THE DESIGN AND DEVELOPMENT OF A MAN-COMPUTER COMMUNICATION SYSTEM

A Thesis

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by

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TO

My wife, Gail

for her

inspiration and devotion

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Finally, my appreciation is extended to my typist, Mrs. R. Warwick.

ABSTRACT

There is an urgent need for a technique of communication that will enable potential computer users to converse directly with a computer, without having to know programming or employ a programmer. The design of one such technique, using a Cathode Ray Tube display as an interface, is the subject of this thesis.

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SECTION ONE

INTRODUCTION TO THE PROBLEM

I-1 Statement of the Problem

The problem of communication between man and the computer has never been more acute. Despite the ever increasing number of computers and the ever increasing number of volumes of information the number of users has been limited to those conversant with computer languages.

Even though high-level languages are currently being developed, they still do not allow the user to communicate directly with the computer. Thus the user is forced to channel his request through the middleman, the programmer, who has to write individual programs from basic elements for each request. A programmer must act as a communication medium between the user and the computer by translating the user's problem into a language that the computer can understand.

After making his request known to the programmer, the user often has to wait days, weeks, even months until his results are available. Such delays tend to cloud the identity of the original problem and inconvenience the user to such an extent that he is often hesitant about asking further requests of the computing facilities.

Most would-be computer users, who are laymen as far as computers are concerned, do not wish to become involved in the mental gymnastics of computer programming. There exists a need for a medium of communication which would enable the users to "talk" directly to the computer. The design and development of such a communication medium is, basically, the problem which this thesis attempts to resolve.

1-2 Previous Methods of Solving the Problem

A number of conversational computer systems[1, 2, 3, 4,] have been developed to date. The success of such systems is reflected by their acceptance and popularity in the field of application. These systems may be classified into several application groups. Two such groups are: the problem oriented group, and the environment oriented group.

This first group consists of computer programming aids.[4] These systems operate at the computer language level and allow the user to enter or change a computer program. In order to use the system one must learn a computer language such as FORTRAN,* COBOL,* or the language specifically designed for that system. The user must also be concerned with such details as program logic,

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*Reader is referred to the glossary for an explanation of any term designated by this symbol

coding, analysis and file management.

In this type of system the user does his own programming, and this is not readily acceptable to managers, doctors, lawyers, nurses, and other professional people who usually do not wish to learn programming. Hence this only partially solves the direct user-computer communication problem in that the translation step is still required.

The second group of communication systems[1, 2, 3] comes closer to solving the problem as previously defined. In such systems the user's needs are first determined by a Systems Analyst group. The system thus defined is then developed and programmed to operate at the user's environment level; that is, to employ words representing such things as processes, events, and names of objects taken from the particular application to which they have been applied. The user may then define his problem or request in the language he uses in his working environment. Thus the definition of the problem does not involve programming, which as far as the user is concerned only serves to distract him from the original problem.

Three such environment oriented systems will be discussed These systems are in various stages of completion and were designed for use in the medical environment and differ in scope and method of operation.

(i) The Hospital Information System (HIS),[2] developed by IBM, functions on a programmed keyboard basis (Figure 1). The user defines his request by depressing one or more keys on the programmed keyboard. The function of each key depends upon its definition on a transparent plastic overlay. One or more words are associated with each key position on the overlay. At least one overlay is required for each related group of operations. For example, one overlay is designed to accommodate dosage, route and time for one drug that a doctor may be ordering for his patient. Transactions are verified by means of a printout and visual examination on a keyboard printer. Rapid multiple ordering is an advantage of this system in that more than one key may be depressed thus defining a number of related requests. These requests of course must be defined on the particular plastic overlay.

The shortcomings of the system are its inflexibilities. The two causing most concern are the large number of keyboard overlays required and the limited ability of the system to accept textual data.

(ii) The Massachusetts General Hospital System.[1] This was developed specifically for the hospital environment and uses a teletypewriter for all input (Figure 2). The user enters predefined key words and modifiers to define his request to the system. For example, to order 50 milligrams of the drug Demerol to be given as required, a doctor or nurse would enter the message

"DEMEROL, 50MG, PRN"

The basic advantage of such a system is its flexibility; particularly in that the system is able to accept both key word and textual data. One disadvantage is that such a system is most effectively operated by trained typists, and most professional people are not skilled in this.

(iii) The Sanders Hospital System [3] recently announced, but not yet marketed, makes use of a CRT with "light pen"* as a communications device. The lack of detailed literature on the system curtails further discussion.

Other systems using more advanced techniques and facilities such as Cathode Ray Tubes and "light pens" are in process of development, but their confidential nature does not allow publication on their behalf.

The systems that have been outlined cover the spectrum of development of environment-oriented systems to date.

I-3 Proposed Method of Solving the Problem

DEMAND (Design and Development of a Man Computer Communication System) was developed concurrently with the above systems in an effort to solve the problem of interfacing man and the computer. The system would provide a medium much more sophisticated yet more readily adaptable and easily used than the classical

HOSPITAL INFORMATION SYSTEM - (HIS)

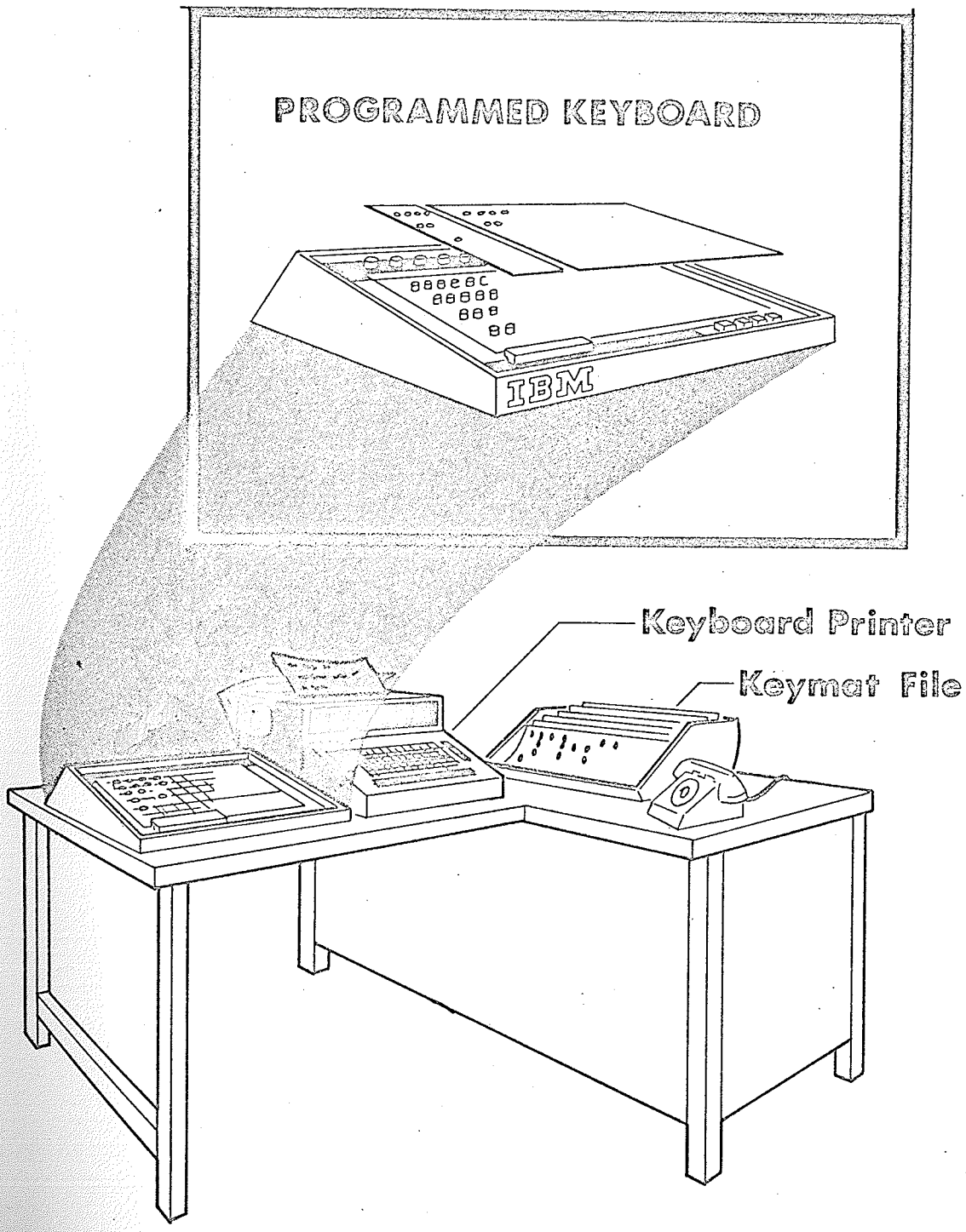


FIGURE 1

THE MASSACHUSETTS GENERAL HOSPITAL SYSTEM

Admission Program

```
4:46 PM 3/13 BBN15-15
A MSF
ADMISSION

1 D ←/L
1 ADMISSION DATE 3/13/68
2 PATIENT NAME FERGUSON, MARTIN
3 ADDRESS 16 WINDSOR ST., CAMBRIDGE, MASS.
4 UNIT NUMBER 888-23-77
5 DIVISION BM
6 SERVICE MED
7 DATE OF BIRTH 11/29/43
8 AGE 24
9 SEX M
10 VISITING DOCTOR GIBSON, EDWARD
11 ADMITTING DIAGNOSIS CHEST PAIN
12 INSURANCE BC
13 LOCATION RR2000
14 INITIALS MSF

1 ADMISSION DATE ←
4:47 PM
```

Note: The entries in BLACK are responses from the computer. The entries in RED are responses from the user.

FIGURE 2


PATIENT SELECTED
JOHNSON PETER
A1234567
DR.COSTIN,D.W.
B.D. 03/05/04
CHOOSE ORDERS DESIRED
1-ORDER LAB TEST
2-ORDER X-RAY
3-ORDER EEG
4-ORDER EKG
5-ORDER NARCOTIC
6-ORDER DRUG
7-ORDER TREATMENT
8-ORDER PHYSIOTH.
9-ORDER SOC.WKER.
10-ORDER DISCHARGE
IBM 2260
ERASE DISPLAY
SHIFT
NEW LINE DOWN
START UP
SHIFT
SPACE/ERASE ADVANCE

FIGURE 3

IMAGE OF CRT SCREEN

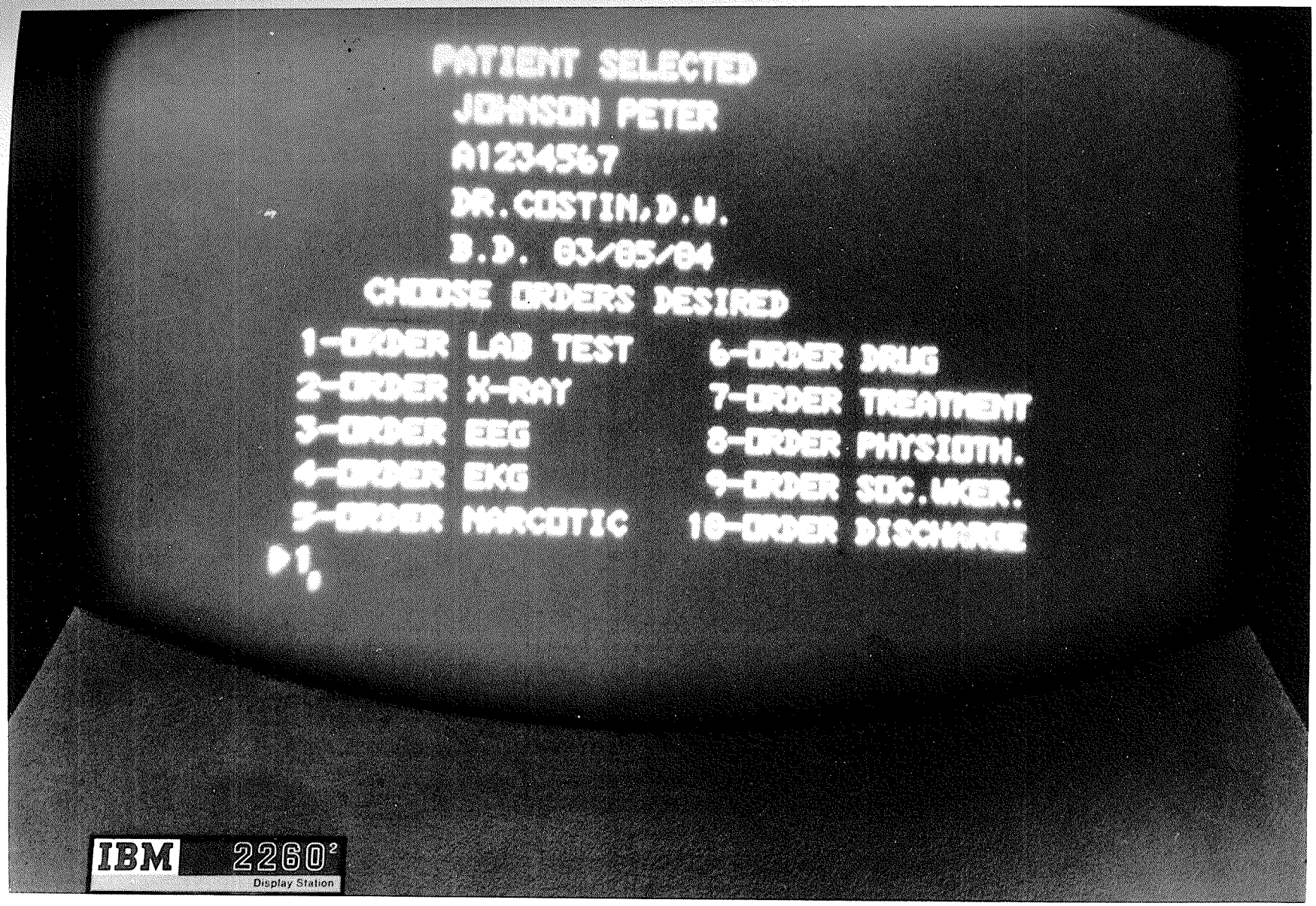
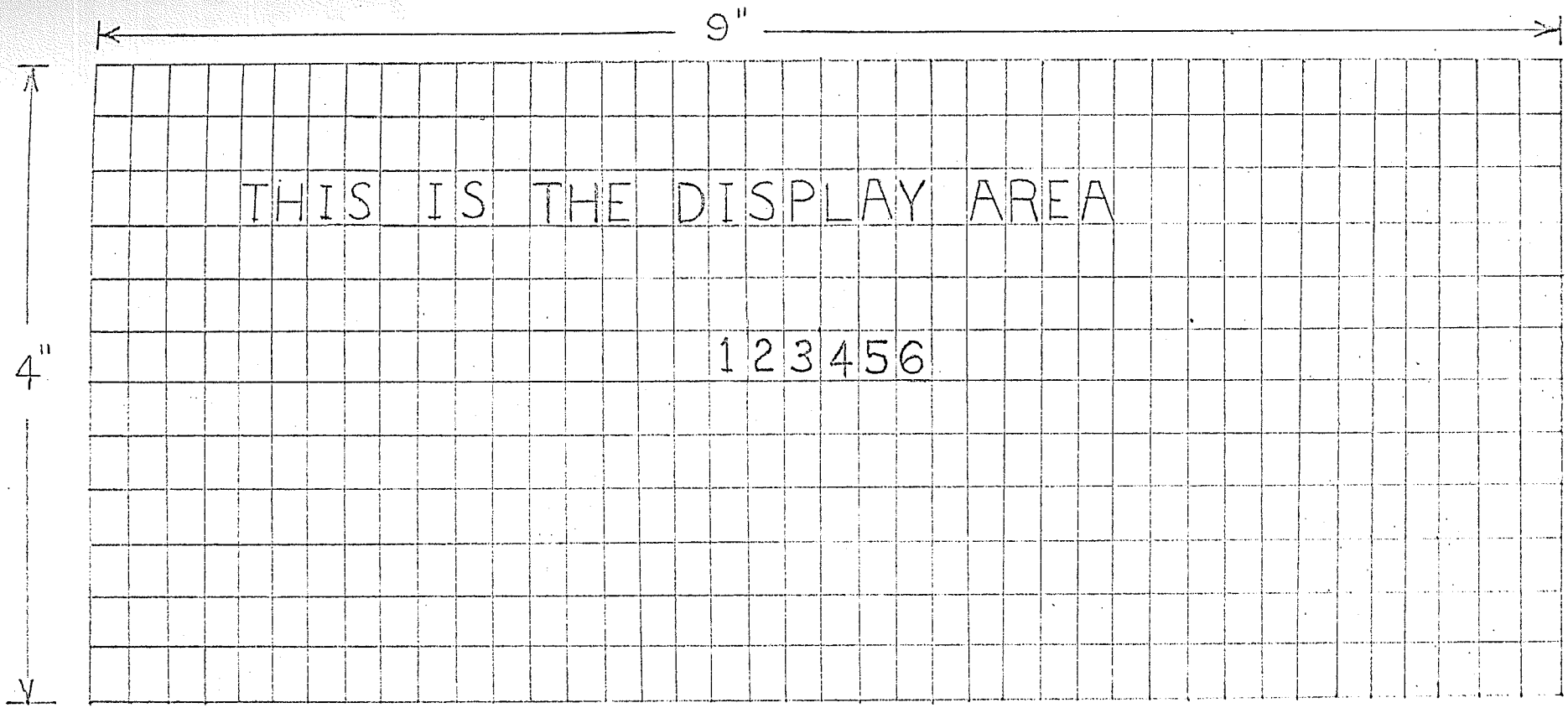


FIGURE 4

2260 KEYBOARD

FIGURE 5

THE DISPLAY AREA



IBM-2260 DISPLAY STATION 480 CHARACTER SCREEN ACTUAL SIZE

FIGURE 6

computer languages such as FORTRAN and COBOL.

DEMAND may be classified in the group of environment oriented systems.

DEMAND makes use of a Cathode Ray Tube with alpha-numeric keyboard as a communications device. This device is most suitable as its rapid operation allows for presentation of large amounts of data in a minimum amount of time (Figures 3, 4, 5).

The system operates on a display-response or question-answer basis. The user is presented with data on the CRT (Cathode Ray Tube) screen and indicates selections by typing in the code associated with his choice. Textual data may also be entered through the keyboard. After making the required selections from several displays, the user is presented with a final display which contains a recapitulation of what he has selected. He then reads this display and either verifies that the data is correct or makes his selections over. The correct transaction is then processed by another phase of the system.

DEMAND was developed as an experimental system to demonstrate the theory, practicability, and feasibility of the display-response method of man-computer communication. The DEMAND system, the first of its type in Canada, has been operational since April, 1967 and has been demonstrated a number of times.

SECTION TWO

THE DESIGN AND CONFIGURATION OF DEMAND

2-1 Design Considerations

This section discusses some of the essential factors in the design and configuration of DEMAND.

2-1-1 Fluency

The most significant consideration was the ease with which the system should operate. The user, who is the person who would make entries into the system from a remote terminal, should require a minimum amount of training. The user's entries should consist of as little textual data as possible so as to prevent the necessity of typing skill. A selection from a list of elements on a CRT screen or entering a typewritten phrase should be sufficient to indicate the user's response. For example, in the case of a library system it would be preferable for a user to enter the code numbers "22 and "25"

22-MATHEMATICS
23-MUSIC
24-OPTICS
25-PHILOSOPHY
26-PHYSICS

Figure 2A

rather than typing the actual names to indicate that he wants the names of textbooks dealing with Mathematics, and with Philosophy. The user should not be required to learn a programming language or to be particularly knowledgeable about computer hardware.

2-2-2 Flexibility of Responses

The user should be able to respond with a code number entry, textual entry, or combinations of these; or ideally by means of such indicative devices as a light-pen or a touch-sensitive screen.

2-1-3 Communication Mechanism

The communication terminal should be able to display a large amount of data for the user in a short period of time. To accomplish this the equipment should be capable of displaying 500-100 characters in one to two seconds. The same device should have the ability to accept the user's reply in any of the above mentioned forms.

2-1-4 Display Design

The displays had to be designed in such a manner that the material presented was easy to read, quickly comprehensible, and yet would make maximum use of the display area on the screen.

2-1-5 Maintenance

The system of displays should be able to be modified through

the display system itself. It would be desirable to have the facility to change any of the information on a display or the tables associated with the display. This includes adding new displays to the system or deleting existing displays from the system.

2-1-6 Adaptability and Portability

The system should be adaptable in concept, in that a minimum amount of modification could adapt the basic concept and design to a variety of applications. Some of these, in addition to the hospital system, are a library book loan system, and a computer aided instruction system.

It is desirable that with little modification the system should be usable on other computers comparable to the IBM 360-65.

2-1-7 Response Time

The system should have a response time of not more than 2-3 seconds. A certain amount of time is needed by the computer to read the user's response, process it, fetch the next display from the disk file, and present this display to the user; but this time should not be so long as to deter or annoy the user.

2-1-8 Display Linkage System

Every "conversation" between the system and the user consists of a sequence of displays and responses. Therefore,

whenever the user makes a response, the system must determine which display to present next. This linkage or addressing system for the displays would make use of existing information and the user's response to point to the next display required.

2-1-9 Multiple Terminal Capability

The system should be able to process responses from more than one terminal simultaneously.

2-1-10 Efficiency

The efficiency of the system was not a prime consideration. The actual central processing unit time would probably be less than 1% of the total response time.

Although all of the above design features are desirable in the DEMAND system, it was considered that the facilities for allowing a combination type of response input (2-1-2) and for multiple terminal capability (2-1-9) would not be included. These facilities could be added later and their existence would be inconsequential as far as the theory of the system was concerned.

2-2 The DEMAND Configuration

The position of DEMAND in two possible computer based communication systems is described. Each system consists of three environments; the users, the communications, and the computer.

ONE COMPUTER LOCAL/REMOTE SYSTEM

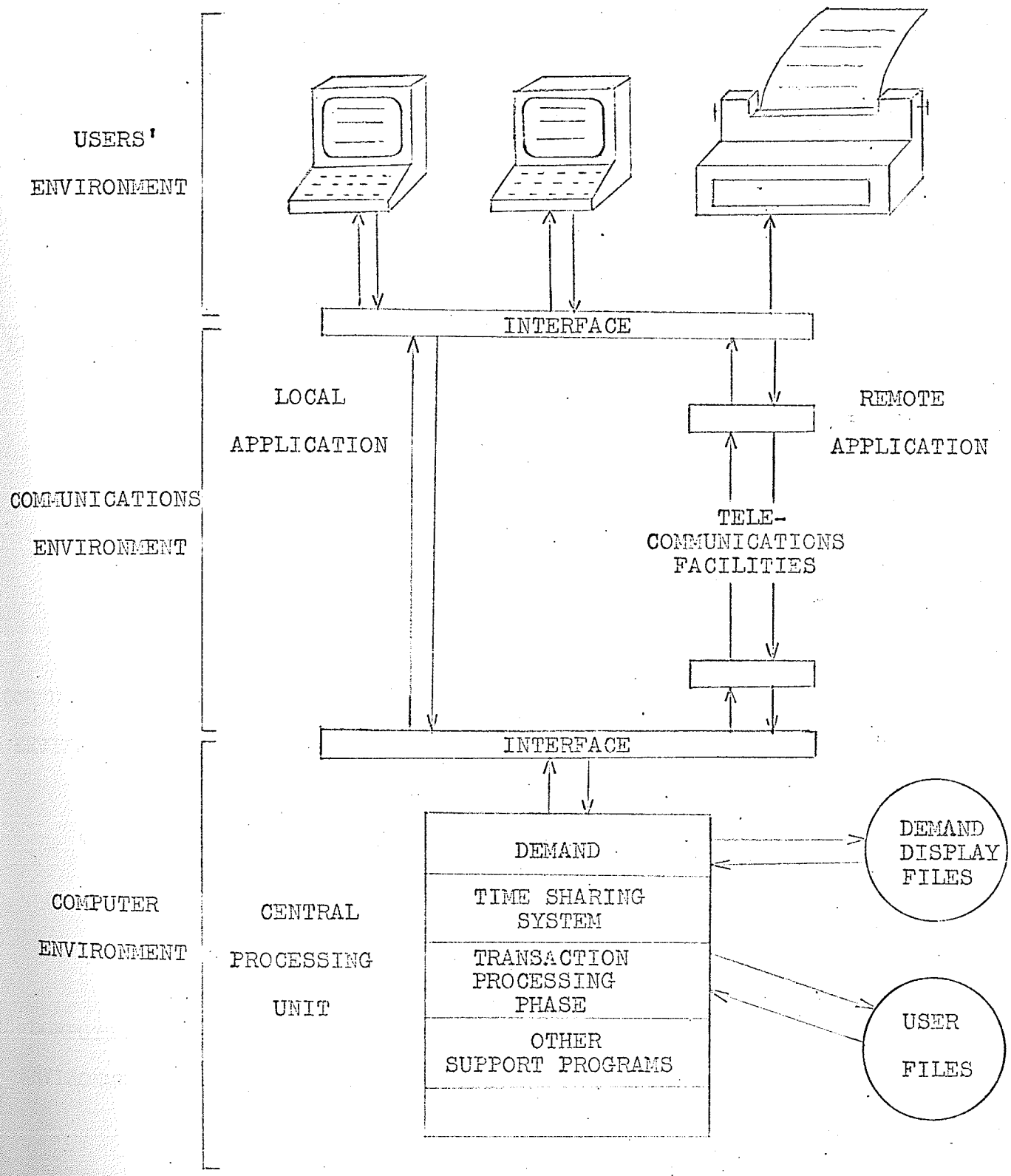


FIGURE 7

TWO COMPUTER LOCAL/REMOTE SYSTEM

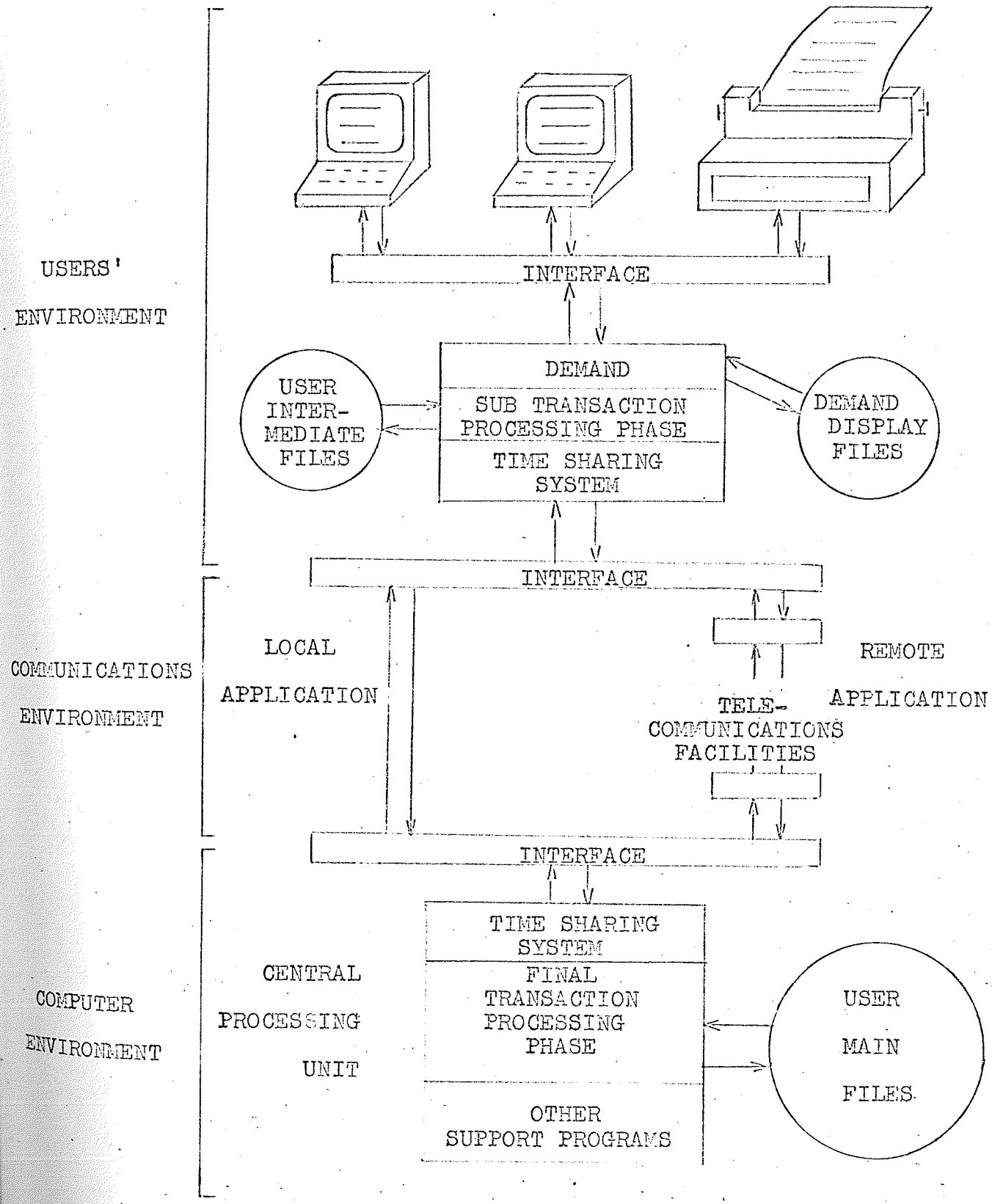


FIGURE 8

In the first system (Figure 7) the users environment consists of such facilities as CRT's, Teletypewriters, and Line-Printers. The communications environment consists of transmission facilities and inter-facing devices allowing for both local and remote applications. The Computer environment consists of a medium to large scale computer together with high speed auxiliary storage devices, and software systems such as a time sharing system, DEMAND, and other user systems and programs.

In the second system (Figure 8) the users environment contains, in addition to the equipment in Figure 7, a medium scale computer with high speed storage devices, and the software facilities required by the DEMAND system. The main function of the additional computer will be to assemble the transactions and store them in a user's intermediate file for later transmission to the larger computer.

In both systems the CRT's and Teletypewriters are used for rapid communication, whereas the line printers are used for logging transactions and for rapid output of lengthy reports. The storage devices contain such information as a display record file and the user's basic files. History and back-up files may be stored on similar devices. It should be noted that the configurations presented are considered minimal and that they represent only a part of the over-all systems.

In either of the above the user has the impression that he alone is using the system and that he is communicating directly with the computer and hence with his files.

SECTION THREE

THE DEMAND SYSTEM

3-1 Basic Structure

The basic medium of communication is a display projected on the screen of a CRT. The user responds to the display via the keyboard attached to the CRT. The CRT used for the initial implementation of the DEMAND system was an IBM 2260 DISPLAY STATION,[7] with a 480 character screen and an alpha numeric keyboard (Figures 3, 4, 5, and Appendix A). This device was connected on a local basis to an IBM System 360/65, at the University of Manitoba Computer Centre.

DEMAND consists of two computer programs and a Tree Structured display file (Figures 9 and 10). The programs are written in Assembler Language and use the basic methods of file processing.[11,12] The main program (Section 3-2) consists of two phases; the display processing phase and the final transaction processing phase. The display processing phase operates the conversational system. This is accomplished by retrieving display records from a disk storage device and presenting the display portion to the user on the CRT, and then processing his response. The present program has provision for one CRT, but can be expanded to handle many CRT's. The second

THE TREE STRUCTURE
DISPLAY LEVELS

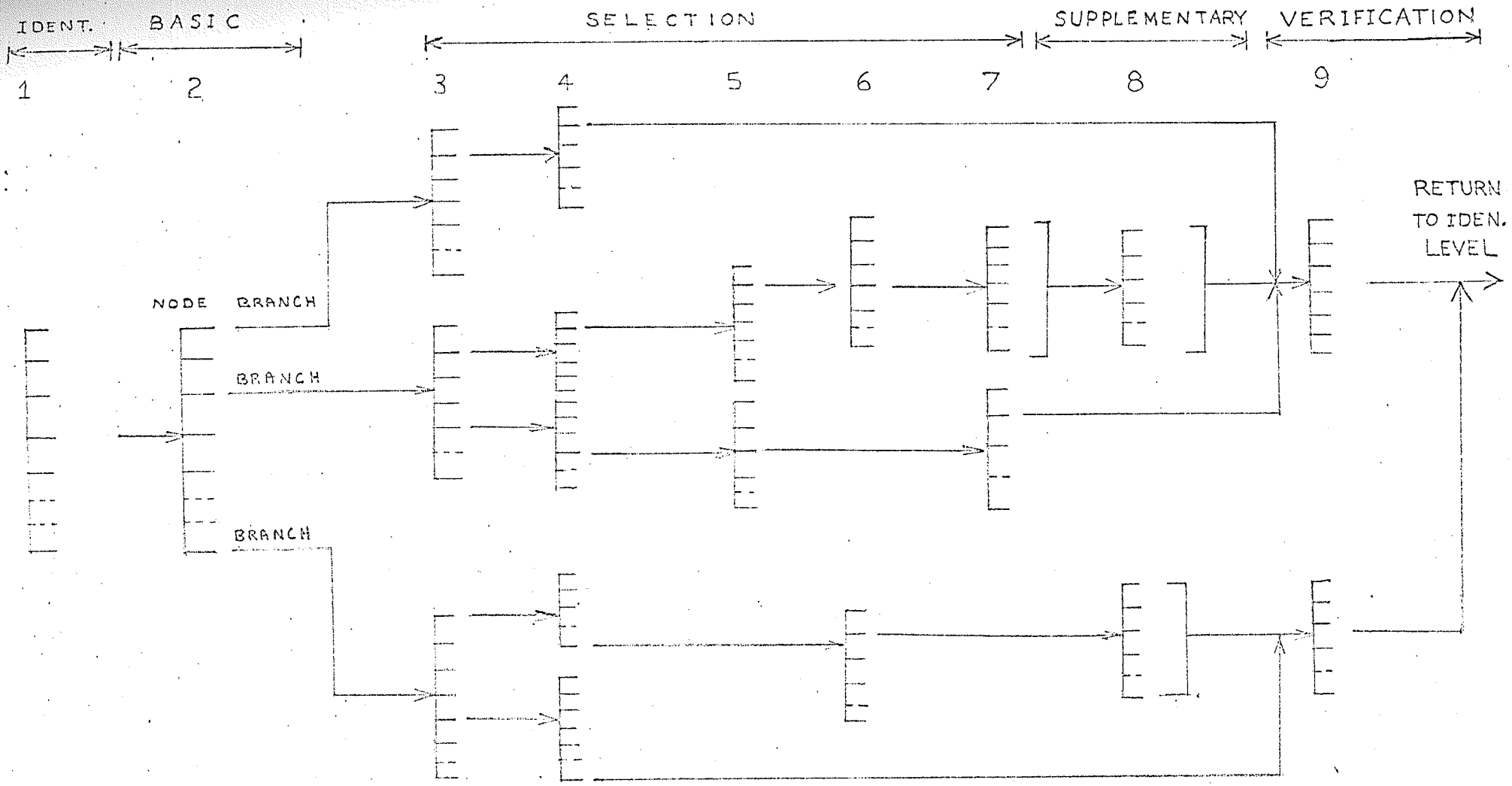


FIGURE 9

NODE AND BRANCHES

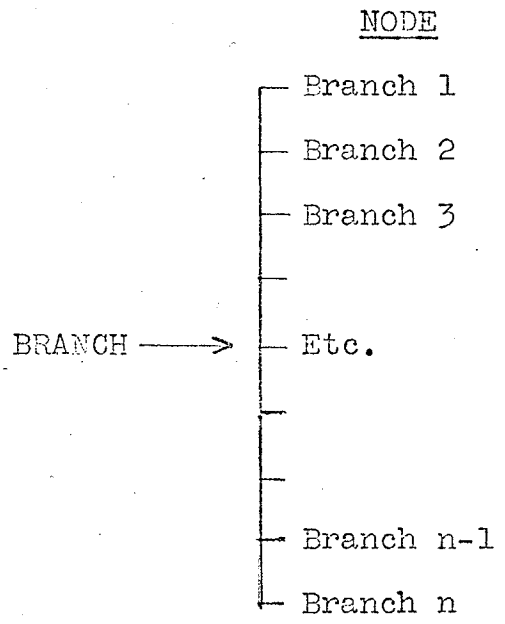


FIGURE 10

phase serves to process the final transaction which the user has defined.

The second program is used to create and maintain the display record file (Section 3-4).

The Tree Structured File (Section 4-1) consists of a set of display records. Each display record represents a node on the tree and each element on the display represents a branch from that node (Figure 10).

3-2 The Basic Logic of the Main Program

3-2-1 The Display Processing Phase

The main program consists of a display processing phase and a transaction processing phase. The general flow of program logic for the display processing phase is illustrated in the following flow diagram (Figure 11). The sequence of displays and responses begins at the BASE display level. The BASE display constitutes the main node of the tree structure (Figure 12 - Level 1). The user is presented with a display on the CRT screen (Figure 11-1). He then reads this information and makes the necessary entry through the keyboard. This response is then processed by the DEMAND system (Figure 11-2). Special processing routines are used to process the response if required (Figure 11-3 and Section 3-3 for details of this

aspect). If the response is invalid, the user is presented with a message to this effect, and is asked to make the entry again (Figure 11-4). If the response is valid, then it and its translation are recorded as a word in the transaction sentence (Section 3-2-3 and Figure 11-5). The next display is then retrieved from the display file and is presented to the user (Figure 11 - 6). The cycle is then repeated. With each cycle the user moves to the next level in the tree structure (Figure 12 - Level 2). Upon reaching the last level (Figure 12 - Level 10) he is asked to verify all of his responses (Figure 11-7). This completes the "conversation" and the transaction sentence, an example of which is given in Section 8 (page 105).

The transaction sentence is then processed by the second phase, called the transaction processing phase (Figure 11-8). This phase of the main program either updates a file or retrieves data from it, depending upon the user's request. If the user's request was invalid, a message to this effect is returned to the user (Figure 11-9). If the request was valid, the transaction processing phase carries out the order (Figure 11-10).

3-2-2 The Transaction Processing Phase of the Main Program

The function of the transaction processing phase is to take the user's request in the form of a transaction sentence, and to carry out that request. The program then either updates a file or retrieves

BASIC LOGIC OF DEMAND

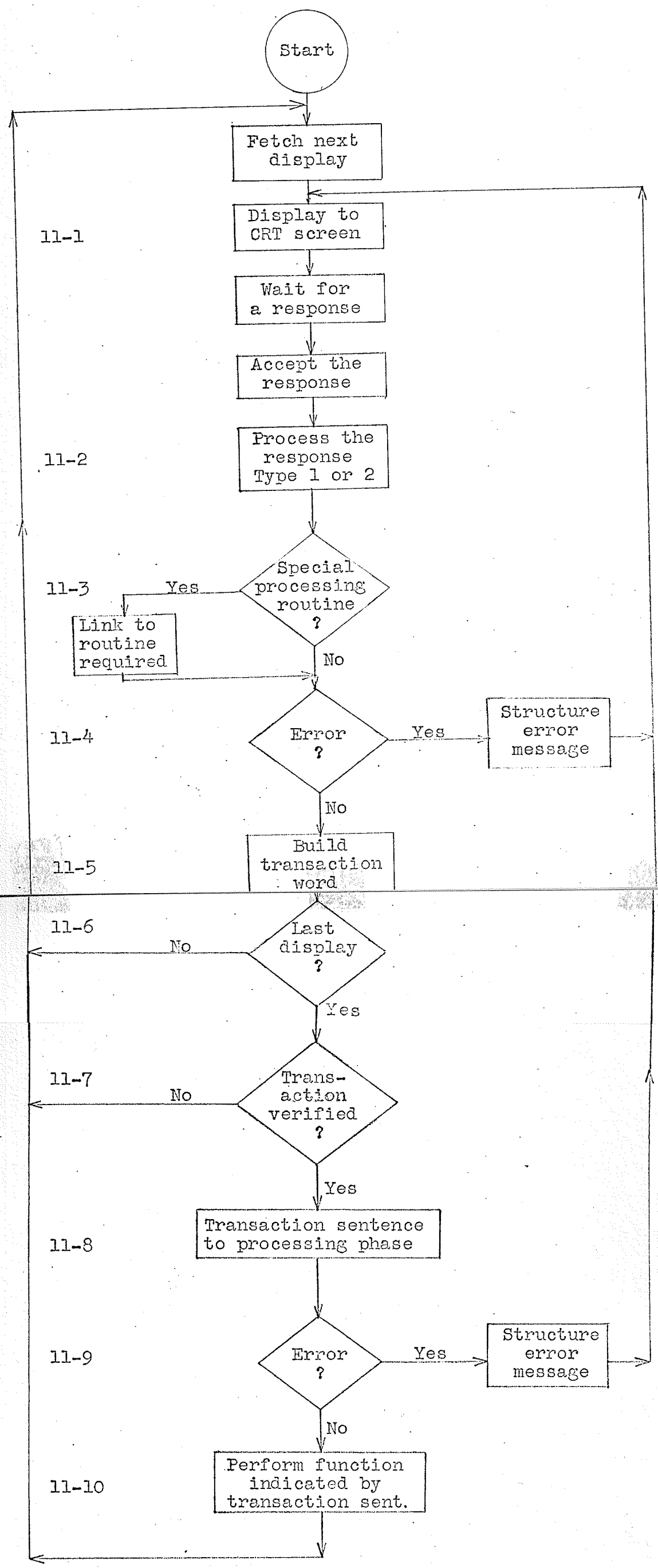


FIGURE 11

THE TREE STRUCTURE - HOSPITAL APPLICATION

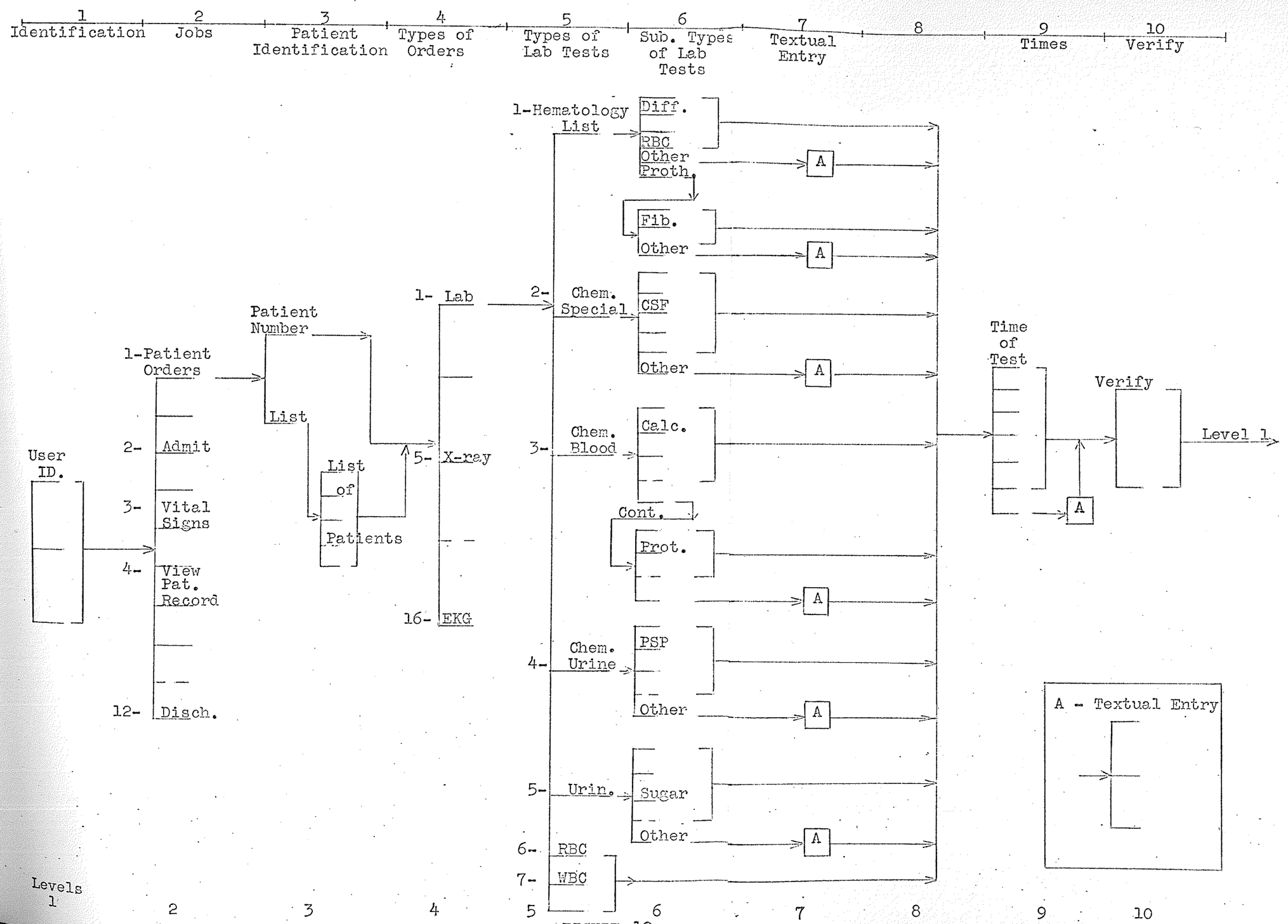


FIGURE 12

data from it.

Since the main objective of the DEMAND system was to provide a conversational man-computer communication system rather than a file updating system, no further detail about the transaction processing phase will be attempted.

The total time required to define a transaction will vary with the user and with the request. A typical transaction time is calculated in the following discussion. The time required to process one display and response, that is one cycle, requires approximately fifteen seconds. This consists of two to five seconds for central processing and transmission times; and five to ten seconds for user think and response time, assuming the user is familiar with the system. On this basis the time necessary to completely define a transaction requiring six cycles would be one to one and one-half minutes.

3-2-3 The Format of a DEMAND Transaction Sentence

The transaction sentence provides a method of communication between the display processing phase and the transaction processing phase of the main program of the DEMAND System. As each display is processed by the DEMAND System, the response code and its "English" translation are recorded as a word in the transaction sentence.

A transaction word consists of a length code "LL", the

Response code "CC", and the "English" translation "TTT..." of the response code.

The format of the transaction sentence is as follows:

1	2	3	4	5	6
SSS	CCC	LLL	LL	CC	TTT....

LL	CC	TTT.....	LL	CC	TTT...

Field No.	Meaning:
(1)	Transaction sentence sequence number.
(2)	Transaction overall code.
(3)	Overall length of transaction sentence, specified in characters. This includes the sum of the length of each of the words plus the length of the field (3) itself.
(4)	Length of the first word (fields 4, 5, and 6). This includes the lengths of the code entered, the translation, and the length field (4).
(5)	The code entered by the user.
(6)	The translation of the above code into English. This could consist of a typewritten entry such as a name, a comment, or the results of a test.

Each transaction word consists of fields 4, 5, and 6. A transaction sentence will consist of fields 1, 2, and 3, and approximately six transaction words, each word consisting of fields 4, 5, and 6. See Section Six for an example.

3-3 Special Processing Routines

3-3-1 Introduction

Many of the user's responses will consist of text or special codes, and must be processed by a routine separate from the logic of the main DEMAND program. These routines are linked to the main program when required as illustrated in Figure 11-3. Seven such routines are coded in the DEMAND System. These are indicated in the display record system by the code 99 and the routine number (Figures 32 and 33 on Pages 88 and 89) in the directory area of each display record where a response requires a special routine.

The code 99 is a reserve code, and is entered in the directory area of the display record followed by the number of a special processing routine.

DISPLAY AREA	DIRECTORY AREA
01 - ENTER SURNAME	99 - - - - - - -21

Figure 3A

The entry, 99 - - - - 21, indicates that the special processing routine identified by the number "21" will be linked to the main program to process the user's response in reply to the request ENTER SURNAME.

All of the routines have been written in Assembler Language[12] and are linked to the main DEMAND program as subroutines. They represent only a portion of the total set that would be required for a fully functional system.

3-3-2 The Routines

ROUTINE I - User Identification

This routine accepts the three characters entered by the user in response to the Identification display (Figure 20, Page 44) and then determines whether or not the user is allowed to use this system. This is accomplished by searching a table of valid users using the entry as a search argument.

ROUTINE 2 - Patient Identification

This routine processes the user's response to the Patient Identification display (Figure 13). The routine begins by determining whether the user has entered an "S" or an eight digit patient number. If the user has entered an "S", this routine supplies the main program with the necessary parameters to present the user with the Patient List display (Figure 14). If the user has entered a valid patient number, then this routine withdraws the necessary information about the patient from the patient file (held in core in readiness) to be entered at the top of the next display (Figure 15).

ROUTINE 3 - Textual Entry

This routine stores the contents of a textual entry in the transaction sentence.

ROUTINE 4 - Patient List

This routine accepts the user's response to the Patient List display (Figure 14) and performs a table look-up. The single digit entered by the user is used to identify a patient from the patient list on that display. When the patient's name is found, the necessary information about the patient is presented to the main program to be put at the top of the next display (Figure 15).

ROUTINE 5 - Verify

This routine accepts the user's response to the Verification display, and determines whether the display is correct as far as the user is concerned, or whether the user wishes to cancel his order (Figure 16).

ROUTINE 6 - Display Number

This routine accepts the user's response to the first of the sequence of modification type of displays. It determines whether the user's response, a display number, is within the range of the displays in the file (Figure 17).

PATIENT IDENTIFICATION

```
1 PATIENT ORDERS
PATIENT IDENTIFICATION
TYPE IN PATIENT NUMBER OR S FOR SEARCH

PRESS ENTER
```

FIGURE 13

PATIENT LIST

```
SELECT PATIENT FROM THIS LIST
1-JOHNSON PETER    A1234567  DR JONES,J.J.
   B.D. 03/05/40
2-KNOWLES BARRY    A0000211  DR SMITH,O.B.
   B.D. 06/08/32
3-KNAPP SAM        A1461372  DR COSTIN,D.W.
   B.D. 07/09/24
4-LESLIE JOHN      A0064273  DR SMITH,O.B.
   B.D. 08/09/30
5-PETERS JOHN      A1062841  DR SMITH,O.B.
   B.D. 09/05/38
```

FIGURE 14

TYPES OF ORDERS

```
PETERS JOHN
A1062841
DR SMITH,O.B.
B.D. 09/05/38

CHOOSE ORDERS DESIRED
 1-ORDER LAB TEST    6-ORDER OTHER DRUG
 2-ORDER X-RAY       7-ORDER TREATMENT
 3-ORDER EEG         8-ORDER PHYSIOTH.
 4-ORDER EKG         9-ORDER SOC.WKER
 5-ORDER NARCOTIC   10-ORDER DISCHARGE
```

FIGURE 15

VERIFICATION

```
      VERIFY DISPLAY BY TYPING 1
      CANCEL BY TYPING X
USER -DR SMITH,O.B.
PAT. -PETERS JOHN      A1062841
      B.D. 09/05/38    DR SMITH,O.B.
ORD. -  01 ORDER LAB TEST
        06 WBC
        02 STAT
```

FIGURE 16

INITIATE CHANGES

```
YOU ARE NOW IN THE SEQUENCE OF DISPLAYS
THAT ALLOW YOU TO CHANGE ANY DISPLAY.

ENTER THE NUMBER OF THE DISPLAY YOU WISH
TO CHANGE.

▶.
```

FIGURE 17

SELECT CHANGE

```
INDICATE WHAT YOU WISH TO DO BY ENTERING
THE CODE ASSOCIATED WITH ONE ENTRY IN
THE FOLLOWING LIST.
     IS THE DISPLAY YOU ARE PRESENTLY
CHANGING.

1-CREATE A DISPLAY    4-DIRECTORY CHANGES
2-LABEL CHANGES       5-TO BASE DISPLAY
3-CHANGES TO DISPLAY AREA
>
```

FIGURE 18

ROUTINE 7 - Modify

This routine accepts the user's response in reply to the second display in this series of modification displays (Figure 18), and determines whether the user wishes to create a new display, change an existing label, change an existing display area, or change the directory area of the display record. It then sets the necessary parameters to perform this function.

The second part of the routine accepts the user's changes to any part of a display; and either rejects the changes, or reconstructs the display record and re-writes it to the display record file.

3-4 The Basic Logic of the Display Record Loading Program

The second program making up the DEMAND system is the Display Record Loading Program. The program is used to establish or update the display record file. The reader is referred to Section 5-2-1 (the SENSE number system), Section 4-5 (the display record format), and Section 4-7 (the display record loading program), for further details relevant to this discussion.

SECTION FOUR

THE DISPLAY SYSTEM

4-1 The Display File

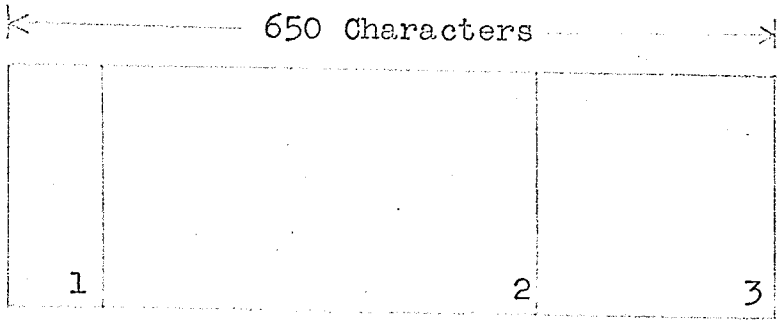
The system of storing the display records and formats of the display records will be discussed in this section. A display record consists of a 30-character information label, a 480-character display, and a 130-character directory (Figure 19). The Information label contains the display record number and various other information particular to the display. The display is the information presented to the user on the CRT screen as a 12-line by 40-character matrix. The contents of the information depend upon the design of the display which in turn is dependant on the user's requirements. The directory area contains the necessary information to link the system of displays together. It also provides linkage to the special processing routines for some specific displays. The format of the directory area is discussed in Section 4-5. The basic design of the display file is that of a Tree Structure[3] (Figure 9, Page 22). Each display represents a node on the tree. Each one of the elements on a display serves as a branch from the node (Figure 10, Page 23). Thus access or linkage from one level in the tree structure to another level is achieved through the elements of the display. To accomplish this each element has associated with it, in the directory, an address

of some other display in the system.

Four categories of displays are contained in the tree structured display file system. These are Identification, Basic, Supplementary, and Verification displays which are described in the following section. The number of each type of display will vary with the application. The displays are stored on some high speed storage device such as a disk or drum;[10] and may be modified, deleted from, or added to, the system at any time through the system itself. It is felt that changes to the displays should be as easy as operating the system. To facilitate these changes a sequence of displays with the appropriate elements is included as part of the system (Figures 17 and 18).

The elements of a display may be words, phrases, questions, statements, instructions, processes, names, etc. All displays are made up of some combination of these elements along with corresponding numeric (where appropriate) codes. The codes consist of one or two characters, and are used to identify an element on the display, one unique code being associated with each element that requires identification. Instructions, headings, and comments do not have codes associated with them. (See Section 4-3 on types of display elements).

GENERAL DISPLAY RECORD FORMAT



Legend

1-Identification label

2-Display area

3-Directory area

FIGURE 19

4-2 Categories of Displays

4-2-1 Identification Displays

The general application of the Identification display allows the user to identify himself to the system. This display will also be used to indicate the desired method of input. Upon completion of one transaction the Identification display is returned to the CRT screen in readiness for the commencement of the next transaction (Figure 20).

4-2-2 Basic Displays

The first of these displays defines the types of transactions that may be completed. The content of this display will vary with physical locations of the CRT within the given system. The selection of an element from a Basic display will call for the use of a following display unique to that selection. A limited number of elements can be contained in any one display. If the required list of elements exceeds this limit, the remaining elements may be contained on one or more following displays. Such displays are referred to as continuation displays (Figures 21 and 22). Selection of the entry "20" ("MORE") in Figure 21 causes the display in Figure 22 to be presented next. The number of continuation displays depends upon the application, further discussion may be found in Section 4-3-4.

IDENTIFICATION

IDENTIFICATION DISPLAY

ENTER YOUR THREE INITIALS FOR I.D.

PRESS ENTER

FIGURE 20

4-2-3 The Supplementary Displays

The Supplementary displays allow for the entry of information more specific to a given transaction. The information is conveyed either by selection or by textual entry (Figures 23 and 24). Textual entries are limited to 80 characters.

4-2-4 Verification Displays

When the last display of a sequence is encountered, the system will ask the user to verify what he has done. This is a display summarizing the selections that have been made and the textual material that has been entered (Figure 16, Page 36). In the present DEMAND system this can be done in one display. The user verifies the transaction correct by entering the code 1 or recalls the base display by entering an X thus cancelling the transaction.

4-3 Types of Elements

Displays may consist of combinations of three types of elements: Selection, Question and Table.

4-3-1 Selection Elements

The selection type of element consists of a meaningful word or phrase and is associated with a unique code. The word or phrase refers to a specific procedure, item, or event related to the area. In the following illustration the user indicates his choice by entering

BLOOD CHEMISTRY-PART 1

```
                    CHEM-BLOOD-1
 1-ACETONE              11-CREAT.CLEARANCE
 2-ALCOHOL              12-AMYLASE
 3-BLOOD VOLUME         13-ELECTROPHORESIS
 4-BROMOSULPHALEIN      14-GLUCOSE(FBS)
 5-CALCIUM              15-GLUCOSE TOLERANCE
 6-CAROTENE             16-L.A.D.
 7-ELECTROLYTES         17-S.GOT
 8-CHOLESTEROL-TOT      18-S-GPT
 9-CHOLESTEROL-ESTR     20-MORE
10-CREATININE
```

FIGURE 21

BLOOD CHEMISTRY-PART 2

```
                    CHEM-BLOOD-2
 1-THVMOL TURBIDITY 11-BLOOD UREA NIT.
 2-CEPH.CHOL.FLOCC. 12-URIC ACID
 3-THYMOL FLOCC.    13-VAN DEN BERGH
 4-PH BLOOD         14-HEMOCHROMOGEN
 5-PHOSPHATASE-ACID 19-OTHER
 6-PHOSPHATASE-ALK.
 7-PHOSPHORUS
 8-PROT.BND.IODINE
 9-PROTEINS
10-SERUM IRON
```

FIGURE 22

TIME OF TEST

TIME OF TEST	
1-ROUTINE	11-EOD 2 DAYS
2-STAT	12-EOD 3 DAYS
3-PRE-OP	13-EOD 5 DAYS
4-POST-OP	
5-DAILY 2 DAYS	19-OTHER
6-DAILY 3 DAYS	
7-DAILY 5 DAYS	
8-BID 2 DAYS	
9-BID 3 DAYS	
10-BID 5 DAYS	

FIGURE 23

TEXTUAL ENTRY

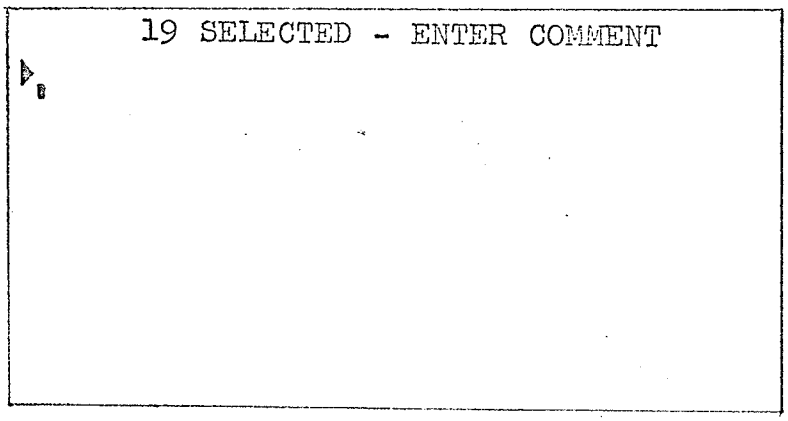


FIGURE 24

the appropriate code, e.g. 01 to indicate he is selecting Aspirin.

NAMES OF DRUGS

01 - ASPIRIN	03 -	05 - FROSST 292
02 - DEMEROL	04 -	06 -

Figure 4A

4-3-2 Question Elements

The question type of element consists of a request or demand for information from the terminal user. The user responds by typing in the appropriate reply.

Example 1. Request for a patient's name:

```
ENTER SURNAME
```

Figure 4B

Example 2. Request regarding the results of a Haematology test:

```
WHITE CELL COUNT =
```

Figure 4C

Example 3. Request for identification of a person's sex:

```
SEX:                    (1) MALE

                        (2) FEMALE


ENTER 1 or 2
```

Figure 4D

4-3-4 Table Elements[1]

The purpose of the table element is to allow the user to enter the first few characters of an element, as opposed to selecting it from a list of elements on a display.

When a list of items from which the user will make selections exceeds approximately thirty, then the list of items can be broken up into two or three displays. However, if a list exceeds 100,then some method of breaking down the list or categorizing the elements in it is required. This would allow the user to have rapid access to any item in the list without having to look at any of the elements preceeding it. For example, if the user wanted to select a drug from a list of 1,000 drugs and there were twenty drugs per display, it is conceivable that

[1] It should be noted that the table element system was not implemented in this version of the DEMAND system and is discussed only for purposes of indicating a technique for solving the particular problem.

he would have to step through as many as forty-nine displays before he obtained the desired drug. The time element involved would be prohibitive and the method would frustrate the user.

The table element functions as follows: When the user makes his entry, it is used as an argument to search a table file. The table file is pre-defined as discussed in Section 4-3-5. If the table look-up system is able to uniquely identify one element in the table using the user's entry as an argument, then information on that element is presented to the user in the next display. If the system is not able to uniquely identify one element, then a list of elements surrounding the user's entry is presented to the user on the next display. The user may then make the selection from that display.

For example, if a doctor wanted to order the drug Demerol, he could type in the letters DEM (or DEMER or DEMEROL). He would then be presented with a list of drugs beginning with DEM, if DEM was not sufficient to select a single drug out of the table. (If he typed in the whole name DEMEROL he would be presented with information on the drug Demerol).

4-3-5 The Table File

A table file contains information about each element of a related group of elements. One file is defined for each related group of elements. For example, one file would be defined for drugs and

information about drugs; another file would be defined for laboratory tests and information about such tests. The file would be defined at the time the system of displays was being set up and would be stored on a separate file from the displays.

4-3-6 Table File Record Format

The format of a record is as follows:

Item Name 1	First Attribute 2	Second Attribute 3	Specified Information 4	Display Address 5

Format Information 6

Figure 4E

1 - Item Name - Up to 20 Characters

The name of an item, such as X-ray, Envelopes, or John Doe, in the case of a test file, a supply file, or a personnel file, respectively. The file is arranged alphabetically according to this field.

2 - First Attribute - Up to 10 Characters

The primary characteristic of that item. For example, the size of the envelopes in the case of a supply file.

3 - Second Attribute - Up to 10 Characters

The secondary characteristic of the item. For example, the number of envelopes in stock in the case of the supply file.

4 - Specified Information - Up to 80 Characters

Textual information pertaining to an item. For example, the lead time required when ordering envelopes from a supplier.

5 - Display Address - 3 Characters

The address of a skeleton form of a Basic display. This type of display contains headings particular to a group of items. In the case of a supply file the headings might be SUPPLIES, ITEM, NUMBER IN STOCK and SUPPLIERS NAMES. If the user's entry is sufficient to uniquely identify the item, then the information in fields 1 through 6 is added to the Basic display and presented to the user; otherwise, the user is presented with a list of items, starting with his entry, and he may then be requested to make positive identification of the required element by selecting it from the list.

6 - Format - 20 Characters

The rules for arranging the information, obtained from fields 1 through 6 in the Table File, on the skeleton display. For example, the rules might indicate that field 1 should be

moved to line 2 on the skeleton display; that field 2 should be moved to line 6; that the second half of field 3 should be ignored; that the information contained in field 4 is not required.

4-4 Display Design Considerations

The general format of the display is discussed in this section. It is most important to present the user with a comprehensible and aesthetically pleasing display of information. At the same time the display must be concise, functional, and serve the purpose of communicating without being wordy. Displays are designed to suit each particular application. Hence the format depends on the application requirements and the designer.

Some basic knowledge about the application in general is required before attempting to design displays. Persons who are qualified in each area of application must be consulted re their requirements. The user, the display screen size, and the response time are three major factors which must be considered in this type of development. From the practical implementation of such a system the user should not be restricted by the design of the display. If the user is not a skilled typist, then the displays should be designed to prevent large amounts of typing. This can be accomplished in part by insuring that the responses from the user are in the form of numeric digits, alphabetic characters, or short phrases. On the other hand,

if the users are skilled typists, then it would be to their advantage to be presented with a display that would allow them to make concise textual entries.

The display screen size will depend on the hardware selected. A display should present as much information as possible without looking cluttered or crowded (Figures 25 and 26). Figure 25 presents a column arrangement or elements, whereas Figure 26 represents a paragraph type of arrangement. Although more information is conveyed to the user through Figure 26, Figure 25 requires less time to read and make a selection. In general if the screen size is relatively small, say less than 400 characters, a greater number of displays will be required to present a given amount of information. If the screen size is relatively large, say over 800 characters, then fewer displays will present the same amount of information. Hence it is quite evident that the size of the CRT screen may have the effect of changing the entire pattern of the display system.

The response time* or the delay between commencing one display transaction and reaching the next display, depends upon the amount of information transmitted to the user, the amount of information received from the user, the number of file references required to process the user's response, and the processor speed.

---

* See Glossary

URINE CHEMISTRY LIST

CHEM-URINE

1-PSP	11-GLUCOSE
2-UROBILINOGEN	12-KETOSTEROIDS
3-ALBUMIN	13-HYDROXYSTEROIDS
4-PROTEIN-B.J.	14-PORPHYRINE
5-CALCIUM	15-PREG-FREEDMAN
6-CATECHOLAMINES	16-PREG-BREVINDEX
7-ELECTROLYTES	17-PREG-PROGNOSTICON
8-CREATINE	18-SCHILLINGS TEST
9-CREATININE	21-UREA NITROGEN
10-AMYLASE	19-OTHER

FIGURE 25

TYPES OF LABORATORY TESTS

LABORATORY TESTS
1-HEMATOLOGY LIST 2-HGB 3-HCT 4-SR5-RBC
6-WBC 7-DIFF 8-PT 9-CHEM-SPEC.LIST
10-BACTI.LIST-NOTYET 11-CHEM-BLOOD LIST
12-BUN 13-LAD 14-ELEC 15-SGOT
16-CHEM-URINE LIST 17-URINALYSIS
18-BILE 19-BLEEDING TIME 20-CLOT RETRACT
21-COOMBS TEST 22-INDICES 23-PLATELETS
24-HEMOBLOBIN 25-HEMATOCRIT 26-L.E.CELLS
27-FRAGILITY TEST 28-COLD AGGLUTININS
29-PROTHROMBIN LIST
30-OTHER TESTS

FIGURE 26

A display must be presented to the user through some transmission facility, and consequently the response time will be greatly dependent on the transmission speed. If the transmission speed is slow, then an average size display of approximately 600 characters may take 2 seconds (300 characters/second) to reach the user. However, if the transmission speed is high, then a large display of over 800 characters will reach the user in a few milli-seconds. In the first case the display must be restricted in size, whereas in the latter case it would be advantageous to construct large displays. The time required to receive the user's response will be related in a similar manner to the transmission speed.

If displays are designed in such a manner that each response requires several file references, then the overall processing time is increased. (Note that the processor time is less than 1% of the overall response time and is not of prime importance.)

4-4-1 Calculation of Response Time

The response time of the DEMAND system is discussed in this sub-section.

Response time = Message transmission time to computer
+ Message transmission time to user
+ File reference time
+ Interference time
+ Processor time . . . . (1)

"Message transmission time to computer" is the time required to transmit the user's response to the computer. This time is determined by multiplying the average response length by the line transmission rate. "Message transmission time to user" is the time required to transmit a message from the computer to the user. This time is determined in a similar manner to the "time to computer" time. "File reference time" is the total time spent while retrieving or writing data to an associated file. This time is determined by multiplying the average file reference time by the number of file references required to process a response. The "Interference time" is the time that the program must wait while the computer is performing other tasks. This is a parameter of the particular Executive Program that is supervising the operations of the computer. The "Processor time" is the amount of Central Processing Unit time required to execute the instructions necessary to perform the operations of message transmission, file references, and general response processing. This time is determined by multiplying the processor speed (average instruction execution time*) by the total number of instructions required to process the response.

Example 1

Suppose the line transmission rate is 250 characters per second; the length of the average response is twenty-five characters;

* See Glossary

the length of the average computer reply is 500 characters; the average file reference time is eighty milliseconds (ms); the total number of file references is five; the interference time is 200ms; the processor speed is five microseconds (us) per instruction; and 500 instructions are required to process a typical response. Evaluation of the right hand side of relationship . . . . (1) yields:

$$\text{RHS} = (25 \times \frac{1}{250})\text{s} + (500 \times \frac{1}{250})\text{s} + (80 \times 5)\text{ms} + 100\text{ms} + (5 \times 500)\text{us}$$

$$= 100\text{ms} + 2000\text{ms} + 400\text{ms} + 100\text{ms} + 2.5\text{ms}$$

$$= 2602.5\text{ms}$$

$$= 2.6 \text{ seconds}$$

$$= \text{LHS} = \text{Response Time}$$

Note that the processor time is (2.5/2602.5) x 100 = 0.1% of the total response time. Note also that if the processor speed was 10 times slower, the above percentage figure would be increased to about 1.0%. However as the average speed of today's computers is 5us, this figure is not likely to be approached. Hence the processor speed is not as critical a factor as the transmission and file reference speeds.

4-5 The Display Record Format

This section describes the format of a display record but does not consider the textual information which each display is to contain.

As previously indicated the display record consists of a 30-character information label area, a 480-character display area, and a 140-character directory area (Section 4-1, Figure 19). All records have the same format as shown in Figure 19 (Page 42).

4-5-1 The Identification Label Area

The identification label area consists of thirty characters formatted as follows:

Field Number	Size	Contents
1	6 Characters	Display record number
2	1 Character	Type of display as Selection, Question or Table
3	1 Character	Indicates the end of a sequence of displays
4	1 Character	Indicates that this is a Verification display
5	1 Character	Indicates that the previous entry is to be placed at the top of the screen.
6	2 Characters	Line number on screen for START symbol
7	1 Character	Specific information to be added to this display
8	20 Characters	Reserved for future expansion

This format is stored in the following manner:

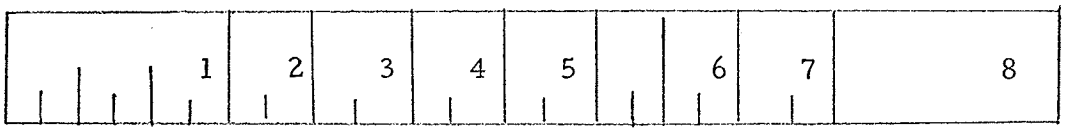


Figure 4F

Of the above format field 6 is the only field converted to an internal binary format by the display loading program. All other fields are stored in character image format.

4-5-2 The Display Area

The display area of each record is a 480-character string of information which is the exact screen image presented to the user as shown in Figure 4 and discussed in Section 4-4. The display area is divided into three areas. The top line is reserved for displaying the user's previous selection as a reminder. The second to eleventh lines inclusive constitute the actual display. The bottom line is reserved for entries and error messages.

```
Line one - Previous selection

Lines two to

            eleven - the actual display

                - - - - - - - - - - - - - - - -

Line twelve - Error Messages
```

Figure 4G

4-5-3 The Directory Area

The directory area of each display record occupies 140 characters. The amount of space actively used depends upon the display type. This area is made up of twenty-eight five-character fields. The arrangement of the fields is sequential; that is, the fields start at position 1 and occupy successive positions.

The format of each field depends on the display type. The method of using these fields to define display linkage is described in Section 6.

(i) The selection type of display (type 1) requires one field of the directory and the entries in the field are a code and a branch address (Figure 30, Page 78). A code and a branch address are required for each possible selection on a given display. The code is stored in character form and the branch address is stored in internal binary format.

CODE (Character)	BRANCH ADDRESS (Binary)

Figure 4H

The code identifies one element on the display. The branch address occupies three binary characters and is immediately usable as a relative record number to retrieve that display.

(ii) For the question and answer type of display (type 2) only three fields are used in the directory area (Figure 31, Page 87).

The first field has the following format: this represents a

QUESTIONS (Character)	ANSWER LENGTH (Binary)

Figure 4 I

question number and a length code. The question number consisting of two decimal digits identifies the question on the display, and the length code represents the maximum allowable length of the user's response. The internal format is identical with the code-branch address format described above.

The second field has the format:

98	BRANCH ADDRESS

Figure 4J

where the code 98 is reserved, and is a signal that a branch address follows. The branch address is stored as a three-character binary integer.

The third field has the format:

99	ROUTINE NUMBER

Figure 4K

where the code 99 is reserved, and is a signal that the number following is the identity of a special processing routine. Special processing routines are discussed in Section 3-3.

(iii) For the table type of display (type 3) five fields of the directory area are used.

The first field has the format:

QUESTIONS (Character)	ANSWER LENGTH (Binary)

Figure 4L

where QUESTION represents the number of a table statement and ANSWER LENGTH represents the allowable length of the user's response. The internal format is identical to the code-branch address described above.

The second field has the format:

BLANK	TABLE NUMBER (Binary)

Figure 4M

A code is not required to identify the Table Number since it follows the Question and Answer Length fields; hence it is left blank. The last three characters represent a binary integer which is the

number of a specific table of information (Section 4-3-5).

The third and fourth fields have the same format as follows:

98	BRANCH ADDRESS

Figure 4N

where the code 98 is reserved, and is a signal that a branch address follows. The branch address is stored as a binary three-character (hexadecimal) integer. The third field represents a branch address if the user's entry was found in the table; the fourth field represents the branch address if the user's entry was not found in the table.

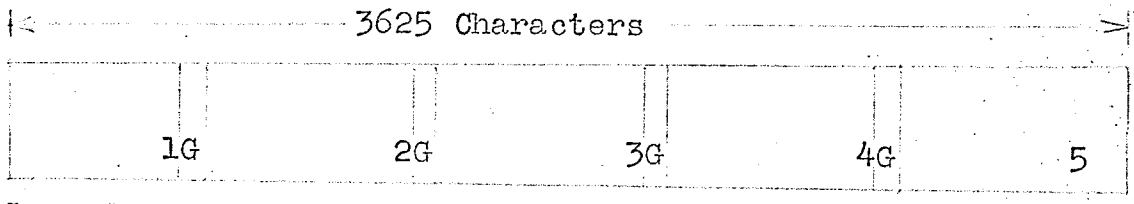
The fifth field has the same format and serves the same function as the third field of the question and answer directory; that is, it identifies a special processing routine.

4-6 Display Record Storage Considerations

The display record file for the DEMAND System was stored on an IBM 2311 disk[10] storage device. The direct access method[11] (DAM) and the relative record number system of storage and retrieval were used. Using the DAM it was possible to store five display records per track or 50 records per cylinder. Since a disk track contains about 200 usable cylinders, the total capacity would be about 10,000 display records (Figure 27). Each display record was stored on the disk using its identification number as a relative record number.

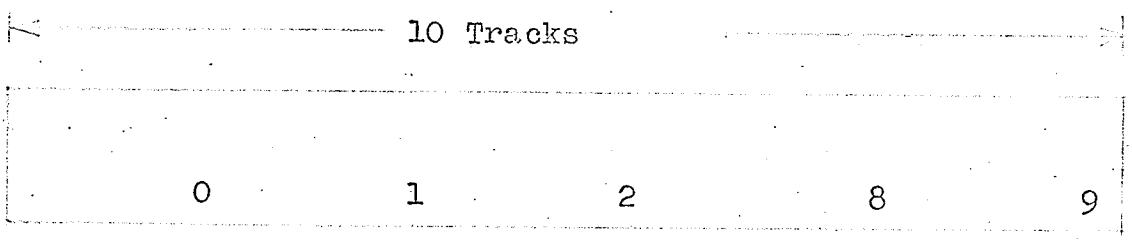
DISK FILE FORMAT

Track format



Legend
- 1-Record number 1
- 2-Record number 2
- 3-5-As above
- G-Inter-record gap

Cylinder format



Legend
- 0-Track zero
- 1-Track one
- 2-9-As above

FIGURE 27

The identification number is in field 1, of the identification label (Section 4-5).

No attempt was made to optimize the location of the display records on the disk. If the system would have a large number of displays, say 200 or more, then it would be more efficient and time saving to locate the most frequently used records at the centre of the file. For the initial DEMAND system fifty-three displays were loaded on the disk. Since this required only slightly more space than one cylinder, no physical motion of the disk access arm would be required, and as a result optimization would serve no point.

4-7 The Display Record Loading Program

The second program comprising the DEMAND system (Section 3-4) is the display record loading program. This program is used to establish or to up-date the display record file.

The display records are initially prepared on punch cards, and are entered into the system via the display record loading program (Figure 22-1).

The information label is then checked to see whether this is a valid type of display; that is, whether it is a type 1, or a type 2 (Figure 28-2). The display record number is then converted to internal binary format and inserted into the key area to become the relative address for writing the display on the disk file (Figure 28-3). The

START symbol line number in field 6 or the label area (Section 4-5-2) is converted to the required format for the CRT. It is then restored in the label area (Figure 12-4). All of the numbers in the directory area following the codes are converted to internal binary format. The directory is now stored in the format of the two character code followed by a three character binary integer. This integer represents a relative address, which could be a branch address, the routine processing number, or, the allowable length of a user's response (Figure 28-5). The display record is now written onto the disk file at the relative address given in the key area (Figure 28-6). The card file is then checked to see if there are any more display records (Figure 28-7). If there are more display records, they are accepted and processed as described above; if there are no more display records, then the loading procedure is complete.

BASIC LOGIC OF THE DISPLAY RECORD

LOADING PROGRAM

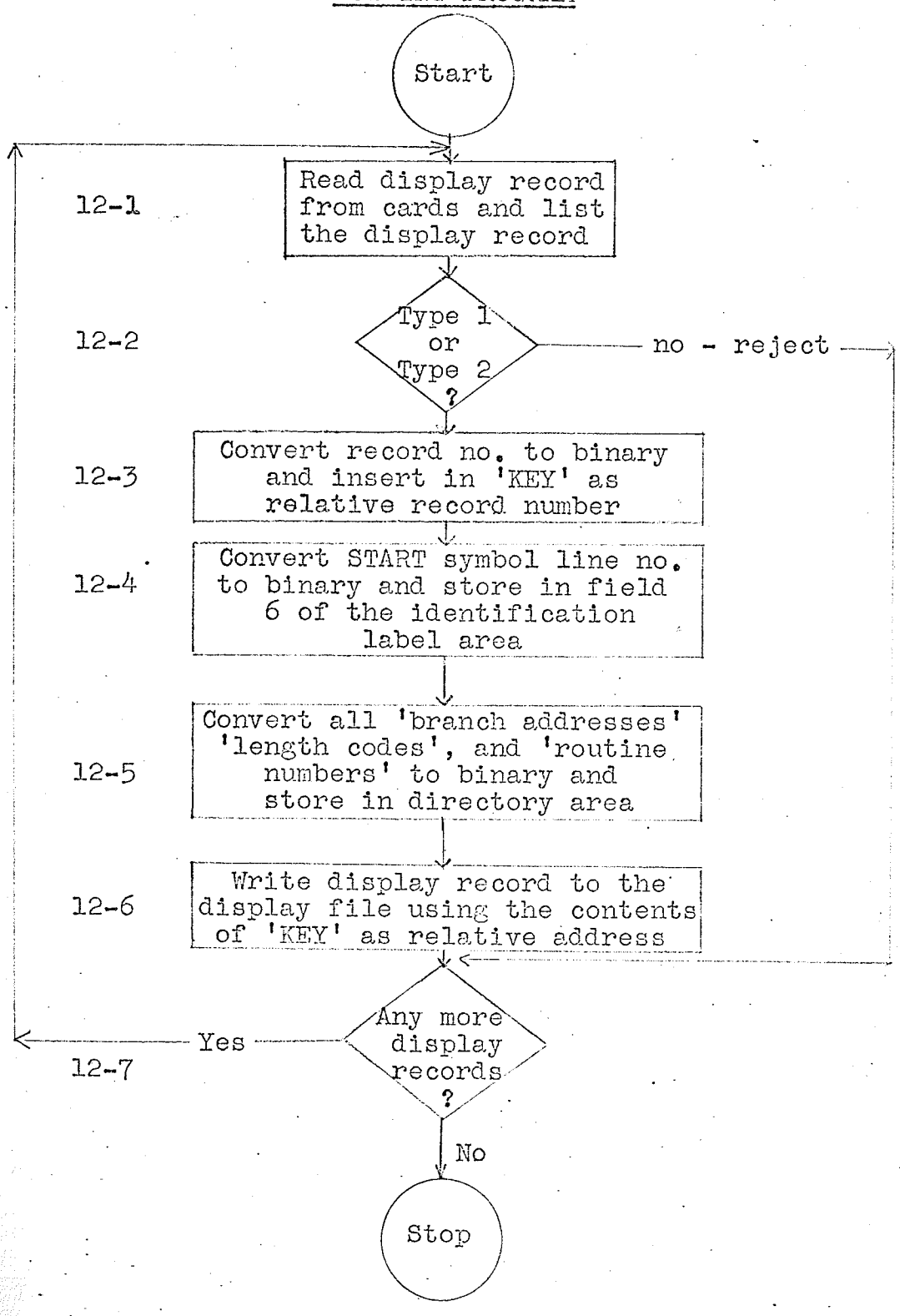


FIGURE 28

SECTION FIVE

THE DISPLAY LINKAGE AND NUMBERING SYSTEMS

5-1 The Display Linkage System

The display linkage or addressing system is necessary to allow the user to selectively step from one display to another. It is also necessary so that the logic of the DEMAND program can select the next display. For example, when the user makes a selection from a group of elements on a display, he is in effect choosing a branch of the Tree Structure which he will then follow. Each successive entry thereafter will select another branch and so on. Each element in the display trunk defines a unique branch. However, the same branch may function for two or more elements, providing these elements are related (Figure 12). The problem of how to define and store the identity or address of the "next display" associated with each element on the CRT screen required a solution before the logic of the display processing phase of the DEMAND system and the display record format could be developed.

Therefore, it was decided to design the displays so that each element of a display has a unique code associated with it. This code can then be duplicated and paired with the address of the next display. This pair, the duplicated code and the address, can be stored in the

directory associated with the display (Section 4-5). Since fixed format display records were used (650 characters), there was space for twenty-eight pairs of codes and branch addresses.

The type of linkage system described above required that only one table be searched in order to locate the next display. The system functions in the following manner. The user reads information on the CRT display and makes a response. When the response is received by the computer, it is checked to see if it is one or two characters in length. If it is one character, it is expanded to two by the use of a leading blank. An entry exceeding two characters constitutes an invalid response. The directory portion of the display record is then searched by a serial table look-up operation. The user's entry is used as a search argument against the code portion of each pair of entries in the table. When an equal comparison is found, the display address, which occupies the next three characters, is then read out of the directory. This address may now be presented to the file management system which will fetch the display record from the display file.

The table search method described is used rather than an index method so that the code on the display screen may be alphabetic as well as numeric. This places less restriction on the design of the display. The table search method of finding the address also prevents the necessity of performing any further checks on the user's response.

other than the length check in that, any one or two character entry is a candidate for a code. The advantage of storing the display address as a binary integer is that there is no intermediate steps of searching index files or using any other index method of storing and retrieving the display records.

5-2 The Display Numbering System

Although the system of displays is based on a Tree Structured File and the displays occupy fixed positions in the TREE, a method of uniquely identifying each display was required. Two number systems could be used to accomplish this. The displays could be numbered according to their level and position in the Tree Structure, referred to as the TREE numbering system. Alternatively the displays could be numbered sequentially; this system is referred to as the SENSE numbering system (Sequential Numbering System).

5-2-1 The Sense Numbering System

The display records are numbered sequentially starting at one (Figure 29). Each display record may be numbered as it is created, or the entire set may be numbered upon its completion. A display record number, referred to as the SENSE number, is entered in the first field of the identification label area. After the displays are designed and numbered, the directory area of each display record is completed by listing the codes and corresponding SENSE

numbers, as described in Section 6. The format of the SENSE numbers in the directory may be relative or absolute as described in Sections 5-4-1 and 5-4-2.

Display records may be loaded in any sequence whatever, as the display numbers (SENSE numbers) are unique and specify the relative address of the display record created. Since the addresses are relative only one loading procedure per display is required. The illustration and documentation of the linkage of the display records in the Tree Structure is simplified as the displays can be arranged in any desired sequence before loading.

5-2-2 The TREE Numbering System

The display records are numbered according to their position or level in the Tree Structure (Figure 30). The position or level of a display record in the Tree Structure is determined by the origin of the branch containing the display record.

With reference to Figure 30, displays in level one are numbered 01, 02, 03, ...N; displays in level two are numbers 01:01, 01:02, ...01:M_1; and 02:01, 02:02, 02:03 .....02:M_2; etc., where M_1 is the number of elements in display No. 01;M_2 is the number of elements in display No. 02; and M_N would be the number of elements in display No. N. As each level is added, the TREE number is increased by two digits, for example the third level would

THE MAIN TREE

THE FINAL BRANCHES

SEQUENTIAL NUMBERING SYSTEM - SENSE

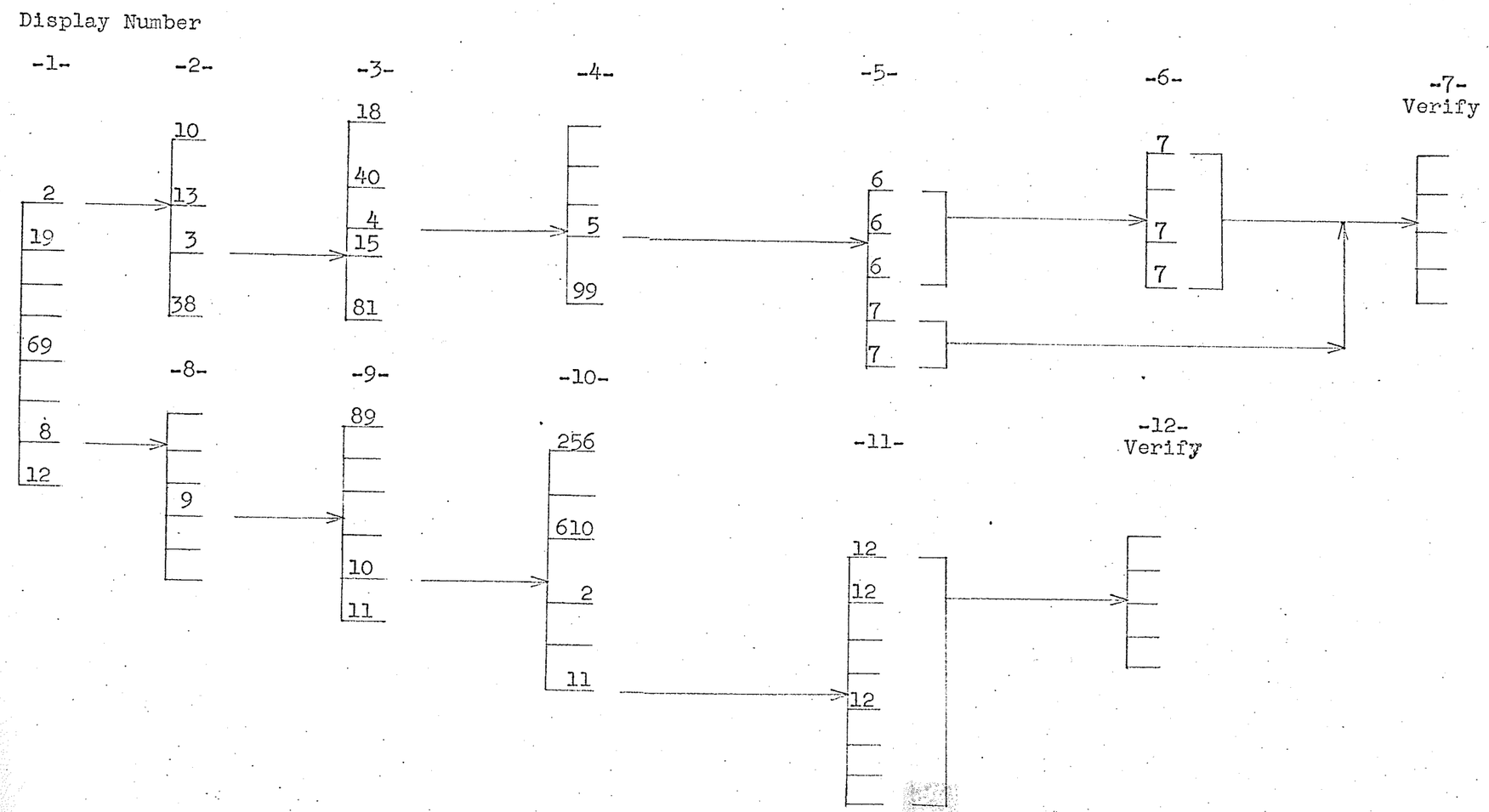


FIGURE 29

have number 01:01:01, 01:01:02, ...01:01:L where L is the number of elements in display No. 01:01.

This numbering system requires a special display record loading program which loads the display records in sequence.

When a display record is read from cards to main core storage, no calculations are made. The display record address is the address of the next available space on the disk. The display record is loaded at this address and the address is recorded in a cross-reference file. When the loading operation has been completed, the display records are then linked together. This is accomplished by sorting the cross-reference file in TREE number sequence, and replacing the TREE numbers by the disk addresses in the directory area of each display. The format of the disk addresses in the directory area is described in Section 5-4-2.

5-3 The Advantages and Shortcomings of the Display Numbering Systems

The TREE numbers are relatively easy to control as each area of organization is assigned a number in level one of the TREE structure system and expands from that point onwards. For example, all the display records associated with the laboratory section of a hospital would have TREE numbers beginning with a number such as 03.

The areas of the system which require, say 8-levels of displays, would have the lowest levels of displays addressed by a

TREE NUMBERING SYSTEM

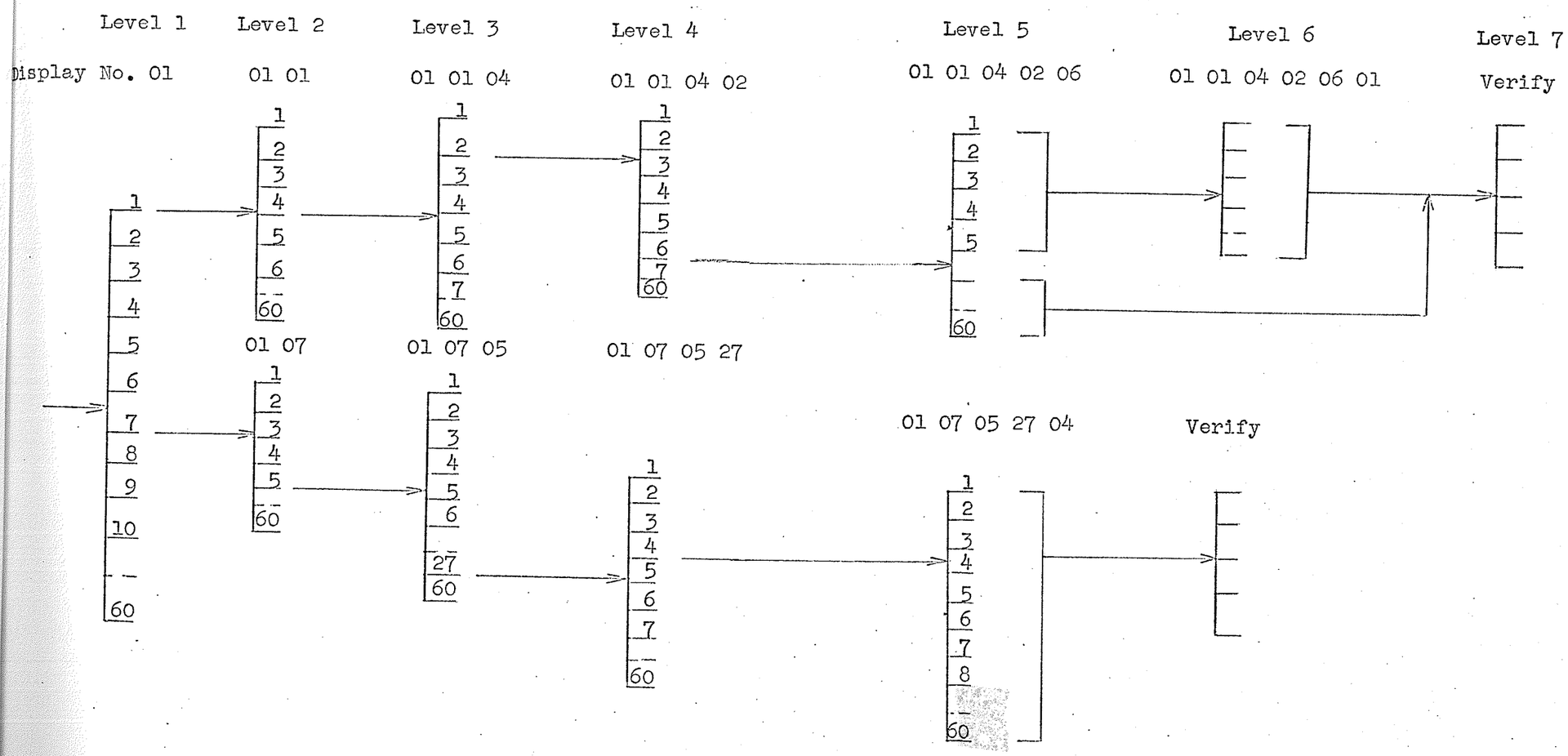


FIGURE 30

16-digit TREE number; that is, two digits for each level. This means either expanding the directory area to accommodate such a number or decreasing the number of entries in the directory. The former method increases the size of the directory area, thus requiring more storage space; the latter method restricts the system.

The SENSE numbers overcome the problem of expansion since they are assigned sequentially rather than level to level. In the system of 9,999 displays, for example, the SENSE number would only consist of four digits. The SENSE numbers must be tightly controlled in order to ensure efficient use of the disk storage area. Any SENSE number not used within a given sequence would mean that a display record is not loaded at that location in the file. Hence a waste of storage space results.

The problems encountered in the SENSE and TREE systems could be overcome by use of a symbolic addressing system. The system would use labels or names to identify displays rather than numbers. Displays would be given names such as "Drug 1", "Drug 2", "Patient", etc. These names would then be used as branch addresses.

5-4 The Format of The Display Branch Addresses

This section describes two possible methods of storing the branch addresses in the directory. In previous discussions (Section 4-5-3, for example) the Relative Address system was used. Both

methods, however, have been implemented, and no difference in operating performance has become apparent.

5-4-1 Relative Addresses

A file consisting of N records is first defined. The size of N depends on the number of display records in the system. Records are stored in sequence starting at 1 and going consecutively up to N. A record is stored or retrieved by stating its relative record number from the beginning of the file. To simplify the system display records would be numbered sequentially starting at 1 so that the display record 1 was in relative position 1, display record 2 was in relative position 2; and so on. In this manner any display record could be retrieved or replaced by specifying its relative position from the beginning of the file; that is, by specifying its SENSE number.

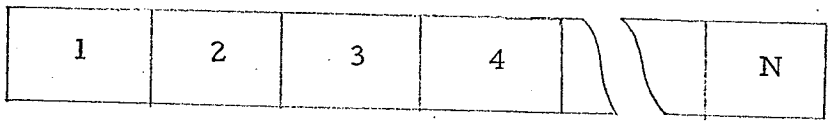


Figure 5A

5-4-2 Absolute Addresses

A file is defined as for the absolute addressing method, but the records are referenced by specifying their hardware address. The file, when defined, must be specified to start at a particular hardware address; that is, at some cylinder number, track number

and record number within the file. When the displays are loaded, the SENSE or TREE numbers are converted to actual hardware addresses of the form cylinder, track, and record numbers. This is accomplished either by adding a displacement computed by the disk algorithm onto the starting address of the file or by picking up the addresses from the index file, if the TREE number system was used. When a display record is to be retrieved, its location must be given in terms of cylinder, track, and record numbers.

5-4-3 The Advantages and Shortcomings of the Absolute and Relative Addressing Systems

The absolute addressing system is more efficient in so far as the actual hardware address of the display record is presented to the disk storage device. These addresses are calculated once only, when the displays are first loaded. However, using this system it is more difficult to change and relocate specific displays. The absolute addressing system accommodates either the SENSE or TREE numbering system.

The relative addressing system is less efficient in that the actual hardware address of the record must be calculated each time a record is retrieved or replaced. This operation is done at the time the record is required in a manner similar to the disk algorithm. The main advantage of this procedure is that the display record system is easily changed as the record numbers are relative from the starting

point of the file.

In order to use the relative numbering system, displays must be numbered sequentially, and therefore the system accommodates the SENSE numbering system only.

5-5 The Disk Algorithm

The object of Disk is to convert a SENSE number to a unique disk hardware address or an absolute address. This address has the form C-cylinder number, T-track number, R-record number. In the following discussions the disk addresses will be referred to by C, T, R.

Assuming that the first few tracks or cylinders of the disk pack are used for systems, programs, and other pertinent data, the final address calculated by Disk will be relative to this used portion. For purposes of discussion let the address of the next available space following this used portion be called the starting address. The process of calculating the final address from a SENSE number is as follows:

(1) Subtract 1 from the SENSE number.

(2) Divide the remaining SENSE number by 50, (since there are 50 records on a cylinder), to get the cylinder number C and the remainder R.

(3) Divide the remainder R by 5 (since there are 5 tracks in a cylinder) to get the track number T. The remainder of this division is the record number R. The address calculated in this manner is absolute with respect to cylinder 0, track 0, record 0.

(4) The final address of the display record is calculated by adding the address calculated by (1), (2) and (3) above to the starting address.

For example suppose the next available space, the starting address, on the particular disk pack is cylinder 21, track 9, record 5; and the SENSE number is 215, then following (1), (2) and (3) above we get;

(1) 215 - 1 = 214

(2) $\frac{214}{50} = 4 \not{+} 14$, hence 4 becomes the cylinder number.

(3) $\frac{14}{5} = 2 \not{+} 4$, hence 2 becomes the track number and 4 becomes the record number.

The cylinder number, track number, record number calculated by (1), (2) and (3) above will be referred to as the displacement address of the record. The sum or final display record address is calculated by adding the displacement record address onto the starting address

(4)

C	T	T
21	9	5
4	2	4
26	2	4

This is cylinder 26, track 2, and record 4.

Since there are five records on a track, the final record number must be 5 or less. Therefore, when the record numbers 5 and 4 are added, their sum is divided by 5, and the quotient is carried into the track number field. Then the track numbers are

added, their sum is divided by 10, since there are 10 tracks on a cylinder, and the quotient carried into the cylinder field. The final cylinder address is calculated by adding the 2 cylinder numbers and the carry digit together. The final address of the display is cylinder number 26, track number 2, and record number 4.

SECTION SIX

THE DISPLAY DESIGN SHEETS

6-1 Introduction

This section defines, in general terms, the basic method of using the display design sheets to set up a display record system.

There are three types of display design sheets:

(1) Type 1 - Selections - (Figure 31)

(2) Type 2 - Question and Answer - (Figure 32)

(3) Type 3 - Table - (Figure 33)

The display design sheets each have three areas; these are discussed in turn.

6-2 The Label Area

The label area is completed in the same manner for all types of displays. The fields are completed as follows:

1. Display record number field. The display record number is entered in this field.
2. Type field. The type code is entered in this field as 1-Selection; 2-Question and Answer; 3-Table.
3. Last display field. The last display of a sequence is indicated by entering a 1 in the "last" field; otherwise this field is left blank.

4. Line number field. This is a 2 digit field for representing the line number at the beginning of which the START symbol will be placed on the CRT screen

5. Verify field. If this display is to be a verify display, containing a recapitulation of information entered via a cycle of displays, then this is indicated by a 1 in this field.

6. Previous entry field. If the previous entry is to be brought forward onto the top of the next screen, a 1 is entered in this field.

7. Specific information field. If specific information is to be added to this display, then the 1 is entered in this field.

8. The remainder of the label area is reserved for future expansion.

For example, in Figure 31 the display record number is 110; it is type 1; and the START symbol will be placed on line 1 of the CRT screen.

6-3 The Display Area

For clarity and greater ease of accuracy in making entries a grid is drawn on the display design sheets (See Figure 31). This grid is not shown in the display itself. The spaces are referenced by rows and columns starting in the upper left hand corner of the screen.

DEMAND DISPLAY DESIGN SHEET - TYPE 1 - SELECTIONS

IDENTIFICATION LABEL AREA

DISPLAY NO.	TYPE	LAST	LINE NO.	VERIFY	ENTRY	SPECIFY
110	1		1			

DISPLAY AREA

```
▷
                    TYPES OF TESTS
                                  C-HEMATOLOGY
01-BIOCHEMISTRY                   D-TREATMENT
02-BMR                            E-PATHOLOGY
 3-DIET                           F-VGH LAB
 4-DRUG                           06-PROV. LAB
 5-ECG
 A-EEG                                G-OTHER TEST
 B-CHEMISTRY
```

LEGEND

▷ START SYMBOL

▮ CURSOR

DIRECTORY

CODE	BRANCH ADDRESS	CODE	BRANCH ADDRESS
01	67	06	78
02	95	F	81
3	98	6	88
A	40		
B	99		
C	176		
4	191		
5	210		
D	35		
E	79		

FIGURE 31

DEMAND DISPLAY DESIGN SHEET TYPE - 2 - QUESTION AND ANSWER

IDENTIFICATION LABEL AREA

DISPLAY NO.	TYPE	LAST	LINE NO.	VERIFY	ENTRY	SPECIFY
645	2		5			

DISPLAY AREA

PATIENT INFORMATION

01 - SURNAME - ▷

DIRECTORY

CODE	LENGTH BR. ADD. RTN. NO.
01	25
99	3
98	631

CODE	LENGTH BR. ADD. RTN. NO.

FIGURE 32

The display area is set up in the following manner:

The codes and elements are entered in the display area in the

DEMAND DISPLAY DESIGN SHEET TYPE - 3 - TABLE

IDENTIFICATION LABEL AREA

DISPLAY NO.	TYPE	LAST	LINE NO.	VERIFY	ENTRY	SPECIFY
257	3		7			

DISPLAY AREA

```
                    DRUG ORDERS

NOTE-ENTER AT LEAST THE FIRST 3 LETTERS
      OF THE DRUG NAME

02-DRUG NAME IS-▷
```

DIRECTORY

CODE	TABLE BR. ADD.	CODE	TABLE BR. ADD.
02	20		
	675		
98	87		
98	42		
99	7		

FIGURE 33

The display area is set up in the following manner:

The codes and elements are entered in the display area in the form of CC-element, where CC represents a two-character code that is unique to that element on that display; the code may be one or two characters, and may be numeric, alphabetic or graphic provided that the symbol appears on the keyboard of the typewriter attached to the CRT screen. The codes 98 and 99 are reserved for later use. The element entered may be a question, statement, selection or phrase, as described in Section 4.1. Each element must be preceded by a code and the separation character "-" as shown above.

For example to enter Aspirin on the display area, the format would be

A-ASPIRIN

or

1-ASPIRIN

or

16-ASPIRIN

The positions of the elements on the CRT screen depend upon the user's requirement, and are determined at the display design time. Display design considerations are discussed in Section 4.4, and Figures 34 to 50 are examples of various ways the information on the displays may be organized. It should be kept in mind that although the display

design is basically of free format, a suitable space and location must be left for the user's response. For example, in Figure 23 the user will be required to enter three initials for his identification. Note that an entire line is left for his entry. In Figure 24 the user will enter a one or two-digit code. Therefore his entry is made in the upper left hand corner of the screen. Note that the cursor could have also been positioned on the bottom line of the screen.

6-2 The Directory Area

The directory area of each display record provides space for twenty-eight five-character entries. The format of each entry is:

1. Selection type of display (Figure 31). This type of display consists of selection type elements only. In general CCBBBBBB is the directory area entry for a selection type of element, where CC corresponds to the code on the display area, and BBBBBB is the address of the next display or the branch address. Each element on the display area must have the above entry in the directory area associated with it. Up to twenty-eight selection elements may be accommodated in the directory. For example in Figure 31 the display entry for 01-BIOCHEMISTRY will have the corresponding directory entry 01bbbb67, where code b represents a blank, 01 is the code beside the display entry BIOCHEMISTRY, and 67 is the branch address.

This logically indicates that when the user enters 01 he will be presented with the display portion of the display record having number 67.

2. Question and answer type of display (Figure 32). This type of display consists of one request or question type element only. Three entries are required in the directory area for this type of display. The first entry requires is CCbbbLLL where CC is the code or question number, LLL is the allowable length of a response.

For example in Figure 32 - the display entry is 01-SURNAME. The corresponding directory entry is 01bbbb25 indicating that the length of surname may be up to twenty-five characters. The second entry required is 98BBBBBB, where 98 is a reserve code indicating that a branch address follows, and BBBBBB is the branch address.

For example in Figure 32 the directory entry is 98bbb631 indicating that after the user's entry of the surname has been processed, the user will be presented with the display number 631.

The third entry required is the logic routine identifier. It is indicated as 99bbbLLL, where 99 is a reserve code indicating the routine number and LLL is the routine number.

For example in Figure 32 the entry is 99bbbbb3 indicating that routine number 3 of the special processing routines would be used to process the user's entry in response to 01-SURNAME.

In summary: When the user is presented with the display in Figure 32, and makes an entry, that entry will be processed by

routine number 3, and the entry must be twenty-five characters or less, and when routine 3 is complete, the user will be presented with the display numbered 631.

3. Table type of display (Figure 33). This type of display consists of table type elements only. Five entries are required in the directory area for this type of display.

The first entry identifies the question or request, and has the format CCbbbLLL where CC is the question number on the display area, and LLL is the allowable length of the user's entry.

For example in Figure 33 the display entry is 02-DRUG NAME IS and the directory entry is 02bbbb20 indicating that the user can enter up to twenty characters in response to question number 2.

The second entry in the directory identifies the number of the table that will be searched using the user's response as a search argument. The entry has the format bbbbbRRR where RRR is the table number.

For example in Figure 33 the entry is bbbbb675 indicating that table number 675 will be searched for the drug name.

The third and fourth entries in the directory are a set of branch addresses. The first branch address will indicate the number of the display to be presented to the user if his entry has been found in the table; otherwise the second branch address will be taken, and

he will be presented with that display. Both entries have the format 98BBBBBB.

For example in Figure 33 the third entry in the directory is 98bbbb87, and the fourth entry is 98bbbb42. These indicate that the user will be presented with the display having number 87, if his entry has been found in the table, or with the display having the number 42, if his entry has not been found.

The fifth entry indicates the special processing routine number. This entry has the format 99bbbRRR. The entry is made as described in 2. above.

In summary: if the user was to type in the letters DEMEROL in response to the question 02-DRUG NAME IS his response would be processed by routine number 7, and he would be presented with display number 87 listing information about the drug Demerol. The table 675 would have been searched to find this name, DEMEROL.

SECTION SEVEN

METHOD OF TRANSACTION

7-1 Introduction

The general method of transaction is described in this section. It will be assumed that the reader understandsthe operation of the IBM 2260 display station with the 480-character screen and alphanumeric keyboard, as described in Appendix A.

In processing any response only those characters between the START symbol and the CURSOR symbol will be considered. Depression of the ENTER key does not cause a character to appear on the screen. In the following discussion the phrase "press the ENTER key" will be substituted for "press the SHIFT and ENTER keys" for purposes of brevity.

When typed entries exceed one line the CURSOR automatically advances to the beginning of the next line where typing may continue. The user's response is processed starting at the last character entered which is checked to determine if it is a control character. If it is a control character, the respective routine is called to perform the required function; if not, the response is processed and the next display is projected.

7-2 Control Characters

A control character allows the user to direct the system to

perform certain functions. Specific keys on the keyboard are used to represent the control characters, or, the control characters may appear on certain displays where the control character is required.

The types of control characters are described below:

BACK - "+"

The "+" key is programmed to perform the function of recalling the last display that was processed. The display is recalled from the display record file on the disk; and any information that was entered immediately before the "+" sign is ignored in the process.

TERM - "$"

The "$" key is programmed to perform the function of terminating the present sequence of displays and returning the identification display to the screen.

RECALL - "="

The "=" key is programmed to perform the function of recalling a display that has been erased either by accident or purposely because of incorrect entry. The user must first press the START key which causes the START symbol and the CURSOR to appear on the screen. He will then press the "=" key followed by the ENTER key.

7-3 Starting A Transaction

When the system is not actively being used, such as between transactions, the identification display will remain projected on the

CRT screen (Figure 34). To begin a transaction the user must enter his personal three character code to gain entry to the system. He then makes selections as described in the following sections. After the user has completed an entry, he pushes the ENTER key which causes this entry to be accepted by the computer. The user's replies required in response to each type of display are described on the following pages.

7-4 Selections

To indicate a selection from a display the user types in the code associated with the element he chooses. The code typed in will appear on the screen following the START symbol. The user then checks the code entered against the desired code appearing beside the element he wishes to select. If it is correct, he then presses the ENTER key. The screen will now be cleared and the next display projected. The keyboard is locked during the clearing and filling process of the screen and hence, no entry can be made during this time. When the screen is filled with the second and succeeding displays the START symbol is placed at the beginning of an appropriate line and is followed by the CURSOR.

Example 1 - If the selected element from a display is 8-RED BLOOD COUNT, the user will indicate his choice by entering 8 and pressing the ENTER key (Figure 41). It should be noted that the code must be entered exactly as it appears on the screen. In this

example the character 8 is checked to determine if it is a control character, since it is the last character entered. Since it is not a control character, the display is processed as usual, and the next display, relevant to a red blood count, is projected on the screen.

Example 2 - Continuation displays. When there is insufficient space on one display to contain all selections that are possible, then the remaining selections will be on other displays immediately following the first display. To call these displays on the screen the user enters the code appearing beside the phrase "MORE" and then presses the ENTER key (Figure 7A). In effect the user is indicating to the system that he wishes to skip that display. In the following example the code entered would be 11. The elements in the continuation display are shown in Figure 7B.

First display is:

```
▶ 11
    01 - TEST 1
    02 - TEST 2
    03 - TEST 3

    :
    :
    10 - TEST 10
    11 - MORE
```

Figure 7A

The next display is (Continuation display)

```
12 - TEST 12
13 - TEST 13

:
:
20 - TEST 20
```

Figure 7B

7-5 Typed Responses

A typed response is a reply to a question or to a table entry.

Example 1 - Suppose the display is:

```
SURNAME ▶

ENTER UP TO 40 CHARACTERS
```

Figure 7C

The user enters the name starting where the CURSOR appears, and then presses the ENTER key. The answer accepted will be that typed entry between the START symbol and the CURSOR.

Example 2 - Suppose the display is

```
01 - TEST 1
02 - TEST 2
03 - TEST 3
04 - OTHER
```

Figure 7D

and the test required is not listed. Then, the user first enters 04 and presses the ENTER key which results in the following display:

```
TYPE IN TEST NAME ▶
```

Figure 7E

The user types in his response starting at the START symbol. The length of the typed response will depend upon the type of display. For example in ordering a new type of test, one would type in the name of the test as "TEST X", and press ENTER. The user's entry will be recorded as a phrase in the system; no further recording takes place; and the next display is then projected on the CRT screen.

Example 3 - Table Search. Suppose the display is :

```
▶04
   01 - DRUG 1
   02 - DRUG 2
   03 - DRUG 3
   04 - OTHER
```

Figure 7F

and the drug required is not listed. Then the user first enters 04 and presses the ENTER key which results in the following display:

```
ENTER AT LEAST THE FIRST THREE
CHARACTERS OF THE DRUG NAME
▶
```

Figure 7G

The user will enter at least the first three letters of the drug name and press ENTER. If the user wishes to order Demerol, then his entry could be DEM. The action following is that described in Section 4-3-4.

7-6 Correcting Typed Errors

(1) Errors made in typing before pressing the ENTER key may be corrected by back-spacing to the character or characters in error and typing in the correct entry. Backspacing moves the CURSOR back one position each time the back space key is pressed. The characters passed over in doing so are not erased.

Example 1	Original entry	▷07	
	Should be	▷08	
	Backspace 1	▷07	
	Enter 8	▷08	
	Press Enter	08	
Example 2	Original entry	SURNAME	▷HAWKENS
	Should be	SURNAME	▷HAWKINS
	Backspace 3	SURNAME	▷HAWK ENS
	Enter I	SURNAME	▷HAWKI NS
	Space 2	SURNAME	▷HAWKINS
	Press ENTER	SURNAME	HAWKINS

(2) Errors made in typing and not realized until after pressing the ENTER key are corrected as follows (i.e. you are at the next display and have to step back one - this also includes the possibility of an incorrect selection). The "+" key (representing the BACK control character) and the ENTER key are pressed causing the last display to reappear. The correct entry is then made.

Example 1 To BACK up one display

Entry is ▶+

The net result is that the previous display is projected and only results to that point are retained.

(3) If the user enters a code that is not listed beside an element of the display, an error condition will result. An appropriate message such as:

INVALID CODE - MAKE ENTRY OVER

Figure 7H

or

NOT ON THE PATIENT LIST

Figure 7I

will appear on the last line of the screen. The user then enters the correct code.

(4) It is possible to start over from any point in the series of displays by pressing the "$" (representing the control character TERM) and ENTER keys. The Identification display is returned to the screen.

Example 2 TERMINATE

Entry is ▶06$

Where 06 was the First Selection made.

When the ENTER key is pressed, the result is that the sequence of displays is terminated, the Identification display is projected on the screen and the system is cleared.

SECTION EIGHT

THE DEMAND SYSTEM IMPLEMENTED

8-1 Introduction

The DEMAND system as implemented for the initial demonstration is described in the following paragraphs.

An IBM 2260 DISPLAY STATION with a 480-character screen, an alphanumeric keyboard and a non-destructive cursor was connected on a local basis to an IBM System/360, model 65 (Figure 56). The DEMAND system was set up to function under both the IBM Operating System and Disk Operating System. The Graphics Express[7] method of handling the CRT input/output was used under the Operating System. The BTAM[6] method of handling CRT input/output was used under the Disk Operating System. The displays were written on the CRT screen using the "write full buffer" feature. A START symbol was then positioned at the beginning of one of the 12 lines on the screen as indicated by the line number field in the identification label of the display in question.

The time required to process a typical display was approximately one second. This time included reading the user's input, processing the input, obtaining the next display from the disk file, projecting that display on the screen, and positioning the START

symbol in readiness for the user's next response. On a telecommunication basis, this time was increased to approximately four seconds due to slow speed transmission lines.

A system of fifty-eight display records, nineteen of which are shown in Figures 34 to 52, were defined and stored on an IBM 2311 Disk Storage Unit using the SENSE numbering system. The display records shown in Figures 34 to 49 were set up to accommodate a model hospital environment. Included were three displays used for modifying the display system itself. The first example following is that of a simulated doctor's order for a white blood count. The second example illustrates the technique of modifying the display system.

8-2 Doctor's Orders

A doctor's order for a white blood count is simulated in the following sequence of displays. The reader should note that the order sequence simulated is only for demonstration purposes and does not attempt to redefine existing hospital methods and procedures.

As each of the user's responses is processed an entry is made into the transaction sentence as described in Section 3-2-3. The transaction sentence build-up is shown in Section 8-2-1.

Suppose that this is the 735'th transaction to be made at this particular CRT. The transaction sentence sequence number is then

735; (1) in the transaction sentence (Section 8-2-1). The transaction over-all code is 374; (2) that is 3 represents a doctor, 7 represents a patient order, and 4 indicates that it was verified. The overall length of this transaction sentence will be 104 characters, as indicated by (3), that is the sum of the lengths of each word.

The first display presented to the user is that of identification. (Figure 34). The user's response is OBS for Dr. O. B. Smith. Since the doctor is a valid user, the system proceeds to make entries (4), (5) and (6) in the transaction sentence. Entry (4) indicates the total length of the entries (4), (5) and (6); that is of the code entered, and the translation, namely OBS and Dr. O. B. Smith respectively.

The next display (Figure 35) is a basic display listing the main functions or jobs that the system allows one to do. Note that across the top line of that display is the entry OBS Dr. Smith O. B. This is the method by which the system acknowledges the user and informs himthat he may now proceed. The Doctor wishes to order a test for a patient so he enters 1 for "PATIENT ORDERS." The entries (7), (8) and (9) are made in the transaction sentence, that is 19-1-ORDERS PATIENT. Here 19 is the length of the entry, 19-1-PATIENT ORDERS; 1 is the doctor's entry; and PATIENT ORDERS is the English Translation.

The next display (Figure 36) is one used to identify the

patient. Note that on the top line of this display the previous selection 01 PATIENT ORDER has been brought forward. This is achieved by a "1" in the "ENTRY" field of the identification label. The doctor has the choice of entering the patient number which is an 8-digit code or an "S" if he wants to see a list of patients. The doctor makes the entry "S". Note that no entry is made in the transaction sentence for this response.

The next display (Figure 37)is a list of names of patients. Since the doctor wants to order the white blood count for John Peters he enters the code 5. The entries (10), (11) and (12) are made in the transaction sentence; that is 13-5-A 1063841. The next display (Figure 38) lists the types of Doctor's orders that may be selected. Note that at the top of this display the patient's name; the patient's number; the patient's doctor's name, and the patient's bed, room, and ward numbers are brought forward. This is to verify that the order is being selected for the correct patient. Since the doctor requires a laboratory test he enters the code 1 for "ORDER LAB TEST" thus creating entries (13), (14) and (15) in the transaction sentence.

The next display (Figure 39) is a list of laboratory tests. The doctor enters the code 6 for "WBC". The entries (16), (17) and (18) are made in a transaction sentence. The next display (Figure 40) lists the times for laboratory tests. Since the doctor wants the test immediately he enters the code 2 for "STAT". The entries (19), (20) and (21)

are made in the transaction sentence.

The final display (Figure 46) is presented to the user for verification purposes. This display is a recapitulation of what the doctor has ordered. If he is satisfied that everything is correct, he enters a 1; and the transaction is then passed to the transaction processing routine. If he wishes to cancel the order, he enters an X which returns him to the identification display. In this example the doctor enters a 1 to signify that the order is correct and entries (22), (23) and (24) are made in the transaction sentence. The entry (24), namely "V" indicates that the transaction was verified.

This concludes the doctor's conversation with the DEMAND system.

8-2-1 The Transaction Sentence Assembled by DEMAND

As the sequence of displays in Section 8-2 are processed the following Transaction Sentence is assembled:

1	2	3	4	5	6	7	8	9
735	374	104	21	OBS	Dr. O. B. SMITH	19	1	PATIENT ORDERS

10	11	12	13	14	15	16	17	18	19	20
13	5	A1062841	19	1	ORDER LAB TEST	8	6	WBC	9	2

21	22	23	24
STAT	6	1	V

1. Transaction Sentence Sequence Number, 735.
2. Transaction Overall Code, 374.

3. Overall length of transaction sentence, 104.

4. Length of the first word, 21.

5. Code entered by user, OBS.

6. Translation of code.

7., 8., 9.,.....21., Second to sixth words.

22., 23., 24. Verification word.

IDENTIFICATION

IDENTIFICATION DISPLAY

ENTER YOUR THREE INITIALS FOR I.D.

▶OBS,

PRESS ENTER

FIGURE 34

MAIN JOBS

```
▶1,        OBS  DR SMITH,O.B.
        SELECT JOB YOU WISH TO DO
 1-PATIENT ORDERS        11-REPORT LAB TEST
 2-ENTER PAT.NOTES       12-REPORT X-RAY
 3-CHART MEDICATION
 4-ENTER VITAL SIGN      14-REPORT DRUGS
 5-ORDER SUPPLIES        16-CALL MEN.LIST
 7-ENTER STAFF TIME      17-CALL LAB STICK.
                         18-CHANGE DISPLAYS
 9-ADMIT PATIENT -AD
10-DISCHARGE PAT.-MR
```

FIGURE 35

PATIENT IDENTIFICATION

```
1 PATIENT ORDERS
PATIENT IDENTIFICATION
TYPE IN PATIENT NUMBER OR S FOR SEARCH

▶S

PRESS ENTER
```

FIGURE 36

PATIENT LIST

```
▶5,     SELECT PATIENT FROM THIS LIST
1-JOHNSON PETER     A1234567   DR JONES,J.J.
   B.D. 03/05/40
2-KNOWLES BARRY     A0000211   DR SMITH,O.B.
   B.D. 06/08/32
3-KNAPP SAM         A1461372   DR COSTIN,D.W.
   B.D. 07/09/24
4-LESLIE JOHN       A0064273   DR SMITH,O.B.
   B.D. 08/09/30
5-PETERS JOHN       A1062841   DR SMITH,O.B.
   B.D. 09/05/38
```

FIGURE 37

TYPES OF ORDERS

```
▶1,              PETERS JOHN
                 A1062841
                 DR SMITH,O.B.
                 B.D. 09/05/38

CHOOSE ORDERS DESIRED
 1-ORDER LAB TEST    6-ORDER OTHER DRUG
 2-ORDER X-RAY       7-ORDER TREATMENT
 3-ORDER EEG         8-ORDER PHYSIOTH.
 4-ORDER EKG         9-ORDER SOC.WKER
 5-ORDER NARCOTIC   10-ORDER DISCHARGE
```

FIGURE 38

TYPES OF LABORATORY TESTS

```
▶6,          LABORATORY TESTS
 1-HEMATOLOGY LIST      11-CHEM-BLOOD LIST
 2-HGB                  12-BUN
 3-HCT                  13-LAD
 4-SR                   14-ELEC
 5-RBC                  15-SGOT
 6-WBC                  16-CHEM-URINE LIST
 7-DIFF                 17-URINALYSIS
 8-PT                   18-BILE
 9-CHEM-SPEC.LIST
10-BACTI.LIST-NOT YET
```

FIGURE 39

TIME OF TEST

```
▶2.                TIME OF TEST
 1-ROUTINE                      11-EOD 2 DAYS
 2-STAT                         12-EOD 3 DAYS
 3-PRE-OP                       13-EOD 5 DAYS
 4-POST-OP
 5-DAILY 2 DAYS                 19-OTHER
 6-DAILY 3 DAYS
 7-DAILY 5 DAYS
 8-BID 2 DAYS
 9-BID 3 DAYS
10-BID 5 DAYS
```

FIGURE 40

HEMATOLOGY LIST

8. HEMATOLOGY LIST

1-BLEEDING TIME	11-INDICES
2-BONE MARROW FILM	12-EOSINOPHIL CNT
3-CLOT RETRACTION	13-PLATELETS
4-COOMBS TEST	14-RETICULOCYTES
5-HEMOGLOBIN	15-L.E.CELLS
6-HEMATOCRIT	16-FRAGILITY TEST
7-SED.RATE	17-COLD AGGLUTININS
8-RED BLOOD COUNT	19-OTHER TESTS
9-WHITE BLOOD COUNT	20-PROTHROMBIN LIST
10-DIFFERENTIAL	

FIGURE 41

CHEMISTRY LIST

```
CHEM.SPECIAL LIST
 1-CSF
 2-GASTRIC ANALYSIS
 3-DIAGNEX BLUE
 4-OCCULT BLOOD
 5-SWEAT CL.EST.
 6-TOT,FAT FECAL
 7-UROBILIN FECAL
 8-URORILINOGEN FEC
19-OTHER
```

FIGURE 42

BLOOD CHEMISTRY-PART 1

5.
CHEM-BLOOD-1

1-ACETONE	11-CREAT.CLEARANCE
2-ALCOHOL	12-AMYLASE
3-BLOOD VOLUME	13-ELECTROPHORESIS
4-BROMOSULPHALEIN	14-GLUCOSE(FBS)
5-CALCIUM	15-GLUCOSE TOLERANCE
6-CAROTENE	16-L.A.D.
7-ELECTROLYTES	17-S.GOT
8-CHOLESTEROL-TOT	18-S-GPT
9-CHOLESTEROL-ESTR	20-MORE
10-CREATININE	

FIGURE 43

BLOOD CHEMISTRY-PART 2

CHEM-BLOOD-2

1-THVMOL TURBIDITY	11-BLOOD UREA NIT.
2-CEPH.CHOL.FLOCC.	12-URIC ACID
3-THYMOL FLOCC.	13-VAN DEN BERGH
4-PH BLOOD	14-HEMOCHROMOGEN
5-PHOSPHATASE-ACID	19-OTHER
6-PHOSPHATASE-ALK.	
7-PHOSPHORUS	
8-PROT.BND.IODINE	
9-PROTEINS	
10-SERUM IRON	

FIGURE 44

URINE CHEMISTRY LIST

CHEM-URINE

1-PSP	11-GLUCOSE
2-UROBILINOGEN	12-KETOSTEROIDS
3-ALBUMIN	13-HYDROXYSTEROIDS
4-PROTEIN-B.J.	14-PORPHYRINE
5-CALCIUM	15-PREG-FREEDMAN
6-CATECHOLAMINES	16-PREG-BREVINDEX
7-ELECTROLYTES	17-PREG-PROGNOSTICON
8-CREATINE	18-SCHILLINGS TEST
9-CREATININE	21-UREA NITROGEN
10-AMYLASE	19-OTHER

FIGURE 45

VERIFICATION

```
▶1,     VERIFY DISPLAY BY TYPING 1
        CANCEL BY TYPING X
USER -DR SMITH,O.B.
PAT. -PETERS JOHN       A1062841
      B.D. 09/05/38     DR SMITH,O.B.
ORD. -  01 ORDER LAB TEST
        06 WBC
        02 STAT
```

FIGURE 46

PROTHROMBIN TESTS

```
                PROTHROMBIN TESTS
 1-FIBRINOGEN EST
 2-FIBRINDEX
 3-FIBRINOLYSIN
 4-PROTH.TIME
 5-PARTIAL PROTH.TM.
 6-PROTH.CONSUMPTION
19-OTHER
```

FIGURE 47

URINALYSIS LIST

```
                    URINALYSIS
 1-URINALYSIS,STD
 2-REACTION PH
 3-SPEC.GRAV.
 4-SUGAR
 5-KETONES
 6-MICRO
 7-BILE
 8-CONC.DILUTIONS
19-OTHER
```

FIGURE 48

TEXTUAL ENTRY

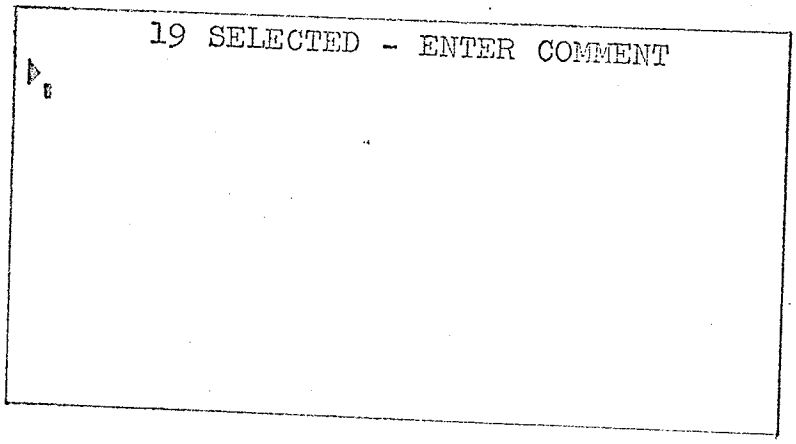


FIGURE 49

MAIN JOBS

```
▶18,      OBS  DR SMITH,O.B.
        SELECT JOB YOU WISH TO DO
 1-PATIENT ORDERS        11-REPORT LAB TEST
 2-ENTER PAT.NOTES       12-REPORT X-RAY
 3-CHART MEDICATION
 4-ENTER VITAL SIGN      14-REPORT DRUGS
 5-ORDER SUPPLIES        16-CALL MEN.LIST
 7-ENTER STAFF TIME      17-CALL LAB STICK.
                         18-CHANGE DISPLAYS
 9-ADMIT PATIENT -AD
10-DISCHARGE PAT.-MR
```

FIGURE 50

INITIATE CHANGES

```
YOU ARE NOW IN THE SEQUENCE OF DISPLAYS
THAT ALLOW YOU TO CHANGE ANY DISPLAY.

ENTER THE NUMBER OF THE DISPLAY YOU WISH
TO CHANGE.

  ▷12
```

FIGURE 51

SELECT CHANGE

```
INDICATE WHAT YOU WISH TO DO BY ENTERING
THE CODE ASSOCIATED WITH ONE ENTRY IN
THE FOLLOWING LIST.
  12 IS THE DISPLAY YOU ARE PRESENTLY
CHANGING.

1-CREATE A DISPLAY    4-DIRECTORY CHANGES
2-LABEL CHANGES       5-TO BASE DISPLAY
3-CHANGES TO DISPLAY AREA
▶3
```

FIGURE 52

DISPLAY BEFORE CHANGES

URINE CHEMISTRY LIST

```
                    CHEM-URINE
▶1-PSP                 11-GLUCOSE
 2-UROBILINOGEN        12-KETOSTEROIDS
 3-ALBUMIN             13-HYDROXYSTEROIDS
 4-PROTEIN-B.J.        14-PORPHYRINE
 5-CALCIUM             15-PREG-FREEDMAN
 6-CATECHOLAMINES      16-PREG-BREVINDEX
 7-ELECTROLYTES        17-PREG-PROGNOSTICON
 8-CREATINE            18-SCHILLINGS TEST
 9-CREATININE          21-UREA NUTROGEN
10-AMYLASE             19-OTHER
POSITION CURSOR AT * WHEN FINISHED                *
```

FIGURE 53

DISPLAY AFTER CHANGES

URINE CHEMISTRY LIST

```
                    CHEM-URINE
▶1-PSP                 11-GLUCOSE
 2-UROBILINOGEN        12-KETOSTEROIDS
 3-ALBUMIN             13-HYDROXYSTEROIDS
 4-PROTEIN-B.J.        14-PORPHYRINE
 5-CALCIUM             15-PREG-FREEDMAN
 6-CATECHOLAMINES      16-PREG-BREVINDEX
 7-ELECTROLYTES        17-PREG-PROGNOSTICON
 8-CREATINE            18-SCHILLING TEST
 9-CREATININE          21-UREA NITROGEN
10-AMYLASE             19-OTHER
POSITION CURSOR AT * WHEN FINISHED                *
```

FIGURE 54

IDENTIFICATION

IDENTIFICATION DISPLAY

ENTER YOUR THREE INITIALS FOR I.D.

PRESS ENTER

FIGURE 55

IBM SYSTEM 360/65 WITH CATHODE RAY TUBES

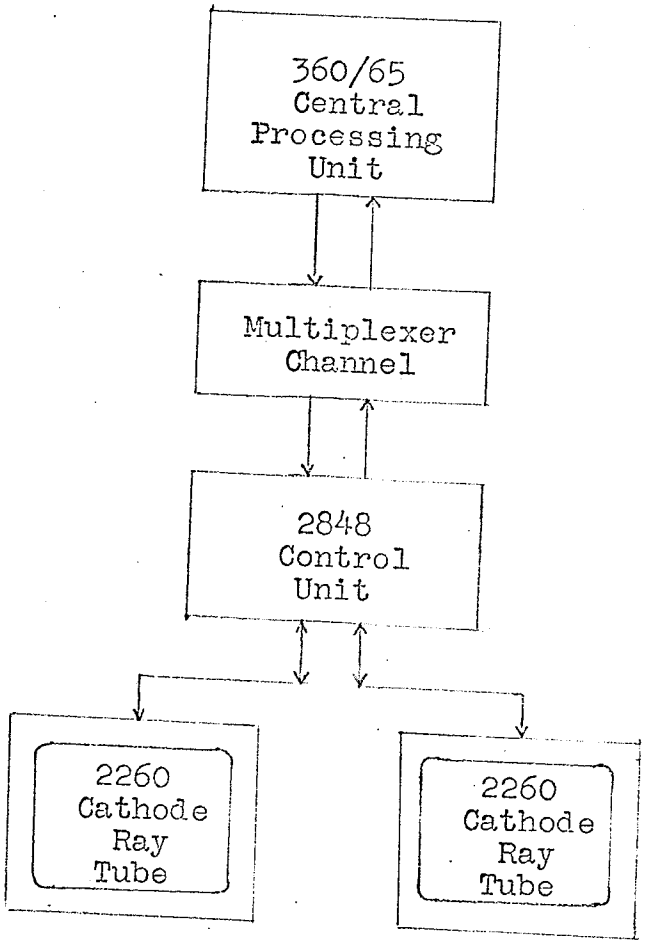


FIGURE 56

8-3 Modifying the System of Display Records

The method by which the user can make modifications to the display record system is described in this Section.

Three displays were designed specifically for this purpose. It should be noted, however, that once the system has been set up these displays can also be used to change themselves. The user then, with these three displays and a suitable version of the DEMAND program could define a system of displays using a CRT only. In this manner the display loading program would be necessary only to load these three displays (as shown in Figures 50, 51 and 52).

The general method of operating the system is the same as that described in Section 8-2. Some method of safeguarding the system is required, so that someone would not destroy it or render it inoperative. As mentioned previously specific types of hardware to read plastic identification cards are not readily available. Therefore, on the orders display (Figure 50) the entry "18-CHANGE DISPLAYS" is used to gain entry to the changing procedure. Note that the user will not enter the system simply by entering "18", he must enter "18," the ", " representing the safeguard character.

After entering the modifying system the user is presented with the first of the modifying displays (Figure 51). He is asked to enter the number of the display that he wishes to modify. After

entering that number he is presented with a display which asks him what part of a display record he wishes to change. In this example the user enters a "3" indicating that he wishes to change the display area (Figure 52). The user is now presented with the display area of the display record he wishes to change (Figure 53). He now proceeds to move the cursor to the place where he wants to make the changes. In this example the user wishes to correct Item 21 on the display. He wishes to correct the spelling of the item from "NUTROGEN" to "NITROGEN". Figure 54 represents the corrected display.

After making all the changes the user replaces the CURSOR to the right hand corner of the screen and presses the ENTER key. The display portion of the display record is now written back into the display record and the display record is written onto the disk file. The user is now returned to the Identification display (Figure 55). A transaction sentence is not constructed in the changing sequence of displays.

SECTION NINE

FUTURE DEVELOPMENTS

9-1 Developments in Progress

Presently under development and to be included as part of a future DEMAND system are the following facilities:

(1) A provision which will allow the user to make multiple entries at any level in the display system. The entry will have the following format:

Code - variable 1, variable 2, variable 3 ....variable N.

The code represents a function and the variables further modify this code.

For example, the entry 001 - Joe Blokes, 621 Hargrave Street, Winnipeg, Manitoba, 4749212, would be the entry when admitting a patient to a hospital This would represent part of the information required, where 001 is the code for patient admission and the information following is about the patient being admitted.

(2) A provision to allow the user to make more than one selection from a screen of elements. The user will be able to enter a string of codes and/or text representing his request.

For example, in Figure 24 (Page 49) if the doctor wishes to select PATIENT ORDERS, REPORT X-RAY, and REPORT LAB TEST,

he may do this in one entry as follows:

"1, 12, 11"

The system will then cycle through the required set of displays for each entry in turn. The doctor would be presented with a verification display at the end of each cycle. In this case there would be three verification displays; one for the doctor's order, one for the drug report, and one for the lab report. At the conclusion of these three cycles the system would return the Identification display to the screen.

9-2 Proposed Developments

This Section lists some developments which would greatly increase the performance of a system such as DEMAND.

(1) The facility to accept an entry from a CRT which has a "light pen", "push-button", or "touch-sensitive", screen.

(2) A more suitable means of user identification. Some method involving reading a plastic identification card; the use of a key; the unique identification of the user's voice; or positive recognition of the user's facial qualities would be preferred to the present procedure. This would prevent misuse of the system and facilitate entries.

(3) The development of a high level type of language. This language would include such verbs as display, load, modify, store, add, delete, fetch, code, element. This would allow the user to define a specific version of the DEMAND program to suit his particular application.

(4) The ability to enter, compile, and execute a program written in a classical language such as FORTRAN OR COBOL.

(5) The facility to accept the user's voice as input.

SECTION TEN

PERFORMANCE OF THE DEMAND SYSTEM

10-1 General Performance

The most notable performance of the system was its response time. The ratio of processor time to transmission and user response time is approximately $\frac{1}{100}$. Therefore the user's thinking time and response time make up over 99% of the total response time (as discussed in Section 4-4).

Adding a number of CRT's to an existing system would degrade the performance very little. The most time consuming operations would be the transmission of the message to and from the central processing unit and the transmission of displays from the display file to the central processing unit as discussed in Section 4-4. Since a user requires approximately ten to fifteen seconds to make an entry, there is adequate time in this interval to process ten other responses. If there were ten users sharing the same DEMAND program, then it is possible, that they would not be aware of each other's existence. It is evident then that the speed of the central processing unit is not of major concern. The transmission rates, the buffering techniques, and the file access speed, are the operations which consume the most time.

SECTION ELEVEN

CONCLUSIONS

11-1 Conclusions

During the development of the DEMAND system it became apparent that several improvements in the design of peripheral hardware devices were required.

The most significant of these concerned the Cathode Ray Tube. The size of the CRT screen should be increased to allow for presentation of more information. In addition specific types of logic should be incorporated in the CRT to facilitate elementary editing of the user's responses. A memory unit should be attached to allow for the storage of the most frequently used displays. Improvement of the present response mechanisms which include the "light pen", the "touch sensitive" screen, and "push button" facility and voice recognition devices should be made.

Another peripheral device requirement concerned identifying the user. A highly sophisticated method of user identification should be developed. This method could make use of the user's voice, finger prints, or facial imagefor more positive identification. Devices such as plastic card or badge readers would only serve as temporary substitutes as they are subject to loss, theft, human error, and damage.

In addition to the above observations the development of new and better equipment and techniques for data transmission and file management would improve the efficiency, effectiveness and overall performance of a system such as DEMAND.

Although DEMAND was initially developed as an experimental system, repeated demonstrations of it have stimulated much interest in the display and response method of man-computer communications.

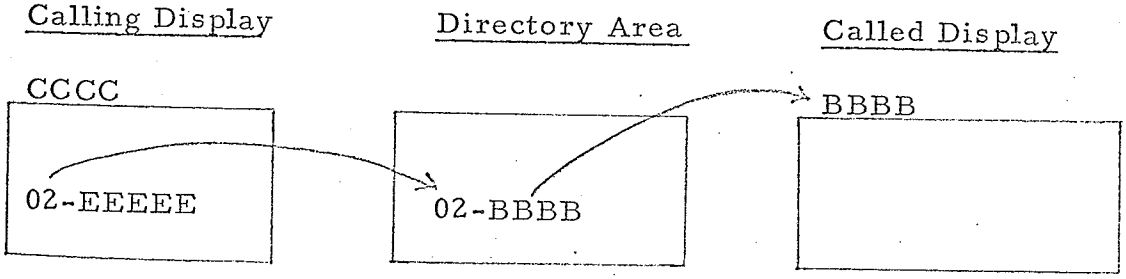
The free format form of display design as discussed in Section 4 (Page 34) and the display linkage convention discussed in Section 5 (Page 45) proved to be invaluable in the development of DEMAND.

It is hoped that the introduction and use of such man-computer communication systems as DEMAND and its successors will allow more persons, both laymen and programmers, to have more rapid and easy access to computing facilities.

GLOSSARY

GLOSSARY

Branch Address	The address of the next display in a sequence. This is a SENSE number in the implemented DEMAND system. The branch address is synonymous with the linkage address.
Called Display	The display pointed to by the branch address.
Calling Display	A display that contains one or more calling elements
Calling Element	An element of a display that has a branch address as its respective entry in the directory area. This is a selective type of element that points to or "calls" a specific display.



EEEEE - The calling element.

BBBB - The branch address (also the address of the Called Display or Linkage Address)

02 - The selection Code.

COBOL — COmmon Business Oriented Language. A commercially oriented computer language.

Communication — "Intercourse by words, letters, or messages; interchange of thoughts or opinions." WEBSTER.

Continuation Display(s) — The additional display(s) required when one display is not sufficient to contain all elements.

Cursor — Position that the next typed character will occupy on the CRT screen. Indicated by the cursor symbol _.

Display — A projection on the CRT screen. The display consists of a set of elements together with the respective codes and a set of instructions in a predetermined format.

Display Record — The Label, Display and Directory areas that are assembled into one record:

Label	Display	Directory

Element — Any meaningful word, phrase, question or statement as defined by the user.

Execution time	The time required to complete one basic computer instruction; this is approximately 1 to 5 micro-seconds.
Format	The arrangement of the elements, codes, etc., that make up the display.
FORTRAN	FORmula TRANslator. A scientifically oriented computer language.
Language	"The vocabulary and phraseology belonging to an art or department of knowledge." "Any means, vocal or other, of expressing or communicating feeling or thought." WEBSTER.
Light pen	A response device, with a trigger mechanism, that is connected to a Cathode Ray Tube and that is used to indicate a particular position on the face of the tube. This is accomplished by pointing the "pen" at the position desired and squeezing the trigger or by touching the "pen" to the screen.
Micro-second	One millionth of a second: (10^{-6} sec.).
Milli-second	One thousanth of a second: (10^{-3} sec.).

Push button mechanism	Any response mechanism which allows the user to respond by pressing one or more of a number of buttons. The buttons are located adjacent to specific words or phrases.
Response Time	The time elapsing between a user pressing the ENTER key and the system accepting and processing his response and acknowledging the user with a new message, phrase or character.
Selection Code	A one or two character entry which preceeds an element of a display. Its purpose is to identify that element.
START Symbol	This is the character displayed on the screen when the START key is depressed.
Touch sensitive screen	A Cathode Ray Tube that is sensitive to pressure. The face of the tube can be used as a response mechanism if pressure is applied to the desired location on the tube. The pressure is usually applied by touching with a finger or stylus type of object.

Transaction	The result of a series of questions and answers between the computer and the user. This message causes the computer system to react in a predefined manner (programmed).

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BIBLIOGRAPHY

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APPENDIX A

This appendix describes the characteristics and basic method of operation of the IBM 2260 DISPLAY STATION.[7] The IBM 2260 DISPLAY STATION is referred to as a "CRT" (Cathode Ray Tube) in the body of this thesis.

A-1 Configuration

The basic hardware configuration required for the operation of the CRT is shown in Figure 56. This configuration consists of the 360/65 Central Processing Unit; the Multiplexer Channel; the 2848 Display Control; and the 2260 Display Stations.

Depending upon the model of CRT selected (Model 1, 2, or 3) a maximum of twenty-four CRT's may be connected to the 2848 Display Control. One Model 2 CRT was used for the implementation of the DEMAND system. This model allows a maximum number of sixteen CRT's to be connected to the Display Control.

A-2 Description

In appearance a CRT has the characteristics of a small television screen (called the display screen) mounted over a typewriter keyboard. Depressing a key on the keyboard causes a character to appear on the screen. The display screen has a 4"x 9" projection area. This area consists of a twelve row by forty column

matrix (total of 480 characters).

Characters may be placed in any position on any of the twelve rows on the screen either by the attached keyboard or by program control from the Central Processing Unit. The keyboard is operated in a similar manner to that of a standard typewriter. The method of program control of the CRT is described in reference 6 in the Bibliography.

The character set associated with the particular model of CRT used, and illustrated in Figure 1 (Page 6), consists of the alphabet (upper cases only), the numbers 0 to 9, a set of fifteen special symbols including $, %, &, and *, and a set of special graphic symbols. The graphic symbols are used as control characters. Two such symbols are the START and the CURSOR symbols.

THIS IS THE "START" SYMBOL ▷

THIS IS THE "CURSOR" SYMBOL ▮

Figure A-1

The START symbol occupies one position on the CRT screen and must be present before data can be transmitted to the computer. It is entered on the screen by pressing the START key or by program control.

The CURSOR symbol indicates the position that the next

character entered via the keyboard will occupy. In some cases it also indicates the position that the next character written from the computer will occupy. When a character is entered, the CURSOR symbol moves forward to the next position on the screen (Figure A-2).

Before entering D	▷ABC
After entering D	▷ABCD
A message ready for sending	▷123

Figure A-2

A set of functional keys is also located on the keyboard. Those keys relevant to this discussion are: BACKSPACE, SHIFT, ERASE, ENTER, and START. The BACKSPACE key causes the CURSOR to be moved backwards one position. The SHIFT key is used in conjunction with those keys that represent two characters or two functions, and is operated in a similar manner to that on a standard typewriter. Three keys that are operative in the SHIFT position only are ERASE, ENTER, and START. The ERASE key causes all character data to be erased from the screen. The ENTER key causes data on the screen to be transmitted to the computer. The START key causes a START symbol to appear on the screen in the position occupied by the CURSOR. The CURSOR moves forward one position when the START symbol is entered.

A-3 Data Entry

Data may be entered to the computer only when the following three conditions have been met :

A" READ" instruction must be issued by the problem program as described in reference 4; a START symbol must be present on the screen; and the ENTER key must be depressed.

A typical sequence to accomplish data entry could be:

i) A WRITE instruction is issued by the problem program (in the computer) to erase the screen and to present the user with a fresh screen of information;

ii) A WRITE instruction is issued by the problem program to position a START symbol for the user;

iii) A READ instruction is issued by the problem program in anticipation of the user's response;

iv) The user proceeds to make his entry;

v) The user signals that he has completed his entry by holding down the SHIFT key and pressing the ENTER key;

vi) The action in v) above completes the READ instruction issued in iii) above and the user's response is transmitted to the computer.

All of the data on the screen that was positioned between the START symbol and the position where the user pressed the ENTER key is transmitted to the computer.

The method of data entry described above does not exhaust all possible methods. It was chosen as it pertains to the method of operation used for the implementation of DEMAND.