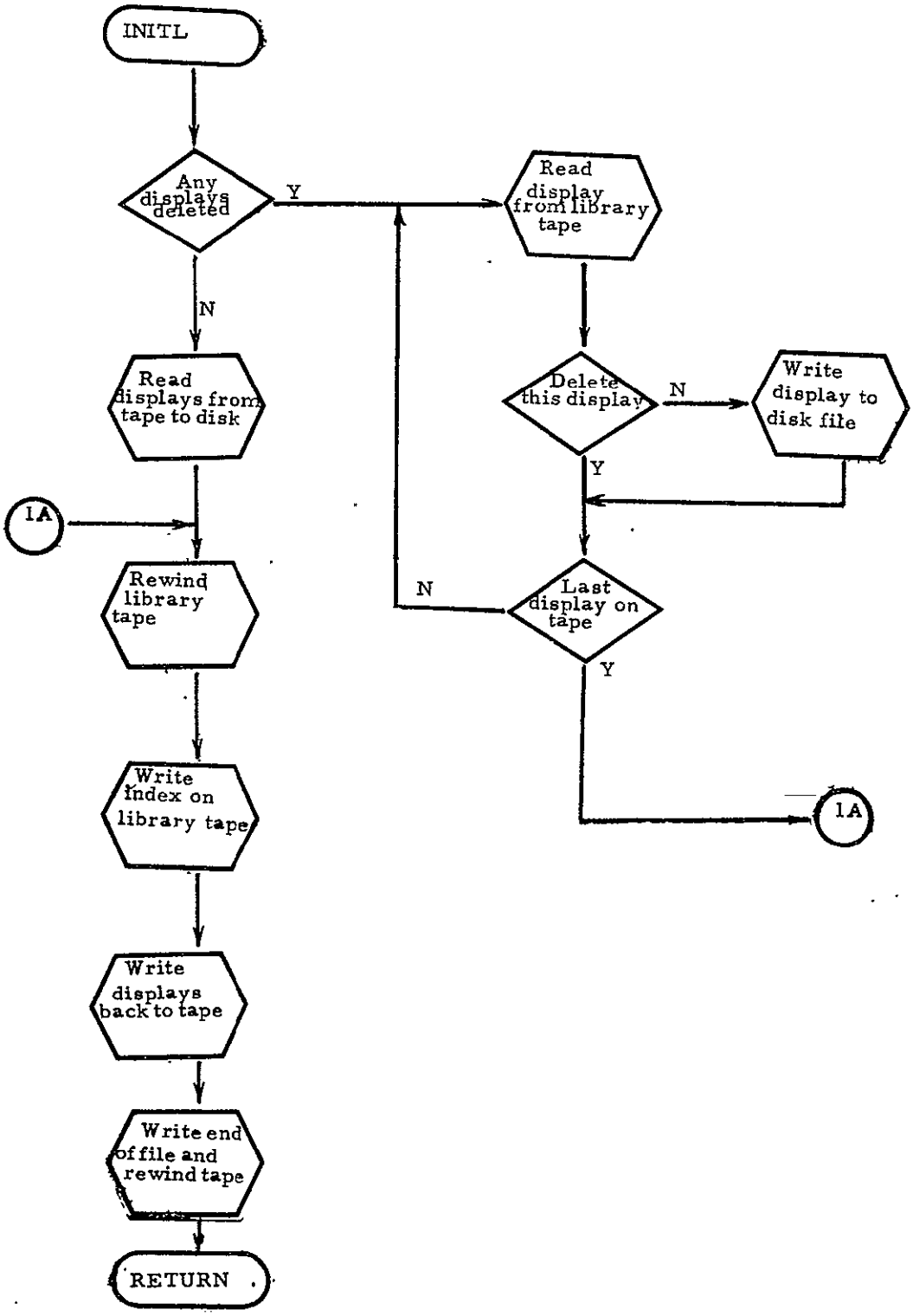


Figure A-19

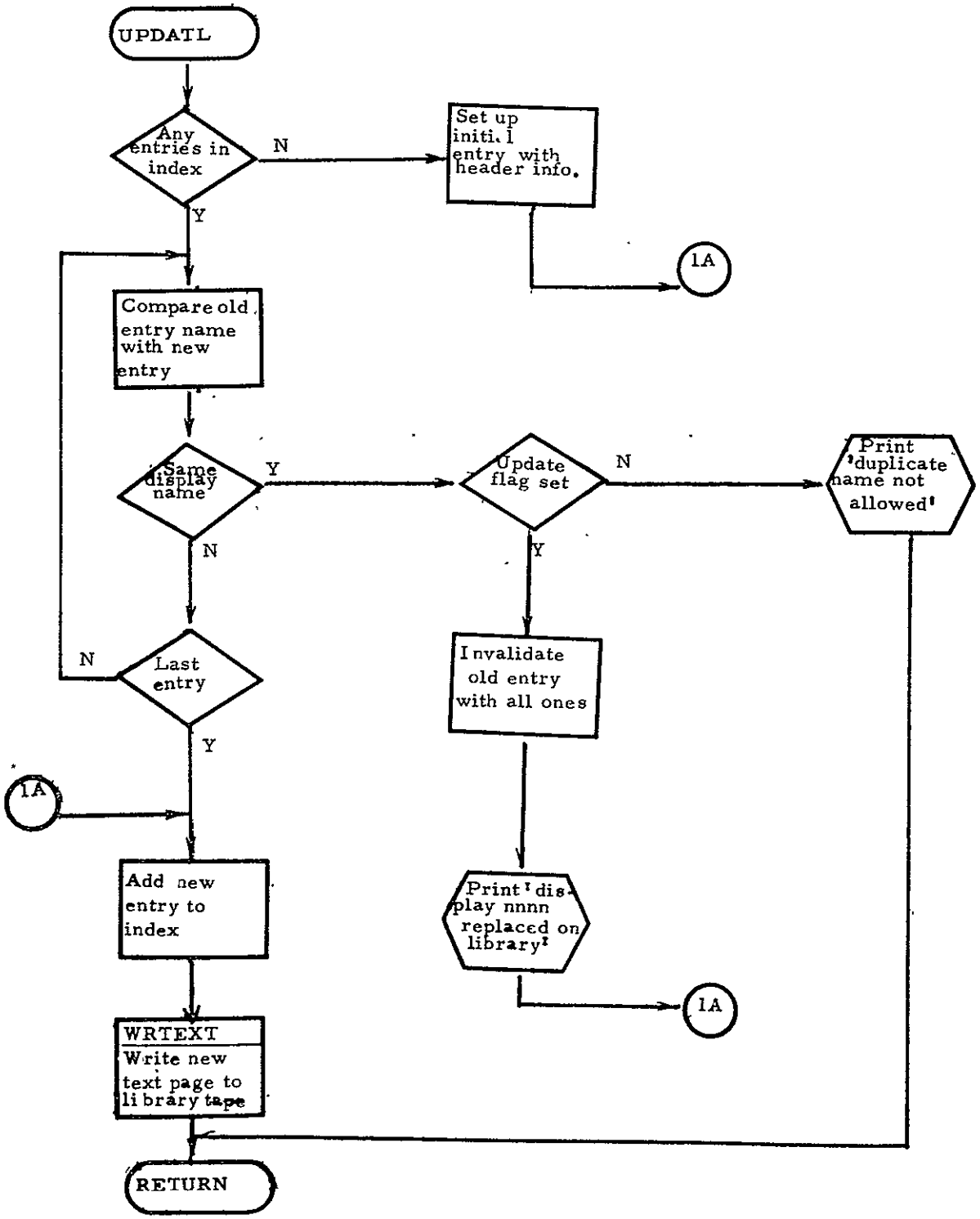

UPDATL
Any entries in index
N
Y
Set up initial entry with header info.
1A
Compare old entry name with new entry
Same display name
Y
Update flag set
N
Print 'duplicate name not allowed'
N
Y
Last entry
N
Y
Invalidate old entry with all ones
1A
Add new entry to index
Print 'display nnnn replaced on library'
1A
WRTEXT
Write new text page to library tape
RETURN

Figure A-20

WRITE TEXT PAGE

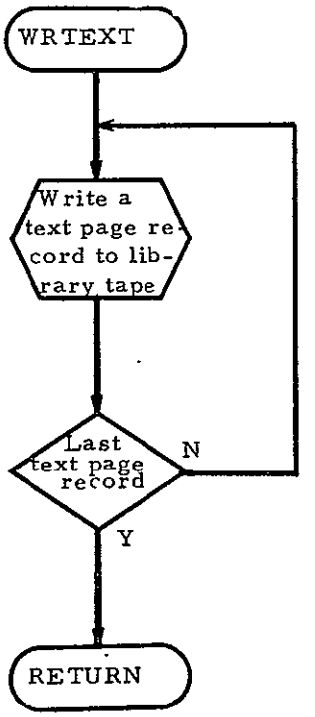


Figure A-21

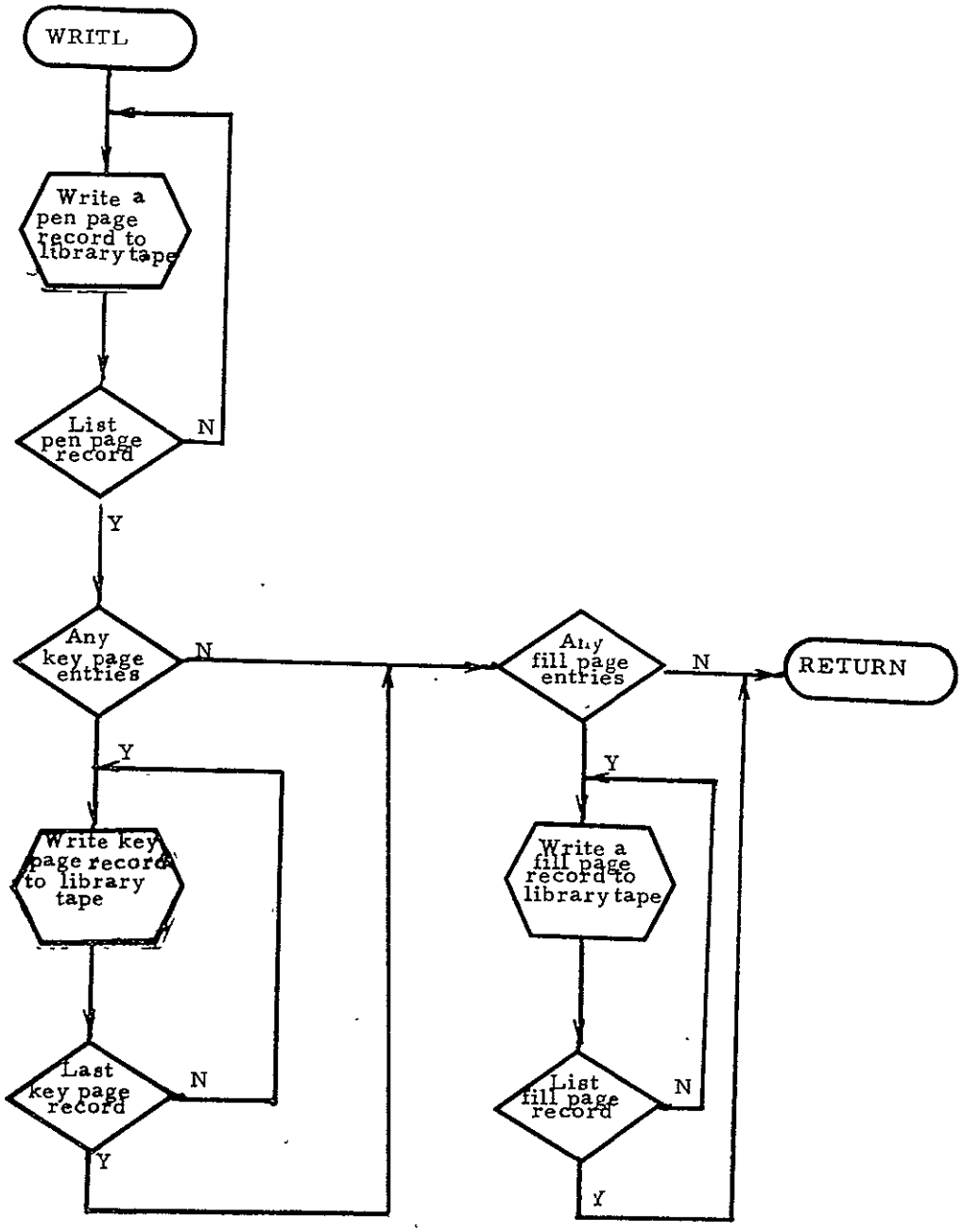

WRITL
Write a pen page record to library tape
List pen page record
N
Y
Any key page entries
N
Y
Write key page record to library tape
Last key page record
N
Y
Any fill page entries
N
RETURN
Y
Write a fill page record to library tape
List fill page record
N
Y

Figure A-22

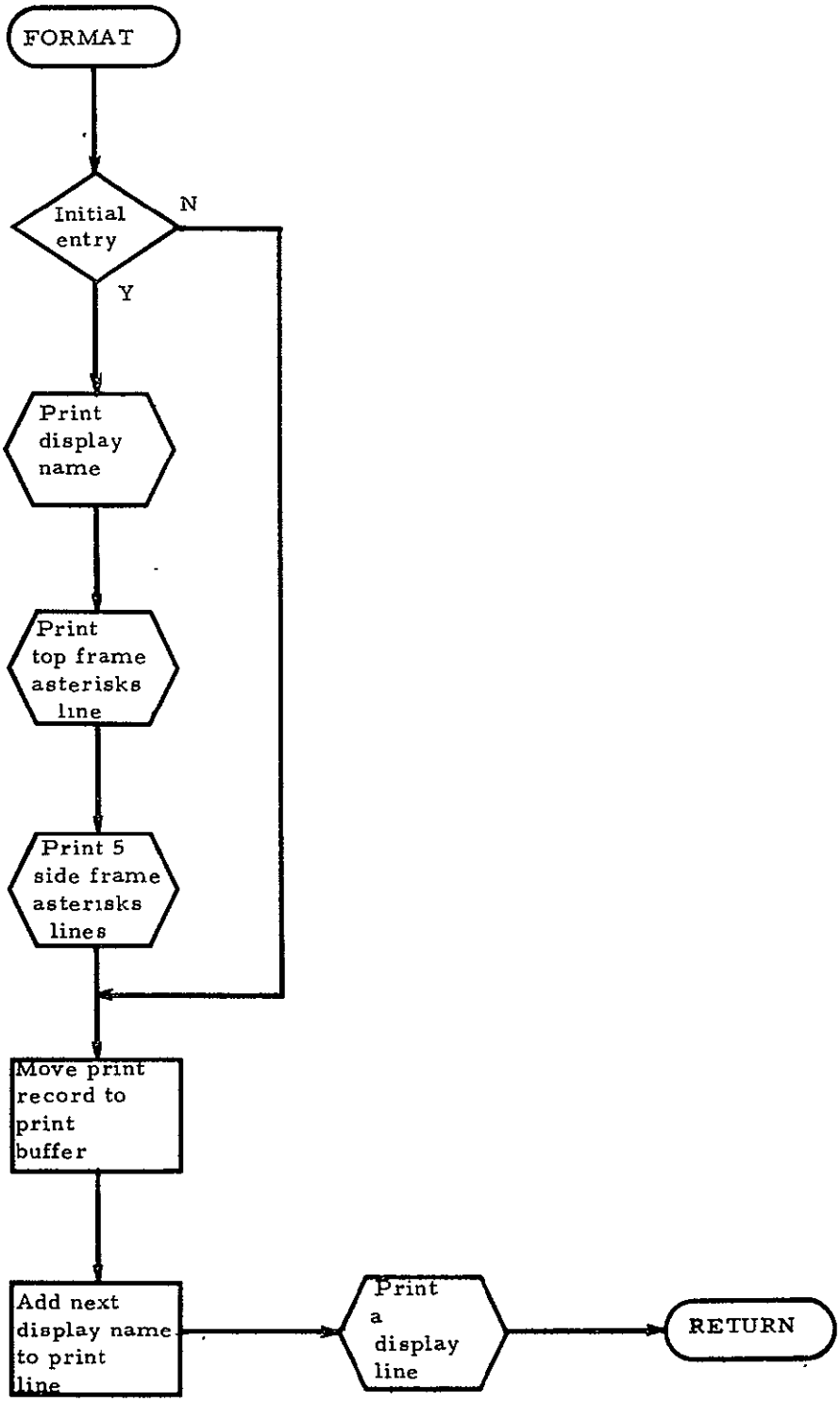

FORMAT
Initial entry
N
Y
Print display name
Print top frame asterisks line
Print 5 side frame asterisks lines
Move print record to print buffer
Add next display name to print line
Print a display line
RETURN

Figure A-23

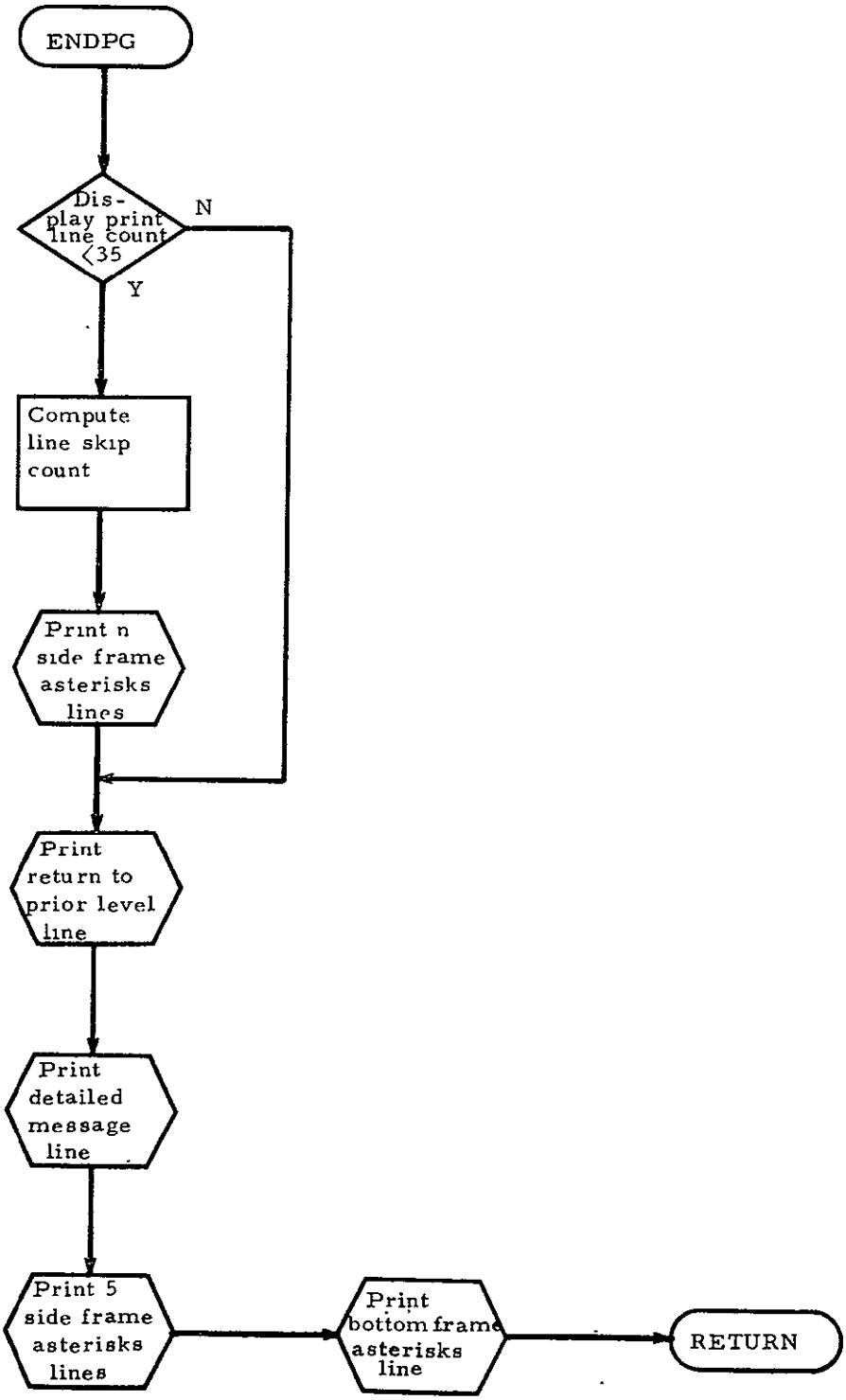

ENDPG
Dis-play print line count <35
N
Y
Compute line skip count
Print n side frame asterisks lines
Print return to prior level line
Print detailed message line
Print 5 side frame asterisks lines
Print bottom frame asterisks line
RETURN

Figure A-24

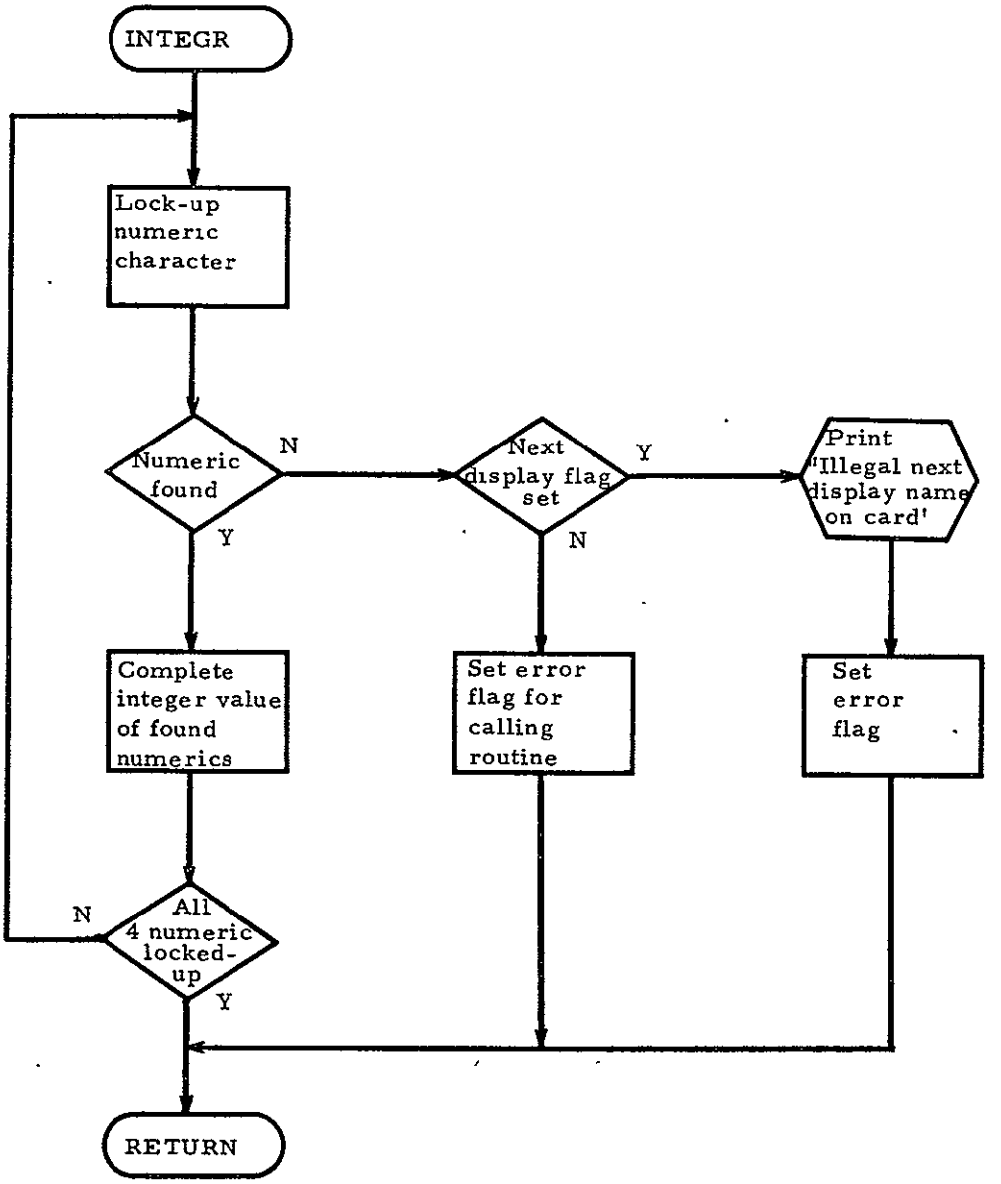


Figure A-25

INITIALIZE PROGRAM VARIABLES

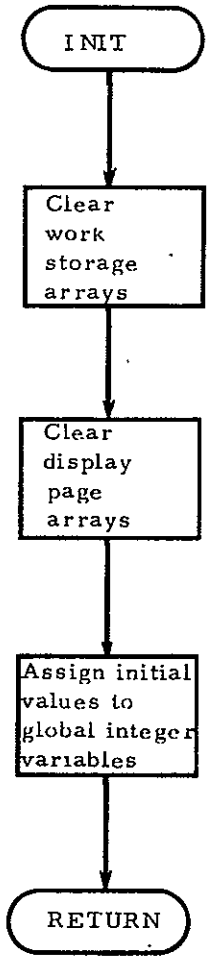


Figure A-26

APPENDIX B

DISPLAY CONTROLLER PROGRAM FLOWCHARTS

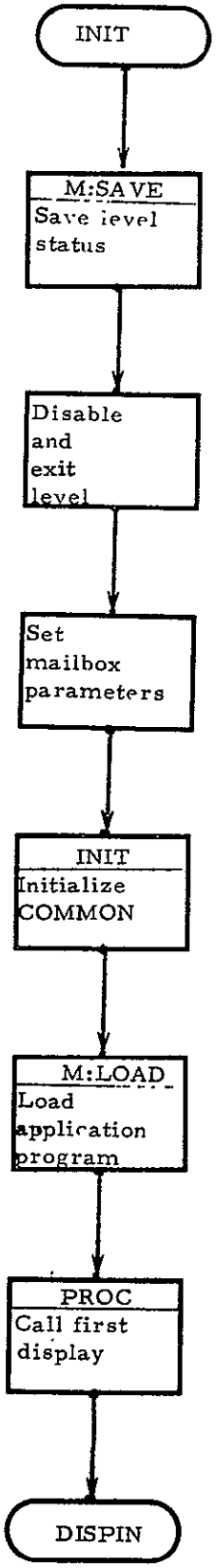
This appendix presents the detail flowcharts of the Display Controller Program. As with the Display Librarian flowcharts in Appendix A, the "Picture-on-a-Page" technique has been utilized in these flowcharts.

An index to the Display Controller Program flowcharts is contained on Page B3. The same flowchart symbol convention described on Page A2 was used in the development of these flowcharts.

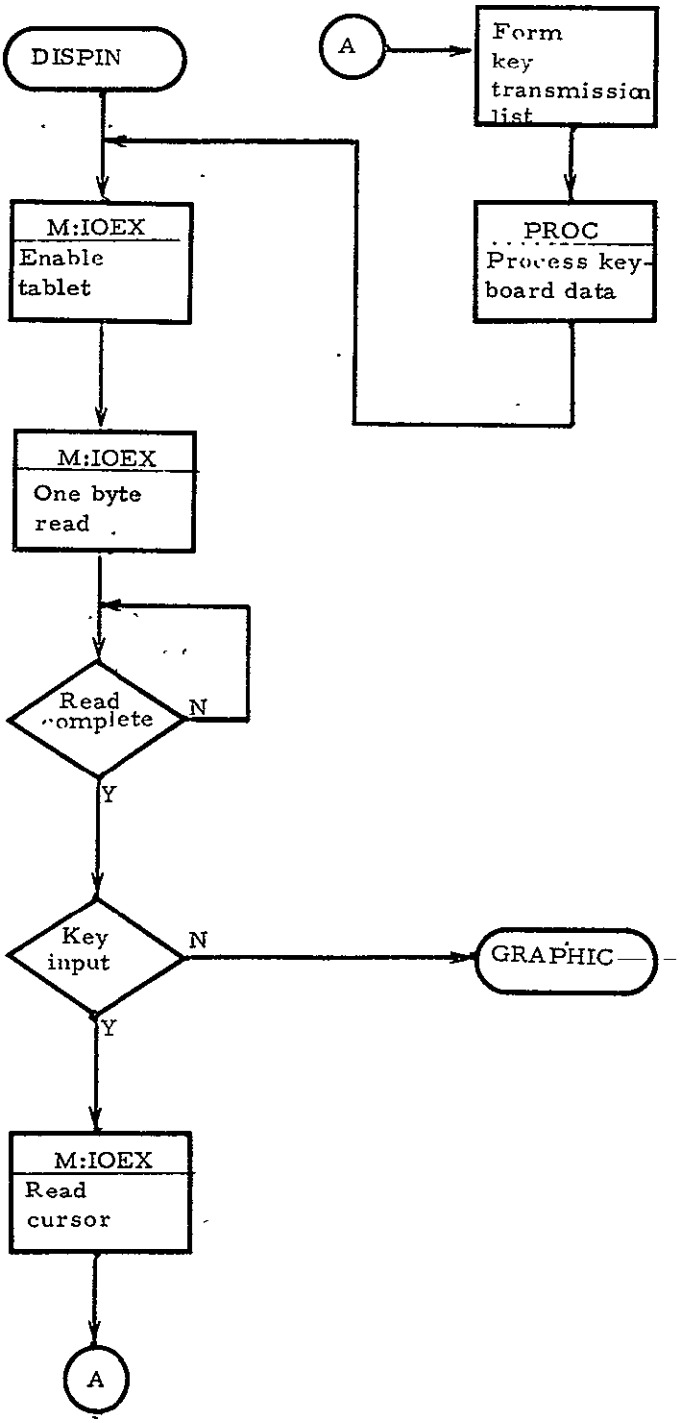
(BLANK)

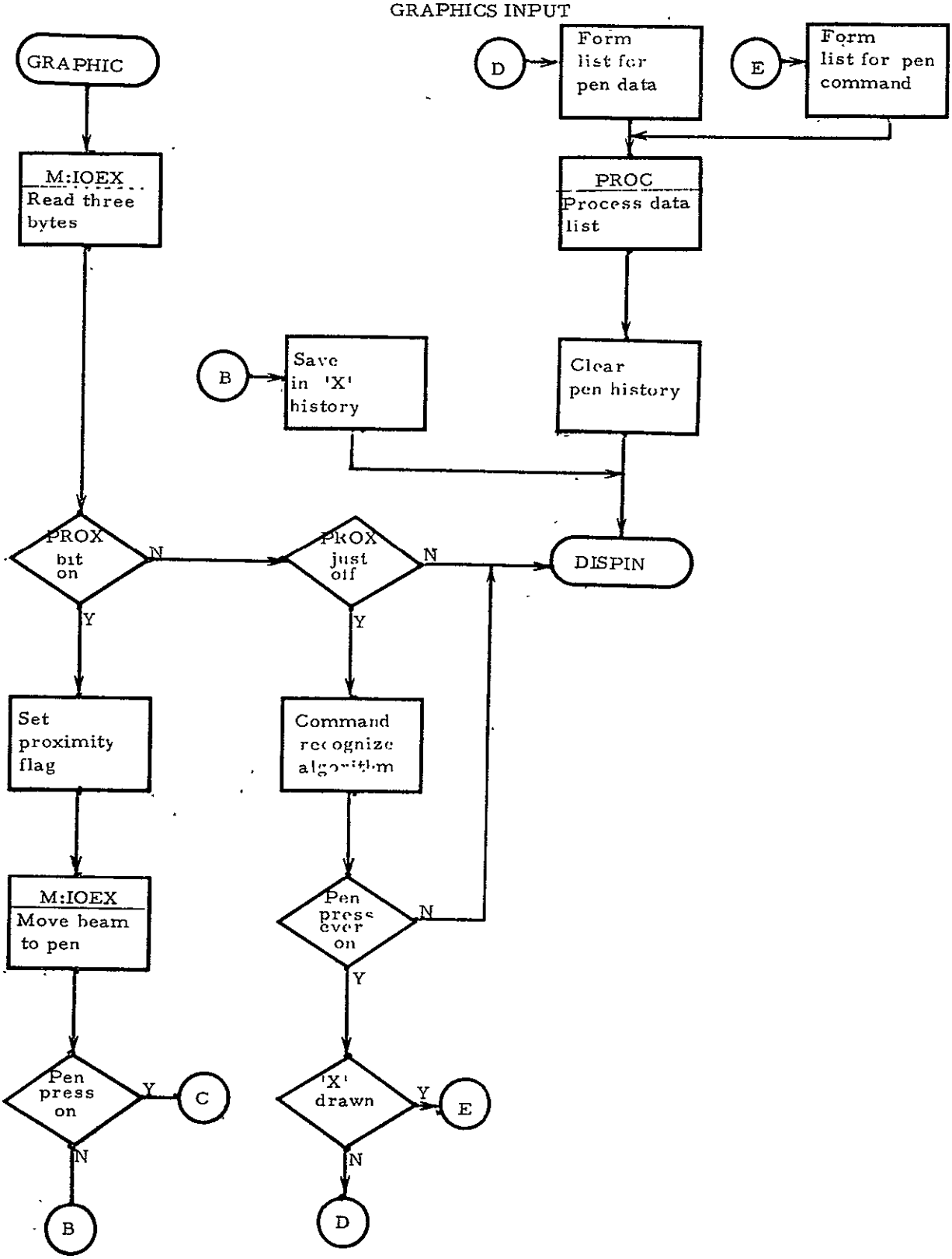
DISPLAY CONTROLLER PROGRAM FLOWCHARTS INDEX

FOREGROUND INITIALIZE

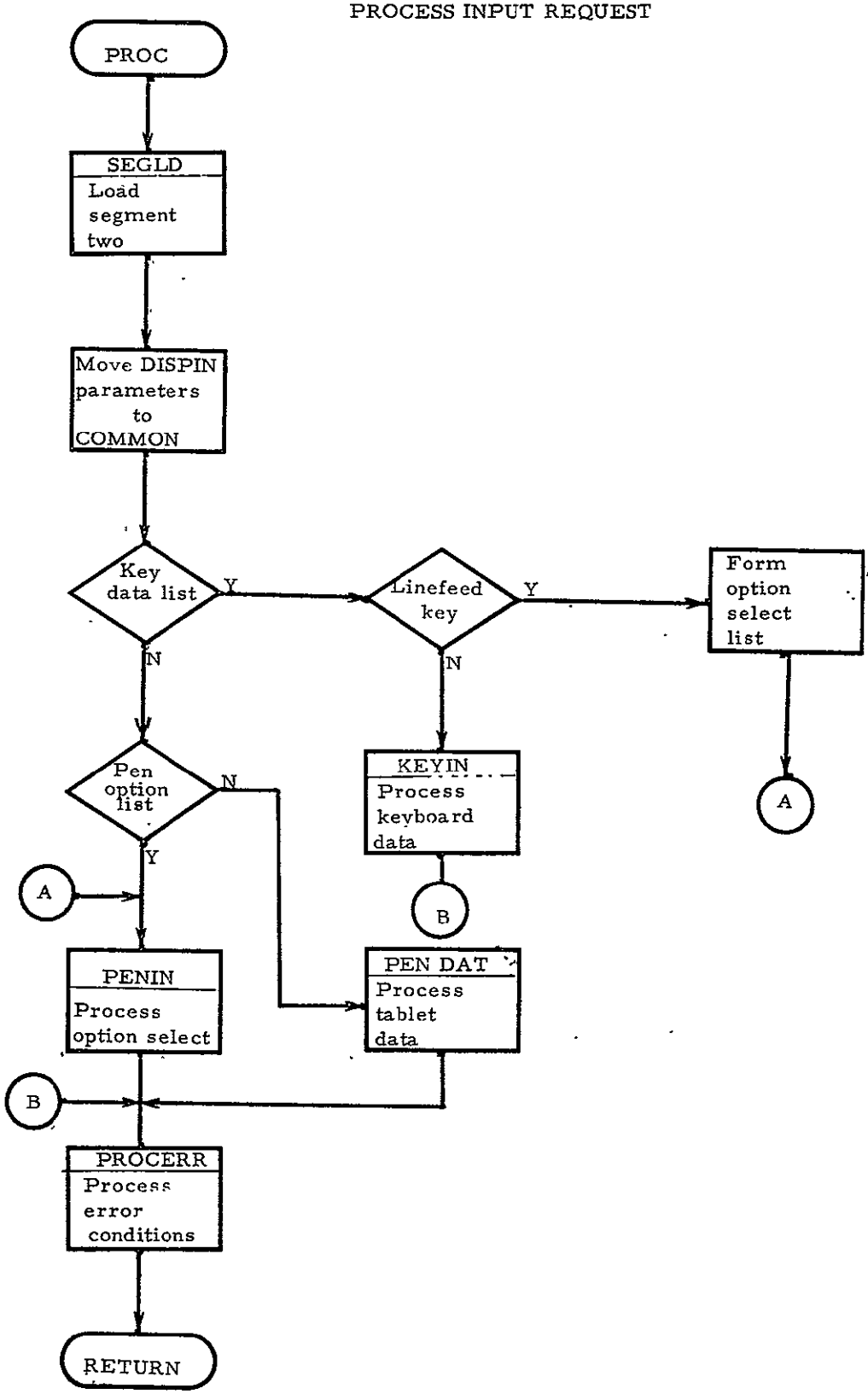


DISPLAY INPUT DRIVER

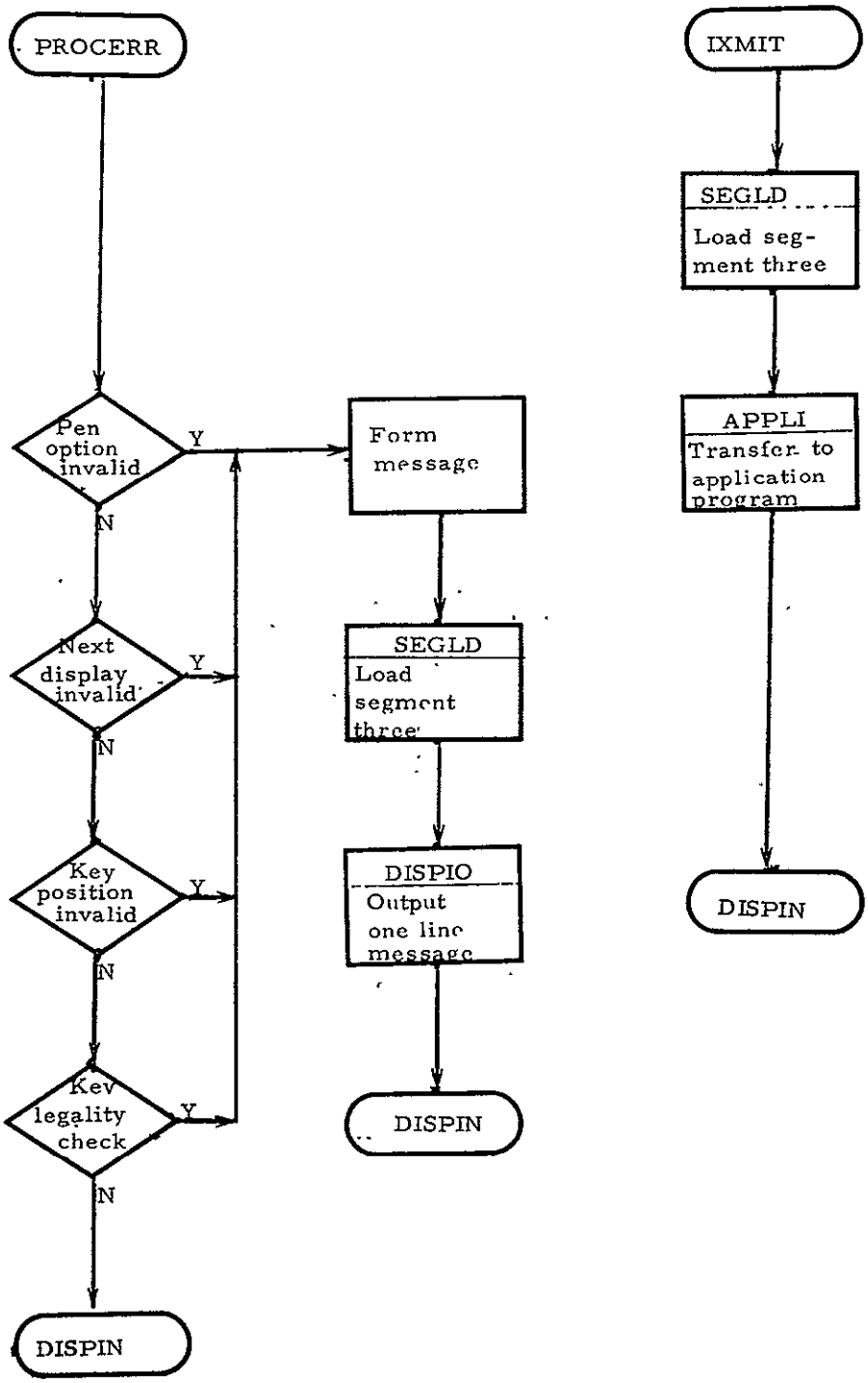



GRAPHIC
M:IOEX
Read three bytes
PROX bit on
N
Y
PROX just off
N
Y
DISPIN
Set proximity flag
Command recognize algorithm
M:IOEX
Move beam to pen
Pen press ever on
N
Y
Pen press on
Y
C
N
B
'X' drawn
Y
E
N
D
B
Save in 'X' history
D
Form list for pen data
E
Form list for pen command
PROC
Process data list
Clear pen history

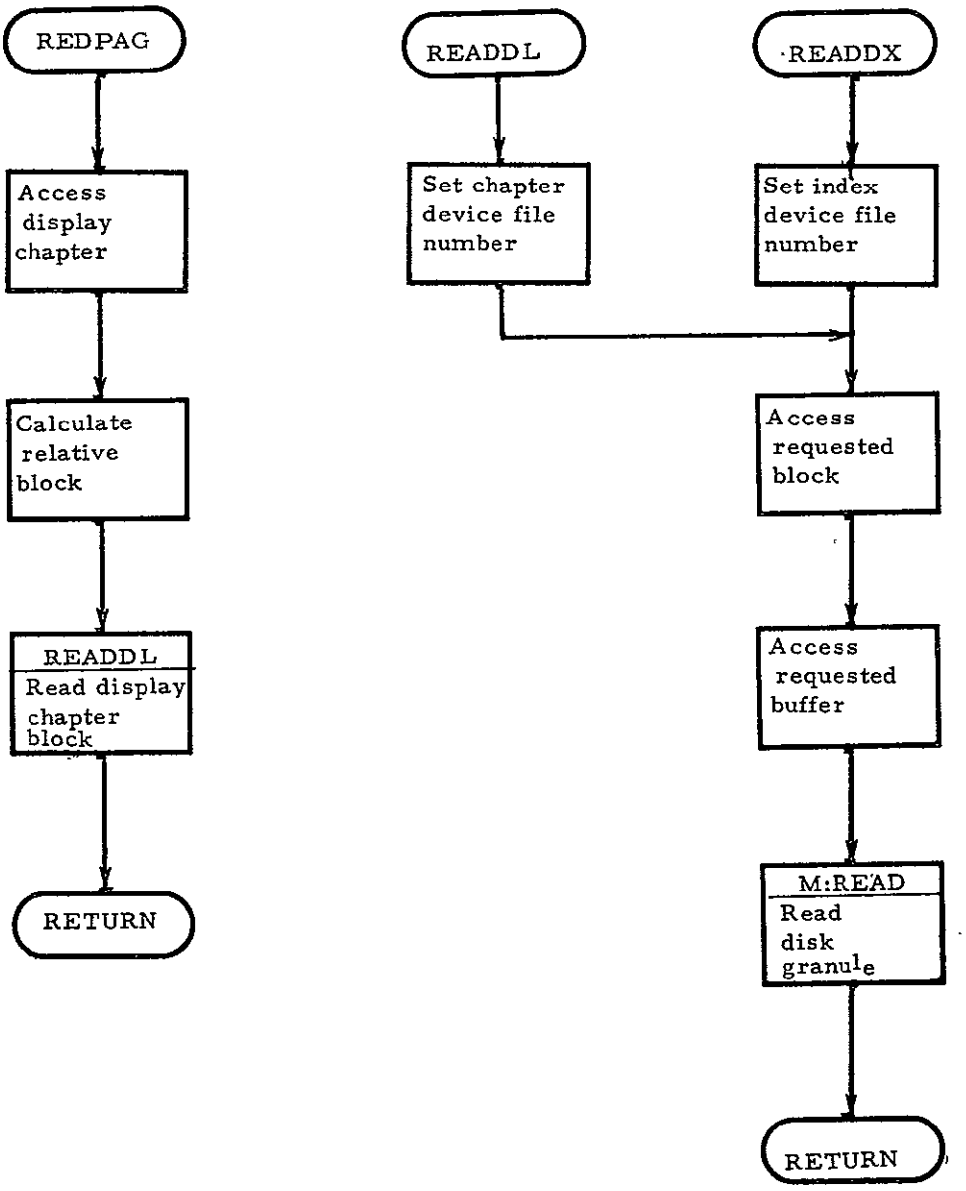
PROCESS INPUT REQUEST



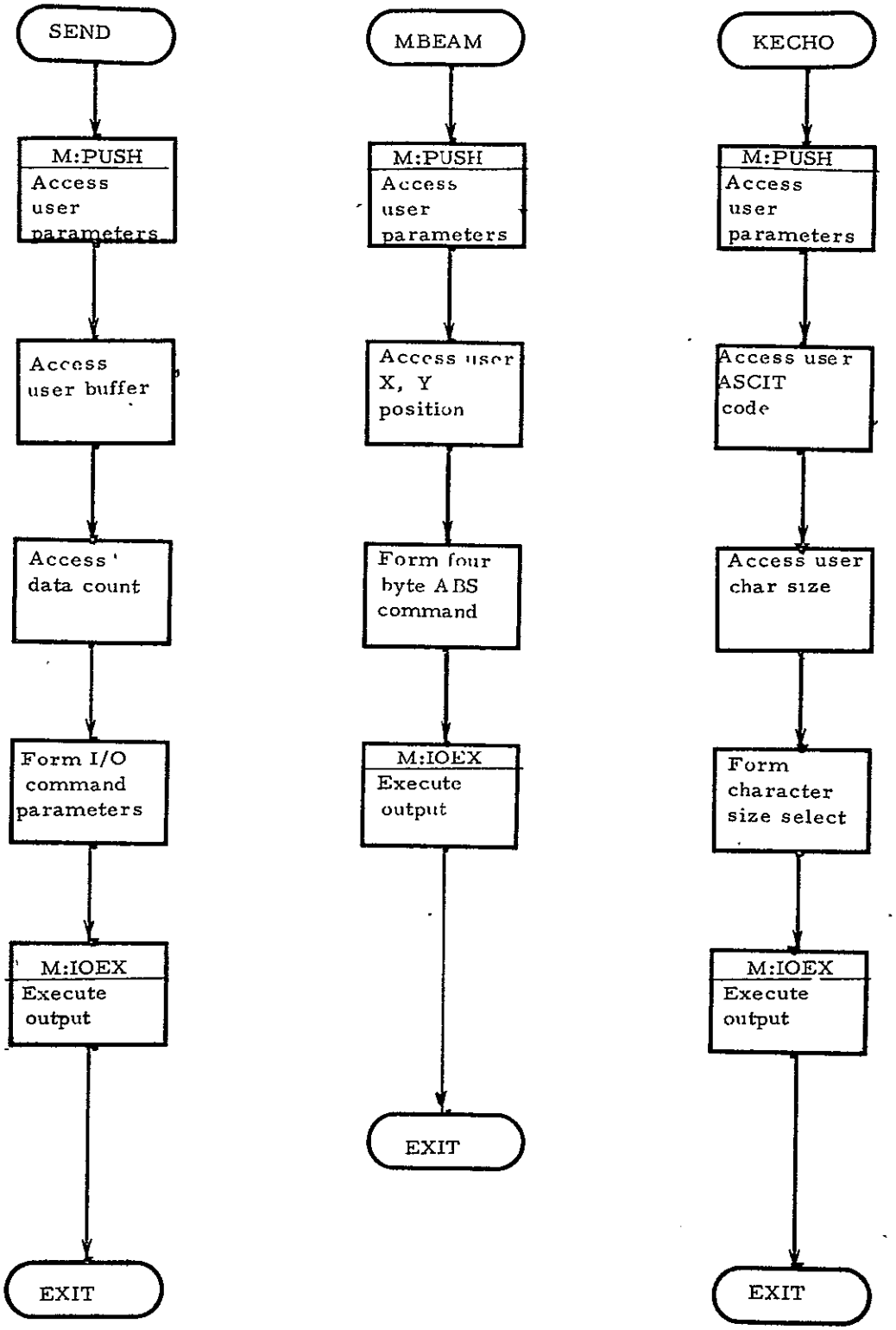
PROCESS ERROR

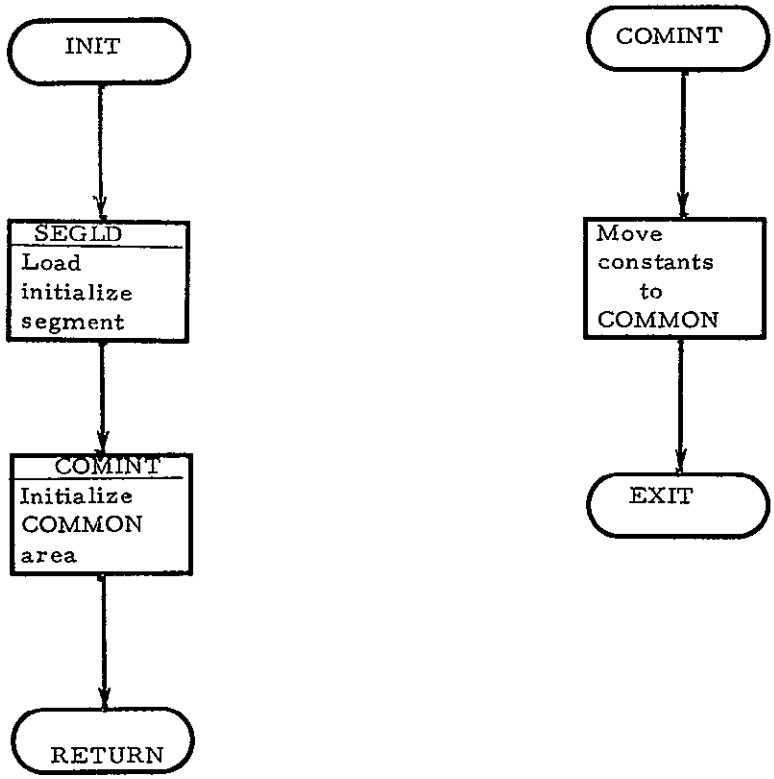


DISPLAY BOOK READ

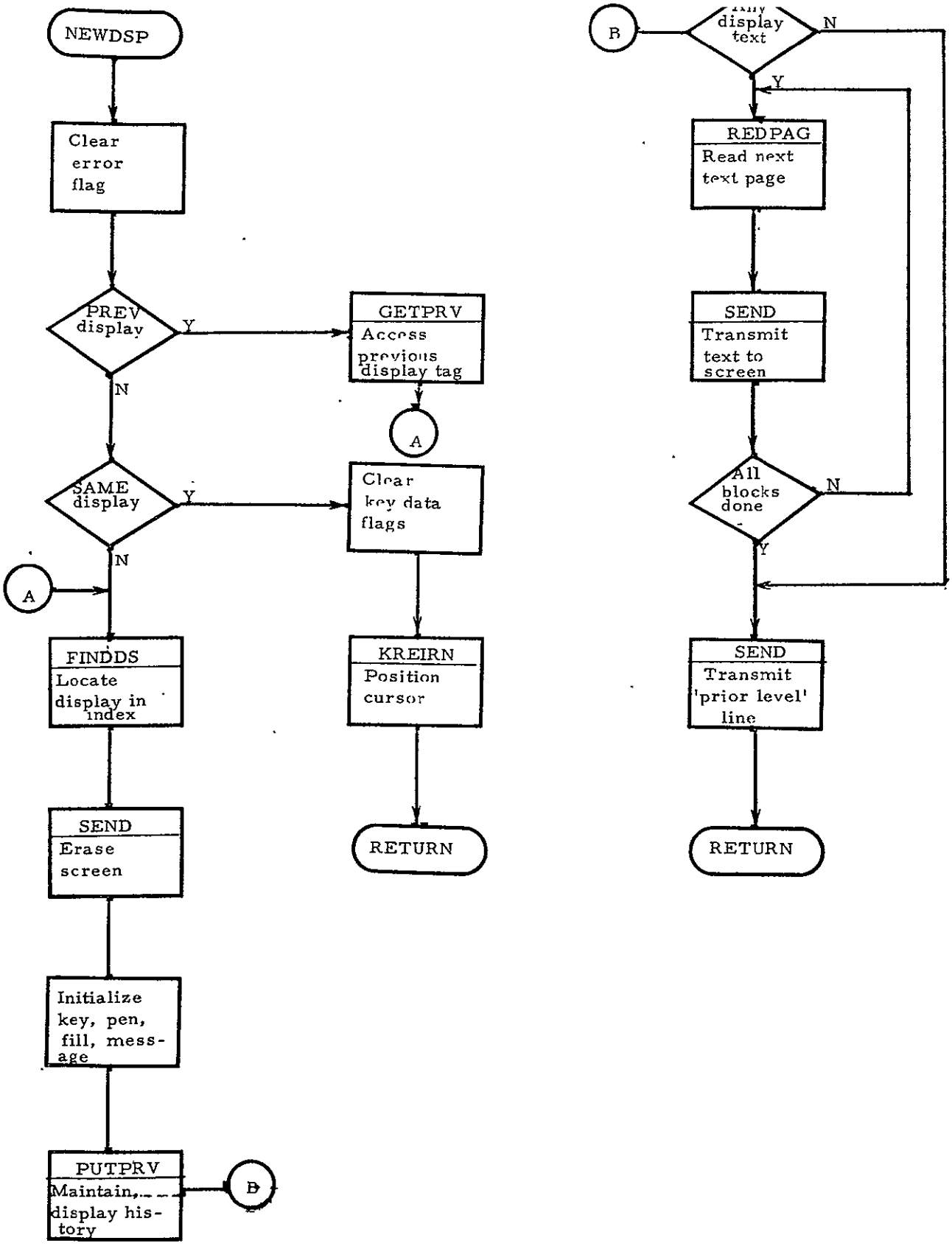


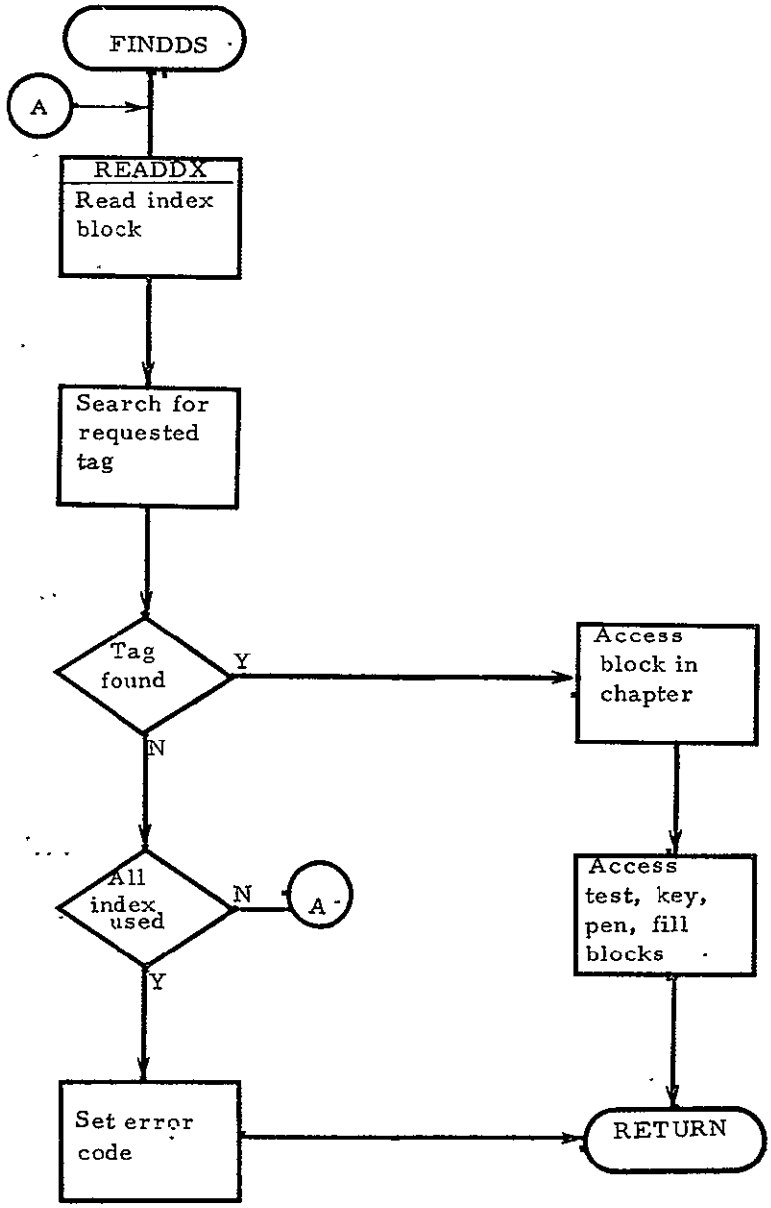
DISPLAY TERMINAL OUTPUT



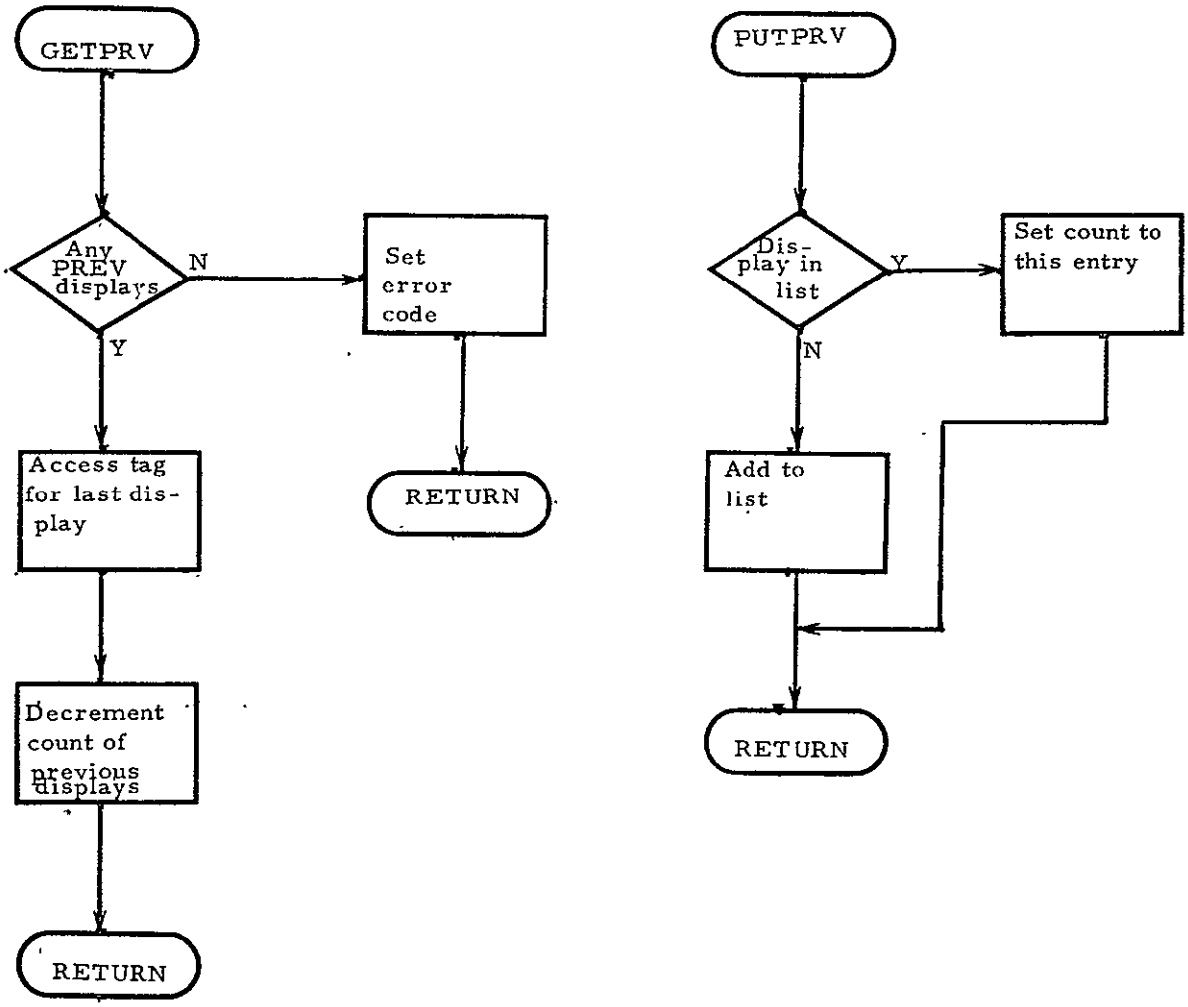

INIT
SEGLD
Load initialize segment
COMINT
Initialize COMMON area
RETURN
COMINT
Move constants to COMMON
EXIT

NEW DISPLAY PROCESS

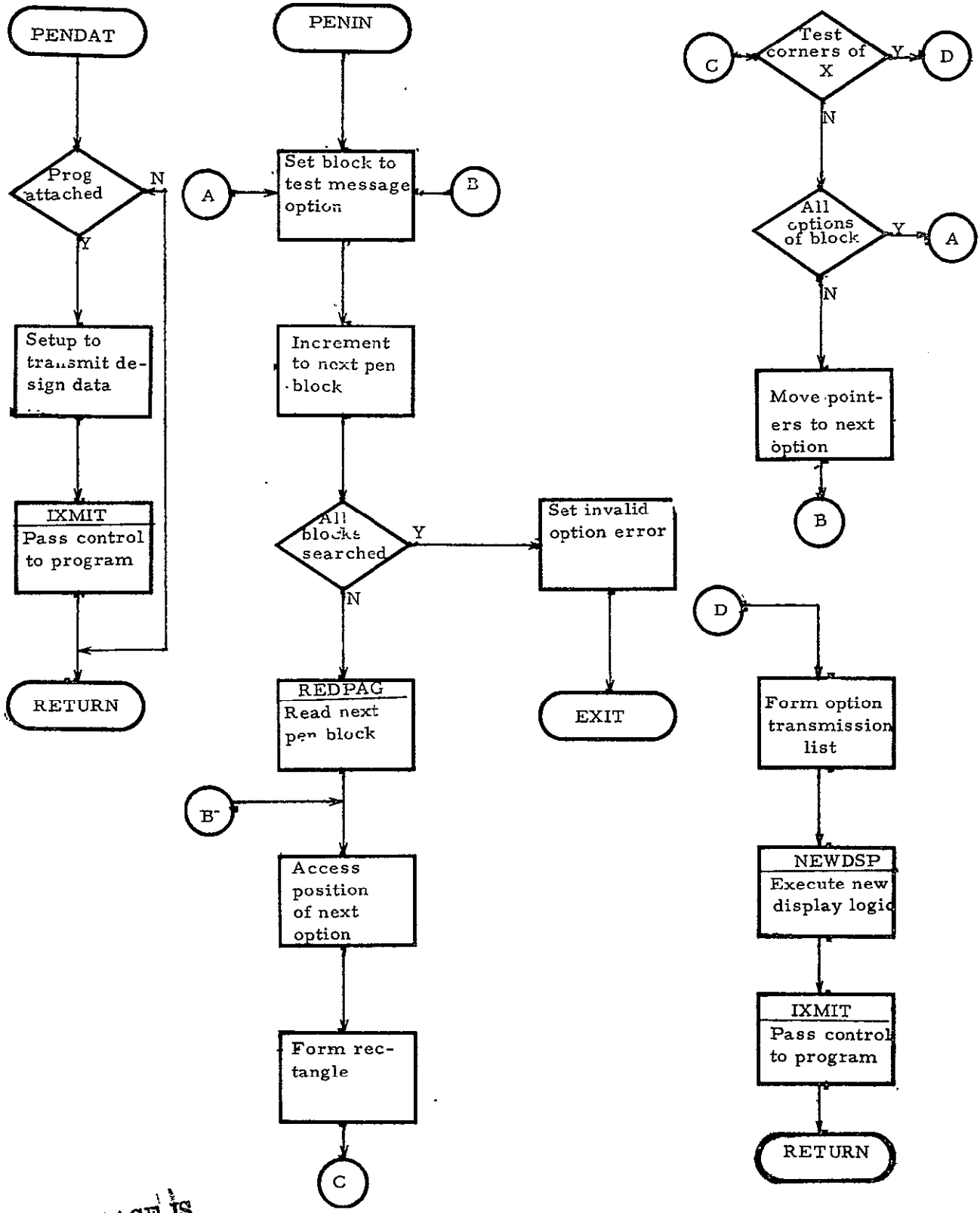




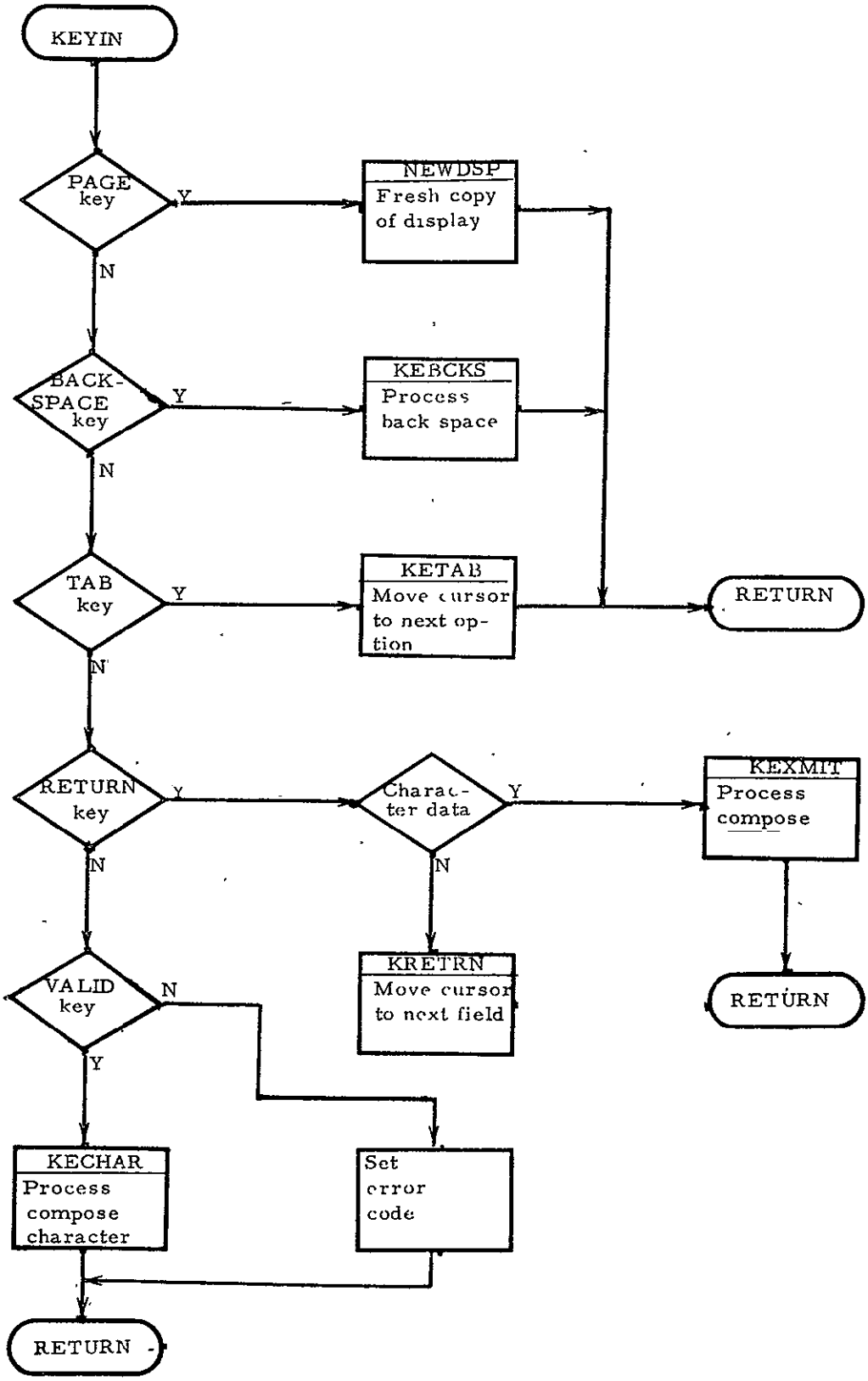
GET/PUT DISPLAY HISTORY



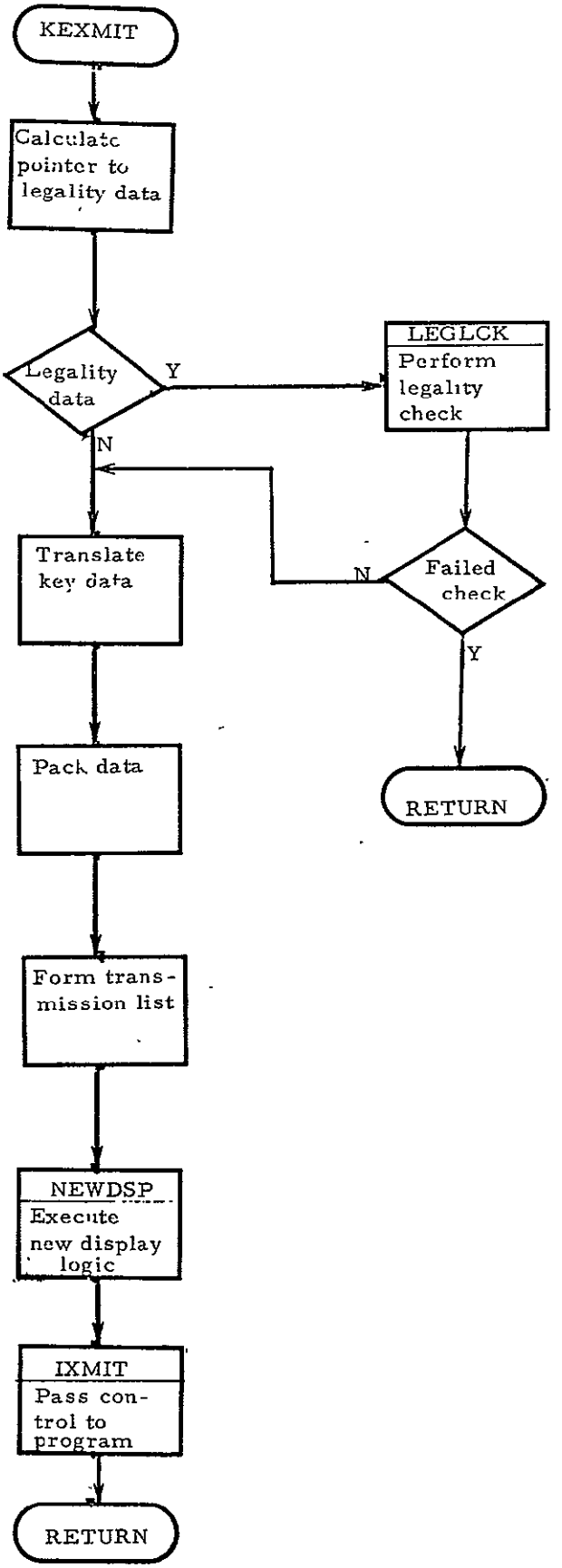
PEN DATA PROCESS



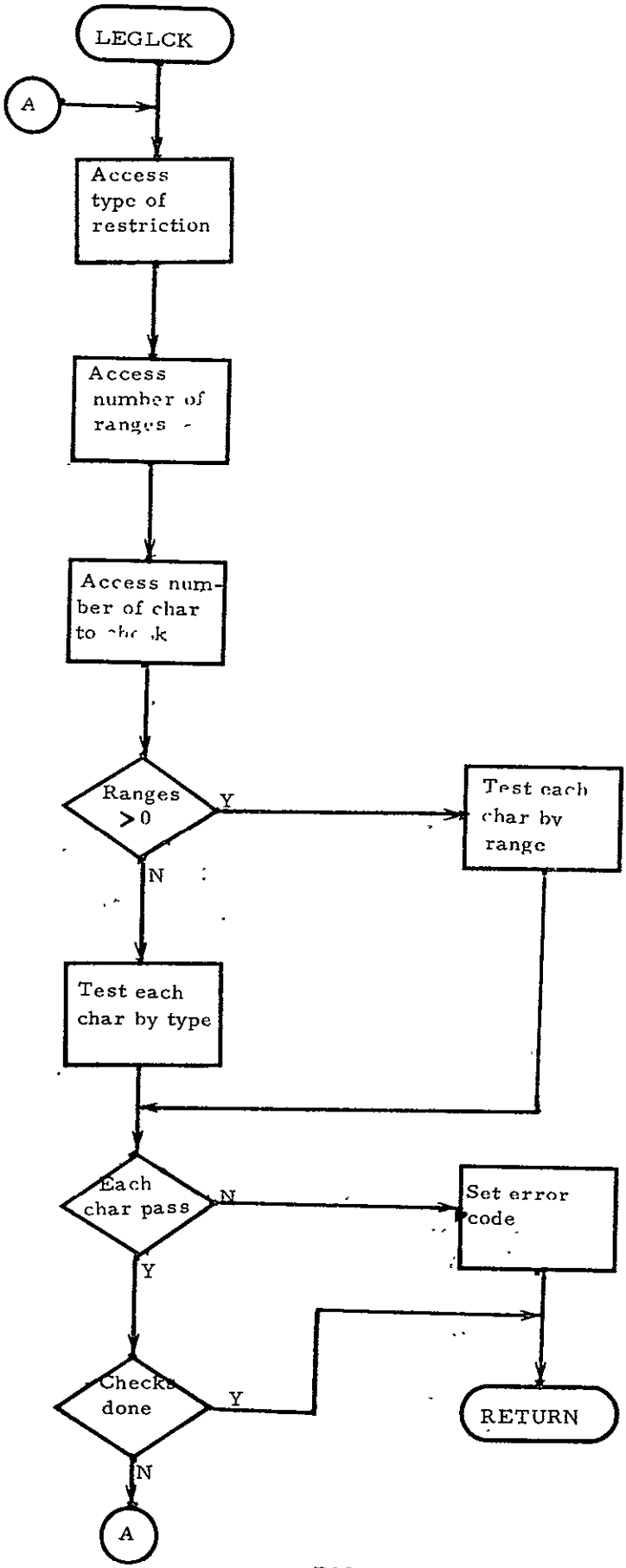
DATA KEY PROCESS



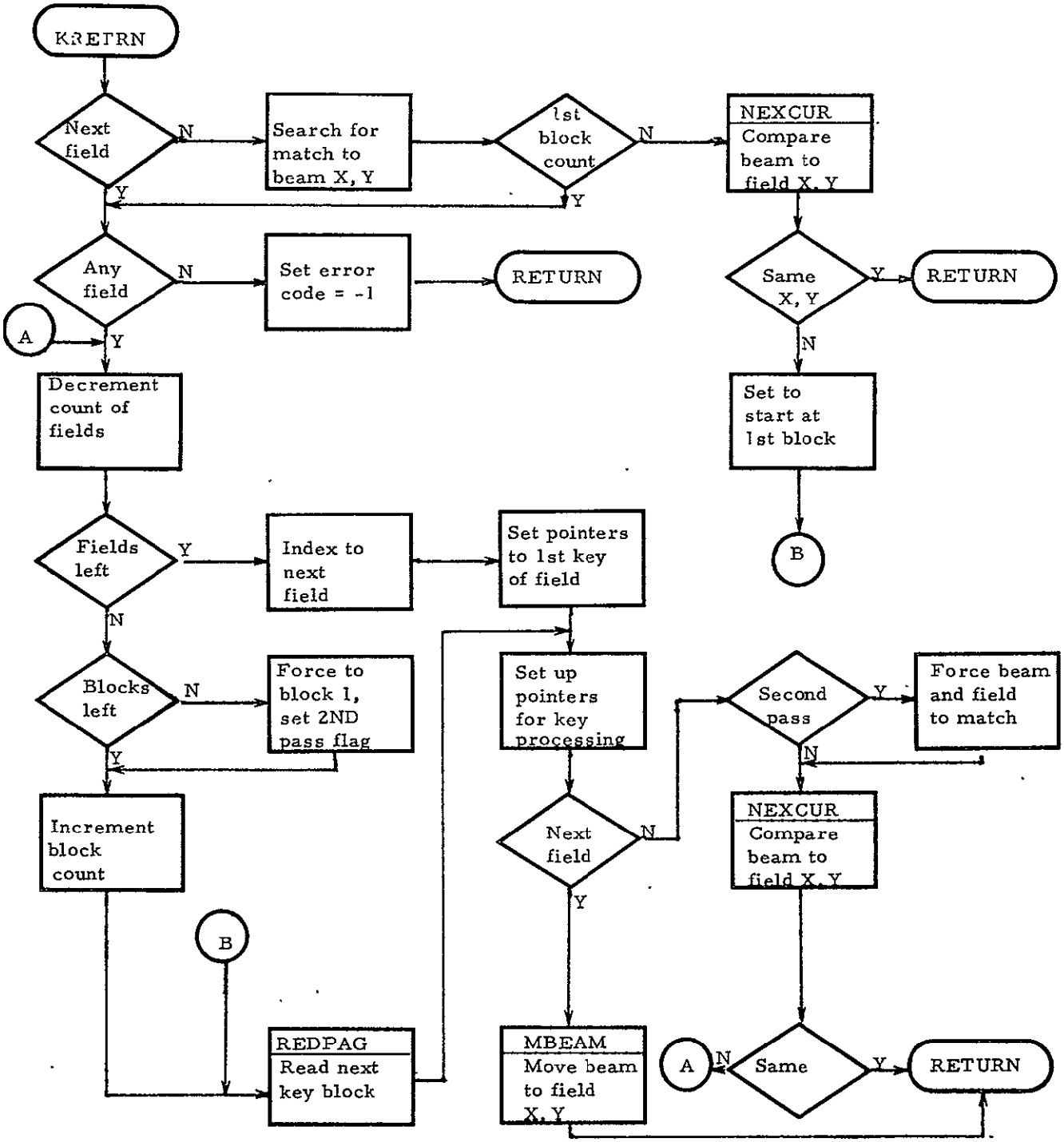
TRANSMIT KEY PROCESS



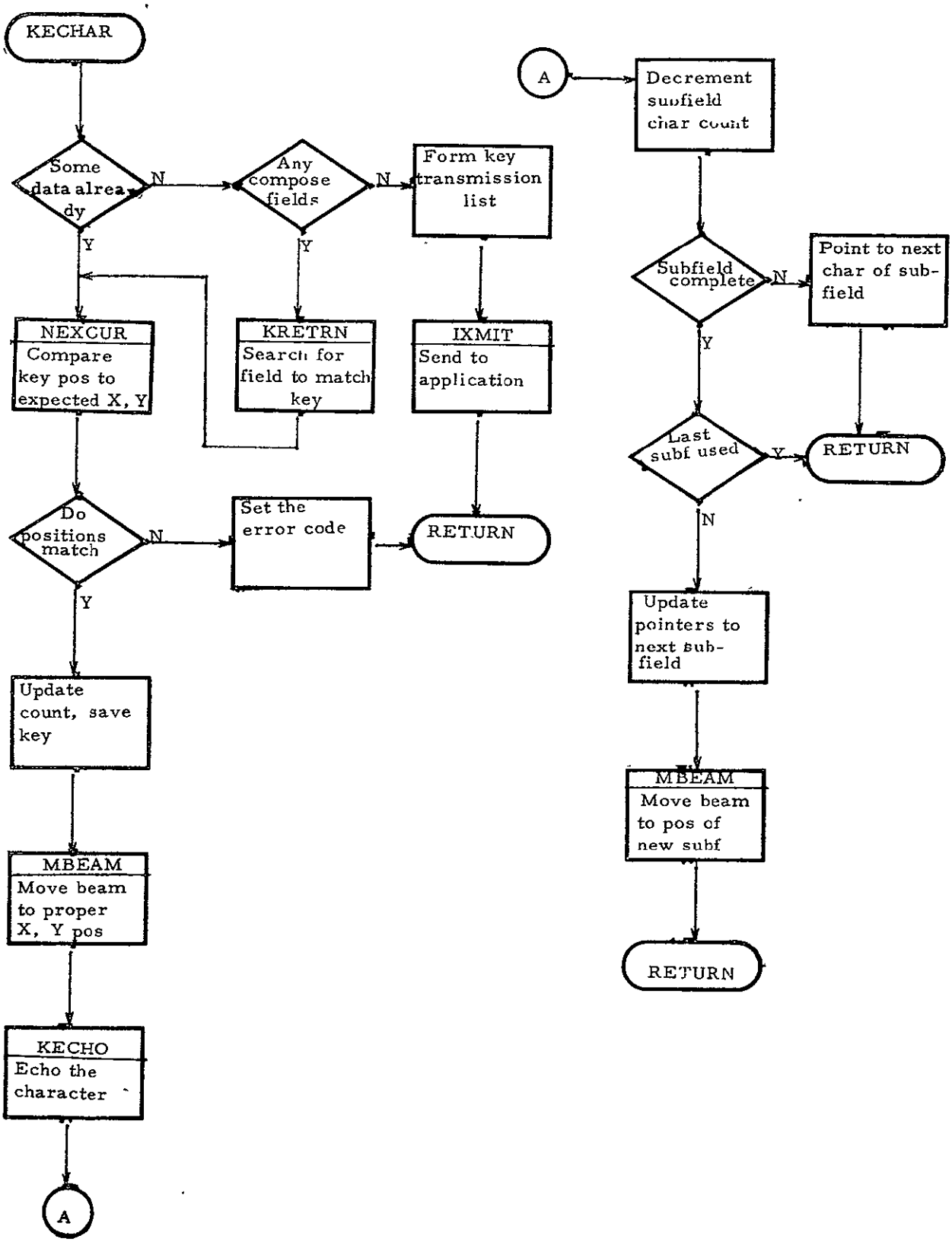
LEGALITY CHECK



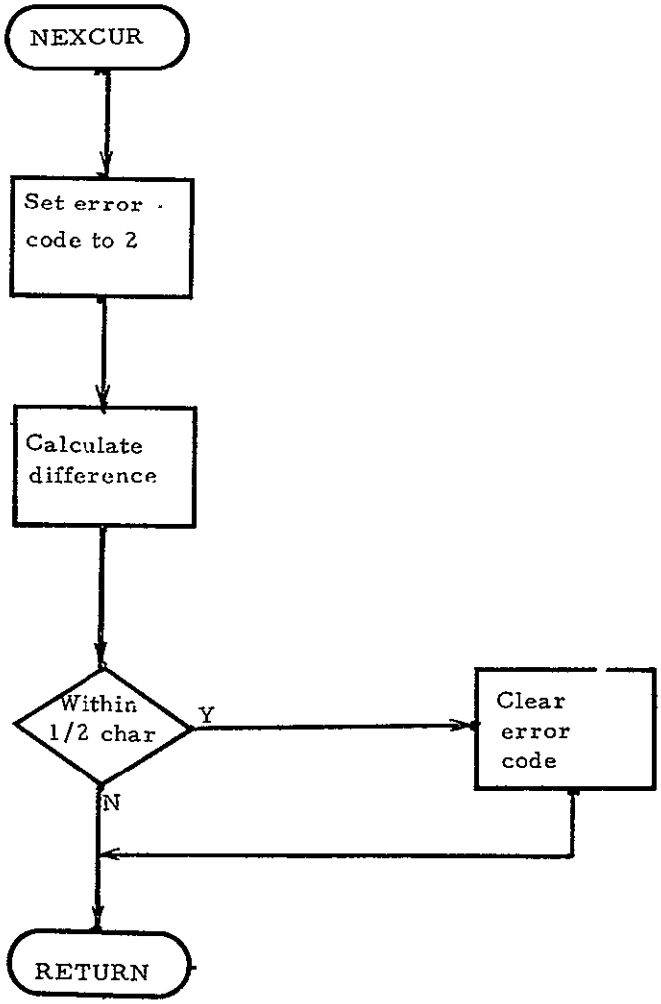
RETURN KEY PROCESS



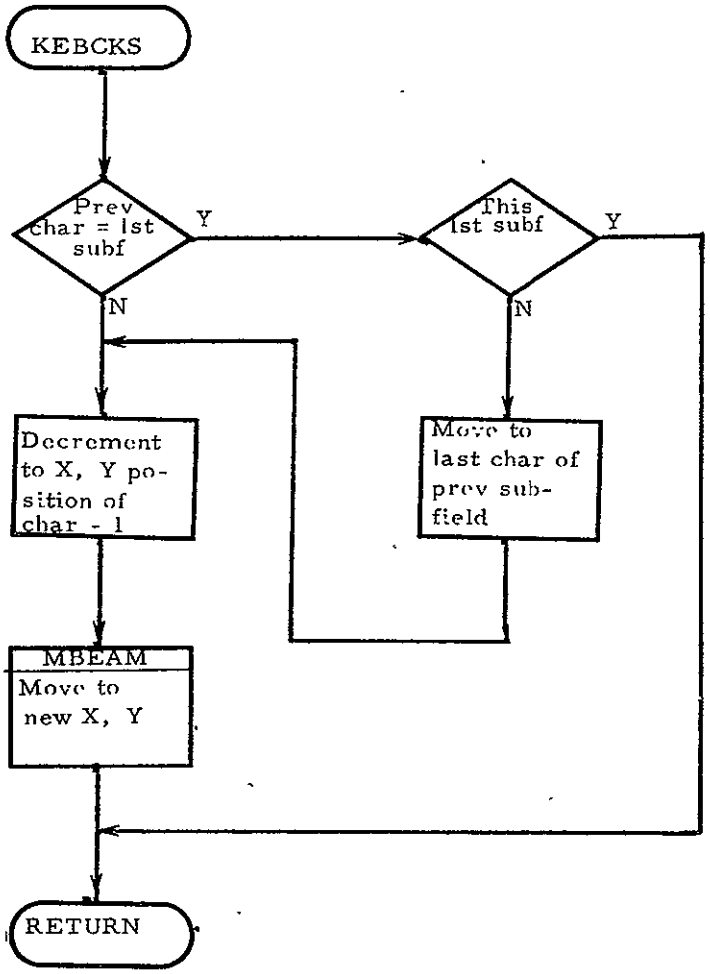
COMPOSE KEY PROCESS



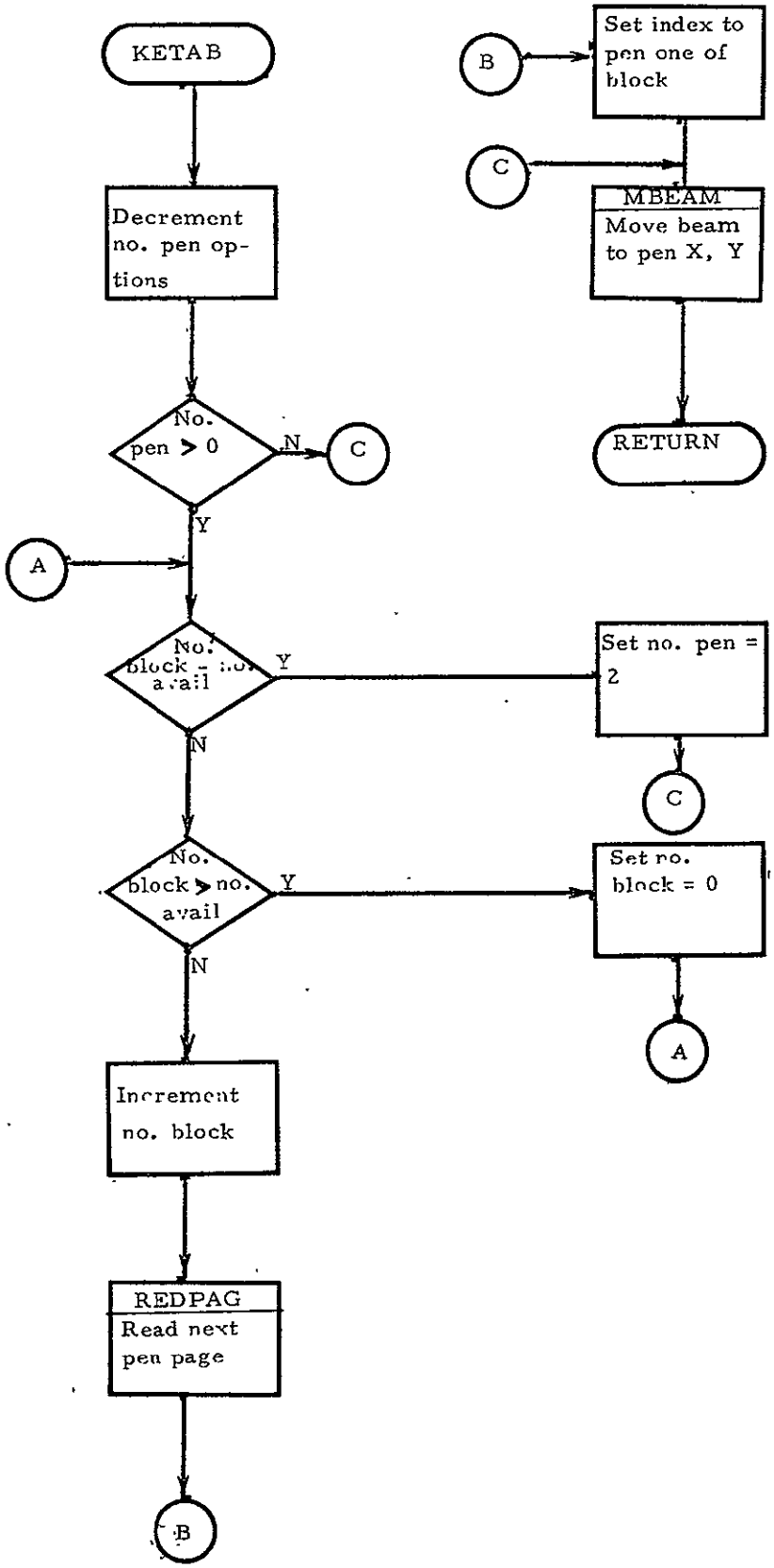
KEY POSITION VERIFY



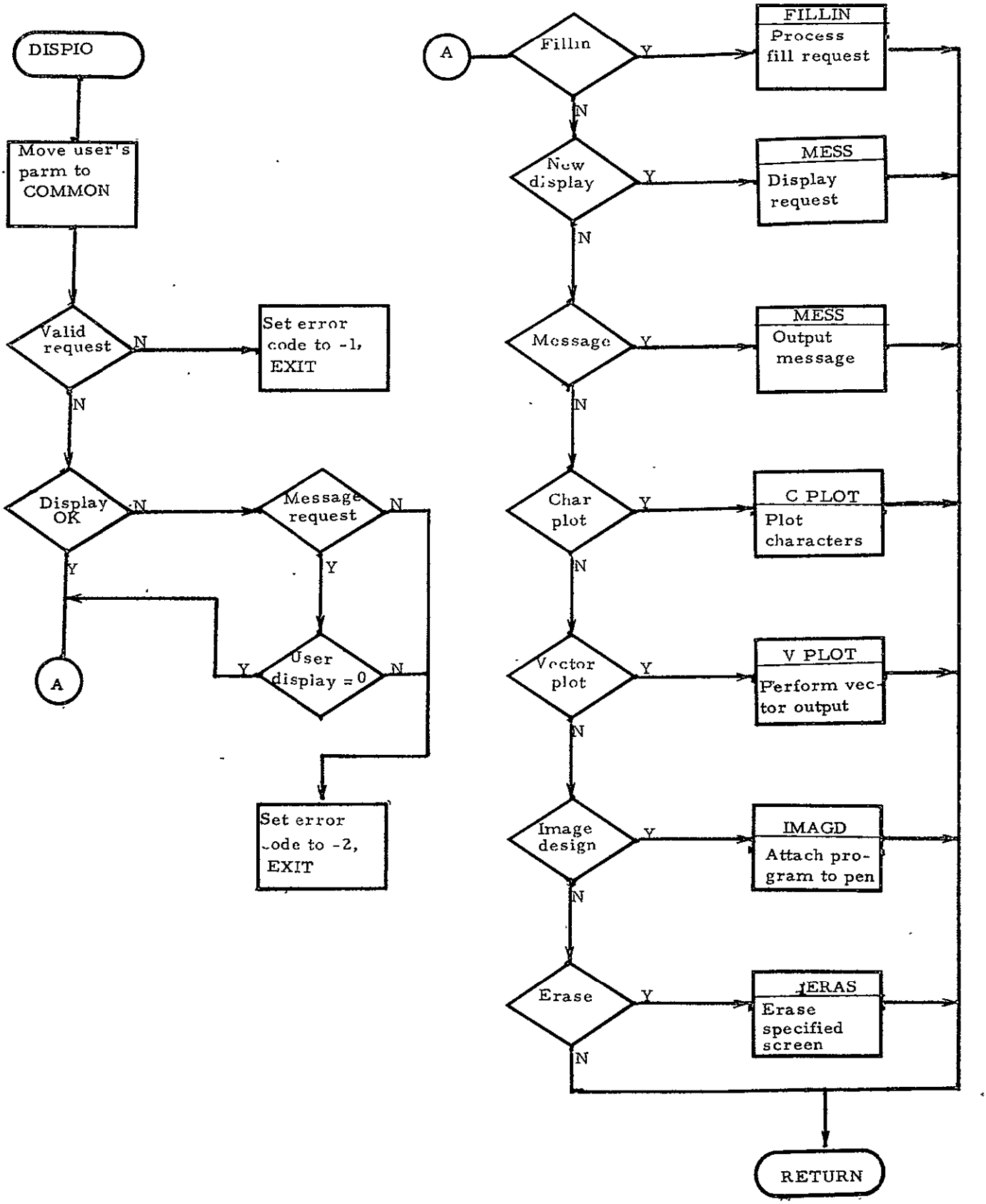
BACKSPACE KEY PROCESS



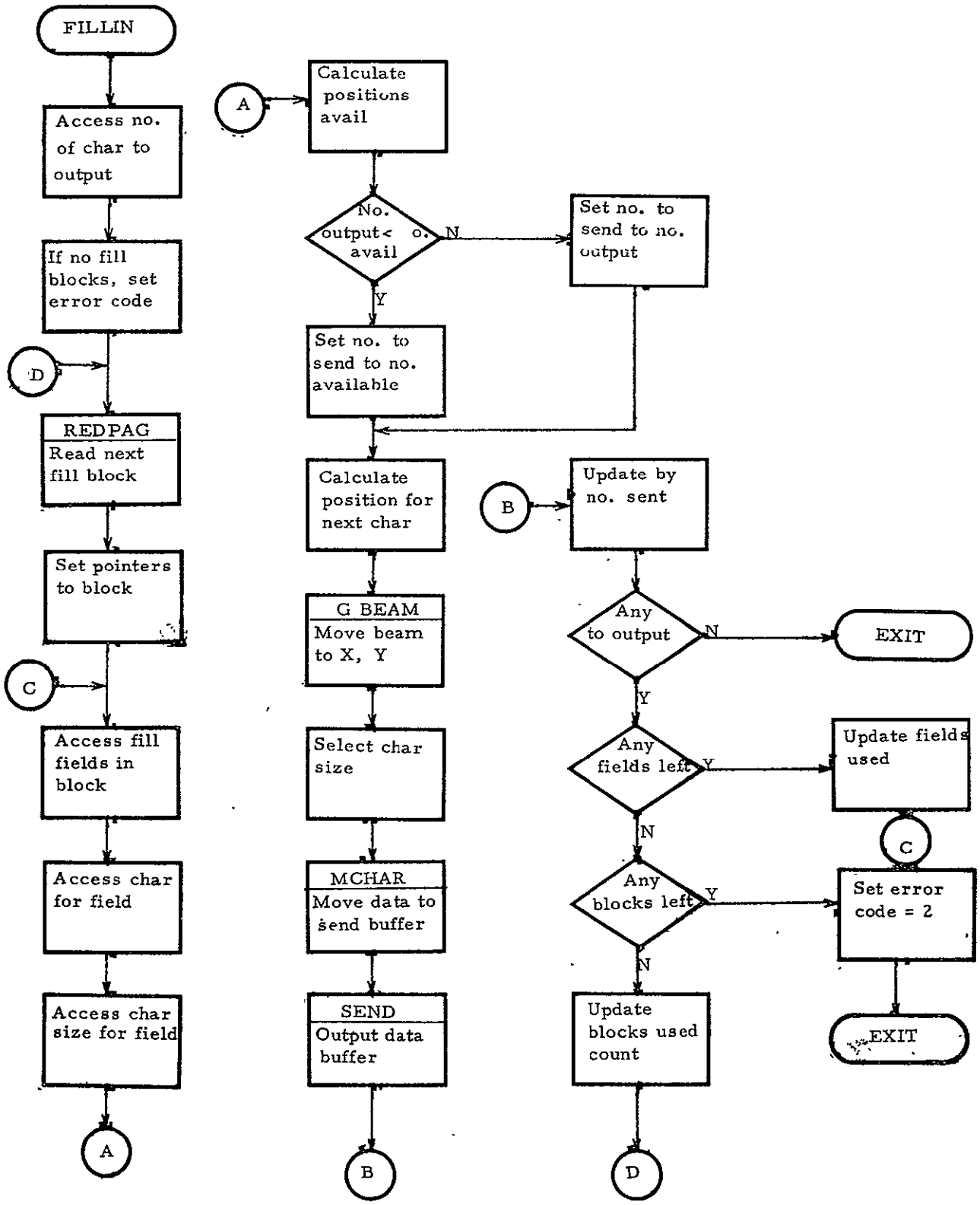
TAB KEY PROCESS



DISPLAY REQUEST PROCESS

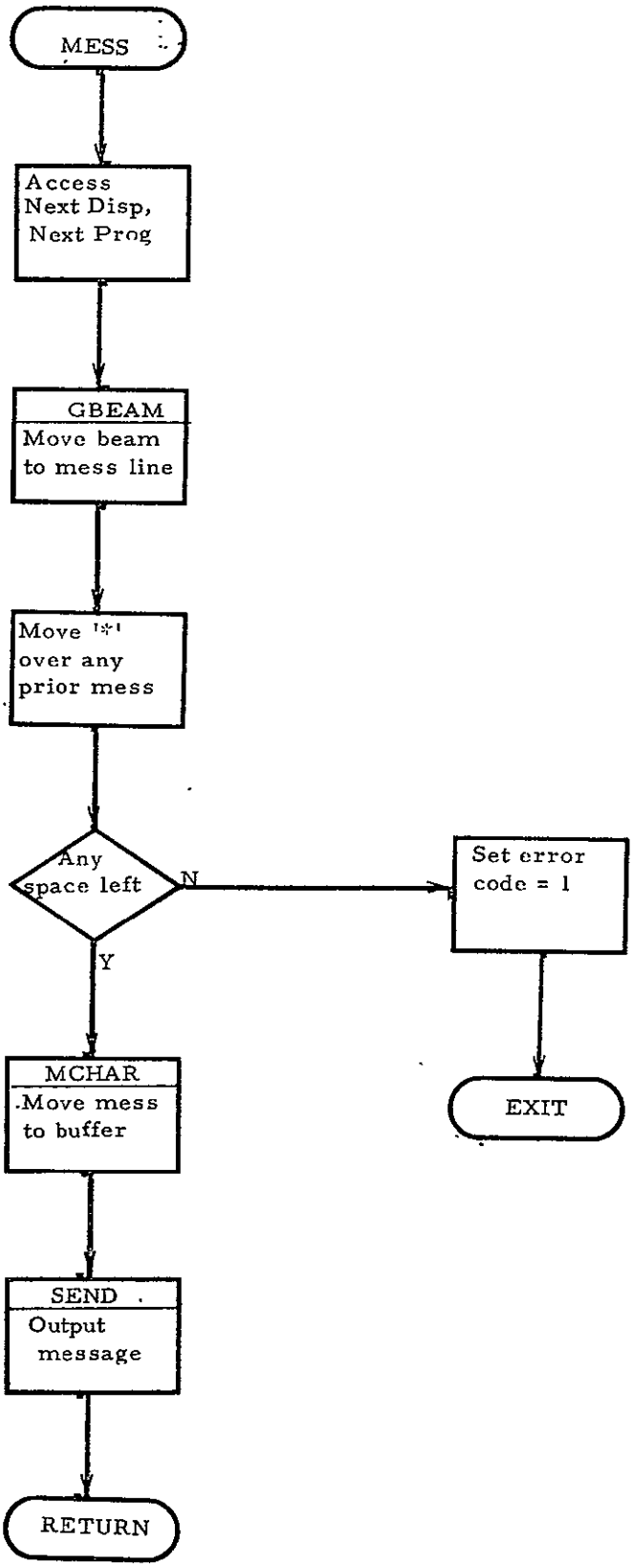


FILL REQUEST

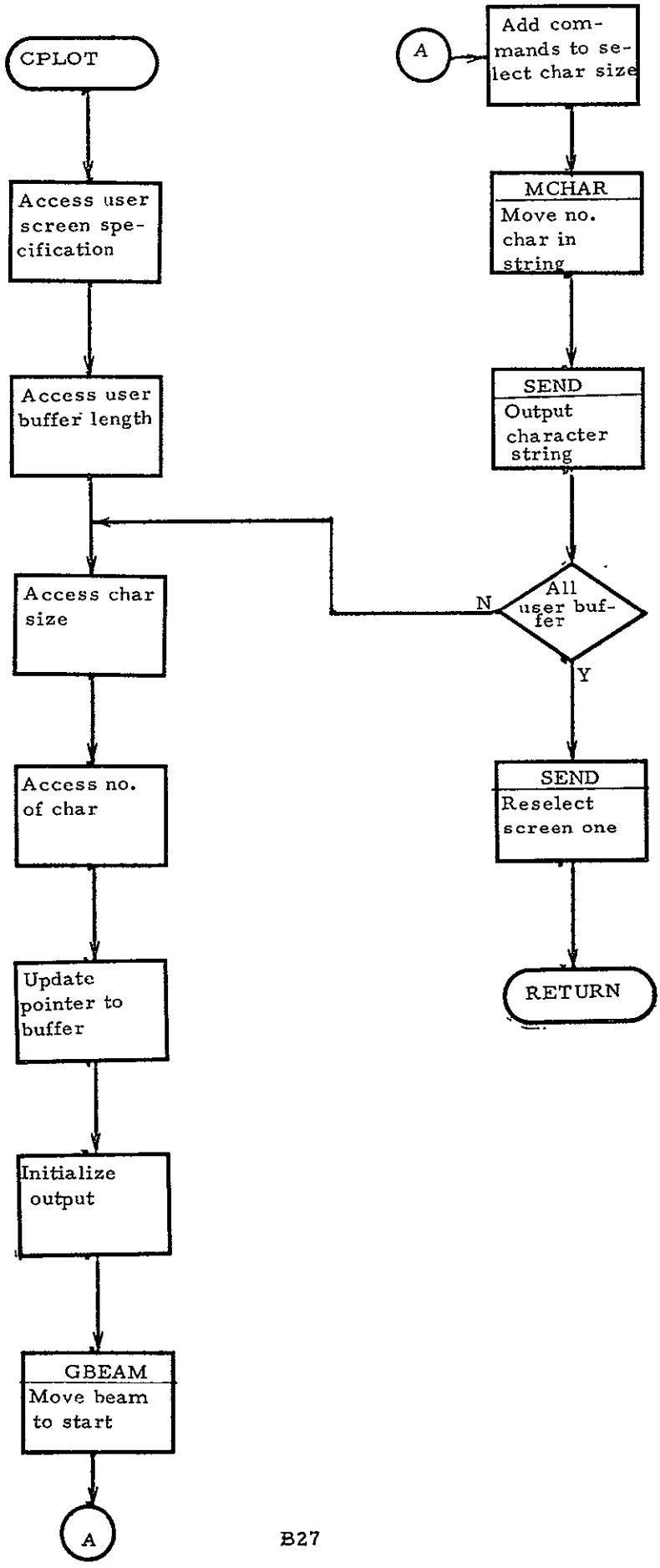


C-2

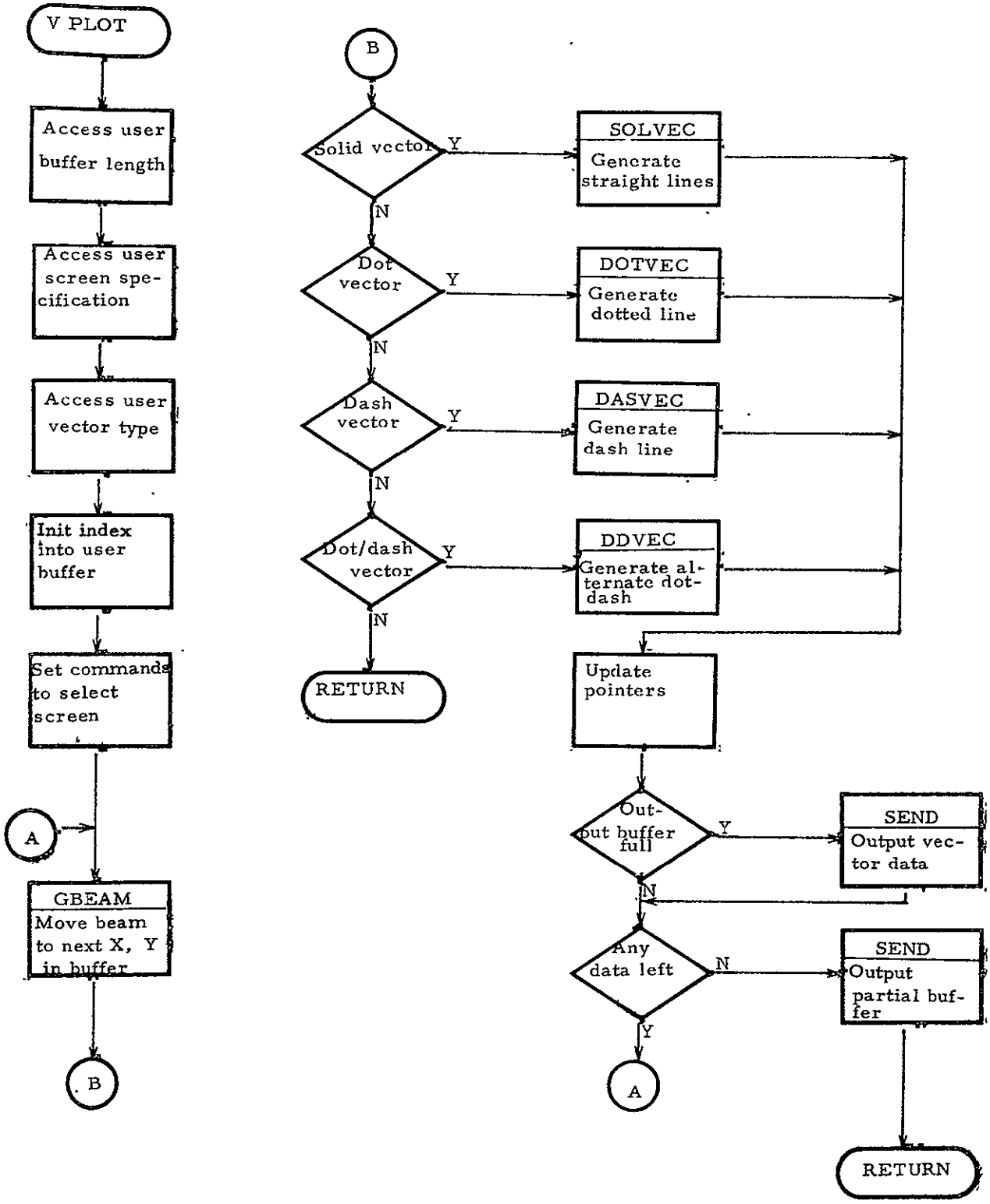
MESSAGE REQUEST/NEW DISPLAY REQUEST



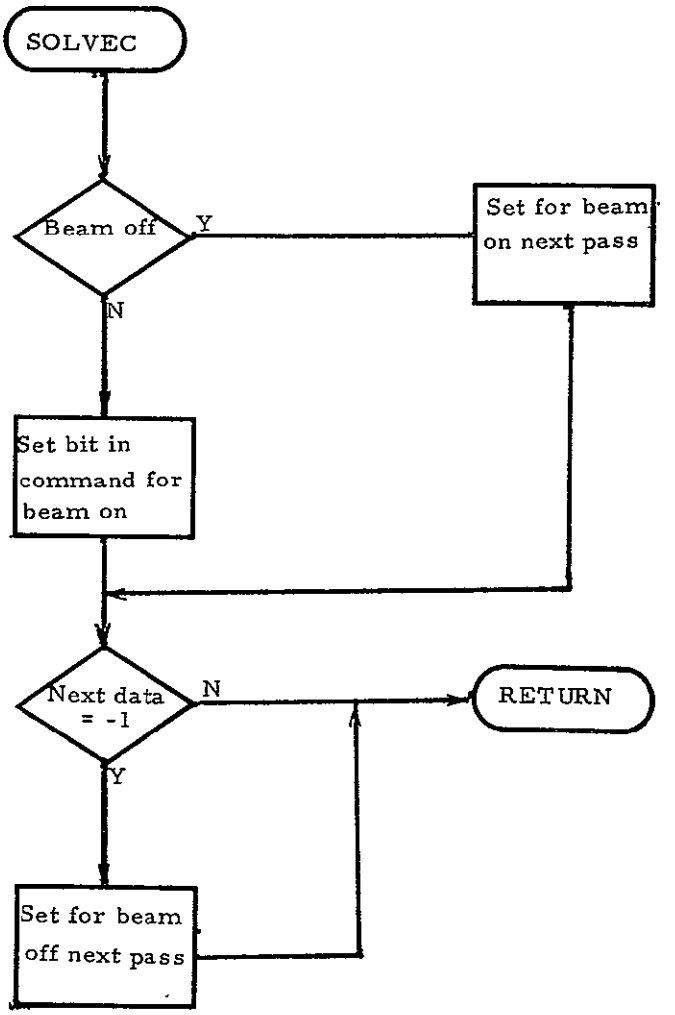
CHARACTER PLOT REQUEST



VECTOR PLOT REQUEST



TYPE 1 VECTOR PROCESS



TYPE 2, 3, 4 VECTORS PROCESS

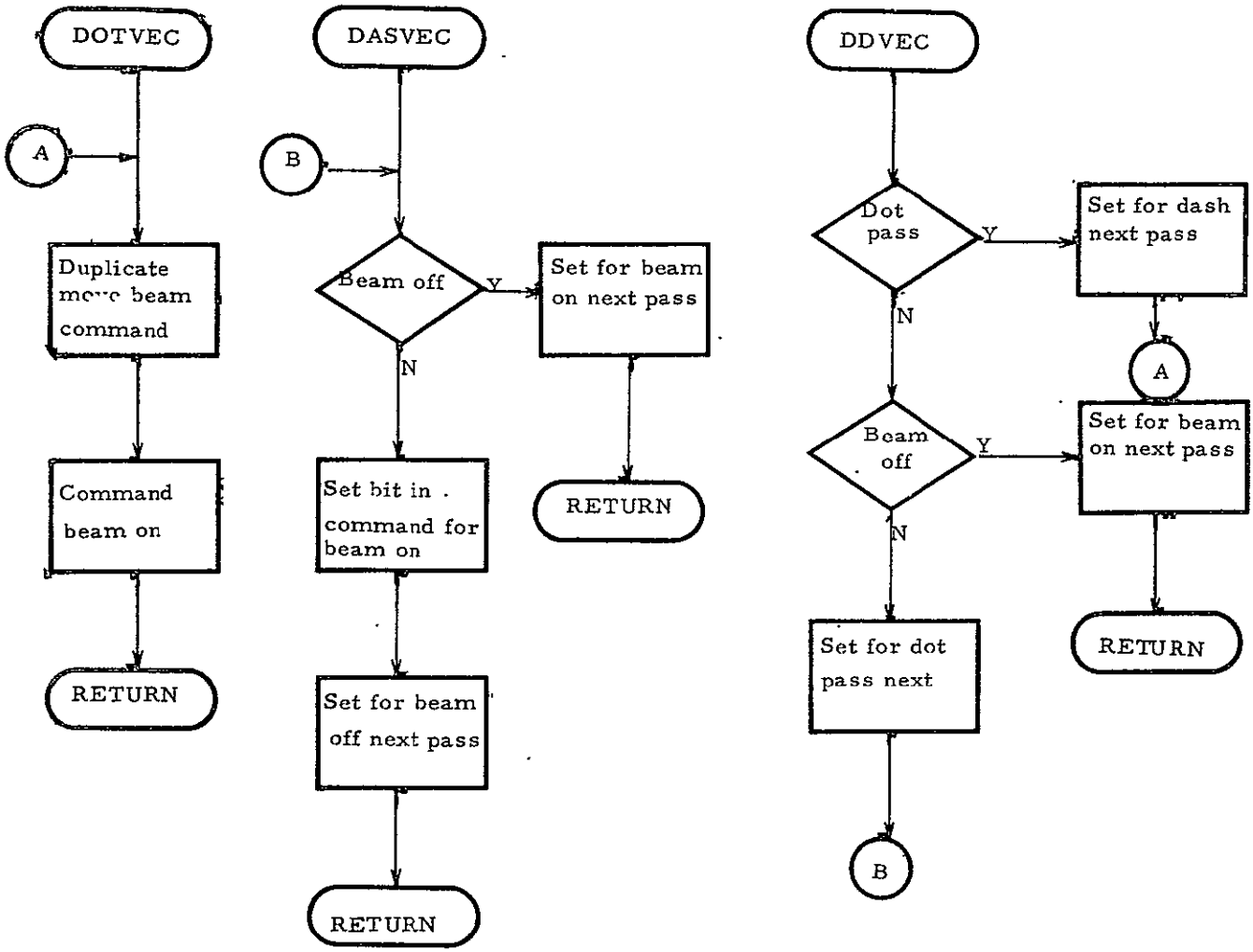
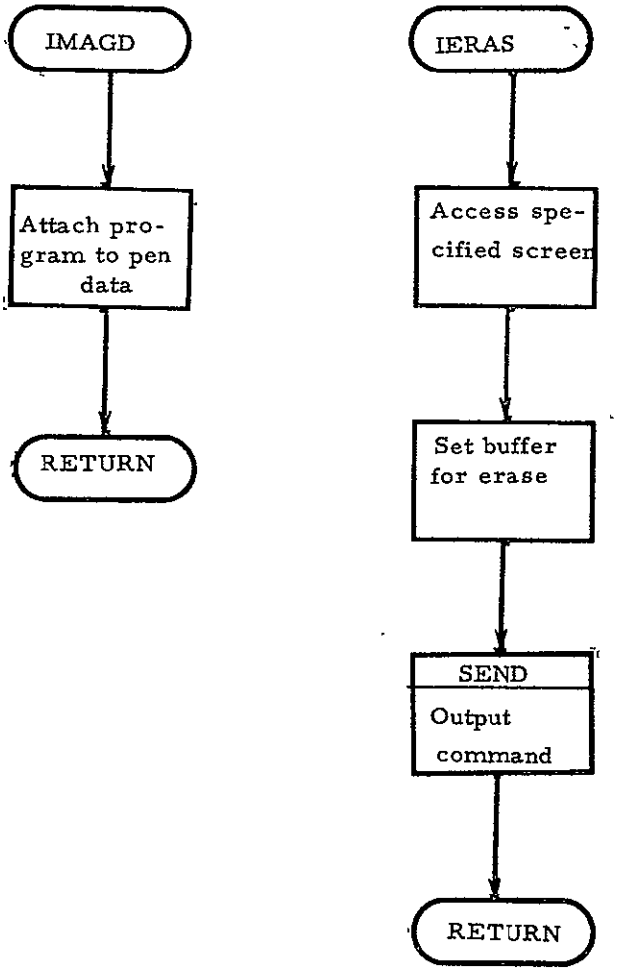
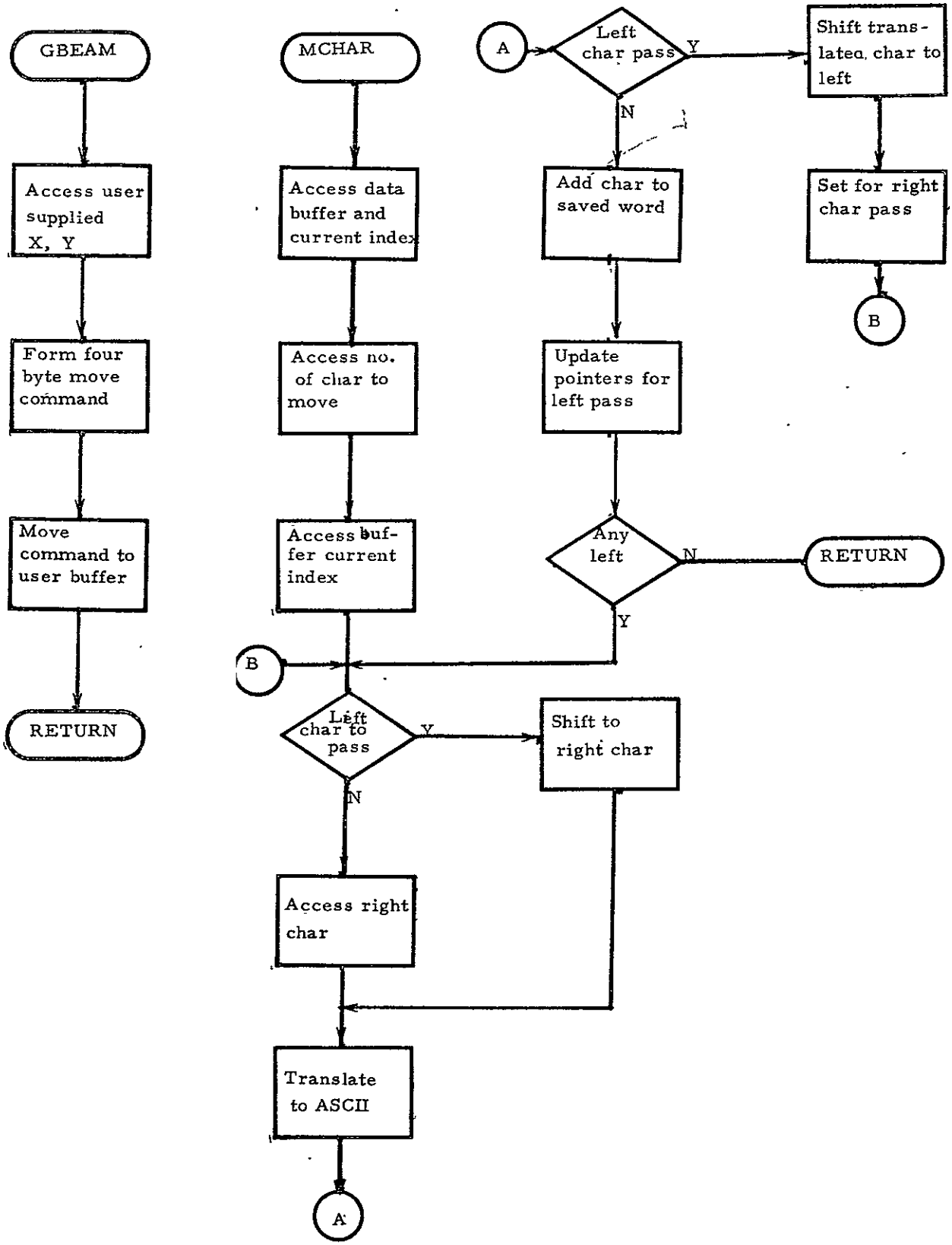


IMAGE DESIGN/ERASE REQUEST





☆ U.S. GOVERNMENT PRINTING OFFICE 1976-641-255/548 REGION NO. 4