COMPUTERIZED CARTOGRAPHIC NAME PROCESSING.

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in Partial Fulfilment of the Requirements

for the degree of

Master of Science

in the

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University of Saskatchewan

by

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Saskatoon, Saskatchewan

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"COMPUTERIZED CARTOGRAPHIC NAME PROCESSING"

Student: William Thomas Wilkie Supervisor: Dr. A. R. Boyle

M.Sc. Thesis presented to the College of Graduate Studies

ABSTRACT

The application of the digital computer to the compilation and drafting of cartographic line data has been extended to the compilation and drafting of cartographic names and symbols. This thesis describes the programs and photo-typesetting hardware forming an integrated system for Computer Aided Name Placement and computer controlled photo-typesetting.

The system utilizes a PDP/8e computer with 8 k word core memory, an 832 k word disc unit, 9 track magnetic tape unit, precision x-y plotting mechanism and the special cathode ray tube photo-typesetter unit mounted on the gantry of the x-y mechanism.

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1. INTRODUCTION

1.1 The History of Mapping

Ever since the dawn of recorded history, man has been drawing maps to aid in navigation and to describe his environment quantitatively. For many centuries, these maps guided travelling man and served as a beautifully hand crafted record of his journeys. However, as time passed, and more emphasis was placed on trade and exploration, the availability of these maps became limited by the slow and tedious process of manual duplication.

It was not until the 15th century that the invention of the printing press eliminated the tedious hand duplication of maps and increased the number of maps available for general use.

As man's methods of measurement improved, the maps became more detailed and improved drawing accuracy was required. More time was demanded for the initial compilation phase, thus slowing down the production of any particular map. More maps, required by more people, had to be more accurately drawn to meet the requirements of improved navigational methods.

The gap between map production and map demand widened to the point where in 1960 it was realised that it had taken ten years to compile The Atlas of Great Britain and thus much of the data was already years out of date prior to its publication.

In 1962, a team, under the directorship of Mr. D. Bickmore, then Cartographic Director of Clarendon Press, and Dr. A. R. Boyle was formed to investigate the possibility of utilizing automation in the production

of atlas maps. A research grant from the British Government paved the way for the development of a system, now known as the Oxford System. An important part of this work was concerned with Name Placement.

About the same time, the problem of Name Placement was also being attacked by a team at the Aeronautical Chart and Information Centre at St. Louis. The system, developed in conjunction with Concord Control Inc., will be referred to as the ACIC system.

The Oxford System was successful, not so much in its production capabilities, as in the development of engineering methods for automated cartography. The reason for its limitation in production was mainly due to the unreliable nature of the electronic equipment of that time.

Meanwhile, in Canada, the Canadian Hydrographic Service was facing a mapping problem suggesting automation. The vast coastline, continental shelf, inland waterways and increased exploration of Arctic waters forced them to look toward automated production methods.

In 1966, contact was made between the Hydrographic Service and Dr. A. R. Boyle, who had moved to the University of Saskatchewan in Canada. Dr. Boyle assembled a team of graduate students and professionals, mainly from the field of electrical engineering, and tackled phase 1 of the project, the development of a high accuracy, highly reliable automated drafting system. In 1971, this drafting system was realized and put into service at the Hydrographic Service in Ottawa. However, its first use was restricted to the drawing of high accuracy, computed, graduated map borders and mathematically shaped navigational lattices. The drafting unit had the capability of drawing a complete chart but there was no method available to the cartographer to examine and edit data prior to automatic drawing.

Phase 2 of the project, the development of a system for the examination and modification of chart data, was commenced in 1971 and is presently approaching completion. This system uses a modern minicomputer and a cathode ray tube display, with interactive capability, to provide facilities for the viewing and editing of spatial data.

Though automatic drafting methods have been developed to speed up the map making process, one field of map compilation has not yet been successfully automated, that is the field of name placement and automated name drafting. Although both the Oxford and the ACIC systems had made attempts at semi-automation, neither yielded a truly workable system.

In 1971, Dr. Boyle and the author began to study the feasability of applying automation to the name placement and name drafting problem. Preliminary studies yielded encouraging results which led to the immediate commencement of work to realize a practical system. It is this system, the University of Saskatchewan System for Name Placement, which is the subject of this thesis.

1.2 The History of Name Placement

For centuries, hand lettered names on maps gave them an artistic beauty still the envy of modern man. However, the time required for hand lettering limited the speed of production such that the demand for new maps exceeded the possible rate of supply. It was obvious that the artistic content of the map lettering had to give way to a more functional type of lettering formed by the use of mechanical aids such as templates and fixed printer's type.

The advent of mechanical, and later the photographic, typesetting machines kept the speed of lettering compatible with the drawing of the actual map line data.

The photographic type setting machine still remains the standard device for generating map names. All names to appear on a map, their size, style and style variant are specified and input to the machine via a manual process or, in the case of more sophisticated systems, by an automatic system based on punched paper tape, punched cards or magnetic tape. The output from the typesetter is in the form of a film strip from which each name segment is cut for individual placement on the name overlay work sheet which is subsequently photocopied to form the master name overlay sheet. This system has worked extremely well in cases where the time required for manual placement is not a critical factor in the map production schedule.

However, with the introduction of automated methods to map line drawing, names once again proved to be the time consuming weak link in the map making process. At this point in time it was recognized that there were really two problems concerned with map names; their styling and positioning, and the drawing of these names on the map sheets. Hence any automated system applied to the name problem must take into account both of these related processes.

Both processes present significant difficulties when automation is considered. The compilation of names is a subjective process in order to achieve artistic balance similar to the old hand drawn maps and provide good visual readability. This involvement of subjective positioning dictates that the automated name compilation process be

performed using an extremely versatile interactive system. This system must rapidly produce an accurate representation of the map and name data as well as providing an easily operable but comprehensive editing and positioning facility.

The automated name drawing process places tight constraints on symbol resolution, positional accuracy and system stability. The size of the symbol library and the required speed of symbol access present considerable problems for the system designer.

Both the Oxford and the ACIC systems attempted to implement a semi-automated name placement process within the constraints imposed by the technology of the time. Both use 70 mm. film projectors mounted on x-y mechanisms for actual name placement. The film carried many hundreds of names, each name arranged across the film and having an uniquely coded position on the film, so that automated selection could be used. In the Oxford system, the man entered the process at the time of placement so that he could modify the name or its position just prior to final placement on the map overlay sheet. In contrast, in the ACIC system, the man set his names at the compilation stage, such that he produced a special 70 mm. film strip for each map.

In the Oxford system, the projector was mounted on an x-y mechanism which had both automatic and manual over-ride control. Working with safelight projection on "immediate image" film, the compiler, by using his manual over-ride controls, could modify the automatically specified name position according to its cartographic relationship to all previously placed names recorded on this film. Once satisfied with the placement, the operator printed the name using

normal light projection on the "immediate image" film to form an accumulative working image, and then a similar exposure was made on normal litho film, eventually to become the name overlay sheet.

In addition to spatial positioning and rotation of the entire name, the operator had the capability of moving single letters within the name for curving the name to parallel a feature such as a river. For this system, the film had to be made from gazetteer information and had to contain all names likely to be of use for the area, each in a variety of sizes, styles and variations. The compiler selected the desired name representation by running the film backward or forward with his manual controls.

In the ACIC system, the actual placement of the names of the map overlay sheet was completely automatic using the 70 mm. projector on a precision x-y mechanism. At the time of compilation, the operator keyed in the name together with its style and other parameters, from a selected list of names. Two outputs were produced on paper tape. The first contained only the name information required by an automatic photo-typesetter. The second contained the name reference position together with values defining the bounding rectangle enclosing the name at its designated size.

The first tape went directly to the photo-typesetter while the second was passed to a manual digitizer. On this unit, the operator moved the viewer, which was set automatically to the bounding rectangle size, over the surface of the map compilation until he had positioned the rectangle in the required location. He then marked the area of

the rectangle with pencil on the compilation sheet so that the area was recorded as being occupied, and digitized its position onto an output tape.

This tape and the 70 mm. film were passed to an automatic precision x-y plotter carrying the automatic projector. The correct names were then automatically exposed to the map overlay film at their selected positions.

Both of these systems proved to yield significant advances in the field of name placement, but had the disadvantage of excessive manual processes and intervention. In order to remove these limitations from the name placement process several attempts were made to create a more automated system; notable is the contribution of Professor P. Yoeli of Tel-Aviv University. His work was based on the premise that;

> "Certain techniques, like light printing and semi-automated lettering, where names lists are printed on film and then projected onto their proper map-place on light sensitive film, take only little less time than the classic methods of manual attachement of labels to the map.

He proposed that the process be split into three basically independent parts;

1) Editing of map name content
2) Computation of name placements
3) Suitable hard copy output.

The editing of name content involves the manual selection of the names to appear on the map and their reference coordinates expressed in terms of latitude and longitude.

Computation of name placement was proposed as an automatic process carried out by a computer utilizing placement algorithms based on typical

or preferential placements. These preferential placements are shown in order of priority in Figure 1.1

The placement program attempts to place the name in the position of highest priority relative to the reference coordinate. However, prior to making the placement final, the program examines the areas occupied by prior placements and advances through the preferred placements until a position is found which does not conflict, in terms of area overlap, with prior placements. A "free zone" surrounds each placement area such that near overlaps are prevented.

The hard copy output should be a fully automatic process involving a suitable hard copy device. For demonstration purposes, Mr. Yoeli used "....what is probably the most unsuited output instrument for map-names placement i.e. the line printer."

Though Yoeli's work has not resulted in a fully workable production system, his investigations have set down many solidly based criteria extremely important to future developments in the name placement field.

His recommendations for further work in this field are:

"To facilitate this automation the following is needed.

A) A comprehensive geographical name data bank including all those parameters which will allow for computer editing of the name contents for any specific map.
B) A definition of the logic of name placement on maps in computer compatible form.
C) A computer controlled printing device for the hard copy output of the final map sheet."

These recommendations, with practical modifications, form the underlying guide lines for the author of this thesis. Recommendations A and B are merged by providing a rapid method of manual editing and positioning of map names while they are in computer

PRIORITY No. 1

NAME

x

PRIORITY No. 2

NAME

x

PRIORITY No. 3

x

NAME

PRIORITY No. 4

x

NAME

PRIORITY No. 5

NAME

x

PRIORITY No. 6

x

NAME

PRIORITY No. 7

NAME

x

PRIORITY No. 8

x

NAME

PRIORITY No. 9

NAME

x

PRIORITY No.10

x

NAME

FIGURE 1.1
PREFERENTIAL NAME PLACEMENTS

compatible form, by utilizing a display unit in conjunction with a small computer. The computer controlled printing device, under advanced development by the author, consists of a cathode ray tube photo-typesetter mounted on the gantry of a precision x-y plotting mechanism. This approach permits the use of human judgement aiding the efficiency and speed of the modern digital computer.

These two operations will be referred to as Computer Aided Name Compilation (CANC) and Computer Aided Name Placement (CANP) respectively.

1.3 The Nature of Cartographic Names

The automated placement of map names is complicated by the nature of the names themselves. Each name represents more information than the meaning of the collective group of individual characters which form it. This extended information is conveyed by the characteristic representation of the letters themselves.

The parameters used to specify the letters such that they convey this additional information are as follows:

a) STYLE: (synonomous with FONT) Style is the structural make up of the letters.

b) VARIANT: A variant is a modification of the style without deviation from the basic letter structure. i.e. italics, lightline

c) CASE: Upper and lower case characters exist for each style and variant.

d) SIZE: The size of letters is specified in units of points (pts.) which are defined as follows:
1 point (pt.) = 1/12 of 1 pica

6 picas = 1 inch

1 pt. = 1/72 of 1 inch = .0139 inch

Letter sizes for maps usually vary from 5 to 40 points.

e) SPACING: Letter spacing is normally based on equal BLANK AREA between all adjacent letters. This spacing, though based on this equal area criterion, may be varied for different name representations

Well established criteria are used to determine the selection of these parameters to establish a name representative of a specific feature. For example; assume all population centres are to be represented in GOTHIC style, with an increase in point size, over 5 points, of 1 point per 100,000 of population, and area capitals are to be in italicized boldline. From these criteria, one can rapidly deduce from a cursory glance at the map, information concerning the importance or relative population of any selected settlement.

Due to the large number of letter representations formed from combinations of these parameters, it is imperative that an automated name compilation system have sufficient flexibility built in to handle all possible cases.

Furthermore, the automated name editing feature, necessary in any compilation system, must have the capability to easily vary each and every parameter, as well as permitting correction of errors such as in spelling.

The following list is a compilation of functions required to be implemented in an automated name compilation system:

1) Provide rapid selection and retrieval of data representing

a selected name.

2) Provide a rapid and realistic visual display of names superimposed on the background map line data.

3) Specify or modify name position

4) Specify or modify style, variant, case.

5) Specify or modify letter point size.

6) Correct letter errors by;

   a) letter deletion

   b) letter addition

   c) letter insertion

   d) letter change.

7) Alter letter spacing criterion

8) Rotate names and symbols

9) Curve names

10) Split multi-word names into individual words for separate manipulation

11) Permit automatic paralleling of a name to its reference feature i.e. a river name paralleling the course of the river.

12) Supply, upon request, a plain language hard copy print out of all parameters concerned with a specified name.

The system should also be capable of permitting a quick-look at any time of data from any of the following sources:

1) Digitized data

2) Data banked data

3) Compilation data

4) Compilation output data

5) Predrawing data

This quick-look feature permits data verification at all stages of map compilation. It enables the cartographer to have confidence in his compilation and his compilation tool, namely the entire system.

The photo-typesetting subsystem, for final map name drawing, has to meet fewer but more severe criteria, most of which are concerned with the performance of the selected hardware. It must;

1) Operate at a speed compatible with automatic line drawing

2) Print characters with high contrast with respect to the background.

3) Produce images with sharply defined corners and edges.

4) Rotate characters with negligible eccentricity error in the centre of rotation

5) Accurately represent all styles, variants, sizes etc.

6) Have sufficient linearity such that no distortions are detectible in any character

7) Have extremely high operational reliability

8) Be fully automatic.

Failure to meet with any one of these criteria renders the drawing unit useless for high quality name drawing, which in turn places operational limitations on the complete name placement and name compilation system.

2. COMPUTER AIDED NAME COMPILATION

2.1 Introduction

This section describes the University of Saskatchewan Computer Aided Name Compilation System. This system, conceived in 1971 is now approaching completion.

The system consists of a small computer with selected peripherals, display unit and interface electronics, "mouse" pointer and the name compilation program.

The system enables the interactive compilation of map name and symbol data in computer compatible form. Computer speed and efficiency are merged with human judgement to form a flexible and practical compilation system.

2.2 Name Data

2.2.1 Sources of Name Data

Name data, for use on a specified map, can originate from any or all of the following sources.

a) DIGITIZATION FROM EXISTING MAP

The reference coordinates for a place or area name can be digitized on a manual digitizer as a point, or series of points. The name is then typed in on a teletype, or other appropriate keyboard device. A two digit classification code is normally typed after the name to specify parameters, such as the type of feature the name represents, and its relative importance. A list of these codes as presently

used can be found in Table 2.1

b) FROM DIRECT SURVEY

Survey data can be entered into the computer files in the same manner as digitized data.

c) FROM COMPUTER COMPATIBLE GAZETTEER

Name data for a selected area can be obtained from a previously prepared computer compatible gazetteer. This gazetteer could be on magnetic tape or held as a permanent file on disc.

d) FROM NAME GAZETTEER

Desired names can be looked up in a gazetteer of names and input, with their reference coordinates and class codes, via a keyboard.

The name source file must then be transformed into a form acceptable to the Name Compilation Program. It is normally stored in longitude/latitude or Universal Transverse Mercator form, depending on which is used in the particular cartographic data bank.

It should be noted that the foregoing processes not only apply to direct name data, but are also valid when speaking of any descriptive alphanumeric data, simple numerics, and cartographic symbols of both single symbol and group symbol varieties.

2.2.2. Formats for Name Type Data

Many standard formats are used for name type data. All are of fixed length to facilitate rapid retrieval during a search of the data files for selected entries. These formats are as follows:

1) FORMAT 1: NAMES, DESCRIPTIONS AND GROUP SYMBOLS

This format, having a fixed length of 21 (decimal) words,

CLASS 0	Subcategory 0 - DOUBTFUL	
CLASS 1	INLAND WATER	
	0. Landing, Bend, Portage, Ferry	5. Creek, Brook
	1. Dam	6. *
	2. Spring	7. River
	3. Rapids, Falls	8. Lake, Arm, Neck
	4. Pond, Slough, Reservoir	9. *
CLASS 2	TOPOGRAPHY	
	0. Flats, Lowland	5. Hills, Col, Bluff
	1. Ice Cap, Glacier, Pingo	6. Ridge
	2. Plateau, Uplands	7. Mountain, Mount
	3. Canyon, Gulch, Valley, Coulee etc.	8. Peak, Summit
	4. Pass, Gap, Saddle	9. Range
CLASS 3	MAN MADE FEATURES	
	0. Routes	5. Rly, Pt., Rly Jct. etc
	1. Mines, Oil wells	6. Depot, Roadhouse, Camp, Stn.
	2. Airport	7. Hamlet, Village, P.O. etc.
	3. Harbour with jetties etc.	8. Towns etc.
	4. Historic Site	9. Cities
CLASS 4	COASTAL FEATURES (sea or lake)	
	0. Beach	5. Peninsula, Isthmus
	1. Lagoon	6. Opening, Inlet, Fiord, Delta
	2. Basin	7. Cape, Point, Head, Bluff
	3. Ice Shelf	8. Cove
	4. Cliffs	9. Gulf, Bay, Harbour Natural
CLASS 5	OFF-LAND FEATURES	
	0. Sea, Ocean	5. Shoal, Bar, Bank, Spit
	1. Sound	6. Reef
	2. *	7. Rock
	3. Gut	8. Islet, Archipelago
	4, Strait, Channel, Passage, Narrows Lagoons, Bright, Road, Reach	9. Island
CLASS 6	AREAS	
	0. Administrative	5. Marsh
	1. Parks	6. *
	2. Geology	7. *
	3. I.R.	8. *
	4. R.M.	9. *
CLASS 7	Not used at present	
CLASS 8 CLASS 9	Non-valid	* Unassigned

TABLE 2.1

DATA CLASS AND SUBCLASS CODES

is illustrated in figure 2.1. The first four words contain the reference coordinate for the name, normally in longitude/latitude form.

The fifth word is reserved as a tag word and normally contains tags as follows:

T1 specifies that the data is longer than one entry and that the following entry is to be interpreted as an extension to the present entry.

T2 specifies that the present file is an extension of the previous entry.

T3 (not assigned)

T4 is the selected/not selected tag. It is set to 1 to represent selected data, (i.e. data approved for output to the predrawing file.)

T5 valid/invalid tags. It is set to 1 to represent invalid or rejected data. Rejected data will not normally appear on the screen of the display.

The next two words, words six and seven are used to represent $\triangle X$ and $\triangle Y$ respectively. These $\triangle$'s represent the distance that the first letter of a name is off-set from the name reference coordinate.

Words, numbers eight and nine, hold data pertaining to the size, style and style variation of the letters in the name as well as the angle of rotation of the name.

It is assumed here that the name is straight but rotated (feature letter x). Curved names (feature letter x, set 3)

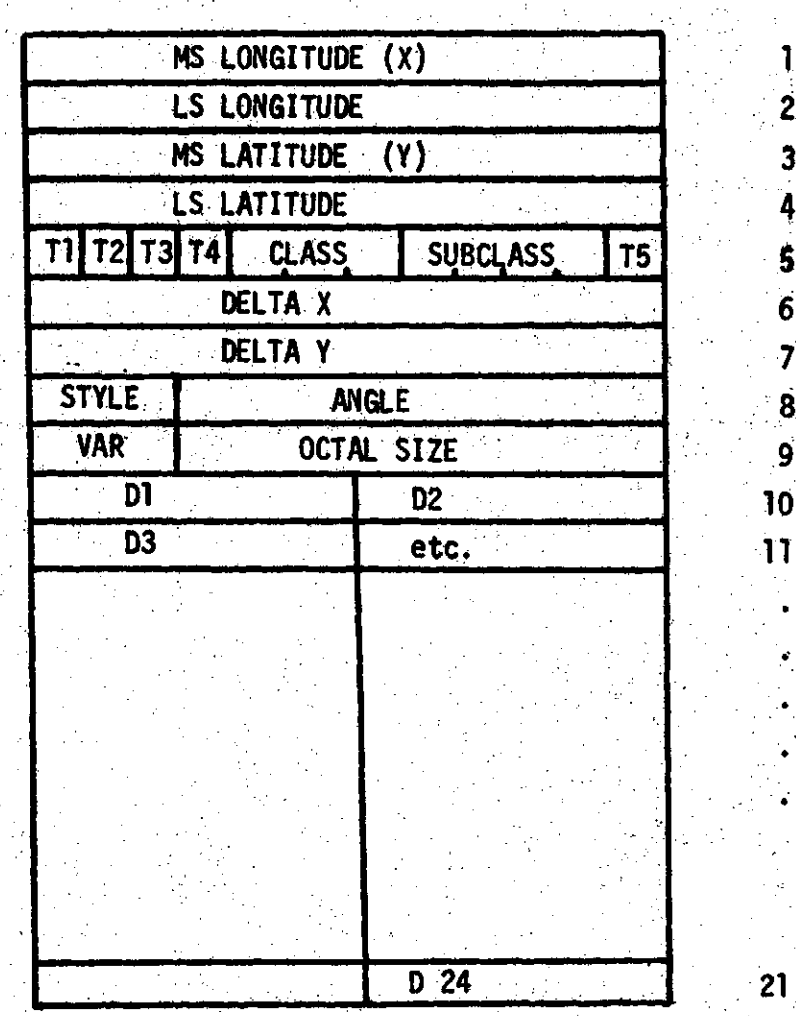


FIGURE 2.1.

FORMAT 1 for Names, Alphanumeric descriptions and Group Symbols.

use a variation of the described format and will be dealt with later.

The remaining words are used to store the actual name data in packed 6-bit ASCII form. The most significant segment holds the first letter, as letters are read from left to right.

2) FORMAT 2: SINGLE SYMBOLS

This format, with a fixed length of 11 (decimal) words, is illustrated in Figure 2.2. The first four words contain the reference coordinate for the symbol, normally in longitude/latitude form.

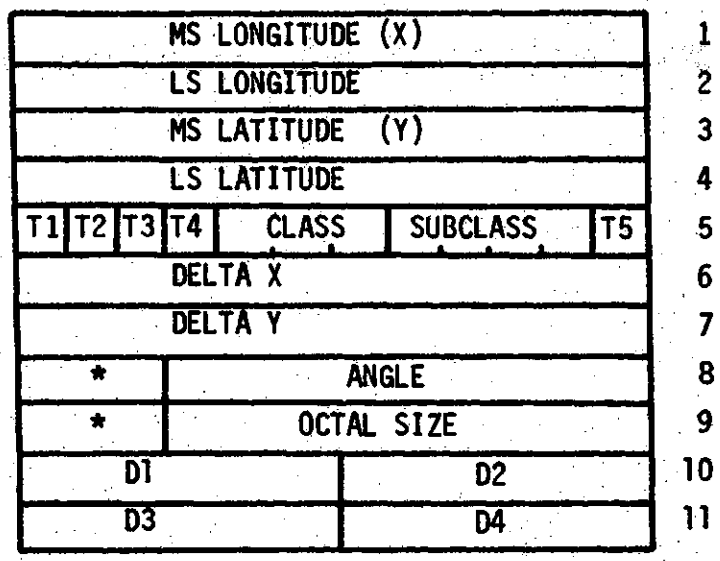
The fifth word is reserved as a tag word and normally contains tags as defined for Format 1.

The least significant nine bits of words eight and nine are used to specify angle of rotation and octal character size respectively; the other bits are not used.

Words ten and eleven hold four 6-bit ASCII characters, alphabetic or numeric, used to specify the symbol. These entries are left justified, any unused positions being filled with binary zeros.

3) FORMAT 3: DRAWN SYMBOLS

This format is used to specify start and end points of vectors which, when taken together, form a drawn representation of a physical feature such as a building. This format, having a fixed length of 21 (decimal) words, is shown in Figure 2.3. The first four words, normally in longitude/latitude form, represent the start point of the first vector and also act



* Indicates not used

FIGURE 2.2

FORMAT 2 for SINGLE SYMBOLS.

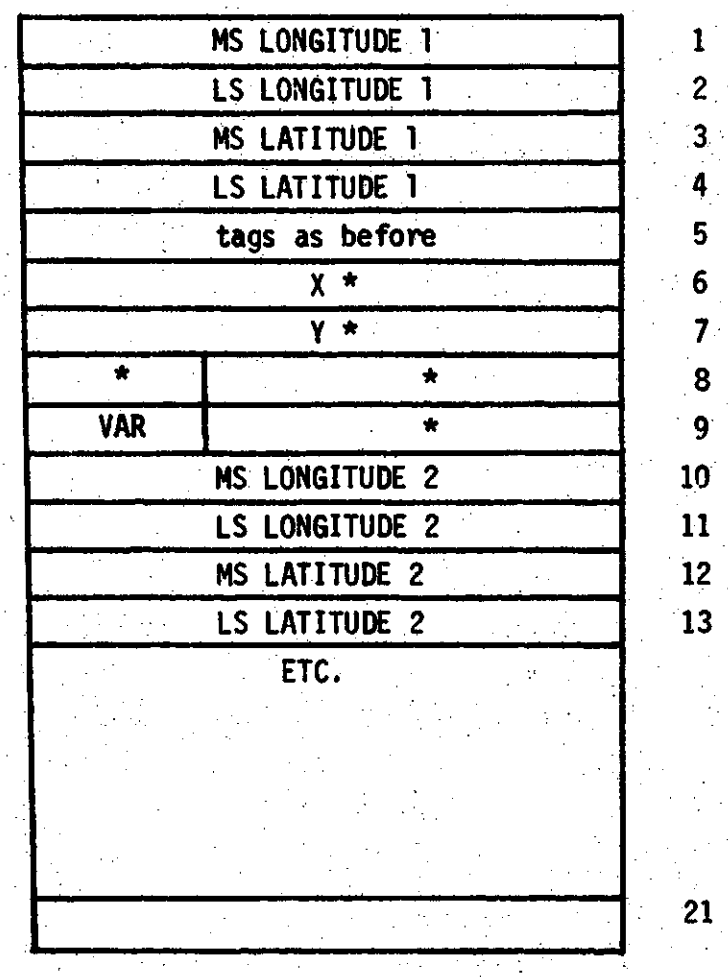


FIGURE 2.3
FORMAT 3 for drawn symbols

* indicates not used in this case

as the reference coordinate for the complex symbol.

The fifth word is reserved as a tag word and normally contains tags as for format 1.

Words six through nine are not normally used.

The remaining twelve words are divided into three sections, each of four words. Each group specifies the end/start point of a vector segment.

Typically, this form of data will require an entry extension since only five successive vector segments, including closure on the first coordinate, can be specified within one entry.

4) FORMAT 4: CURVED NAMES (AND DESCRIPTIONS)

This format, having a fixed length of 40 (decimal) words, is illustrated in figure 2.4. The first four words contain the reference coordinate, normally in longitude/latitude, for the name or alphanumeric description.

The fifth word is reserved as a tag word and normally contains tags as defined for format 1.

Words six and seven contain the ΔX and ΔY offsets of the first letter with respect to the reference coordinate in display screen units for normal (magnification of 1) map size.

The eighth word contains the letter style in the most significant three bits and the angle of rotation for the entire name in the remaining bits.

The same bit designations are used in the ninth word to specify the style, variant, and octal size.

The remaining words are divided into groups of three. The

x8		
MS LONG		0
LS LONG		1
MS LAT.		2
LS LAT.		3
TAGS AS FOR TYPE X		4
XØ		5
YØ		6
STYLE	ANGLE	7
VAR.	OCTAL SIZE	10
CØ		11
X1		12
Y1		13
C1		14
X2		15
Y2		16
C2		17
X3		20
Y3		21
C3		22
X4		23
Y4		24

C4	25
x 5	26
y 5	27
C5	30
x 6	31
y 6	32
C6	33
x 7	34
y 7	35
C7	36
x 8(10)	37
y 8	40
C8	41
x 9	42
y 9	43
C9	44
x 10(10)	45
y 10(10)	46
C10	47

FIGURE 2.4
DATA FORMAT 4
DATA TYPE X (SET = 3)

first of these three conveys the character in eight bit ASCII with a leading case bit forming the 9 bit "ASCII" used internally by the program. The most significant three bits of the word are reserved for future expansion. This expansion could easily encompass superscript, subscript and capitalized capitals, as the facility for handling these has been planned for rapid insertion into the program.

The next two words contain the $\triangle X$ and $\triangle Y$ offsets of the next character, with respect to the previous, in display units at normal map size.

In this format, ten characters can be specified without the generation of an entry extension. If an extension is required, it is handled in the same manner as that used for the other formats.

5) FORMAT 5: AREA NAMES

This format, having a fixed length of 21 words, is soon to be incorporated into the program. It is used to specify the names of map areas. Area names will have a unique feature letter, separating them from map-place names and alphanumeric descriptions.

The first four words specify the longitude/latitude of the centre of the map area, as indicated in figure 2.5.

The fifth word is reserved for tags as defined for format 1.

The next four words hold the positive and negative limits of the area respectively. These limits, defining an approximating rectangle for the area, are analysed such that

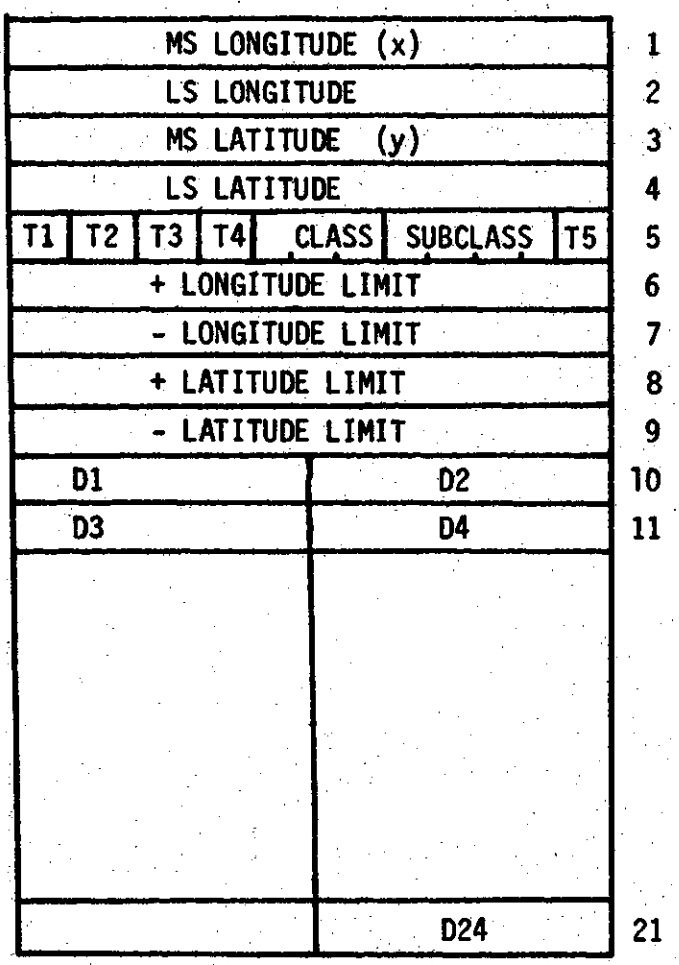


FIGURE 2.5

FORMAT 5: for AREA NAMES

the name is placed at the centre of the area, or area segment, appearing on the display.

Since this format is used for data bank data only, the name parameters normally occupying these words are not required, as name parameters are derived from the specified class and subclass for the name.

The remaining words in the format hold character data as in format 1.

2.2.3. Organization of Disc Data Files

The name data is assembled in a number of files on the disc. Each file is specified by a feature letter and a set number. Separate files are created for each feature letter available. This set structure, for name (feature letter X) files, is shown in Table 2.2.

The original data files are sorted in order of longitude/latitude prior to loading into the disc files. This permits the use of an ordered location search routine to shorten data retrieval time, either for normal display, or for selection of a particular name for modification.

As unsorted files lengthen due to manual input or modifications during map compilation, causing extended retrieval time, they can be sorted in with an existing sorted file (set 5 or 6), but this takes an appreciable length of time and is done at 'off peak' periods.

At the time of retrieval, the set number is obtained from the disc data and used to specify the starting block of the desired data file. The set number is also passed to the search routine to inform it of the mode of search to select.

Each file has an end code formed of a negative longitude/latitude.

FEATURE	SET	TYPE	USE
X	0	SORT	DIGITIZED DATA
X	1	UNSORT	ADDED DATA (editings)
X	2	UNSORT	DATA BANK CHANGES
X	3	UNSORT	DATA FOR SYMBOL PRINT
X	4	SORT	DATA BANK
X	5	SORT	EXTRA DATA INPUT
X	6	SORT	EXTRA DATA INPUT

TABLE 2.2

DISC DATA SETS (feature X)

2.2.4 Representation of upper and lower case letters

Allowance has been made in the Computer Aided Name Placement Program for the manipulation of both upper and lower case letters. Construction data for the character matrices (digitized characters) are stored on disc in two separate files, one for each case.

Though received from the data files in packed 6-bit ASCII, all characters are converted to 8-bit ASCII for manipulation within the program. This 8-bit representation is automatically interpreted as upper case. Upper case is specified in the data files or from the teletype by the occurrence of the "↑" character. Each letter following this character will be represented in upper case until the occurrence of the lower case specifying character is encountered.

Lower case characters are represented by a 9-bit code consisting of 8-bit ASCII preceded by a binary 1 to specify lower case. Lower case is specified by the occurrence of the "←" character. Each letter following this character will be in lower case until the occurrence of the upper case specifying character.

Digits and punctuation may be specified while in either upper or lower case, since the program ignores the lower case specification bit for these characters.

The program automatically defaults to upper case when entering the editing mode from the keyboard monitor routine.

2.3 611 Display Symbol Library

2.3.1 Reason for Symbol Library

The University of Saskatchewan System of Name Compilation utilizes a Tektronix 611 storage display as a visual window to the data. Connecting the display to the computer is a specially built interface which, though

extremely versatile in its capabilities, does not contain a hardware character generator. The reason for this becomes obvious once one sees the complexity of the generated images. The software generation of characters requires that a digitized symbol library be formed to instruct the display on how to form each character. There must be a separate library for each different set of symbols that is desired for display.

The method used to form these libraries and store them on the disc for rapid use will now be discussed.

2.3.2 Digitization of Symbols for 611 Display

The symbol libraries used to construct the characters for drawing on the Tektronix 611 storage display are held on the disc in several binary files which are called into core memory as required by the drawing routines of the Computer Aided Name Compilation Program.

Symbols are digitized as dot matrix arrays of either 7 x 12 for alphanumeric symbols or 13 x 12 for some special symbols as defined by the user.

The first matrix, illustrated in figure 2.6 is 7 words each of 12 bits. One extra word precedes the actual matrix data for use in letter spacing as will be discussed later.

The matrix is shown again in figure 2.7 overlaying a symbol to be digitized. Digitization commences in the lower left hand corner and proceeds upwards so that the lower left point forms the most significant bit. For simplicity, all coding is expressed in octal. Table 2.3 represents the digitized data, in binary and octal, for the character shown in figure 2.7.

Since the Computer Aided Name Compilation Program spaces letters based on equal blank areas between all adjacent letters, the blank areas within the symbol matrix on either side of the character bounded area must be specified to the program. These data are contained in a word preceding the matrix data as mentioned earlier. This word is divided into two 6-bit segments. The most significant segment holds the blank area to the left of the character; the least significant, the area to the right. The determination of these areas is a subjective estimate of vacant grid squares ascertained by counting during the digitization process. The subjective estimate of these areas for the character of figure 2.7 is indicated by the first word of table 2.4 which shows the complete digitized data for input to the symbol library via the teletype.

The second digitization matrix, 13 words of 12 bits, is shown in figure 2.8. The digitization procedure is the same as before with the exception of the designation of the word preceding the matrix data. This "preceding" word is divided into three 4-bit segments.

The most significant segment is used to represent the horizontal distance from the upper right corner of the matrix to the centre of rotation of the symbol and is expressed as a positive number.

The middle segment represents the corresponding vertical distance, also in a positive sense.

The last segment is used only with certain grouped symbols to specify the vertical distance from the centre of rotation to the highest point in the matrix occupied by the symbol. This value is used for the vertical positioning of auxiliary symbols. These parameters are

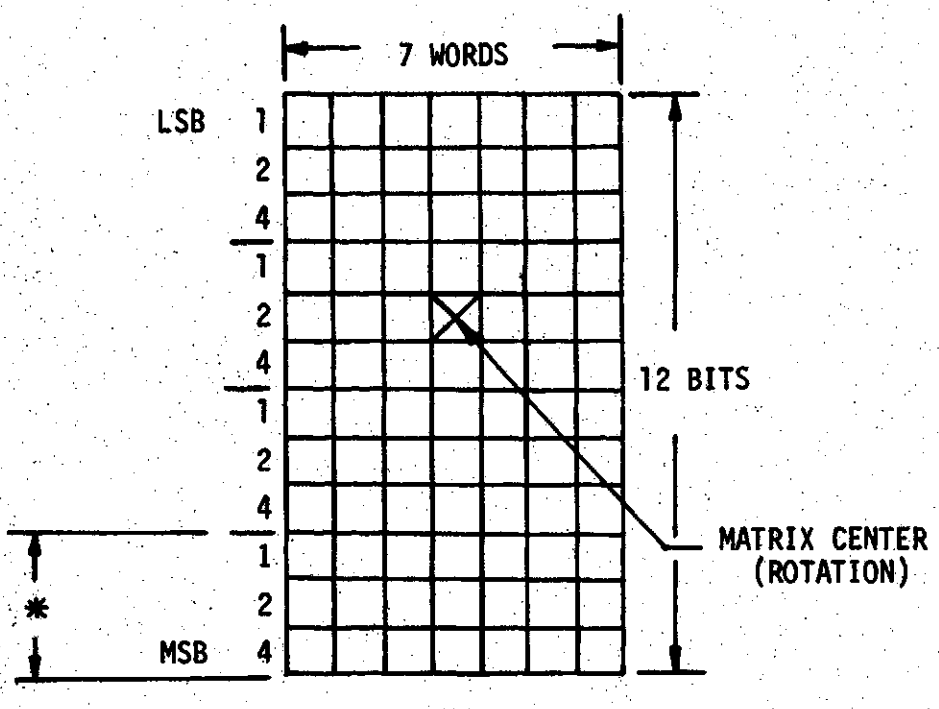


FIGURE 2.6

7x12 DIGITIZATION MATRIX
* used only for small letter trailers

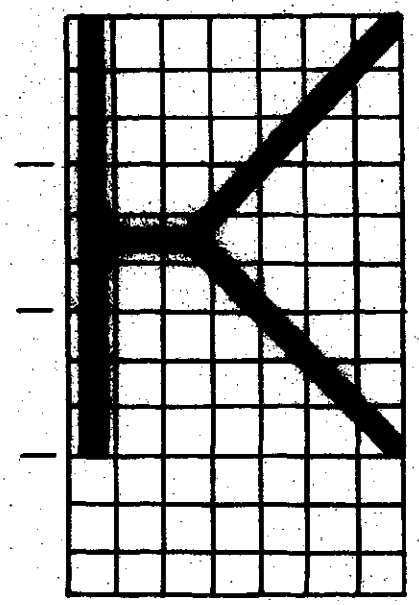


FIGURE 2.7

LETTER OVERLAYING 7x12 MATRIX

BINARY	OCTAL
000 111 111 111	0777
000 000 010 000	0020
000 000 010 000	0020
000 000 101 000	0050
000 001 000 100	0104
000 010 000 010	0202
000 100 000 001	0401

TABLE 2.3

DATA FOR DIGITIZED LETTER OF FIGURE 2.7

Subjective area sums for Figure 2.7 are approx.

Left = 0000 Right = 0010

The first data word therefore is 00,10 → 0010

The complete data ready for input are;

0010
0777
0020
0020
0050
0104
0202
0401

TABLE 2.4

DIGITIZED DATA WITH AREAS READY FOR INPUT

illustrated in figure 2.9.

Table 2.5 shows the data for the symbol of figures 2.9 including the assembly of the "preceding" word.

2.3.3. Symbol Library File Structure

The storage and retrieval of symbol library data presents a case where a retrieval time / storage space trade off must be made to optimize operational efficiency.

In the case of the 8 word by 12 bit format, the unit length of 8 words is most convenient since 8 is a binary multiple. This optimizes retrieval time; binary shifts only are required and it is therefore not necessary to use multiplication to advance the unit pointer for entry selection. This also optimizes convenience of storage since a 256 word disc block will hold exactly 32 unit entries.

The situation is not so convenient when 14 words per unit are required. It is then necessary to use multiplication resulting in a lower retrieval speed. Also, each 256 word disc block can hold only 18 unit entries, leaving four vacant words at the end of each block. It is justifiable to leave these words blank and start the next entry at the beginning of the next disc block.

2.4 Description of CANC Program

2.4.1 Introduction to the Name Compilation Program

The University of Saskatchewan Name Compilation System utilizes a PDP8E digital computer, Tektronix 611 storage display, special display interface and "mouse" pointer in conjunction with an 832-k word magnetic disc unit.

The disc is used to store name data, symbol libraries and program

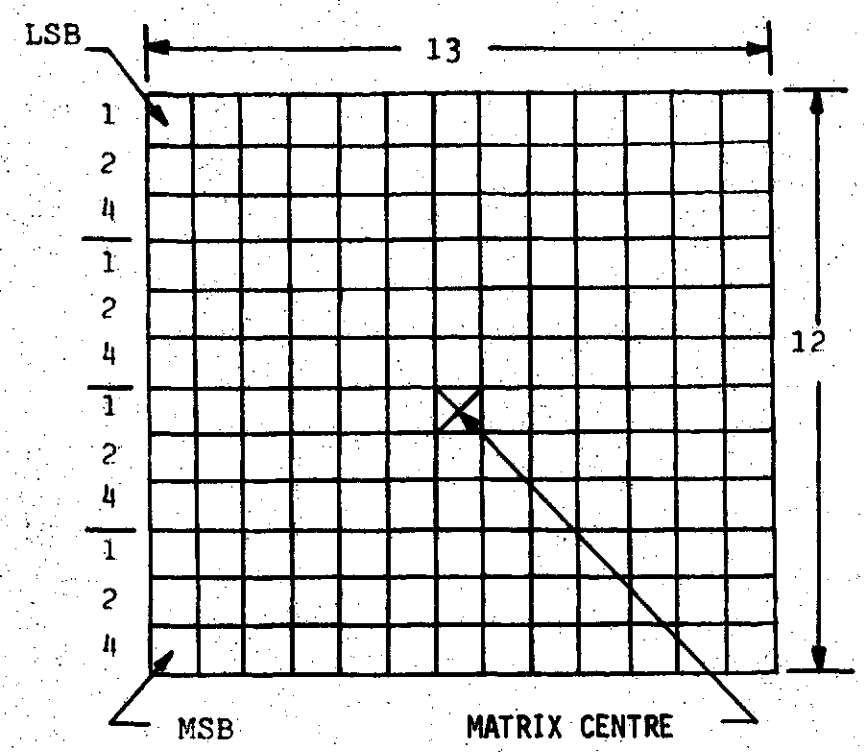


FIGURE 2.8 13 x 12 matrix

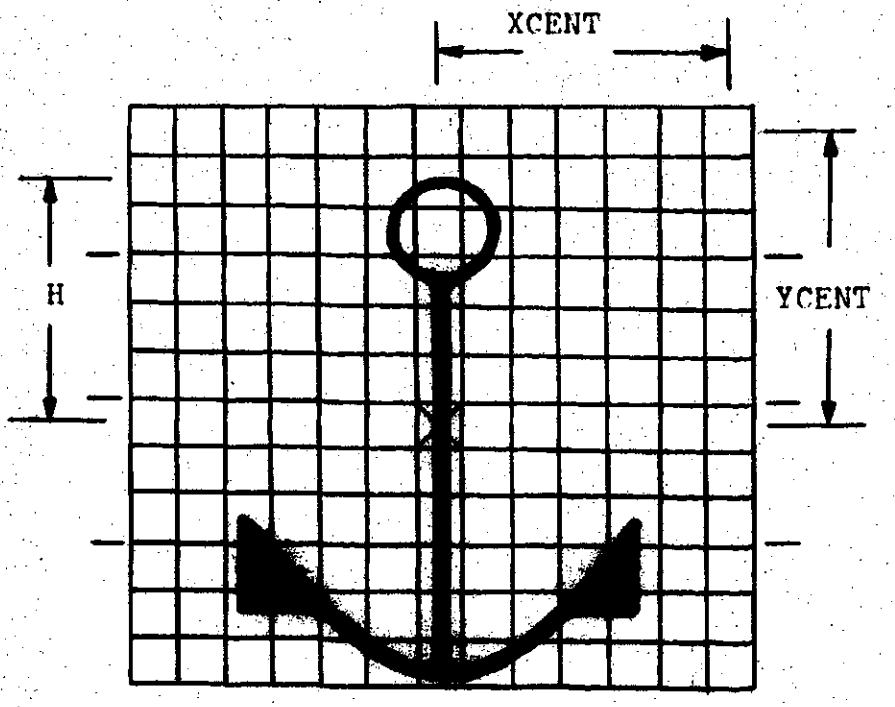


FIGURE 2.9 SYMBOL ON DIGITIZATION MATRIX

BINARY	OCTAL
0110 0110 0101 = 011 001 100 101 = 3145	
first word	.3145
000 000 000 000	0000
000 000 000 000	0000
011 100 000 000	3400
011 000 000 000	3000
010 000 010 000	2020
100 000 010 100	4024
111 111 111 010	7772
symmetry yields:	4024
	2020
	3000
	3400
	0000
	0000

TABLE 2.5.
DATA FOR NAVIGATIONAL AID OF FIGURE 2.9

segments, the latter being transferred into core memory of the computer as required by core resident control routines. This technique of program swaps and overlays provides the computer with an effective extension of core memory.

The Tektronix 611 storage display, special display interface, and "mouse" pointer collectively form an interactive display subsystem for display and manipulation of cartographic data of all types.

The Name Compilation Program is used in conjunction with the University of Saskatchewan Computer Aided Map Compilation (CAMC) program. This program provides the facility for drawing and editing all line data as well as passing name and symbol data and image parameters to the Name Compilation Program.

The Name Compilation Program is responsible for the display and interactive manipulation of the following data types:

a) Names

b) Alphanumeric descriptions.

c) Single and group symbols

Interactive manipulation, utilizing the "mouse" pointer and teletype keyboard, consists of the following operations:

a) Retrieval of data from data files for the purpose of manipulation

b) Addition of new data to data files

c) Erasure of data from data files by tagging as reject

d) Modification of data by;

   1) letter insertion, deletion, change and addition

   2) Modification of data coordinates by relocation of the data image on the display

3) Rotation of the data image on the display screen.

4) Selection of image size, style, and style variants.

5) Curvature of the image.

e) Reinsertion of modified data into the data files.

All of these operations are specified by simple commands, by alphanumeric text entered via the teletype keyboard, and by positional instructions specified via the "mouse" pointer.

Figures 2.10 and 2.11 illustrate the various components of the system.

Figure 2.12 indicates the generalized flow of data and commands throughout the overall system.

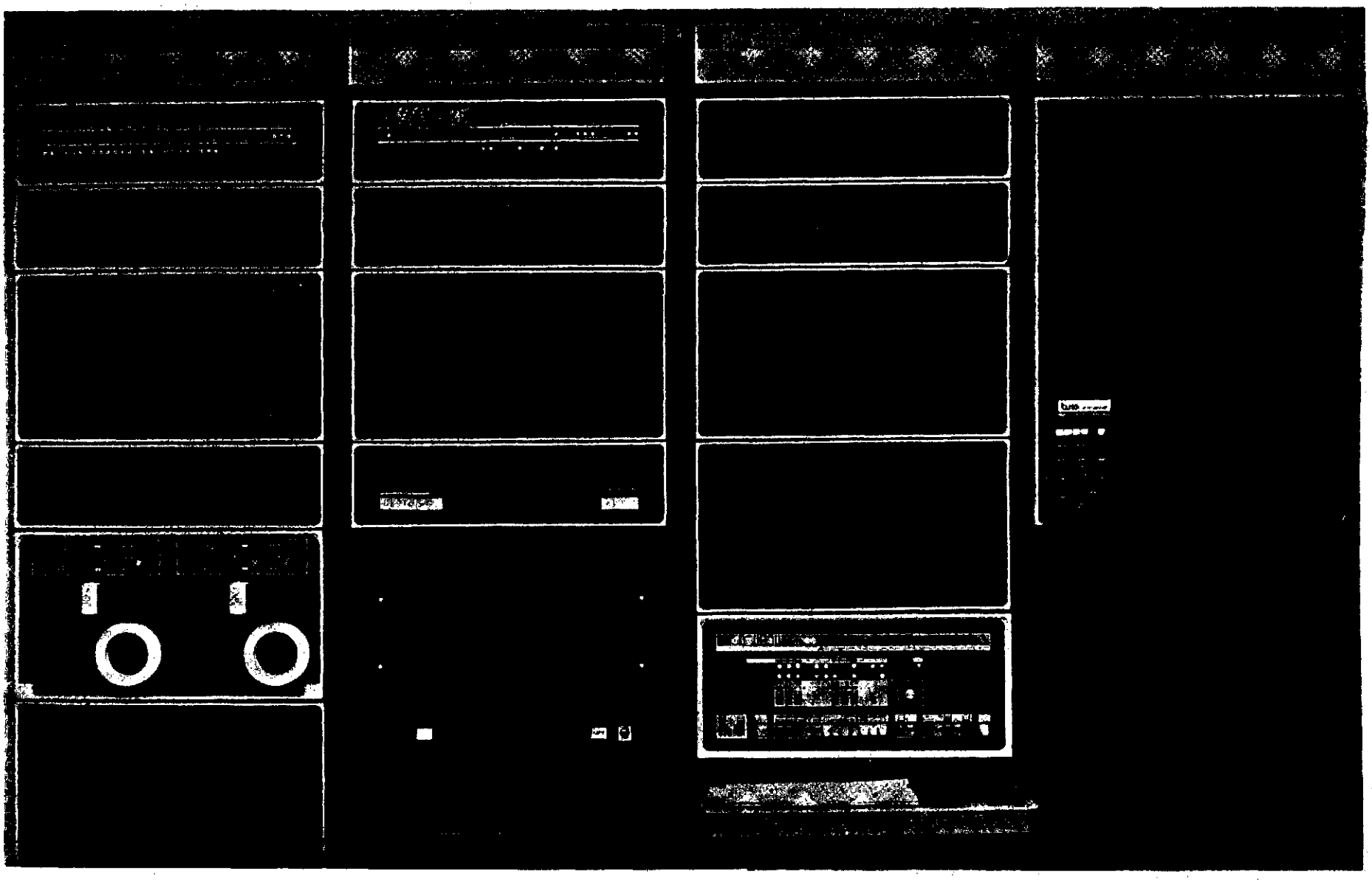
2.4.2 Image Modes

Two types of image modes are utilized in the Name Compilation Program; store and nonstore. Data drawn on the Tektronix 611 are normally placed there in the stored condition. However, during the manipulation process, a ghost image is generated in the nonstore mode. This ghost image, requiring continual update by the computer, can be moved and altered by the manipulative routines under operator control. When all manipulations on the selected data have been completed, this ghost image is replaced by a stored image containing all changes as specified during the manipulation phase.

A more fully detailed description of these modes is presented in the section describing the display hardware.

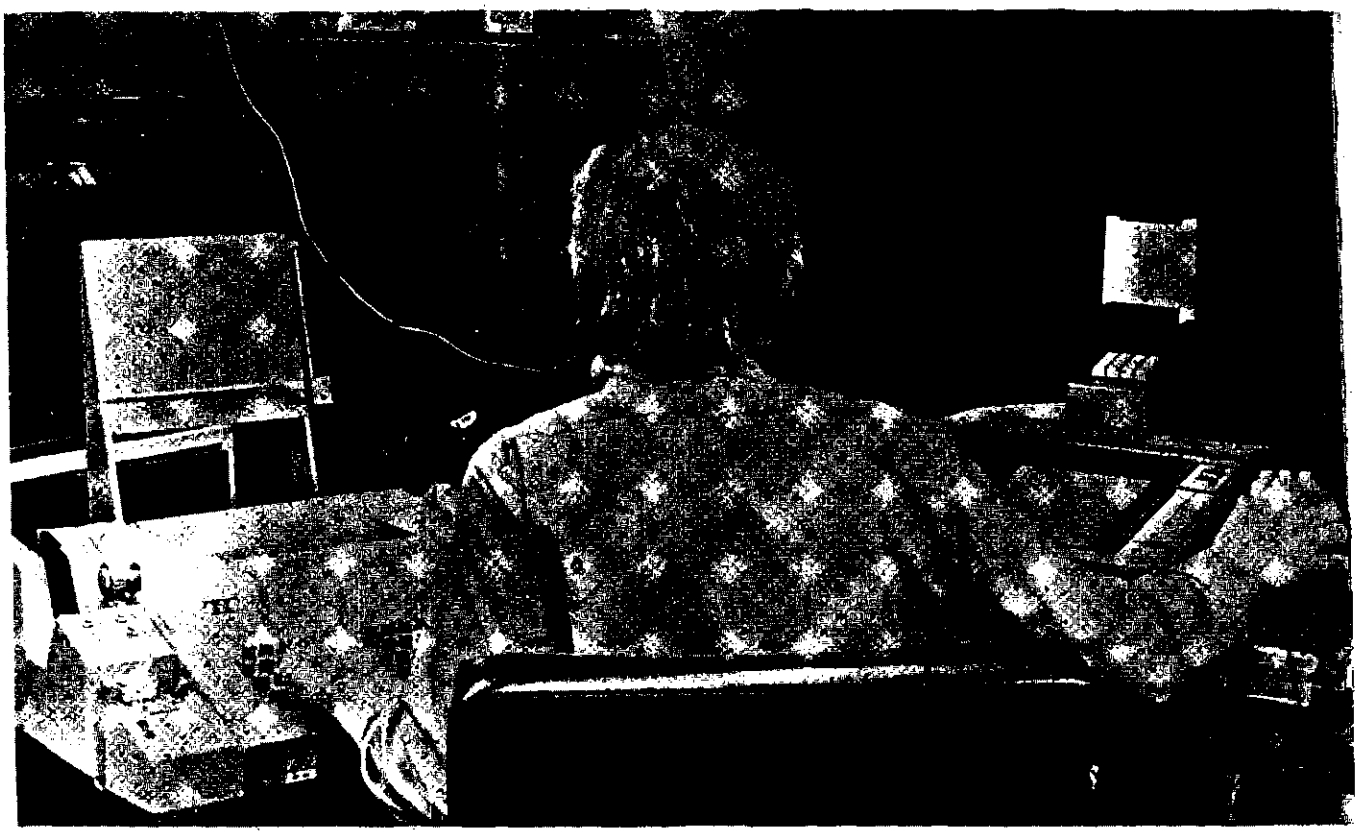
2.4.3 Program Commands

The following keyboard commands are used for retrieval, manipulation and output of data. (A $ is used to indicate an operation by the "Mouse" pointer.)

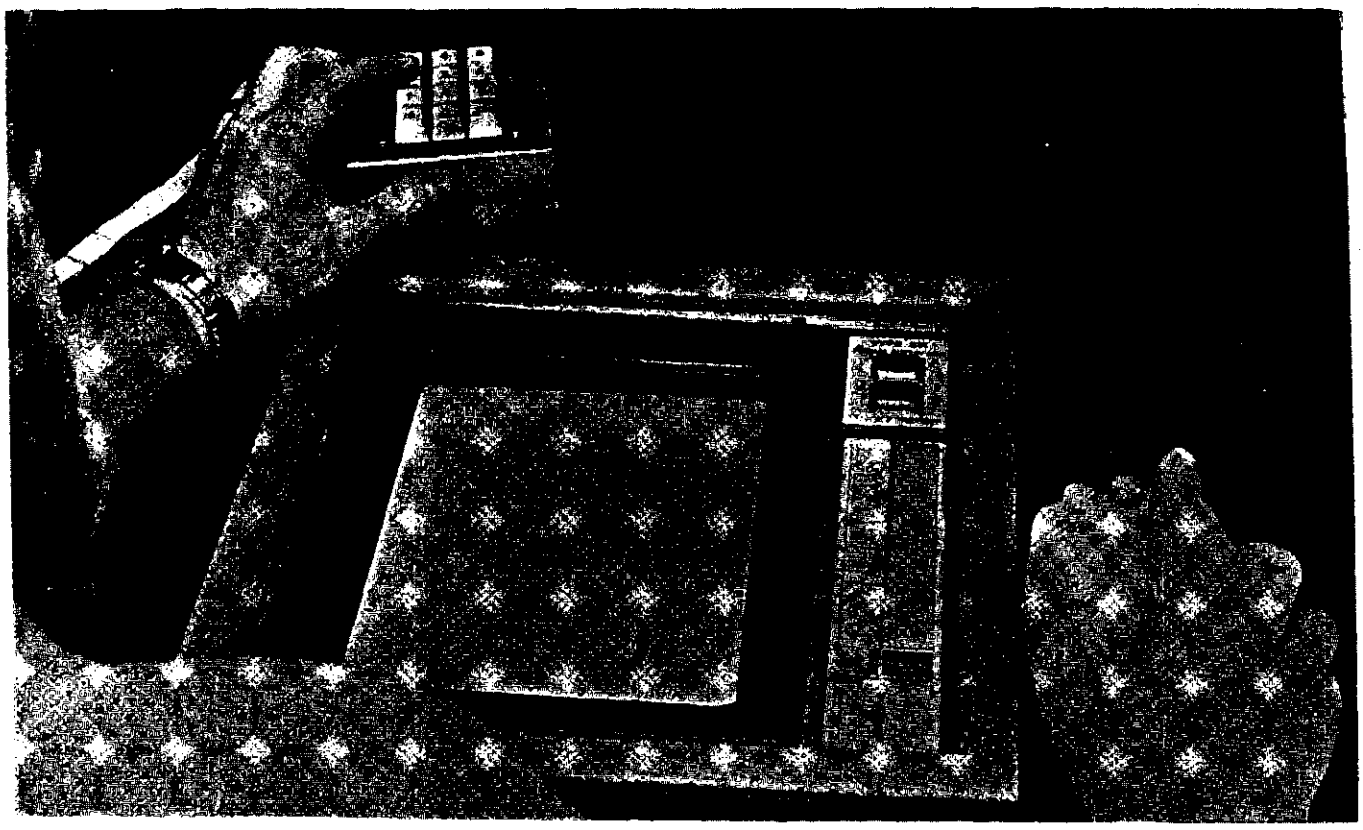


DECTAPE RK8 DISK FIGURE 2.10 PDP8/e TU10 MAGTAPE

PDP8/e COMPUTER SYSTEM



OPERATION OF CANP PROGRAM



TEKTRONIX 611 WITH KEYBOARD AND MOUSE
FIGURE 2.11
DISPLAY SUBSYSTEM

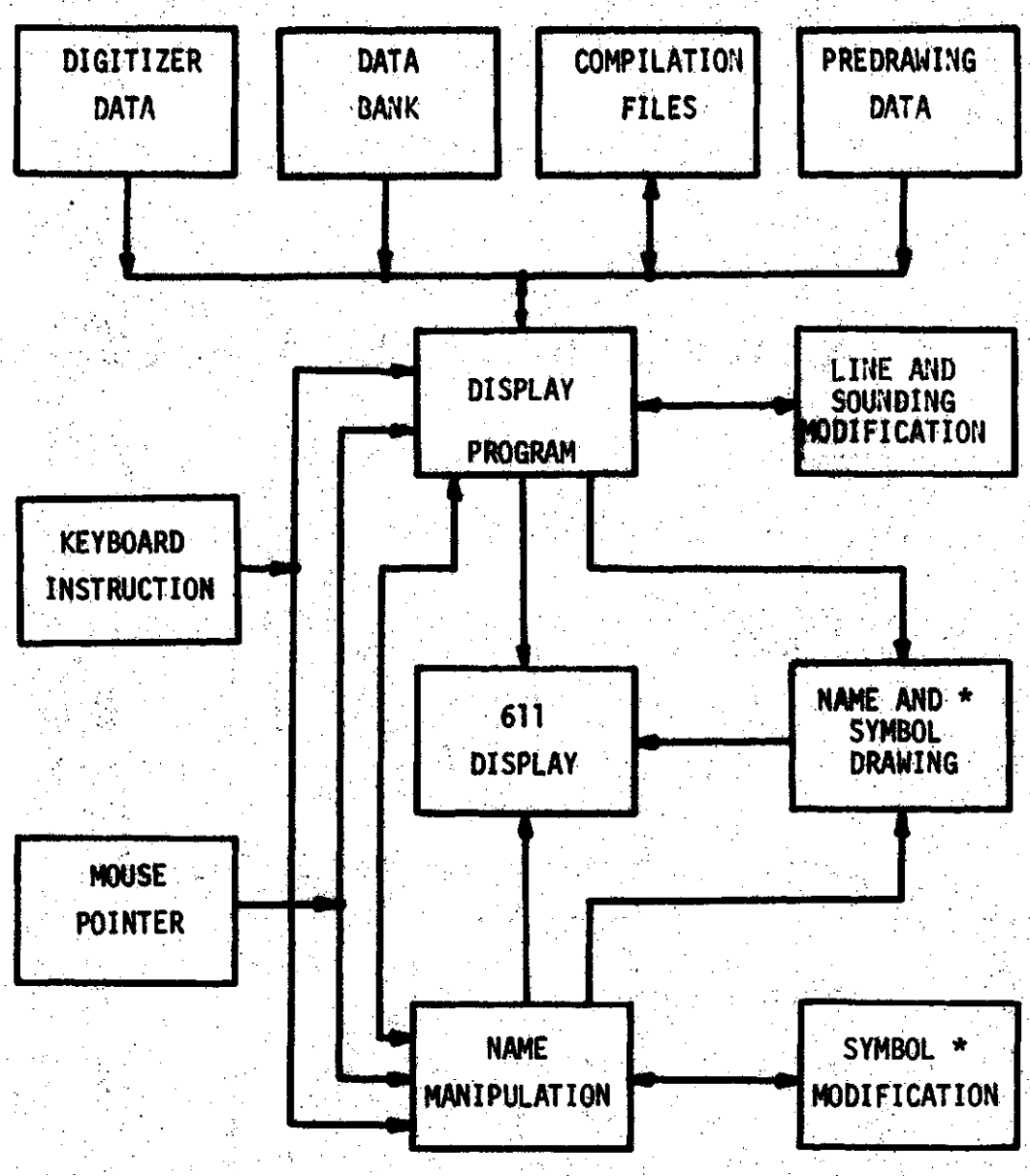


FIGURE 2.12

GENERALIZED FLOW OF DATA AND COMMANDS

* contribution of the author.

a) IN THE DISPLAY PROGRAM

1) NW NAME MODIFICATION

This command calls in the name manipulation routines.

2) NA NAVIGATIONAL AID MODIFICATION

This command calls in the group symbol modification routines.

b) IN NAME MANIPULATION PROGRAM

1) H¢: RETRIEVE DATA

The "H", for here, indicates to the program that the pointer is to be used to select a name or symbol to be retrieved from the data file for editing. The "¢" represents the specification of the feature letter of the selected item to be retrieved. This command results in the search for the data and the subsequent generation of a ghost image when the data is found. The colon is inserted by the program.

2) WA:$ WORD ADDITION

Enables the addition of a text string from the teletype at the position specified by the "mouse" pointer. The colon is inserted by the program. Text termination is specified by the "return" character. The "rubout" character enables deletion of the previously typed character. The program generates a ghost image of the characters

immediately after the stored image is drawn and returns to the keyboard monitor for further manipulation commands.

3) WE: WORD ERASURE

Permits the deletion of a word from the display screen and data files by tagging the word as invalid. The colon is inserted by the program.

4) WC: WORD CHANGE

This command generates an erasure followed by an addition. The colon is inserted by the program. Text is terminated by the "return" character and a "rubout" deletes the previously entered character.

5) WD:$ WORD DIVISION

This command effects the dividing of a name into two separate word segments. The "mouse" pointer specifies the first letter of the name segment to be relocated. The unselected portion is stored on the screen and entered into the output data file. All available manipulations are valid for the selected portion of the name. The colon is inserted by the program.

6) Q QUIT, CONFIRM CHANGES

This command transfers program control back to the Display Program.

7) M MONITOR

This command transfers program control to the OS8 system monitor. In effect, this is an abort instruction.

8) O OUTPUT DATA

This command is used at the completion of a manipulation process. It results in the transfer of data to the output file and the drawing of a stored image on the display screen.

9) S:¢ SET LETTER STYLE

The "¢" represents a number, from 1 to 3 inclusive, which specifies letter style. The colon is inserted by the program.

10) V:¢ SET STYLE VARIANT

The "¢" represents the specification of the style variant as follows

I italics

N non italics. i.e. block

L lightline

B boldline

The colon is inserted by the program. Input is terminated by the "return" character. i.e. V:LI(return)

11) P:¢¢.¢ SET POINT SIZE

The colon and decimal point are inserted by the program. The "¢" represents the input of the letter size in points. Two digits prior to the

decimal point and a 0 or 5 after it must be specified. e.g. P:05.5

Sizes from 02.5 to 40.0 are permitted. Point size increments are 0.5.

12) LA:¢ LETTER ADDITION

This command specifies the addition of characters onto the end of a selected name. The colon is inserted by the program. Termination of the character string is specified by the "return" character.

13) LC:$¢ LETTER CHANGE

The pointer is used to select the character to be changed. The "¢" indicates the replacement character. The colon is inserted by the program. Only one character at a time may be changed.

14) LE:$ LETTER ERASURE

The pointer specifies the character to be deleted from the name. The colon is inserted by the program.

15) LI:$¢ LETTER INSERTION

The pointer is used to specify the character before which the insert is to be made. The "¢" indicates a single character to be inserted. The colon is inserted by the program.

16) LS:$ CHANGE LETTER SPACING

The pointer is used to specify a new location for

the last letter in the name The name will then be changed in length so that the last letter will fall on the selected point. A series of these spacings can be carried out in succession to yield the desired spacing. The colon is inserted by the program. Exit from the spacing mode is via the "return" character.

17) MOUSE SPECIFICATIONS

While in the command mode as indicated by an * in the left margin of the teletype printout, the "mouse" pointer can be used without further keyboard instructions as follows:

a) MOVE MODE

The selection of the first letter in a name enables the operator to move the ghost image of the name by using one of two modes:

1. POINT MODE. By pressing the point mode button on the "mouse" to select the first letter and again to specify its new location, the name will jump to the new location.
2. LINE MODE. By holding the "mouse" line mode button, the ghost image will follow the pointer as it is moved.

b) ROTATE MODE

By specifying a position off the end of a name

and within ±15 degrees of a line joining the last and first characters, the name can be rotated by using the "mouse" in either line or point mode as described for the move mode.

c) CURVE MODE

Selection of individual letters via the point or line mode enables the selected letter to be moved independently. Letters adjacent to the selected letter alter their angular orientation so that the name forms a mathematically defined curve.

2.4.4. Symbol Modification

The routine to modify a selected type of symbol is called from the Display Program by typing an "N" followed by the feature letter of the desired symbol type. This sequence results in the loading into core memory of both fields of the Name Placement Program, field 1 being partially overlayed by the required symbol modification routine.

Once in core memory, the symbol modification routine types an "@" character in the left margin of the teletype printout to indicate that the "mouse" pointer can now be used to select a symbol (of the requested type) from those presently on the display.

Once found, the program types out the following:

OLD LABEL

(old label typed out)

X(DEC) = (x coordinate typed out)

Y(DEC) = (y coordinate typed out)

CHANGE ? (Y OR N)

If an "N" is typed, the Display Program is recalled into core memory and control is transferred to its keyboard monitor. If, however, Y is typed, the following interactive dialogue is carried out:

NEW LABEL

(type in new label)

NEW X(DEC) = (type in new x coordinate)

NEW Y(DEC) = (type in new y coordinate)

Once this dialogue is completed, the program tags the old symbol data as invalid and generates a new entry containing the modified data. Control is then transferred back to the Display Program keyboard monitor.

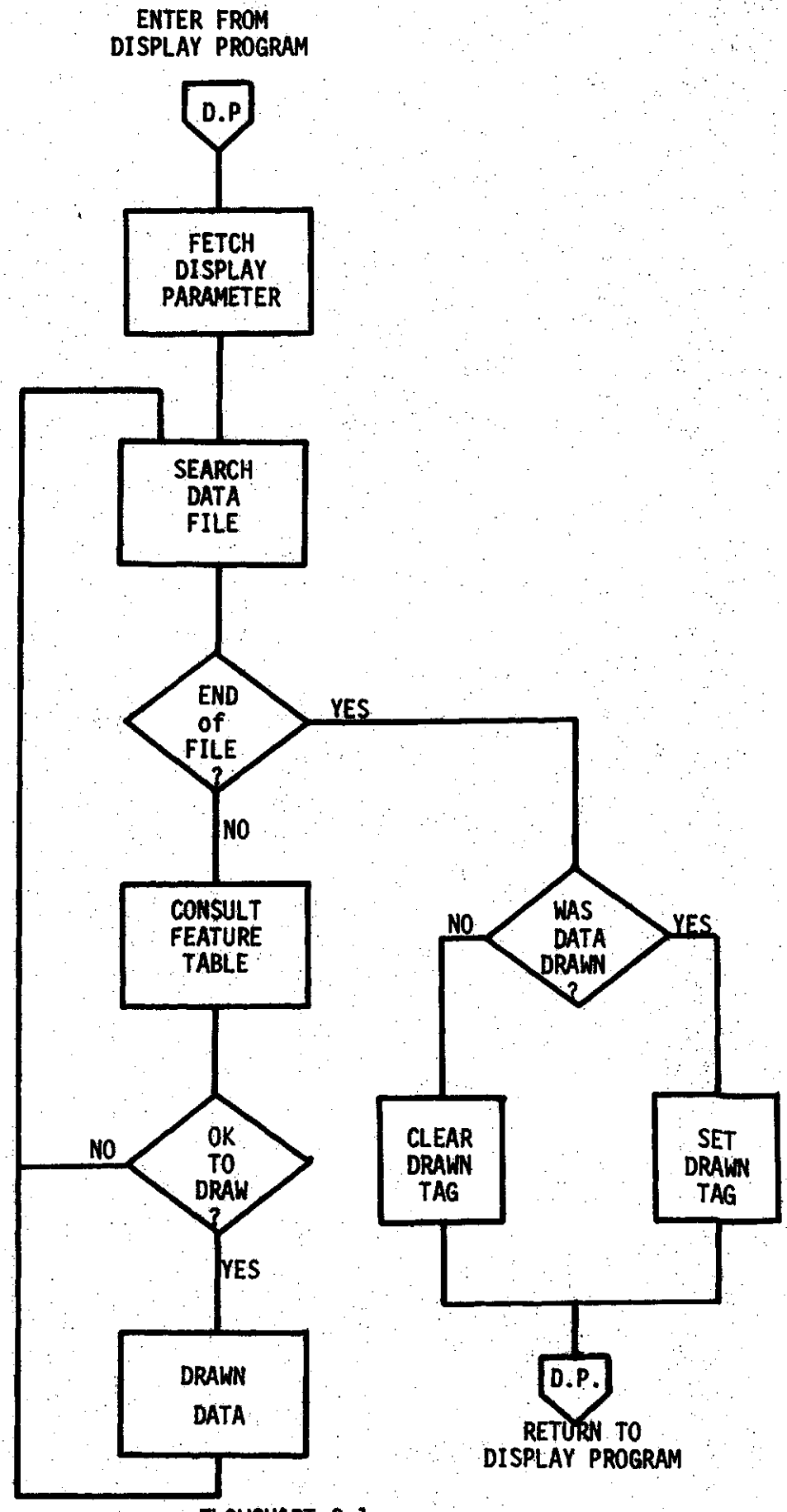
During the interactive dialogue, the typing of the "rubout" character deletes the previously typed character.

2.5 Program Internal Operations

2.5.1 Data Drawing

The Computer Aided Name Compilation Program (field 1 portion) is utilized by the University of Saskatchewan Computer Aided Map Compilation Program to draw on the display screen, all data types with the exception of line and depth sounding data.

Flowchart 2.1 indicates, in a simplified manner, the general sequence of events for the data search and drawing operation as directed by the Display Program.



FLOWCHART 2.1

NAME DRAWING

For standard drawing application, the Display Program performs the disc directory lookup function to find which data file or files hold the desired data. The subsequent disc block address as well as x and y scale factors, image magnification, the set number of the data file, the feature letter of the data and the screen reference coordinates are passed as display parameters to the character drawing routine via a common core page at the top end of field 1.

The character drawing routine then carries out a data file search, either sequential or "ordered" as specified by the data set number, for entries whose coordinates fall within a given tolerance of the display screen area coordinates. The tolerance for this search depends on the nature of the data and the type of search call.

Once an entry is found which qualifies in location and feature letter, it is checked against each entry in the feature table for the selected image presentation. This feature table contains the specification of those features which have been selected for display for each of the three image presentations; present, last or generic. In this feature table search, the data class and subclass are also used as qualifiers.

If the data qualifies for display, it is drawn and a "drawn" tag is set. In either case, the search of the data file continues.

Once the end of the data file is reached, as specified by a negative longitude and latitude, the "drawn" tag is tested and its status is stored in the common page area for use in directory updating by the Main CAMC Program.

Control is then transferred to the CAMC Program which is recalled into core memory.

2.5.2. Character Matrix Decoding and Drawing

Character construction data, used for display on the Tektronix 611 storage display, are held in dot matrix form of either 8 x 12 or 14 x 12 size as discussed in the section of the 611 character library. This coded dot matrix must be decoded into a series of individual x-y display coordinates for character drawing.

Firstly, the character to be drawn, as specified by the input data, is analysed for the data type by determination of the feature letter classification; X for names, P for alphanumeric descriptions, and various others for special symbols. The result of this analysis is used to read the appropriate drawing control overlay into the overlay area of the program and to ascertain the disc address of the proper character construction matrix data.

The position of the input character within its "alphabet" is determined. The multiplication of this by the number of computer words utilized to represent one entry in the construction matrix file is added to the construction file disc start address to yield the block address of the required entry and the address of the entry itself within this block.

The disc block is then read into core memory and a pointer is set at the address of the start of the desired entry.

The construction data matrix size is used to set two counters, one for the number of dot entries per computer word (Y size) and one for the number of computer words used per construction data matrix entry (X size). These are used to control the matrix decoding.

The first word of the matrix data, representing the letter

spacing in the case of names or the centre offset in the case of group symbols, is read and decoded, the appropriate spacing or offset is calculated, and the position of the matrix centre on the screen is determined.

Using the matrix dimensions, the location of the lower left hand corner of the matrix is then determined relative to the centre of the matrix.

The second word in the construction data matrix is read into the accumulator and ANDED with the decode mask, initially set to 4000. If the result of this ANDING is a one, the present point in the matrix is to be drawn. If rotation is required, the point is rotated about the centre of the matrix, producing a new $\triangle x$ and $\triangle y$ with respect to the centre. This distance from the centre is then added to the centre x-y screen coordinate and this point is intensified.

The mask is then rotated one position to the right, the Y size pointer, previously negated, is incremented and tested for zero. A zero indicates that all points in a column have been drawn. If it is not zero, the ANDING is repeated and another point may be intensified.

When a zero finally occurs, the mask and Y size counter are restored to their initial values and the X size counter, previously negated, is incremented to give the x position of the next column. Drawing of this column proceeds as before.

In fact, several decoding sequences occur simultaneously to yield a knowledge of surrounding points. This knowledge is used to determine the start and end points of vectors* used to join points in

* Subroutine composed by R. McMillan

the matrix which are to be displayed. The line width used in the drawing of these vectors is a function of image magnification, character size, and character style variation.

This process of matrix retrieval, analysis, spacing, rotation and drawing continues until the character count, previously negated and incremented when each character is drawn, goes to zero indicating that all characters have been drawn.

2.5.3. Rotation of Character Matrices

The rotation of a character matrix is the result of the rotation of all the points within the matrix.

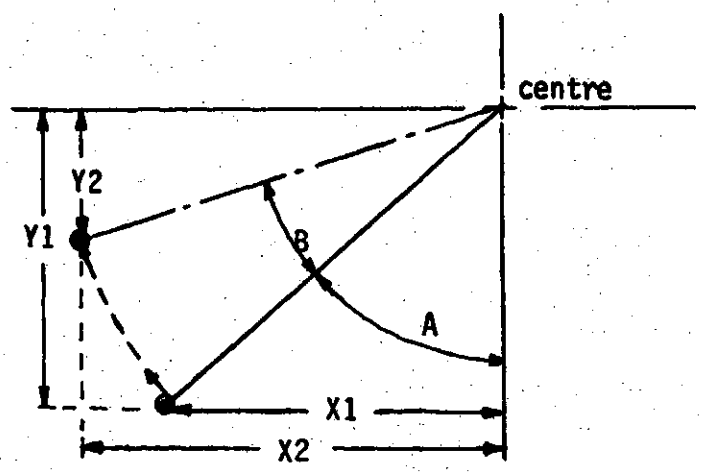
All matrix rotations are referenced to the centre of the matrix. This centre may be rotated with reference to another point prior to the actual matrix rotation.

The rotation of a point with respect to another, whether within the matrix or an external point, is carried out using the following trigonometric formulae:

$$SIN(A+B) = SIN(A)COS(B)+SIN(B)COS(A)$$

$$COS(A+B) = COS(A)COS(B)-SIN(A)SIN(B)$$

where A and B are angles defined as follows:



From this figure it can be seen that:

X1 = (R) COS(A)

Y1 = (R) SIN(B)

X2 = (R) COS(A+B)

Y2 = (R) SIN(A+B)

Multiplying the two original equations by R and then substituting the latter equalities into it yields:

X2 = (X1)COS(B)-(X1)SIN(B)

Y2 = (Y1)COS(B)+(Y1)SIN(B)

This enables the rotation of a point by specifying its $\triangle x$ and $\triangle y$ from the centre of rotation and the sine and cosine of the angle of rotation; the result being a new $\triangle x$ and $\triangle y$ from the centre of rotation.

Within the program, $\triangle x$ and $\triangle y$ are read directly from the data in the character construction matrix. The sine and cosine of the angle of rotation are obtained from a lookup table holding sine and cosine in three degree increments.

2.5.4 Italicization of Characters

For representation of italicized characters on the Tektronix 611, the slope of the "vertical" segments of the character was approximated to be 21 degrees, an integer multiple of the normal angular increment of 3 degrees.

Rather than having a separate character construction matrix file for italicized letters, it was decided to calculate the italicization by modifying the matrix point values. Essentially, coordinates are

rotated by 21 degrees but only the change in X is retained, the Y values remaining with their initial values.

This altered character matrix can then be rotated as for normal symbols.

2.5.5. Editing Operation Output

The output of name data from the editing routines back into the data files is a complex operation consisting of the following procedures:

1) Determine what editing operations have been carried out on the data.
2) If a new entry in the data files has to be created, tag the old entry as invalid.
3) Carry out a directory and data file search to determine if the new entry can be appended to an existing set file; if so, append it.
4) If a new set file must be created, find, from the directory, a blank area of disc for the new file. This new file is then generated, complete with its descriptor block, and the file parameters are used to generate a new directory entry.

The determination of what editing operations have been done is accomplished by simple bit coding of a status word. Each possible operation is assigned a single unique bit which is set to a '1' if the editing operation has been carried out. This status word is decoded prior to the output phase to determine into which category of output the data falls. Status word bit assignments are as follows:

0000 Style, Variant, Size, Relocation only.

0001 Angle changed

0002 Letter content changed

0004 Letter quantity changed

0010 Curvature changed or added

0020 Word split

0040 Word added.

This status word coding is used in conjunction with the feature letter and data set number to determine the actions required on output.

Analysis of all status combinations with respect to output options yields the following status word decoding.

0000 No operation

0001 Update entry (x or z*)

0002, 0004, 0040 Unconditional new entry (x or z*)

0010 New z* entry if original was x

Update z* if original was z*

The case of 0020, word split is unique in that several new entries must be created at different times, one for each word subdivision of the name.

The feature letter and set number are also used in the directory search for an existing file to which the data might be appended.

In all cases where a new entry must be created, the old entry is tagged as no longer valid.

If a suitable file is found, the end of file code (7777 in the longitude) is searched for and a check is made to determine if there

* z is a feature x, set 3.

is enough vacant room in the fixed length file for the addition of the new entry. If room exists, the entry is written over the old end code and followed by a new end code.

If, on the other hand, no existing file of the proper type will hold the entry, a new file must be created. The last directory entry, specifying the first vacant disc block after existing data files is found and the new file, of suitable length, is created. The last directory entry is changed to specify the new file and new "last entry" is created.

In the first block of the new file, a descriptor, containing data description, file size parameters and entry size parameters, is created. Immediately following this, in the next block, the data are entered and a proper end code created at its termination.

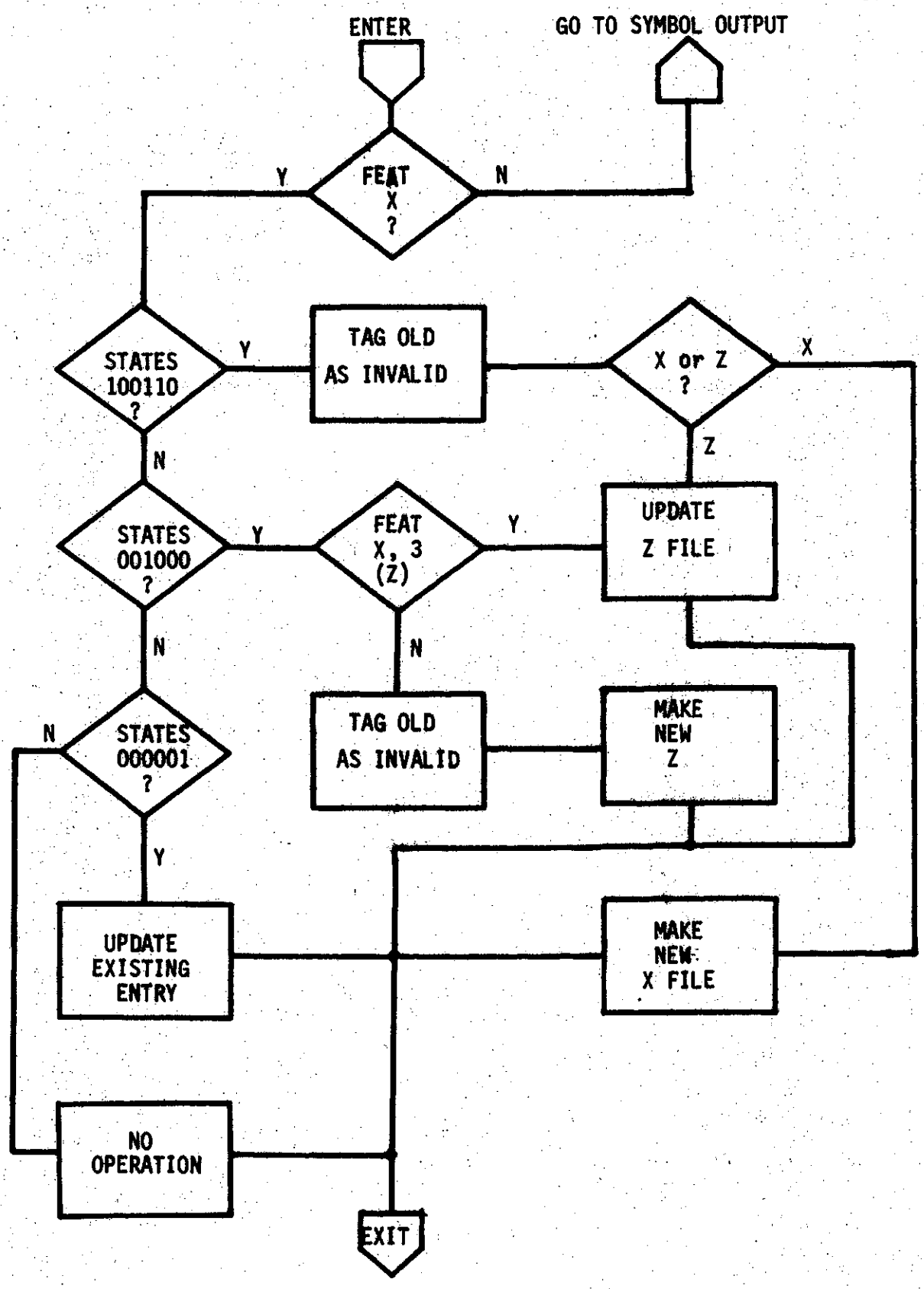
The generalized decoding of the status word is shown in Flowchart 2.2. Flowchart 2.3 indicates the operations required to define where the data are to be written on the disc.

2.6 Auxiliary Programs

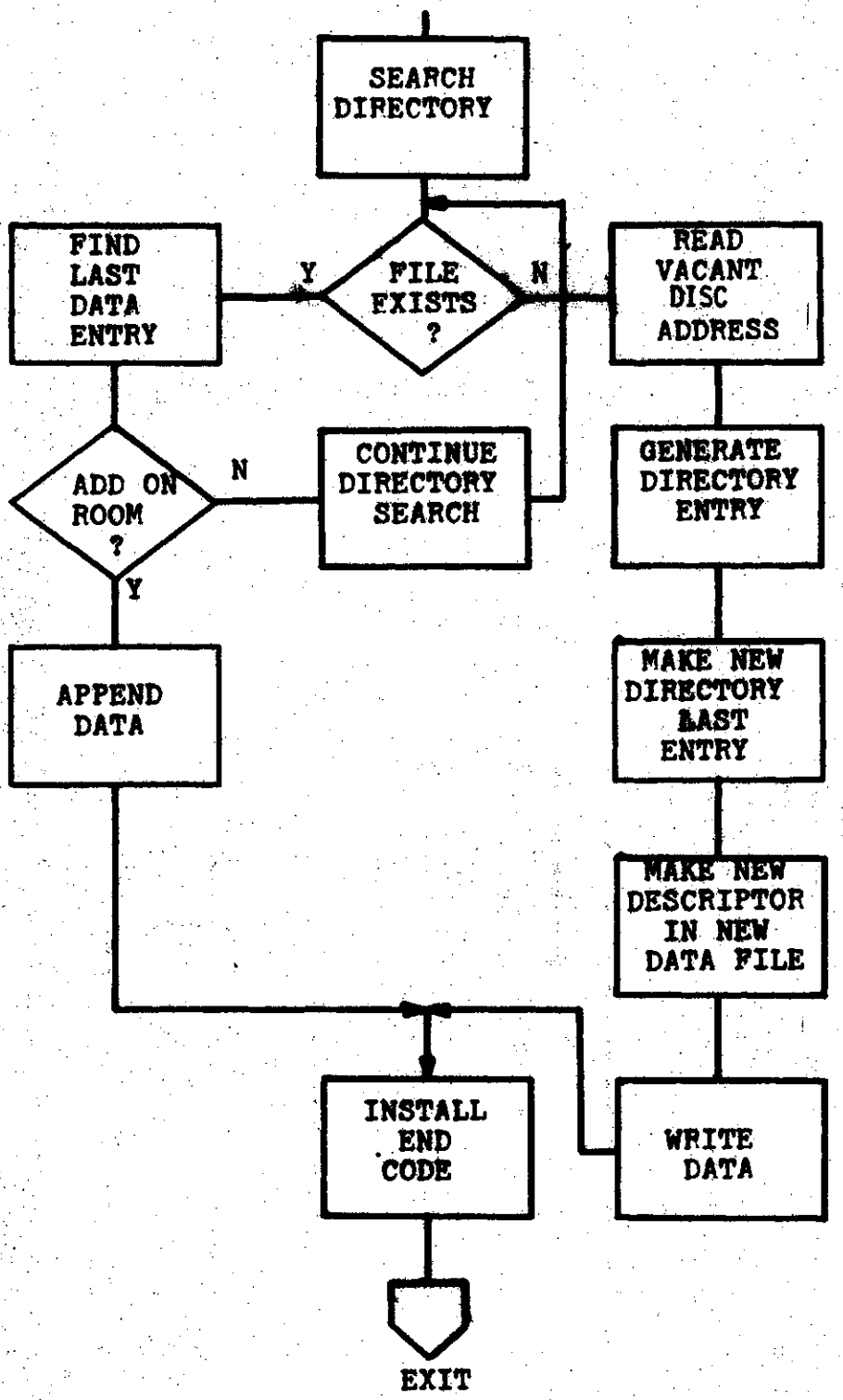
The programs outlined below are auxiliaries to the CANC and CAMC programs. They are required to transform and manipulate data to and from CAMC/CANC operations.

2.6.1 DIGIG 3:

This program is the main on-line digitizing program. It accepts inputs from a manual digitizer of the pencil follower type. Data identification codes are entered via a thumbwheel descriptor unit



FLOWCHART 2.2.
DECODING OF STATUS WORD



FLOWCHART 2.3

DATA OUTPUT OPERATIONS

and program commands, or text data, via the teletype.

The program output is a disc file consisting of unordered, variable length entries.

2.6.2. DIGTAP:

This small program transfers digitizer output files from the disc to industry compatible magnetic tape, compacting the data in the process.

2.6.3. DATAC:

This program operates on digitizer output files, located in either disc or magnetic tape, to convert the digitizer coordinates into data bank coordinates of longitude/latitude or Universal Transverse Mercator form. The program also transforms the data obtained from the rectangular coordinate digitization of a map in Lambert Conformal projection.

Another function within the program is the correction of skew of the map on the digitizer. Digitized grid crossover points are used as a reference for digital rotation of the map data into the axes of the coordinate system chosen for output.

2.6.4 DECIN:

This program assembles data from digitizer or databank files, on disc or magnetic tape, into individual files, based on feature letter, on the disc in formats compatible with the CAMC/CANC requirements. In the process, the directory files, to be used by the CAMC/CANC programs in data retrieval, are created.

The program also can utilize a sub-program which sorts all

entries of a specified data set in order of longitude/latitude prior to creating the file on the disc if this operation is specified by the user.

2.6.5 DRFTIN:

DRFTIN is similar in operation to DECIN but is used to transform pre-drawing files in IBM magnetic tape format back into CAMC/CANC compatible disc data files to enable verification of predrawing data. Coordinate sizes of .004, .002 and .001 inch and increment sizes of .004, .002, .001 and .0001 inch are selectable by the user.

2.6.6. DECOUT:

This program is used for the output of data from the CANC/CAMC disc data files onto industry compatible magnetic tape in IBM format. It groups two input files into one or a series of output files, based on data set numbers, as requested by the operator. At the same time, added or modified data is incorporated, and rejected data is ignored, which may involve a resorting of ordered data.

The output data can then be operated upon, in a large computer, to transform coordinate and increment sizes into unit values for the selected drawing table to be used for map sheet drawing.

2.7 Display System Hardware

2.7.1 Definition of Subsystem.

The Computer Aided Name Compilation display subsystem consists of a Tektronix 611 storage display, "mouse" pointer, and interface electronics. This combination results in a high resolution interactive

display subsystem particularly applicable to the process of cartographic compilation. Each unit of this subsystem is described seperately.

2.7.2 Tektronix 611 Display

The Tektronix 611 storage display unit is a high resolution storage display unit with remote operation option, specifically designed for quality graphic input/output terminals. Its main features are:

a) 6-3/8" x 8-1/4" useful viewing area

b) 3:1 contrast ratio

c) 0.008 inch resolution

d) 20 usec. dot writing time

e) 0.5 sec. erase time

f) 0.1 % full scale/hr. drift

g) 1% full scale linearity

h) Manual VIEW and ERASE

i) Remote VIEW, ERASE, STORE, NONSTORE, WRITE THROUGH

j) Highly reliable and rugged

The 611 display has a built in spiral generator for use when adjusting front panel focus and intensity controls. This spiral generator electronics is also used to generate the circular write through pointer used in conjunction with the "mouse".

The rear panel holds three BNC connectors for x, y and z axis signals and a 25 pin remote operation connector.

2.7.3 Mouse Pointer

The "mouse" pointing device consists of a small box supported

by two orthogonal metal wheels and a ball bearing "third leg". Connected to the wheels are one turn precision potentiometers which generate an analog voltage level proportional to the relative position of the mouse as it is moved over the table, the wheels acting in a manner similar to a "ball and disc" integrator.

On the top of the box, there are three push buttons which have been defined as

a) Computer selected mode.

b) Manually selected line mode.

c) Manually selected point mode.

For Computer Aided Name Compilation and in fact, all cartographic applications, this multi-mode "mouse" device is more suitable than a joystick or light pen since it closely resembles the standard cartographic scribing tool in function, and does not result in the physical obscuring of the screen by a pointing device, such as a light pen, or the operator's hand.

2.7.4 Interface Electronics

The Tektronix 611/PDP8 interface unit provides a two way communication link between display and computer and provides automatic control of CRT beam intensification and analog to digital conversion of the "mouse" position analog signals.

The existing interface, designed by S.K. Agarwal and modified by the author, is a negative voltage logic external bus unit meant for operation with a PDP8 computer and made operational with the PDP8/e by the addition of level shifters. A new positive voltage

level external bus interface, designed and presently under construction is nearing completion. Figure 2.13 shows this new interface.

The Tektronix 611, under program control via the interfacing electronics, normally operates three major modes:

a) Storage mode for static images.

b) Nonstore mode for dynamic images

c) Write through mode for display of "mouse" pointer.

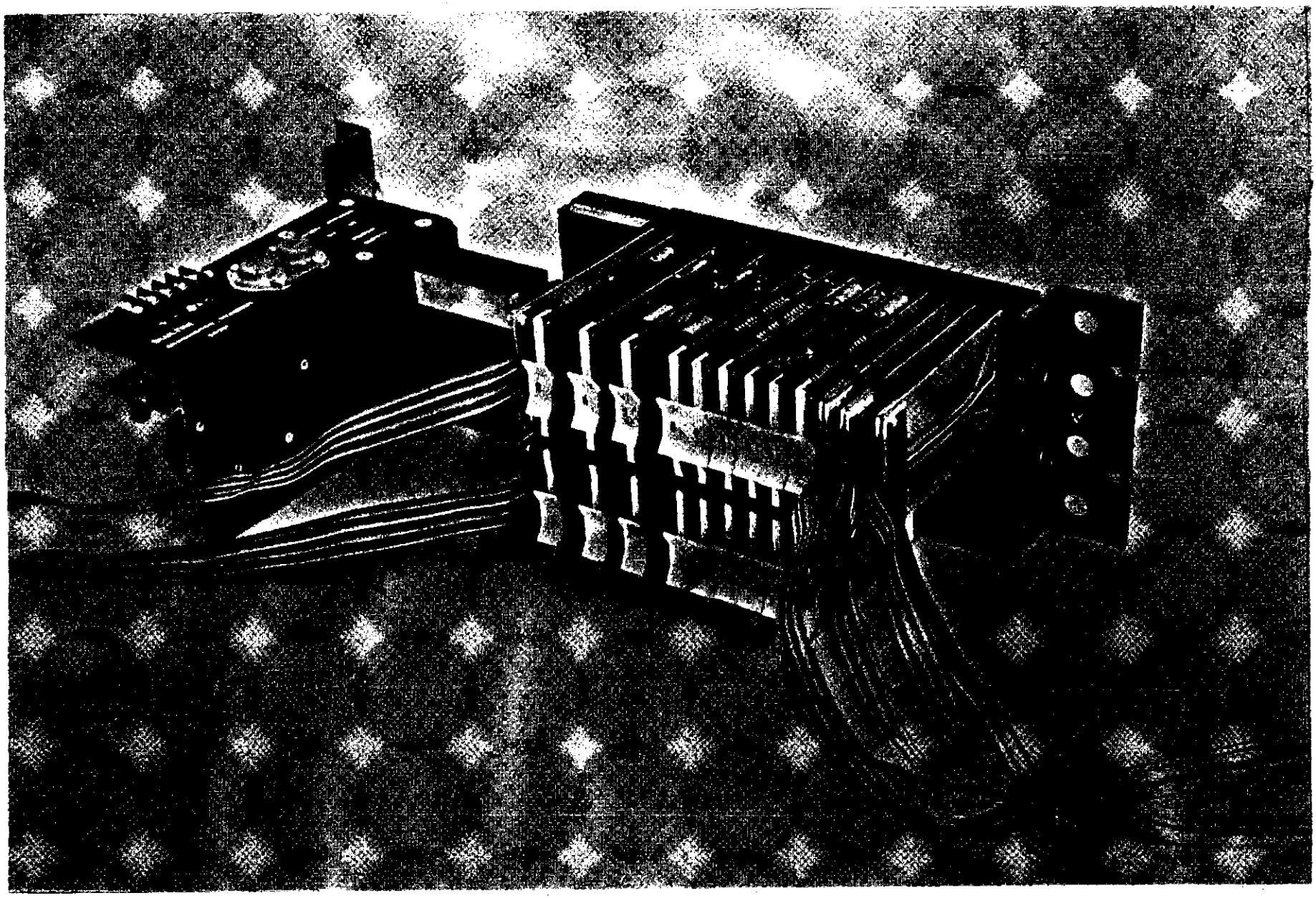
In the first mode, the 611 storage display is utilized as a static display device, displaying points presented to it from the computer accumulator via the digital to analog converters in the display interface. Lines and characters are displayed as a sequential string of intensified and stored x-y coordinates.

In the second mode, nonstore, the image is not stored on the screen and therefore requires continual update from the computer.

The third mode permits viewing of a previously stored image while simutaneously displaying a nonstored "write-through" pointer which is under positional control of the "mouse". The mouse mode, as determined by the selection of the appropriate mouse push button, is directly interpreted within the interface, which signals the program as to the selected mode by code bits in the unused two most-significant bits of the x "mouse" coordinate.

A block diagram of the interface, indicating the organization of the logic, is shown in Figure 2.14.

In the drawing mode, digital x-y coordinates are sent from the computer to the x and y buffers, under IOT control. These buffer values are applied to the x and y digital to analog converters



INTERFACE ELECTRONICS FOR TEKTRONIX 611 and "MOUSE" POINTER

FIGURE 2.13

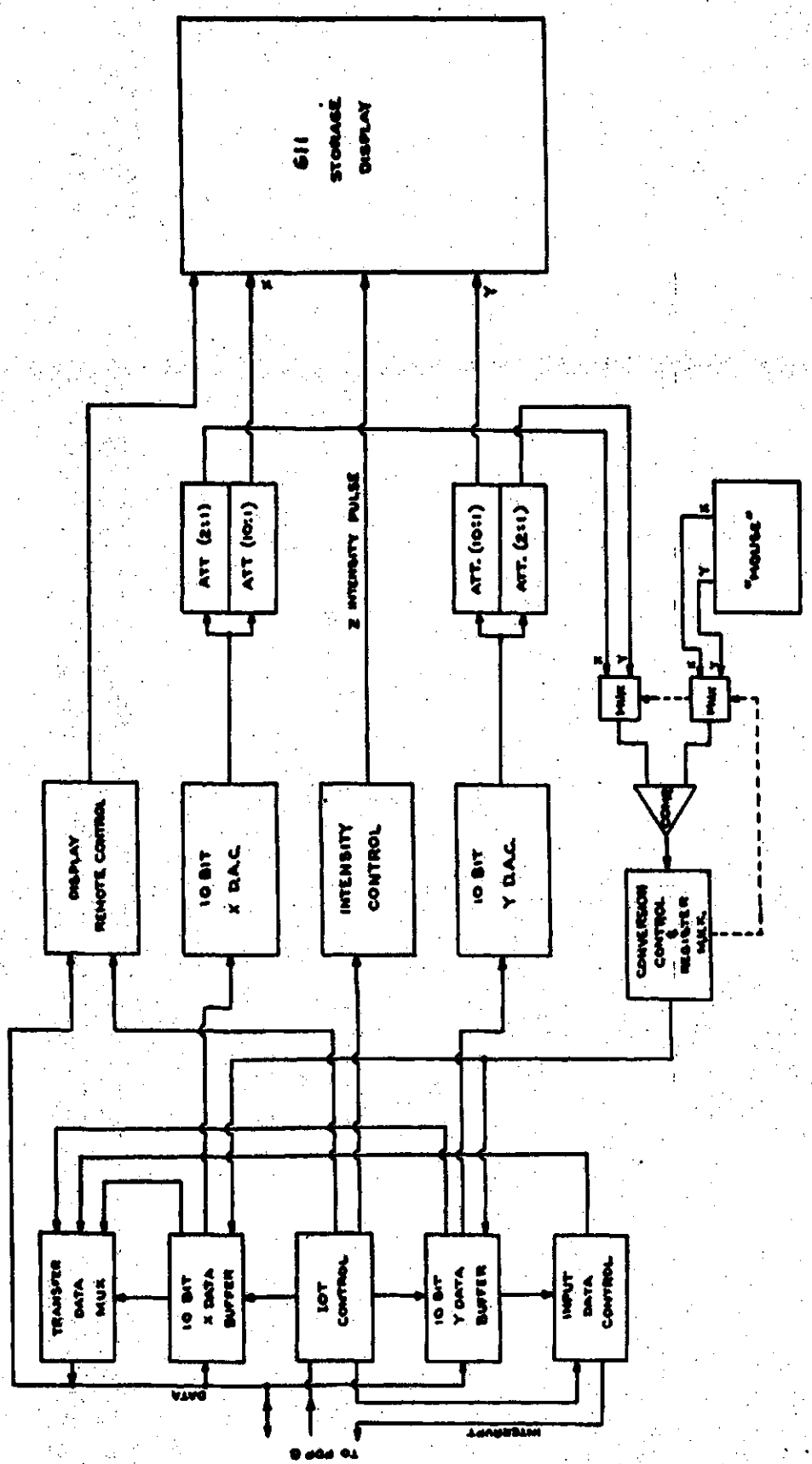


FIGURE 2.14

611 INTERFACE BLOCK DIAGRAM.

(10 bit) which supply scales analog voltages to the display deflection inputs. The point is then intensified by the drawing program under IOT control.

The choice of store or non-store drawing is determined solely by the intensity information held in the intensity control.

In the pointer mode, the analog coordinate voltages obtained from the mouse are multiplexed into the analog to digital conversion circuits by the "conversion control and register mux". The digitized coordinates are stored in the x and y buffers. Once a coordinate pair has been digitized and the "digitize" button on the mouse has been pressed, an interrupt and flag are set, signifying to the computer that data from the mouse is ready to be transferred. The pointer on the screen receives its coordinates from the x and y buffers via the digital to analog converters at the end of each conversion cycle, regardless of the state of the "digitize" push button. This assumes a precise correlation between the pointer on the screen and its digital coordinate value.

During transfer of digital coordinate data to the computer, the x and y buffers are sequentially and automatically multiplexed to the accumulator input lines by the "transfer data mux". In this manner a single repeated IOT command causes data transfers from the x and y buffers in that order.

The "display remote control" is used in conjunction with the intensity control in specifying the desired drawing mode to the display.

3. COMPUTER AIDED NAME PLACEMENT

3.1 Introduction

Photo-typesetters, utilizing direct symbol projection from an optical symbol disc or generation of character images on the face of a cathode ray tube, are the conventional means of generating, on film, high quality characters for use in cartographic name placement.

The CRT typesetters are of special interest for the automation of name placement since they require simple interface electronics between them and a digital computer and have the capability of drawing any type of symbol. Ideally, the computer would be able to direct the motion of an x-y mechanism, carrying the CRT typesetter, to the map-place for a name and then print the name in any specified orientation, size or style. In this manner, the process of map name placement could be automatic, requiring only manual film changing and bulk loading of new data into the computer.

This chapter presents a short survey of selected existing CRT photo-typesetters, a definition of cartographic requirements relative to name placement units, and a presentation of the proposed cartographic name placement unit, its symbol bank structure and its interfacing electronics.

3.2 Existing CRT Photo-typesetters

For the purpose of cartographic name placement, the CRT photo-typesetter must produce characters of "graphic arts" quality. The

present discussion will consider only this category, thereby ignoring high speed text and page printers utilizing travelling lenses, image masks in the CRT, systems employing fixed vector drawing and systems employing restrictive dot matrices.

Several methods, as outlined below can be used to form characters of "graphic arts" quality on photographic film.

1) A fine line raster scan can be used to produce optical characters from predigitized character construction data usually in digital form.

2) Multiple vectors can be generated in sequence to form "graphic arts" quality characters. Again, it is necessary to store the vector strokes necessary for the formation of each character.

3) To eliminate the requirement of digital character construction data storage, an optically readable matrix of characters can be prepared. Using selectable back lighting, the character to be drawn can be illuminated and scanned by a vidicon or alternately time multiplexed onto the vidicon. The vidicon output is then transmitted to a high quality CRT drawing unit which "prints" the character onto a film sheet.

Several high speed, "graphic arts" quality, CRT typesetting systems are worthy of discussion as they have been in use for several years and have proven their operational benefits. Selected examples will now be presented in general terms.

1) LINOTRON 505

The Linotron 505 uses a CRT "index" tube as a positionally controlled scanning light source for the illumination of a block of 16 optical characters within a frame of 16 such blocks. Each block has a lens which enables its contents to be projected onto an array of 16 photo-cathode devices when illuminated by the "index" raster. Any one of the 16 characters within the selected block can be selected by energizing the appropriate photo-cathode device.

The printout CRT's scan is slaved to the "index" CRT and its beam intensity is controlled by the output of the selected photo-cathode device.

Printout positioning on a film strip is accomplished by a travelling lens which traverses the film.

Character sizes are varied by changing the deflection magnitude, in the direction of scanning, and by insertion of additional raster lines in the other direction.

2) LINOTRON 1010

The Linotron 1010 is an extension of the Linotron 505 with significant improvements.

Characters are stored on four optical grids, each of which holds an array of 1024 characters. All characters on a grid are simultaneously illuminated and projected onto a large photo-cathode in an evacuated chamber via an aperture plate containing a matrix of .001 holes, one for each character. The character grid is oscillated back and forth, effectively generating a scan output from the aperture plate.

The photo-cathode, when struck by the light passing through the aperture plate, generates a secondary emission of electrons. The electron beam from the desired character image is then selected by an electronic grid which permits passage of only the desired beam. A collector transfers the instantaneous electronic image to the intensity circuit of the high resolution printout CRT. The image is then indexed on the CRT and drawn with a scan synchronized with the image grid oscillation. This system enables the printing of an entire page of high quality text directly from the CRT with a resolution of 1000 lines per inch.

3) SIEMENS-HALL DIGISET

This system utilizes digitally stored vector matrices which are used for character drawing. These vectors, for each character, are obtained by using an optical scanner to digitize high quality sample characters.

These vectors, for a selected character, are retrieved from core-memory at the time of character printing and are drawn vertically on the high resolution printout CRT, the beam of which has been previously indexed to the desired character location.

The Siemens-Hall Digiset has been marketed in the U.S.A. by RCA under the name of Videocomp 70/820 and has formed the background for RCA's development of its own Spectra series of digitally controlled, "graphic arts" quality photo-typesetters.

For comparison, Table 3.1 illustrates the characteristics of these selected examples.

Though of "graphic arts" quality, these type-setters are not

	PARAMETER	LINOTRON 505	LINOTRON 1010	DIGISET (VIDEOCOMP 70/830)
1)	Image Master	Optical Grid	Optical Grid	Digital Store
2)	Number of Masters	4	4	2 or 4
3)	Master Change Time	.075 to 1.5 seconds electronically	0.5 seconds electronically	16 seconds for memory reload of a font
4)	Method of Character Generation	CRT raster and photocathode shift	Electronic raster shift	Call from digital store
5)	Line write out device	Moving lens	CRT deflection	CRT deflection
6)	Type size selection	Electronic, Fixed Optics	Electronic, Fixed Optics	Electronic, Fixed Optics
7)	Maximum writing Speed	180 characters/sec.	1000 characters/sec.	300-650 characters/sec. (6000)
8)	Horizontal and Vertical definition	650-1300 lines/in.	835 lines/in.	120-100 lines/char.
9)	CRT recording element	Single raster line	Character raster for 8x10½ inch page	Line of composed characters

TABLE 3.1

COMPARISON OF CHARACTERISTICS FOR SELECTED TYPESETTERS

directly applicable to the problem of cartographic name placement for the following reasons:

1) No facilities exist for the rotation of characters other than physical rotation of the entire type-setting unit.
2) They are intended to print on high speed, magazine held film sheets used in cartography.
3) They are too heavy and large to be mounted, as an entire unit, on a standard, digitally controlled x-y mechanism commonly used for automated cartography.
4) They provide no facility for the printing of complex special symbols such as navigational aids.

Because of these restrictions, the Graphic Systems Design and Application Group of the University of Saskatchewan Department of Electrical Engineering concluded that a more flexible system, meeting all cartographic requirements, would have to be developed based on desirable characteristics of existing CRT photo-typesetting units. The following section outlines the cartographic requirements, physical restrictions and system philosophy underlying the design of a system for a cartographic name placement.

3.3 System Requirements

3.3.1 Definition of Subsystems

As for all systems comprised of a number of subsystems, the characteristics of each subsystem must be determined prior to over-all system specifications to ensure that intelligent balances in unit

performance are made to benefit the overall system performance.

The Name Placement photo-type system is comprised of the following such subsystems:

1) The precision cathode ray tube and associated electronics
2) The optics system to project the CRT image onto the drafting film
3) The x-y mechanism used to move the CRT units over the film
4) The interfacing electronics used to connect the CRT unit and x-y mechanism to the computer
5) The computer and its control programs

Each of these will now be discussed in turn in order to outline the parameters which must be taken into account in order to specify the performance of the overall system.

3.3.2 The CRT Unit and Associated Electronics.

The photo-typesetting application of a cathode ray tube places tight restrictions on the selection of the CRT and associated electronics suitable for this application. The specifications dictated by cartographic requirements further restrict the selection of a suitable CRT unit. These requirements are:

1) RESOLUTION: In order to meet the specifications of a normal CRT photo-typesetter, a resolution of at least 1000 lines per inch (1000 unit elements per inch) in the resulting printed symbol is required.
2) LINEARITY: There must be no discernable linearity

deviations in the printed symbol. Due to the basic optically flat faceplate CRT geometry, the probability of detectable linearity errors varies directly with the degree of deflection of the electron beam, which is in turn determined by the desired image size. Linearity error can then be limited by the use of a restricted area of a large screen CRT which has dynamic linearity correction circuitry in its electronic package.

3) SPOT SIZE: The required CRT beam spot diameter is determined by:

   a) The desired sharpness of corners in the produced image

   b) The required resolution in lines per inch

   c) The selected image to screen size ratio

   d) The amount of spot overlap between adjacent points required to fill in between scan lines

4) STABILITY: The CRT spot position, on the CRT faceplate when centered, should not deviate more than ± .001 inch over any 24 hour period. Furthermore, the centered beam position should fall within this tolerance of the true CRT centre. A similar tolerance applies to x-y maximum deflection positions.

5) REPEATABILITY: No point should deviate more than half a beam diameter from its previously written position for a rapidly repeated sequence of similar points, and long term repeatability must fall within the tolerance for stability.

6) INTENSITY: The CRT light output must be more than sufficient for rapid exposure of the selected film without variation in spot size. A balance exists between exposure time and light intensity.

7) LIGHT SPECTRUM: The light output of the CRT should have a peak amplitude in the spectrum range where the film has its peak sensitivity.

3.3.3 System Optics.

Further system restrictions result when the lens system used to focus the CRT image onto the film is taken into account. It should:

1) have minimal abberations
2) have good depth of field
3) have short focal length to specify physical size restrictions
4) have high transmissivity to minimize light attenuation
5) have a large aperture to permit maximum light transmission from CRT to film

Many of these requirements are contradictory and care must be taken to insure the optimum result from all major decisions. The optical system will be discussed more fully later.

3.3.4 x-y Mechanism.

The x-y mechanism used to carry the photo-typesetter must have the following characteristics:

1) Be of solid, vibration free construction
2) Have adequate resolution of step size for the job at hand

3) Have repeatability as good as that of the typesetter itself

4) Have an extremely flat bed equipped with some means of holding the film flat, such as vacuum hold-down

5) Have the gantry a constant height above the bed of the film plane

6) Have a means of maintaining constant distance between the film and the CRT unit such as an air bearing support for the CRT units

7) Be located in a controlled atmosphere darkroom, of suitable dimensions, to maintain film and x-y mechanism at constant lineal dimensions

3.3.5 Interfacing Electronics.

The interfacing electronics must be highly reliable and noise free. It should, for production operations, have self checking capabilities to insure that it will never be responsible for a system error which might destroy the accumulative work on the film sheet.

3.3.6 Computer and Control Programs.

The computer must be reliable and be equipped with such safeguards as power-fail protection and memory parity detection.

The control programs should be designed to be as self checking as possible, as well as having the capability of monitoring the performance of the rest of the system.

3.4 Proposed System

3.4.1 Outline of Proposed System.

The University of Saskatchewan System for Automated Name Placement consists of a PDP-8e digital computer, a magnetic disc storage unit, a 9 track magnetic tape unit, a precision x-y drawing mechanism, a photo-typesetter interface and a precision CRT photo-typesetter unit mounted on the gantry of the x-y mechanism.

Input to this system is via magnetic tape, the data having previously been processed by the University of Saskatchewan Computer Aided Name Compilation Program.

The input data of each entry consists of:

1) x-y coordinate of one character in machine coordinates of the x-y mechanism
2) the character or symbol
3) all parameters of the name or symbol such as:
   a) Point size
   b) Angular orientation
   c) Style, variant, case

The coordinates are passed directly to the x-y mechanism to position the CRT photo-typesetting unit at the position of the character centre.

The other data are used by the CANP program to retrieve, from a large symbol library, the symbol construction information as required. This symbol construction data undergoes manipulation according to the other parameters used to instruct the CRT unit in the drawing

of characters.

In order to obtain maximum flexibility with minimum positional error and disc storage, character size scaling and rotation are carried out by the program. Each character is drawn separately to maintain the highest possible resolution in the CRT image.

A fixed lens system reduces the image to the proper size, (normal ratio 4:1) and focuses the image onto conventional lithographic film positioned on the platen of the x-y mechanism. This film forms the name overlay sheet for the production map.

3.5 Photo-type Symbol Library Preparation

3.5.1 General Discussion

The Photo-typesetting system required a library of symbol construction data digitized from large scale high quality symbols. In order to conserve disc storage, this library data must be efficiently coded and compacted.

It was decided that a specially coded line scan form would be most suitable for character storage and drawing and offer enough flexibility in concept for other forseen applications such as line drawing and area fill which are to be discussed in the concluding chapter.

3.5.2 Unit Element Size Determination

An examination of magnified printed characters indicated that a radius greater than .00025 inch on a "square corner" of a character resulted in poor definition of the corner. This results in a maximum unit element diameter in the printed character of .0005 inch.

Using a fixed lens system having a ratio of 4:1 from the CRT to the film, a spot diameter no larger than .002 inch on the CRT faceplate is required.

Table 3.2 shows the size of the matrix area on the CRT screen, the matrix size on the film and the maximum character size, allowing for character rotation, as a function of the number of resolvable elements in the construction data matrix, and the percentage of overlap of adjacent unit elements.

Overlapping of adjacent points on the film causes a double exposure in the area of overlap which results in a spreading of the image on the film about the overlap region. Due to the small unit element size, this spreading effect is sufficient to smooth out the element intersection to give the appearance of a straight edge to a series of circular dots. Utilizing this, a 10% overlap of unit element appears to be sufficient for cartographic characters.

Due to practical considerations of storage requirements and digitization complexity, it was decided that all construction matrix data entries would be of an equivalent dot matrix size of 256 x 256 resolvable elements. Software interpolation can be used to expand this basic data structure to the other matrix sizes, indicated in Table 3.2, at the time of drawing on the CRT unit.

3.5.3 Method of Digitization of Symbols

An optical drum scanner* was used to digitize images of the characters drawn 20 times larger than normal. The output of the scanner consisted of an absolute y coordinate for each transition from black to white, or vice versa. This data, as well as scan line

* Loaned by V.Pollack, Biomedical Engineering Division.

MATRIX SIZE (No. of Elements)	SIZE IN INCHES AS A FUNCTION OF PERCENT ELEMENT OVERLAP			
	0%	10%	20%	30%
256	.512	.4096	.4608	.358
	(.038)	(.1024)	(.1152)	(.0895)
	[.027	[.0724	[.0814	[.0633
512	1.024	.9216	.8192	.716
	(.256)	(.2304)	(.2048)	(.1790)
	[.181	[.1629	[.1448	[.1266
1024	2.048	1.843	1.638	1.432
	(.512)	(.4608)	(.4095)	(.358)
	[.362	[.3258	[.2895	[.2531

.... = MATRIX SIZE ON CRT

(....)= MATRIX SIZE ON FILM FOR 4:1 LENS

[.... = MAXIMUM CHARACTER SIZE ON FILM WITH A .707 REDUCTION IN SIZE TO PERMIT CHARACTER ROTATION.

TABLE 3.2

IMAGE SIZES AS A FUNCTION OF NUMBER OF ELEMENTS IN A MATRIX AND PERCENT OVERLAP OF ADJACENT ELEMENTS.

marker information, was recorded on magnetic tape.

This data was then passed through a program* to scale it and format it for the symbol bank. During this processing, visual checks were made by displaying the character on the Tektronix 611 display.

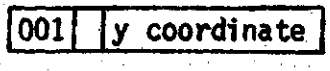
3.5.4 Symbol Construction Data Format

Symbol construction data is held in vector form where start and end coordinates of a vertical vector are stored. A single coordinate or a special count value is held in the least significant 8 bits of a data word. The three most significant bits hold a specially coded drawing mode specification. This leaves one spare bit for future expansion of mode or coordinate size.

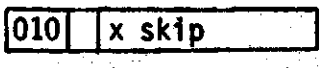
Four modes are presently defined as follows:

MODE 0 specifies vector start or end

MODE 1 specifies the last vector in a vertical scan and specifies that the scan is to be drawn once



MODE 2 specifies that the coordinate bits are to be interpreted as "skip n x increments"



MODE 4 specifies that the coordinate bits are to be interpreted as the number of times that the specific column is to be drawn in succession

All coordinates and counts are in octal representation.

* Program composed by G. Bailey

Figure 3.1 illustrates the format as applied to the digitization of a simple filled in rectangle.

3.5.5. The Application of Symmetry

It is obvious that many characters and symbols have symmetry about one or more axis. By using special coding in the construction data, some entries in the library of construction date can be significantly reduced in length.

The third and fourth words in the construction data are devoted to the specification of symmetry. The first of these is used to specify symmetry about a vertical bisecting line. A 7776 code in this word specifies symmetry, whereas a 0000 occurs if there is no symmetry. The second specifies the existance of symmetry about a horizontal line whose coordinate is specified in the least significant nine bits of this word. The first three bits are set to a seven. If no symmetry exists, this word is set to 0000.

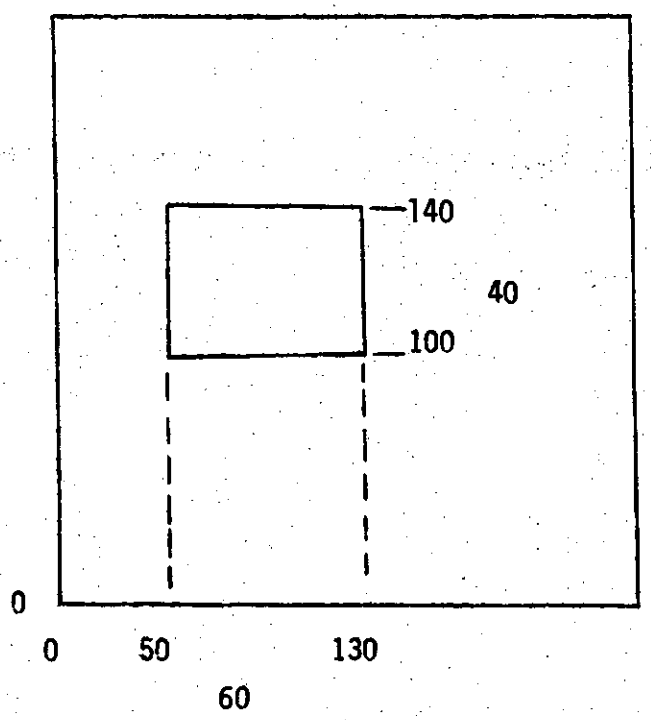
There is one other special code used in the construction data format. An end code for the construction data is specified by 7777.

3.6 Printing of Symbols by CANP Program

3.6.1 General Discussion

The Computer Aided Name Placement Program, which is responsible for actual character drawing, can be broken down into four main sections as follows:

1) Positioning of the x-y mechanism
2) Retrieval of character construction data from library files
3) Decoding of the construction data and symmetry expansions



DIGITIZED DATA IS:

2050	skip 50 columns
0100	vector start at 100
0140	vector end at 140
4060	draw it for 60 columns

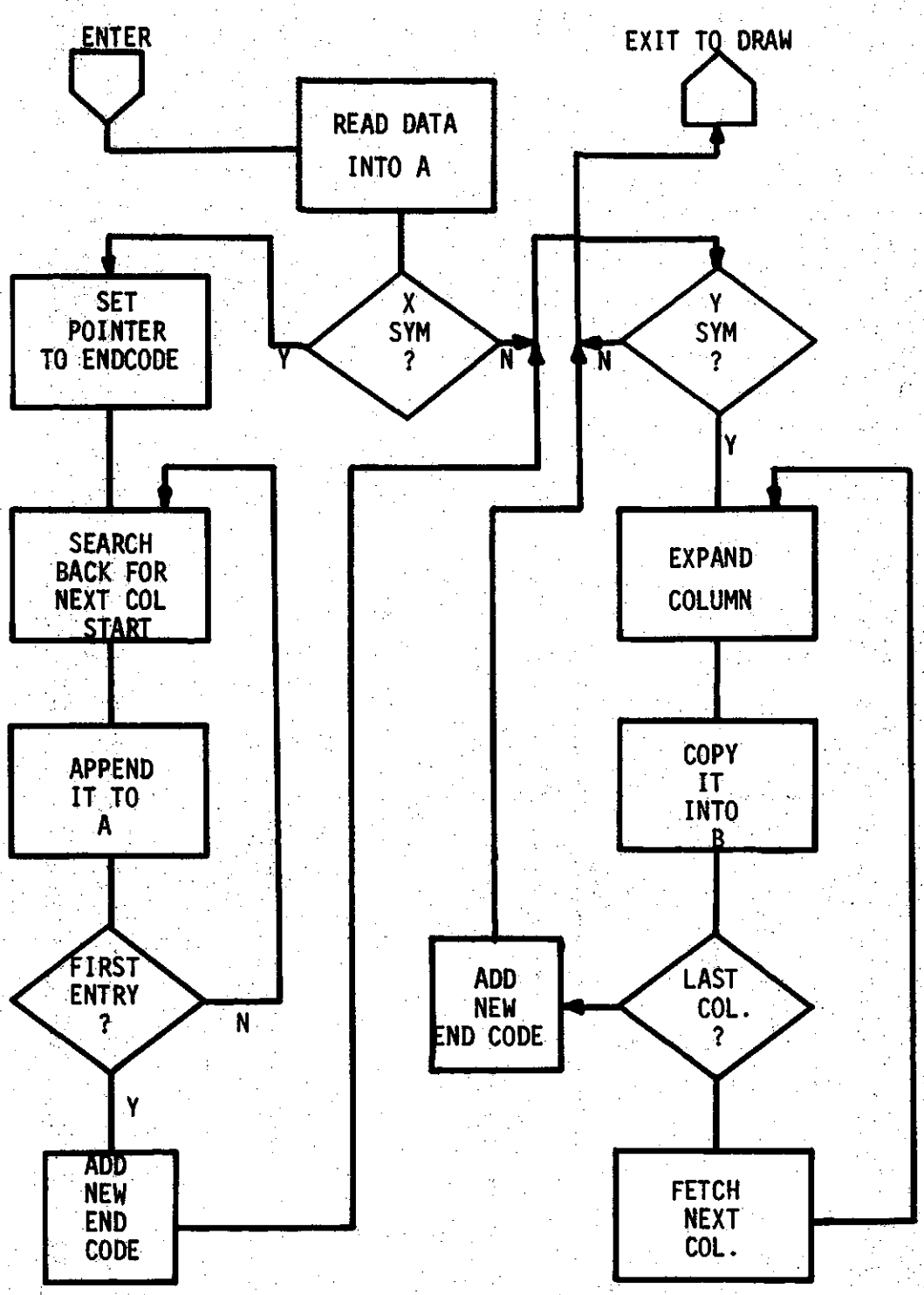
FIGURE 3.1 DIGITIZATION OF RECTANGLE

4) Rotation, scaling and printing of the character or symbol onto the film sheet.

The positioning of the x-y mechanism is a straightforward procedure of reading the x-y coordinate of the data in plotting table increments, and directing the plotter interface and control to move the CRT unit to the specified position. This position, however, can undergo modification for certain types of rotated symbols as will be discussed later.

The retrieval of the character construction data is facilitated by the use of a disc directory system. Each combination of style and variant acts as a pointer to the appropriate area of the directory. An "alphabetic" search is then carried out on this directory segment to obtain the entry corresponding to the specified character. Each directory entry consists of three words. The first word is the character itself, followed by the disc block address of the start of the construction data, and lastly, the address of the start within the specified disc block. Once a match is found between a directory entry and the input data character, the indicated disc block and two subsequent blocks are read into core memory, and a pointer is set to the location of the start of the construction data.

In decoding the construction data, the first two words are checked to see if an off-centre point for symbol rotation exists. If one does exist, and the angle of rotation specified by the data is not zero, these values are rotated about the matrix centre to generate a centre offset. This is sent back to the plotter moving



FLOWCHART 3.1
SYMMETRY EXPANSION

routine to offset the location of the CRT unit relative to the actual character centre.

The next two construction data words are then analysed to determine if character symmetry exists. If it does exist, the specified symmetry expansions are carried out in core on the undecoded construction data.

3.6.2 Symmetry Expansions

As previously described, there are two symmetry expansions incorporated into the Computer Aided Name Placement program:

1) about a vertical bisection line

2) about a specified horizontal line

Two data buffers are utilized for symmetry expansion. Data is initially read into buffer A. If expansion about a vertical line is specified, the data is copied, in vertical column segments, in reverse order onto the end of the initial data to produce an extended file. If there is subsequent symmetry about a horizontal axis, this buffer is then copied, one column segment at a time, into buffer B. The symmetry expansion is carried out on each column segment during this transfer.

A small buffer control routine handles data transfers into and out of these buffers as circumstances require.

The symmetry expansion process is illustrated in a simplified manner, by Flowchart 3.1

3.6.3 Matrix Rotation

As previously mentioned, all character rotation is carried out within the computer to eliminate errors inherent in electro-mechanical methods of image rotation.

Each column in the construction matrix is decoded into a number of vectors representing line segments in the column. The start and end points of each vector are rotated by the same method as used in the Computer Aided Name Compilation program. Also, the slope of the column is calculated and stored as a double precision number for use in generating the vector segment.

3.6.4 Interpolation

For high resolution images larger than those obtainable by using the 256 element matrix, it is necessary to increase the number of unit elements within the construction data matrix. This is accomplished by interpolation to generate column and row unit elements between those specified in the construction data matrix. Simple linear interpolation was found to be adequate.

However, certain modifying criteria must be used in the situation of discontinuous curvature such as internal corners.

This situation is taken into account by determining the difference in Y value between adjacent columns and determining, from its magnitude, if a discontinuity exists. If so, the previous column data for the vector segment of interest is repeated directly, overriding the interpolation process.

For cases of even larger symbols, double interpolation, the insertion of two points, is required. This case had not yet been investigated to determine if a second order curve is necessary instead of simple linear interpolation.

3.7 Photo-type System Hardware

3.7.1 CRT Subsystem Description

Drawing 3.1 is a simplified block diagram of the photo-type subsystem.

The CRT and power supplies are units salvaged from an old General Precision video recording monitor, model PA-300. This salvaged equipment, though insufficient in quality for a final unit, proved to be an acceptable test bed for basic photo-type test and software development.

The deflection amplifiers were built out of components which were readily available within the laboratory.

The deflection coil assembly was salvaged from an older oscillographic dark trace display unit experiment. It is a high quality Syntronic yoke which, unfortunately, could not be mated with available specification sheets. Characteristics of this yoke were determined experimentally as will be discussed in the amplifier section.

The intensification amplifier was designed to give a step cathode bias of approximately 24 volts which is more than sufficient for the nominal 10 volt blanking level. The 200 pfd. capacitor on the amplifier input speeds up the transient response of the circuit by rapidly transferring charge to the base region of the 2N3641 transistor.

Focus and intensity adjustments are provided by potentiometers which obtain their power from the salvaged ± 150 volt supply. A focus coil current of approximately 40 milliamps is required for a nominal anode voltage of 25KV.

Figure 3.2 shows the experimental CRT typesetter used for concept testing and program development.

3.7.2 CRT photo-typesetter Interface

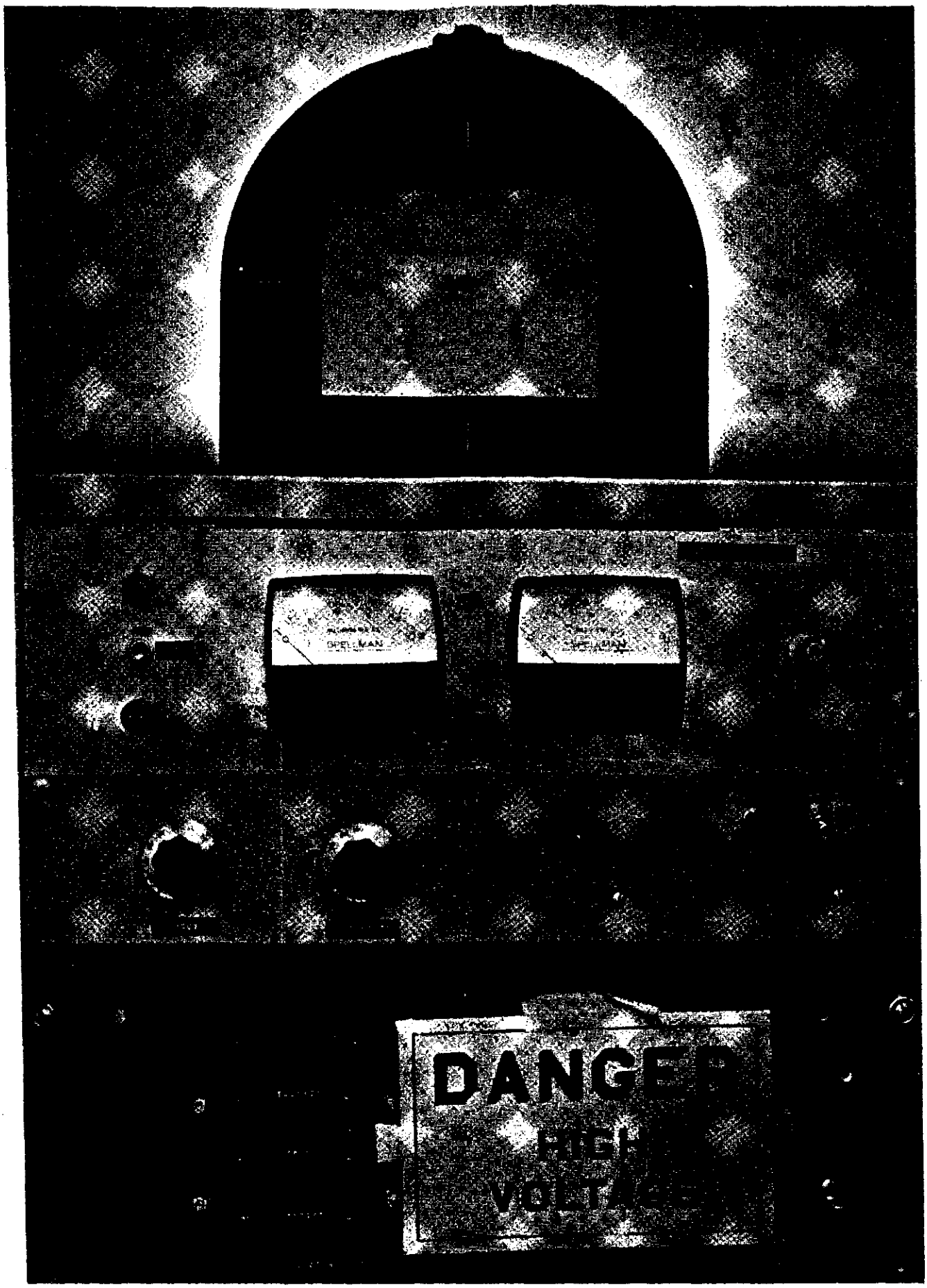
The interface electronics for the experimental CRT photo-typesetter, shown in Figure 3.3, consists of five circuit boards held in a single mounting rack via edge connector blocks. Interboard connections of the TTL long sub-units are formed by back panel wire wrapping. The five circuit boards and their functions are as follows.

1) Device Selectors (DS-3-8E-PT)
2) Control Logic (PTC-1-8E-PT)
3) Y data buffer (GR-12-8E-PTy)
4) X data buffer (GR-12-8E-PTx)
5) Dual Channel D/A (DA-8-8E-PT)

The rack also contains a Blulyne 55P3000 five volt, three amp power supply and a Blulyne 15 DPM100 plus/minus fifteen volt, one hundred milliamp power supply, making the interface independent of other system power sources. Each logic subsystem will now be discussed.

1) DEVICE SELECTOR (DS-3-8E-PT) (DRAWING 3.2)

This module contains three device selection circuits of which, only two are used for the present photo-type interface. All circuitry incorporated TTL integrated circuit packages. The device code is programmable by the use of jumper wires used to apply selected buffered memory buffer (BMB) lines to the 8-input device code selection gates (A1, B1).



EXPERIMENTAL CRT PHOTO-TYPESETTER

FIGURE 3.2

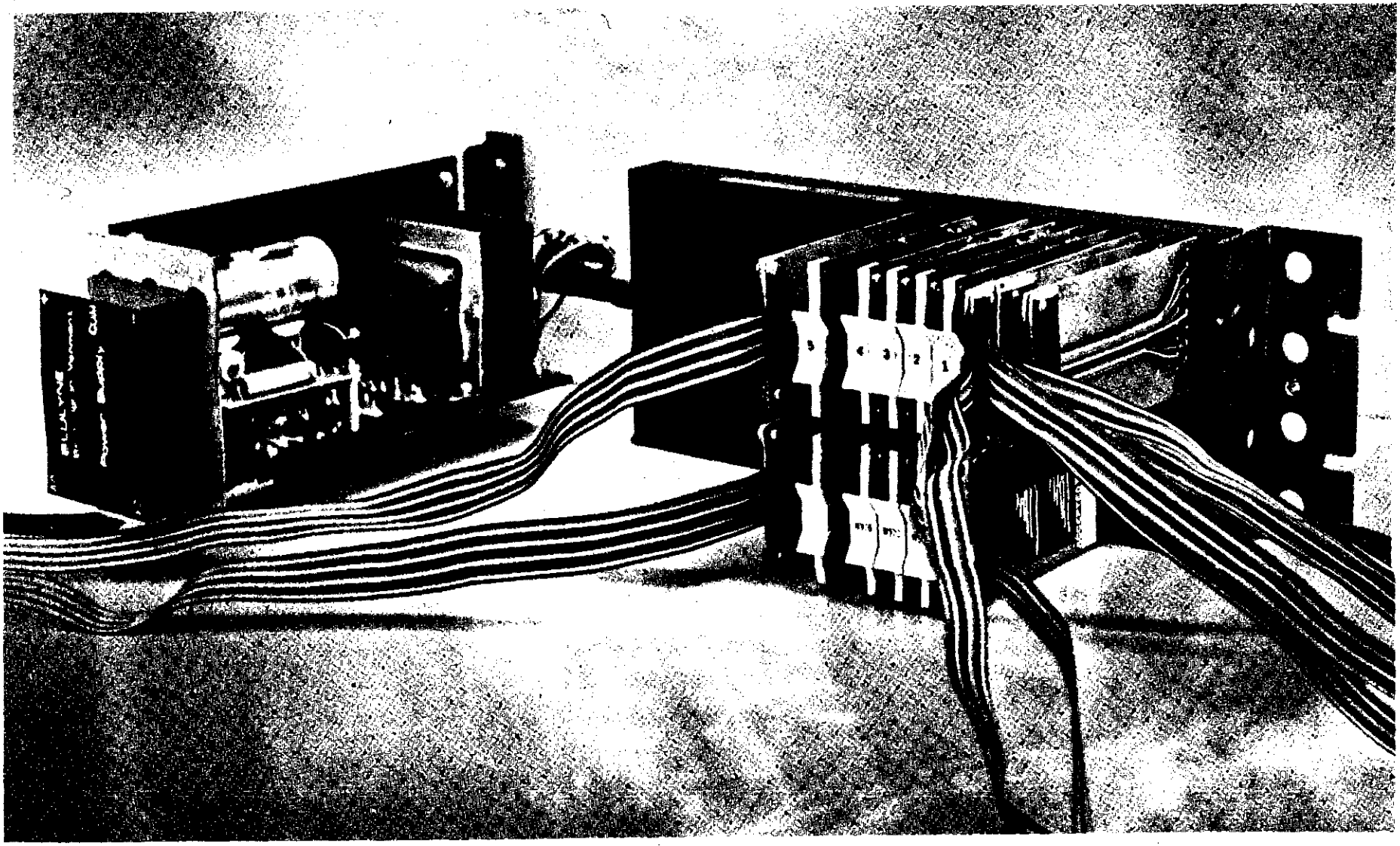
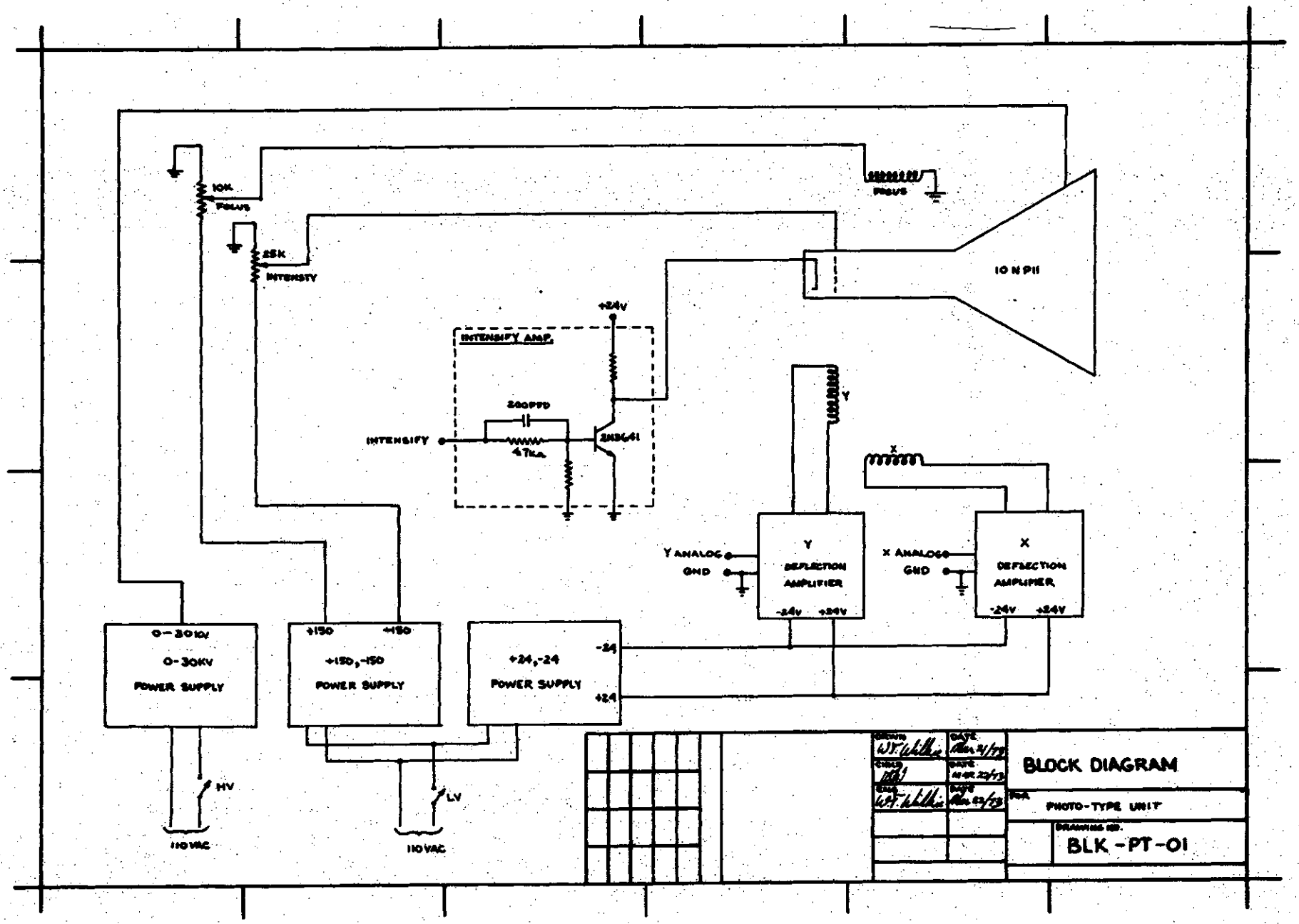
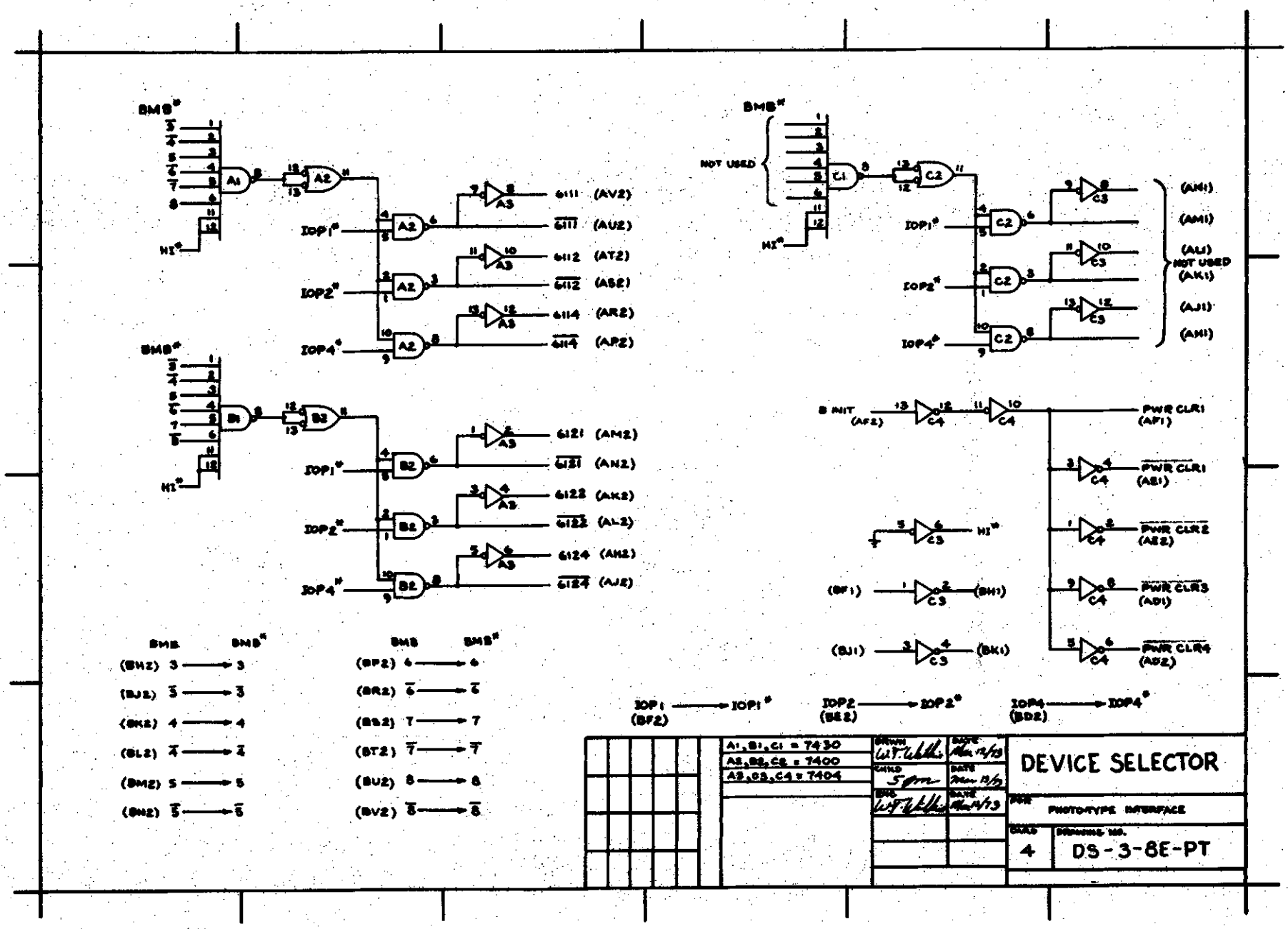


FIGURE 3.3
CRT PHOTO-TYPESETTER INTERFACE


10K
FOCUS
25K
INTENSITY
FOCUS
ION PU
+24V
INTENSIFY AMP.
200PFD
INTENSIFY
47K
2N3641
Y
X
Y ANALOG
GND
Y
DEFLECTION
AMPLIFIER
-24V +24V
X ANALOG
GND
X
DEFLECTION
AMPLIFIER
-24V +24V
0-30KV
0-30KV
POWER SUPPLY
+150 -150
+150,-150
POWER SUPPLY
+24,-24
POWER SUPPLY
-24
+24
HV
110VAC
LV
110VAC
BLOCK DIAGRAM
PHOTO-TYPE UNIT
BLK-PT-01

DRAWING 3.1


BMB*
HI*
IOP1*
IOP2*
IOP4*
6111 (AV2)
6111 (AU2)
6112 (AT2)
6112 (AS2)
6114 (AR2)
6114 (AP2)
6121 (AM2)
6121 (AN2)
6122 (AK2)
6122 (AL2)
6124 (AH2)
6124 (AJ2)
NOT USED
(AH1)
(AM1)
(AL1) NOT USED (AK1)
(AJ1)
(AH1)
B INIT (AF2)
PWR CLR1 (AP1)
PWR CLR1 (AS1)
PWR CLR2 (AS2)
PWR CLR3 (AD1)
PWR CLR4 (AD2)
(BF1)
(BH1)
(BJ1)
(BK1)
(BH2) 3 → 3
(BJ2) 5 → 5
(BK2) 4 → 4
(BL2) 6 → 6
(BM2) 5 → 5
(BN2) 8 → 8
(BP2) 6 → 6
(BR2) 6 → 6
(BS2) 7 → 7
(BT2) 7 → 7
(BU2) 8 → 8
(BV2) 8 → 8
IOP1 (BF2) → IOP1*
IOP2 (BE2) → IOP2*
IOP4 (BD2) → IOP4*
A1, B1, C1 = 7430
A2, B2, C2 = 7400
A3, B3, C4 = 7404
DEVICE SELECTOR
PHOTO-TYPE INTERFACE
4
DS-3-8E-PT

DRAWING 3.2

Bits 3 through 8 inclusive of the memory buffer, specify the device code. Input/output transfer (I.O.T.) pulses are generated by ANDING the "device selected" levels from level inverters (A2,B2) with the computer generated input/output pulses (I.O.P.). These I.O.P's are time sequenced in order of their numbers allowing microprogramming of I.O.T's within one machine cycle. Both the I.O.T. pulses and their complements are available as outputs.

The following is a definition of selected I.O.T's and their function.

6111 Clear point complete flag.

6112 Load x buffer register from PDP8/e accumulator. The accumulator is not automatically cleared by this operation.

6114 Intensify a point by an intensification pulse whose duration is specified by the adjustment of a hardware pulse generating one-shot.

6121 Test point complete flag. This pulse causes a pulse on the computer skip bus when the intensification complete pulse sets the point complete flag.

6122 Load y buffer register from PDP8/e accumulator. The accumulator is not automatically cleared by this operation.

6124 Turn interrupt on or off. This pulse reads the contents of bit 0 of the accumulator to determine the desired status. (AC0-1, turn interrupt on; AC0-0, turn interrupt off.)

Power clear pulses, of both complements, are generated on this board from the buffered-initialize (B INIT) pulse generated within the computer. Two spare inverters are also provided for extension of power clear drive capability or for general use within an interface.

2) CONTROL LOGIC (PTC-1-8e-PT)

The photo-type control unit consists of interrupt, flag and intensification logic.

On initialization, the point complete flip-flop (A2 section 2)* is reset by the $\overline{\text{PWR CLR 1}}$ pulse.

The interrupt mode is then loaded into flip-flop C2 by the 6124 interrupt on/off command. In the absence of this command, the flip-flop assumes the interrupt off mode due to the $\overline{\text{PWR CLR 1}}$ pulse sent to its reset on initialization.

The output of the interrupt on/off flip-flop is used to hold the interrupt flip-flop in the off state via negated input NOR gate (C1 section 2) if the interrupt on mode is not selected.

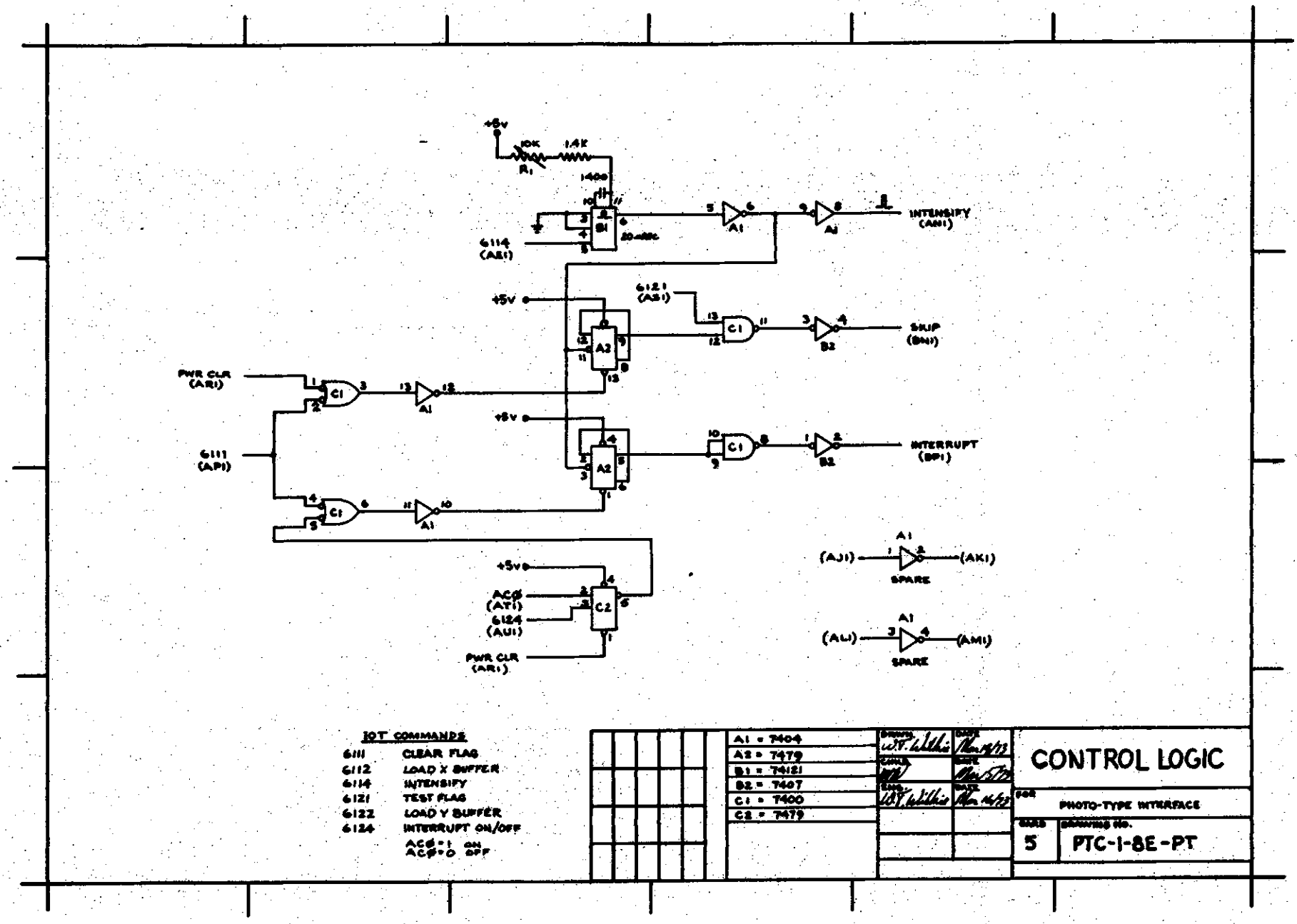
For intensification, the intensification pulse, 6114, triggers one shot B1 to generate a 20 usec. intensification pulse for the CRT unit. The duration of this pulse is adjustable by changing the resistance of R1.

At the end of the intensification pulse period, the rising pulse edge at A1 pin 6 sets the intensification complete flip-flop (A2 section 2) and, if the interrupt mode is selected, the interrupt flip-flop (A2 section 1).

If the interrupt mode is not selected, the intensification complete flag must be tested by the program. The 6121 "check flag" command is issued to generate a "skip" signal to the computer if, and only if, this flag is set.

This flag and the interrupt flip-flop, if interrupt mode were

* Section 2 is the flip-flop with the higher numbered pins.


+5v
10K
1.4K
R1
1400
B1
20 μsec
6114
(AE1)
A1
INTENSIFY
(AN1)
6121
(AS1)
C1
A2
B2
SKIP
(BN1)
PWR CLR
(AR1)
6111
(AP1)
INTERRUPT
(BP1)
ACØ
(AT1)
6124
(AU1)
C2
(AJ1)
(AK1)
SPARE
(AL1)
(AM1)
IOT COMMANDS
6111 CLEAR FLAG
6112 LOAD X BUFFER
6114 INTENSIFY
6121 TEST FLAG
6122 LOAD Y BUFFER
6124 INTERRUPT ON/OFF
ACØ=1 ON
ACØ=0 OFF
A1 = 7404
A2 = 7479
B1 = 74121
B2 = 7407
C1 = 7400
C2 = 7479
CONTROL LOGIC
PHOTO-TYPE INTERFACE
5
PTC-1-8E-PT

DRAWING 3.3

used, is then reset by a 6111 "clear flag" command. Two spare inverters are provided on this board for general use.

3) X & Y DATA BUFFERS (GR-12-8e-PT x and y) (DRAWINGS 3.4 and 3.5)

This circuit board was designed to be a general purpose 12-bit data buffer. Common reset, common clock, parallel sets, parallel data input lines, and complementary outputs are provided.

Clock and reset lines are buffered by open collector high power inverters (B1) to provide drive capability for the 12-bit register clocks and resets.

For applications, such as this, where the direct set lines are not used, they are all tied to the "pull-up" at pin BV1.

The "true" outputs of bits 4 through 11 supply data to the appropriate digital to analog converters.

4) DIGITAL TO ANALOG CONVERTERS (DA-8-8e-PT) (DRAWING 3.6)

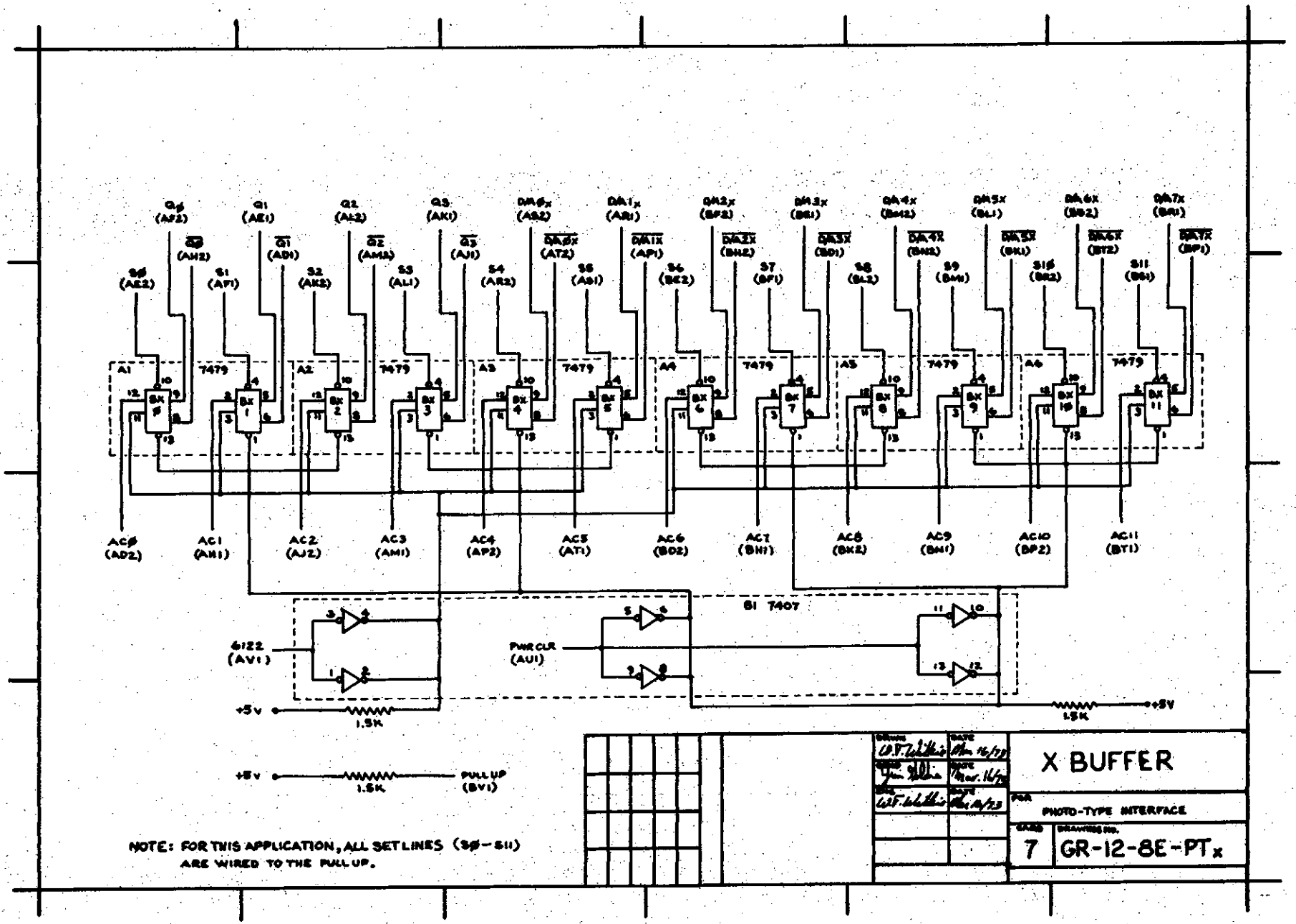
This board holds two Zeltex ZD440 digital to analog converters. Potentiometers, for full scale range adjust and zero-offset, are provided.

The output range is selected to be ±5 volts by selection of the ±5 volt strapping option as indicated on the drawing.

The reference voltage output on one D.A.C. is used as the reference input of both D.A.C.'s to maintain proportional relationship between the two axes.

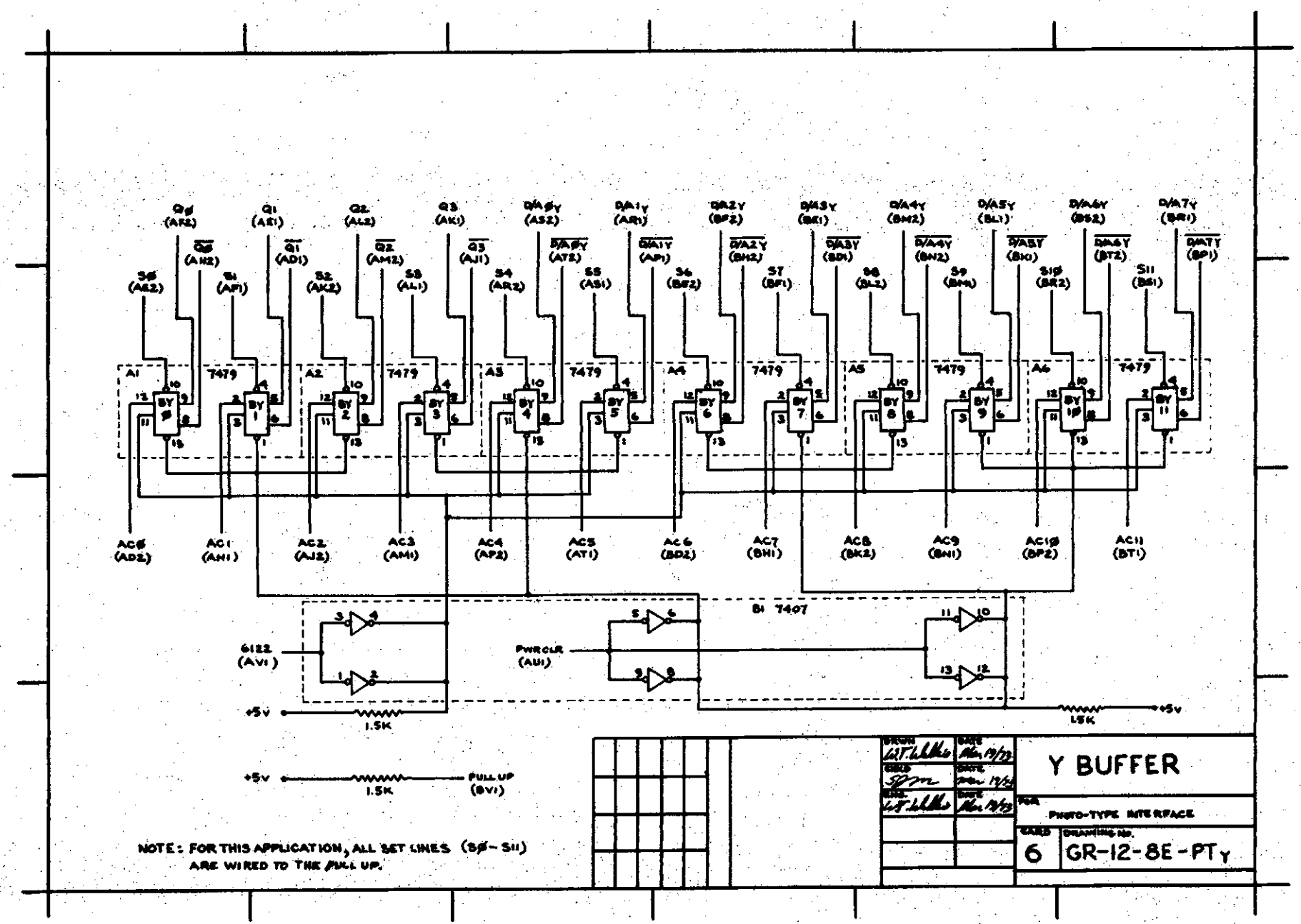
3.7.3. Deflection Amplifiers (AMP-PT-01) (DRAWING 3.7)

The experimental deflection amplifier shown in drawing AMP-PT-01 was built, using components readily obtainable within the laboratory, for use in the experimental photo-type unit. In no way should it



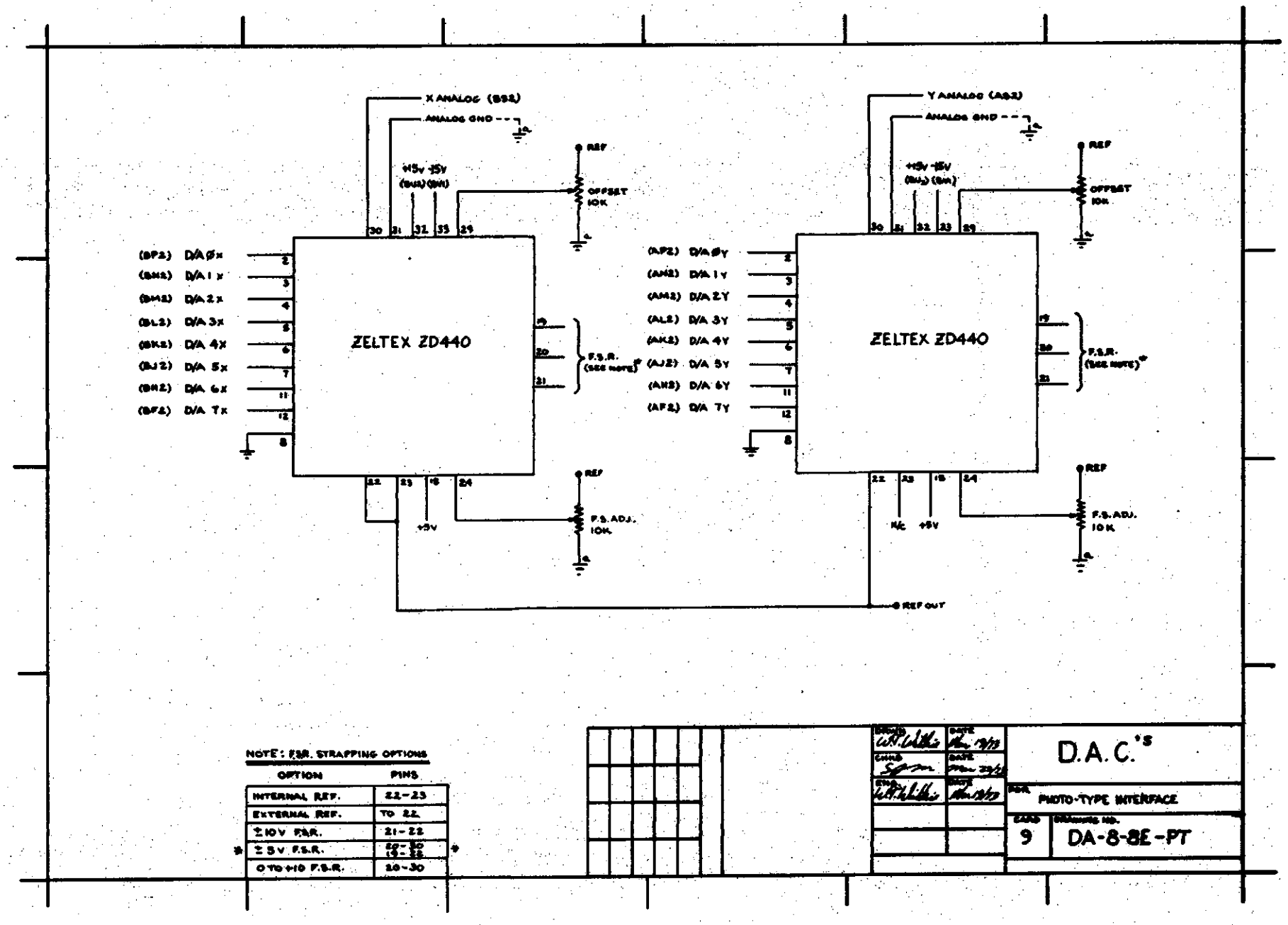
DRAWING 3.4

X DATA BUFFER

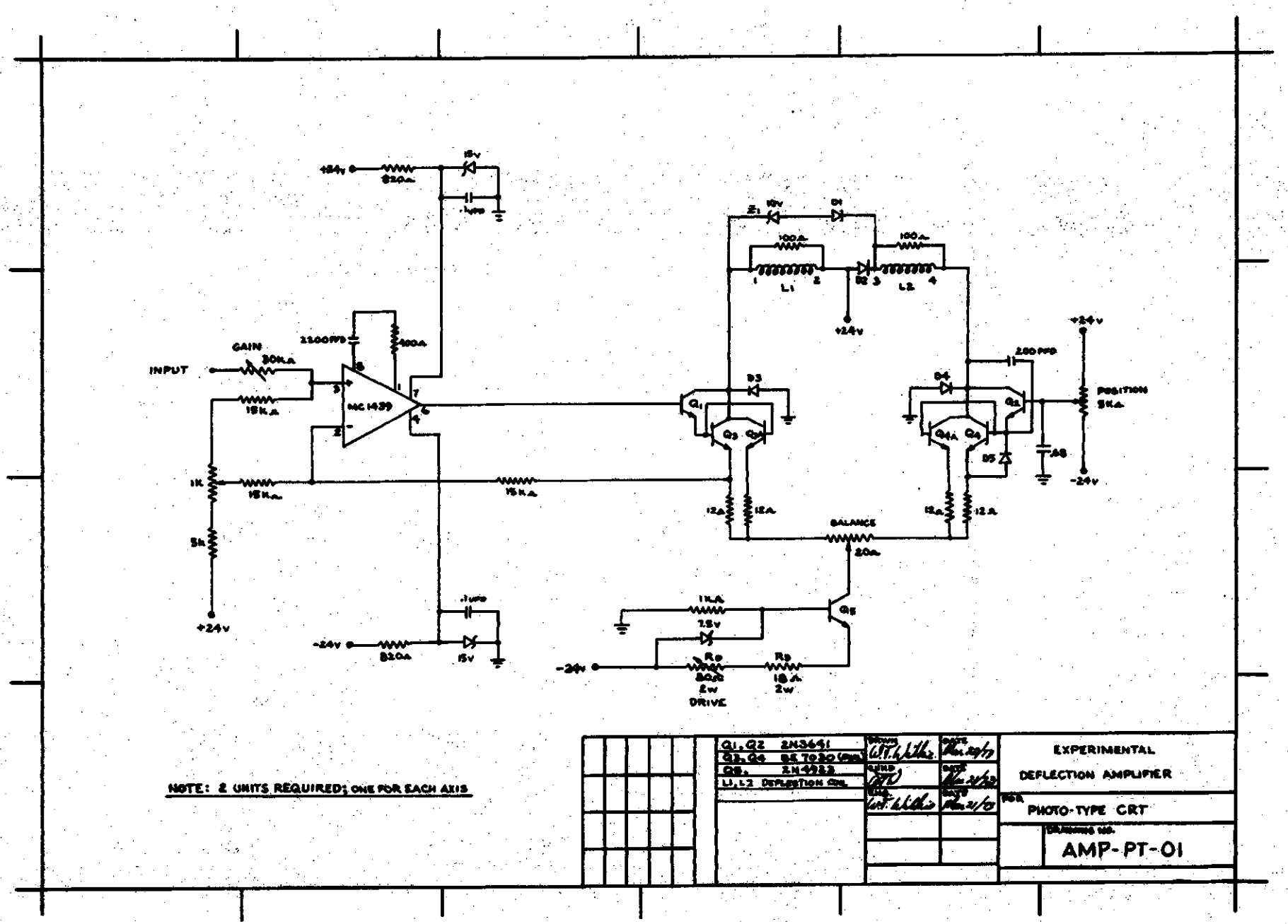


DRAWING 3.5

Y DATA BUFFER



DRAWING 3.6
DIGITAL TO ANALOG CONVERTERS



DRAWING 3.7

EXPERIMENTAL DEFLECTION AMPLIFIER

be considered adequate for a production unit.

The amplifier consists of two stages, an integrated circuit preamplifier and a discrete component differential power amplifier.

The preamplifier, an MC 1439 operational amplifier, is set to operate near unity gain. Its main function is to provide small gain and offset adjustments, and to provide a means of feedback monitoring of the deflection current for increased stability and more rapid step response.

The power amplifier is a normal differential amplifier. Q5 and associated components form a constant current source. The drive control allows adjustment of the current value to suit the selected image size.

The current is approximately:

$$I = \frac{E_{zener} - V_{be}}{RD + RS}$$

which for the case at hand yields a maximum current of 380 ma.

The balance control is used to set equal current through each leg of the differential amplifier when the bases of Q1 and Q2 are held at equal potential.

The position control is used to set the conduction of the Q1, Q2 combination to give beam centering on the CRT for a zero voltage input to the preamplifier after the balance control has been set.

The 0.68 ufd capacitor on the base of Q2 stabilizes the wiper voltage of the position potentiometer. Q1, Q3 and Q2, Q4 form Darlington pairs to give high current gain and high input impedance at the bases of Q1 and Q2.

D5 insures that the base of Q4 does not become excessively negative with respect to its emitter, thereby preventing reverse breakdown of the emitter base junction. The 200 pfd. capacitor between the collector and base of Q4 is meant to protect the collector base junction of Q4 against voltage spikes generated by the collapse of the field of L2.

D3 and D4 prevent the coTlectors of Q3 and Q4 from going too far negative in the case of negative spikes being generated from L1 and L2.

The deflection coils, L1 and L2 were tested for their parameter values, yielding the following.

HORIZONTAL L = 5.7 mh.
R = 10.5 ohms.

VERTICAL L = 6.1 mh.
R = 10.5 ohms.

These values were determined on single coils at 1000 HZ.

Circuit testing revealed that 100 ohms represented a good choice for the damping resistors to yield fast flyback response with negligible ringing, for the constant rate sweep used for column drawing.

The dynamic response of the amplifier - deflection coil combination is of interest from the point of view of minimizing the retrace time at the end of a vertical scan line.

A change of current, I, flowing through the deflection coil inductance, L, will reach 99% of its final value in time T with a voltage, V across the inductor. Ignoring the small resistance of

the inductor, this relationship is approximated by:

$$T = \frac{L\ I}{E} \quad \ldots\ldots, 1$$

where: T = time for 99% response (microseconds)

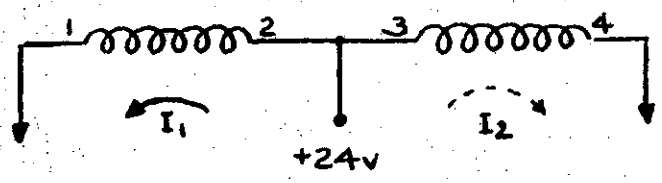
L = inductance (microhenries)

I = current change (amps)

E = forcing voltage across the winding (volts)

Applying this to the initial coil configuration shown below and assuming maximum current, yields a step response time of:

$$T = \frac{.0061 \times .380}{24} = 96.5 \text{ usec.}$$



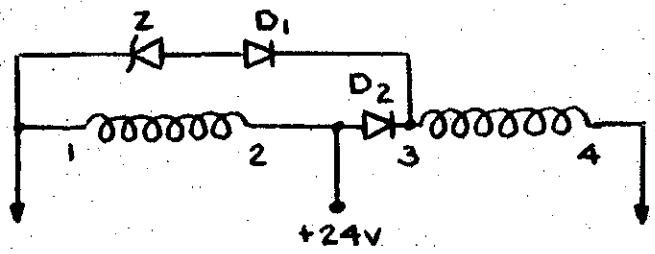
This response time could be improved by:

1) lower inductance
2) higher driving voltage
3) reducing the current requirement.

However, each of these parameters is of fixed value. Therefore, some modification must be applied to the simple coil configuration in order to alter the effective value of one of the parameters.

The coil configuration chosen was that shown in drawing AMP-PT-01 and on page 105. The diode network, Z, D1 and D2, is utilized to couple the back EMF, developed by the collapsing field in coil 1-2

to terminal 3 resulting in a desirable increase in step response.



Assume that retrace is to occur at time TO. Prior to TO, an initial current of I flows from terminal 2 to terminal 1 of coil 1-2 while I2, the current in coil 3-4, is zero. At TO the current I1, must rapidly go to zero and an equal current I2, must flow from terminal 3 to terminal 4 of coil 3-4.

Equation 1 can be used to determine the instantaneous EMF developed across coil 1-2 for a retrace response time of 20 usec., a more than adequate retrace time. This calculation yields 120 volts to be the resulting EMF.

The 120 volt rise in voltage at I with respect to 2 is applied, via diodes Z1 and D1, to terminal 3. Diode 2 becomes back biased allowing the voltage, V-VZ-VD, to appear across coil 3-4 and aid in building its field.

This technique increased the step response by approximately 60% resulting in a response time of close to 30 usec. which is well within the range of response required by program execution speed.

4. CONCLUSION & RECOMMENDATIONS

The work described in the body of this thesis has been carried to a level where it can be said that the Computer Aided Name Compilation system now exists. However, the same cannot be said for the Computer Aided Name Placement system at this time.

The CANC system development has followed a logically outlined extension of the investigatory work of Professor P. Yoeli and heavily based on the experience of Dr. A. R. Boyle with the Oxford System. The recommendations of Professor Yoeli, with practical modifications, have, in essence, been embodied in an operational system.

The concept of interactive name compilation, though possibly not extended to its fullest extent, has been proved to be a viable approach to the problem of map name compilation.

When considering the Computer Aided Name Placement System it must be recognised that considerable financial support will be required to provide equipment capable of performing according to the requirements set down in this thesis. However, work to date, using only equipment at hand, has, in the author's opinion, proved the practicability of such a system. It is estimated that at least one more year of effort, with suitable equipment, is required to develop a working system. To this must be added sufficient time for the preparation of the symbol library unique to the user.

The following is a presentation and discussion of recommendations

for future development of the CANP system.

1) CRT SUBSYSTEM.

It is essential that a CRT subsystem fulfilling the requirements presented in this thesis be obtained. Units such as the Celco Ds5-50-0 and the Gould, previously Beta, PD900 are available at a cost of around $10,000. Both of these units are illustrated in Figures 4.1 and 4.2.

2) LENS SYSTEM

A suitable lens system must be designed and assembled to meet the following general specifications.

a) Large aperture to permit minimum light loss

b) Aberrations minimized

c) Short focal length to restrict the height of the CRT from the table to within reasonable limits. This height also affects the selection and operation of the x-y mechanism since the CRT mass, if not in a plane of the moving force, causes undesired twisting moments on the support mechanism of the gantry

d) Though contradictory to the requirements of a) and c) the depth of field should be as large as possible. These must be taken into account as conflicting parameters in the optics design.

3) CRT/LENS SUPPORT

It is essential that the distance of the CRT/lens system from the film plane be held constant. Three factors contribute to variability:

a) Film platen not flat

b) Film not held securely on the film platen

c) Physical variations in the trueness and stability of the x-y mechanism supporting members

In order to alleviate all of these possible errors, it is suggested that the CRT/lens system be supported by an air bearing, riding on the table platen. Not only does this insure the correct position of the CRT/lens system relative to an untrue platen but also the exhausting air from the air bearing will hold the film tightly down on the platen. Figure 4.3 illustrates the method suggested.

4) CALIBRATION UNIT

For applications involving precise cartographic placements, it is essential that the CRT unit and all support electronics maintain extreme stability with time and temperature change. In order to insure this stability it is recommended that an auto calibration/check system be added to the CRT subsystem. This would allow program controlled positional error detection of the CRT beam and subsequent computer controlled recalibration of the electronics.

It has been suggested that four .001 inch diameter light guides, mounted on a material with properties similar to the film to be used, be attached to the CRT faceplate at the x-y coordinate centre limits such that they pick up the CRT spot light when the beam is deflected to their position. The light impinging on the guides would trigger a photo transistor to register the light strike.

If the beam was deflected the specified distance and a light strike was not produced, the beam would be moved in a spiral pattern

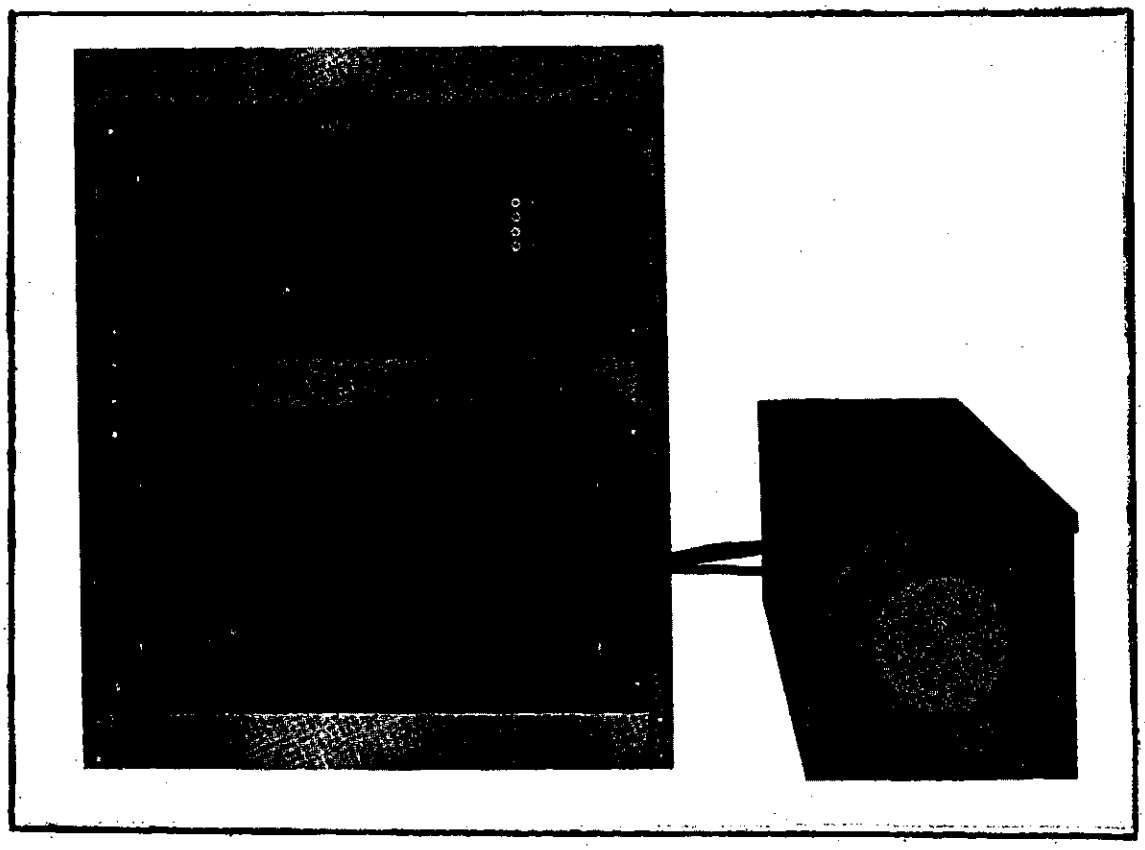


FIGURE 4.1

CELCO DS5-50-0 LOW-COST DISPLAY SYSTEM

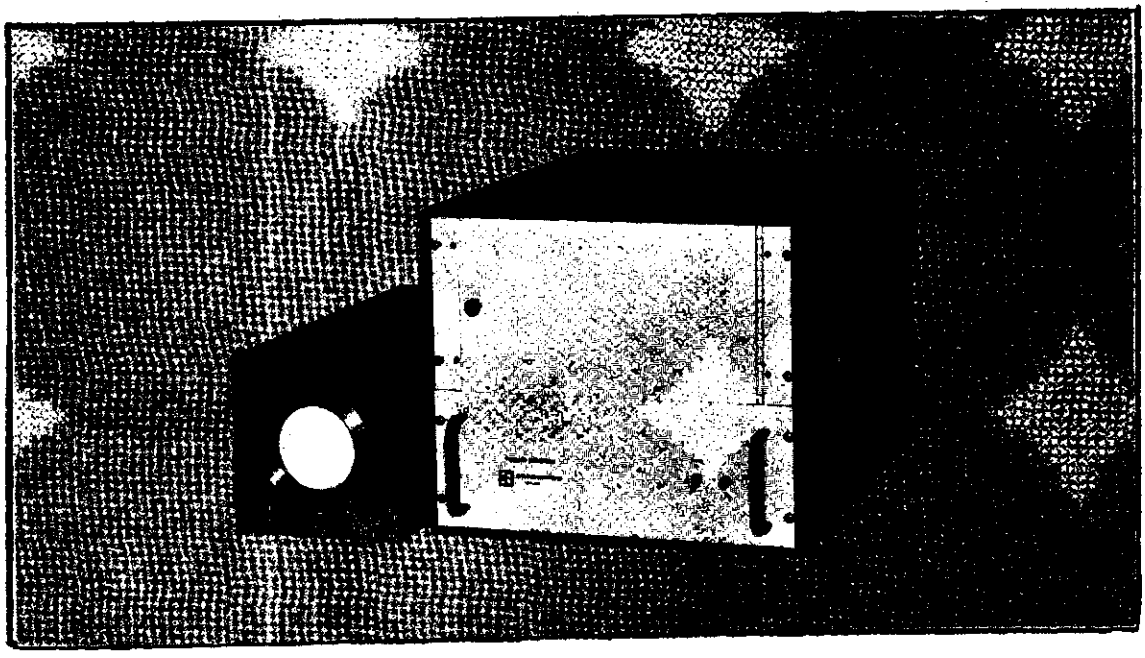


FIGURE 4.2

BETA MODEL PD900 PRECISION X-Y CRT DISPLAY

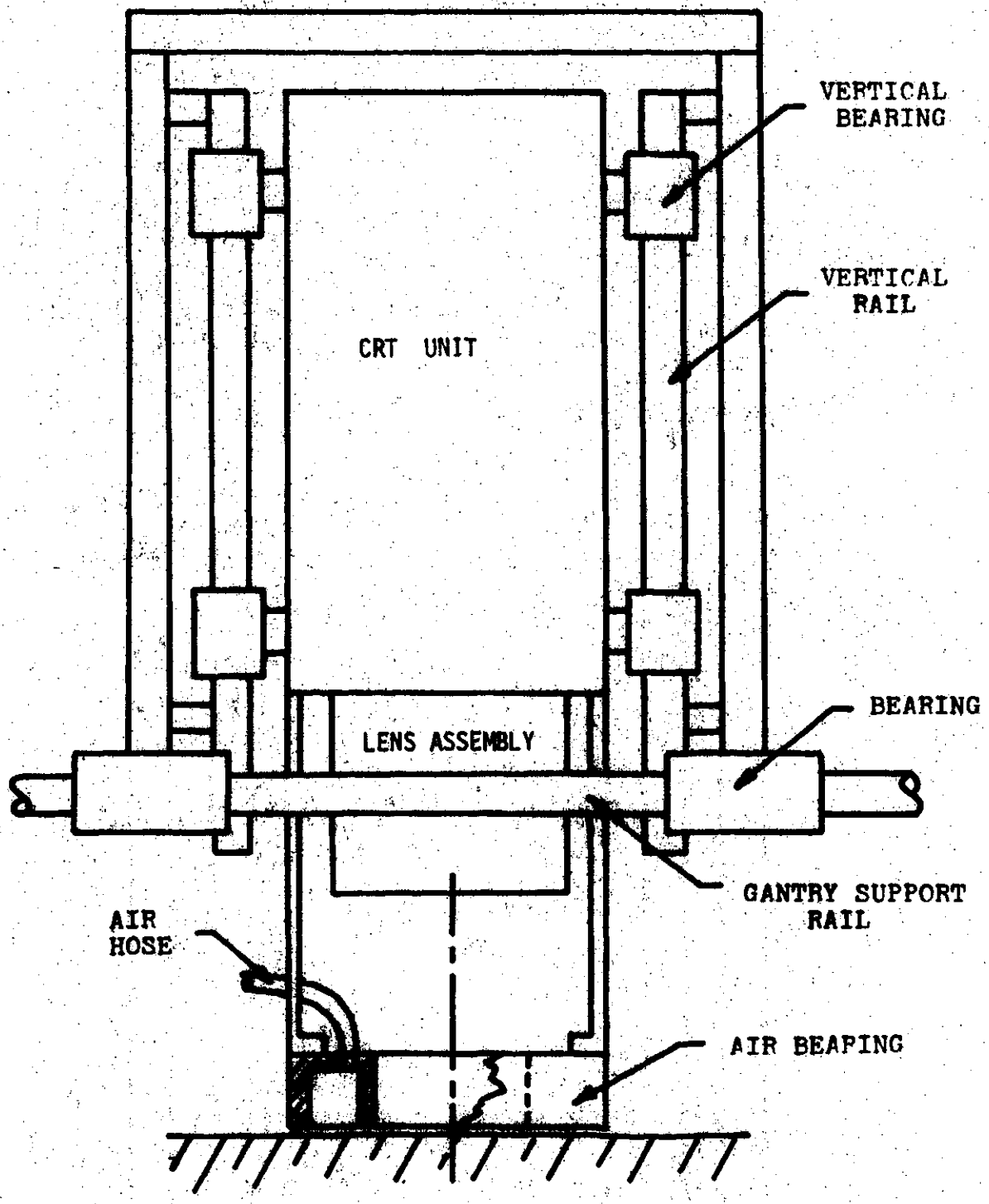


FIGURE 4.3

PHOTO-HEAD ASSEMBLY

until a strike occurred. The required deviation would then be registered for this point and all others, and used to calculate the type and magnitude of the error.

If required, correction signals could be sent via D/A converters to voltage controlled resistors in the CRT electronic package such that these errors would be compensated. A block diagram of this proposal is shown in Figure 4.4.

This auto calibration/check facility would enable the cartographic personnel and technical staff to place greater confidence in the accuracy of the name placement and the quality of the printed character.

In addition to name placement, extended uses are forseen for the Name Placement system. No tests have been carried out to date relative to these applications, but it would appear that the following extensions are possible.

1) AREA FILL

The pseudo line scan format used to draw characters on the CRT seems to be ideally suited for application to problems of area fill by methods of:

a) Symbol spray: where blocks of symbols are used to fill a defined area

b) Cross hatching: where cross hatching lines of various symbolizations are used

c) Block fill: where the entire defined area undergoes solid fill. This is especially applicable to the generation of colour overlays presently made by removing

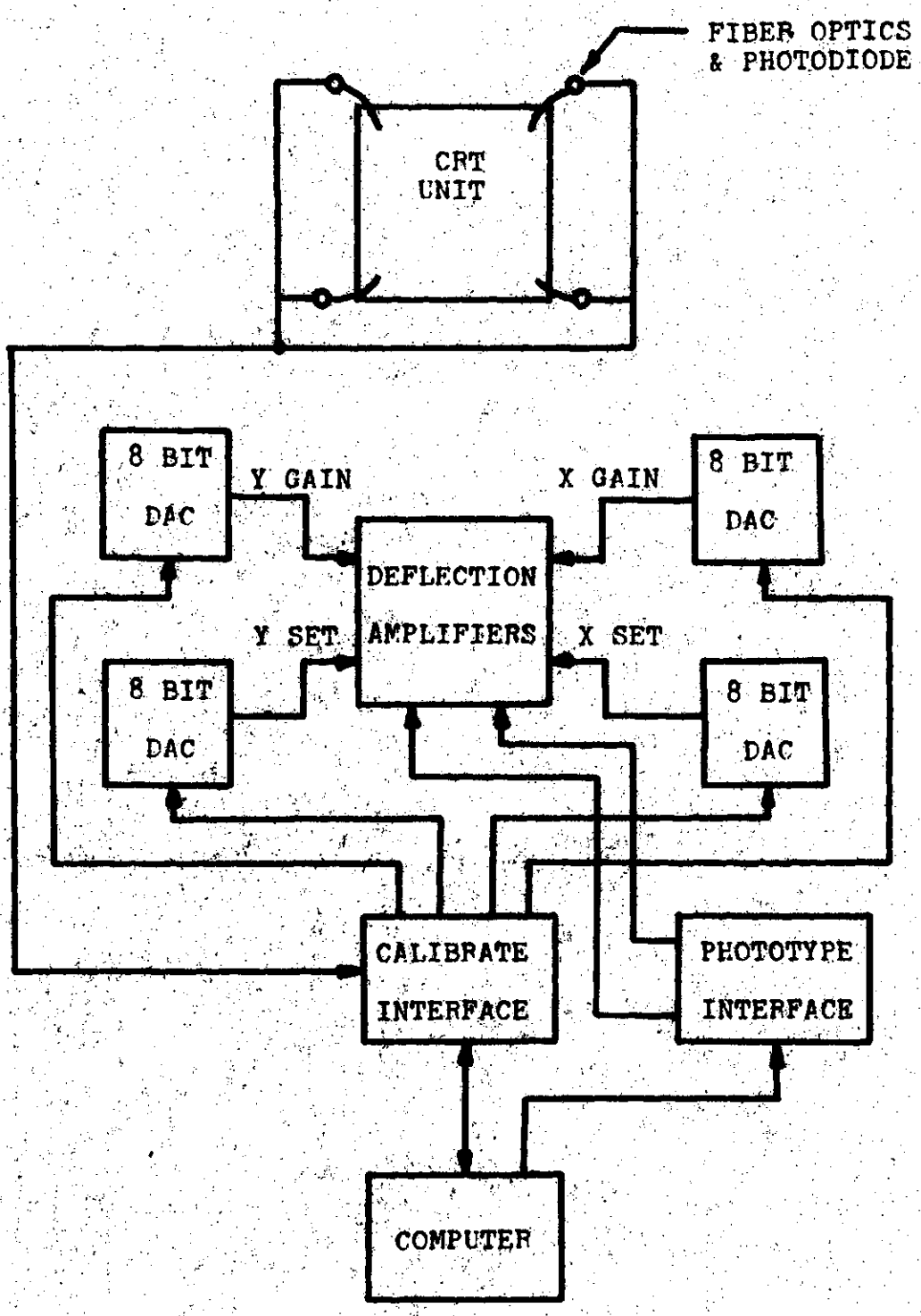


FIGURE 4.4

CALIBRATION SYSTEM BLOCK DIAGRAM

areas on peel coat

2) LINE DRAWING

The CRT unit, being a versatile drawing device, also appears to be well suited to line drawing by two different methods;

a) Light Spot Emulation: The CRT unit could be used as a standard light spot projector of the rectangular spot type. The rectangular spot would be generated on the CRT and rotated via software according to the line direction. The x-y mechanism would move continuously as for "pen type" drawing

b) Line Segmentation: The CRT unit could also be used to generate short, precise line segments. For this application, the x-y mechanism would operate in steps, possible of considerable size, positioning a line segment start at the end point of the previous line segment.

In the first case, vectored velocity determination, by calculation or feedback, could be used to adjust the intensification period of the CRT beam for constant exposure of the film.

In conclusion, it is felt by the author that the recommendations of Professor Yoeli, the experience of Dr. Boyle and the work of the author have resulted in a useful system of Computer Aided Name Compilation. Furthermore, a system of Computer Aided Name Placement, though in embryonic form at present, has been proven in concept and worthy of future financial support and energetic effort.

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APPENDICES

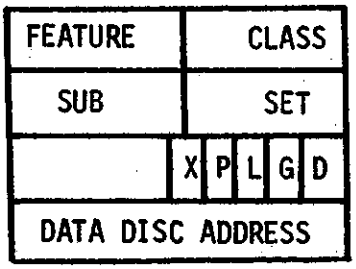
APPENDIX A

NOTES ON THE DISC DIRECTORY

NOTES ON DISC DIRECTORY SYSTEM

In order to obtain rapid retrieval of data from disc data files, a simple but effective disc directory system has been incorporated into the CAMC Program. The CAMC Program generates, maintains, and updates this directory except in the case of simple look-up functions carried out by the editing routines of the CANC Program.

Each directory entry is four words in length as shown in the following figure.



Each term is defined as follows:

FEATURE	Feature letter
CLASS	Feature classification
SUB	Subclass of feature classification
D	Diminished Image tag
G	Generic Image tag
L	Last Image tag
P	Present Image tag
X	Specifies First segment of line

The three images, present, last and generic, make possible comparison of any one step in the compilation process with respect

to the previous step or with a reserved image. The "last" is always useful for rapid retrieval if an error in selection has been made.

The present image is the one presently being modified during compilation whereas the last image is the one previous to the present.

At anytime during the compilation process, a reserve or "generic" image may be formed from the present image. This can be subsequently redisplayed for use in comparison of data images in varicus stages of compilation.

If the feature and class are a binary 0, the disc address refers to the next vacant block where data can be written. This case also indicates end of directory.

This directory system is set up to work in conjunction with a feature table (appendix B) to enable rapid location of data on the disc.

For further information about the various tag functions and use of the directory consult the CANC Program documentation.

APPENDIX B

NOTES ON FEATURE TABLE OPERATION

NOTES ON FEATURE TABLE.

In order to update images on the display, the CANC Program maintains a feature table for each of the possible image categories of present, last, generic and diminished. These tables are a record of all features requested for display and their associated parameters.

All feature tables are resident on the disc and are loaded into a location called FETUR in field 0 of core memory. The Display Program handles all aspects of these feature tables except for simple look up functions performed by the name drawing routines of the Name Placement Program.

Each entry in the feature table is 11 (decimal) words in length. The first four words are the actual feature specification words as shown in the diagram and explained as follows:

FEATURE is the feature letter of the data.

CLASS is the main class of the feature i.e. population centre, water body etc..

SUBCLASS is the secondary classification i.e. hamlet, city; lake, river etc..

**** is presently reserved for expansion for name specifications.

In some applications, mainly lines and special symbols, a request to use certain HEADER words (words in the data header) as qualifiers can be made. Words five and six are used to hold such requests. These words are filled as follows:

POS HEADER POSITION; the position or location of the desired qualifier word within the header is specified.

TOL TOLERANCE: 0 = equal to

neg.= less than

pos.= greater than

This permits the program to selectively display data based on the value of the specified header word, i.e. contours above 50'.

VALUE WORD VALUE: This word would be set to the value to be used to qualify the data e.g. 50'.

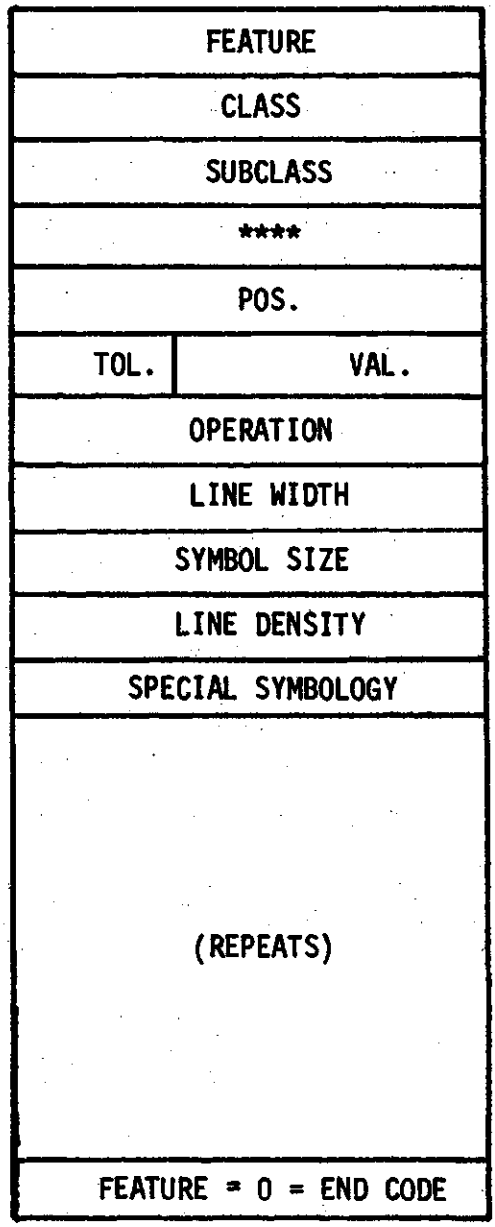
Word 7 is used to specify the operation as follows:

positive value	ADD
negative value	ERASE
0 (binary)	SYMBOLIZE

The specification to symbolize causes the program to interpret the remaining four words to result in the desired symbolization of the data on the display.

Entry follows entry until a 0 is encountered in the FEATURE, which specifies the end of the table.

The CANC search routine utilizes the feature table entries to qualify data for display. Once a data entry compares in longitude/latitude with the display screen values, the data is compared with every entry in the feature table to insure that it has been selected for display. It is essential that all feature table entries are compared since a general data class may have the add operation specified and further down the table a request may be registered to erase (not display) a certain subclass falling within the previous general class addition category.



FEATURE TABLE FORMAT OUTLINE

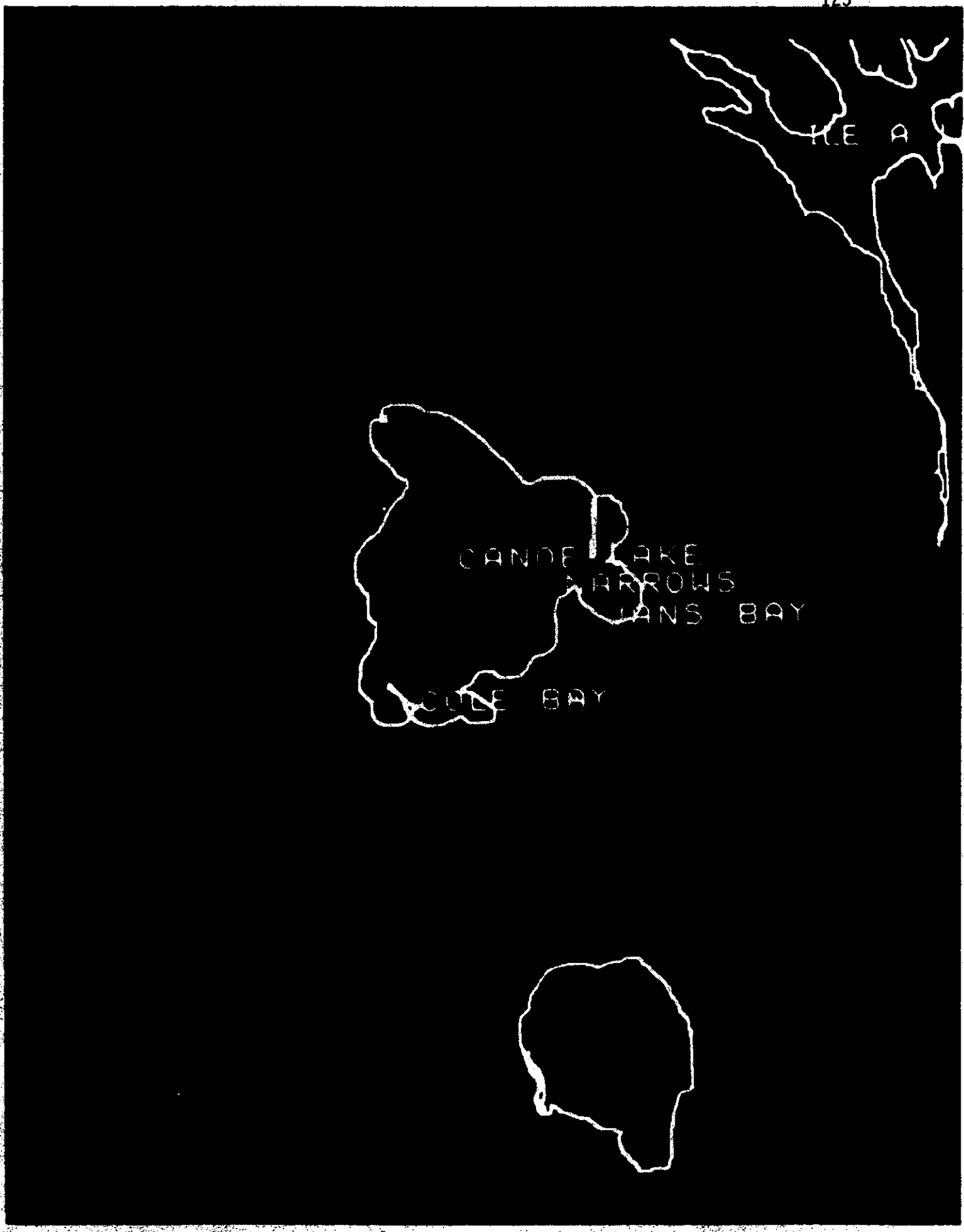
APPENDIX C

AN EXAMPLE OF NAME COMPILATION

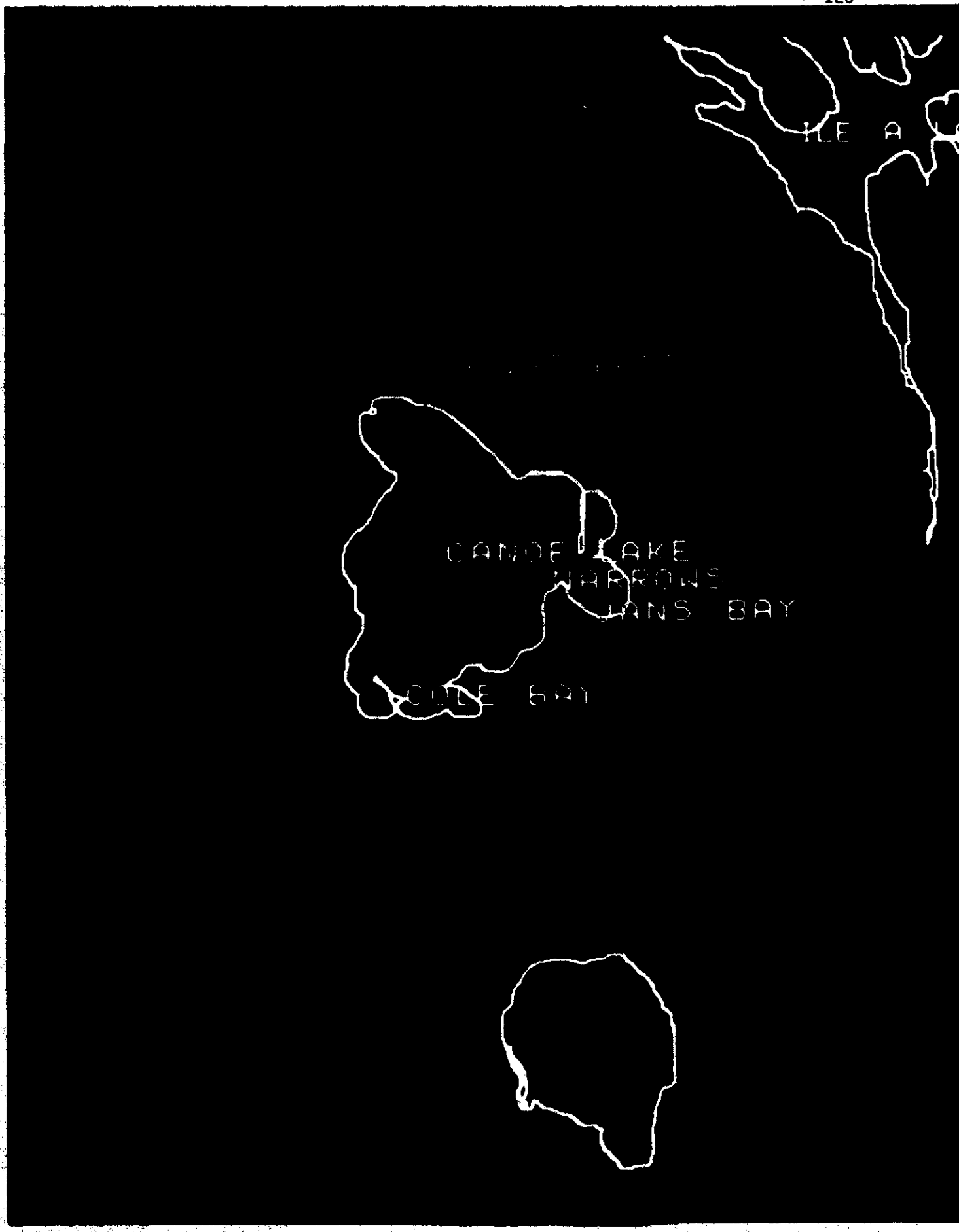
The photographs, shown in this appendix, are taken directly from the Tektronix 611 storage display.

The map data shown is a section of Northern Saskatchewan. Only lake outlines, lake names, and names of population centres are selected for display from data bank information.

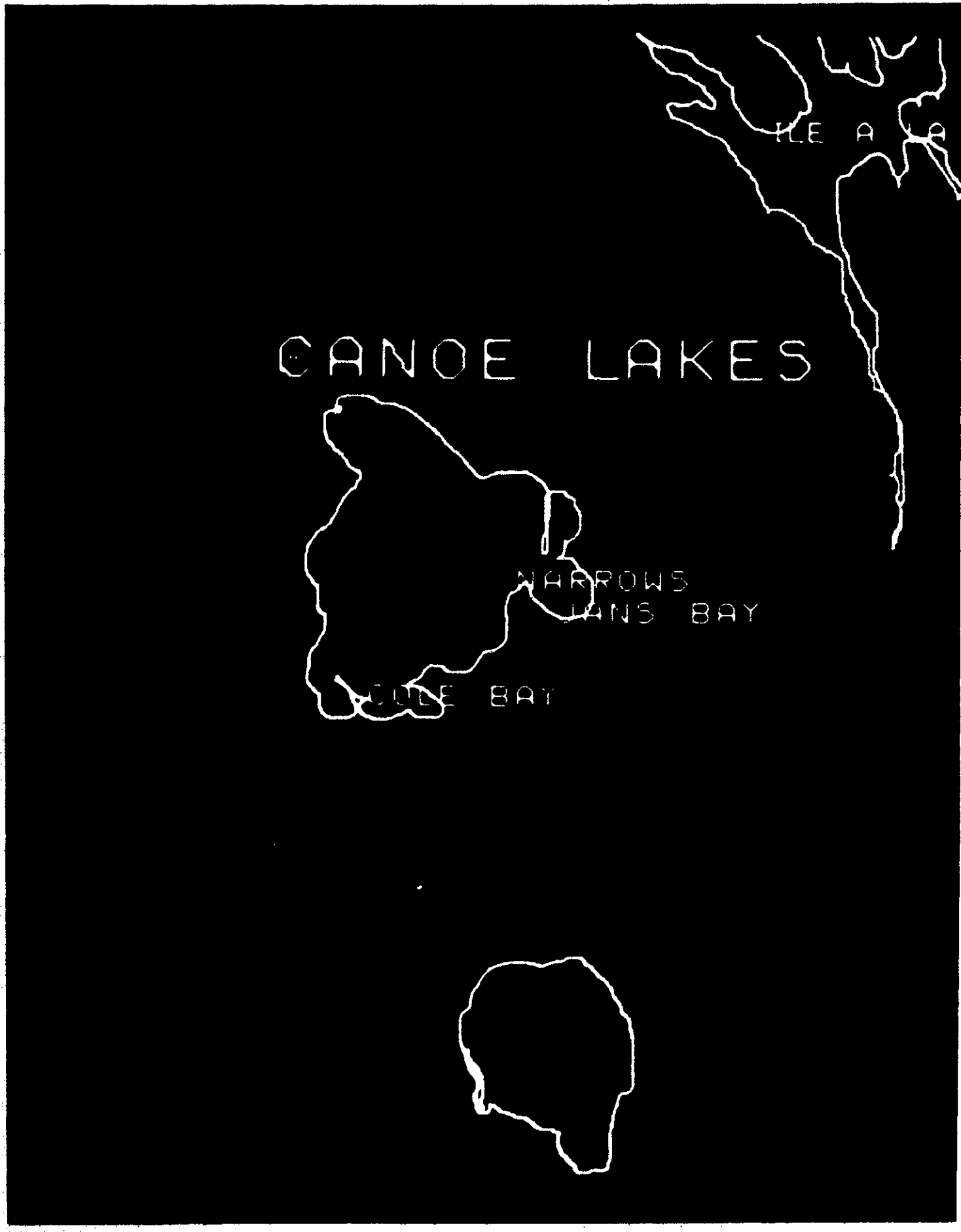
The image manipulations are noted below each photograph.



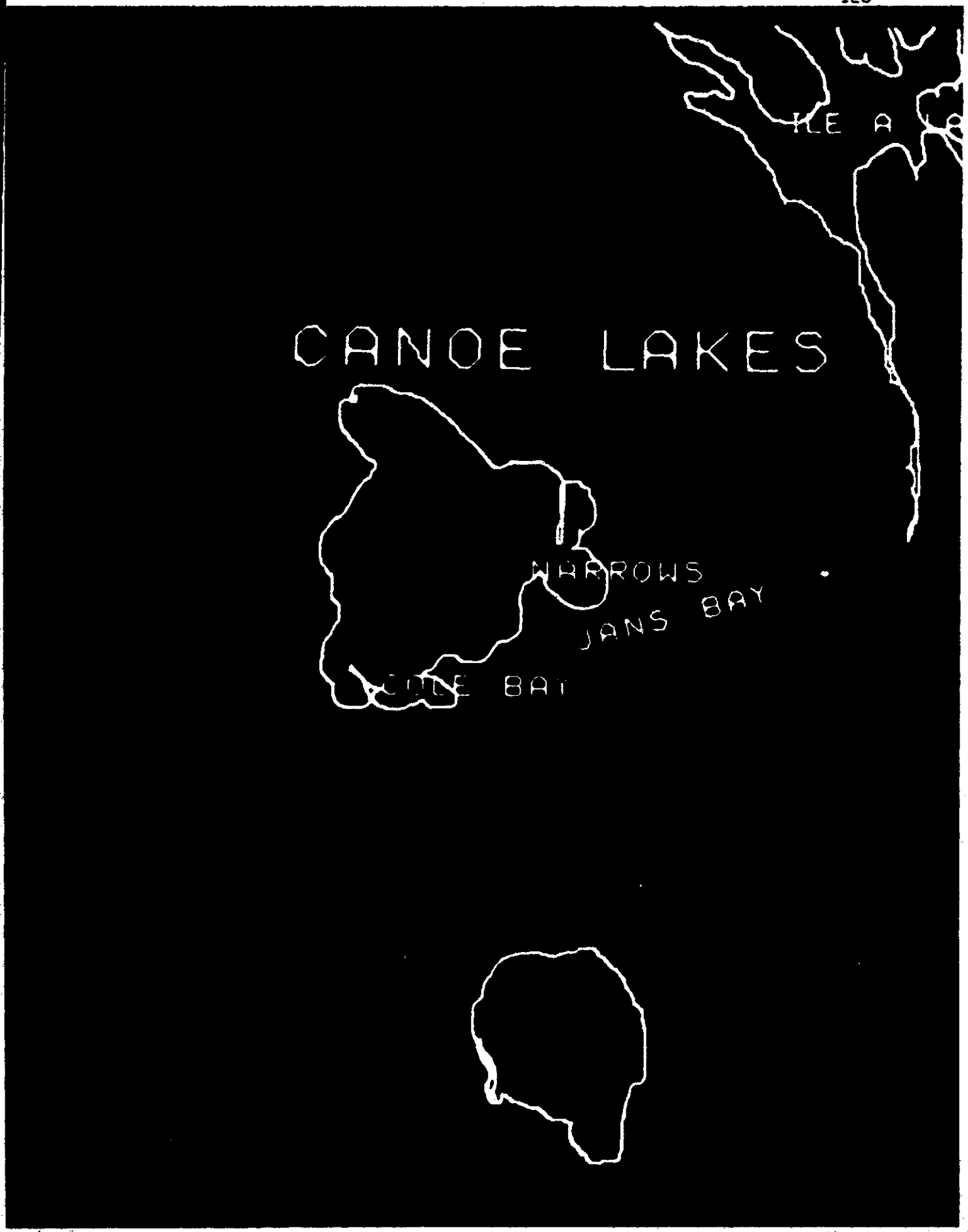
ORIGINAL DIGITIZED DATA



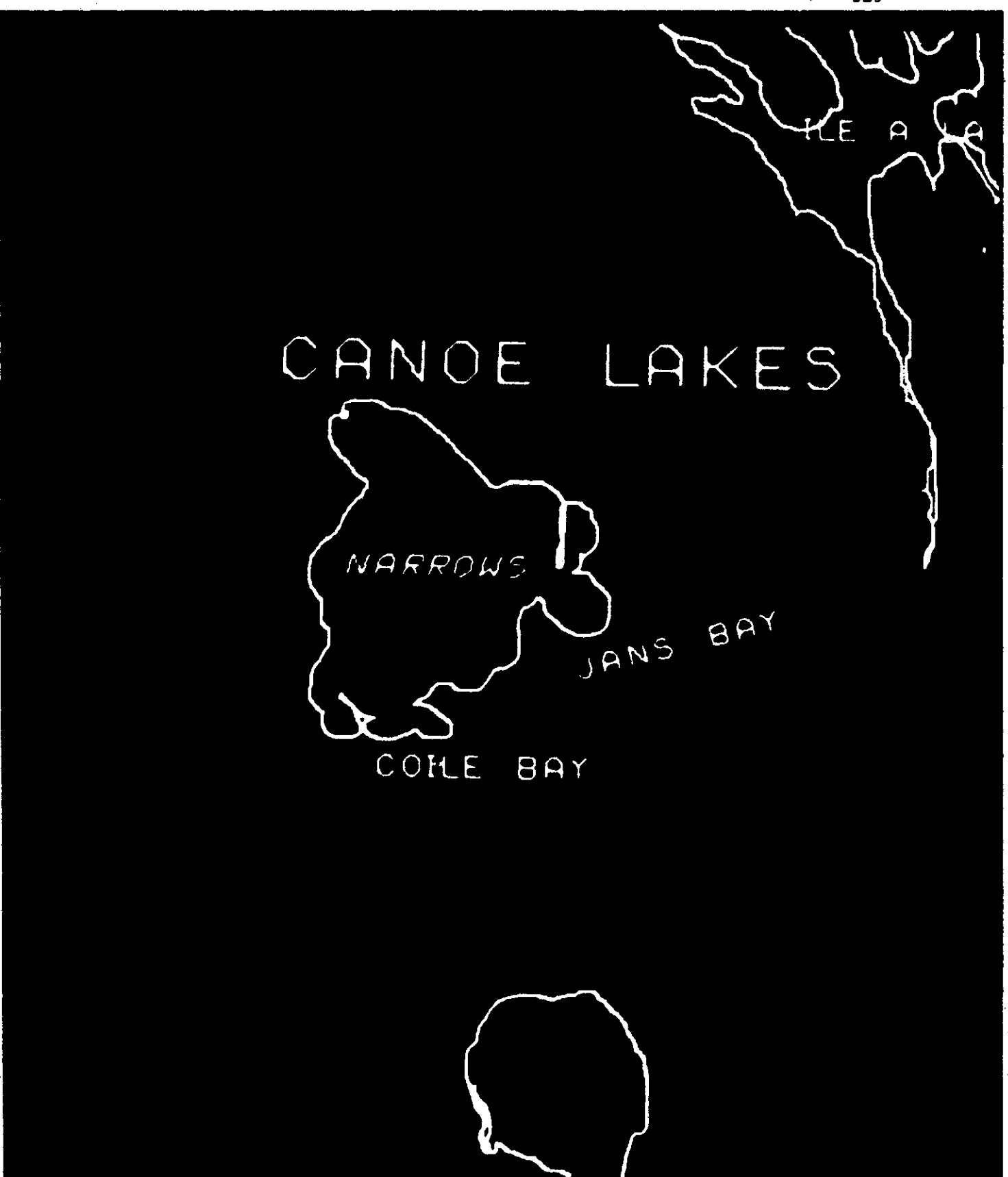
MOVING A NAME (GHOST IMAGE, CANOE LAKE)



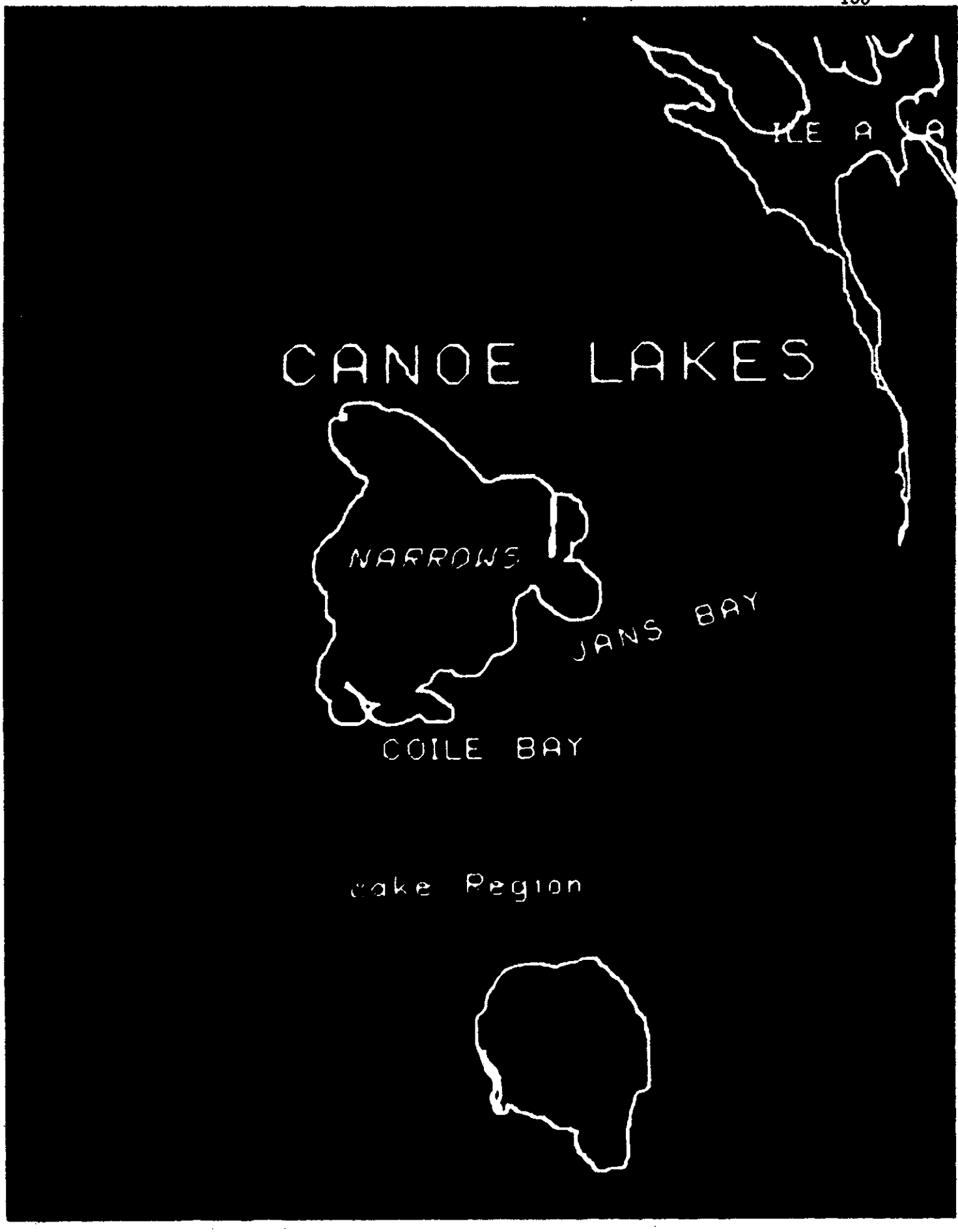
INCREASE IN LETTER SIZE: ADDITION OF A LETTER:



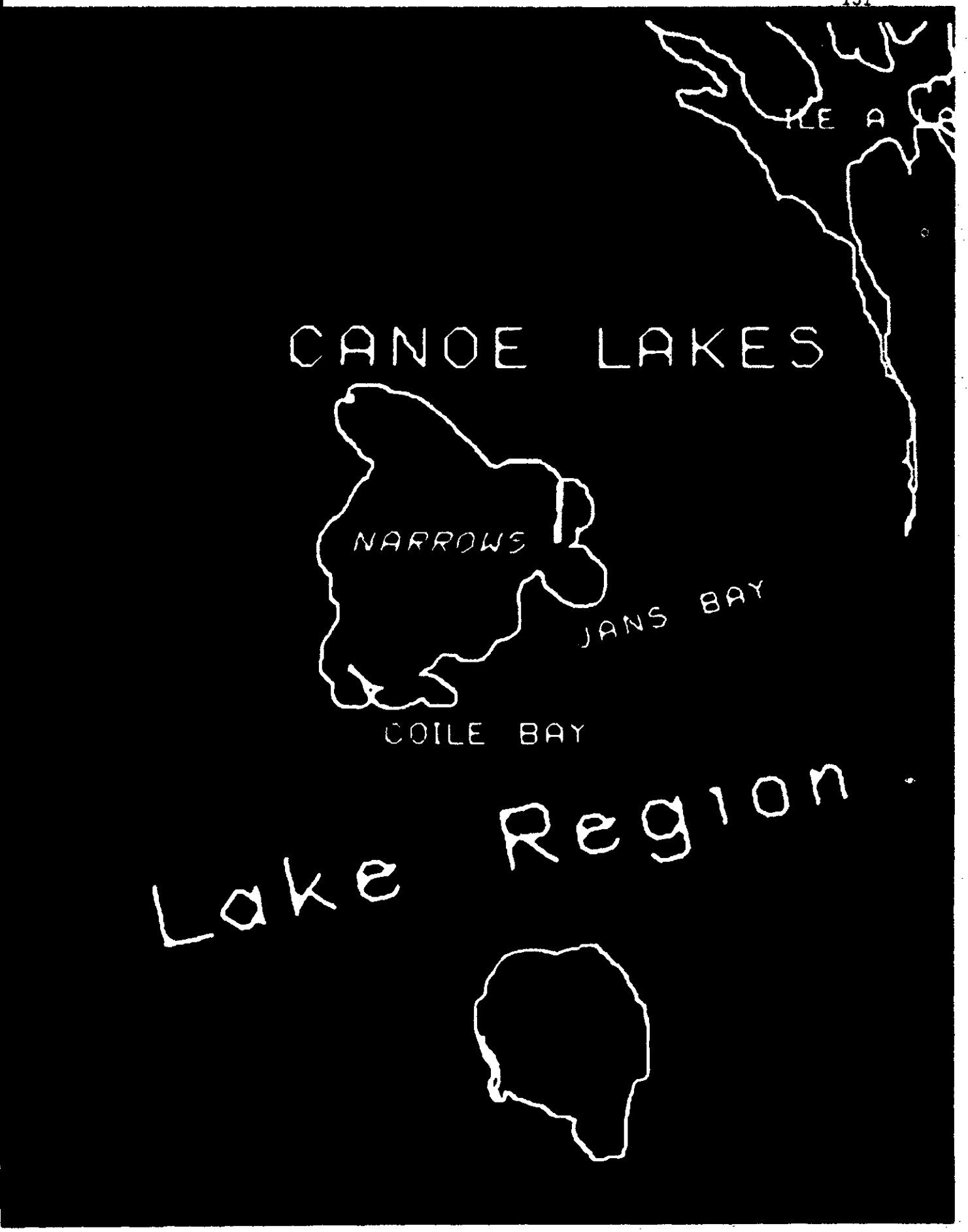
NAME ROTATION (JANS BAY)



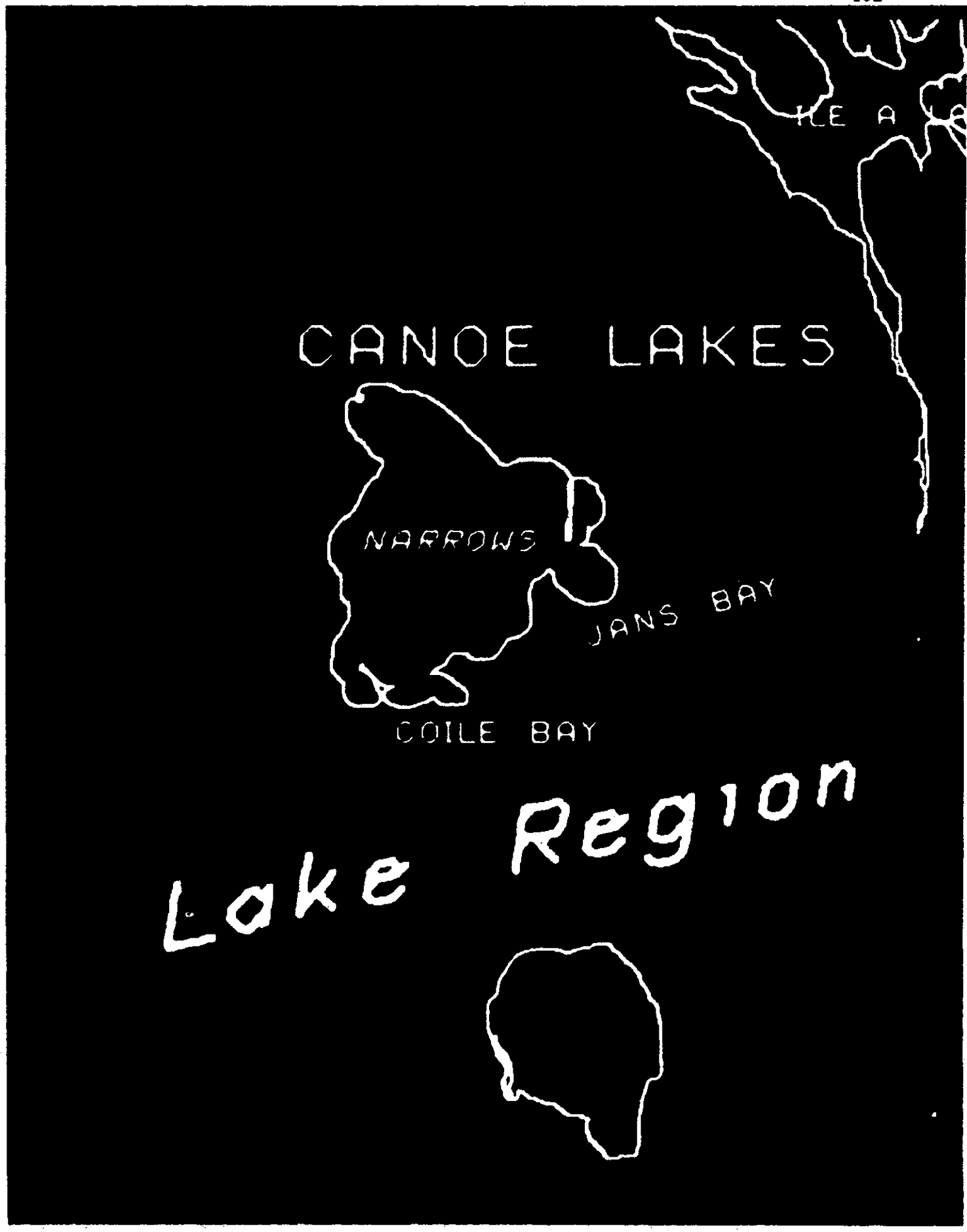
MOVE AND ITALICIZE (NARROWS): INSERTION OF LETTER (COILE BAY)



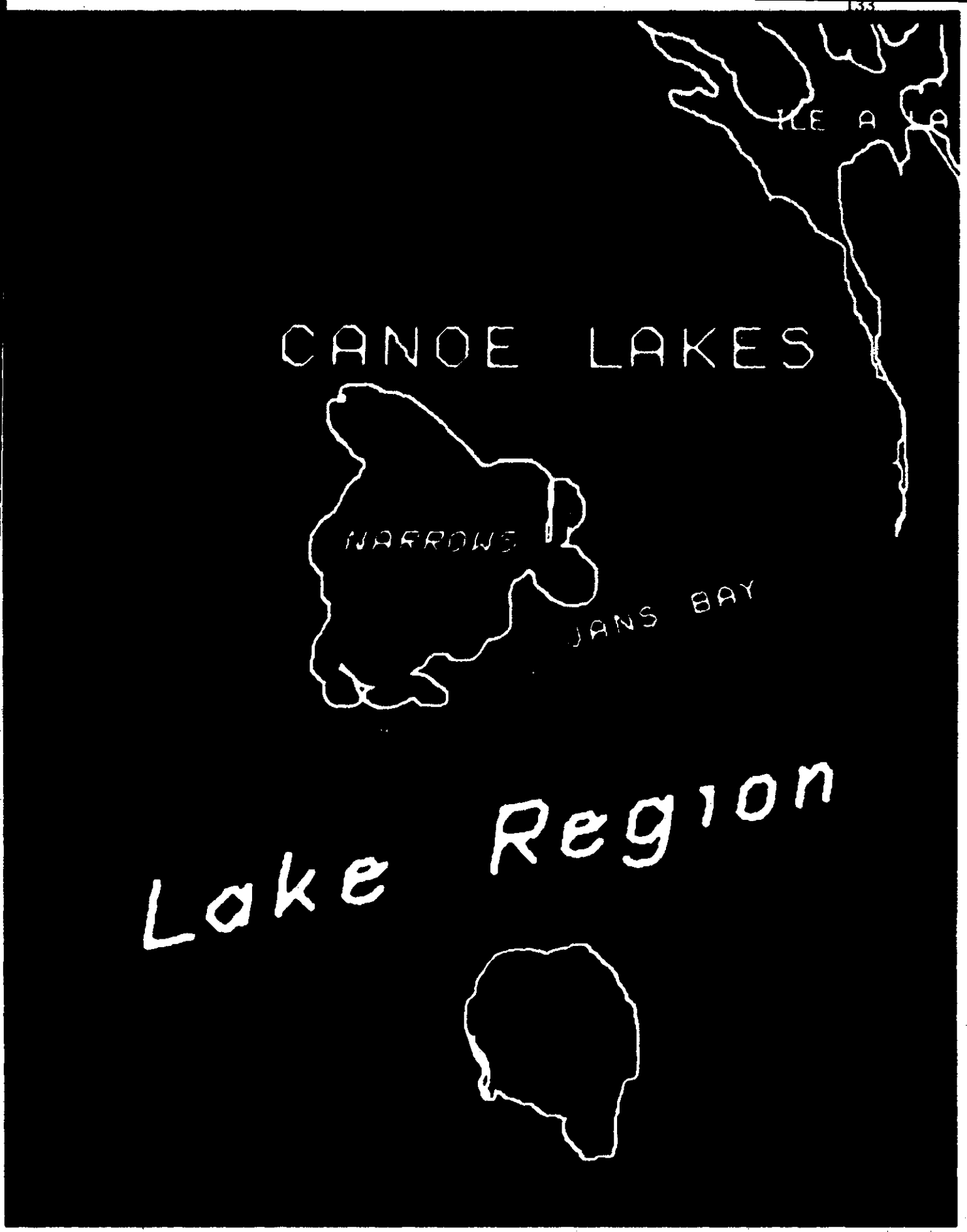
NAME ADDITION AND LOWER CASE LETTERS



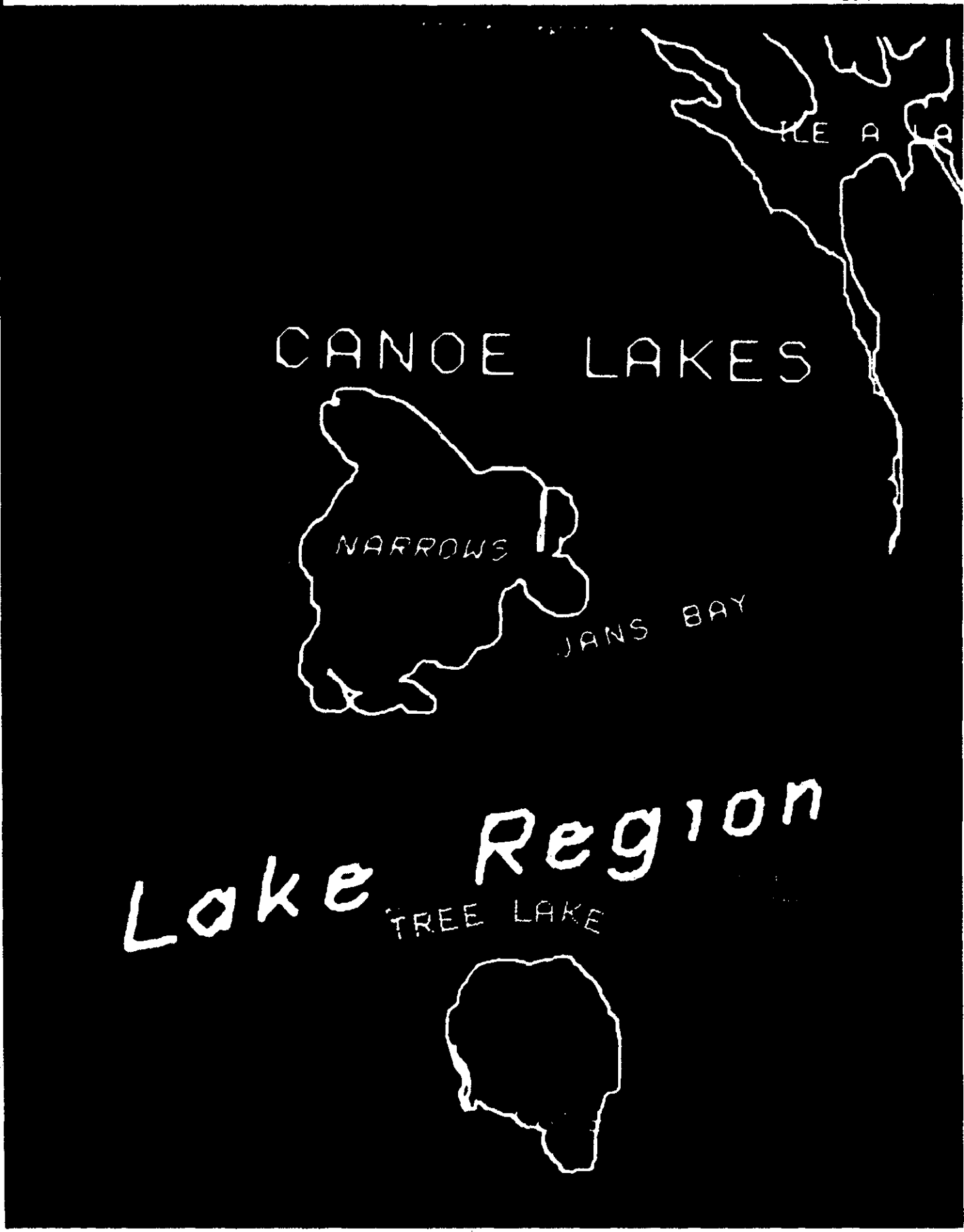
NAME ROTATION AND SIZE INCREASE



VARIANT CHANGE, ITALICIZED BOLD LINE



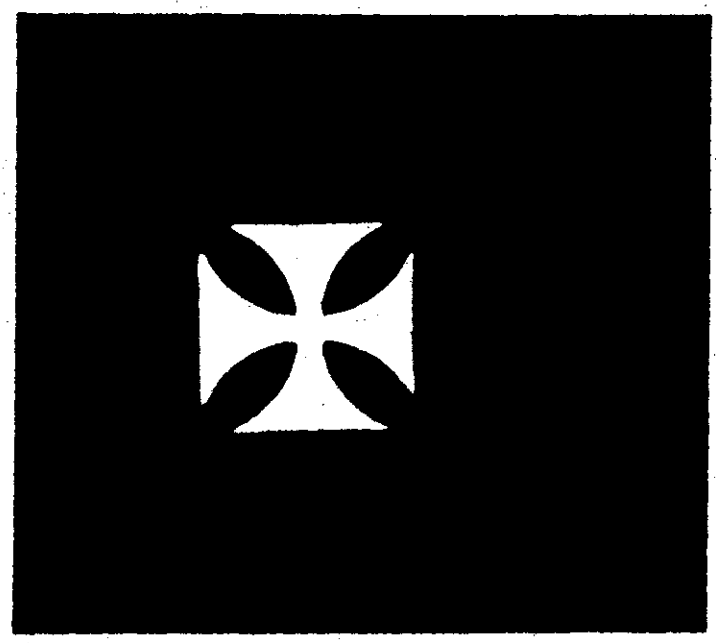
WORD DELETION



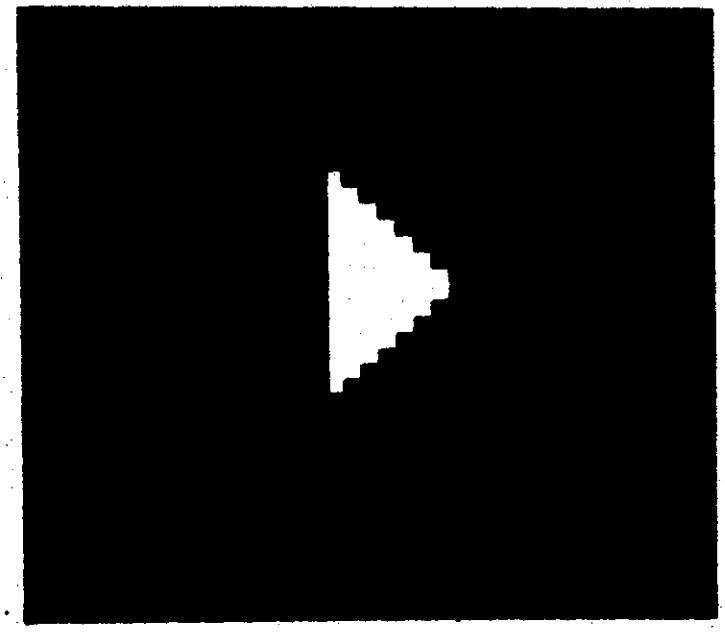
NAME ADDITION AND CURVATURE

APPENDIX D

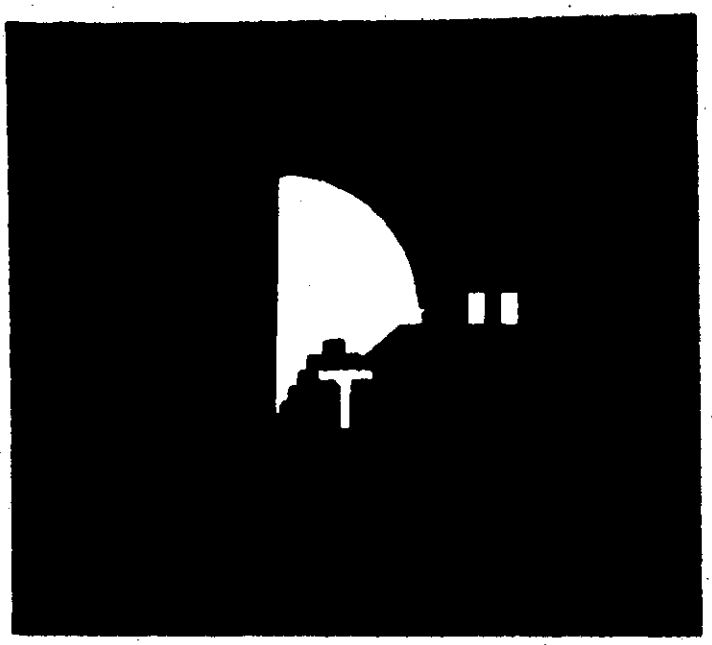
SAMPLES OF TYPESET CHARACTERS



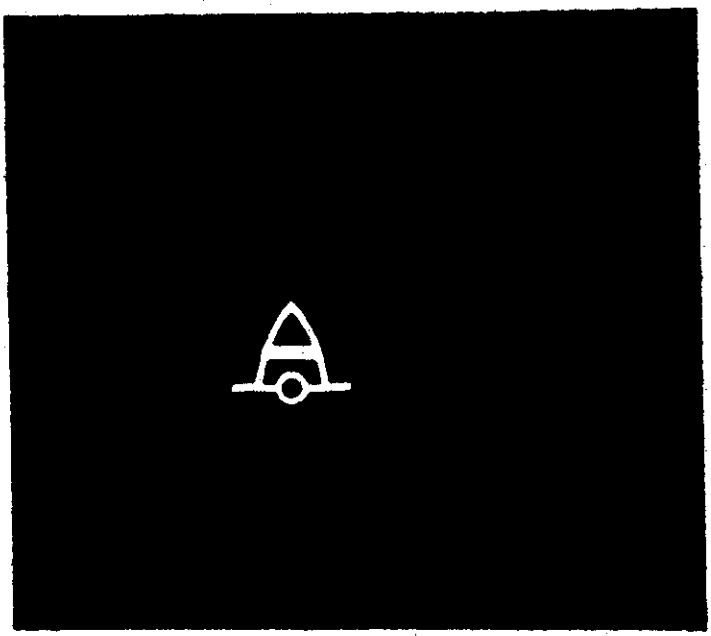
MALTESE CROSS (x10 ENLARGEMENT)



TEST PATTERN (x10 ENLARGEMENT)



TEST PATTERN (x10 ENLARGEMENT)



CARTOGRAPHIC SYMBOL (x10 ENLARGEMENT)

APPENDIX E

GLOSSARY OF CAMC TERMS

GLOSSARY OF CAMC TERMS

ABSOLUTE COORDINATES

An absolute value coordinate pair representing a location in either machine or databank (geographic) coordinates. It is always retained at full system resolution and never shortened. Values up to 23 binary bits are available, i.e. approx. 8×10^6.

ASCII

This is a special coded character set used in the PDP8 system and the CAMC. Both 8 and 6-bit systems are used. Other sets such as EBCDIC used in IBM would be changed on input to the CAMC.

ASSEMBLER LANGUAGE

This is a low level language utilizing a mnemonic code for instructions. Use of assembler language results in a highly efficient, compact program.

Assembler language programs are not machine independent, hence must usually be rewritten if it is desired to run them on a different computer. However, conversions between some machines can be accomplished by the use of translation or simulation programs.

ATTRIBUTE DATA

Information in plain language and/or coded as a list about a location, route or area.

BINARY INCREMENT MULTIPLIER.

In order to save storage space for increments in line work, a

binary increment multiplier can be placed in the descriptor at the start of a line. This indicates the power to base 2 of the multiple to be applied to each recorded increment in the line. A value of 4 would mean, in the U. of S. GIS, that each increment has a value 16x128 millisecs. Each line section can have a different multiplier and they can be different in X and Y (or longitude and latitude.)

In the U. of S. program, converting digitizer coordinates to databank ones, the appropriate values are calculated and entered automatically - a multiple is chosen which is slightly more detailed than is warranted, thus no resolution is lost, although of course, it cannot really be gained. Essentially the multiple depends on the scale of the source.

BINARY SCALE

A special U. of S. system enables databank coordinates and increments to be displayed at various BINARY scales on the display screen. The presentation can thus be scaled approximately to well known map scales, e.g. 1 to 10,000,000. A binary scale of "4" in the U. of S. CIS system means that one databank unit (125 millisecs) would be the equivalent of one sixteenth (2^4) of 0.004". on the screen, whereas a binary scale of 0 would be one databank unit as 0.004" on the screen. The binary scale is the power to base 2 of the reduction in size. The binary scale in X and Y can be set independently. A ratio of 2 to 1 in Y and X produces an approximation to the Mercator projection in Canada.

BOTTOM SAMPLES.

A one or two alphabetic symbol indicating type of bottom, e.g. mud.

CAMC

Computer Aided Map Compilation Program.

CANP

Computer Aided Name Placement Program.

CARTOGRAPHIC COMPILER

A cartographer responsible for a) the quality and form of data entered into a cartographic databank and b) the quality and form of data placed on a drawn map or chart. He is specifically concerned with decision making, annotation and warranted modification to data.

CHAINING

a) a method of linking programs together in sequence

b) a method of linking line sections together to indicate as part of single line feature.

C.H.S.

The Canadian Hydrographic Service and their cartographic hydrographic system in Ottawa.

DATABANK COORDINATES

Longitude and latitude coordinates of a location. The resolution in the U. of S. system is at present based on millisecs. For CHS work a resolution of 2 millisecs is used and for the GIS, a resolution of 128 millisecs. For ease of handling in the display program either longitude or latitude value may be complemented on entry into the system (longitude in Canada).

DATACODE

A numerical reference indicating datatype, e.g. line, symbol, etc.

DECTAPE

A special formatted magnetic tape system made by Digital Equipment Corp. It is useful for data storage but is not used within the CAMC system.

DEFAULT OPTION

A preset option which is used by the program if another or over-ride specification is not made by the user.

DESCRIPTOR

The descriptive data positioned at the start of each set of data, i.e., a line section or a group of location symbols or data. It is 40 characters long.

DESCRIPTOR UNIT

A special thumbwheel device used as an alternative to the keyboard for entry of descriptor data.

DIMINISHED

A special 1:8 reduced image called by keying D.

DIRECTORY

A list of descriptors and their locations on disc. It can be tagged to note data appearing or not appearing on the image to aid faster regeneration.

DISPLAY

Refers to the Tektronix 611 storage display unit.

END CODES

End codes are present for each set of data and for end of all data.

FEATURE

A cartographic feature, e.g. a coastline or a symbol.

FEATURE CODE

A three character alphanumeric code detailing the type of cartographic feature.

FEATURE LETTER

The first and most important of the three alphanumerics of the feature code. A list of ones normally used is available, e.g. R for River.

FEATURE TABLES.

Tables listing requested data and their symbology. Tables are maintained for Present, Last and Generic images.

FORMAT

This is the word used to describe the arrangement of data within the system. It is designed to optimize aspects of bulk of data, speed of access, etc. It is not necessarily the same format as used externally and I/O conversions are carried out. Even within the system a number of different formats are used for different types of data.

FORMATTED TAPE

A special formatting arrangement has been set up to use the ½" magnetic tape system in a manner similar to Dectape. It is very useful as a back up storage system. It cannot be used externally in normal circumstances.

GAZETTEER

A list of names and their longitude/latitude for a specified area. Normally available in book form. In the CAMC system this list is recorded on disc.

GENERIC IMAGE

At any time the Present image can be reserved by keying R and can be retrieved by keying G. It has its own feature table and directory tags. It is only erased by requesting a new Reserve image.

G.I.S.

Geographic Information System - the phrase is here particularly applied to the U. of S. system.

HEADER

a) A special U. of S. facility to access parts of the Descriptor other than the first three of the feature code.

b) Reference data which can be positioned at top of screen images.

IMAGE

The selection of lines and symbols appearing on the screen.

IMAGE 1;1

This image represents true size on the display if working from digitizer or drafting input. When working with the databank the conditions of this image are set by the operator. During operation, full manipulation and symbolization are available at magnifications greater, but not if reductions are requested.

INCREMENT

In order to save storage space when recording points making up a line and to speed access, only the difference between one point and the previous one is recorded after the starting absolute coordinate. A number of increments may be grouped. Increments may be machine or databank increments (millisecs.)

INDUSTRY COMPATIBLE MAGNETIC TAPE

This is used for external communication to other computer system. At present 9-track 800 bpi is used. Others are easily adapted.

INTERFACE

An interconnecting device between the PDP-8 and a peripheral device. Particularly refers to the Tektronix 611 and mouse interface.

1/O ROUTINES

These are special routines which change the user's data format to that of CAMC and vice versa. They may also do such processes as the ordering of data to aid speed of search.

ISLAND CLOSURE

A method in digitization or in a subsequent program to make certain there is no gap or overlap.

ISLAND DATA

As line data but it is checked that there is no gap or overlap of data.

ITEM

One distinct group in a attribute or symbol set.

LAST IMAGE

This image is the same as Present but is the one previous to the latest. It has its own feature table and set of directory tags.

LINE DATA

A string of coordinate pairs representing a line. Absolute coordinates are at start and end and intermediate data are as increments.

LINE JOINING

The procedure of closing lines end to end or at T junctions

either automatically or on the display.

LONG.-LAT.

As far as the user is concerned, he normally enters and receives such data in the normal forms of degs., mins. and secs. Within the system however, the value is stored as a simple number of millisecs. (x2 or x128). The present system is limited to a value of 23 binary bits for each, i.e. 8×10^6 in decimal. At present two values are used, 2 millisecs. for the U. of S. CHS system and 128 millisecs. for the U. of S. GIS; others are equally possible.

Longitude precedes latitude to make it more compatible with the display coordinates of X followed by Y. In Canada the value of longitude is complemented to make it in the same direction as X i.e. left to right (This is done on entry to the system).

MACHINE COORDINATES

X and Y coordinates of a location derived from or for a machine operation, e.g. digitizer or plotter. Normally of equal amounts in two axes. The resolution is normally set by the mechanics of the device e.g. 0.0001".

MAGNIFY

A specification by the user of "M" followed by a binary number (2,4,8,16 or 32) produces a magnified image of that value on the screen with line thickened and symbols enlarged automatically. A shift in screen coordinates can also be applied. Full manipulation facilities are available with all images.

MATRIX

The dot format making up a character or symbol form.

MAIN HEADER

The first block of the display data containing general information. Can be displayed by calling a separate program called 'MAIN'.

MOUSE

A hand-held device, which, when moved over a table surface provides X and Y output signals to move the write thru spot on the screen to act as a pointer.

MULTI COORD. PAIR SYMBOLS

A drawn symbol as an outline, filled or following a laid-down routine, e.g. for a bridge symbol.

NAV. AID (HYDROGRAPHIC)

A complex symbol made of a number of individual symbols each stored as a matrix.

OS 8 SYSTEM

A monitor system developed by the Digital Equipment Corp. for the PDP8. The CAMC assumes this has been implemented as various aspects such as device handlers are used.

PRESENT IMAGE

The latest image is always known as Present. After certain manipulation, e.g. calling Diminished or attribute data, it can be recalled by keying P. It is recorded in the form of a feature table and tagged in the directory. It is regenerated from original data using the directory tags and the feature table as control.

PROJECTION

Map projection, e.g. Lambert Conformal.

RESERVE IMAGE

See Generic image.

RESOLUTION

This phrase is applied to the unit value used in the absolute coordinate. This need not be the same as the increment size.

SCALING

No true scaling of data is at present available. Its implementation would require the use of the EAE (Extended Arithmetic Element). The binary scale system provides an approximation to the desired scale and this is usually sufficient. When examining digitized or drafting data a true 1:1 scale is available within the accuracy limits of the display.

SCREEN

The face of the Tektronix 611 upon which the image appears.

SET

A subdivision of data contained within a descriptor defining its type. e.g. digitized data, databank data, display addition data, etc. It is designated by the 4th alphanumeric of the descriptor.

SINGLE COORD. PAIR SYMBOL

A simple symbol whose centre is specified (with or without offset) and the shape is stored as a matrix of dots. A number may be grouped to form a composite.

SMALL

A specification of "S" followed by a digit produces a reduced sized image about the same centre. Symbolization is not available and only preset selections of data are available. Symbols appear as dots and

lines are of minimum thickness.

SOUNDINGS (HYDROGRAPHIC)

A numerical value representing depth of water. Never exceeds 4 digits or 3 digits with decimal point (or slash).

SWAP

An interchange of routines between core and disc storage takes approx. 80 msecs. for 4k words.

TAGS

A complex system of bit designation automatically handling the control of the different images, noting data which has been changed, etc.

TEKTRONIX 611

A storage CRT display unit with'write thru'spot capabilities.