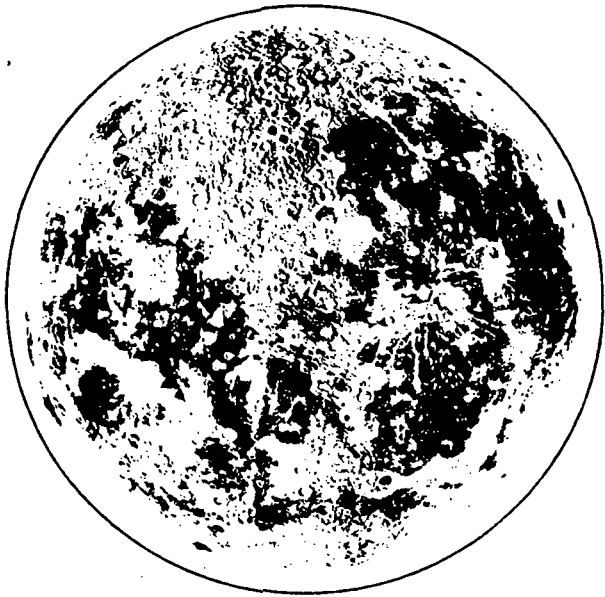


772-15927

Final Contract Report for Development of Medical Data Information Systems



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Submitted to
National Aeronautics and Space Administration
Manned Spacecraft Center
Information Systems Branch
Houston, Texas

PHILCO 
Philco-Ford Corporation
Houston Operation

FINAL CONTRACT REPORT FOR
DEVELOPMENT OF
MEDICAL DATA INFORMATION SYSTEMS

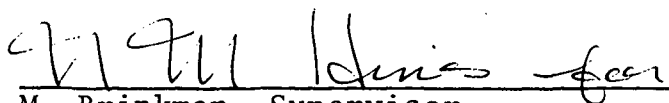
Contract NAS 9-11579

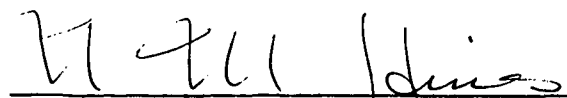
Submitted to the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
INFORMATION SYSTEMS BRANCH
Houston, Texas

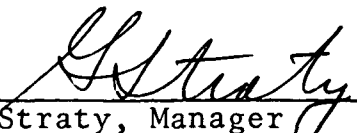
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FOREWORD

This report is prepared under the authorization of Contract NAS 9-11579.

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SECTION 1

INTRODUCTION

The efforts provided under contract NAS 9-11579 were in accordance with the Statement of Work of the subject contract. In addition to the tasks specified in the Statement of Work, several unspecified tasks were accomplished. The tasks performed in accordance with the Statement of Work were as follows:

- Flight Crew Health Stabilization Computer System
- Medical Data Input System (MDIS) Refinements
- CRT Graphics Software Development
- Lunar Receiving Laboratory (LRL) Support
- Statos V Printer/Plotter Software Development.

The tasks performed by the contractor which were not specified in the Statement of Work but were requested by the contract monitor were as follows:

- Medical Data Tape Retrieval System (MDTRS)
- Support for the Computerized Flight Crew Medical Data System
- Card Reader Software Development
- Varian Assembler Modifications (allowing card and tape assemblies and high-speed printer output)
- Execuport/103 Modem Interface
- CRT Input/Output Routines
- 1108 Cross Assembler Checkout
- Recovery Ship Medical Data Transmission System
- Numerous System Demonstrations for NASA
- Sizing, costing, and conceptual design of proposed computer systems within the Medical Directorate.

It can be seen that the contractor has provided a diverse software systems capability involving the development of requirements and conceptual and detailed software systems design, as well as programming and implementation of software systems. This complete software capability has permitted the accomplishment of the peripheral tasks which might not have been recognized had this total system capability not existed.

A more detailed description of the task accomplishments, computer usage and contract deliverables is given in the following sections.

SECTION 2

TASK ACCOMPLISHMENTS

2.1 FLIGHT CREW HEALTH STABILIZATION COMPUTER SYSTEM

The contractor provided courier service for tape and computer listings and coordination of computer runs for the Apollo 14 Surveillance Program. The last of the Apollo 14 Surveillance data was input to the computer system. The final record count was 2159 records.

New forms were developed for the Apollo 15 Surveillance Program and were reviewed on the computerized CRT system and approved by Gary McCollum, Nelson Pettit, Janet Bardin and K-Sue Blake. The contractor assisted NASA in the coordination of programming, equipment delivery, and forms development milestones for the Apollo 15 flight.

The contractor provided technical assistance in the preparation of requests for Apollo 15 Surveillance equipment as follows:

- CCI Display CRT
- CCI Display CRT, Keyboard and Controller
- Varian Priority Interrupt Module
- Execuport 300 Transceivers and Magnetic Tape Cassettes.

Courier service for tape and computer listings, in addition to coordination of computer runs for the Apollo 15 Surveillance Program, was provided by the contractor. Approximately 2000 records were entered into the MEDATA system via the MDIS CRT Terminal Input System.

The contractor provided technical support to troubleshoot the cause of buffer transmission problems between KSC and the MDIS CRT in Building 32.

Coordination with NASA shipping and the Flight Crew Health Stabilization Program for the delivery of the Apollo 15 equipment to Cape Kennedy was also provided by the contractor.

The contractor implemented the Medical Data Tape Retrieval System (MDTRS), described in Paragraph 2.2 of this report, in support of the Surveillance Program.

2.2 MEDICAL DATA TAPE RETRIEVAL SYSTEM (MDTRS)

The development and implementation of MDTRS was completed on schedule (30 June 1971) to support the Flight Crew Health Stabilization Program Office at KSC; and on 16 July 1971, the MDTRS was implemented to support the Flight Medicine Office. This retrieval system replaces the rudimentary system developed for Apollo 14 support and is capable of much more sophisticated retrievals and reports. Typical of the capabilities available are Boolean strings in data selection and mean and standard deviations on output reports. A description of the MDTRS is provided in Attachment A, which is Section 3.0 of PHO-TN516, *Medical Data Tape Retrieval System Programming Documentation*.

In addition to the development of the MDTRS, the contractor has maintained the Computerized Flight Crew Examination Forms and provided courier service and computer coordination for the Flight Crew Data System.

2.3 MEDICAL DATA INPUT SYSTEM (MDIS) REFINEMENTS

Several improvements were implemented in the Medical Data Input System (MDIS). These improvements were as follows:

- A. Cursor Positioning Routine. This routine permits the user to position the cursor at the proper position on the background for the next sequential answer by pressing the INTERRUPT key. Previously, the user had to manually position the cursor with the cursor positioning keys.
- B. Additional Line Capability. This capability permits the user to request more space on the CRT if he exceeds the allocated answer area. Previously, the user had to remain within the allocated space for answers or comments.
- C. Automatic Insertion of ID Information. Automatic insertion permits the user to retain the Social Security number and date from one form to the next if he desires. Previously, the user had to type in these items on every form, although they might be the same from one form to the next form.
- D. Improved Form Numbering Procedure. A new numbering scheme was developed and implemented into MDIS which allows a more direct correlation between manually maintained forms and their corresponding form in the computer system. Previously, it was difficult for the user to relate the collection form number to the computerized form number.
- E. Forms Card-To-Tape Program. A card-to-tape program was developed utilizing the new card reader in Building 32. This new program provides NASA with the capability to implement changes to the background forms tape with much more reliability and ease. Previously, the forms cards had to be loaded on the 620A computer in Building 15, and thus the Medical Directorate was subject to inavailability of computer time and to the very serious tape incompatibility between computer systems. Changes may now be made to the background forms in a matter of minutes.

2.4 VARIAN COMPUTER SYSTEMS SOFTWARE SUPPORT

The following system software was developed for the Varian computer systems and their associated input/output devices:

- A. Statos V Printer/Plotter Software Development. The following routines were developed for the Statos V to be implemented on the CLINC computer system:
 - Core dump to operate from AIDS and/or independently
 - Print routine to be called by a non real-time operating program
 - Real-time interruptable print routine designed to meet CLINC II Requirement Specifications.
- B. Card Reader Software Development in the CLINC. The contractor developed a card-to-tape or card-to-printer routine which outputs a tape format compatible to the Varian Assembler System. In addition, card listings may be obtained from the card-to-tape routine. The described software development permits users of the CLINC System to perform assemblies, thereby eliminating the necessity of performing assemblies in Building 15.
- C. Varian Assembler Modifications. The Varian Assembler System in the CLINC was successfully modified by the contractor to utilize the new card reader for assembly input and the Statos V for output of the assembly listings. Assemblies in Building 15 are no longer mandatory.

The Varian Assembler on the 620A in Building 15 was modified by the contractor to output the object coding on magnetic tape instead of paper tape. This capability has been needed for several years due to the poor reliability of the paper tape punch which has a history of punch errors and lengthy down-times.

- D. Execuport/103 Modem Interface. Coordination and technical assistance was provided in the original installation and checkout of the 103 Modem Interface at 10 characters per second. The contractor also modified the software, and coordinated the hardware checkout, to upgrade the input/output rate from 10 to 30 characters per second.
- E. CRT Input/Output Routines. The contractor designed CRT input/output routines to operate in the character mode in a real-time system environment. These routines are currently being tested.
- F. 1108 Cross Assembler. The contractor tested the 1108 Cross Assembler for the Varian.

2.5 CLINC APPLICATIONS SOFTWARE SUPPORT

The new Medical Data Input System (MDIS) and the Medical Data Update System (MDUS) were implemented in the CLINC to conform with recent hardware changes.

The Medical Data Tape Retrieval System (MDTRS) was implemented on the CLINC System.

2.6 CRT GRAPHICS SOFTWARE DEVELOPMENT

The CRT graphics software package for the CCI-30 System was developed, implemented and documented.

2.7 LUNAR RECEIVING LABORATORY (LRL)

Lunar Receiving Laboratory support included the following items.

- A. Botany Experiments. User documentation on the following Botany applications programs was completed and delivered to NASA:

- Botany Analysis
- Group Data Analysis
- Group Data Master File Update
- Contamination Search
- Seedling Death Report
- Percentage Germination Plots
- Species Influence Factor Analysis.

Modifications to the Botany programs and tables were made for the Apollo 14 flight.

- B. Microbiology Experiments. A total of 2520 cards was coded for Apollo 14 Microbiology data, (F-30, F-14, F-000, and R+000). The Apollo 14 computer file was constructed by the contractor. Several unknown searches were run on the computer system to identify unknown organisms. A new test period (R+018) has been established by NASA, and the contractor is implementing the test period into the computer system. The contractor is presently coding the (R+018) data.

2.8 RECOVERY SHIP MEDICAL DATA TRANSMISSIONS

The contractor supported the Apollo 15 Flight Surgeon (Dr. Clarence Jernigan) by providing computer software, operations, and coordination. This support permitted Dr. Jernigan to input the splashdown physical data from an acoustic coupled teleprinter on the Okinawa via the satellite circuit to the MSC Building 30 patchboard to the Varian in Building 32. In addition, the contractor provided a program to send/receive hardcopy communique. Dr. Jernigan also had the Astronaut Medical File available for retrievals.

2.9 MISCELLANEOUS

The contractor assisted NASA in sizing and costing several computer systems for possible future applications within the Medical Directorate.

The contractor prepared a demonstration at the request of NASA which included the input system (MDIS) using the Surveillance Forms and the Flight Crew Forms, the CRT Retrieval System on Flight Crew Data, the CRT Graphics Software Capabilities, and the Execuport Retrieval System. In addition, sample outputs from the LRL Botany and Microbiology Systems were made available.

A highly successful trip was made to KSC by H. Kingham and Jerry Anderson for the purpose of instructing the Flight Crew Health Stabilization Program Office in the operations of the Varian Retrieval System (MDTRS).

Demonstrations of the MDTRS, utilizing the Execuport, and MDIS, utilizing the CRT's, were given during the contract period. In addition, an outline was prepared to instruct non-MDTRS oriented individuals in how to demonstrate the system's capabilities.

New input CRT forms for the Environmental Medicine Branch were developed and implemented for the Medical Data Input System (MDIS).

SECTION 3
COMPUTER USAGE

Computer time used from 1 February 1971 to 25 October 1971 was as follows:

- Univac 1108 - 2 hours
- Varian 620a - 30 hours
- Varian 620i - 475 hours.

SECTION 4

DELIVERABLES

The following were deliverable items under Contract NAS 9-11579.

- A. Complete program documentation and users guides for the Medical Data Input System (MDIS), the Medical Data Update System (MDUS), and the Medical Data Tape Retrieval System (MDTRS).
- B. Program tapes and user documentation for the Statos V Printer plotter routines, CLINC and DOC card reader routines and modified Varian assembler programs.
- C. Program tapes and listings for the Recovery Ship Medical Data Transmission Program.
- D. Program tape for a communications program to receive and transmit messages to and from the Execuport 300 Transceiver System over the telephone lines.
- E. User documentation for the following Botany Applications programs:
 - Botany Analysis
 - Group Data Analysis
 - Group Data Master File Update
 - Contamination Search
 - Seedling Death Report
 - Percentage Germination Plots
 - Species Influence Factor Analysis.
- F. Program tapes, program listings, and user documentation for the CCI-30 CRT graphics software package.

- G. The coding for 2520 laboratory cards for the Apollo 14 Microbiology Data File.
- H. Two quarterly progress reports and the final contract report.

SECTION 5

SUMMARY

Philco-Ford has provided specification development, system design, computer programming, documentation, data management, and consultation for the Medical Research and Operations Directorate Data System during the course of Contract NAS 9-11579.

The diversity of the project team should be apparent when reviewing the types of support and number of areas in which the contractor has successfully performed during the last 4 years. It should also be noted that the contractor far exceeded the work commitments delineated in the Statement of Work for Contract NAS 9-11579.

ATTACHMENT A

MEDICAL DATA TAPE RETRIEVAL SYSTEM (MDTRS) DESCRIPTION

This appendix contains a reproduction of PHO-TN516, *Medical Data Tape Retrieval System Programming Documentation*, Section 3.0, which is a description of the MDTRS.

3.0 MDTRS SYSTEM

3.1 GENERAL SPECIFICATIONS

3.1.1 Background

After the input system (MDIS) and the update system (MDUS) were implemented in the latter part of 1970 at the Manned Spacecraft Center, it became apparent that a retrieval system on the Varian 620I computer would be a worthwhile complement to the overall storage and retrieval operations at MSC. At the time, all retrievals were done in a batch processing environment which did not lend itself to the near-real-time requirements of certain individuals in the Medical Directorate. Once they had identified the types of information they required from the data base, these scientists and doctors were not at all satisfied with the twenty-four hour delay that was necessary before they could receive their data. Thus, at the start of 1971, work began on the Medical Data Tape Retrieval System (MDTRS) which was modeled after the system used in the batch processing environment. The principle difference was to be in the use of a computer dedicated to retrieving data from a master file, and operated either locally at the computer or from a remote station over an ordinary telephone line. On July 1, 1970, it was implemented.

The MDTRS permits a user to retrieve specific information from his data base. What information is selected, and the format in which it is output, is determined by the request the user submits via a keyboard connected to the computer. There are a number of different types of outputs the user may specify, as well as a limited amount of statistical information on the data.

3.1.1 Background (Continued)

During the twenty-one day preflight quarantine of Apollo 15, the MDTRS got its first real test in the Flight Crew Health Stabilization Program. In order to minimize the possibility of any prime crew member contacting a disease, all persons coming in contact with the crew during this quarantine period were put under medical surveillance. Personal and family medical information was collected on each individual. This information was available for retrieval via the MDTRS as any need arose. Rapid access to the data base and the statistics the retrieval system provides were the key components of the surveillance program which is planned for use in all remaining Apollo missions.

3.1.2 Functions of the System

In order to understand any further discussion concerning the MDTRS, several terms should first be defined.

- operator - the individual who loads the computer with the programs necessary for operation of the MDTRS
- user - the individual who wishes to retrieve data, and will operate the local or remote station that controls the MDTRS
- request - a set of seven questions and answers completed by the user at his station, which direct the MDTRS in its operation
- response (request response) - answers to the seven questions of the request; keyed in by the user at his station
- retrieval - all inputs, outputs, and processing necessary to fulfill all phases of a user-input request

3.1.2.1 Input

Input to the MDTRS is of two types:

- (1) keyboard manual data entries, and
- (2) magnetic tape master file data input.

Keyboard entries are made both by the operator and the user. Operator entries define the computer location and the user input device. User inputs are in the form of request responses. All processing is done on these inputs or the data tape inputs described in detail in Appendix A.

3.1.2.2 Processing

A request specifies three things: (1) identification of the record or records to be dealt with, (2) what portion of that record to be output, and (3) what format to be used for output. Once this request has been input and validated, the data tape is searched for the record identified. The specified output is then begun. Processing continues until all requested data has been output, or until the user aborts the retrieval.

3.1.2.3 Output

Two types of output, magnetic tape or printed pages, are available with the MDTRS. Tape output is used to make a duplicate of portions of the master file. This may be helpful when many retrievals are to be done using the same small portion of the data over and over again. The printed output applies to all or a portion of a record and may be in several formats.

3.2 TECHNICAL SPECIFICATIONS

3.2.1 System Description

The MDTRS can be divided into four functional modules: Initialization, Request, Record Match, and Output. Each module plays a critical role in the successful operation of all succeeding modules.

C O N T R O L	INITIALIZATION	I/O Device Selection
	REQUEST	Retrieval Definition
	RECORD MATCH	Record Selection
	OUTPUT	Data Formatting and Output

3.2.2 Input

There are three types of input data used in the MDTRS: operator initialization data, user request data, and master tape data. The first type is used during Initialization when three questions concerning the computer configuration are answered via the system input device, the teletype. These three answers tell (1) on what computer configuration the system is running, (2) what device is to be used for user input and output, and (3) on what unit (10 or 11) the Master File is mounted.

After Initialization the MDTRS is ready to accept the user's inputs. These inputs define the retrieval to be performed, and make up the data input for

the Request module. There are seven questions that must be answered and they are:

- SS NO:
- RECORD:
- TYPE:
- DATE
- CONDITION:
- ACTION:
- WHAT:

The first five questions identify a specific record from the master; the last question defines what portion of that record is to be output; and the sixth question specifies the output format. There exist strict rules for the input of request data. These rules are stated in Section 4 of this document.

Appendix A details the exact layout of the Master File and the records on the file.

3.2.3 Processing

Initialization

The first thing done after the system is loaded into the computer is the initialization of all I/O handlers based on the computer configuration and the location of the user terminal. This initialization includes inserting the correct device codes into the input/output instructions and inserting any other device-dependent coding necessary for proper interface with all peripheral devices. All routines using the I/O handlers are to assume that the primary input and output device is a teletype. The appropriate handlers will take the necessary action with special characters.

Request

In the Request module, the seven questions of the Retrieval Request are processed separately. In each case, there is a limited amount of error checking. This is done to prevent a retrieval from being rendered useless after several minutes of processing, due to some error in the format of a user's inputs which makes it impossible to determine what he actually wants. Each question is checked for a blank response. In this event there is one, the default response can be assumed for each question.

These default responses are:

- SS NO: ALL
- RECORD: ALL
- TYPE: ALL
- DATE: ALL
- CONDITION: NONE
- ACTION: LIST
- WHAT: ALL

As a Request Response is processed, it is placed in a buffer called the Request Buffer (CPRB). In the Request Table (CPRT), the beginning location of each response is saved and used later by the Record Match and the Output modules.

Record Match

Once all responses have been successfully input, the tape is searched for a record that matches the selection criteria (the first five questions) of the Request. The processing in the Record Match module is relatively simple for

the first four questions. These make up the ID section of the record (see Appendix A). In most cases a straight comparison can be made between the Request Response in the Request Buffer and a fixed area of the Tape Input Buffer. If the two are exact, the match is true. However, the response to CONDITION may have Boolean operators, which allow the user to specify complex conditions. These responses are made up of Headings and Answers from the Body Section of a record. In the Request module, the response to CONDITION was placed in the Request Buffer, and a tree network was created to facilitate easy and rapid determination of the logical conclusion of the Boolean expression in this response. The Headings and Answers make up the base of the tree. In the Record Match module, as each Heading-Answer pair is matched, a flag is set that allows the program to proceed further up the tree from the base. Once the top of the tree is reached, the Boolean expression is true. If the expression is true, the record is said to match the CONDITION response.

Output

A record is selected when the first five questions of the selection criteria of the Request are fulfilled. The sixth question specifies the format of the output. The appropriate routine is called and collects the data specified by the response to the WHAT question. As soon as enough data for one line of output is collected, the Output Message routine (OM00) is called. This routine selects the necessary output handler, based on the operator input data of the Initialization module. When all the requested data on the record is processed, control is again passed to the Record Match module which searches

for another record to match the selection criteria of the Request.

End Action

Three things will terminate the retrieval processing:

- (1) the SS NO on record exceeds the one specified in the Request;
- (2) the end of the tape data (end-of-file) is reached; and
- (3) the user elects to abort the retrieval from his remote station.

Each Output subroutine in the Output module has some specific action that must be performed in the event one of the above events occurs. Once this action is completed, control is transferred to the Request module and the processing begins again.

3.2.4 Output

There are three types of output in the MDTRS: user I/O device output, system I/O device output, and user-requested tape output. The three types will fall into one of three categories:

- (1) user-requested output may go to either tape or the user I/O device;
- (2) error messages may go to the system or user I/O devices;
- (3) advisory messages may go to the user I/O device during retrievals, or to the system I/O device during initialization.

The user I/O device may be any one of the following:

- (1) CLINC Teletype #1
- (2) CLINC Teletype #2
- (3) DOC Teletype
- (4) 103A Modem

The system I/O device is the Teletype in all cases.

Examples of user-requested output may be found in Appendix J. These outputs are in one of four ACTION formats:

- (1) LIST
- (2) COUNT
- (3) COPY
- (4) TABULATE/ANALYZE.

3.2.5 Buffers and Tables

The function of the Request module is to accept the user's inputs, save the responses in the Request Buffer (CPRB), and organize a set of buffers and tables that will be used in the remaining two modules of the MDTRS. To completely comprehend the processing done in the last two modules, these buffers and tables, and their interrelationships must be fully understood. Appendices B through G define the layout of each of the specific buffers of concern in the Request module.

Request Buffer and Table

In Figure 3-1, there is a diagram showing the relationship between the Request Table and the Request Buffer. All Request responses are placed in the Request Buffer, with the starting addresses of the first four saved in the Request Table. Should any Request question not have a response, a zero is placed in the position of the Request Table associated with that response. This zero indicates the Default Condition for that question.

Operand Buffer - simple response

For the response to CONDITION, one of two situations may exist: a complex response with Boolean operators or a simple response without Boolean operators.

Figure 3-2 is a buffer diagram for the simple response. In this example, the first location in the Operand Buffer contains the beginning location of the CONDITION response. The second location contains a -1 to indicate that there are no more parameters in the response.

Condition Table

Each simple response may be one of four forms:

- (1) Heading only - flag = 0;
- (2) Heading plus alpha Answer - flag = 1;
- (3) Heading plus numeric Answer - flag = 2;
- (4) Heading plus range of numeric Answer - flag = 3.

To signify which form each simple response may be, a table (Condition Table) has been created containing a flag to signify the form of the response, and a pointer to locate the answer associated with each simple response. In the sample in Figure 3-2, the flag is two, indicating a Heading with a numeric Answer. The pointer is next in the table and locates the Answer in the Request Buffer.

Bool Buffer and Operand Buffer - complex response

A complex response is a series of simple responses separated by the Boolean operators AND and OR, and possibly grouped using parentheses as required.

Figure 3-3 is an example of the buffer arrangement associated with a complex response. The Operand Buffer is now a series of two word sets - the first word of the set contains a pointer to the Heading portion of the simple response in the Request Buffer; the second word contains a pointer to the Boolean operator associated with that simple response. Every simple response of the Operand Buffer is linked to an operator. This operator is located in the Bool

Buffer and may link to other operators in the Bool Buffer depending on the degree of complexity of the CONDITION response.

What Table

The responses to the question WHAT are handled in exactly the same manner as the CONDITION responses, with the exception that the What Table is used in place of the Condition Table.

The ACTION response results in a flag being set in the sixth location of the Request Table. For a list of these flags and their meanings see Appendix B.

SS NO: 123-45-6789*
 RECORD: REPORT*
 TYPE: MEDICAL BACKGROUND*
 DATE: 07MAY71*
 CONDITION: *
 ACTION: *
 WHAT: *

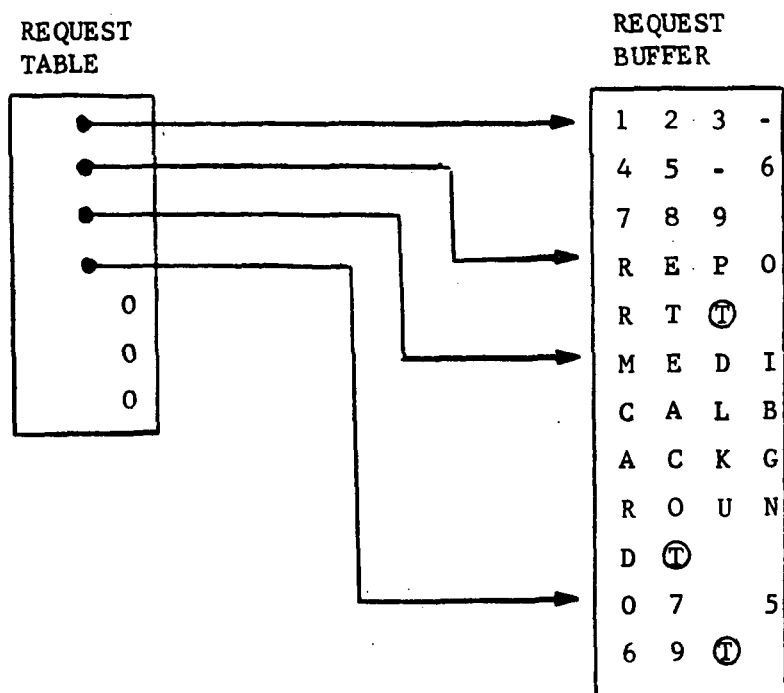


FIGURE 3-1 BUFFER DIAGRAM FOR SS NO,
 RECORD, TYPE, AND DATE RESPONSES

SS NO: *
 RECORD: *
 TYPE: *
 DATE: *
 CONDITION: TEMP:100*
 ACTION: *
 WHAT: *

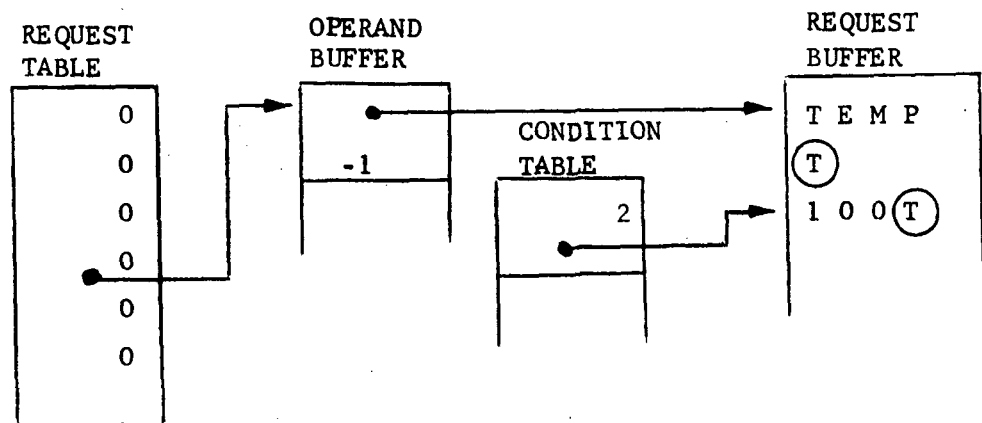


FIGURE 3-2 BUFFER DIAGRAM FOR SIMPLE
CONDITION RESPONSE

SS NO: *
 RECORD: *
 TYPE: *
 DATE: *
 CONDITION: TEMP:100 AND HIGH BP:POS*
 ACTION: *
 WHAT: *

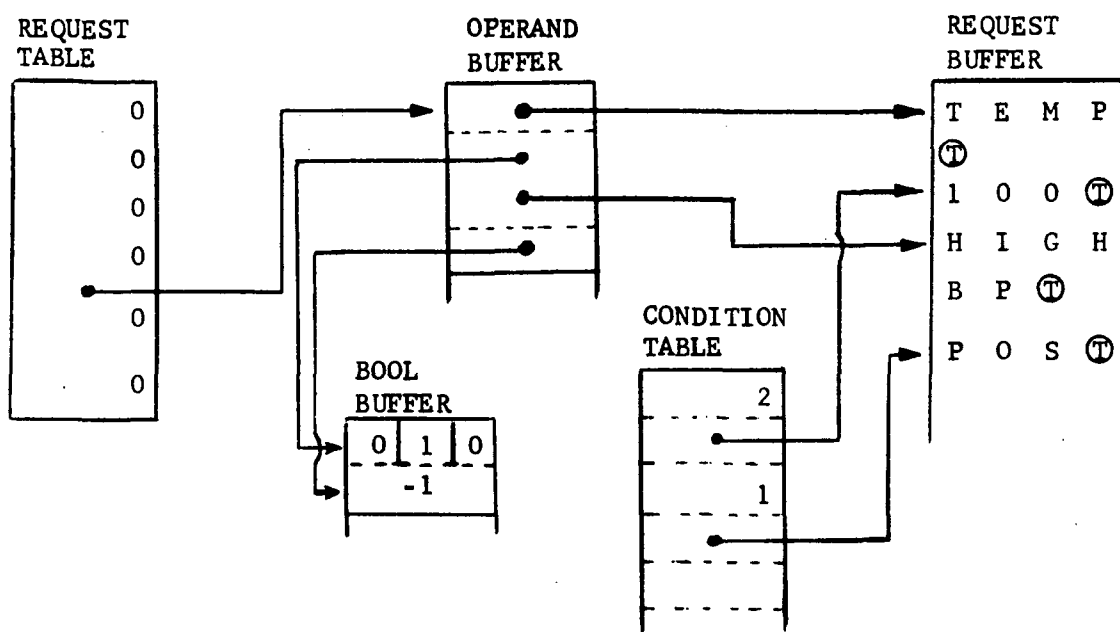
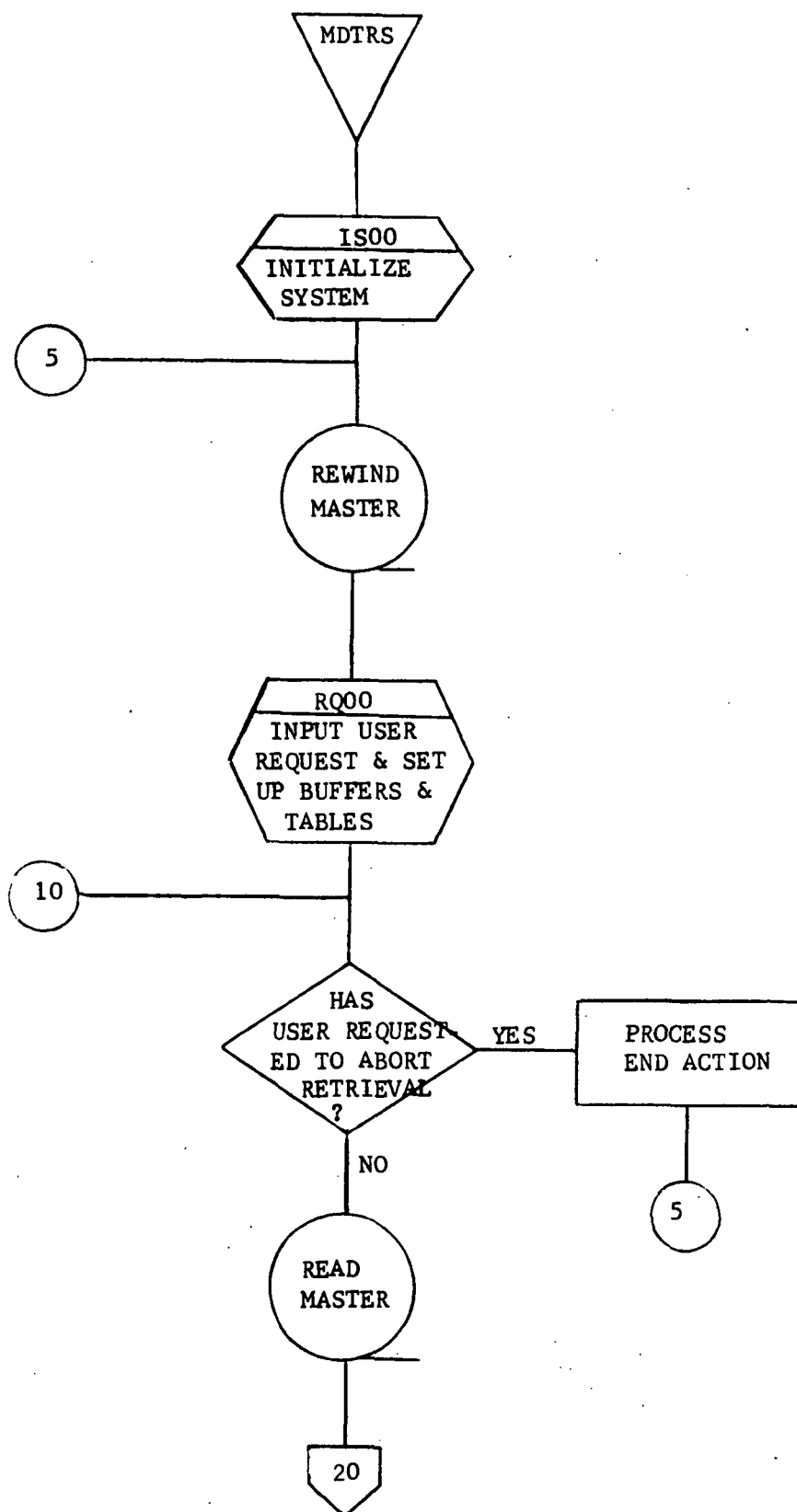
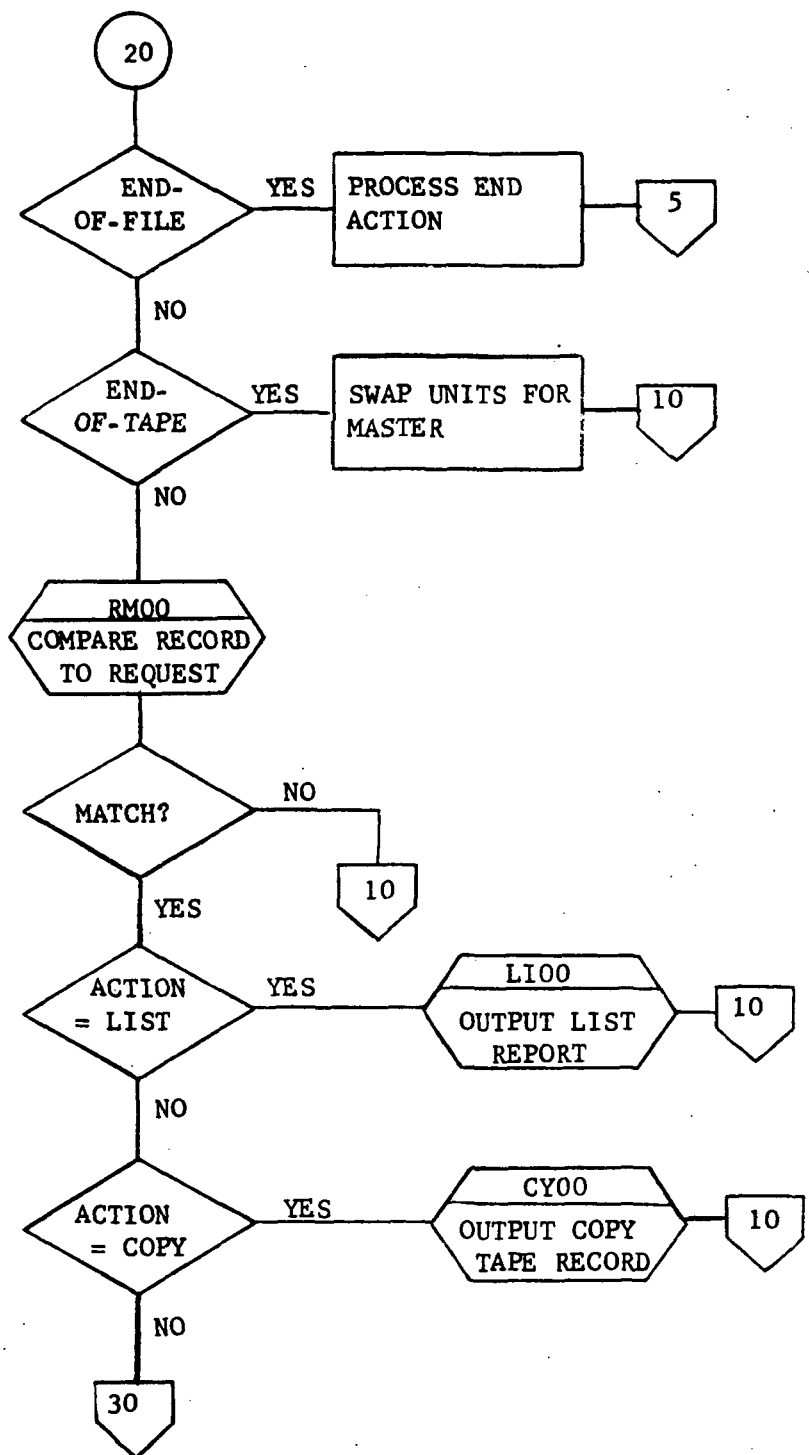
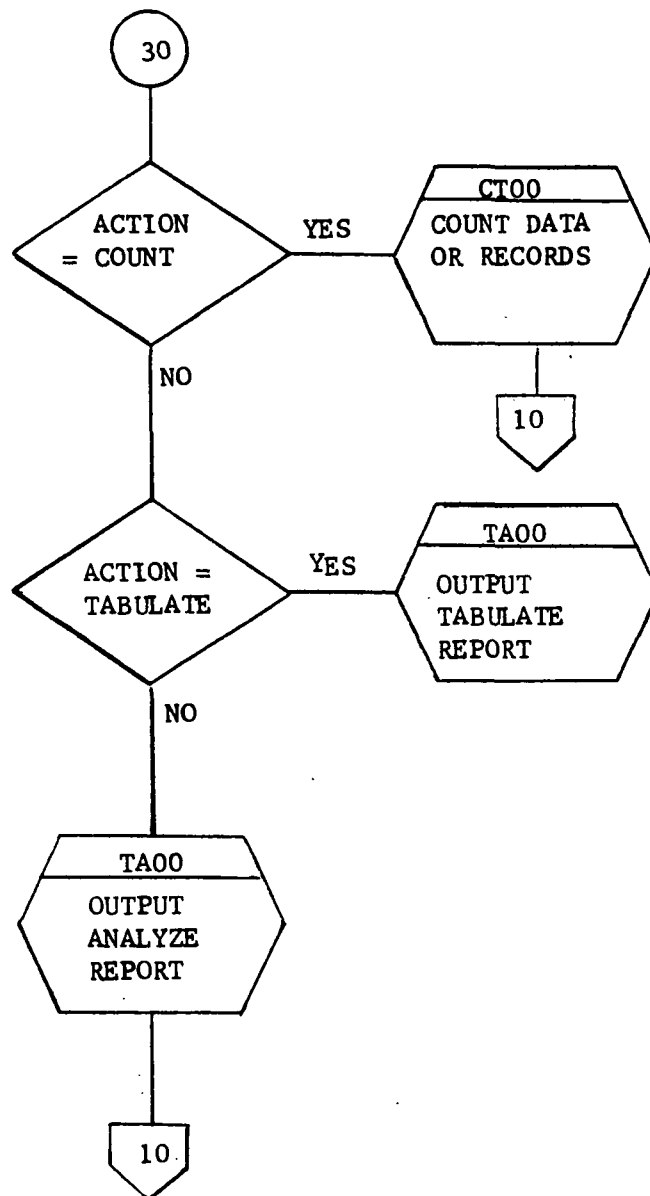


FIGURE 3-3 BUFFER DIAGRAM FOR COMPLEX
CONDITION RESPONSE

3.2.6 System Flow







3.2.7 Hardware Configuration

Following is a minimum hardware configuration for operation of the MDUS;

- 1 - Varian 620/i computer with 20K of core memory
- 2 - tape drives
- 1 - teletype
- 3 - Buffer Interlace Controllers (BIC)
 - 1 - Priority Interrupt Module with the following interrupts.
 - End of Transmission interrupts on all BIC's
 - CRT keyboard interrupt
- 1 - 103A Modem

The two tape drives should be connected to separate BIC's.

3.2.8 System Block Diagram

See Figure 3-4.

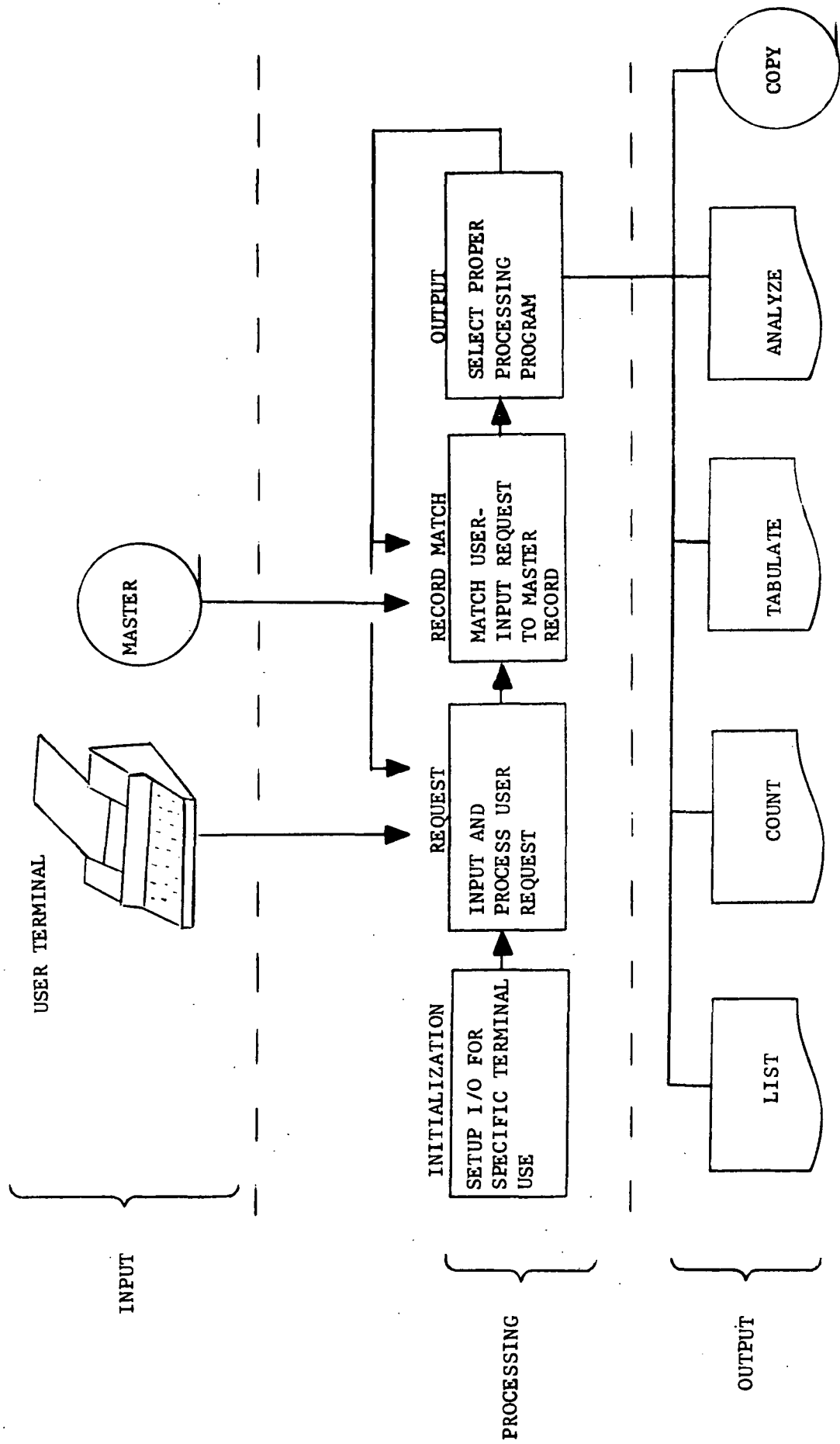


FIGURE 3-4 MDTRS SYSTEM BLOCK DIAGRAM