A COMPUTER COMPATIBLE

GRAPHIC NOTATION FOR

THE MANUAL ALHPABET

by

Cynthia Lynne Ireland

B.S., University of Kansas, 1976

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A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas
1980

Approved by:

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Major Professor

# ACKNOWLEDGEMENTS

There are many people to thank for their help in this research endeavor.

A very large thanks goes to Dr. Elizabeth Unger, who was always available when problems arose and whose guideance and helpfulness were unmeasurable.

I would also like to thank the other members of my committee, Dr. Paul Fisher and Dr. Rod Bates. I appreciate the time they took out of their busy schedules to serve on this committee.

Thanks also goes to Brian Ferguson whose technical expertise on the Chromatics graphic system was of great help during implementation.

The largest thanks goes to my husband, Patrick Ireland, whose brilliance and inate abilities on a multitude of areas are only surpassed by his loving devotion.

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

# TABLE OF CONTENTS

## LIST OF FIGURES

# CHAPTER 1

## 1.1 INTRODUCTION

The use of computers in education and training of the handicapped in the United States has been increasing in the last several years. Our research indicates little has been done with computers to aid the deaf individual. The most productive group seems to be the New York Technological Institute for the Deaf. However, much more can be done to provide the deaf with linguistic help via media involving computers. There is a need to teach deaf children especially the very young deaf child and his/her parents a signing system. This form of education or training is amenable to the application of drill and practice using a graphic computer system for display of the signs. However, there is no appropriate notational system presently available in which to express the positions and movement of the finger-hand placement in the Computer production of these signs. The development of a notation that may be easily used with most common Computer Graphic Systems for the production of manual signs is the general goal of the Master's Report.

The terms manual symbol, sign language,

finger-spelling, and symbols are used frequently in this paper. The manual alphabet is the hand formation of the letters in the alphabet, While symbols are used to refer to a sign that may be created using the hand in the formation. Sign language consists of visible movements of the hands, many which have derived from natural gestures. Finally finger spelling differs from signing in that it is used when a sign is unavailable. In such case the word is "finger spelled" using the manual alphabet for the deaf.

## 1.2 BACKGROUND

In spite of the progress made towards acceptance of handicapped individuals, the deaf generally are known to only a few "outsiders". The deaf are largely excluded by their communication handicap from ordinary society, and tend to group together and form their own community within the wider society (Furth, 1966). Among themselves the deaf communicate in the "language of signs", a system of conventional manual symbols supplemented by some finger spelling. Sign language is not a dialect form of English or any other language. Sign language as used in the United States may be traced to manual symbols introduced from France in 1816 at the time when the first United States school for the deaf was founded at Harvard Connecticut. Sign language is no longer taught in most schools but acquired by the deaf child in associations with other deaf persons. Sign language is considered to be a living language in that it fulfills the primary function of language, providing communication.

For two reasons we decided to work with the manual alphabet instead of signs. The first reason is the fact the manual alphabet must be used whenever there is no symbol to represent the chosen word. Additionally, our research indicates that all but a few of the most simple terms involved in computing must be finger spelled. Secondly, the manual alphabet is smaller and has more constrained graphic problems. The manual alphabet has 26 symbols expressed by the hand.

The literature provided only two graphic notations that are used to represent human movement. These two graphic notation systems are Eschkol-Wachmann Movement Notation and Laban Movement Notation (LABANOTATION). The major problem with these two notations is that they do not describe in detail finger and hand movement. Therefore, we were forced to either extend one of the existing systems or create a new notation. After examining the existing systems (Eschkol-Wachmann and Laban) it was determined that a new notation was appropriate.

The major emphasis of this paper is the presentation of a graphics notation and the preliminary design of a model which will represent the manual alphabet of the deaf. The graphic notation was designed to ease understanding and use by both the Computer Scientists and individuals who work with the deaf. The graph on which the notation is placed was designed to look similar to a table where each finger is represented as a column in the table and each segment (part) of the finger is represented by rows of the table

## 1.3 OVERVIEW OF THE REPORT

In the next chapter, a general background explains the problems of the deaf,followed by potential advancements for the deaf and potential advancements for computer science. One of the advancements for the deaf is the acquisition of a new tool, which will help them learn signs. This tool may also be considered a basice building block to development of verbalization by the deaf child. Advancements for computer science could include research of a new field, evaluations of two existing notations for representing human movement and a new computer-compatable graphic notation to represent human movement.

Chapter 3 presents two existing graphic notations and evaluates their deficiencies for the needs present in our work.

Chapter 4 contains the new notation capable of representing the manual alphabet with characteristics which lend it to computer translation. Included in chapter four is a series of figures which represent the hand in a formal manual representation, the notation in table form, and the suggested computer representation of each letter in the manual alphabet.

General implementation of the manual alphabet including a example of the letter B, is discussed in chapter 5.

The concluding chapter of the study evaluates the results and gives direction for future work.

# CHAPTER 2

## 2.1 PROBLEMS OF THE DEAF

Because deafness is an invisible and almost unnoticable disability which manifests itself mainly in the failure to communicate, hearing people can not readily understand the effects of the handicap, Profound childhood deafness. More than a medical diagnosis, it is a cultural phenomenon in which social, emotional,linguistic and intellectual patterns are bound together. The diagnosis immediately plunges parents and children into a potential conflict between the exclusive use of muffled or non-existant sounds and the exclusive use of auxiliary visual gestural signs. From our vantage point, parents and professionals must consider the optimal growth patterns of the deaf infant from diagnosis to adulthood, if they are to provide him with the key ingredient in the developmental process, i.e. communication with others. For the deaf infant meaningful and joyful communication does not evolve naturally and without conflict as it does in hearing infants. If the deaf child has normal hearing parents they may find his handicap difficult to accept. Their efforts to mold their child into their image may cause a negativism that focuses on the very skills the parents are most anxious to encourage: speech, lipreading, and (native) language development.

Cognitive retardation and psychological maladapation remains frequent among deaf children and adults, the core of these difficulties may lie in the absence of gratifying reciprocal communication with the family during the deaf childs early years. A lack of meaningful language in the early years may contribute to low school achievement of deaf students. The biologically appropriate time for learning a first language is before the age of three. In this "critical period" the infants intelligence blossoms in symbol formation (Furth 1966). During this "critical period" language and cognitive development are acquired easily. If the critical peroid has passed, then language acquisition is much more difficult. psychologists stress the importance of the first few years of life for cognitive development and language acquisition. Many deaf children do not receive any language training until the age 6 when they are placed in school,clearly this is too late to fall within the critical period.

Although deaf children are usually surrounded by hearing persons in their homes and in their neighborhoods,generally their schoolmates are also deaf. The language of manual signs is seen by the hearing community as the hallmark of a deaf person. While sign language is known by almost all deaf adults it is often prohibited to deaf children. It is then learned surreptitiously from peers and quite frequently hidden from hearing adults. This ban against a potentially helpful means of communication emanates for a pervasive fear that the use of signs will inhibit the develoment of speech and lipreading skills as well as oral skills which are seen by hearing parents as the badge of entry into their world - THE HEARING WORLD.

## 2.2 POTENTIAL ADVANCEMENTS FOR THE DEAF INDIVIDUALS

Instead of being feared, the use of signs should be encouraged at a very early age(Brill,1974). The use of signs by the deaf child helps him/her to acquire the basic language building blocks. The normal hearing child understands his mothers verbal communication long before he himself can verbalize. How can the deaf child be expected to acquire speech and lip reading without prior linguistic acquistion?

A computer compatible notation for manual signs will give the deaf child a tool to help him acquire the manual alphabet as a first step to eventual verbalization. Verbalization should be the ultimate goal but we should not expect the deaf child to verbalize without acquisition of the basic linguistic building blocks. The system will help the deaf child's family and other hearing adults in that they will be able to learn a communication tool for use with the deaf individual.

## 2.3 POTENTIAL ADVANCEMENTS FOR COMPUTER SCIENCE

In the research area of Computers and the Deaf, research shows The New York Technical Institute for the Deaf is the most productive group. John Vonfeldt seems the most productive member of the group, as he has published 3 papers in the area of Computers and the Deaf. The first describes a Computer Assisted instruction program which used instruction which used phonetic or diacritical markings for students to learn to speak more clearly. The procedure they used was similar to the use of a phonetic dictionary to aid the deaf individual in speaking. The Computer was used to keep track of the students progress. The second paper described a Computer Assisted Instruction course in basic business rules and procedures. The third paper dealt with the developmental of a prototype system designed to merge the strengths of computer-assisted instruction,data gathering,interactive learning with color and audio features of television. The Creation of the prototype was to allow testing of both television and interactive computer assisted instruction strategies in auditory and speech therapy. An other paper from The New York Technical Institute for the Deaf was written by Walter Geard and John Vonfeldt. This paper compared two methods of English instruction for adult deaf students. The methods where Computer Assisted Instruction and normal classroom environment. The results indicated that there was no learning result differences in the two methods, the authors, however, stated this was probably due to a design fault in the experiment.

The only other relevant article discovered the literature search that dealt with Computers and the Deaf was authored by Benet Freund who was the project director for the Minnesota school for the Deaf. In his paper,he described the type of computer asssisted instruction available at The Minnesota School for the Deaf. The work done by the New York Technical Institute for the Deaf and by Freund are all aimed at computer instruction for the deaf adult. The work we are doing is aimed at a more fundimental level that of the deaf child and his family.

The work described in this paper makes three contributions to Computer Science. The first of these contributions is a search of the literature on computers and the deaf. The sparsity of literature points out the need for additional studies in the area of Computers and the Deaf. The second contribution is the evaluation of the deficiencies of the existing notational systems for representing human body position and movement as is demanded for the representation of the manual alphabet and the third contribution is the development of a new graphic notation for use with the fingers and hand. This could be used with any application which requires graphic representation of the fingers and hand.

# CHAPTER 3

## 3.1 INTRODUCTION

The two notations are described in section 3.2 and 3.3 they are Laban Movement Notation and Eschkol-Wachmann Movement Notation. An evaluation of these systems are described in 3.4.

We searched for a graphic system capable of representing human movement. To this end two existing systems for representing human movement were discovered. They are Laban Movement Notation (also know as Kinetography) and Eschkol-Wachmann Movement Notation. The following list represents the capabilities we wanted from a notation.

1. Capability of representing movement.
2. Capability of representing finger movement.
3. Ability to change positions of various parts of individual fingers.
4. Ease of understandability to both Computer and lay people.
5. Possibility of computer implementaion.

## 3.2 Labanotation

The labanotation is based upon an abstraction of the structure of the human body. The basic elements of this abstraction are the individual joints and extremities of the body. Figure 1 shows an illustration of Labanotation. The essential task of labanotation is to describe the positions and trajectories of a set of points in space. The position of each joint is specified with respect to a cross of axis which defines a rectangular coordinate system.

Movement may be expressed by using 5 types of description:

(1) direction signs

(2) revolution signs

(3) facing signs

(4) contact signs

(5) shape descriptions

The direction signs describe the translation of the joint while the revolution signs allow for description of various forms of rotational movement like turning or twisting. Facing signs involve the establishment of an orientation of some point on the surface of the body part while contact signs indicate contact of the body parts with other body parts or the floor. Finally shape descriptions are used to describe the tracing of a path or formation of a shape by some body part.

Labanotation uses abstract symbols to indicate various parts of the body. This is shown in figure 2.

Figure 3 illustrates the basic organization of the staff into columns and the structure of the direction signs.

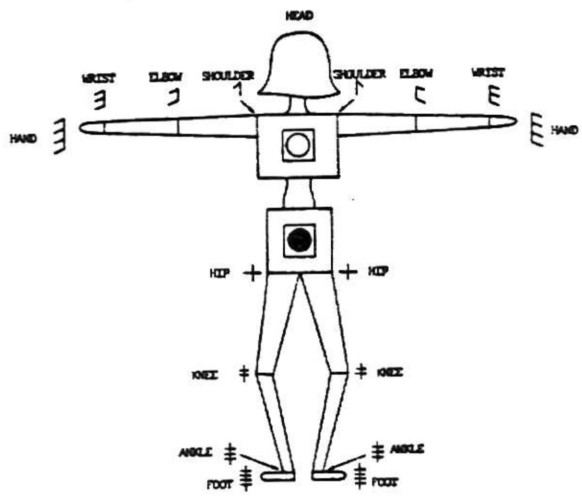



Figure 1.   ILLUSTRATION OF LABAN MOVEMENT NOTATION

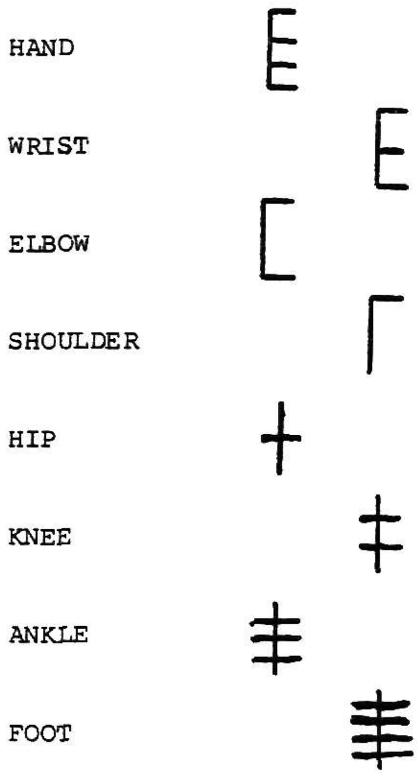



Figure 2. SYMBOLS IN LABANOTATION

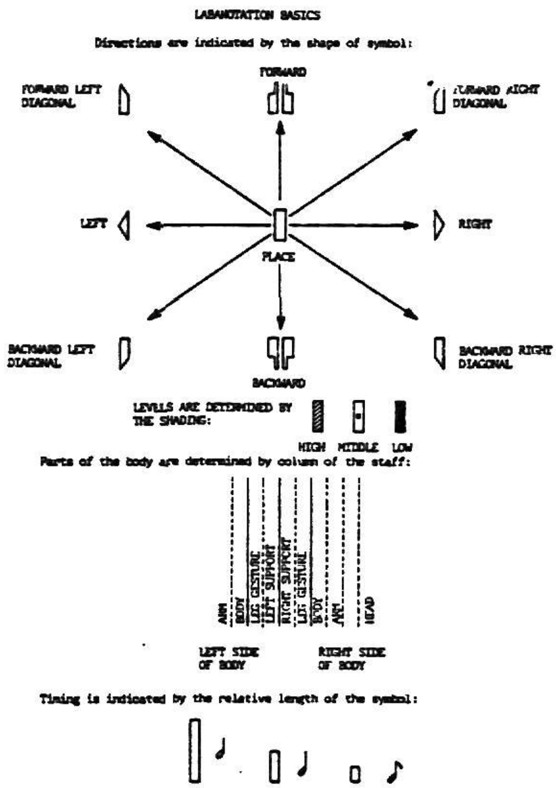



Figure 3. THE BASIC'S OF LABANOTATION

## 3.3 ESCHKOL-WACHMANN NOTATION

The structure of the human body is abstracted somewhat differently in the Eshckol-Wachmann notation (see Figure 4). While Labanotation views the body as a set of joints connected by limbs, Eschkol-Wachmann Notation views it as a set of limbs connected by joints. Where each limb has associated with it a longitudinal axis. The orientation of the longitudinal axis is determined with respect to a rectangular cross of axis, however, it is not as flexable as labanotation.

In the Eschkol-Wachmann notation, there is a law of light and heavy limbs. This law states that when a given limb moves it carries along limbs which do not lie between it and the support of the entire body. For example, when the body is standing on both feet, movement of the right upper arm implies movement of the entire right arm as a rigid body unless movement of the forearm is specifically stated. The usual mode of description is similar to those expressed by labanotation. The following are movements which can be used in the Eschkol-Wachmann notation:

1. Longitudinal movement
2. Plane movement
3. Curved movement
4. Specific description

Longitudinal movement refers to the type of movement a

Figure 4. ILLUSTRATION OF ESCHKOL-WACHMANN MOVEMENT NOTATION

limb can make about its longitudinal axis. Plane and curved movement are both formed when the longitudinal axis sweeps out a curved surface. The difference is that the plane movement is achieved by moving at right angles to the axis while the curved movement is achieved by moving at an acute angle to the axis of movement. Finally, movement may be defined by specifying the position a limb is to assume.

The alternative approach to movement description deals with how the body concentrates its energies (effort qualities). Effort qualities can be described in terms of the combinations of the following four parameters:

1. Tension flow
2. Weight
3. Time
4. Space

Tension flow describes the boundedness of movement. The weight parameter describes a quality of lightness or forcefulness with respect to the build of the body. The time parameter indicates the duration of the movement, i.e., sustained or sudden. The final parameter space deals with the spatial focus of movement, to indicate whether it is directed to a single focal point or indirectly divided among many foci.

## 3.4 EVALUATION OF THE TWO EXISTING SYSTEMS.

1. Neither system deals with movement of fingers of the hand

2. The use of symbols results in a system where the diagram of desired movement is difficult to understand, it thus impedes implementation in a graphical system as it often forces the user to reference a symbol chart to decode or encode the meaning of a symbol.

3. When forming the letters of the manual alphabet, only one hand-finger combination is used. Therefore, we need not be concerned, at this time, with the body. Future extensions of our new system may need signs to include body movement when forming the more complicated manual symbols of the deaf.

4. Eschkol-Wachmann notation and Labanotation are concerned with the orientation of the hand. For our purposes the hand always faces the viewer and takes on two positions within that orientation, upright and on its side.

5. Timing is not relative to the formulation of manual alphabetic signs.

# CHAPTER 4

# A NEW NOTATIONAL SYSTEM

## 4.1 INTRODUCTION

The system developed is different from Eschkol-Wachmann and Labanotation in that it is directly concerned only with finger-hand movement. The second major difference is that while the other two systems use a plethora of symbols for their notation this system uses only the letters and numbers. This change is an effort to make the notation more readable, understandable, and directly translatable to computer code for a graphics system. Software engineering principles indicate the simularity and familiarity of the notational symbols should bring about coding efficiencies and thus reduce errors.

Section 4.2 is a desription of the general notation that we developed. Section 4.3 lists the special cases that arise in using the notation in forming the manual alphabet. Section 4.4 describes and lists the formal hand drawing, the notation in table form, and the suggested computer representation of the letters of the manual alphabet.

4.2 DESCRIPTION

The fingers are indicated by F1, F2, F3, F4, F5. Where F1 is considered to be the thumb and F2 thru F5 are the fingers, starting with F2 for the index finger. Movement of the fingers causes parts (segments) of the fingers to be moved. There are 3 natural bends made by each of the 4 fingers, while the thumb has 2 natural bends. Figure 5 shows the representation of the segmentation of the fingers.

B1 indicates a bend in the joint closest to the palm. B2 indicates a bend in the middle joint of the finger, while B3 indicates a bend in the joint farthest from the palm. As previously stated, the thumb has only 2 natural bends therefore bends in the thumb are indicated by only B1 and B2.

No bend in a joint is represented by an E in a table cell. Side motion to the right (with respect to the viewer) is indicated by E> and side motion to the left is by E<, while Possible notations for indicating a straight or side motion is a follows:

E a fully extended finger which is straight up.

E> a fully extended finger but it is slightly to the right

E< a fully extended finger but is slightly to the left.

A table of 4 horizontal rows intersected and 5 vertical columns will be used to indicate the position of each finger and joints in forming each letter of the manual alphabet. The order

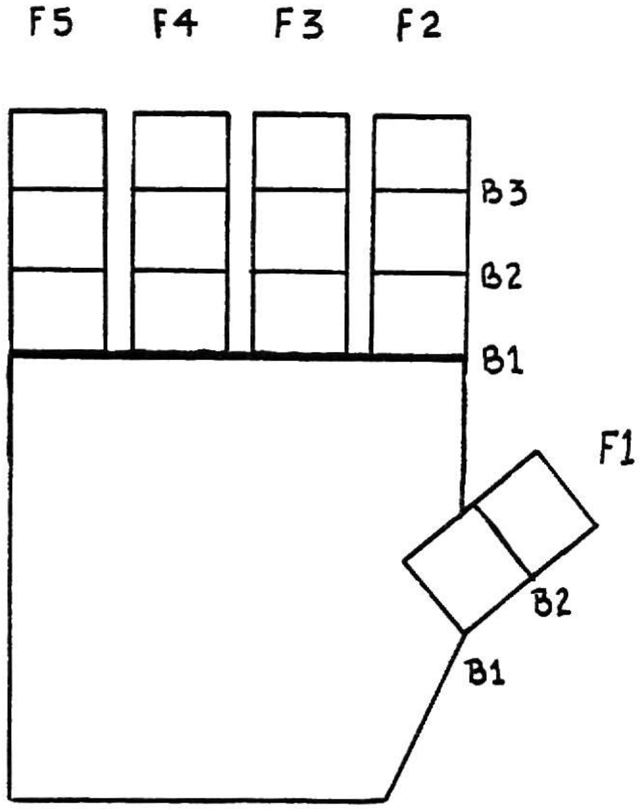



Figure 5. GRAPHIC COMPUTER REPRESENTATION OF THE HAND

of the columns of the table is dependent upon the order of the digit in appearance when the sign is formed. For example, the letter F has the thumb labeled F1 in the first column of the table. The next four fingers(F1 thru F5) are in the next four columns (see figure 8B). However, the letter K has the thumb in the second position and the finger F2 first in appearance (see figure 11B ).

The rows are labeled on the left of the table. Row 1 is labeled finger. The second, third, and fourth rows are labeled Part 1, Part 2, and Part 3. Part 1 contains the notation for representing movement in the segment of the finger closest from the palm, while the notation for the second segment or the middle segment of the finger is placed in the row labeled Part 2.

For example, the letter "B" has the thumb (F1) in the first column of the table, with the next four fingers in the following columns. The movement of the thumb is moved to the left in both the first and second segment. This is represented by E< in row 1 and row 2 under F1. The four fingers are fully extended in all 3 segments of the finger so an E is placed in rows 1, 2, and 3 under the columns F2, F3, F4 and F5 (see figure 6B).

4.3 SPECIAL CASES

A vacant position in the table part 3 (row 3) in the thumb column (F1) is due to the fact there is no third segment of the thumb. This blank cell which will occur in row 4 of the table is used to indicate special cases. There are four instances where a special symbol may be placed into the table.

The first instance occurs when the thumb touches a finger. This is the case in the formation of letters D, F, and R. The notation to indicate this special case is Tn where n is the number of the finger touched. Examples of how this appear in the notation may be found in figures 7B, 8B, or 14B.

The second instance is when there is movement in the formation of the sign. The letters involved in this are J and Z. The notation for representing this movement in the table is a M followed by either a J or Z depending on which letter is being formed (See figure 10B or 18B).

In the third special case, the hand is not in an upright position but is on its side. The notation to represent this is an S inserted in the normally vacant cell. Examples can be found in figures 9B and 13B.

The fourth special case occurs when the letters are formed with the thumb between two of the fingers. A BTW is inserted in the vacant cell to encode the information. Examples of this occur in the letters M, N, T, and K.

## 4.4 REPRESENTATION OF LETTERS

This section contains the figures which represent the formal manual representation, the notation in table form, and the Computer representation of each letter in the manual alphabet.

The formal manual representation is an artistic drawing of the manual alphabet for the deaf. The drawings were sketched by hand using line drawings in the manual alphabet form Rickenhof's book "Talk to the Deaf". By examining these drawings it can be percieved that the hand always faces the viewer when forming the manual alphabet. The second observation is that only one hand is required to form the letters of the manual alphabet.

Following the formal manual representation of a letter is the tabular notation developed. Finally, a stylized representation is given as a suggestion for graphic computer representation.

While the formal representation is naturally curved and has softer lines, the Computer representation is more rectangular in design. It is easy to identify the representation as a human hand with the fingers forming various letters of the manual alphabet. If a color grapic capabality is available it is suggested that the implementation show the fingers each in a different color to aid discrimination.

The formal representation of the human right hand forming each letter,the notation for each letter, and the Computer representation of the human right hand for the entire alphabet are contained in the following figrues.

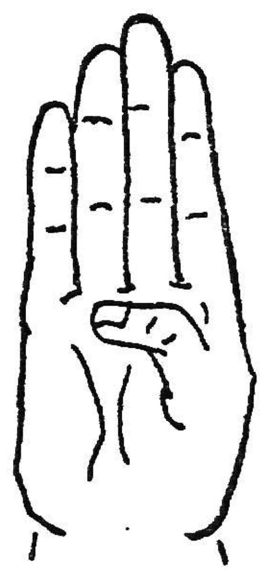


FIGURE 6A.    FORMAL REPRESENTATION OF LETTERS A & B

THE LETTER 'A'

| FINGER | F1 | F2 | F3 | F4 | F5 |
| --- | --- | --- | --- | --- | --- |
| PART 1 | E | B3 | B3 | B3 | B3 |
| PART 2 | E | B2 | B2 | B2 | B2 |
| PART 3 | | E | E | E | E |

THE LETTER 'B'

| FINGER | F1 | F2 | F3 | F4 | F5 |
| --- | --- | --- | --- | --- | --- |
| PART 1 | E< | E | E | E | E |
| PART 2 | E< | E | E | E | E |
| PART 3 | | E | E | E | E |

FIGURE 6B. TABLE NOTATION OF LETTERS A & B

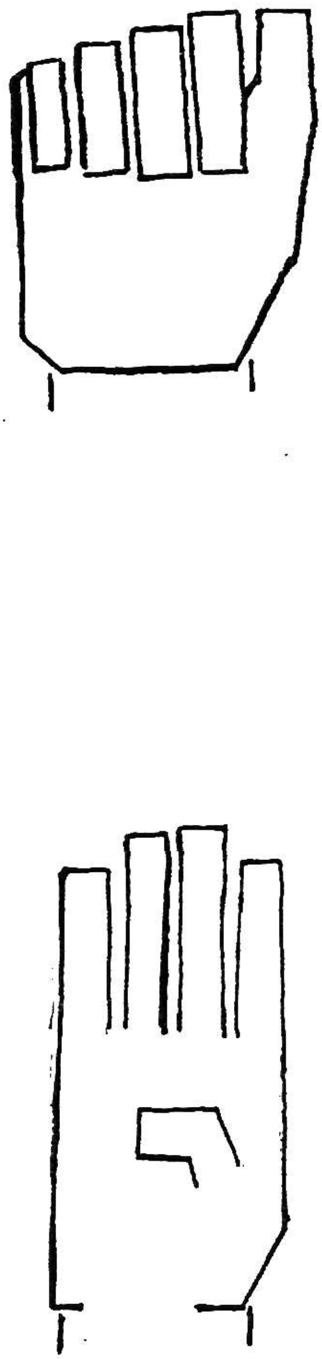


FIGURE 6C.    COMPUTER REPRESENTATION OF LETTERS A & B

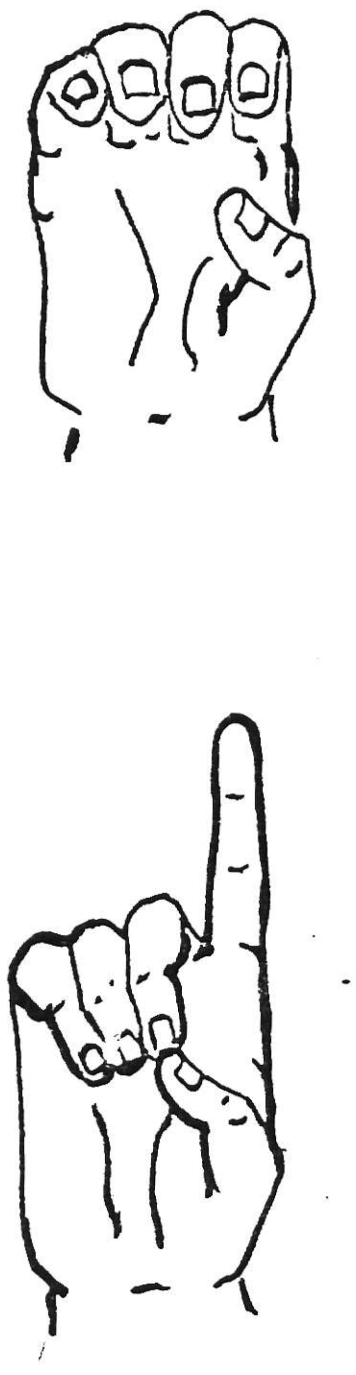


FIGURE 7A.    FORMAL REPRESENTATION OF LETTERS C & D

THE LETTER 'C'

| FINGER | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| PART 1 | B2 | E | E | E | E |
| PART 2 | B1 | B2 | B2 | B2 | B2 |
| PART 3 | | B1 | B1 | B1 | B1 |

THE LETTER 'D'

| FINGER | F2 | F1 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| PART 1 | E | E< | B3 | B3 | B3 |
| PART 2 | E | E< | B2 | B2 | B2 |
| PART 3 | E | TF3 | E | E | E |

FIGURE 7B. TABLE NOTATION OF LETTERS C & D

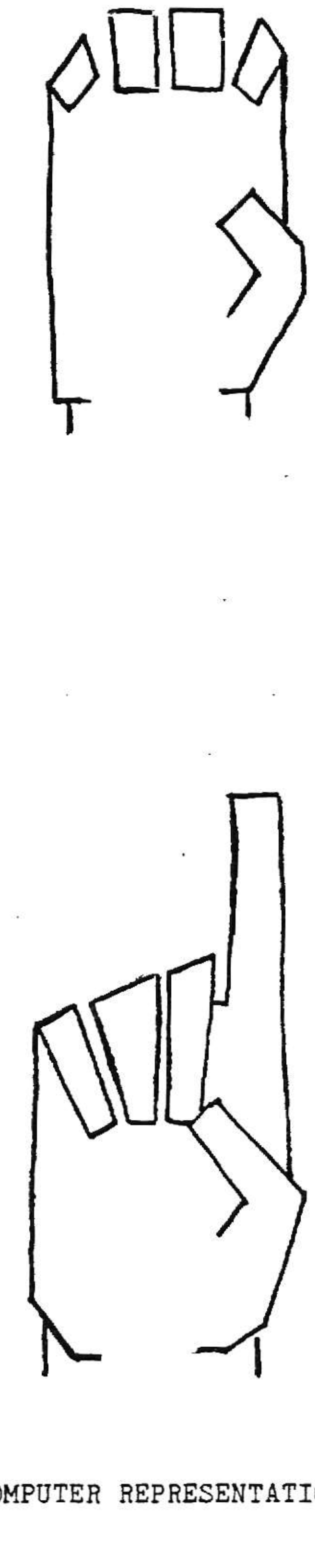


FIGURE 7C. COMPUTER REPRESENTATION OF LETTERS C & D

FIGURE 8A. FORMAL REPRESENTATION OF LETTERS E & F

THE LETTER 'E'

| FINGER | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| PART 1 | E< | B3 | B3 | B3 | B3 |
| PART 2 | E< | B2 | B2 | B2 | B2 |
| PART 3 | | B1 | B1 | B1 | B1 |

THE LETTER 'F'

| FINGER | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| PART 1 | E< | E | E | E | E |
| PART 2 | E< | B2 | E | E | E |
| PART 3 | TF2 | B1 | E | E | E |

FIGURE 8B. TABLE NOTATION OF LETTERS E & F

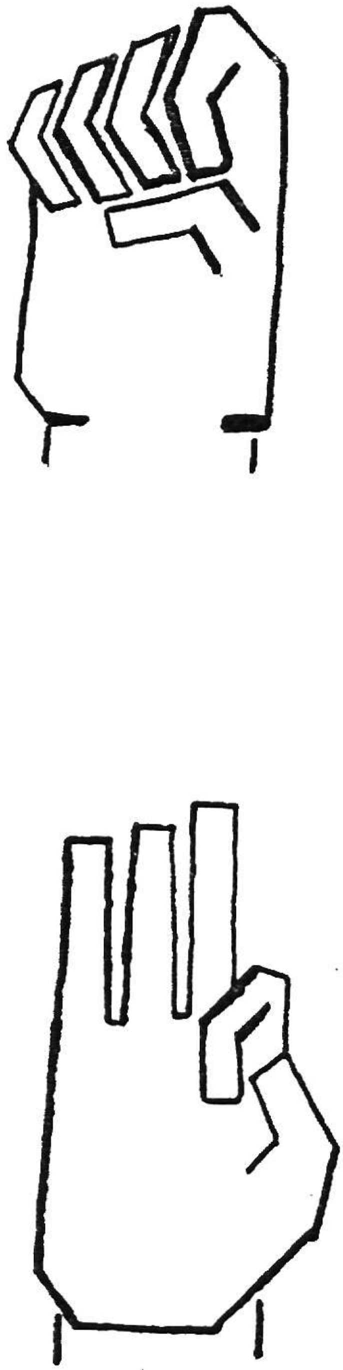


FIGURE 8C. COMPUTER REPRESENTATION OF LETTERS E & F

FIGURE 9A. FORMAL REPRESENTATION OF THE LETTERS G & H

THE LETTER 'G'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F1 | F3 | F4 | F5 |
| PART 1 | E | E< | B3 | B3 | B3 |
| PART 2 | E | E< | B2 | B2 | B2 |
| PART 3 | E | S | E | E | E |

THE LETTER 'H'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F3 | F1 | F4 | F5 |
| PART 1 | E | E | E< | B3 | B3 |
| PART 2 | E | E | E< | B2 | B2 |
| PART 3 | E | E | S | E | E |

FIGURE 9B. TABLE NOTATION OF LETTERS G & H

FIGURE 9C. COMPUTER REPRESENTATION OF THE LETTERS G & H

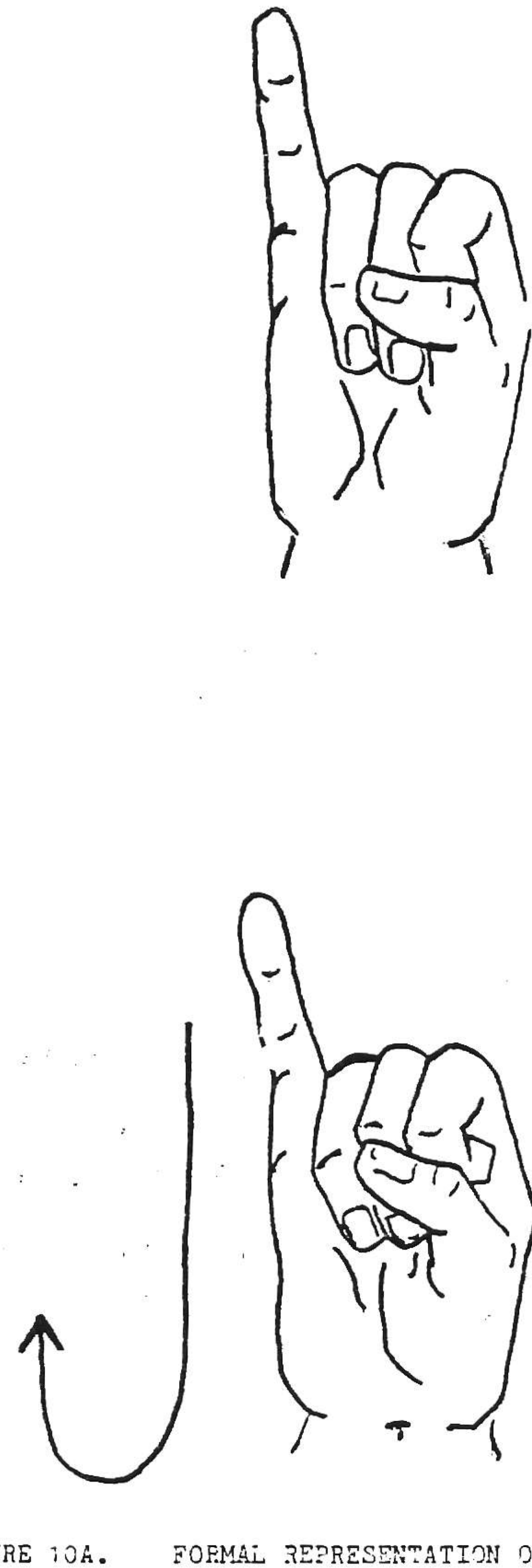


FIGURE 10A. FORMAL REPRESENTATION OF THE LETTERS I & J

THE LETTER 'I'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F1 | F2 | F3 | F4 | F5 |
| PART 1 | E< | B3 | B3 | B3 | E |
| PART 2 | E< | B2 | B2 | B2 | E |
| PART 3 | | E | E | E | E |

THE LETTER 'J'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F1 | F2 | F3 | F4 | F5 |
| PART 1 | E< | B3 | B3 | B3 | E |
| PART 2 | E< | B2 | B2 | B2 | E |
| PART 3 | MJ | E | E | E | E |

FIGURE 10B. TABLE NOTATION OF LETTERS I & J

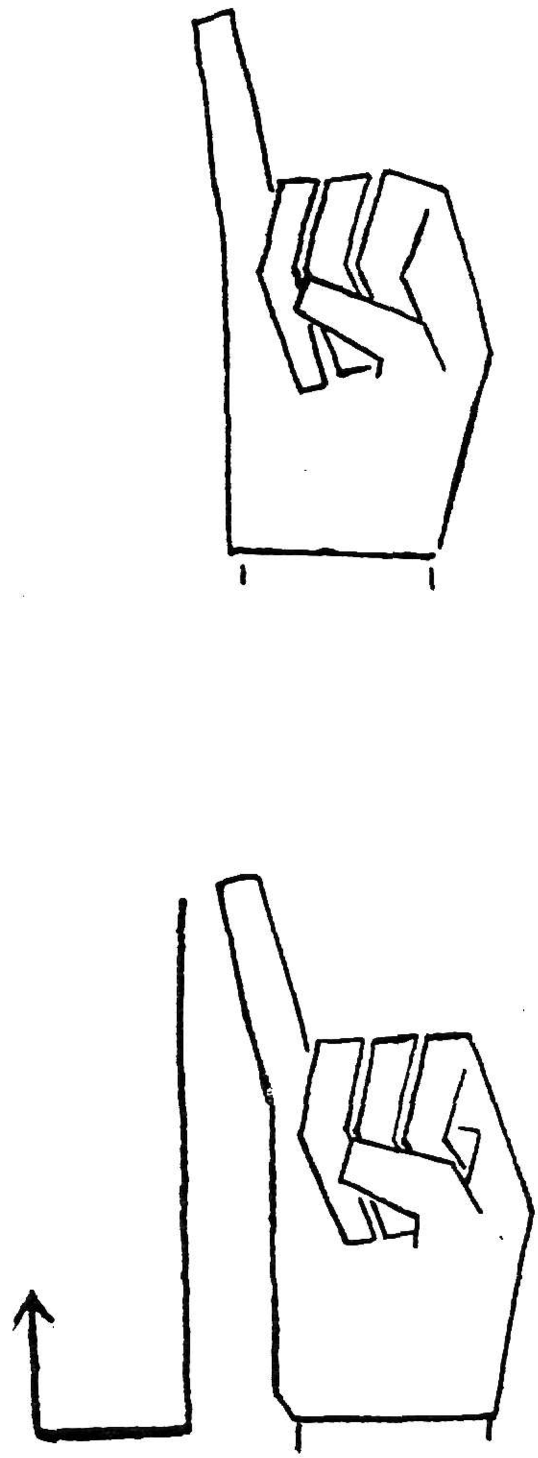


FIGURE 10C.    COMPUTER REPRESENTATION OF LETTERS I & J

FIGURE 11A FORMAL REPRESENTATION OF THE LETTERS K & L

THE LETTER 'K'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F3 | F1 | F4 | F5 |
| PART 1 | E> | E< | E | B3 | B3 |
| PART 2 | E> | E< | E | B2 | B2 |
| PART 3 | E> | E | BTW | E | E |

THE LETTER 'L'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F1 | F2 | F3 | F4 | F5 |
| PART 1 | E> | E | B3 | B3 | B3 |
| PART 2 | E> | E | B2 | B2 | B2 |
| PART 3 | | E | E | E | E |

FIGURE 11B. TABLE NOTATION OF LETTERS K & L

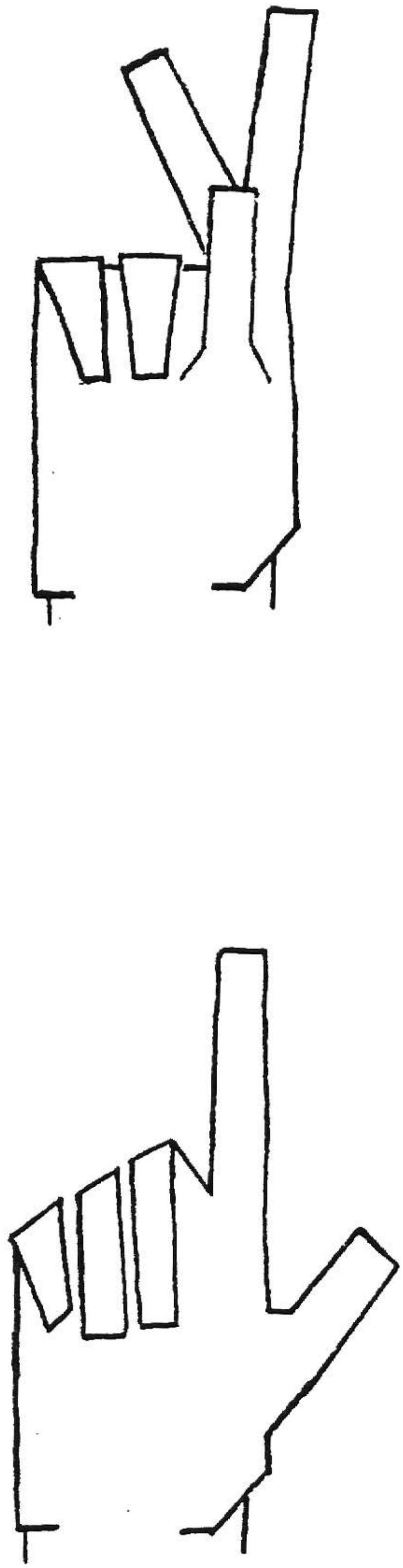
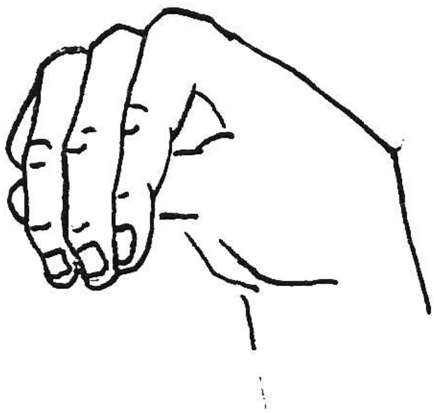


FIGURE 11C. COMPUTER REPRESENTATION OF LETTERS K & L



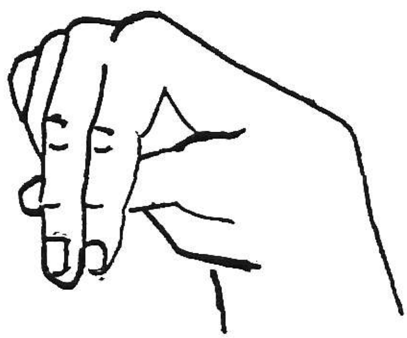


FIGURE 12A. FORMAL REPRESENTATION OF THE LETTERS M & N

THE LETTER 'M'

| FINGER | F5 | F1 | F2 | F3 | F4 |
|---|---|---|---|---|---|
| PART 1 | B3 | E< | B3 | B3 | B3 |
| PART 2 | B2 | E< | B2 | B2 | B2 |
| PART 3 | E | BTW | E | E | E |

THE LETTER 'N'

| FINGER | F5 | F4 | F1 | F2 | F3 |
|---|---|---|---|---|---|
| PART 1 | B3 | B3 | E< | B3 | B3 |
| PART 2 | B2 | B2 | E< | B2 | B2 |
| PART 3 | E | E | BTW | E | E |

FIGURE 12B. TABLE NOTATION OF LETTERS M & N

FIGURE 12C. COMPUTER REPRESENTATION OF LETTERS M & N

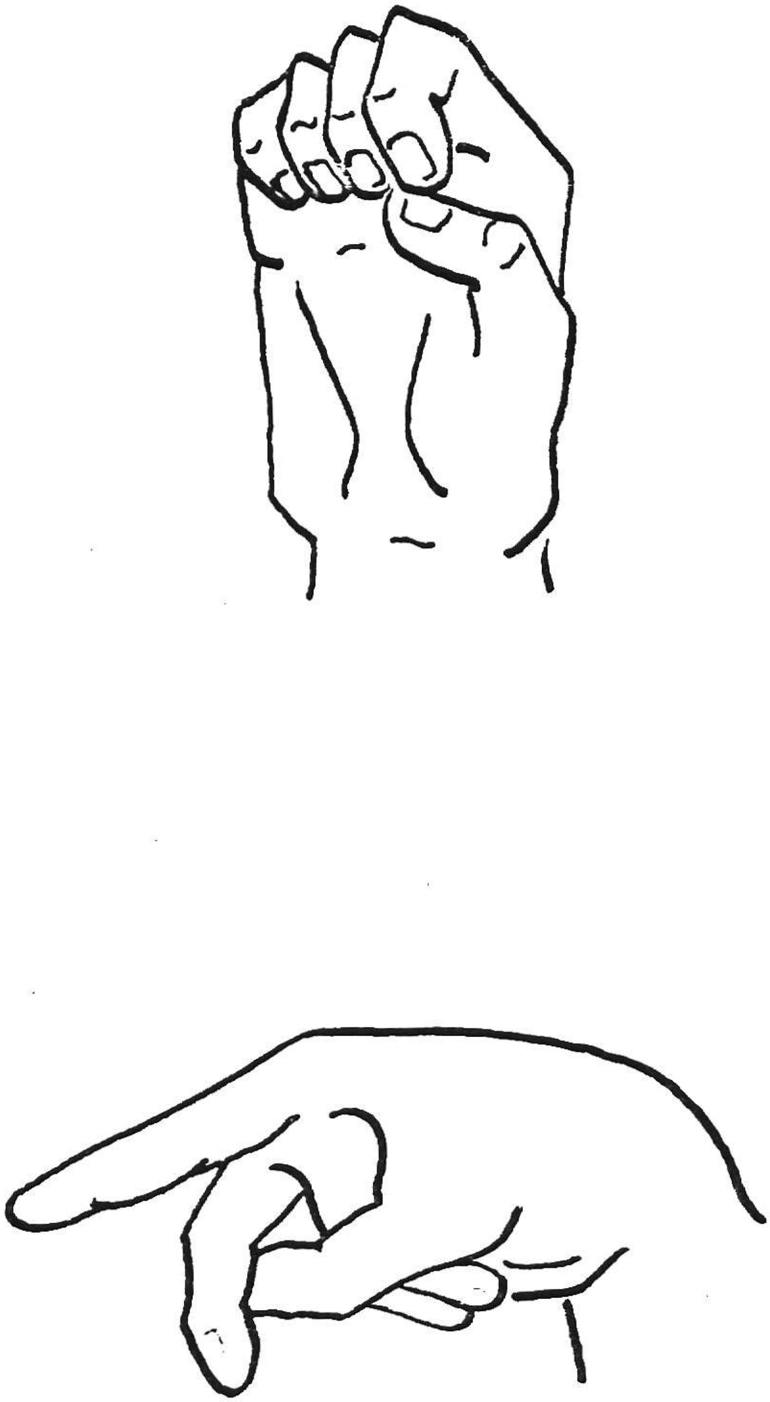


FIGURE 13A. FORMAL REPRESENTATION OF THE LETTERS O & P

THE LETTER 'O'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F1 | F2 | F3 | F4 | F5 |
| PART 1 | E< | B3 | B3 | B3 | B3 |
| PART 2 | E< | B2 | B2 | B2 | B2 |
| PART 3 | | B1 | B1 | B1 | B1 |

THE LETTER 'P'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F3 | F1 | F4 | F5 |
| PART 1 | E> | E | E< | B3 | B3 |
| PART 2 | E> | E | E< | B2 | B2 |
| PART 3 | E> | E | S | E | E |

FIGURE 13B. TABLE NOTATION OF LETTERS O & P

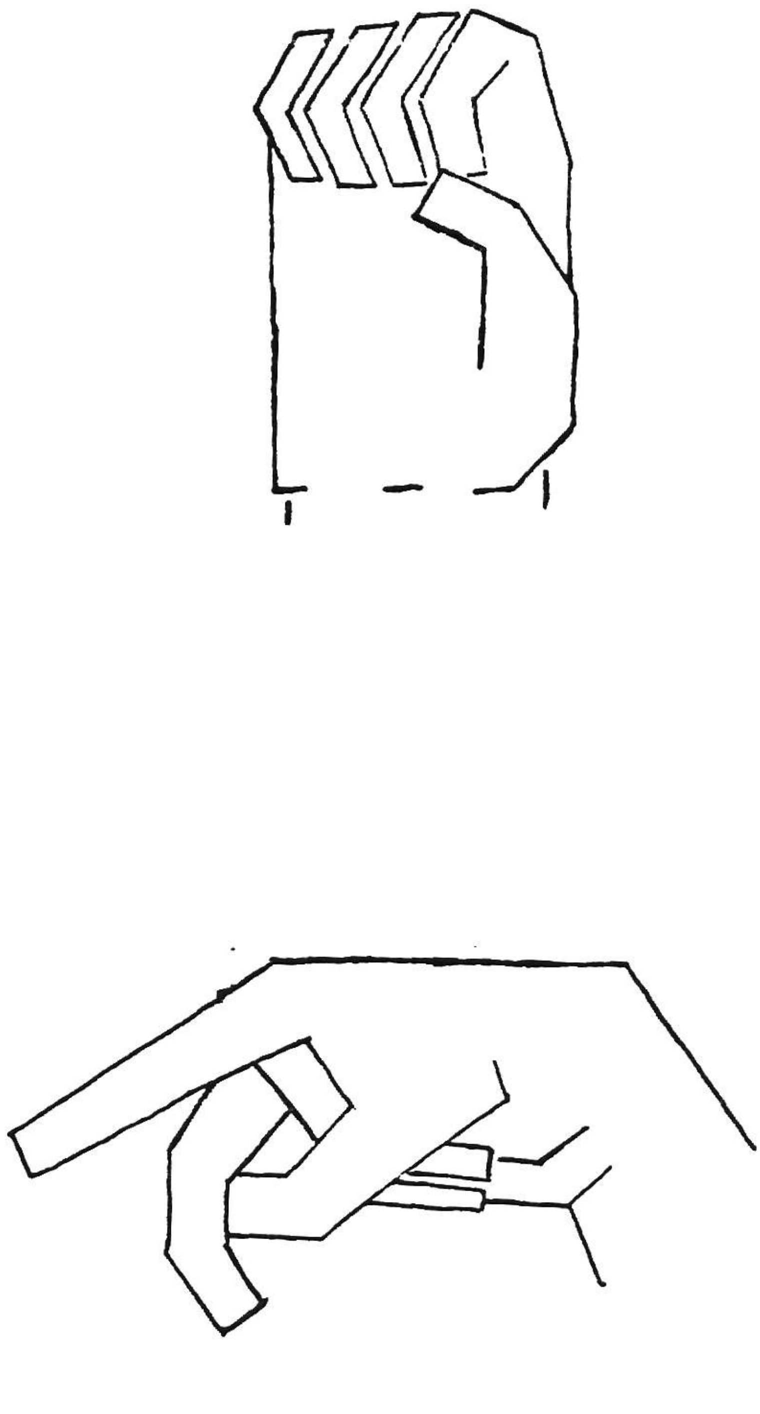


FIGURE 13C. COMPUTER REPRESENTATION OF LETTERS O & P

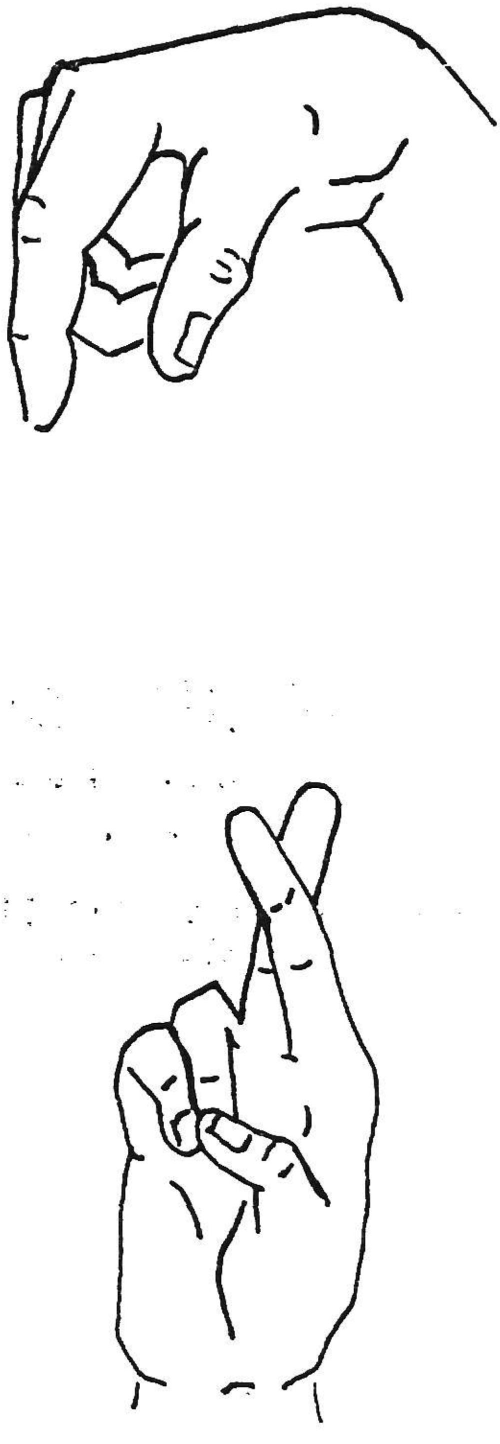


FIGURE 14A. FORMAL REPRESENTATION OF THE LETTERS Q & R

THE LETTER 'Q'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F5 | F4 | F3 | F2 | F1 |
| PART 1 | B3 | B3 | B3 | B3 | E< |
| PART 2 | B2 | B2 | B2 | E | E< |
| PART 3 | E | E | E | E | |

THE LETTER 'R'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F5 | F4 | F3 | F2 | F1 |
| PART 1 | B3 | B3 | E | E< | E< |
| PART 2 | B2 | B2 | E | E< | E< |
| PART 3 | E | E | E | E< | TF4 |

FIGURE 14B. TABLE NOTATION OF LETTERS Q & R

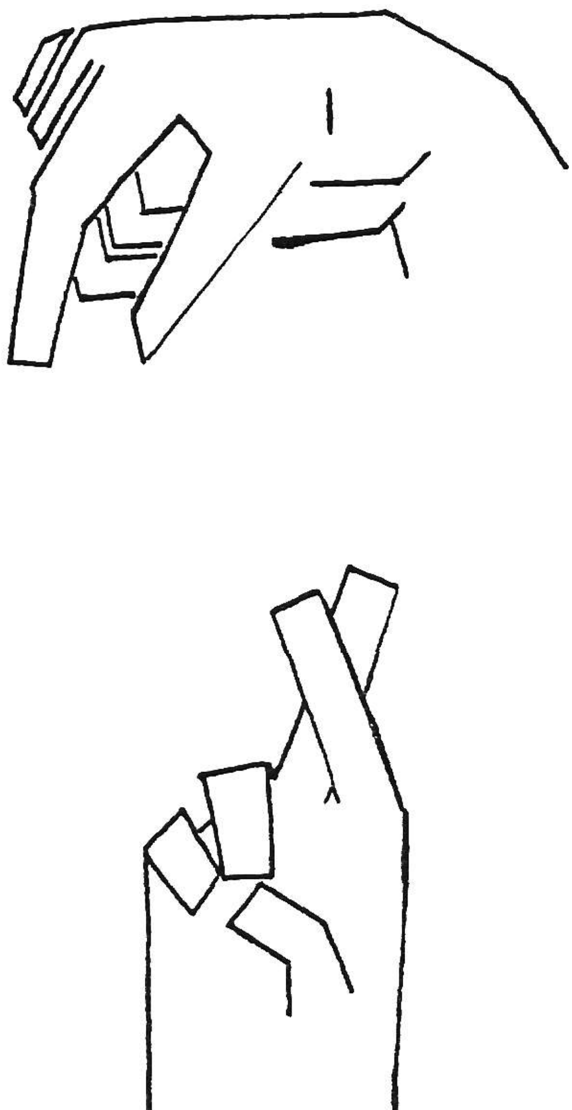


FIGURE 14C. COMPUTER REPRESENTATION OF LETTERS Q & R

FIGURE 15A. FORMAL REPRESENTATION OF THE LETTERS S & T

THE LETTER 'S'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F3 | F4 | F5 | F1 |
| PART 1 | B3 | B3 | B3 | B3 | E< |
| PART 2 | B2 | B2 | B2 | B2 | E< |
| PART 3 | E | E | E | E | |

THE LETTER 'T'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F3 | F4 | F5 | F1 | F2 |
| PART 1 | B3 | B3 | B3 | E< | B3 |
| PART 2 | B2 | B2 | B2 | E< | B2 |
| PART 3 | E | E | E | BTW | E |

FIGURE 15B. TABLE NOTATION OF LETTERS S & T

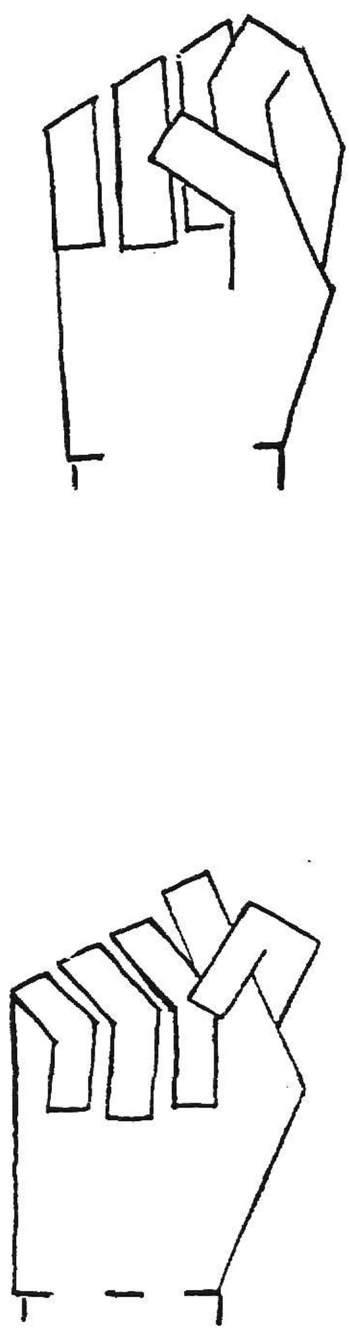


FIGURE 15C. COMPUTER REPRESENTATION OF LETTERS S & T

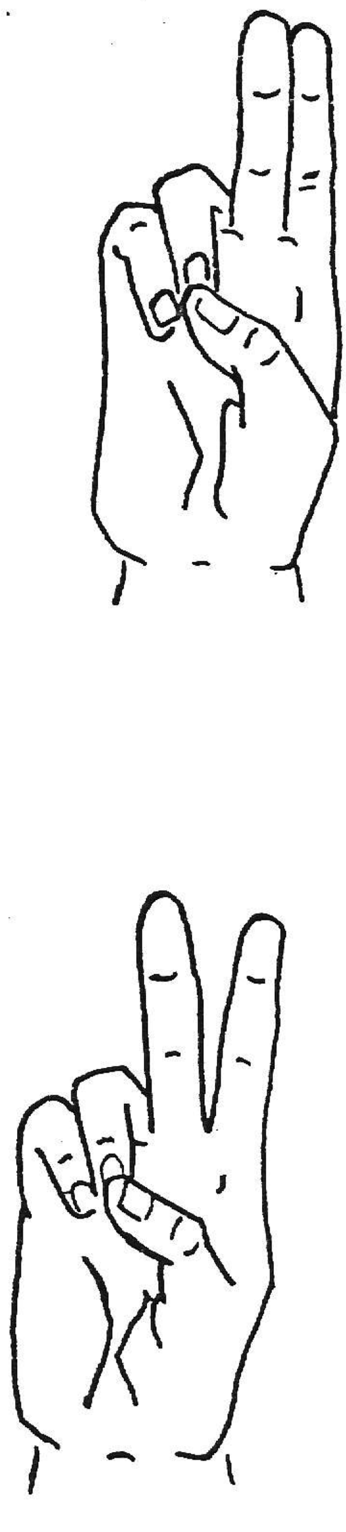


FIGURE 16A.    FORMAL REPRESENTATION OF THE LETTERS U & V

THE LETTER 'U'

| FINGER | F5 | F4 | F1 | F3 | F2 |
|---|---|---|---|---|---|
| PART 1 | E | E | E< | B3 | B3 |
| PART 2 | E | E | E< | B2 | B2 |
| PART 3 | E | E | TF4 | E | E |

THE LETTER 'V'

| FINGER | F5 | F4 | F1 | F3 | F2 |
|---|---|---|---|---|---|
| PART 1 | B3 | B3 | E< | E< | E> |
| PART 2 | B2 | B2 | E< | E< | E> |
| PART 3 | E | E | TF4 | E< | E> |

FIGURE 16B. TABLE NOTATION OF LETTERS U & V

FIGURE 16C. COMPUTER REPRESENTATION OF LETTERS U & V

FIGURE 17A. FORMAL REPRESENTATION OF THE LETTERS W & X

THE LETTER 'W'

| FINGER | F2 | F3 | F4 | F5 | F1 |
|---|---|---|---|---|---|
| PART 1 | E> | E | E< | B3 | E< |
| PART 2 | E> | E | E< | B2 | E< |
| PART 3 | E> | E | E< | B1 | TF5 |

THE LETTER 'X'

| FINGER | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| PART 1 | E< | E | B3 | B3 | B3 |
| PART 2 | E< | B2 | B2 | B2 | B2 |
| PART 3 | | B1 | E | E | E |

FIGURE 17B. TABLE NOTATION OF LETTERS W & X

FIGURE 17C. COMPUTER REPRESENTATION OF LETTERS W & X

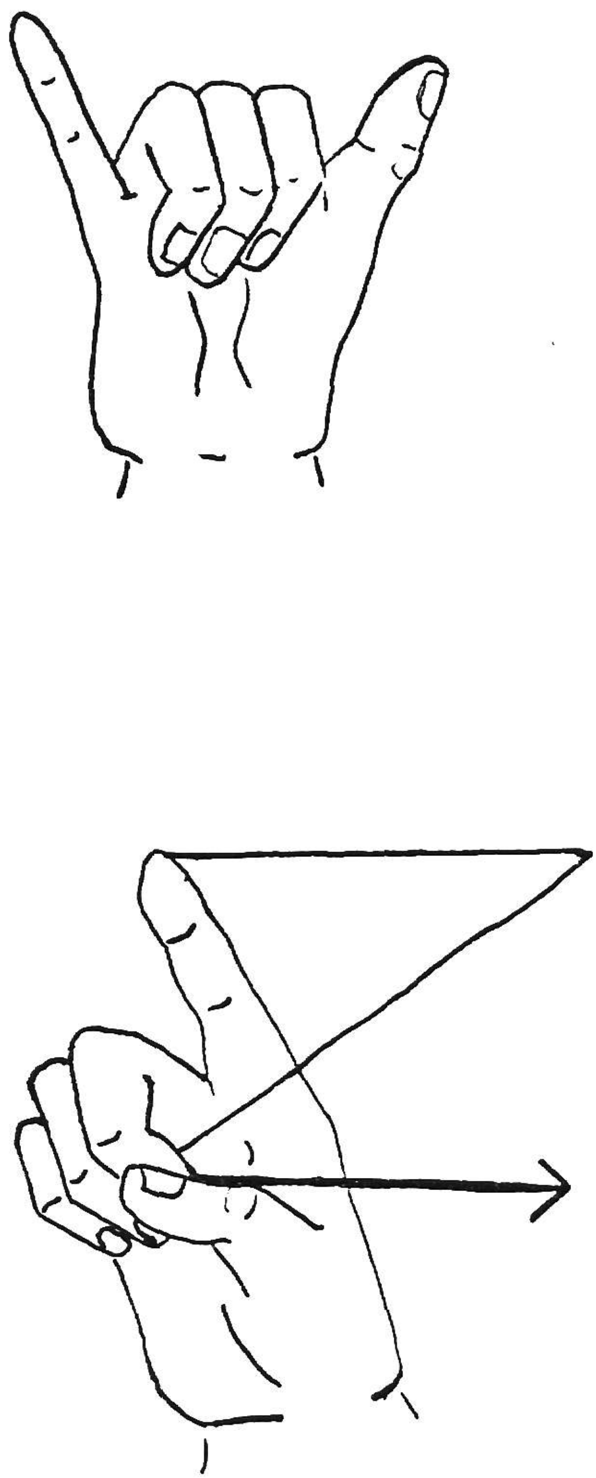


FIGURE 18A. FORMAL REPRESENTATION OF THE LETTERS Y & Z

THE LETTER 'Y'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F1 | F2 | F3 | F4 | F5 |
| PART 1 | E> | B3 | B3 | B3 | E< |
| PART 2 | E> | B2 | B2 | B2 | E< |
| PART 3 | | E | E | E | E< |

THE LETTER 'Z'

| | | | | | |
|---|---|---|---|---|---|
| FINGER | F2 | F1 | F3 | F4 | F5 |
| PART 1 | E | E< | B3 | B3 | B3 |
| PART 2 | E | E< | B2 | B2 | B2 |
| PART 3 | E | MZ | E | E | E |

FIGURE 18B. TABLE NOTATION OF LETTERS Y & Z

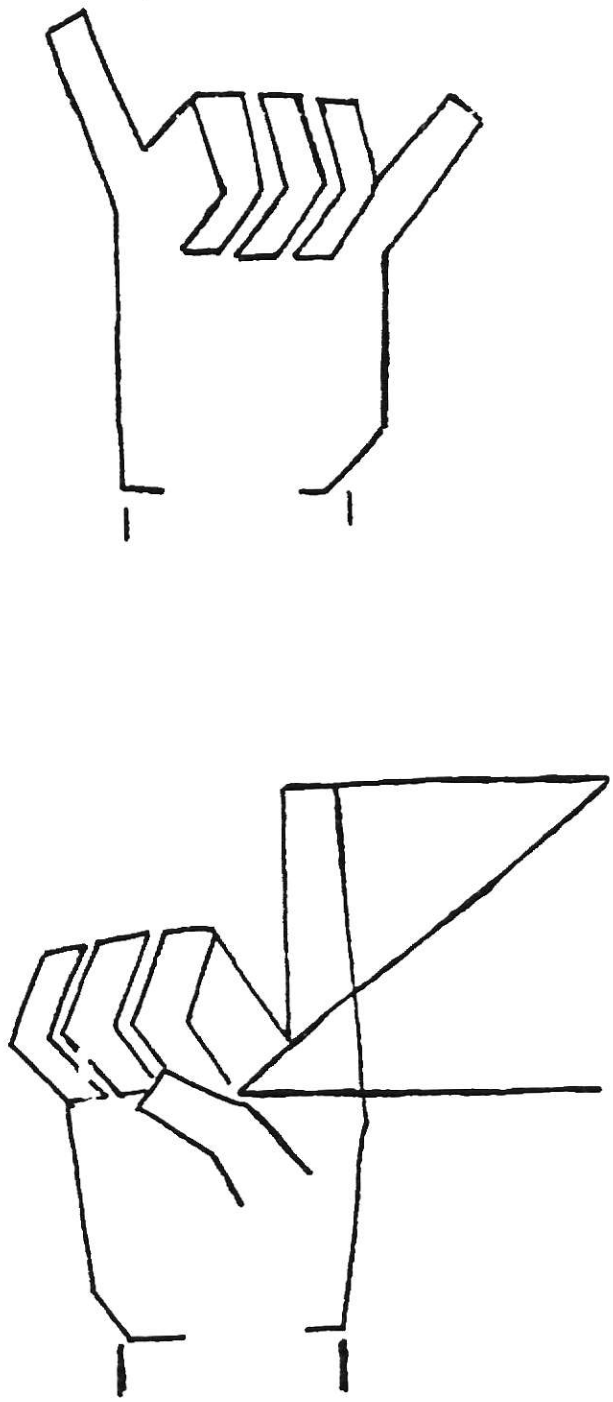


FIGURE 18C. COMPUTER REPRESENTATION OF LETTERS Y & Z

# CHAPTER 5

## 5.1 IMPLEMENTATION

The software implementation of the graphic representation of the manual alphabetic symbols is based on the defined notation and can be accomplished with minimal effort. The basic concepts indicated by the notation remain invariant from hardware system to hardware system. However, the implementation of the notation will vary from installation to installation due to hardware configuration and the capabilities of the graphic equipment. The basic algorithm for handling graphic finger spelling is as follows:

1. Get the input letter.

2. Convert the letter into a useable subscript for access to the appropriate letter description table.

3. Clear the user's screen

4. Draw the basic palm with orientation based on the requested letter.

5.0 Repeat for each of the 5 fingers

5.1 Draw the requested finger.

6.0 Handle special cases.

The implementation of the graphic representation using the Chromatics color graphics system was accomplished by using the table of notation to drive the existing software package available with that equipment. The fingers and hand are drawn by a series of 14 rectangles and 1 polygon for the palm. The 14 rectangles are formed by giving 2 coordinates for each rectangle. The polygon is formed by the joining of the lines that would make-up the palm.

The letters B and L were implemented in color on the Chromatics system to verify that the model and notation are valid.

# CHAPTER 6

# CONCLUSION

## 6.1 SUMMARY

This research consisted of survey of the literature related tc area of Computers and the Deaf, in order to identify what had been done in this field. Based upon the examination it was decided to create a graphic display of the manual signs for the deaf. This work was geared toward the deaf child and his family, and others wishing to learn the manual alphabet. To our knowledge there has been no previous work done in this area.

In order to accomplish the goal of a grapic display of the manual signs, a notation to express the hand positions was required two existing graphic notations for representing human movement were studied.

Upon closer look at these two notation it was determined they were not suitable for our needs. The major fault lies in the fact they did not allow expression of movement of the digits. Additional deficiencies included the fact that, they are extremely difficult to learn and keep track of the meanings of the various abstract symbols. Secondly, they are concerned with movement of the body. Future work might cause the upper body to be considered in our notation.

To make the notation more readable, understandable, and useable we developed a new Computer-compatible graphic notation to represent the finger-hand movement. Briefly, this notation consists of letters or letters and symbols arranged in a table. The parts of the finger were divided according to the possible bends that the digits. The columns of the table each represents a digit, the rows a segment of the digit. Special cases were designated by placing a symbol in the vacant table cell left in F1, Part 3. The symbols that can be placed in the vacant table cell are as follows:

1. S-meaning the hand is on its side not upright.
2. TF2-The thumb is touching the finger designated in the notation.
3. MJ MZ-Movement in a letter, either J or Z.
4. BTW-The thumb is between w fingers.

The ordering of the column is significant and varies according to the first appearance of the thumb.

The implementation of the graphic representation was accomplished by using the table of notation to drive the software package. Using Chromatics's innate built-in graphics capabilities, the fingers and hand are drawn using series of 14 rectangles, and 1 polygon for the palm.

## 6.2 FUTURE WORK

The work accomplished deals mainly with the notation, model and general concept of implementation of the manual alphabetic signs for the Deaf. Work yet to be done includes the full implementation of each letter in the manual alphabet. This could be accomplished using a decision table processor, table driver translator, or a specific implementation. One useful extension of the notation and model would be to include the entire symbol system for signing used by the deaf. Several modifications and extensions to the notation would be necessary to accomplish this extension arere listed below:

1. Special cases listed in section 4.3 would no longer apply because of the movement involved in forming the manual symbols.

2. The hands would require representation within a general spatial orientation.

3. Development of notation to represent use of the head, both hands and arms, and the chest would have to be accomplished. When the symbols are used to represent human speech there is a considerable amount of touching of the various part of the body(head, arm, hands, chest). These could not be included as special cases and the notation would have to be expanded.

4. Development of the notation to include the use of both hands in signing words.

5. Develop a dictionary of signs for Computer terms to eliminate the necessity for finger spelling each Computer term.

# BIBLIOGRAPHY

[ADLE70] Adler, Edna; Research Trends in Deafness: State of Art; Washington Dept. of Health, Educ., Welfare, and Social Rehabilitation; NTIS; 1970.

[BADL79] Badler, Norman I. and Smoliar, Stephen W.; Digital Representation of Human Movement; Computing Surveys; Vol 10; No. 1; March 1979.

[BEND70] Benden, Ruth; The Conquest of Deafness; Harvard University Press; 1970.

[BRIL74] Brill, Richard; Education of Deaf: Administrative and Professional Developments; Gallaudet College Press; 1974.

[BROW73] Brown, Roger; A First Language: The Early Stages; Harvard University Press; 1973.

[COHE77] Cohen, Einya, Namir, Lila, and Schlesinger; A New Dictionary of Sign Language Employing the Eschkol-Wachman Movement Notation System; Mouton and Co. B.V.; 1977.

[DAVI75] Davis, M.; Towards Understanding the Intrinsic in Body Movement; Arno Press; 1975.

[FURT66] Furth, Hans, G.; Thinking without Language; The Free Press Macmillian Publishing Co. Inc.; 1966.

[GEAR78] Geard, Walter and Vonfeldt, John; The Evolution of a Computer Assisted Instruction Drill Program for Increasing Language Skills of Young Deaf Adults; NTID; 1978.

[HUTC70] Hutchinson, A.; Labanotation; Theatre Art Books; 1970.

[JAMI75] Jaminison, Steven, L.; Domputing Careers for Deaf People; Proceedings of the National Conference on Computing Careers for Deaf People; Sponsored by ACM special intrest group on Computers and the Handicapped; 1975.

[VONF77] Vonfeldt, John; The Development of an Individualized Course in Basic Bussiness filing Rules and Procedures for Post Secondary Deaf, Utilizing Computer Assisted Instruction, Gregg Program Instruction, and Classroom Teacher; NTID; 1977.

[VONF78] Vonfeldt, John; Description and Evaluation of Websters Diacritical Markings, Computer Assisted Instruction Program; NTID; 1978.

[VONF79] Vonfeldt, John; A Description of a Prototype System at NTID Which merges Computer Assisted Instruction and Instructional Television; NTID; 1979.

[RIEK63] Riekehof, Lottie; Talk to the Deaf; Gospel Publishing House; 1963.

[SCHL72] Schlesinger, Hilde S. and Meadow, Kathryn P.; Sound and Sign Childhood Deafness and Mental Health; University of California Press; 1972.

[STOK78] Stokoe, William, C.; Sign Language Structure; Linstok Press Inc.; 1978.

# A COMPUTER COMPATIBLE GRAPHIC NOTATION FOR THE MANUAL ALPHABET

by

CYNTHIA LYNNE IRELAND

B.S., University of Kansas 1976

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfullment of the

requirements for the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

ABSTRACT

This work reports an investigation of notational systems presently available in which to express the positions and movement of finger-hand placement in the computer production of the manual alphabet of the deaf.

The two existing notational systems studied are Labanotation and Eschkol-Wachmann. They are not suitable due to their inability to express movement of the fingers. An additional problem of the two existing notation is that they are difficult to learn and to remember the meaning of the various symbols.

A computer-compatible graphic notation to represent the finger-hand movement was developed which makes the notation more readable, understandable, and useable. A general implementation of the model/notation is discussed.