1.	IDENTIFICATION
1.1	Digital-7-22A-I/O
1.2	Bidirectional PDP-7 DECtape Subroutines
1.3	January 21, 1966

2. ABSTRACT

The Bidirectional PDP-7 DECtape Subroutines allow the programmer to transfer variable length records to or from DECtape in either direction depending on the current position of the tape. The only requirement is that the standard DECtape format be used (1100_8 usable blocks of 400_8 words each). Mainly the subroutines minimize access time to the DECtape, and allow program overlap with data transfers using the program interrupt or automatic priority interrupt facilities. With three exceptions,* the subroutines are completely compatible with the unidirectional subroutines described in Digital-7-22-I/O (which are not obsolete). Information written with either set can be read with the other. In addition, data is written as if it were in the forward direction; so that the record need not be read in the same direction as it was written. The amount of data transferred need not be an integral number of blocks. Though the routines themselves are loaded into the first 8K of core, data transfers can address normal or extended memories. These new subroutines make more efficient use of the DECtape; however, as they are significantly larger than the basic set (450_8 locations for the unidirectional, 604_8 locations for the bidirectional), the user must choose the set most applicable to the job.

3. REQUIREMENTS

3.1 Storage

The subroutines occupy approximately 604_8 locations including variable registers and literals, and must be loaded into the first 8K of memory.

3.3 Equipment

The subroutines function with a 555 or TU55 DECtape drive and a 550 or 550A DECtape control interfaced to a PDP-7. The subroutines will not run on a PDP-4.

4. USAGE

4.1 Loading

The subroutines are in ASCII format designed to be assembled as part of the user's program. The tapes contain no origin, no starting address, and no undefined symbols. In order to link with the user's program, however, the following items are required as part of the main program.

4.1.1 In order to correctly use the program interrupt or automatic priority interrupt facilities, the main program must include the following coding. Reference should be made to the description of the interrupt facilities in the PDP-7 Users Handbook (F-75).

For the standard program interrupt control, the main program should store a JMP X instruction at location 1 where X must include the following instructions:

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*1) The Search subroutine can no longer be used as a separate independent subroutine.

2) The register MMWA1 no longer holds the next block to be transferred (or the next free block). See Section 4.2.7, page 5.

3) Starting and ending core addresses for the Read and Write Subroutines must be 15-bit addresses and can no longer be LAW instructions.

```
X,      DAC ACSAVE            /SAVE THE ACCUMULATOR
        MMEF                  /SKIP ON DECTAPE ERROR FLAG
        SKP
        JMP I MMERR
        MMDF                  /SKIP ON DECTAPE DATA FLAG
        SKP
        JMP I MMDATA
        MMBF                  /SKIP ON DECTAPE BLOCK END FLAG OR HLT
        SKP                   /IF NO OTHER OPTIONS ATTACHED
        JMP I MMBLF
        (Any additional options attached
        to the interrupt are checked here)
```

For the automatic priority interrupt, the program should store a JMS X instruction at location 43 (assuming DECtape is attached to channel 3) where X must include the following instructions:

```
X,      0
        DAC ACSAVE            /SAVE THE ACCUMULATOR
        MMEF                  /SKIP ON DECTAPE ERROR FLAG
        SKP
        JMP I MMERR
        MMDF                  /SKIP ON DECTAPE DATA FLAG
        SKP
        JMP I MMDATA
        MMBF                  /SKIP ON DECTAPE BLOCK END FLAG ERROR
        HLT                   /UNLESS OTHER OPTIONS ATTACHED
        JMP I MMBLF
```

4.1.2 The tag "DISMIS" must be defined in the main program as a jump to the instructions which restore the link bit and accumulator and reenable the interrupt or channel. (The examples assume the interrupt routines were coded as in Section 4.1.1 above.)

For the standard program interrupt control:

```
DISMIS = JMP.
         LAC 0
         RAL                  /RESTORE LINK
         LAC ACSAVE           /RESTORE ACCUMULATOR
         ION                  /ENABLE INTERRUPT
         JMP I 0              /RETURN TO MAIN PROGRAM
```

For automatic priority interrupt:

```
DISMIS = JMP.
         LAC X
         RAL                  /RESTORE LINK
         LAC ACSAVE           /RESTORE ACCUMULATOR
         DBR                  /DEBREAK, ENABLE CHANNEL
         JMP I X              /RETURN TO MAIN PROGRAM
```

4.1.3 In order to differentiate between programs using the program interrupt and automatic priority interrupt facilities, the main program must contain a register named "MMAPII" containing a + 0 if the program interrupt is used, and any nonzero word if the automatic priority interrupt is used. Since it is not destroyed or changed MMAPII may be defined as equal to any other register which always contains the zero or nonzero word as required.

4.1.4 The subroutines assume that DECtape is attached to channel 3 if the automatic priority interrupt is used. If attached to any other channel, the register named "MMAPIC", within the subroutines themselves, must be modified to contain a 1 bit in one of the bits 2-17 (representing channels $0\text{-}15_{10}$ respectively) to indicate the channel.

For example:

If MMAPIC contains "1"	channel 15 is used
If MMAPIC contains "100000"	channel 0 is used
If MMAPIC contains "40"	channel 10 is used

MMAPIC need <u>not</u> be changed if the program interrupt, or channel 3 of the automatic priority interrupt, is used.

4.1.5 The program interrupt or automatic priority interrupt (and channel) will be enabled by the subroutines themselves whether or not they were enabled by the user previously. The main program must guarantee that no flags can come up (or be up) from devices which are not checked by the user's interrupt service routine (as outlined in Section 4.1.1).

4.2 Calling Sequence

To transfer information the following calling sequence must be used:

```
JMS MMRDS        /OR JMS MMWRS                See Section 4.2.1
LAC BLOCK        /BLOCK NUMBER                See Section 4.2.2
JMP XX           /ERROR RETURN                See Section 4.2.3
ZZ0000           /UNIT                        See Section 4.2.4
C1               /FIRST ADDRESS               See Section 4.2.5
C2               /LAST ADDRESS                See Section 4.2.6
RETURN           /MULTIPROGRAMMING RETURN     See Section 4.2.7
```

4.2.1 The JMS MMRDS instruction is used for reading; the JMS MMWRS instruction is used for writing.

4.2.2 The DECtape block number on which the information transfer is to begin can be loaded into the accumulator with a LAC instruction as shown (where BLOCK is any register containing the correct block number), or with a LAW instruction containing the correct block number. The user should always assume the information is being transferred in the forward direction. As the instruction is executed, the location cannot contain just the block number itself. The low order twelve bits of the block number are examined, however, only block numbers 1 through 1100_8 are acceptable to the subroutines.

4.2.3 The JMP XX instruction is the instruction executed should any type of error occur. The accumulator contains a code indicating the type of error which occurred and location MMRSA contains the status of the DECtape system (obtained by means of an MMRS instruction) at the time of the error. The error may be detected in either the main program level or interrupt level of the program and, therefore, the interrupt system or the particular channel used will be disabled when this instruction is executed.

NOTE: If the main program is normally in extend mode while the DECtape is running, the error return must be a JMP I (XX+400000) so that the extend mode will be restored if an error occurs.

At the time the instruction is executed, the contents of the accumulator can be interpreted as follows:

Contents of Accumulator		Meaning
LAW	100	Illegal format. Block number or core locations requested were illegal.
LAW	200	Block requested cannot be found.*
LAW	300	The DECtape error flag was raised while searching for other than an end-of-tape condition.*
LAW	400	The DECtape error flag was raised while reading.**
LAW	500	The calculated checksum does not agree with the checksum read from tape.**
LAW	600	The DECtape error flag was raised while writing.**
LAW	700	The block number read was not the block mark number predicted, while reading or writing.**

At the present the DECtape error flag can only be raised by end-of-tape, a timing error (the program did handle data fast enough), or a mark-track error.

4.2.4 ZZ represents the unit number (1-10) which must be placed in bits 2 through 5 of the register. Only those bits are examined.

4.2.5 C1 represents the 15-bit address of the first core location to be read into or written from (always assuming the data is transferred in the forward direction). It can be any address in normal or extended memory. (Only 15 bits are examined.)

4.2.6 C2 represents the 15-bit address of the last core location (inclusive) to be read into or written from (again assuming the data is transferred in the forward direction). C2 must be equal to or greater than C1. (Only 15 bits are examined.) The area transferred should not normally include the subroutines themselves or location 0. The subroutines are not designed to read over themselves.

Since each block written contains its own checksum, the area read need not be the same as that written. For example, if the user requested that locations 1000-3777 be written beginning with block 100, he could at some future time request that locations 2000-2777 be read beginning with block 102.

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*The number of the block being searched for can be found in the register called MMBLKM. The block mark number last read can be found in the location whose address is contained in MMWA1, (i.e., it has been stored with a DAC I MMWA1 instruction).

**The block number last read can be found in the location whose address is contained in MMWA1, (i.e., it has been stored with a DAC I MMWA1 instruction).

Any number of words may be transferred. If a nonintegral number of blocks is specified, the following takes place:

> If reading, the correct number of words will be deposited in memory and the remainder of the last block will be read but not deposited in order to verify the checksum.
>
> If writing, the remainder of the last block will be filled with +0's and a correct checksum written.

4.2.7 As soon as searching starts, the subroutines return to the register marked "return" with the interrupt enabled. If necessary, this allows the programmer to continue processing while both the searching and data transfer takes place. In terms of usable programming time, the user has approximately 200 msec + 53 msec per block searched + 35 msec per block transferred which can be used after the subroutines are initially called.

The register named MMDONE is set to a +0 after each block mark is passed and to −0 when the data transfer is complete or if an error occurs. This allows the user three possible ways of determining when the transfer has been completed:

```
1. ISZ MMDONE
   JMP ?                  /NOT DONE

2. LAM
   SAD MMDONE
   JMP ?                  /DONE

3. LAC
   SNA
   JMP ?                  /NOT DONE ETC.
```

Method 1 has the advantage of not destroying the accumulator. However, if for any reason the DECtape data flag did not occur as it should, the ISZ would skip incorrectly after approximately 1.4 sec.

If the user should call the DECtape subroutines before a previous DECtape transfer has been completed, the subroutines will remain in a wait loop and not return to the main program until the first transfer has been completed and the second has begun.

It sometimes is necessary to determine what is the next forward block number on the tape, after the information just transferred. The following sequence of instructions places the correct block number in the accumulator:

```
LAW 61          /SEARCH BACK COMMAND
SAD MMWA3       /LAST COMMAND ISSUED
JMP ---------------------------------->   LAC MMBLKM    /BLOCK SEARCHED FOR
LAM -2          /TO SUBTRACT 3             ADD (1)
TAD I MMWA1     /ADD CURRENT POSITION        |
  <------------------------------------------+
```

4.3 Switch Settings

None

4.4 Start Up and/or Entry

See Section 4.2, Calling Sequence

4.5 Errors in Usage

Only one HLT exists in the subroutines:

HLT Location	Meaning	Procedure
MMERRX+1	Error return parameter was not a JMP instruction and an error occurred. Type of error is indicated by the number in the accumulator. (See Section 4.2.3)	Correct the calling sequence to provide a JMP instruction for the error return.

5. RESTRICTIONS

None except those mentioned in the preceding paragraphs. The standard tape format of 1100_8 usable blocks of 400_8 words each must be used.

6. DESCRIPTION

6.1 Discussion

The subroutines attempt to make variable length DECtape data transfers as easy and efficient as possible. They are completely self-contained, include only one possible error halt, indicate all possible errors which can occur, and allow fastest access to the DECtape itself. The last is accomplished by keeping track of the current position of each DECtape drive being used, calculating the effective starting and ending block numbers of the transfer requested, and starting the search in the direction causing the least number of turnarounds. Thus the direction of the data transfer is predetermined before the tape is started and does not depend on the first block actually read during searching. If the tape is currently sitting within the area to be used by the data transfer, the ultimate transfer direction will be determined by which end of the DECtape area is nearest. The current position of the tape is always assumed to be the last block number read ± 3 blocks depending on the direction of the last transfer. Initially all tapes are assumed to be sitting at block number 3.

The main thing to remember is that the user need never worry about the actual direction-transfer of the data since data always appears in memory or on tape as if it were transferred in the forward direction. For example, assuming the user has requested that locations 1000 through 1477 be written beginning at block 100, the tape appears as follows irrespective of the direction in which it was written:

← BLOCK 100 →	← BLOCK 101 →	
← Locations 1000 - 1377 →	← Locations 1400 - 1477 →	← 300_8 Filler Words of +0 →

1	1	1	1
0	3	4	4
0	7	0	7
0	7	0	7

If the data is transferred in the forward direction, the core locations are written first in ascending order followed by 300_8 filler words. If the data is transferred in reverse, 300_8 filler words are written first followed by the core locations in descending order. In either case, the end result is the same, and the technique is applicable to both reading and writing.*

6.2 Examples

The search routine has been rewritten to allow four different entrances:

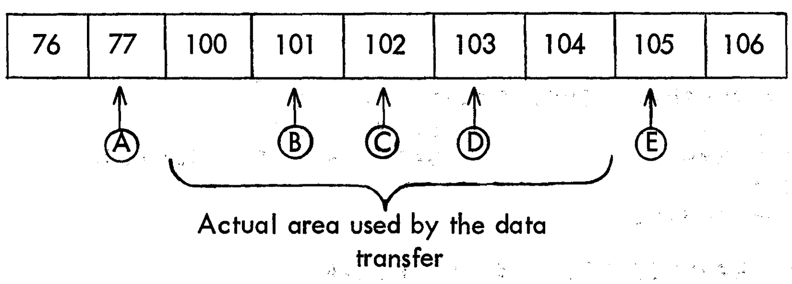
1. Start the tape in the forward direction and exit when the correct block is found in the forward direction.

2. Start the tape in the reverse direction and exit when the correct block is found in the reverse direction.

3. Start the tape in the forward direction and exit when the correct block is found in the reverse direction.

4. Start the tape in the reverse direction and exit when the correct block is found in the forward direction.

In the following example assume the tape is sitting at the locations indicated by the letters shown, and a request is made to transfer 2001_8 words beginning at block 100:



Case A	Block 77 or less	The program will use entrance 1
Case B	Closest to initial block	The program will use entrance 4
Case C	Equidistant from start or end	The program will use entrance 4
Case D	Closest to final block	The program will use entrance 3
Case E	Block 105 or more	The program will use entrance 2

7. METHODS

See Description, Section 6.

8. FORMAT (Not Applicable)

9. EXECUTION TIME (Not Applicable)

*Should it ever become necessary to determine which way a block on tape was actually written, the following method can be used. If written in the forward direction, a checksum of −0 will appear at the front of the block (the end near the preceding lower-numbered block). If written in reverse, the −0 checksum will be at the end of the block near the next higher-numbered block.

10. PROGRAM

10.4 Program Listing

```
/BI-DIRECTIONAL PDP-7 DECTAPE SUBROUTINES
/ASSUMES STANDARD 400 (OCTAL) WORD BLOCKS
/LMH    JANUARY 21, 1966
/DISMIS MUST BE DEFINED AS JMP TO DISMISS INTERRUPT ROUTINE

/PDP-7 DEC-TAPE SEARCH SUBROUTINE

MMWR=707504
MMLC=707604
MMSE=707644
MMRS=707612
MMDF=707501
MMBF=707601
MMEF=707541
MMRD=707512
SKP7=703341
ASC=705502
EPI=700044
DBR=705601
LEM=707704
EEM=707702
EMIR=707742


/LEAVE IN SEARCH REVERSE MODE, START REVERSE
MMSCHR,         LAW 41                  /SEARCH FWD
                DAC MMWA3               /SET CURRENT DIRECTION
                CLA
                JMP MMSCH8

/LEAVE IN SEARCH REVERSE MODE, START FORWARD
MMSRF,          LAW 61                  /SEARCH REVERSE
                JMP MMSCHR+1
/LEAVE IN SEARCH FORWARD MODE, START REVERSE
MMSFR,          LAW 41                  /SEARCH FORWARD
                SKP


/LEAVE IN SEARCH FORWARD MODE, START FORWARD
MMSCH0,         LAW 61                  /SEARCH REVERSE, USED AS CONSTANT
                DAC MMWA3               /SET CURRENT DIRECTION
                LAM                     /LOAD -0, USED AS CONSTANT
MMSCH8,         DAC MMSBK
                TAD (1)
                DAC MMSFK
                LAW MMERS               /SET UP INTERRUPT RETURN
                DAC MMERR
                LAW MMDATS
                DAC MMDATA
                LAC MMBLKM              /PICK UP BLOCK NUMBER
                ADD MMEK
                SMA
```

```
                JMP MMSCH5          /FORMAT ERROR
                LAM -7
                DAC MMSUM           /CHG OF DIRECTION COUNTER


/35 MILLISECOND SELECT DELAY LOOP
MMWAIT,         MMRS
                AND (400)           /SAVE CONTROL TYPE ONLY
                SZA
                JMP MMSCH9          /NO DELAY FOR NEW DRIVES
                LAC MMCHK1+1        /PICK UP SELECT
                SAD MMSEL           /PREVIOUS SELECT
                JMP MMSCH9+1        /SAME SELECT
                DAC MMSEL           /SAVE SELECT
MMW2,           CLA                 /USED AS CONSTANT
                MMSE                /SELECT UNIT ZERO
                LAM DECIMAL -5000+1 OCTAL
                DAC MMBLF           /TEMPORARY STORAGE AREA
                ISZ I .-1           /7 MICROSECONDS PER LOOP
                JMP .-1             /COUNT 35 MILLISECONDS
MMSCH9,         LAC MMCHK1+1        /UNIT SELECTION
                MMSE
                LAC (NOP)
                DAC MMSAVE
                LAC MMAPII          /DECTAPE ON API INDICATOR
                SZA                 /DO ION IF NOT ON API
                JMP MMAPI           /TURN ON API
                ION

MMTURN,         ISZ MMSUM
                SKP
                JMP MMERX2-1        /NOT FOUND
                LAC MMWA3           /CURRENT SELECT
                XOR (20)            /COMPLEMENT DIRECTION
                MMLC                /SEARCH IN CORRECT DIRECTION
                DAC MMWA3           /SAVE SELECTION
                SAD MMSCH0          /LAW 61
                JMP MMREV           /SET UP REVERSE CONSTANTS
                LAC MMCK3           /SMA, SET TO CONTINUE IN FORWARD DIRECTION
                DAC MMSCH2
                LAC MMBLKM
                TAD MMSFK
                DAC MMWA2           /BLOCK TO LOOK FOR IN THIS DIRECTION
                DZM M+MDONE
MMSAVE,         NOP                 /OR DISMIS
                LAC MMRD3B+1        /DISMIS
                DAC MMSAVE
                ISZ MMWA            /INDEX POINTER
                EMIR
                JMP I MMWA          /RETURN TO MAIN PROGRAM
MMREV,          LAC MMCK2           /SPA, SET TO CONTINUE IN REVERSE DIRECTION
                DAC MMSCH2
                LAC MMBLKM
                TAD MMSBK
                JMP MMSAVE-2
```

```
/INSTRUCTIONS FOR AUTOMATIC PRIORITY INTERRUPT
MMAPI,          LAC MMAPIC              /DECTAPE CHANNEL NUMBER
                EPI                     /ENABLE API
                ASC                     /ENABLE DECTAPE CHANNEL
                JMP MMTURN

/ROUTINES TO ANSWER INTERRUPT SEQUENCE
MMERS,          MMRS
                AND (40000)             /CHECK EOT BIT
                SZA
                JMP MMTURN              /EOT, TURN AROUND
                LAW 300                 /NON-EOT ERROR DURING SEARCH
                JMP MMERX2
MMDATS,         MMRD
                DAC I M+MWA1
                SAD MMWA2
                JMP MMSCH3
                CMA
                ADD MMWA2
MMSCH2,         SMA                     /OR SPA FOR REVERSE
                JMP MMSAVE-1            /KEEP GOING
                JMP MMTURN              /TURN AROUND
MMSCH3,         SAD MMBLKM
                JMP I MMCHK             /EXIT TO READ OR WRITE ROUTINES
                JMP MMTURN
MMSCH5,         LAW 100
                JMP MMERX2              /FORMAT ERROR
MMEK,           DECIMAL -576 OCTAL


/ERROR LOOP
                LAW 200                 /NOT FOUND
MMERX2,         DAC MMBLF               /STORAGE AREA
                MMRS
                DAC MMRSA
                JMS MMROLL              /ADD ROLL CONSTANT
                LAC MMERRX
                AND (20000)
                SZA                     /JMP
                EMIR                    /JMP I
                CLC
                DAC MMDONE
                LAC MMBLF               /STORAGE AREA
                MMLC
MMERRX,         JMP .
                HLT                     /ERROR EXIT WAS NOT A JMP INSTRUCTION
MMSEL,          0                       /SAVE SELECTION
MMERR,          0                       /ERROR RETURN
MMDATA,         0                       /DATA RETURN
MMBLF,          0                       /BLOCK FLAG RETURN
MMAPIC,         10000                   /NORMAL DECTAPE CHANNEL=3
MMWAX,          3                       /POSITION OF UNIT 1
                3                       /POSITION OF UNIT 2
                3                       /POSITION OF UNIT 3
                3                       /POSITION OF UNIT 4
                3                       /POSITION OF UNIT 5
                3                       /POSITION OF UNIT 6
```

```
                3                       /POSITION OF UNIT 7
                3                       /POSITION OF UNIT 10


/INTERLOCK LOOP, HANGS UP MAIN PROGRAM UNTIL GO=0
MMITLK,         0                       /USED FOR MMSUM
                LEM                     /LEAVE EXTEND MODE
                MMRS                    /GET STATUS
                AND (4000)              /CHECK GO BIT
                SZA                     /NOT GOING?
                JMP .-3                 /WAIT
                JMP I MMITLK            /SYSTEM AVAILABLE

/LOOP TO ADD ROLL CONSTANT TO CURRENT ADDRESS
MMROLL,         0                       /USED AS WORK AREA, MMSBK
                LAC MMWA3               /LAST SEARCH COMMAND
                AND (20)                /SAVE DIRECTION BIT
                SZA                     /GOING FORWARD
                LAM -5                  /TO CREATE LAM -2
                ADD (3)                 /ROLL CONSTANT
                TAD I MMWA1             /ADD CURRENT LOCATION
                DAC I MMWA1             /STORE CURRENT LOCATION
                JMP I MMROLL
/COMMON ROUTINE FOR PICKING UP CONSTANTS AND SEARCHING
/PICK UP PARAMETERS
MMCHK,          0
                XCT I MMWA              /BLOCK NUMBER
                AND (7777)
                DAC MMBLKM              /SAVE BLOCK NUMBER
                ISZ MMWA                /INDEX POINTER TO ERROR RETURN
                LAC I MMWA              /ERROR RETURN
                DAC MMERRX              /IN SEARCH EXIT
                ISZ MMWA                /INDEX POINTER TO UNIT
                LAC I MMWA              /UNIT
                AND (170000)            /KEEP UNIT ONLY
                DAC MMCHK1+1            /IN CALLING SEQUENCE
                RCL                     /CLEAR AND ROTATE LINK
                RTL                     /PUT UNIT NUMBER IN L.O.POSITION
                RTL
                RTL
                ADD (MMWAX-1)
                DAC MMWA1               /ADDRESS OF POSITION POINTER
                                        /FOR THIS UNIT
                ISZ MMWA                /INDEX POINTER TO STARTING ADDRESS
                LAC I MMWA              /STARTING ADDRESS
                AND (77777)             /15 BIT ADDRESS
                DAC MMADDR              /LOCATION POINTER
                ISZ MMWA                /INDEX POINTER TO ENDING ADDRESS

/CALCULATE NUMBER OF DATA AND FILLER WORDS
                LAC I MMWA              /FINAL ADDRESS
                AND (77777)             /15 BIT ADDRESS
                CMA
                ADD MMADDR              /STARTING ADDRESS
                SMA
                JMP MMSCH5              /ILLEGAL FORMAT
                DAC MMWDC               /-NO. OF DATA WORDS+1
```

```
                AND (377)               /LOW ORDER 8 BITS
                XOR (777400)            /MAKE NUMBER NEGATIVE
                TAD (377)
                CMA
                DAC MM2CN               /-NO OF FILLER WORDS+1
                LAM -1
                DAC MMFILC              /SECTION COUNTER
/CALCULATE THE DIRECTION TO SEARCH
                LAC MM+BLKM             /BLOCK DESIRED
                SNA
                JMP MMSCH5              /BLOCK Ø, FORMAT ERROR
                CMA
                ADD I MMWA1             /CURRENT POSITION
MMCK2,          SPA                     /CURRENT POSITION HIGHER THAN DESIRED BLOCK
                JMP MMGF                /SEARCH AND TRANSFER DATA FORWARD
                DAC MMWA5               /DISTANCE TO START BLOCK
                LAC MM+WDC              /-NUMBER OF DATA WORDS+1
                CMAVCLL                 /NUMBER OF DATA WORDS-1
                AND (777400)            /KEEP NUMBER OF BLOCKS-1
                RTR                     /DIVIDE BY 400 OCTAL
                RTR
                RTR
                RTR

                ADD MMBLKM              /STARTING BLOCK
                DAC MMWA7               /LAST BLOCK
                CMA
                ADD I MMWA1             /CURRENT POSITION
MMCK3,          SMA                     /CURRENT POSITION IS WITHIN TRANSFER SECTION
                JMP MMGR2               /SEARCH AND TRANSFER DATA IN REVERSE
                ADD MMWA5               /DISTANCE TO START BLOCK
                SMA                     /START IN REVERSE, TRANSFER DATA FORWARD
                JMP MMGR                /START FWD, TRANSFER DATA IN REVERSE

/START IN REVERSE, TRANSFER DATA FORWARD
                LAW MMSFR
                SKP

/START AND TRANSFER DATA FORWARD
MMGF,           LAW MMSCHØ
                DAC MMWA5               /SET UP SEARCH ENTRANCE
                LAC (1)
                DAC MMDK                /FOR INCREMENTING ADDRESS
MMGF2,          LAC (DAC I MMADDR)      /SET READ ROUTINE
                DAC MMRD3
                LAC (LAC I MMADDR)      /SET WRITE ROUTINE
                DAC MMWR3+1
/START SEARCH
MMCHK1,         JMP I MMWA5             /TO SEARCH
                Ø                       /UNIT AND WORK AREA MMWA2
```

```
/START FORWARD, TRANSFER DATA IN REVERSE
MMGR,           LAW MMSRF
                SKP

/START AND TRANSFER DATA IN REVERSE
MMGR2,          LAW MMSCHR
                DAC MMWA5               /SET UP SEARCH ENTRANCE
                LAM
                DAC MMDK                /TO DECREMENT ADDRESS
                LAC MM2CN               /FILLER COUNTER
                SZA!CMA                 /+Ø IF THERE ARE NO FILLERS
                ADD (1)
                ADD I MMWA              /ENDING ADDRESS
                DAC MMADDR              /DATA LOCATION POINTER
                LAC MMWA7               /SEARCH FOR LAST BLOCK
                DAC MMBLKM
                LAC MM2CN
                SNA
                JMP MMGR3               /NO FILLERS
                DAC MMWA6               /EXCHANGE MMWDC AND MM2CN
                LAC MMWDC
                DAC MM2CN
                LAC MMWA6
                DAC MMWDC
                LAC (NOP)
                DAC MMRD3               /FOR FILLERS IN RD ROUTINE
                LAC MMW2  /FOR FILLERS IN WRITE ROUTINE, CLA
                JMP MMCHK1-1
MMGR3,          ISZ MMFILC
                JMP MMGF2
/DECTAPE SUBROUTINE, READ  PDP-7
/FORMAT         JMS MMRDS
/               LAW B                   /OR LAC (B), BLOCK NUMBER
/               JMP X                   /ERROR RETURN
/               ZZØØØØ                  /UNIT SELECTION
/               C1                      /15-BIT CORE STARTING ADDRESS
/               C2                      /15-BIT CORE ENDING ADDRESS, INCLUSIVE
/               MULTI-PROGRAM RETURN

MMRDS,          Ø
                JMS MMITLK              /CHECK IF SYSTEM IS FREE
                LAC MMRDS
                DAC MMWA                /STORE POINTER TO ARGUMENTS
                JMS MMCHK               /GET ARGUMENTS AND SEARCH

/RETURN FROM SEARCH WITH BLOCK FOUND
                LAW MMRD1               /SET UP INTERRUPT RETURNS
                DAC MMERR
                LAW MMRD4
                DAC MMBLF
MMRDØ,          XCT MMWA3               /SEARCH COMMAND
                ADD (1)                 /MAKE READ COMMAND
                MMLC
                LAW MMRD1A
                DAC MMDATA
                DZM MMDONE
                DISMIS
```

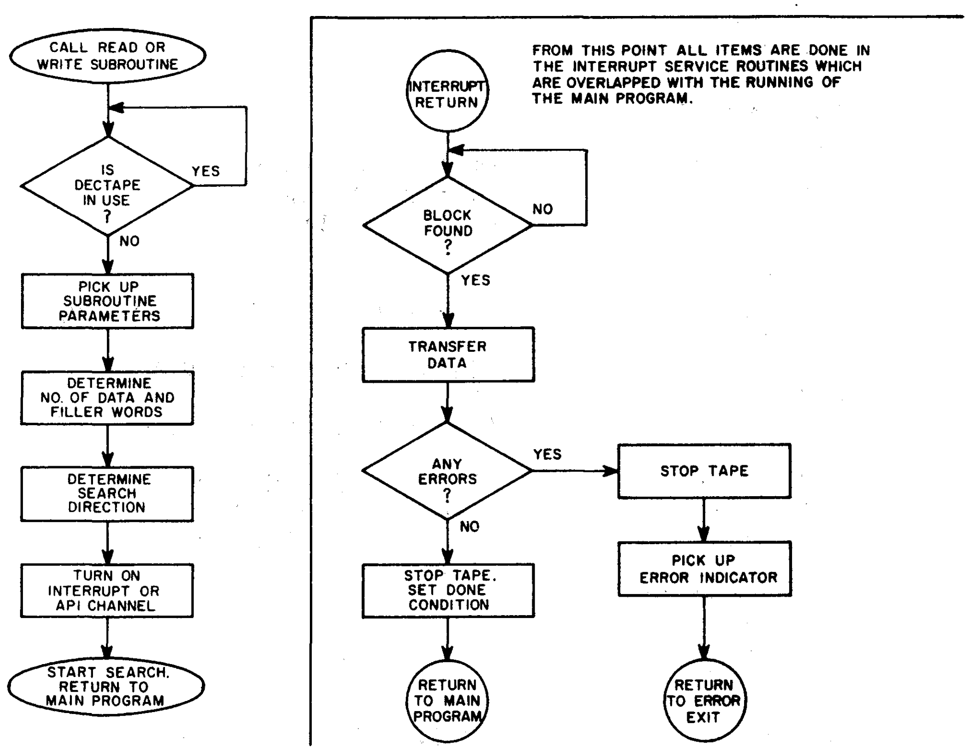
```
MMRD1,          LAW 400                 /ERROR FLAG DURING READING
                JMP MMERX2
MMRD1A,         MMRD                    /READ REVERSE CHECKSUM
                DAC MMSUM
                LAW MMRD2
                DAC MMDATA
                DISMIS
MMRD2,          MMRD                    /READ DATA
                EEM                     /ENABLE EXTENDED MEMORY
MMRD3,          DAC I MM+ADDR           /OR NOP
                LEM                     /DISABLE EXTENDED MEMORY
                JMS MMRD6               /CALCULATE CHECKSUM
MMRD3A,         ISZ MM+FILC             /SECTION COUNTER
                JMP MMRD5               /SET UP FOR SECTION
                LAC (NOP)
MMRD3B,         DAC MMRD3               /DO NOT STORE REMAINDER OF BLOCK
                DISMIS                  /USED AS CONSTANT
MMRD4,          MMRD                    /READ FORWARD CHECKSUM
                ADD MMSUM
                SAD MMSCH8-1            /-0
                JMP .+3
                LAW 500                 /SUM CHECK READING
                JMP MMERX2
                JMS MMBLC               /CHECK NEXT BLOCK NUMBER
                JMP MMRD0               /READ NEXT BLOCK

MMRD5,          LAC MM+2ON              /2ND SECTION COUNTER
                SNA
                JMP MMRD3A              /NO FILLERS
                DAC MMWDC               /SET UP WORD COUNTER
                LAC (DAC I MMADDR)
                SAD MMRD3
                JMP MMRD3B-1            /STORE NOP
                JMP MMRD3B              /STORE DAC INSTRUCTION

/ADD TO CHECKSUM AND INCREMENT OR DECREMENT ADDRESS
MMRD6,          0                       /USED AS WORK AREA, MMWA5
                ADD MMSUM               /PREVIOUS CALCULATION
                DAC MMSUM               /STORE NEW RESULT
                LAC MMADDR              /CURRENT ADDRESS
                TAD MMDK                /+1 OR -1
                DAC MMADDR              /NEW ADDRESS
                ISZ MMWDC               /WORD COUNTER
                DISMIS
                JMP I MMRD6             /CHECK FOR FILLERS ETC.

/CHECK NEXT BLOCK MARK NUMBER
MMBLC,          0                       /USED AS WORK AREA, MMSFK
                LAW MMBLC2
                DAC MMDATA              /SET DATA FLAG RETURN
                XCT MMWA3               /SEARCH COMMAND
                MMLC
                DISMIS
MMBLC2,         LAC I MMWA1             /CURRENT BLOCK NUMBER
                TAD MM+DK               /+1 OR -1
                DAC I MMWA1             /NEW BLOCK NUMBER
                MMRD
```

```
                SAD I MMWA1         /COMPARE TO CORRECT NUMBER
                JMP .+3
                LAW 700             /BLOCK MARK ERROR
                JMP MMERX2
                LAC MMFILC          /SECTION COUNTER
                SZA
                JMP I MMBLC         /RETURN FOR NEXT BLOCK
                MMLC                /STOP THE TAPE
                JMS MMROLL          /ADD ROLL CONSTANT
                CLC
                DAC MMDONE          /SET DONE SWITCH
                DISMIS
/DEC-TAPE WRITE SUBROUTINE, PDP-7
/FORMAT         JMS MMWRS
/               LAW B               /OR LAC (B), BLOCK NUMBER
/               JMP X               /ERROR RETURN
/               ZZ0000              /UNIT SELECTION
/               C1                  /15-BIT CORE STARTING ADDRESS
/               C2                  /15-BIT ENDING ADDRESS,INCLUSIVE
/               MULTI-PROGRAM RETURN

MMWRS,          0
                JMS MMITLK          /CHECK IF SYSTEM IS FREE
                JMS MMCHK           /PICK UP ARGUMENTS AND SEARCH

/RETURN FROM SEARCH WITH BLOCK FOUND
                LAW MMWR2           /SET UP INTERRUPT RETURNS
                DAC MMERR
                LAW MMWR4
                DAC MMBLF
MMWR1,          LAW MMWR3
                DAC MMDATA
                DZM MMDONE
                CLC
                DAC MMSUM           /START CHECKSUM
                XCT MMWA3           /SEARCH COMMAND
                ADD (2)             /CREATE WRITE COMMAND
                MMLC
                DISMIS
MMWR2,          LAW 600             /ERROR FLAG DURING WRITING
                JMP MMERX2
MMWR3,          EEM                 /ENABLE EXTENDED MODE
                LAC I MMADDR        /OR CLA
                LEM                 /DISABLE EXTEND MODE
                MMWR
                JMS MMRD6           /CALCULATE CHECKSUM
MMWR3A,         ISZ MMFILC          /SECTION COUNTER
                JMP MMWR6           /SET UP FOR 2ND SECTION
                LAC MMW2            /CLA
MMWR3B,         DAC MMWR3+1
                DISMIS
MMWR4,          LAC MMSUM           /WRITE CHECKSUM
                CMA
                MMWR
                JMS MMBLC           /CHECK NEXT BLOCK NUMBER
                JMP MMWR1
```

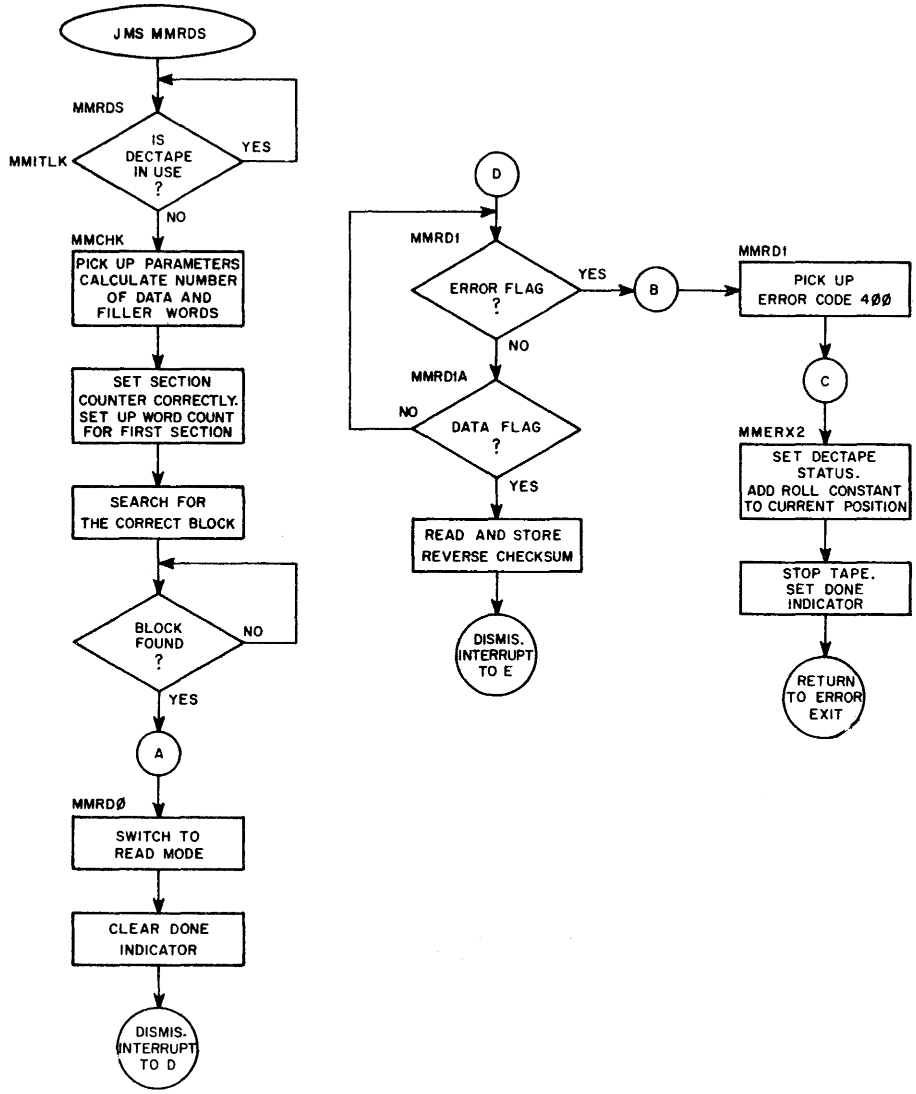
```
MMWR6,          LAC MM2CN
                SNA
                JMP MMWR3A
                DAC MMWDC
                LAC (LAC I MMADDR)
                SAD MMWR3+1
                JMP MMWR3B-1
                JMP MMWR3B

MMWA6=MMSAVE
MMWA5=MMRD6
MMWA3=MMRDS
MMSFK=MMBLC
MMWA2=MMCHK1+1
MMSBK=MMROLL
MMWA=MMWRS
MMSUM=MMITLK
MMWA7=MMSUM
MMRSA=MMERR

START
```

11. DIAGRAMS

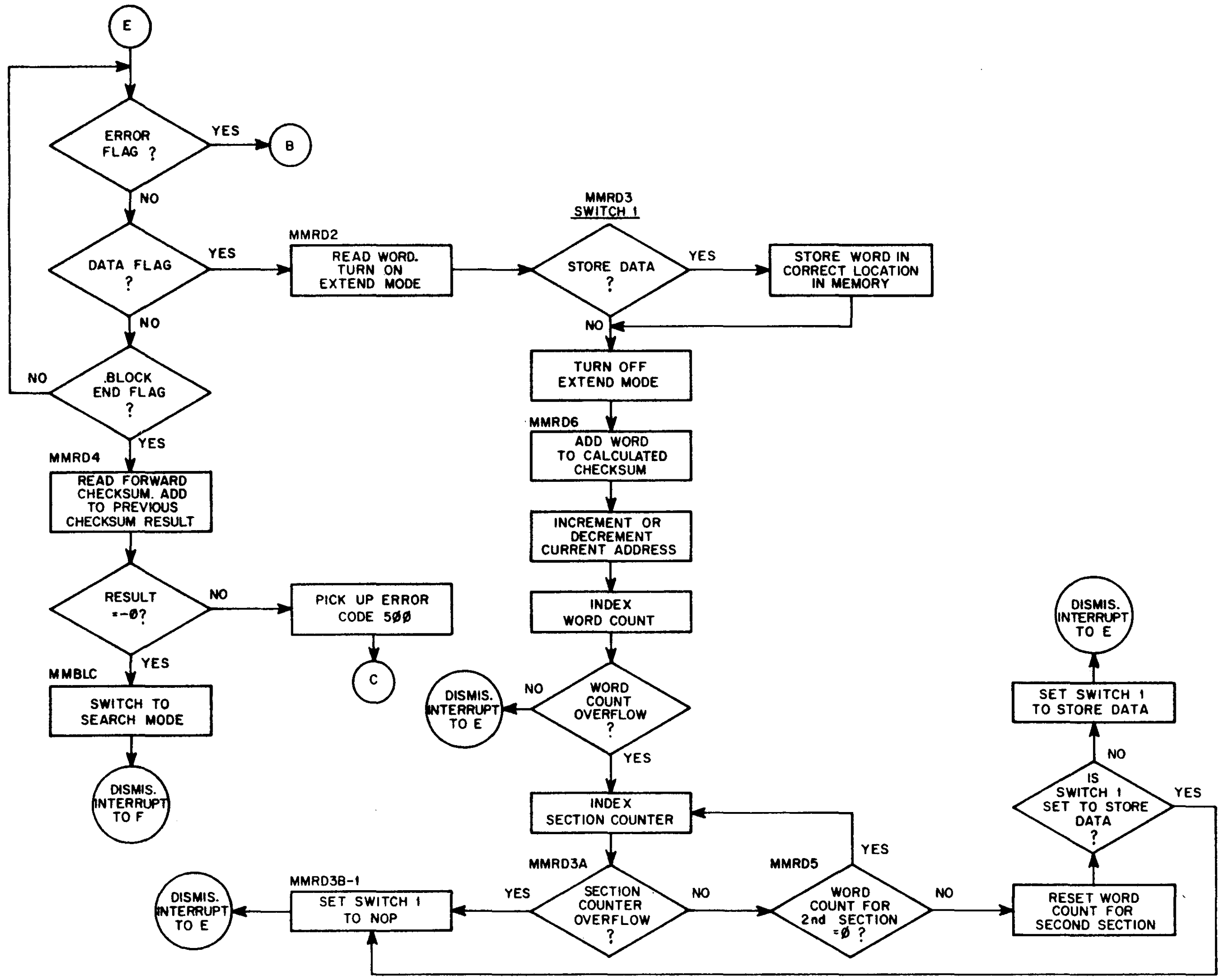
11.1 Flow Charts



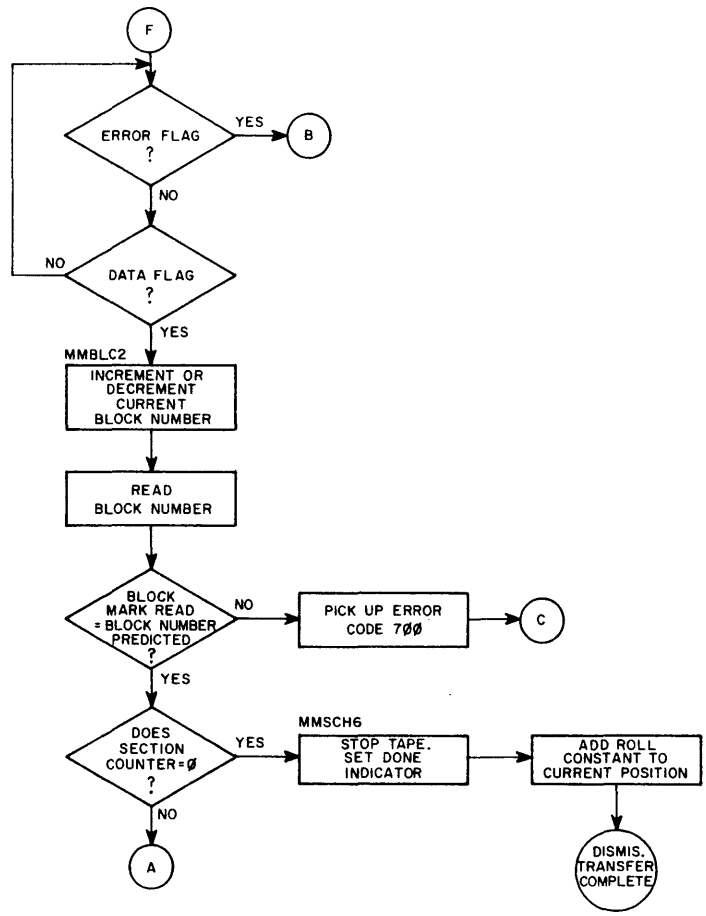
Gross DECtape Subroutine



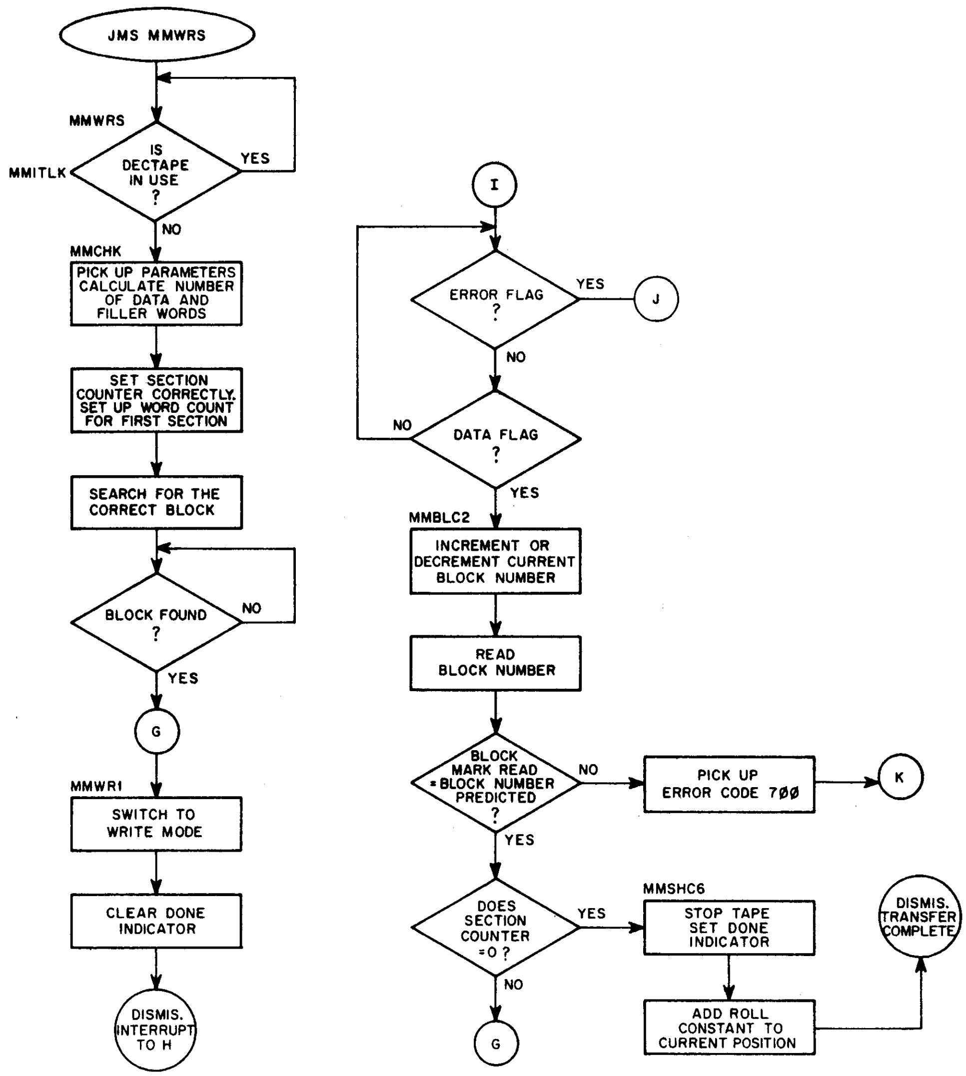
Read Routine



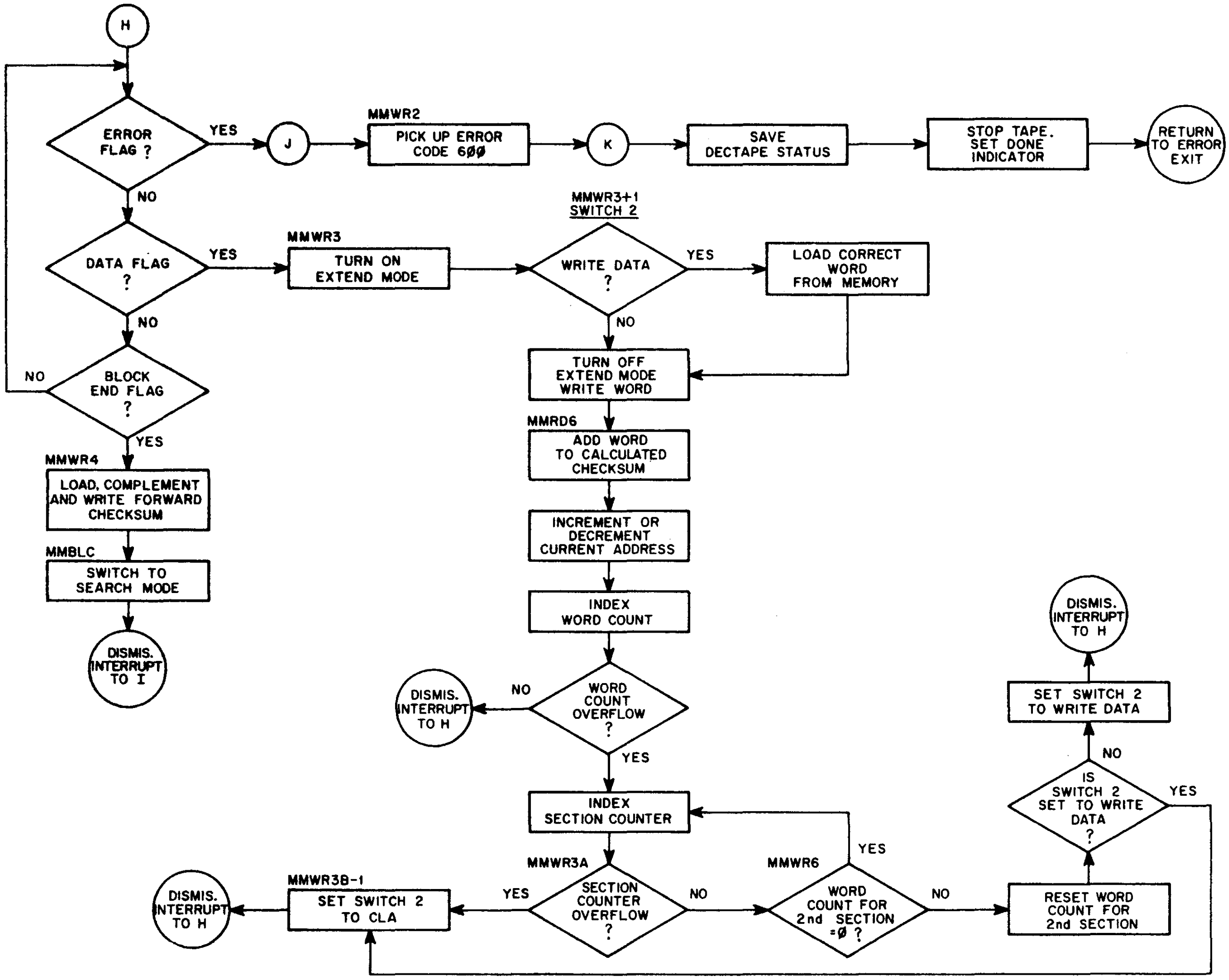
Read Routine (continued)



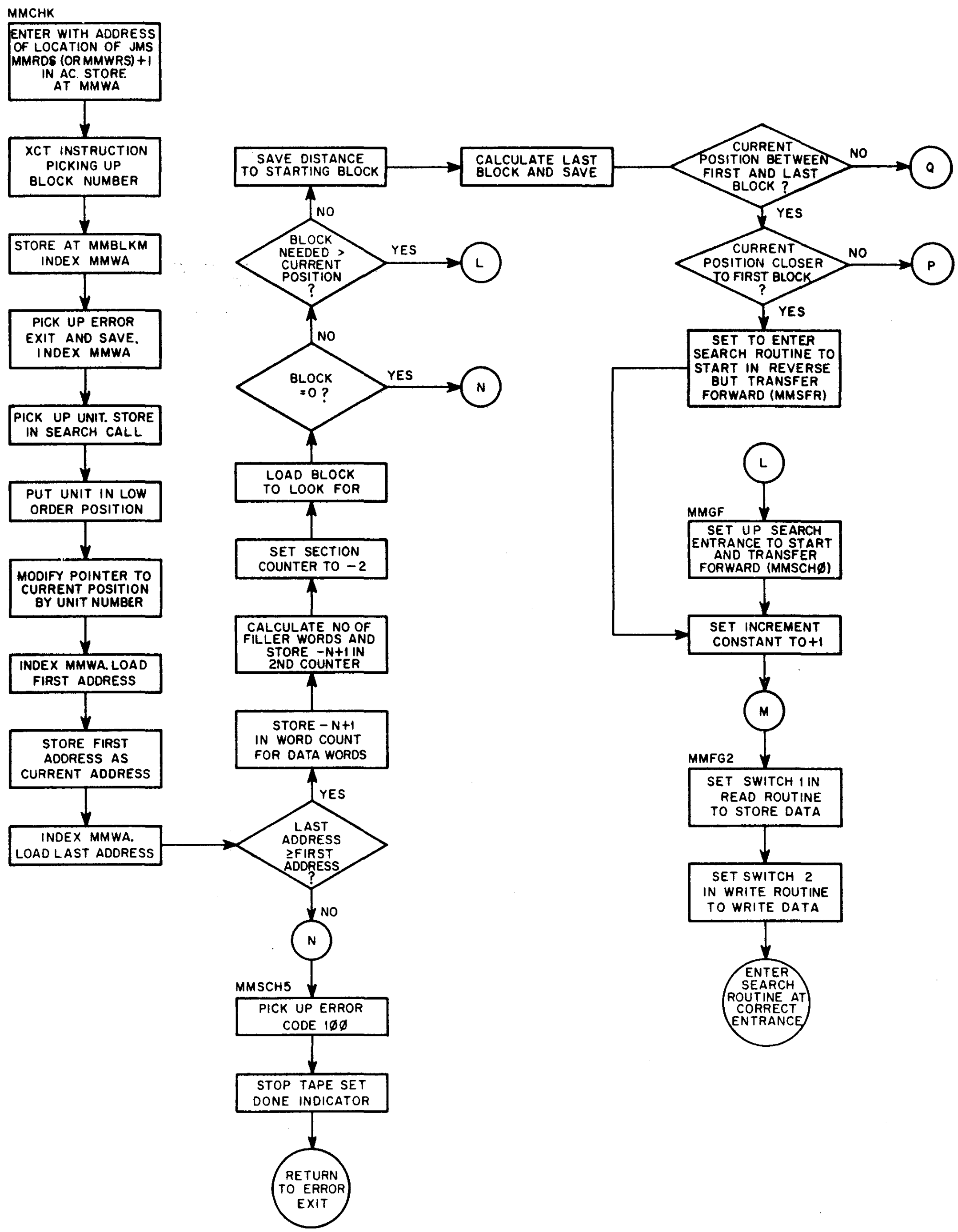
Read Routine (continued)



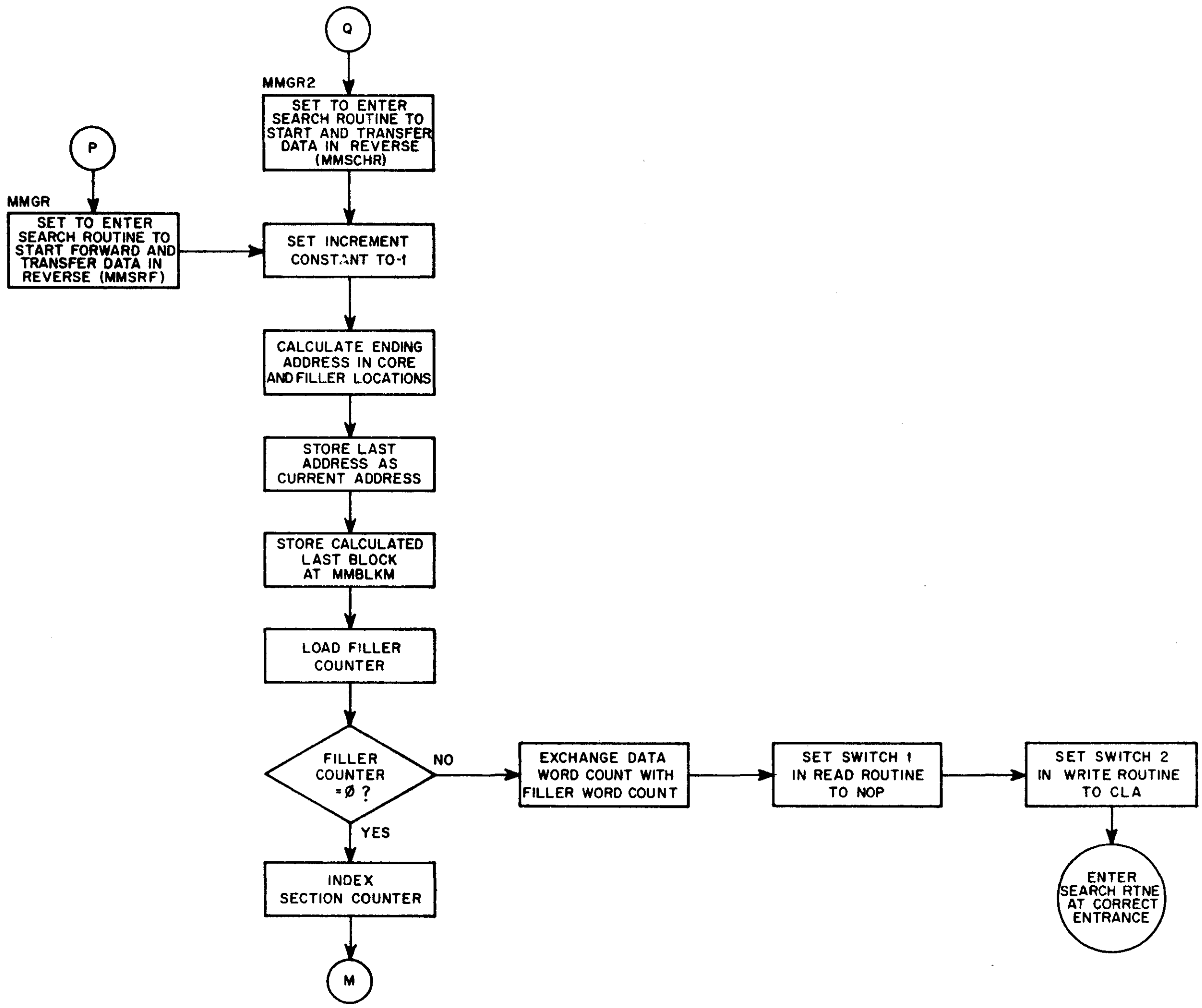
Write Routine



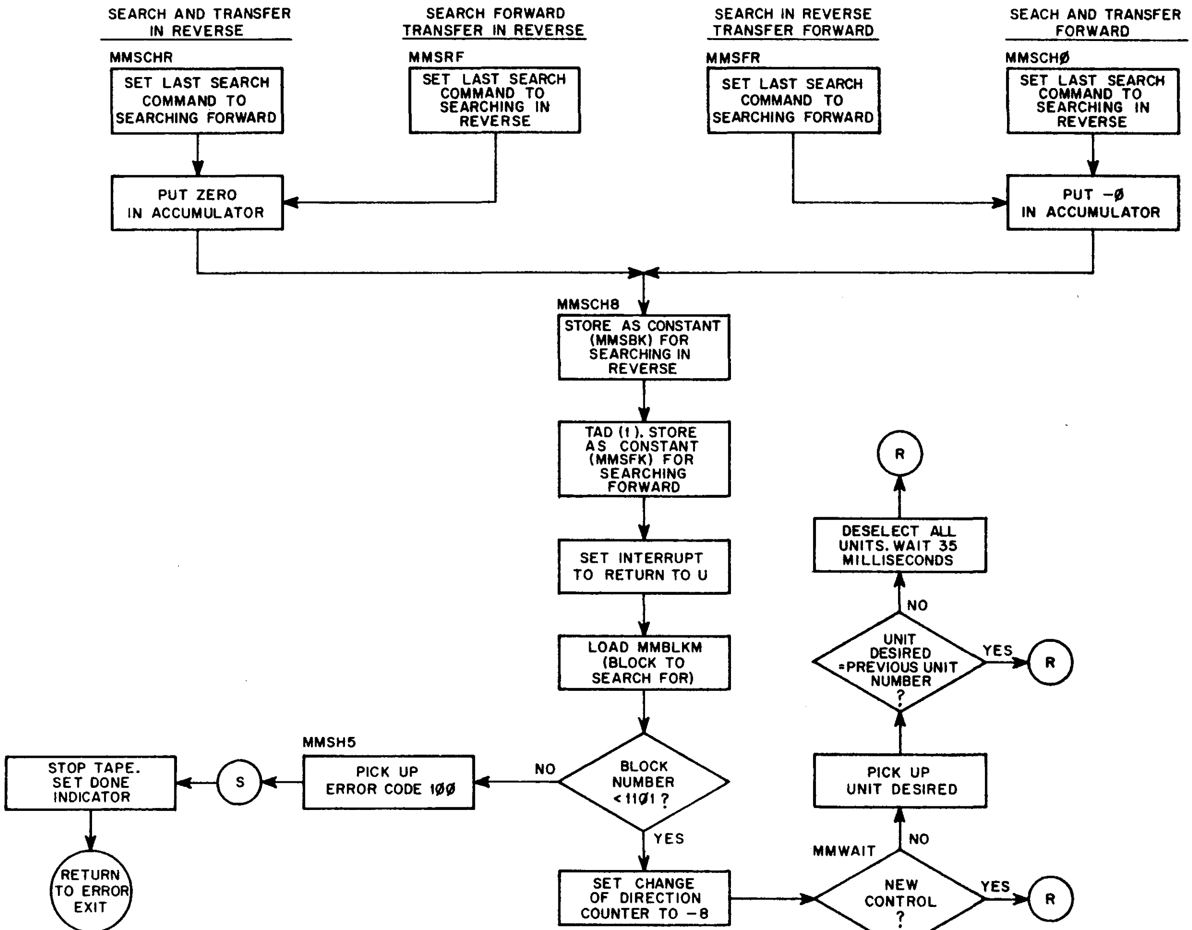
Write Routine (continued)



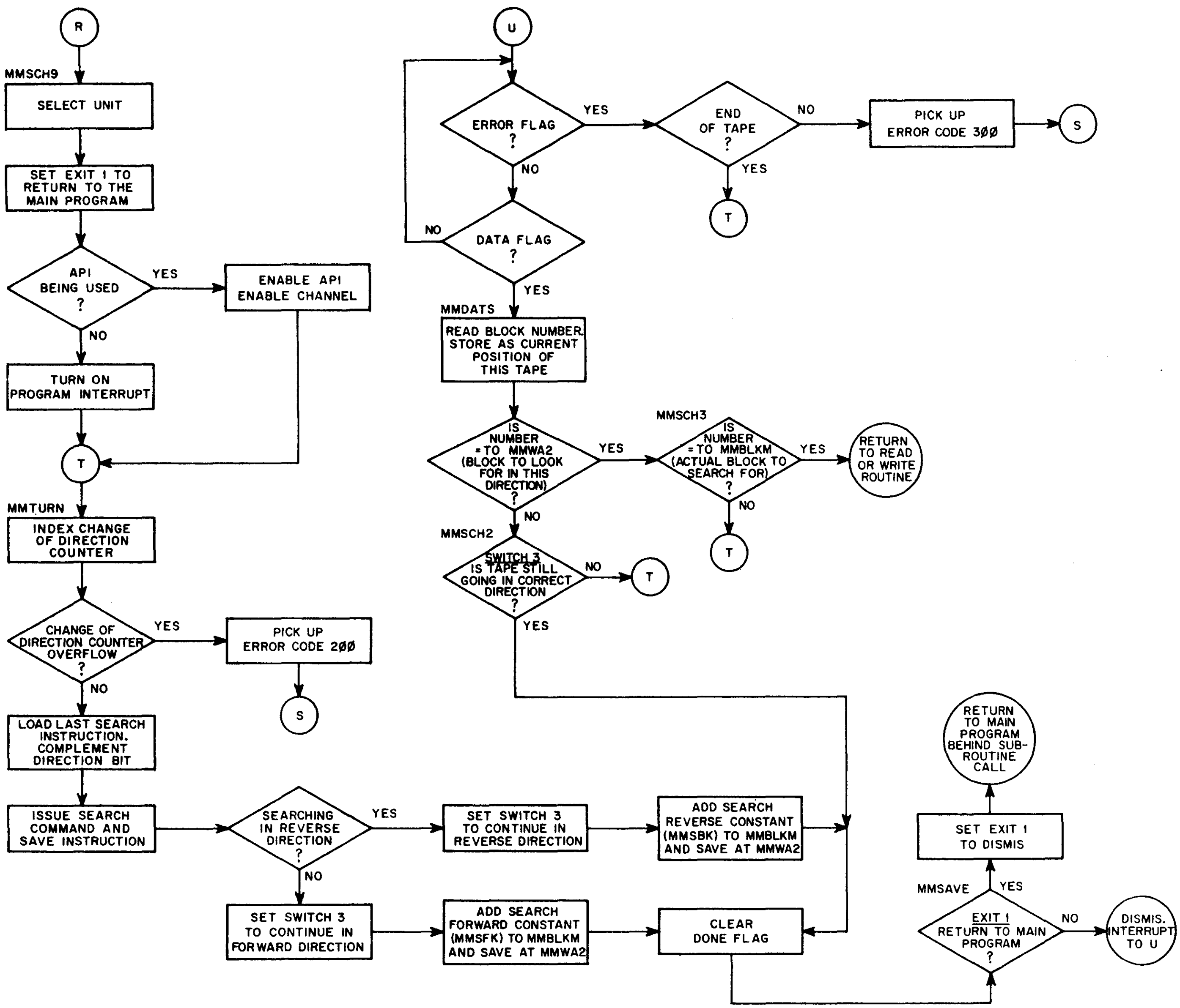
Common Routine to Pick Up Parameters and Initiate Searching



Common Routine to Pick Up Parameters
and Initiate Searching (continued)



Search Routine



Search Routine (continued)