decsystem10

Monitor Calls Manual

digital

decsystem10

MONITOR CALLS

DEC-10-OMCMA-A-D

This manual reflects the software of the 5.07 and 6.01 releases of the monitor.

digital equipment corporation · maynard, massachusetts

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The postage prepaid READER'S COMMENTS form on the last page of this document requests the user's critical evaluation to assist us in preparing future documentation.

CONTENTS

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

CONTENTS (Cont)

ILLUSTRATIONS

TABLES

TABLES (Cont)

PREFACE

DECsystem-10 Monitor Calls is a complete reference document describing the monitor programmed operators (UUOs) and is intended for the experienced assembly language programmer. The information presented in this manual reflects the 6.01 and 5.07 releases of the monitor. The monitor calls are grouped in a manner that facilitates easy learning, and once they are mastered, the user can refer to the end of the Table of Contents and to the Index for an alphabetical list of the UUOs.

DECsystem-10 Monitor Calls does not include reference material on the operating system commands. This information can be found in DECsystem-10 Operating System Commands (DEC-10-MRDD-D). Included in DECsystem-10 Operating System Commands are discussions on commands processed by both the monitor command language interpreter and the programs in the Batch system. The two manuals, DECsystem-10 Monitor Calls and DECsystem-10 Operating System Commands, supersede the Timesharing Monitors manual (DEC-T9-MTZD-D) and all of its updates.

A third manual, Introduction to DECsystem-10 Software (DEC-10-MZDA-D), is a general overview of the DECsystem-10. It is written for the person, not necessarily a programmer, who knows computers and computing concepts and who desires to know the relationship between the various components of the DECsystem-10. This manual is not intended to be a programmer's reference manual and, therefore, it is recommended that it be read at least once before reading the above-mentioned reference documents.

SYNOPSIS OF DECsystem-10 MONITOR CALLS

Chapter 1 discusses the format of memory and briefly describes the job data. Chapter 2 introduces all of the monitor programmed operators available to a user program and the various processor modes in which a user program operates. The UUOs available for non-I/O operations are presented in Chapter 3. These programmed operators are used to obtain execution, core, and segment control; program identification; environmental information; and real-time status. An introduction to I/O programming is presented in Chapter 4; the services the monitor performs for the user and how the user program obtains these services are discussed. I/O programming specific to the nondirectory devices and directory devices is explained in Chapters 5 and 6, respectively. Algorithms of the monitor, described in Chapter 7, give the user an insight into system operation. The appendices contain supplementary reference material and tables.

CONVENTIONS USED IN DECsystem-10 MONITOR CALLS

The following conventions have been used throughout this manual:

dev:	Any logical or physical device name. The colon must be included when a device is used as part of a file specification.

list	A single file specification or a string of file specifications. A file specification consists of a filename (with or without a filename extension), a device name, a directory name, and a protection.
job n	A job number assigned by the system.
file.ext	Any file legal filename and filename extension.
core	Decimal number of 1K blocks of core (KA10). Decimal number of pages of core (KI10).
adr	An octal address.
C(adr)	The contents of an octal address.
[proj,prog]	Project-programmer numbers; the square brackets must be included in the command string.
fs	Any legal file structure name or abbreviation.
s	The symbol used to indicate the ESCAPE Key.
↑X	A control character obtained by depressing the CTRL key and then the character key x.
←	A back arrow used in command string to separate the input and output file specifications.
=	An equal sign used in a command string to separate the input and output file specifications.
*	The system program prompt for a command string.
.	The monitor's indication that it is awaiting a command.
↲	The symbol used to indicate that the user should depress the RETURN key. This key may be used to terminate every command to the monitor command language interpreter.
___	Underscoring used to indicate computer typeout.
n	A decimal number.
[directory]	A designation identifying a particular disk area. This designation can be in the form [proj,prog] which identifies a UFD or [proj,prog,sfd,sfd,...] which identifies a sub-file directory path branching from a UFD. The square brackets are required.

ALPHABETICAL LIST OF MONITOR CALLS

CHAPTER 1
MEMORY FORMAT

1.1 USER PROGRAMS

User programs must first be loaded into core memory before they can be executed. Two methods are available to load a user program into core. The simplest method is to load a core image stored on a retrievable device (refer to the Commands Manual, RUN and GET commands). The other method is to use the linking loader to load a collection of relocatable binary (.REL) files (refer to the LINK-10 manual).

The address space of a user's program can be divided into two parts, known as segments. Such programs contain a high segment and a low segment while others contain just a low segment. All user programs must have a low segment.

When single segment programs are saved, they are given the .SAV extension. The .SAV extension indicates that the file contains a program with no high segment. When a user program consists of a low segment and a high segment, the files will be so designated with the extensions .LOW and .HGH . If the high segment of a user job is sharable, meaning that more than one user job can reference the same copy of the high segment when in core, the file containing the high segment will be so designated with a .SHR extension.

The high segment (if present) can be used by one user job (.HGH extension), or the same copy of the high segment can be shared by many user jobs (.SHR extension). The low segment is always used by one individual user job; and each user job has its own low segment.

The monitor will, by default, write-protect the high segment so that a user job cannot alter the segment's contents, i.e., write anything into it. Any user job that has the appropriate privileges can request that the monitor clear the write-protect status of its high segment. A user might desire this, for instance, when making a modification to the high segment during the debugging process.

The same high segment can be shared by any number of jobs that each have their own unique low segment. For instance, there may be five users each with a low segment containing his own BASIC user program. Each of the five users may then share a high segment containing the BASIC interpreter. The monitor performs this function automatically; each user believes he has his own high segment containing the BASIC interpreter and is therefore completely unaware of the existence of other users.

Any user job that attempts to write in a write-protected high segment is aborted and receives an error message. If the user job consists of two segments and the user has requested that the monitor clear the write-protect status of the high segment, the user has a two-segment writable user job (refer to Paragraph 3.2.4).

All user programs are assembled and loaded as if they were to execute in an address space starting at zero. In fact, user programs are never placed in core memory starting at location zero. The monitor places a program at the most convenient available location. Then, all address references during execution are relocated to actual physical core memory addresses. The process of relocation is accomplished in different manners depending on the type of processor included in the system.

1.2 MEMORY PROTECTION AND RELOCATION

When a user program is executing, the processor operates in user mode. In this mode certain operations are illegal (such as I/O instructions) and all address references are relocated. The relocation hardware also prevents a user from accessing any locations in memory which have not been assigned to him by the monitor for his job; and conversely, prevents any other user from accessing locations within his assigned area.

The user specifies the size of his program; from that information the DECsystem-10 monitor determines the position within core memory where the program can reside. There are two types of processors available with the DECsystem-10 – the KA10 and the KI10. Monitors for the KI10 are supplied either with the virtual memory option or without the virtual memory option. There are three methods of relocating, they are:

1. the KA10 method
2. the KI10 method
3. the KI10 with virtual memory method.

The monitor will determine the core resident size and position of each user's area somewhat differently in each of these three cases; but to the user program each executes in the same manner. A program that runs on the KI10 with the virtual memory is upwards compatible from those run on the KI10 without virtual memory and those run on the KA10.

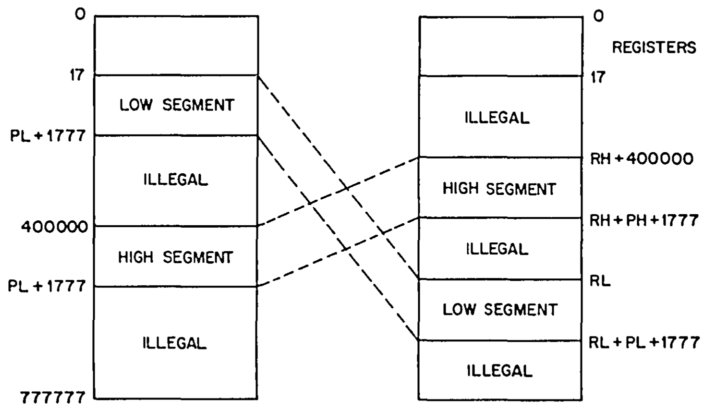
1.2.1 The KA10 Processor

On a KA10 (DECsystem-1040, 1050, 1055), the monitor relocates each user program on a per segment basis. Each segment composing the user program (just a low segment, or both a high and a low segment) is relocated into core memory occupying contiguous blocks of 1024 words each. This relocation is accomplished through the use of protection and relocation registers. In addition, segment protection is performed by these relocation (and protection) registers. Protection ensures against one user job accessing the memory assigned to the monitor or to another user job.

Each segment of a user program has a protection address and a relocation address. The relocation address is the absolute core address of the first location in the segment, as seen by the hardware. The protection address of each segment is the maximum relative address the user can reference. The hardware defines these addresses in units of 1024-word blocks. Relocation is accomplished dynamically by adding the contents of the appropriate relocation register to every user address reference.

All physical address locations are actually invisible to the user, as is the process of relocation. The relative user and relocated address configurations on the KA10 are shown in Figure 1-1, where PL, RL, PH, and RH are the protection and relocation addresses for the low and high segments, respectively. If the low segment is more than half the maximum memory capacity (PL greater than or equal to octal 400000), the high segment starts at the first location after the low segment (at PL+2000). The high segment is limited to 128K.

In summary, the KA10 relocates each segment of a user program in contiguous blocks of core memory. Relocation and protection are accomplished via the relocation and protection hardware registers. An entire program will be core resident when executing.



USER ADDRESS SPACE BEFORE RELOCATION

TYPICAL ADDRESS CONFIGURATION AFTER RELOCATION

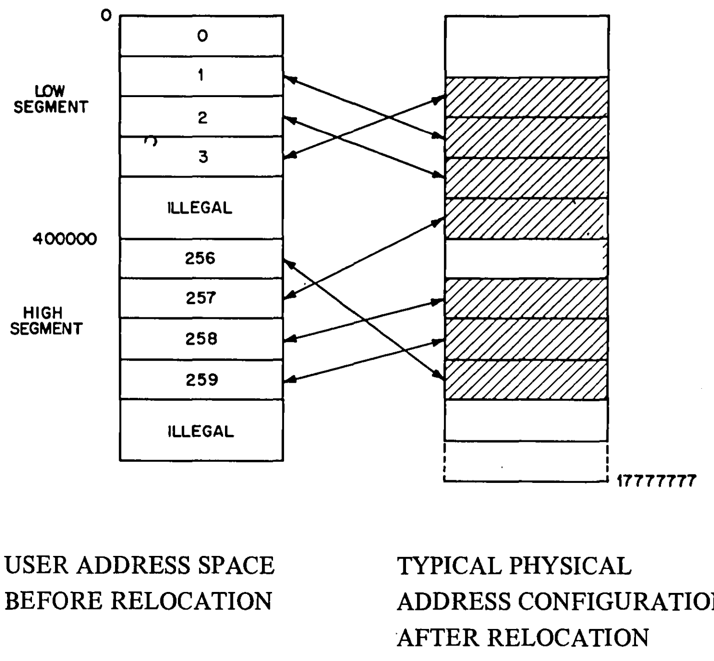
Figure 1-1 KA10 User Address Relocation

1.2.2 The KI10 Processor

KI10 based programs are relocated and protected as KA10 based programs are; this is accomplished using paging hardware. When operating with a KI10 processor, user programs are relocated into core memory in the form of pages. A page consists of 512 words, and the maximum possible user address space is 512 pages or 256K. A user program that is greater than 512 words in length will, when relocated, be comprised of several pages.

The pages composing a user program are relocated individually. The physical placement of one page in core memory need have no connection with the placement of any other page. The monitor maintains a map for translating user addresses into actual physical addresses. The map is kept in a page (invisible to the user) known as the user process table or the user page map page. The paging hardware in the KI10 employs the user process table to relocate all user address references. Since all address references must be mapped through the process table, a user program can access only those physical pages contained in his process table. Therefore, the paging hardware provides protection and relocation capabilities that are compatible with the KA10's protection and relocation registers.

The most important difference between the KA10 and the KI10 (without virtual memory) is that the pages of a segment do not have to be contiguous on the KI10 as they do on the KA10. However, all of the pages forming a program must be in core whenever that program executes.



0
LOW SEGMENT
400000
HIGH SEGMENT
0
1
2
3
ILLEGAL
256
257
258
259
ILLEGAL
17777777
USER ADDRESS SPACE BEFORE RELOCATION
TYPICAL PHYSICAL ADDRESS CONFIGURATION AFTER RELOCATION

Figure 1-2 KI10 Paging Configuration

1.2.3 KI10 Processor Utilizing Virtual Memory

The virtual memory option of the 6.01 and later releases of the monitor makes further use of the KI10's paging hardware. Pages are relocated individually. However, there no longer is a requirement that all of the pages of a program need be resident in core memory during execution. Some of the pages may be in core while the remainder are kept in secondary storage (disk or drum). Therefore, the virtual memory option makes it possible to run programs that are significantly larger than the physical core memory available for their execution.

Assume that user A has a program consisting of 50 pages, but core memory is filled with information except for 20 blank pages. With the virtual memory option, the monitor can swap into core several of user A's pages, while keeping the remainder of the user's pages on a secondary storage device (disk or drum). When one of the pages kept in secondary storage is referenced, the page can be brought into core while another page is swapped out to make room for it.

The decision as to what pages will be stored in core, and what pages will be stored in secondary storage is a function of the page fault handler. The page fault handler also decides which page will be swapped to secondary storage when a new page has to be brought into core. Users may create their own page fault handler. If a user-supplied page fault handler is not present, a default DEC-supplied page fault handler will be used.

Using virtual memory is a privilege which is granted (or denied) by the system administrator. Therefore, not all users at an installation may utilize the virtual memory features.

1.2.3.1 Virtual Memory Organization – Virtual memory permits a program to reference an address space that is larger than the actual physical core occupied during execution. No modifications to user programs are needed when operating under a VM system. It is possible, with the VM option, to execute very large programs (such as BLISS-10) on small systems.

In order to maintain efficiency and rapid response, the monitor itself is core resident under VM monitors. High segments can be paged or shared, but not both. A sharable high segment must be completely in core during execution.

Every program will not necessarily utilize the virtual memory capability. If a user is authorized to employ the VM feature, his program will "go virtual" only when one of the following is true:

1. The program exceeds the user's physical core limit at the time of the GET or RUN which brings it into memory.
2. The program uses the CORE UUO (or command) to expand memory beyond the user's physical core limit and then references one of the newly created pages.
3. The program assumes direct control of its memory management with the PAGE. UUO.

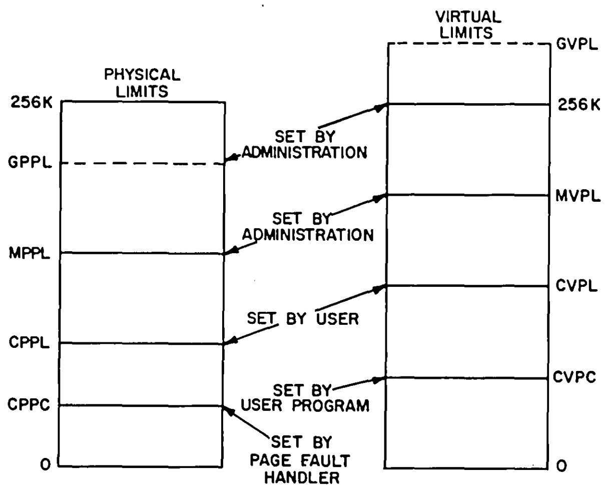


Figure 1-3 Physical and Virtual Page Limits

Figure 1-3 uses the following abbreviations:

GPPL	–	Global physical page limit (established by a privileged SETUUO).
GVPL	–	Global virtual page limit (established by a privileged SETUUO).
MPPL	–	Maximum physical page limit (established by a privileged SETUUO executed by LOGIN).
MVPL	–	Maximum virtual page limit (established by a privileged SETUUO executed by LOGIN).
CPPL	–	Current physical page limit (set by user with SET PHYSICAL LIMIT command or SETUUO).
CPPC	–	Current physical page count (established by user program or page fault handler).
CVPL	–	Current virtual page limit (set by user with SET VIRTUAL LIMIT and SETUUO).
CVPC	–	Current virtual page count (established by user program).

At the moment a job's current physical page count is greater than that of the user's physical page limit, that job will go virtual. If a user has been granted the privilege of using virtual memory, he can control how much of his job will be core resident at any one time. By the user lowering his physical page limit to fewer pages than his job consists of, the user forces his job to use virtual memory. A user can control his physical page limit with the .SET PHYSICAL LIMIT command and his virtual page limit with the .SET VIRTUAL LIMIT command.

The system administrator can establish a maximum virtual page limit (MVPL) for each user. They are set by LOGIN using privileged functions of SETUUO. In addition, the administrator can establish a maximum physical limit that applies to all users (GPPL) and a combined virtual limit that applies to the total amount of virtual memory (i.e., secondary storage) in use by all virtual memory users (GVPL).

1.3 JOB DATA AREA (JOBDAT)

The first 140 octal locations of the user's core area are always allocated to the job data area (refer to Table 1-1). Locations in this area are given mnemonic assignments where the beginning characters are .JB. The job data area provides storage for specific information of interest to both the monitor and the user. Some locations, such as .JBSA and .JBDDT, are set by the user's program for use by the monitor. Other locations, such as .JBREL, are set by the monitor and are used by the user's program. In particular, the right half of .JBREL contains the highest legal address set by the monitor when the user's core allocation changes.

Table 1-1
Job Data Area Locations
(for user-program reference)

Name	Octal Location	Description
.JBUUO	40	User's location 40 (octal). Used by the hardware when processing user UUOs (001 through 037) for storing op code and effective address.
.JB41	41	User's location 41 (octal). Contains the beginning address of the user's programmed operator service routine (usually a JSR or PUSHJ).
.JBERR	42	Left half: Unused Right half: Accumulated error count from one system program to the next. System programs should be written to look at the right half only.
.JBREL	44	Left half: Zero. Right half: The highest relative core location available to the user (i.e., the contents of the memory protection register when this user is running).
.JBBLT	45	Three consecutive locations where the LOADER puts a BLT instruction and a CALLI UUO to move the program down on top of itself. These locations are destroyed on every executive UUO by the executive push-down list.
.JBDDT	74	Left half: The last address of DDT. Right half: The starting address of DDT. If contents are 0, DDT has not been loaded. If the monitor contains the virtual memory option, this location contains zero; and the user types the DDT command (refer to the DECsystem-10 Commands Manual). The monitor will attempt to read SYS:DDT.VMX into the program's virtual address space, starting at the user virtual address 700000 (octal). If successful, the left and right halves of .JBDDT are set up.
.JBPFI	114 (value)	All user I/O must be to locations greater than .JBPFI.

Table 1-1 (Cont)
Job Data Area Locations
(for user-program reference)

Name	Octal Location	Description
.JBHRL	115	Left half: First relative free location in the high segment (relative to the high segment origin so it is the same as the high segment length). Set by the LOADER and subsequent GETs, even if there is no file to initialize the low segment. The left half is a relative quantity because the high segment can appear at different user origins at the same time. The SAVE command uses this quantity to know how much to write from the high segment. Right half: Highest legal user address in the high segment. Set by the monitor every time the user starts to run or does a CORE or REMAP UUO. The word is > 401777 unless there is no high segment, in which case it will be zero. The proper way to test if a high segment exists is to test this word for a non-zero value.
.JBSYM	116	Contains a pointer to the symbol table created by the linking loader. Left half: Negative of the length of the symbol table. Right half: Lowest address used by the symbol table.
.JBUSY	117	Contains a pointer to the undefined symbol table created by the linking loader or defined by DDT. This location has the same format as .JBSYM. There are no undefined symbols if the contents are greater than or equal to 0.
.JBSA	120	Left half: First free location in low segment (set by the LOADER). Right half: Starting address of the user's program.
.JBFF	121	Left half: Zero. Right half: Address of the first free location following the low segment. Set to C (.JBSA) (LH) by RESET UUO.
.JBPFH	123	Left half: The last address of the page fault handler (PFH). Right half: The starting address of PFH. If the contents are zero, the program does not currently have a page fault handler. If a page fault occurs, and .JBPFH contains zero, the monitor will read SYS:PFH.VMX into the top of the program's virtual address space and setup the left and right halves of .JBPFH.
.JBREN	124	Left half: Unused. Right half: REENTER starting address. Set by user or by loader and used by REENTER command as an alternate entry point.
.JBAPR	125	Left half: Zero. Right half: Set by user program to trap address when user is enabled to handle APR traps such as illegal memory, pushdown overflow, arithmetic overflow, and clock. See APRENB UUO.

Table 1-1 (Cont)
Job Data Area Locations
(for user-program reference)

Name	Octal Location	Description
.JBCNI	126	Contains state of APR as stored by CONI APR when a user-enabled APR trap occurs.
.JBTPC	127	Monitor stores PC of next instruction to be executed when a user-enabled APR trap occurs.
.JBOPC	130	The previous contents of the job's last user mode program counter are stored here by monitor on execution of a DDT, REENTER, START, or CSTART command. After a user program HALT instruction followed by a START, DDT, CSTART, or REENTER command, .JBOPC contains the address of the HALT. To proceed at the address specified by the effective address, it is necessary for the user or his program to recompute the effective address of the HALT instruction and to use this address to start. Similarly, after an error during execution of a UUO followed by a START, DDT, CSTART, or REENTER command, .JBOPC points to the address of the UUO. For example, if DDT is to continue after a HALT, type `.JBOPC/10000,,3010 JRST @ .$X`
.JBOVL	131	Left half: Zero. Right half: Pointer to header block for root link.
.JBCOR	133	Left half: Highest location in low segment loaded with non-zero data. No low file written on SAVE or SSAVE if less than 140. Set by LINK-10. Right half: User argument on last SAVE or GET command. Set by the monitor.
.JBINT	134	Left half: Reserved for the future. Right half: Zero or the address of the error-intercepting block (refer to Paragraph 3.1.3.2).
.JBOPS	135	Reserved for all object time systems.
.JBCST	136	Reserved for customers.
.JBVER	137	Program version number. The bits are defined as follows: Bits 0-2 The group who last modified the program 0 Digital development group. 1 Other Digital employees. 2-4 Reserved for customers. 5-7 Reserved for customer's users. Bits 3-11 Digital's major version number. Usually incremented by 1 after a release.

Table 1-1 (Cont)
Job Data Area Locations
(for user-program reference)

Name	Octal Location	Description
.JBVER (cont)		Bits 12-17 Digital's minor version number. Usually 0, but may be used if an update is needed after work has begun on a new major version. Bits 18-35 Edit number which is increased by one after each edit. Usually not reset. The VERSION and the SET WATCH VERSION commands output the version number in standard format. Refer to DECsystem-10 Operating System Commands.
.JBDA	140	The value of this symbol is the first location available to the user. **NOTE** **Only those JOBDAT locations of significant importance to the user are given in this table. JOBDAT locations not listed include those that are used by the monitor and those that are unused at present. User programs should not refer to any locations not listed above because such locations are subject to change.**

JOBDAT is loaded automatically, if needed, during the linking loader's library search for undefined global references, and the values are assigned to the mnemonics. JOBDAT exists as a .REL file on device SYS: for loading with user programs that symbolically refer to the locations. User programs should reference locations by the assigned mnemonics, which must be declared as EXTERN references to the assembler. All mnemonics in this manual with a .JB prefix refer to locations in the job data area.

1.4 VESTIGIAL JOB DATA AREA

A few constant data in the job area may be loaded by a two-segment, one-file program without using instructions on a GET command (.JB41, .JBREN, .JBVER), and some locations are loaded by the monitor on a GET (.JBSA, .JBCOR, .JBHRL). The vestigial job area (the first 10 locations of the high segment) is reserved for these low-segment constants; therefore, a high-segment program is loaded at the high segment origin +10 (see .JBHGA in Table 1-2) instead of at the high segment origin (refer to Table 1-2). With the vestigial job data area in the high segment, the loader automatically loads the constant data into the job data area without requiring a low file on a GET, R, or RUN command, or a RUN UUO. SAVE will write a .LOW file for a two-segment program only if the LH of .JBCOR is 140 (octal) or greater.

Table 1-2
Vestigial Job Data Area Locations

Symbol	Octal Location*	Description
.JBHSA	0	A copy of .JBSA.
.JBH41	1	A copy of .JB41.
.JBHCR	2	A copy of .JBCOR.
.JBHRN	3	LH: restores the LH of .JBHRL. RH: restores the RH of .JBREN.
.JBHVR	4	A copy of .JBVER.
.JBHNM	5	High segment name set on a SAVE.
.JBHSM	6	A pointer to the high-segment symbols, if any.
.JBHGA	7	BYTE (9) 0 (9) high segment origin (18) 0 unused fields are reserved for further expansion and must contain zero, the monitor places the high segment at 400000 or at the first available page boundary (1K boundary on KA10 based systems) above the low segment, if the segment is larger than 128K. This 9 bit byte should always be zero on KA10 based systems. However, if the field is non-zero on KI10 based systems, it is taken as the page where the high segment is to start. This field is setup by the linking loader and the Monitor SAVE Command.
.JBHDA	10	First location not used by vestigial job data area.

*Relative to origin of high segment, usually .JBHGH = 400000 (octal).

CHAPTER 2 INTRODUCTION TO USER PROGRAMMING

2.1 PROCESSOR MODES

In a single-user, non-timesharing system, the user's program is subject only to those conditions inherent in the hardware. The program must

1. Stay within the memory capacity.
2. Observe the hardware restrictions placed on the use of certain memory locations.
3. Observe the restriction on interrupt instructions.

With timesharing, the hardware limits the central processor operations to one of three modes: user mode, user I/O mode, and executive mode.

2.1.1 User Mode

Normally, user programs run with the processor in user mode and must operate within an assigned area of core. In user mode, certain instructions are illegal. User mode is used to guarantee the integrity of the monitor and each user program. The user mode of the processor is characterized by the following:

1. Automatic memory protection and mapping (refer to Chapter 1).
2. Trap to absolute location 40 in the monitor on a KA10; or store the UUO at location 424, the UUO at location 425, and load a new PC from location 436 of the user's process table on the KI10 on any of the following:
   a. Operation codes 040 through 077 and operation code 00,
   b. Input/output instructions (DATAI, DATAO, BLKI, BLKO, CONI, CONO, CONSZ, and CONSO),

      NOTE
      The KI10 processor divides executive mode into kernal and supervisor modes. It divides user mode into concealed and public modes.

   c. HALT (i.e., JRST 4,),
   d. Any JRST instruction that attempts to enter executive mode or user I/O mode.
3. Trap to relative location 40 in the user area on execution of operation codes 001 through 037.

2.1.2 User I/O Mode

The user I/O mode (bits 5 and 6 of PC word = 11) of the central processor allows privileged user programs to be run with automatic protection and mapping in effect, as well as the normal execution of all defined operation codes (except the HALT instruction on the KI10 processor). The user I/O mode provides some protection against partially debugged monitor routines and permits infrequently used device service routines to be run as a user job. Direct control of special devices by the user program is particularly important in real-time applications.

To utilize this mode, the user must have bit 15 (JB.TRP) set in the privilege word. RESET AC, or CALLI 0 terminates user I/O mode. User I/O mode is not used by the monitor and is normally not available to the time-sharing user (refer to Paragraph 3.8.3).

2.1.3 Executive Mode

The monitor operates with the processor in executive mode, which is characterized by special memory protection and mapping (refer to Chapter 1) and by the normal execution of all defined operation codes.

User programs run in user mode; therefore, the monitor must schedule user programs, service interrupts, perform all input and output operations, take action when control returns from a user program, and perform any other legal user-requested operations that are not available in user mode. The services the monitor makes available to user-mode programs, and how a user program obtains these services, are described in Chapters 3 and 4.

2.2 PROGRAMMED OPERATORS (UUOs)

Operation codes 000 through 077 in the PDP-10 are programmed operators, sometimes referred to as UUOs. They are software-implemented instructions because from a hardware point of view, their function is not prespecified. Some of these op-codes trap to the monitor, and the rest trap to the user program.

After the effective address calculation is complete, the contents of the instruction register, along with the effective address, are stored, and an instruction is executed out of the normal sequence. Refer to the Systems Reference Manual for additional information on UUO handling by the central processor.

Although there is one operating system for all configurations of the DECsystem-10, some UUOs may not be included in each DECsystem-10. This is especially true of the DECsystem-1040, the basic system intended for small installations that do not want all of the system's features because of a constraint on core. UUOs are deleted from the DECsystem-1040 by feature test switches defined at MONGEN time. In the standard DECsystem-1040, many of these switches are off, and therefore, the corresponding UUOs are not available. This saves core but limits various features of the operating system. In the UUO descriptions that follow, footnotes indicate if the switch is normally absent in the DECsystem-1040. If not stated, the UUO is available on all configurations of the DECsystem-10.

2.2.1 Operation Codes 001-037 (User UUOs)

Operation codes 001 through 037 do not affect the mode of the central processor; thus, when executed in user mode, they trap to user location 40, which allows the user program complete freedom in the use of these programmed operators.

If a user's undebugged program accidentally executes one of these op-codes when the user did not intend to use it, the following error message is normally issued:

```
HALT AT USER PC addr
```

This message is given because the user's relative location 41 contains HALT (unless his program has overtly changed it) which is provided by the loader; addr is the location of the user UUO.

2.2.2 Operation Codes 040-077 and 000 (Monitor UUOs)

Operation codes 040 through 077 and 000 trap to absolute location 40 on a KA10; or store the UUO at location 424, the UUO at location 425, and load a new PC from location 436 of the user's process table on the KI10, with the central processor in executive mode. These programmed operators are interpreted by the monitor to perform I/O operations and other control functions for the user's program.

Operation code 000 always returns the user to monitor mode with the error message:

```
?ILLEGAL UUO AT USER PC addr
```

Table 2-1 lists the operation codes 040 through 077 and their mnemonics.

Table 2-1
Monitor Programmed Operators

Op Code	Call	Function
040	CALL AC, [SIXBIT/NAME/], or NAME AC,	Programmed operator extension (refer to Paragraph 2.2.2.1).
041	INIT D, MODE SIXBIT/DEV/ XWD OBUF, IBUF error return normal return	Select I/O device (refer to Paragraph 4.2.3).
042		No operation } Reserved for installation-dependent definition.
043		No operation
044		No operation
045		No operation
046		No operation
047	CALLI AC, N	Programmed operator extension (refer to Paragraph 2.2.2.1).
050	OPEN, D, E error return normal return E: EXP STATUS SIXBIT /DEV/ XWD OBUF, IBUF	Select I/O device (refer to Paragraph 4.2.3).
051	TTCALL AC, ADR	Extended operations on job-controlling terminal (refer to Paragraph 5.10.4).
052		Reserved for future expansion by DEC.

Table 2-1 (Cont)
Monitor Programmed Operators

Op Code	Call	Function
053		Reserved for future expansion by DEC.
054		Reserved for future expansion by DEC.
055	RENAME D, E error return normal return E: SIXBIT /FILE/ SIXBIT /EXT/ EXP <PROT> B8+DATE XWD PROJ, PROG	Rename or delete a file (see Section 4.4.3).
056	IN D, normal return error of EOF return	INPUT and skip on error or EOF (see Section 4.5).
057	OUT D, normal return error return	OUTPUT and skip on error or EOT (see Section 4.5).
060	SETSTS D, STATUS	Set file status (see Section 4.6.2).
061	STATO D, BITS R0: NO SELECTED BITS = 1 R1: SOME SELECTED BITS = 1	Skip if file status bits = 1 (see Section 4.6.1).
062	GETSTS D, E	Copy file status to E (see Section 4.6.1).
063	STATZ D, BITS R0: SOME SELECTED BITS = 1 R1: ALL SELECTED BITS = 0	Skip if file status bits = 0 (see Section 4.6.1).
064	INBUF D, N	Set up input buffer ring with N buffers (refer to Paragraph 4.3.2).
065	OUTBUF D, N	Set up output buffer ring with N buffers (refer to Paragraph 4.3.2).
066	INPUT D,	Request input or request next buffer (refer to Paragraph 4.5).
067	OUTPUT D,	Request output or request next buffer (refer to Paragraph 4.5).
070	CLOSE D,	Terminate file operation (refer to Paragraph 4.7).
071	RELEAS D,	Release device (refer to Paragraph 4.8.1).
072	MTAPE D, N	Perform tape positioning operation (refer to Paragraphs 5.5.3 and 6.1.6.5).

Table 2-1 (Cont)
Monitor Programmed Operators

Op Code	Call	Function
073	UGETF D,	Get next free block number on DECtape (refer to Paragraph 6.1.6.3).
074	USETI D, E	Set next input block number (refer to Paragraph 6.1.6.1 and 6.2.9.2).
075	USETO D, E	Set next output block number (refer to Paragraphs 6.1.6.2 and 6.2.9.2).
076	LOOKUP D, E error return normal return E: SIXBIT /FILE/ SIXBIT /EXT/ 0 XWD PROJ, PROG	Select a file for input (refer to Paragraph 4.4.1).
077	ENTER D, E error return normal return E: SIXBIT /FILE/ SIXBIT /EXT/ 0 XWD PROJ, PROG	Select a file for output (refer to Paragraph 4.4.2).
100	UJEN	Dismiss real-time interrupt (refer to Paragraph 3.8.4).

2.2.2.1 **CALL and CALLI** – Operation codes 040 through 077 limit the monitor to 40 (octal) operations. The CALL operation extends this set by specifying the name of the operation by the contents of the location specified by the effective address (e.g., CALL [SIXBIT/EXIT/]). This capability provides for indefinite extendability of the monitor operations, at the overhead cost to the monitor of a table lookup.

The CALLI operation eliminates the table lookup of the CALL operation by having the programmer or the assembler perform the lookup and specify the index to the operation in the effective address of the CALLI. Table 2-2 lists the monitor operations specified by the CALL and CALLI operations.

Table 2-2
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, -2 . . . -n		Customer defined	Reserved for definition by each customer installation.

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, -1	LIGHTS	CALL AC, [SIXBIT/LIGHTS/]	Display AC in console lights (refer to Paragraph 3.6.4.2).
CALLI AC, 0	RESET	CALL [SIXBIT/RESET/] return	Reset I/O device (refer to Paragraph 4.1.2).
CALLI AC, 1	DDTIN	MOVEI AC, BUFFER CALL AC, [SIXBIT/DDTIN/] only return	DDT mode console input (refer to Paragraph 5.10.3).
CALLI AC, 2	SETDDT	MOVEI AC, DDT-start-adr CALL AC, [SIXBIT/SETDDT/] only return	Set protected DDT starting address (refer to Paragraph 3.1.1.1).
CALLI AC, 3	DDTOUT	MOVEI AC, BUFFER CALL AC, [SIXBIT/DDTOUT/] only return	DDT mode console output (refer to Paragraph 5.10.3).
CALLI AC, 4	DEVCHR	MOVE AC, [SIXBIT/DEV/] or MOVEI AC, channel no. CALL AC, [SIXBIT/DEVCHR/] only return	Get device characteristics (refer to Paragraph 4.12.2).
CALLI AC, 5	DDTGT	CALL AC, [SIXBIT/DDTGT/] only return	No operation, historical UUO.
CALLI AC, 6	GETCHR	AC: = SIXBIT/DEV/ CALL AC, [SIXBIT/GETCHR/] only return	Same as CALLI AC, 4.
CALLI AC, 7	DDTRL	CALL AC, [SIXBIT/DDTRL/] only return	No operation, historical UUO.
CALLI AC, 10	WAIT	CALL AC, [SIXBIT/WAIT/] only return	Wait until device is inactive (refer to Paragraph 4.5.3).
CALLI AC, 11	CORE	MOVE AC, [XWD HIGH ADR or 0, LOW ADR or 0] CALL AC, [SIXBIT/CORE/] error return normal return	Allocate core (refer to Paragraph 3.2.3).
CALLI AC, 12	EXIT	CALL AC, [SIXBIT/EXIT/] return	Stop job, may release devices and stop the job depending on contents of AC (refer to Paragraph 3.1.2.3).
CALLI AC, 13	UTPCLR	CALL AC, [SIXBIT/UTPCLR/] only return	Clear DECtape directory (refer to Paragraph 6.1.6.4).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 14	DATE	CALL AC, [SIXBIT/DATE/] only return AC: = date in compressed format	Return date (refer to Paragraph 3.6.1.1).
CALLI AC, 15	LOGIN**	MOVE AC, [XWD -N, LOC] CALL AC, [SIXBIT/LOGIN/] R0: return Does not return if C(R0) is a HALT instruction.	Privileged UUO in that the calling job must not be logged in. Is a no-op if executed by a job already logged-in.
CALLI AC, 16	APRENB	MOVEI AC, BITS CALL AC, [SIXBIT/APRENB/] return	Enable central processor traps (refer to Paragraph 3.1.3.1).
CALLI AC, 17	LOGOUT**	CALL AC, [SIXBIT/LOGOUT/] no return	Privileged UUO available only to system-privileged programs. Is treated like an EXIT UUO if executed by a non system-privileged program.
CALLI AC, 20	SWITCH	CALL AC, [SIXBIT/SWITCH/] return AC: contents of console switches	Read console data switches (refer to Paragraph 3.6.4.1).
CALLI AC, 21	REASSI	MOVEI AC, job number MOVE AC+1, [SIXBIT/DEV/] CALL AC, [SIXBIT/REASSI/] return If C(AC)=0 on return, the job specified has not been initialized. If C(AC+1) = 0 on return, the device not assigned to calling job, or device is TTY.	Reassign device (refer to Paragraph 4.8.3).
CALLI AC, 22	TIMER	CALL AC, [SIXBIT/TIMER/] return AC:=time in jiffies, right justified.	Read time of day in clock ticks (refer to Paragraph 3.6.1.2).
CALLI AC, 23	MSTIME	CALL AC, [SIXBIT/MSTIME/] return AC:=time in milliseconds, right-justified.	Read time of day in milliseconds (refer to Paragraph 3.6.1.3).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 24	GETPPN	CALL AC, [SIXBIT/GETPPN/] normal return alternate return AC:=XWD proj. no., prog. no. of this job. Alternate return is taken only if job is privileged and the same proj-prog number occurs twice in the table of jobs logged in.	Return project/programmer number of job (refer to Paragraph 3.6.2.3).
CALLI AC, 25	TRPSET	MOVE AC, [XWD N, LOC] CALL AC, [SIXBIT/TRPSET/] error return normal return LOC: JSR TRAP	Set trap for user I/O mode (refer to Paragraph 3.8.3).
CALLI AC, 26	TRPJEN	CALL [SIXBIT/TRPJEN/]	Illegal UUO; replaced by UJEN (op code 100).
CALLI AC, 27	RUNTIM	MOVE AC, job number or 0 CALL AC, [SIXBIT/RUNTIM/] only return AC:=running time of job AC:=0 if nonexistent job	Return the job's running time in milliseconds (refer to Paragraph 3.6.2.1).
CALLI AC, 30	PJOB	CALL AC, [SIXBIT/PJOB/] return AC:=job number, right justified.	Return job number (refer to Paragraph 3.6.2.2).
CALLI AC, 31	SLEEP	MOVE AC, time in seconds CALL AC, [SIXBIT/SLEEP/] return	Stop job for specified time in seconds (refer to Paragraph 3.1.4.1).
CALLI AC, 32	SETPOV	CALL AC, [SIXBIT/SETPOV/] return	Superseded by APRENB UUO.

CALLI AC, 33	PEEK	MOVEI AC, exec adr
		CALL AC, [SIXBIT/PEEK/]
		return
		AC:=C (exec-adr)
			Return contents of executive address (refer to Paragraph 3.6.3.1).

CALLI AC, 34	GETLIN	CALL AC, [SIXBIT/GETLIN/]
		return
		AC:=SIXBIT TTY name, left-justified (e.g., CTY, TTY27)
			Return SIXBIT name of attached terminal (refer to Paragraph 5.10.5).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 35	RUN	MOVSI AC, start adr increment HRRI AC, E RUN AC, error return normal return	Transfer control from one program to another (refer to Paragraph 3.3.1).
CALLI AC, 36	SETUWP	MOVEI AC, BIT SETUWP AC, error return normal return	Set or clear user mode write protect for high segment (refer to Paragraph 3.2.4).
CALLI AC, 37	REMAP	MOVEI AC, highest adr, in low seg or MOVE AC, [XWD high seg origin, low seg] REMAP AC, error return normal return	Remap top of low segment into high segment (refer to Paragraph 3.3.3).
CALLI AC, 40	GETSEG	MOVEI AC, E GETSEG AC, error return normal return	Replace high segment in user's addressing space (refer to Paragraph 3.3.2).
CALLI AC, 41	GETTAB	MOVSI AC, job. no. or index no. HRRI AC, table no. GETTAB AC, error return normal return	Return contents of monitor table or location (refer to Paragraph 3.6.3.4).
CALLI AC, 42	SPY	MOVEI AC, highest physical adr, desired SPY AC, error return normal return	Make physical core be high segment for examination of monitor (refer to Paragraph 3.6.3.2).
CALLI AC, 43	SETNAM	MOVE AC, [SIXBIT/NAME/] SETNAM AC. return	Set program name in monitor job table (refer to Paragraph 3.4.1).
CALLI AC, 44	TMPCOR	MOVE AC, [XWD code, block] TMPCOR, AC error return normal return	Allow temporary in-core file storage for job (refer to Paragraph 3.5.1).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 45	DSKCHR	MOVE AC, [XWD+N, LOC] DSKCHR AC, error return normal return AC:=XWD status configuration LOC:=SIXBIT/NAME/ 0 } 0 } values returned 0 }	Return disk characteristics (refer to Paragraph 6.2.9.13).
CALLI AC, 46	SYSSTR	MOVEI AC, 0 or MOVE AC, [SIXBIT/FSNAME/] SYSSTR AC, error return normal return	Return next file structure name, (refer to Paragraph 6.2.9.10).
CALLI AC, 47	JOBSTR	MOVE AC, [XWD N, LOC] JOBSTR AC, error return normal return AC:=argument	Return next file structure name in the job's search list (refer to Paragraph 6.2.9.8).
CALLI AC, 50	STRUUO	MOVE AC, [XWD N, LOC] STRUUO AC, error return normal return AC:=status or error code	Manipulate file structures (refer to Paragraph 6.2.9.7).
CALLI AC, 51	SYSPHY	MOVEI AC, 0 or MOVE AC, [last unit name] SYSPHY AC, error return normal return	Return all physical disk units (refer to Paragraph 6.2.9.11).
CALLI AC, 52	FRECHN		Reserved for future use.
CALLI AC, 53	DEVTYP	MOVE AC, [SIXBIT/dev/] or MOVEI AC, channel no. or MOVEI AC, UDX DEVTYP AC, error return normal return	Return properties of device (refer to Paragraph 4.12.3).
CALLI AC, 54	DEVSTS	MOVEI AC, channel no. of device DEVSTS AC, error return normal return	Return hardware device status word (refer to Paragraph 4.12.1).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 55	DEVPPN	MOVE AC, [SIXBIT/DEV/] or MOVEI AC, channel DEVPPN AC, error return normal return AC:=XWD proj-prog, number on a normal return	Return the project programmer number associated with a device (refer to Paragraph 6.2.9.12).
CALLI AC, 56	SEEK***	AC is software channel number SEEK AC, return	Perform a SEEK to current selected block for software channel AC (refer to Paragraph 6.2.9.3).
CALLI AC, 57	RTTRP	MOVEI AC, RTBLK RTTRP AC, error return normal return	Connect real-time devices to PI system (refer to Paragraph 3.8.1).
CALLI AC, 60	LOCK	MOVE AC, [XWD high seg code, low seg code] or MOVE AC, [XWD -n, adr] LOCK AC, error return normal return	Lock job in core (refer to Paragraphs 3.2.2 and 3.2.2.2).
CALLI AC, 61	JOBSTS	MOVEI AC, channel no. or MOVNI AC, job JOBSTS AC, error return normal return	Return status information about device TTY and/or controlled job (refer to Paragraph 5.9.4.4).
CALLI AC, 62	LOCATE	MOVEI AC, station no. LOCATE AC, error return normal return	Change the job's logical station (refer to Paragraph 3.4.3).
CALLI AC, 63	WHERE	MOVEI AC, channel no. or MOVE AC, [SIXBIT/dev/] WHERE AC, error return normal return	Return the physical station of the device (refer to Paragraph 4.12.5).
CALLI AC, 64	DEVNAM	MOVEI AC, channel no. or MOVEI AC, UDX or MOVE AC, [SIXBIT/dev/] DEVNAM AC, error return normal return	Return physical name of device obtained through generic INIT OPEN or logical device assignment (refer to Paragraph 4.12.6).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 65	CTLJOB	MOVEI AC, job number CTLJOB AC, error return normal return	Return job number of controlling job (refer to Paragraph 5.9.4.5).
CALLI AC, 66	GOBSTR	MOVE AC, [XWD N, LOC] GOBSTR AC, error return normal return	Return next file structure name in an arbitrary job's search list (refer to Paragraph 6.2.9.9).
CALLI AC, 67	ACTIVATE		Reserved for the future.
CALLI AC, 70	DEACTIVATE		
CALLI AC, 71	HPQ	MOVEI AC, high-priority queue no. HPQ AC, error return normal return	Place job in high priority scheduler's run queue (refer to Paragraph 3.8.5).
CALLI AC, 72	HIBER	MOVSI AC, enable bits HRRI AC, sleep time HIBER AC, error return normal return	Allow job to become dormant until the specified event occurs (refer to Paragraph 3.1.4.2).
CALLI AC, 73	WAKE	MOVE AC, job no. WAKE AC, error return normal return	Allow job to activate the specified dormant job (refer to Paragraph 3.1.4.3).
CALLI AC, 74	CHGPPN**	MOVE AC, new proj. prog. no. CHGPPN AC, error return normal return	Change project-programmer number. Gives an error return if executed by a job already logged-in.
CALLI AC, 75	SETUUO	MOVE AC, [XWD function, argument] SETUUO AC, error return normal return	Set system and job parameters (refer to Paragraph 3.4.2).
CALLI AC, 76	DEVGEN		Reserved for the future.
CALLI AC, 77	OTHUSR	OTHUSR AC, non-skip return skip return AC:=proj. prog. no.	Determine if another job is logged in the same project/programmer number (refer to Paragraph 3.6.2.4).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 100	CHKACC	MOVEI AC, CHKLOC CHKACC AC, error return normal return	Check user's access to the file specified (refer to Paragraph 6.2.9.6).
CALLI AC, 101	DEVSIZ	MOVE AC, [EXP LOC] DEVSIZ AC, error return normal return	Determine buffer size for the specified device (refer to Paragraph 4.12.4).
CALLI AC, 102	DAEMON	MOVE AC, [XWD+length, adr of arg. list] DAEMON AC, error return normal return	Request DAEMON to perform a specified task (refer to Paragraph 3.7).
CALLI AC, 103	JOBPEK**	MOVE AC, adr of arg block JOBPEK AC, error return normal return	Read or write another job's core. Gives the error return if executed by a non-system-privileged program.
CALLI AC, 104	ATTACH**	MOVE AC [XWD line no., job no.] ATTACH AC, error return normal return	Attach the job to the specified TTY line number. Gives the error return if executed by a non-system-privileged program.
CALLI AC, 105	DAEFIN**	MOVE AC, [XWD+length, adr of arg. list] DAEFIN AC, error return normal return	Indicate that the request to the DAEMON program has been completed. Gives the error return if executed by a non-system-privileged program.
CALLI AC, 106	FRCUUO**	MOVE AC, [XWD+length, adr of arg. list]. FRCUUO AC, error return normal return	Force a command for a job. Gives the error return if executed by a non-system-privileged program.
CALLI AC, 107	DEVLNM	MOVE AC, [SIXBIT/dev/] or MOVEI AC, channel no. MOVE AC+1, [SIXBIT/logical name/] or MOVEI AC, UDX DEVLNM AC, error return normal return	Set a logical name for this specified device (refer to Paragraph 4.8.4).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 110	PATH.	MOVE AC, [XWD+length, adr. of argument list] PATH. AC, error return normal return	Read or modify the default directory path or read the current path of a file OPEN on a channel. (Refer to Paragraph 6.2.9.1).
CALLI AC, 111	METER.	MOVE AC, [XWD N, LOC] METER. AC, error return normal return	Provide performance analysis and metering of dynamic system variables. (Refer to Paragraph 3.9).
CALLI AC, 112	MTCHR.	MOVE AC, [XWD +n, LOC] or MOVEI AC, channel no. or MOVE AC, [SIXBIT/dev/] MTCHR. AC, error return normal return	Return characteristics of the magnetic tape. (Refer to Paragraph 5.5.3.3).
CALLI AC, 113	JBSET.**	MOVE AC, [2, , BLOCK] JBSET. AC, error return normal return BLOCK: 0, , job number BLOCK+1: function, , value	Execute the specified function of SETUUO for a particular job.
CALLI AC, 114	POKE.	MOVE AC, [3, ,BLOCK] POKE. AC, error return normal return	Alter the specified location in the Monitor. (Refer to Paragraph 3.6.3.3).
CALLI AC, 115	TRMNO.	MOVEI AC, job number TRMNO AC, error return normal return	Return number of the terminal currently controlling the specified job. (Refer to Paragraph 5.10.5).
CALLI AC, 116	TRMOP.	MOVE AC, [XWD N, ADR] TRMOP. AC, error return normal return	Perform miscellaneous terminal functions. (Refer to Paragraph 5.10.7).
CALLI AC, 117	RESDV.	MOVEI AC, channel no. RESDV. AC, or MOVEI AC, UDX error return normal return	Reset the specified channel. (Refer to Paragraph 4.8.2).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 120	UNLOK.	MOVSI AC, 1 or MOVSI AC, 0 HRRI AC, 1 or HRRI AC, 0 UNLOK. AC, error return normal return	Allow a job to unlock itself. (Refer to Paragraph 3.2.2.4).
CALLI AC, 121	DISK.	MOVE AC, [XWD function, ADR] DISK. AC, error return normal return	Set or read a disk or file system parameter (e.g., set the disk priority for a channel or the job). (Refer to Paragraph 6.2.9.14).
CALLI AC, 122	DVRST.**	MOVE AC, [SIXBIT/dev/] or MOVEI AC, channel no. DVRST AC, error return normal return	Restrict the specified device to a privileged job.
CALLI AC, 123	DVURS.**	MOVE AC, [SIXBIT/dev/] or MOVEI AC, channel no. DVURS AC, error return normal return	Remove the restricted status of the specified device.
CALLI AC, 124	XTTSK.		Reserved for XTCSER.
CALLI AC, 125	CAL11.**	MOVE AC, [XWD N, ADR] CAL11. AC, error return normal return	Front-end debug UUO.
CALLI AC, 126	MTAID.**	MOVE AC, [SIXBIT/DEV] or MOVEI AC, channel no. MOVE AC+1, [SIXBIT/REELID/] MTAID. AC, error return normal return	Privileged UUO that associates a visual identification (REELID) with a magtape drive during a mount.
CALLI AC, 127	IONDX.	MOVE AC, channel no. or MOVE AC, [SIXBIT/DEV/] IONDX. AC, error return normal return	Returns universal I/O index for a device. (Refer to 4.12.7).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 130	CNECT.	MOVEI AC, PLIST CNECT. AC, error return normal return	Connect (disconnect) individual devices to (from) an MPX channel. (Refer to Paragraph 4.11.4.1).
CALLI AC, 131	MVHDR.	MOVE AC+1, [new output adr, new input adr] MOVEI AC, channel number MVHDR. AC, error return normal return	Move a buffer ring header between core locations. (Refer to Paragraph 4.12.9).
CALLI AC, 132	ERLST.	MOVEI AC, block ERLST. AC, error return normal return	Provides user with a list of non-operational devices connected to an MPX channel. (Refer to Paragraph 4.11.4.2).
CALLI AC, 133	SENSE.	MOVE AC, [XWD length, adr] SENSE. AC, error return normal return	Provide information necessary for error diagnosis and recovery for a specific device (refer to Paragraph 4.12.10).
CALLI AC, 134	CLRST.	MOVE AC, [XWD length, block] CLRST. AC, error return normal return	Allow device to continue after a device error condition (refer to Paragraph 4.12.8).
CALLI AC, 135	PIINI.	MOVE AC, base-address PIINI. AC, error return normal return	Initializes the software interrupt system. (Refer to Paragraph 3.1.3.6).
CALLI AC, 136	PISYS.	MOVE AC, [flags, , e] PISYS. AC, error return normal return	Controls the software interrupt system. (Refer to Paragraph 3.1.3.7).
CALLI AC, 137	DEBRK.	DEBRK. error return	Dismisses an interrupt. (Refer to Paragraph 3.1.3.8).
CALLI AC, 140	PISAV.	MOVE AC, [size, , addr] PISAV. AC, error return normal return	Saves the state of the interrupt system. (Refer to Paragraph 3.1.3.9).

Table 2-2 (Cont)
CALL and CALLI Monitor Operations

CALLI	CALLI* Mnemonic	CALL	Function
CALLI AC, 141	PIRST.	MOVEI AC, addr PIRST. AC, error return normal return	Restores the state of the interrupt system. (Refer to Paragraph 3.1.3.10).
CALLI AC, 142	IPCFR.	MOVE AC, [XWD n, LOC] IPCFR. AC, error return normal return	Receives an IPCF packet. (Refer to Paragraph 7.1.7).
CALLI AC, 143	IPCFS.	MOVE AC, [XWD n, LOC] IPCFS. AC, error return normal return	Sends an IPCF packet. (Refer to Paragraph 7.1.6).
CALLI AC, 144	IPCFQ.	MOVE AC, [XWD n, LOC] IPCFQ. AC, error return normal return	Obtains information about an IPCF input queue. (Refer to Paragraph 7.1.8).
CALLI AC, 145	PAGE.	MOVE AC, [XWD function, LOC] PAGE. AC, error return normal return	Manipulate pages and the data associated with these pages. (Refer to Paragraph 3.2.6).
CALLI AC, 146	SUSET.**	MOVE AC, [XWD n, LOC] SUSET. AC, error return normal return	Set next I/O block number.
CALLI AC, 147	COMPT.		Reserved.
CALLI AC, 150	TYPST.	TYPST. AC, error return normal return	Special functions for TYPESET devices.

*The CALLI mnemonics are defined in a separate MACRO assembler table, which is scanned whenever an undefined OP CODE is found. If the symbol is found in the CALLI table, it is defined as though it had appeared in an appropriate OPDEF statement, that is

```
          RETURN: EXIT
```

If EXIT is undefined, it will be assembled as though the program contained the statement

```
          OPDEF EXIT [CALLI 12]
```

This facility is available in MACRO V.43 and later.

**This CALLI is a system-privileged UUO available only to users logged in under [1, 2] or to programs running with the JACCT bit set. Complete documentation for system-privileged UUOs appears in UUOPRV, a part of the Specifications section of the DECsystem-10 Software Notebooks.

***All CALLI's above CALLI 55 do not have a corresponding CALL with a SIXBIT argument. This is to save monitor table space.

The customer is allowed to add his own CALL and CALLI calls to the monitor. A negative CALLI effective address (-2 or less) should be used to specify such customer-added operations.

2.2.2.2 **Suppression of Logical Device Names** – Some system programs, e.g., LOGOUT, require I/O to specific physical devices regardless of the logical name assignments. Therefore, for any CALLI, if bit 19 (UU.PHS) in the effective address of the CALLI is not equal to bit 18, only physical names will be used; logical device assignments will be ignored. This suppression of logical device names is helpful, for example, when using the results of the DEVNAM UUO where the physical name corresponding to a logical name is returned.

2.2.2.3 **Restriction on Monitor UUOs in Reentrant User Programs** – A number of restrictions on UUOs that involve a high segment prevent naive or malicious users from interfering with other users while sharing segments and minimize monitor overhead in handling two-segment programs. The basic rules are as follows:

1. All UUOs can be executed from the low or high segment although some of their arguments cannot be in or refer to the high segment.
2. No buffers, buffer headers, or dump-mode command lists may exist in the high segment for reading from or writing to any I/O device.
3. No I/O is processed into or out of the high segment except via the SAVE and SSAVE commands.
4. As a convenience in writing user programs, the monitor makes a special check so that the INIT UUO can be executed from the high segment, although the calling sequence is in the high segment. The monitor also allows the effective address of the CALL UUO, which contains the SIXBIT monitor function name, and the effective address of the OPEN UUO, which contains the status bits, device name, and buffer header addresses, in the high segment. The address of TTCALL 1, and TTCALL 3, may be in the high segment for convenience in typing messages.

2.2.3 Operation Codes 100-127 (Unimplemented Op Codes)

Op code 100 (UJEN)	Dismiss real-time interrupt from user mode (refer to Paragraph 3.8.4).
Op codes 101-107 114-117 123	Monitor prints ?ILL. INST. AT USER n and stops the job.
Op codes 110-113 120-122 124-127	These op codes are valid on the KI10. If used on the KA10, the monitor prints ?KI10 ONLY INST. AT USER n and stops the job.

2.2.4 Illegal Operation Codes

The eight I/O instructions (e.g., DATAI) and JRST instructions with bit 9 or 10 = 1 (e.g., HALT, JEN) are interpreted by the monitor as illegal instructions (refer to the System Reference Manual in the Software Notebooks). The job is stopped and a question mark is printed immediately. A carriage-return/line-feed is then output, followed by an error message. For example, a DATAI instruction would produce the following:

```
?
? ILL INST AT USER addr
```

2.2.5 Naming Conventions for Monitor Symbols

The names of the monitor's data base symbols contain dots or percent signs so that they can be made user-mode symbols without conflicting with previously-coded user programs. Data symbols can be divided into five classes:

1. numbers
2. masks
3. UUO names
4. GETTAB arguments
5. error codes

Symbols defining numbers begin with a dot, followed by a two-letter prefix indicating the type of number, and end with a three-character abbreviation representing the specific number. Numbers are 18-bit quantities and include core addresses and function codes. The following are examples of names of various numbers:

.JBxxx	Job Data Area
.GTxxx	GETTAB table numbers
.RBxxx	Extended arguments for LOOKUP, ENTER, RENAME

Names for masks start with a two-letter prefix indicating the individual word, followed by a dot, and end with three characters representing the specific mask. Masks are 36-bit quantities and include bits and fields. The following are examples of names of masks:

JP.xxx	Privilege word bits
JW.xxx	WATCH word bits
PC.xxx	PC word bits

Names for UUOs implemented after the 5.03 release of the monitor are five or less characters followed by a dot. For example,

PATH.	UUO to modify directory path.
TRMOP.	UUO to perform terminal functions.

Individual words within a GETTAB table start with a percent sign, followed by two characters representing the generic name of the table, and end with three characters identifying the specific word. For example,

%NSCMX	CORMAX word in the nonswapping data table.
%CNSTS	States word in the configuration table.

Names of bytes and bits within a GETTAB word begin with two characters representing the word, followed by a percent sign, and end with three characters designating the specific byte.

ST%DSK	Byte representing disk system; contained in the states word.
ST%SWP	Byte indicating swapping system; contained in the states word.

Error codes returned on a UUO error have names with the following pattern: two characters indicating the UUO, three characters designating the failure type, and a terminating percent sign.

DMILF%	DAEMON error; illegal function.
RTDIU%	RTTRP error; device in use.
LKNLPL%	LOCK error; no locking privileges.

Many of the values useful in user programming are encoded in the parameter file C.MAC for the convenience of writing and modifying programs.

CHAPTER 3
NON I/O UUOS

3.1 EXECUTION CONTROL

3.1.1 Starting

A user program may start another program only by using the RUN or GETSEG UUOs (refer to Paragraphs 3.3.1 and 3.3.2). A user at a terminal may start a program with the monitor commands R, RUN, START, CSTART, CONT, CCONT, DDT, and REENTER (refer to DECsystem-10 Operating System Commands). The starting address of the program either appears as an argument of the command or is stored in the user's job data area (refer to Chapter 1).

3.1.1.1 **SETDDT AC, or CALLI AC, 2** – This UUO causes the contents of the AC to replace the DDT starting address, which is stored in the protected job data area location .JBDDT. The starting address is used by the monitor command DDT.

3.1.2 Stopping

Any of the following procedures can stop a running program:

1. One Control-C from the user's terminal if the user program is in a TTY input wait; otherwise, two Control-C's (↑C↑C) from the user's terminal (refer to DECsystem-10 Operating System Commands);
2. A monitor detected error;
3. Program execution of HALT, EXIT AC, or LOGOUT AC, (CALLIs 12 and 17, respectively).

3.1.2.1 **Illegal Instructions (700-777, JRST 10, JRST 14) and Unimplemented OP Codes (101-127)** – Illegal instructions trap to the monitor, stop the job, and print:

```
?ILL INST. AT USER  adr  or  ?KI ONLY INST. AT USER adr
```

Refer to Paragraph 2.2.3 for an explanation of op codes 101-127. Note that the program cannot be continued by typing the CONT or CCONT commands.

3.1.2.2 **HALT or JRST 4** – The HALT instruction is an exception to the illegal instructions; it traps to the monitor, stops the job, and prints:

```
?HALT AT USER adr
```

where adr is the location of the HALT instruction. If the HALT instruction is in location 41 and the program executed a user UUO (operation codes 001-037), the address in the error message is that of the user UUO instead of address 41.

However, the CONT and CCONT commands are still valid and, if typed, will continue the program at the effective address of the HALT instruction. After a user program HALT instruction followed by a START, DDT, CSTART, or REENTER command, .JBOPC contains the address of the HALT. To proceed at the address specified by the effective address, it is necessary for the user or his program to recompute the effective address of the HALT instruction and to use this address to start (refer to .JBOPC description, Table 1-1 in Paragraph 1.2.1). HALT is not the instruction used to terminate a program (refer to Paragraph 3.1.2.3). HALT is useful for indicating impossible error conditions.

3.1.2.3 **EXIT AC, or CALLI AC, 12** – When the value of AC is zero, all I/O devices (including real-time devices) are RELEASed (refer to Paragraph 4.8.1); the job is unlocked from core; the user mode write protect bit (UWP) for the high segment is set; the APR traps are reset to 0; the PC flags are cleared; and the job is stopped. If timesharing was stopped (refer to Paragraph 3.8.3), it is resumed. In other words, after releasing all I/O devices that close out all files, a RESET is done (refer to Paragraph 4.1.2). The carriage-return/line-feed is performed, and

```
EXIT
```

is printed on the user's terminal, which is left in monitor mode. The CONT and CCONT commands cannot continue the program.

When the value of AC is nonzero, the job is stopped, but devices are not RELEASed and a RESET is not done. Instead of printing EXIT, only a carriage-return and line-feed is performed, and a period is printed on the user's terminal. The CONT and CCONT commands may be used to continue the program. In other words, this form of EXIT does not affect the state of the job except to stop it and return the terminal to monitor mode. Programs using EXIT 1, (MONRT.) as a substitute for EXIT (to eliminate the typing of EXIT) should RELEASE all devices first.

3.1.3 Program Trapping, Interception, and Interruption

Execution of a program is normally performed in a sequential manner, whereby one instruction is executed followed immediately by the next and so on. By using skip and branch instructions, it is possible to deviate from the normal sequential method of execution. Deviation from normal program flow may also be accomplished by trapping to user trap-servicing routines (APRENB UUO), enabling for error interception (utilizing .JBINT), or using the software interrupt system. User-trap servicing routines and error interception are simple methods of controlling error conditions while the software interrupt system provides a much more general and powerful facility.

Two important reasons for wanting a program to deviate from simple sequential operation are as follows:

1. Responding to special conditions without having to test for them wherever they might arise. For instance, it is possible to test for an arithmetic overflow condition after every instruction which might cause the condition. However, it is frequently easier to request that the system interrupt normal sequential operation whenever an overflow takes place and transfer control to an error routine. With this approach, there is no need to insert a special test after every arithmetic instruction. This reduces program size and execution time as well as being a less error-prone way to write a program.

2. Responding to asynchronous events without having to test for them repeatedly. For example, some programs need to take special action when the user types a CONTROL-C, rather than permit control to return immediately to monitor level. It would be an unreasonable constraint on program design if the program had to test with high frequency for the user typing a CONTROL-C. It is much more efficient for the system to interrupt normal sequential operation when a CONTROL-C is typed and to transfer control to a special processing routine than for the program to have to test for the event repeatedly.

APR trapping allows a user to handle traps that occur while his job is running, including illegal memory references, non-existent memory references, push-down list overflows, arithmetic overflows, floating-point overflows, and line frequency clock pulses. Error interception may be used when certain conditions occur in the program. The monitor will intercept, when the condition occurs, and examine location .JBINT in the job data area. It does this to find out whether an error interception routine has been provided. In addition, the TOPS10 Monitor provides a generalized software interrupt mechanism for interrupting sequential operation under a wide variety of special conditions.

3.1.3.1 **APRENB AC, or CALLI AC, 16** – To enable for trapping, an APRENB AC, or CALLI AC, 16 is executed, where the AC contains the central processor flags to be tested on interrupts, as defined below:

Name	AC	Bit	Trap On
AP.REN	18	400000	Repetitive enable
AP.POV	19	200000	Pushdown overflow
AP.ILM	22	20000	Memory protection violation
AP.NXM	23	10000	Nonexistent memory flag
AP. PAR	24	4000	Parity error
AP.CLK	26	1000	Clock flag
AP.FOV	29	100	Floating-point overflow
AP.AOV	32	10	Arithmetic overflow

When one of the specified conditions occurs while the central processor is in user mode, the state of the central processor is conditioned into (CONI) location .JBCNI, and the PC is stored in location .JBTPC in the job data area (refer to Table 1-1 in Paragraph 1.2.1). Then control is transferred to the user trap-answering routine specified by the contents of the right half of .JBAPR, after the arithmetic and floating-point overflow flags are cleared. (However, the job is stopped if the PC is equal to the first or second instruction in the user's trap routine.) The user program must set up location .JBAPR before executing the APRENB UUO. To return control to his interrupted program, the user's trap-answering routine must execute a JRSTF @ .JBTPC which clears the bits that have been processed and restores the state of the processor.

The APRENB UUO normally enables traps for only one occurrence of any selected condition and must be reissued after each condition of a trap. To disable this feature, set bit 18 to a 1 when executing the UUO. However, even with bit 18 = 1, clock interrupts must be re-enabled after each trap.

If the user program does not enable traps, the monitor sets the PDP-10 processor to ignore arithmetic and floating-point overflow, but enables interrupts for the other error conditions in the list above. If the user program produces such an error condition, the monitor stops the user job and prints one of the following appropriate messages:

```
?PC OUT OF BOUNDS AT USER PC addr
?ILL MEM REF AT USER PC addr
?NON-EX MEM AT USER PC addr
?PDL OV AT USER PC addr
?MEM PAR ERROR AT USER PC addr
```

The CONT and CCONT commands will not succeed after such an error.

3.1.3.2 **Error Intercepting** – When certain conditions occur in the program, the monitor intercepts the condition and examines location .JBINT in the job data area. Depending on the contents of this location, control is either retained by the user program or is given to the monitor for action. If this location is zero, the job is stopped and the user and possibly the operator are notified by appropriate messages, if any. If location .JBINT is non-zero, the contents is interpreted as the address of a block with the following format:

LOC:	XWD N, INTLOC
LOC+1:	XWD BITS, CLASS
LOC+2:	0
LOC+3:	0

where N is the number of words in the block ($N > 3$).

INTLOC is the location at which the program is to be restarted.

BITS is a set of bits interpreted as follows:

If bit 0 = 1, an error message, if any, is not to be typed on the user's terminal or, in some cases, the operator's terminal.

If bit 0 = 0, an error message, if any, will be typed on the user's terminal and possibly the operator's terminal.

CLASS is a set of bits interpreted as follows:

For each type of error, CLASS has a specific bit. For a given error, the job will be interrupted if the appropriate bit is 1 and LOC+2 contains zero. The job will be stopped if either the appropriate bit is 0 or the appropriate bit is 1 and the contents of LOC+2 is not zero. By requiring LOC+2 to be zero, the possibility of a loop occurring is prevented.

The monitor examines the CLASS bits and the contents of LOC+2 to determine if the job is to be stopped or interrupted on the particular error. If the job is interrupted, the following information is then stored in LOC+2 and LOC+3:

LOC+2	The last user PC word
LOC+3	RH = the channel number
	LH = the error bit as defined in CLASS (see below)

The job is then restarted at location INTLOC.

The CLASS bits are defined as follows:

Device Errors

Bit 35(1) (ER.IDV) represents device errors that can be corrected by human intervention. The appropriate message returned to the user is

```
DEVICE xxx OPR zz ACTION REQUESTED
```

where xxx is the device name, and zz is the number of the station at which the operator is located. The operator receives the message

```
%PROBLEM ON DEVICE xxx FOR JOB n
```

where xxx is the device name, and n is the number of the job that is stopped. When the operator has corrected the error, he starts the job with the JCONT command and the message

```
CONT BY OPER
```

appears on the user's terminal to signify that the error has been corrected.

↑C Intercept

Bit 34(1) (ER.ICC) indicates a ↑C intercept. This intercept allows the user's program to process a ↑C itself instead of allowing the job to automatically return to monitor level. If this bit is a 1, the job does not return to monitor level on two ↑Cs (or on one ↑C if the job is in TTY input wait), but instead traps to the user's interrupt routine. There are no messages associated with this bit. When enabled for ↑C, the program should normally exit immediately by releasing any special resources and issuing an EXIT UUO (MONRT. or CALLI 1, 12) . . If the user types .CONT, the job continues. .

(1) This bit depends on FTOPRERR which is normally off in the DECsystem-1040.

(1) This bit depends on FTCCIN which is normally off in the DECsystem-1040.

```
        TITLE    CONCIN -- SAMPLE FOR CONTROL-C INTERCEPT

;THIS ROUTINE SHOWS HOW TO ENABLE FOR A CONTROL-C INTERCEPT
;AND HANDLE IT CORRECTLY.  THE IDEA IS TO GET THE USER TO
;MONITOR LEVEL AS QUICKLY AS POSSIBLE.

        LOC      134                ;SET POINTER IN .JBINT
        EXP      INTBLK             ;TO THE INTERRUPT BLOCK
        RELOC

INTBLK: XWD      4,INTLOC           ;4 WORDS LONG,,PLACE TO START
        XWD      0,2                ;NO MESSAGE CONTROL,,TYPE 2 (^C)
        Z                           ;GETS LAST USER PC
        Z                           ;LH GETS INTERRUPT TYPE

;THE INTERRUPT ROUTINE STARTS HERE

INTLOC: MOVEM    1,TEMP1            ;SAVE AC 1
        HLRZ     1,INTBLK+3         ;GET REASON FOR INTERRUPT
        CAIE     1,2                ;SEE IF CONTROL-C
        HALT     .                  ;ERROR IF NOT
                         ;RELEASE ANY SPECIAL RESOURCES HERE
                         ;BUT BE CAREFUL THAT THIS DOES NOT
                         ;TAKE VERY LONG OR CAUSE A LOOP.
        EXIT     1,                 ;RETURN TO MONITOR
        MOVE     1,INTBLK+2         ;GET RETURN PC
        EXCH     1,TEMP1            ;RESTORE AC
        PUSH     P,INTBLK+2         ;SAVE RETURN ADDRESS
        SETZM    INTBLK+2           ;CLEAR INTERRUPT TO ALLOW ANOTHER ONE
        POPJ     P,                 ;RETURN TO WHERE PROGRAM STOPPED

TEMP1:  Z                           ;TEMPORARY
```

The following example illustrates user ↑C processing by a program which will not let users reach monitor level by means of a ↑C.

```
        LOC      134                ;SET UP .JBINT TO POINT TO
        EXP      INTBLK             ;THE INTERRUPT BLOCK
        RELOC

INTBLK: XWD      3,INTLOC           ;3 WORDS LONG,,PLACE TO START
        XWD      0,2                ;NO MESSAGE CONTROL,,TYPE 2 (^C)
        Z                           ;GETS LAST USER PC
        Z                           ;LH GETS INTERRUPT TYPE

;THE INTERRUPT ROUTINE

INTLOC: SKIPL    RENFLA             ;OK TO FAKE A REENTER?
        JRST     .+3                ;NO, CURRENT ROUTINE CANNOT BE
                                    ;INTERRUPTED.
SETZM   INTBLK+2         ;YES, RE-ENABLE INTERRUPT AND GO
JRST    REENRT           ;TO INTERRUPT ROUTINE

SETOM   RENSWH           ;SET FLAG TO SAY "REENTER AS SOON AS
                         ;YOU CAN"
PUSH    P,INTBLK+2       ;GET LAST PC, PUSH/POP
SETZM   INTBLK+2         ;RE-ENABLE INTERRUPT
POPJ    P,               ;GO BACK TO INTERRUPTED ROUTINE
                         ;NOTE THAT IF A CONTROL-C IS
                         ;TYPED AFTER THE SETZM, THE
                         ;INTERRUPTS NEST.
```

Off-line Disk Unit

Bit 33 (ER. OFL) indicates a disk unit has dropped off-line. The operator is given the message

```
UNIT xxx WENT OFF-LINE (FILE UNSAFE)
PLEASE POWER DOWN AND THEN TURN IT ON AGAIN
```

immediately and then once every minute. The user receives the message

```
DSK IS OFF-LINE.  WAITING FOR OPERATOR
ACTION.  TYPE ^C TO GET A HUNG MESSAGE
(IN 15 SECONDS). DONT TYPE ANYTHING TO WAIT
FOR THE OPERATOR TO FIX THE DEVICE.
```

If the user has a system resource, he receives the additional message:

```
THE SYSTEM WILL DO NO USEFUL WORK UNTIL
THE DRIVE IS FIXED OR YOU TYPE ^C
```

Full File Structure

Bit 32 (ER. FUL) indicates that a file structure has filled up with data (i.e., there are no free blocks). There are no messages associated with this bit.

Exhausted Disk Quota

Bit 31 (ER. QEX) indicates that the user's disk quota has been exhausted. The user receives the message

```
[EXCEEDING QUOTA file structure name]
```

Exceeded Time Limit

Bit 30 (ER. TLX) indicates that the user's run time limit (as set by a previous SET TIME command) has been exceeded. This bit is used only by non-batch jobs. The user receives the message

```
?TIME LIMIT EXCEEDED
```

Error in Job

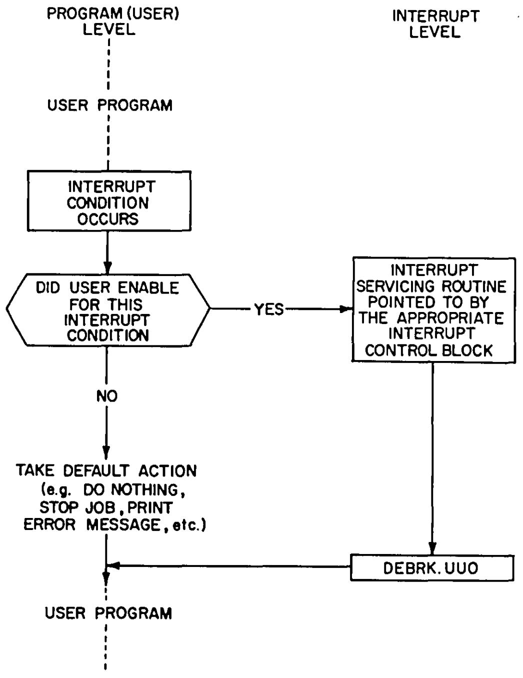
Bit 29 (ER. EIJ) indicates that the user has had a fatal error, such as:

```
?ILLEGAL UUO
?ADDRESS CHECK
?PC OUT OF BOUNDS
```

3.1.3.3 **Software Interrupt System** – The software interrupt system is a generalized mechanism for interrupting sequential execution under a wide variety of special conditions. In order to use the sofware interrupt system, it must first be initialized by the PIINI. UUO. PIINI. will specify the base address of an interrupt vector. Within this vector are one or more four-word interrupt control blocks, which control the operation of the software interrupt system. After initializing the software interrupt system, the system must be turned on. The PISYS. UUO is used to turn the interrupt system.on. This UUO is also used to specify:

- on what conditions the user wishes control to be passed to an interrupt servicing routine.
- the location of the appropriate interrupt control block (this is specified as an offset from the base of the interrupt vector).

When a interrupt condition occurs, the monitor first determines whether this type of condition is to cause a transfer to an interrupt servicing routine. If it is not to cause a transfer of control, the default action for the condition will take place. If a transfer of control is to take place, control is transferred to the location specified in the appropriate interrupt control block. This process can be represented by the following illustration:


PROGRAM (USER) LEVEL
INTERRUPT LEVEL
USER PROGRAM
INTERRUPT CONDITION OCCURS
DID USER ENABLE FOR THIS INTERRUPT CONDITION
YES
INTERRUPT SERVICING ROUTINE POINTED TO BY THE APPROPRIATE INTERRUPT CONTROL BLOCK
NO
TAKE DEFAULT ACTION (e.g. DO NOTHING, STOP JOB, PRINT ERROR MESSAGE, etc.)
DEBRK. UUO
USER PROGRAM

3.1.3.4 **Interrupt Conditions** – The conditions for which interrupts can be requested are divided into two categories:

1. I/O interrupts
2. Non-I/O interrupts.

For any device, the user can specify interrupt processing for one or more of the following I/O conditions that may occur during the execution of a program:

input done
output done
end of file
input error
output error
device off-line
device full
quota exceeded
input/output wait

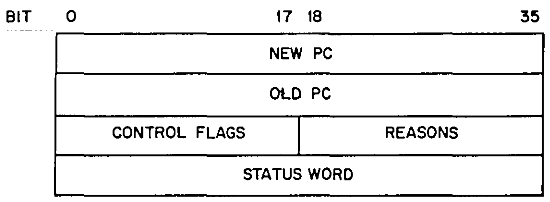
Examples of non-I/O conditions resulting in a possible interrupt are:

time limitation exceeded
execution of a UUO
address check
overflow of push-down list
APR clock
arithmetic overflow
Control-C
occurrence of an undefined UUO
reference to illegal memory location
non-existent memory reference
floating point overflow

3.1.3.5 **Interrupt Control Block** – The interrupt control block is the controller of the software interrupt system; it keeps track of such things as:

- where the program was when an interrupt occurred
- where to find the interrupt servicing routine for processing the current interrupt
- the reason for the interrupt

There may be more than one interrupt condition associated with the same interrupt control block; but the preferred usage is to associate one interrupt condition with one interrupt control block. An interrupt control block can be represented as:



The monitor stores the PC (program counter) at the time of the interrupt in the second word of the interrupt block. If a UUO was executed, the word will contain the address of the UUO + 1 or +2 (i.e., the return point of the UUO). If an attempted UUO was aborted, the address of the UUO will be contained in PC. The location of the routine that is to be used in servicing the interrupt is stored in the first word of the interrupt control block. The control flags, in the left half of the third word, are used to indicate under what circumstances an interrupt is to take place.

The reason for a particular interrupt is indicated by the bits stored in the right half of the same word as the control flags. The status word contains status information pertinent to the type of interrupt detected.

The bit settings that may be set within the flags half-word are:

Bit	Mnemonic	Meaning
0		Reserved to DEC.
1	PS.VPO	Disable all interrupts until re-enabled by a PISYS. UUO.
2	PS.VTO	Disable all interrupts until a DEBRK. UUO is executed.
3	PS.VAI	Allow additional interrupts to be received by this interrupt block. Normally, no other interrupts for the current block are permitted until a DEBRK. UUO is executed. The use of this bit is not recommended since an interrupt servicing routine could be interrupted resulting in lost information.
4	PS.VDS	Dismiss any additional interrupt requests for this control block that are received while an interrupt is in progress. This is useful if the interrupt service routine wants to perform functions that would cause another interrupt. For example, a service routine for all UUO's may want to do UUO's.
5	PS.VPM	Print the standard message (if any) relevant to this interrupt condition.
6	PS.VIP	This bit indicates that an interrupt is in progress for this block. The user should clear this bit at the start of the program. It is set and cleared by the monitor as interrupts are processed and should not be altered by the user.

The fourth word in the four-word interrupt block contains status information relating to the type of interrupt condition detected. For instance, a device-related interrupt will cause this word to contain the UDX in its left half, and a GETSTS value in its right half. For an interrupt on KSYS warning, the word contains the number of minutes until KSYS (i.e., number of minutes until time-sharing ends).

The new PC word and flags half-word are preset by the user. The old PC word, reasons half-word, and status word are set by the monitor.

After an interrupt request is granted, the program operates at interrupt level until the user issues a DEBRK. UUO. DEBRK. will dismiss the interrupt, reenable the interrupt control block (if it was disabled) and cause any pending interrupt requests to be granted. If there are no pending interrupts, the user job is restarted as if no interrupt had occurred.

The act of granting an interrupt request does not change any of the conditions which caused the interrupt. If the user issues a DEBRK. UUO without doing anything else, the result will be the same as if the interrupt condition was not enabled. The monitor does not clear any reason bits on DEBRK. UUO's; the user must clear these himself.

EXCEPTION: If the interrupt occurs while the machine was executing a UUO for the user, that UUO is aborted. The only conditions which can cause interrupts during the processing of UUO's are error conditions in the UUO. All other conditions are deferred until the UUO exit.

3.1.3.6 **PIINI. AC, or CALLI. AC, 135** – The PIINI. UUO initializes the software interrupt system, specifying the base address of the interrupt vector block. This interrupt vector block will contain one or more four-word interrupt control blocks. The format of the UUO is:

```
MOVE AC, base-address
PIINI. AC,                          ;or CALLI AC, 135
error return
normal return
```

PIINI. will perform the following functions:

- turn off the software priority interrupt system.
- unlink any devices that have enabled interrupt conditions associated with them.
- store the base address of the interrupt vector block.

3.1.3.7 **PISYS. AC, or CALLI AC, 136** – PISYS. is the primary means by which the user can control the interrupt system. It accepts a three word interrupt argument block specifying the type of event the user wishes to service with an interrupt servicing routine and the offset from the interrupt vector base address that points to the appropriate interrupt control block. The format of PISYS. is:

```
MOVE AC, [flags,,e]
PISYS. AC,                          ;or CALLI AC, 136
error return
normal return
```

where: the flags which may be set with this call are:

Bit	Mnemonic	Meaning
1	PS.FOF	Turn the interrupt system off.
2	PS.FON	Turn the interrupt system on.
3	PS.FCP	Clear all pending interrupts.
4	PS.FCS	Clear all pending interrupts for a specified device.
5	PS.FRC	Remove the specified device or condition.
6	PS.FAC	Add the specified device or condition.

e points to a block that contains information pertaining to the interrupt condition the user wishes to service.

This block can be represented as:

0 17	18 35
DEVICE/CONDITION TO USE	
VECTOR OFFSET	ENABLED REASONS
PRIORITY LEVEL	RESERVED

This first word of the interrupt argument block specifies the device or the condition to be associated with the interrupt, and is one of the following:

- SIXBIT /device-name/
- channel-number
- UDX
- negative integer

The negative integer is used when desiring to specify a non-I/O condition as the enabled interrupt condition. Certain non-I/O interrupts will cause information to be stored in the status word of the interrupt control block; the possible non-I/O conditions, their codes, and the information (if any) that will be stored in the status word are:

Code	Mnemonic	Meaning	Status Word
-1	.PCTLE	Time limit exceeded. This interrupt cannot be specified for BATCH jobs.	Run time in milliseconds for this job.
-2	.PCABT	Not yet implemented.	
-3	.PCSTP	Control-C	1B0 = 1 if terminal in input-wait status; otherwise word = 0.
-4	.PCUUO	Any UUO was executed.	UUO
-5	.PCIUU	Illegal UUO was executed.	0
-6	.PCIMR	Illegal memory referenced.	0
-7	.PCACK	Address Check.	device name
-10	.PCARI	Arithmetic exception.	0
-11	.PCPDL	Push down list overflow.	0
-12	.PCTT3	Not yet implemented.	
-13	.PCNXM	Non-existent memory referenced.	0
-14	.PCAPC	Line frequency clock tick.	universal date/time word
-15	.PCUEJ	User-induced fatal error.	0
-16	.PCXEJ	External condition results in fatal error.	0

Code	Mnemonic	Meaning	Status Word
-17	.PCKSY	KSYS warning.	minutes to KSYS
-20	.PCDSC	Dataset status has been changed.	new status
-21	.PCDAT	ATTACH/DETACH was executed.	-1 (if detach) or TTY UDX (if attach)
-22	.PCWAK	WAKE UUO was executed.	job number of waker
-23	.PCABK	Address break.	0
-24	.PCIPC	IPCF has received a packet.	length (RH) and flags (LH) associated with first message in the queue.

The vector offset is the address of the four-word interrupt control block to be associated with this interrupt condition. The address is given as an offset from the base address specified in the PIINI. UUO. Since the interrupt control blocks are each four words in length, the offset is always given in multiples of four words. The same four-word interrupt block may be associated with several interrupt conditions, but a one-to-one correspondence is preferred.

If within PISYS., e specifies a device within its first word, the enabled reasons half-word specifies the type of interrupt the user is interested in. The bit assignments, which may be set, are:

Mnemonic	Bit	Meaning
PS.RID	19	Input done.
PS.ROD	20	Output done.
PS.REF	21	End-of-file.
PS.RIE	22	Input error.
PS.ROE	23	Output error.
PS.RDO	24	Device off-line.
PS.RDF	25	Device full.
PS.RQE	26	Quota exceeded.
PS.RWT	27	Input/Output wait.

The bit corresponding to the reason for the interrupts will be ORed in the reason field of the four word interrupt control block also.

The possible error codes which might result from this call are:

Error Code	Mnemonic	Meaning
0	PSTMA%	The right half of the AC is non-zero; no bits in the left half require an argument block.
1	PSNFS%	The left half of the AC does not have any function bits set.
2	PSUKF%	The left half of the AC contains function bits which have been set that have no defined meaning.

Error Code	Mnemonic	Meaning
3	PSOOF%	In the left half of the AC the bits to turn the system on and to turn the system off have both been set.
4	PSUKC%	The contents of e do not specify a valid device or condition.
5	PSDNO%	The device specified by the contents of e has not been INITed for this job.
6	PSPRV%	A restricted condition (illegal) has been specified.
7	PSIVO%	The vector table offset is too large or, not a multiple of four words. A GETTAB table (table number 11, Item 76) provides the maximum value that the vector offset may assume.
10	PSUKR%	An invalid bit was set in E+2.
11	PSPTL%	The priority level specified is too large. The maximum priority level which may be assumed is specified within GETTAB table number 11, Item 77. (It is 0 for the 6.01 release.)
12	PSNRW%	The reserved half-word (the right half of word three) is non-zero.
13	PSPND%	A PIINI. UUO has not been executed.
14	PSARF%	Both of the "add the device" and "remove the device" bits have been set.

3.1.3.8 **DEBRK. or CALLI AC, 137** – The DEBRK. UUO is used to dismiss a software interrupt, reenabling anything which may have been disabled by the occurrence of the interrupt. The DEBRK. UUO will scan the pending interrupt queue, looking for any conditions which may require servicing by an interrupt servicing routine. If such a condition does exist, the newly found interrupt request will be granted and a transfer will be made to the interrupt servicing routine. If there are no pending interrupts, DEBRK. will restart the interrupt process beginning at the point within the user program where the program was originally interrupted (e.g., the instruction after the last instruction executed).

The format of the DEBRK. UUO is:

```
DEBRK.                                ;or CALLI AC,137
error return
```

The normal return taken by DEBRK., if no interrupts are pending, is old PC in the interrupt control block. The skip return is used if the software interrupt system has not been initialized. The error return is only taken when DEBRK. has not been implemented.

3.1.3.9 **PISAV. AC, or CALLI AC, 140** – The PISAV. UUO returns the entire monitor data base related to the software interrupt facility. This UUO can be used by modules such as QMANGR to save and reload (via PIRST.) the complete interrupt system. It can also be used to provide detailed error messages.

The format of the PISAV. UUO is:

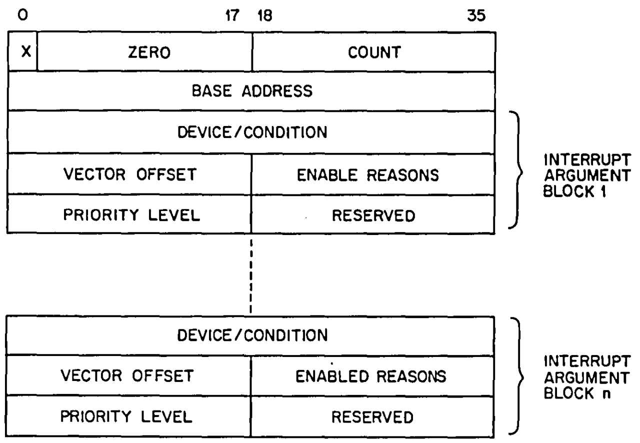
```
MOVE AC, [size,,addr]
PISAV. AC,                          ;or CALLI AC, 140
error return
normal return
```

The state of the interrupt system is not altered by the execution of this UUO.

Size is the length (in words) of the block pointed to by addr. The size of this block can be determined by:

(3 * argblocks) + 2 = size in words

addr points to a block which can be represented as:



where: x can be 1 or 0; 1 indicates that the software interrupt system is turned on, 0 indicates that it is turned off.

count is the number of words the monitor actually returned with the saved status block.

base address is the base address of the interrupt vector block which contains one or more 4-word interrupt control blocks.

Words 2 through n contain one or more interrupt argument blocks. These interrupt argument blocks are those the user has set up through use of the PISYS. UUO.

The possible error return resulting from the PISAV. UUO is:

Code	Mnemonic	Meaning
0	PSBTS%	The block is too small to hold the data. The right half of the first word contains the count of the number of words which would have been returned, if the block had been large enough.

3.1.3.10 PIRST. AC, or CALLI AC, 141 – The PIRST. UUO reloads the saved state of the interrupt system. It does not, however, remember pending instructions. If a condition is still existent within the interrupt block (i.e., has not been cleared), the interrupt will be granted. The PIRST. UUO should not be used to load the interrupt system at program initialization time, this function is performed by the PIINI. UUO.

The format of the PIRST. UUO is:

```
MOVEI AC,addr
PIRST. AC,                          ;or CALLI AC, 141
error return
normal return
```

where: addr is the address of the saved status block which was specified in the PISAV. UUO.

There is one possible error code which may be returned:

Error Code	Mnemonic	Meaning
0	PSNRS%	The user has modified his program prohibiting the PIRST. UUO from performing its specified task.

3.1.3.11 Software Interrupt Example –

```
TITLE PISAMP -- SAMPLE PROGRAM TO SHOW PSISER USE WITH NON-BLOCKING I/O


;THIS PROGRAM WRITES A FILE CONTAINING THE NUMBERS FROM 1 TO 100,000
; WHILE DOING A COMPUTE BOUND BACKGROUND COMPUTATION.  SINCE THE PROGRAM
; NEVER BLOCKS FOR I/O IT CAN USE 100% OF THE AVAILABLE CPU TIME. BY USING
; THE PI SYSTEM IT CAN DRIVE THE DISK AT FULL SPEED.

;AC USEAGE
        T1=1                ;TEMPORARY
        N=2                 ;NUMBER TO WRITE ON THE DISK

;I/O CHANS.
        DSK=1               ;THE DISK FILE

        SEARCH  C           ;SYMBOL DEFS.


;INITIALIZATION
START:  RESET                           ;RESET THE WORLD
        MOVEI   T1,VECTOR               ;BASE OF INTERRUPT VECTOR
        PIINI.  T1,                     ;INIT PI SYSTEM
          HALT  .                       ;NOT INPLEMENTED
        OPEN    DSK,[UU.AIO+.IOBIN;OPEN DISK FOR ASYNCHRONOUS BINARY OUTPUT
                    SIXBIT /DSK/
                    OB,,0]
          HALT  .                       ;DISK NOT AVAILABLE
        ENTER   DSK,[SIXBIT "SAMPLE" ;ENTER THE OUTPUT FILE
                    SIXBIT "BIN" ; ON THE DISK
                    EXP 0,0]     ; ..
          HALT  .                       ;CAN'T WRITE
          MOVE     T1,[PS.FAC+[ EXP DSK
                        4,,PS.ROD     ;OFFSET,,OUTPUT DONE
                        0]]           ;PRIORITY,,RESERVED
          PISYS.   T1,                ;CALL MONITOR TO TURN ON SYSTEM AND
                                      ; ENABLE FOR OUTPUT DONE ON CHAN DSK
            HALT   .                  ;PISYS. UUO FAILED
          MOVEI    N,0                ;PRESET N



;HERE ON AN OUTPUT DONE INTERRUPT OR AT THE START OF THE PROGRAM

OUTDON:  SOSGE    BYTECT              ;ROOM IN THIS BUFFER?
         JRST     DUMPBF              ;NO--GO OUTPUT BUFFER
         IDPB     N,BYTEPT            ;STORE IN BUFFER
         CAME     N,[^D100000]        ;DONE?
         AOJA     N,OUTDON            ;NO--WRITE NEXT NUMBER
         CLOSE    1,
         EXIT                         ;ALL DONE

DUMPBF:  OUT      1,                  ;WRITE OUT THE BUFFER
           JRST   OUTDON              ;NO ERRORS AND MORE BUFFERS
         STATZ    1,IO.ERR            ;ANY ERRORS?
           HALT   .                   ;FATAL I/O ERROR
;AT THIS POINT WE FILLED ALL AVAILABLE BUFFERS AN WANT TO GO BACK TO THE
; BACKGROUND TASK.
         DEBRK.                       ;DISMISS THE INTERRUPT
           HALT   .                   ;CAN NEVER GET HERE
;IF WE GET HERE THERE WAS NO INTERRUPT IN PROGRESS.  THAT MEANS WE WERE
; CALLED BY INITIALIZATION AND NOW MUST START THE BACKGROUND TASK.
         MOVSI    T1,(PS.FON)         ;TURN ON THE PI SYSTEM SO WE CAN GET TRAPS
         PISYS.   T1,                 ; OUT OF THE BACKGROUND TASK.
           HALT   .                   ;CAN'T TURN ON SYSTEM
         MOVEI    T1,0
         AOJA     T1,.                ;SUPER SIMPLE BACKGROUND TASK


;BUFFER RING HEADER
OB:      BLOCK    1
BYTEPT:  BLOCK    1                   ;BYTE POINTER
BYTECT:  BLOCK    1                   ;BYTE COUNT

;INTERRUPT VECTOR
VECTOR:  BLOCK    4                   ;FIRST SLOT IS UNUSED
         EXP      OUTDON              ;NEW PC
         EXP      0                   ;OLD PC STORED HERE
         EXP      0                   ;FLAGS
         EXP      0                   ;STATUS

         END      START
```

3.1.4 Suspending

3.1.4.1 SLEEP AC, or CALLI AC, 31 – This UUO temporarily stops the job and continues it automatically after the elapsed real-time (in seconds) indicated by the contents of the AC. There is an explicit maximum of approximately 68 sec (82 sec in 50-Hz countries). A program that requires a longer SLEEP or HIBER time should call DAEMON, via the clock function, then use HIBER with no clock request.

3.1.4.2 HIBER AC, or CALLI AC, 72(2) – The HIBERNATE UUO allows a job to become dormant until a specified event occurs. The possible events that can wake a hibernating job are:

1. input activity from the user's TTY or any TTY INITed by this job (both line mode and character mode),
2. PTY activity for any PTY currently INITed by this job,
3. the time-out of a specified amount of sleep time, or
4. the issuance of a WAKE UUO directed at this job either by some other job with wake-up rights or by this job at interrupt level.

The HIBERNATE UUO must contain in the left half of AC the wake-condition enable bits and in the right half the number of ms for which the job is to sleep before it is awakened.

The call is as follows:

```
MOVSI AC, enable bits                   ;set HIBERNATE conditions
HRRI AC, sleep time                     ;number of ms to sleep
HIBER AC,                               ;or CALLI AC, 72
error return
normal return
```

The HIBERNATE UUO enable condition codes are as follows:

Bits	Meaning
18–35	Number of ms sleep time. It is rounded up to an even multiple of jiffies (maximum being 68 seconds). Zero means no clock request (i.e., infinite sleep).
15–17	WAKE UUO protection code: Bit 17 (HB.RWT) = 1, project codes must match. Bit 16 (HB.RWP) = 1, programmer codes must match. Bit 15 (HB.RWJ) = 1, only this job can wake itself.
13–14	Wake on TTY input activity: Bit 14 (HB.RTC) = 1, wake on character ready. Bit 13 (HB.RTL) = 1, wake on line of input ready.
12	(HB.RPT) Wake on PTY activity since last HIBERNATE.
10	(HB.IPC) IPCF
0	(HB.SWP) Causes job to be swapped out immediately.

(2) This UUO depends on FTHIBWAK which is normally off in the DECsystem-1040.

An error return is given if the UUO is not implemented. The SLEEP UUO should be used in this case. A normal return is given after an enabled condition occurs.

In order to insure that a job does not sleep for too long, missing an event, the wakeup bit is set by the monitor even if the event occurs while the job is not sleeping. When the job issues another HIBER UUO, the bit will be cleared and the HIBER will return immediately to the user. Specifically, a job issuing a HIBER UUO must test all events that may have caused it to wake up, however, the job cannot be assured that any one of the events actually took place.

Jobs either logged-in as [1,2] or running with the JACCT bit on can wake any hibernating job regardless of the protection code. This allows privileged programs, which are the only jobs that can wake certain system jobs, to be written.

A RESET UUO always clears the protection code and wake-enable bits for the job. Therefore, until the first HIBERNATE UUO is called, there is no protection against wake-up commands from other jobs. To guarantee that no other job wakes the job, a WAKE UUO followed by a HIBERNATE UUO with the desired protection code should be executed. The WAKE UUO ensures that the first HIBERNATE UUO always returns immediately, leaving the job with the correct protection code.

3.1.4.3 WAKE AC, or CALLI AC, 73(1) – The WAKE UUO allows one job to activate a dormant job when some event occurs. This feature can be used with Batch so that when a job wants a core dump taken, it can wake up a dump program. Also, real-time process control jobs can cause other process control jobs to run in response to a specific alarm condition. The WAKE UUO can be called for a RTTRP job running at interrupt level, thereby allowing a real-time job to wake its background portion quickly in order to respond to some real-time condition. (Refer to Paragraph 3.8.1.2 for the restrictions on accumulators when using the RTTRP UUO at interrupt level.)

The call is as follows:

```
MOVE AC, job-number            ;number of job to be awakened
WAKE AC,                       ;or CALLI AC, 73
error return
normal return
```

Job number is -1 if referring to the current job.

An error return is given if the proper wake privileges are not specified. There is a wake bit associated with each job. If any of the enabled conditions specified in the last HIBERNATE UUO occurs, then the wake bit is set. The next time a HIBERNATE UUO is executed, the wake bit is cleared and the HIBERNATE UUO returns immediately. The wake bit eliminates the problem of a job going to sleep and missing any wake conditions.

On a normal return, the job has been awakened and has started at the location of the normal return of the HIBER UUO that caused it to become dormant.

(1) This UUO depends on FTHIBWAK which is normally off in the DECsystem-1040.

3.2 CORE CONTROL

For various reasons, privileged jobs may desire to be locked in core so that they are never to be considered for swapping or shuffling. Some examples of these jobs are as follows:

Real-time jobs	These jobs require immediate access to the processor in response to an interrupt from an I/O device.
Display jobs	The display must be refreshed from a display buffer in the user's core area in order to keep the display picture flicker-free.
Batch	Batch throughput may be enhanced by locking the Batch job controller in core.
Performance analysis	Jobs monitoring the activities of the system need to be locked in core so that they can be invoked quickly with low overhead in order to record activities of the monitor.

3.2.1 Definitions

In swapping and non-swapping systems, unlocked jobs can occupy only the physical core not occupied by locked jobs. Therefore, the locked jobs and timesharing jobs contend with one another for physical core memory. In order to control this contention, the system manager is provided with a number of system parameters as described below.

Total User Core is the physical core that can be used for locked and unlocked jobs. This value is equal to total physical core minus the monitor size.

CORMIN is the guaranteed amount of contiguous core that a single unlocked job can have. This value is a constant system parameter and is defined by the system manager at monitor generation time using MONGEN. It can be changed at monitor startup time using the ONCE ONLY dialogue. This value can range from 0 to Total User Core.

CORMAX is the largest contiguous size that an unlocked job can be. It is a time-varying system parameter that is reduced from its initial setting as jobs are locked in core. In order to satisfy the guaranteed size of CORMIN, the monitor never allows a job to be locked in core if this action would result in CORMAX becoming less than CORMIN. The initial setting of CORMAX is defined at monitor generation time using MONGEN and can be changed at monitor startup time using the ONCE ONLY dialogue. CORMAX can range from CORMIN to Total User Core. A guaranteed amount of core available for locked jobs can be made by setting the initial value of CORMAX to less than Total User Core.

3.2.2 LOCK AC, or CALLI AC, 60(1)

This UUO provides a mechanism for locking jobs in user memory. The user may specify if the high segment, low segment, or both segments are to be locked, and whether the core is to be physically contiguous. Note that on KA10-based systems, core is always allocated contiguously, and that the job may be moved to an extremity of user core before it is locked.

A job may be locked in core if all of the following are true:

1. The job has the LOCK privilege (set from the accounting file ACCT.SYS by LOGIN).

(1) This UUO depends on FTLOCK which is normally off in the DECsystem-1040.

2. The job, when locked, would not prevent another job from expanding to the guaranteed limit, CORMIN.

3. The job, when locked, would not prevent an existing job from running. Note that unlocked jobs can exceed CORMIN.

4. The job, when mapped, if specifying exec mapping, would not exceed the maximum amount of exec virtual address space available for locking (KI10 only).

The call is:

```
MOVE AC, [xwd high seg,  code, low seg,  code]
LOCK AC,                                              ;or CALLI AC, 60
error return                                          ;AC contains an
normal return                                         ;error code
```

The segment codes are a series of bits which specify the way in which the high segment (LH code) and the low segment (RH code) are to be locked. The order and position of the bits in the left half correspond to the order and position of the bits in the right half; that is, to obtain the bit number for the high segment, subtract 18 from the corresponding bit for the low segment. The bits are shown below.

Bit 17 (high segment) LK.HLS Bit 35 (low segment) LK.LLS	If 1, lock the segment in the manner indicated by the following bits. If 0, do not lock the segment; the following bits are ignored.
Bit 16 (high segment) LK.HNE Bit 34 (low segment) LK.LNE	If 0, map contiguously in the exec virtual memory (always implied on the KA10). This causes the segment to be added to the exec virtual address space so that it can be executed in exec mode. For example, this is required when exec mode real-time trapping (RTTRP) is used. On the KI10, the amount of exec virtual address space used by locked jobs is a limited resource with a defined maximum per processor. If mapping the segment would cause the maximum to be exceeded, the LKNEM% error return is given. The maximum amount available can be obtained from the CPU variable GETTAB table for each processor (GETTAB word %CVEVM). The current amount used can also be obtained from the table (%CVEVU).
Bit 15 (high segment) LK.HNP Bit 33 (low segment) LK.LNP	If 1, do not map in exec virtual memory. If 0, lock in contiguous physical memory locations (always implied on the KA10). This causes the segment to be moved and remapped, if necessary, so that its physical core is contiguous. On the KA10 system, the segment is also moved to one end of user core in order to minimize fragmentation of memory. If 1, do not attempt physical contiguity.

If the user requests a segment to be locked in contiguous physical memory, the monitor attempts to lock the segment as low in physical memory as possible. When the segment is locked below 112K, physical and virtual contiguity are equivalent, and thus in this case, virtual contiguity does not require the exec virtual memory resource to achieve contiguity.

On a KA10-based system, physical memory is always allocated contiguously and user segments are directly addressable in exec mode and, therefore, bit codes 1, 3, 5 and 7 are synonymous.

The setting of bits 33 and 34 (bits 15 and 16) is compatible with the implementation of the LOCK UUO on a KA10-based system. That is, code 1 is the most restrictive, so that a program coded for the KA10 system that implicitly uses these properties will also run on the KI10 system. Applications that do not require all properties can add the appropriate bits to the LOCK UUO.s calling sequence.

On a normal return, the job is locked in core. If there is a high-segment, the LH of AC contains its physical core address in units of pages (one page is 512 words). The value can be converted to a word address by shifting it left nine bits. If there is no high segment, the LH of AC contains zero. The RH of AC contains the physical core address of the low segment, shifted right nine bits.

On an error return, the job is not locked in core and AC either is unchanged or contains an error code. The AC is unchanged when the LOCK UUO is executed in monitors previous to the implementation of the UUO. An error code indicates the condition that prevented the job from being locked. The error codes are as follows:

Error Code	Name	Explanation
0	LKNIS%	The UUO is not included in this system or the requested function is not implemented because it has not been defined with MONGEN or because the appropriate feature test switch is off.
1	LKNLP%	The job does not have locking privileges, or RTTRP privileges, if required.
2	LKNCA%	If the job were locked in core, it would not be possible to run the largest existing non-locked job. (Applies only to swapping systems.)
3	LKNCM%	If the job were locked in core, it would not be possible to meet the guaranteed largest size for an unlocked job, that is, CORMAX would be less than CORMIN.
4	LKNEM%	The mode of locking requested exec virtual memory mapping but the allowable amount of exec mapping has been exhausted.
5	LKNIA%	An illegal subfunction argument has been supplied.
6	LKNPU%	The specified page is unavailable.

NOTE

The CORE UUO may be given for the high segment of a locked job only if it is removing the high segment from the addressing space. When the segment is locked in core, the CORE UUO and the CORE command with a non-zero argument cannot be satisfied and, therefore, always give an error return. The program should determine the amount of core needed for the execution and request this amount before executing the LOCK UUO.

Although memory fragmentation is minimized by both the LOCK UUO and the shuffler, the locking algorithm always allows job locking, even though severe fragmentation may take place, as long as

1. all existing jobs can continue to run, and
2. at least CORMIN is available as a contiguous space (see Figure 3-1E).

Since memory fragmentation can degrade system throughput, it is important that system managers use caution when granting locking privileges. The following are guidelines for minimizing fragmentation when using the LOCK UUO.

3.2.2.1 **KA10 Systems** – The guidelines for KA10 systems are:

1. There is no memory fragmentation if two jobs or less are locked in core.
2. There is no fragmentation if the locked jobs do not relinquish their locked status (i.e., no job terminates that has issued a LOCK UUO). In general, jobs with locking privileges should be production jobs.
3. If a job issuing a LOCK UUO is to be debugged and production jobs with locking privileges are to be run, the job to be debugged should be initiated and locked in core first, since it will be locked at the top of core. Then, the production jobs should be initiated since they will all be locked at the bottom of core. This procedure reserves the space at the top of core for the job being debugged and guarantees that there is no fragmentation as it locks and unlocks.
4. With a suitable setting of CORMIN and the initial setting of CORMAX in relation to Total User Core, the system manager can establish a policy which guarantees
   a. a maximum size for any unlocked job (CORMIN),
   b. a minimum amount of total lockable core for all jobs (Total User Core – CORMAX), and
   c. the amount of core which locked and unlocked jobs can contend for on a first-come-first-served basis (Total User Core – initial CORMAX + CORMIN).

3.2.2.2 **LOCK UUO Extension** – The extension to LOCK is distinguished from the description of LOCK in Paragraph 3.2.2 by the sign bit in the AC. If the sign bit is off, the LOCK UUO is interpreted as in 3.2.2; but if the sign bit is on, LOCK will be interpreted as described in the paragraphs that follow. The extended LOCK UUO is used to lock at a specified page location in physical memory. This is useful when writing diagnostics to test memory online. The format of the extended LOCK is:

```
        MOVE AC, [XWD -n, ADR]
        LOCK AC,                ;or CALLI AC, 60
        error return
        normal return

ADR:    function
        ARG1
        ARG2
         .
         .
         .
        ARGn-1
```

where: function 0 is the only function currently implemented.

Function	Meaning	n =	ARG1 =
0	Lock the high and/or low segment(s) into physical contiguous pages starting at the physical page number specified in ARG1.	-2	Left Half = 0 – do not lock the high segment. Left Half ≠ 0 – lock the high segment starting with page specified in LH of ARG1. Right Half = 0 – do not lock the low segment. Right Half ≠ 0 – lock the low segment starting with page specified in RH of ARG1.

Note that if the UUO indicates that the low segment is to be locked, the physical page number specified in the right half of ARG1 is where the user's page map page is placed. The first page of the low segment is locked in the next higher physical page location.

There is one possible error return, it is:

```
SPECIFIED PAGE(S) NOT AVAILABLE FOR LOCKING
```

This return would occur when locking the segment at the page(s) specified by ARG1, would either cause the two segments to overlap, cause one or both segments to overlap another locked job, cause one or both segments to overlap the monitor, or would cause one or both segments to be outside the range of on-line memory.

An example of the extended LOCK UUO is:

```
        MOVE AC, [XWD -2, ADR]
        LOCK AC,
           JRST ERROR
        ...
ADR:    0                         ;function = lock at specified
        230,,224                  ;physical page.
```

On a successful return, the user's page map page would be locked into physical page location 224; the first page of the low segment would be locked into page location 225; the second page in 226, and so on. The first page of the high segment would be locked in page 230, the second page in 231, and so on.

3.2.2.3 Core Allocation Resource – Because routines that lock jobs in core use the swapping and core allocation routines, they are considered a sharable resource. This resource is the semi-permanent core allocation resource (mnemonic=CA). When a job issues a LOCK UUO and the system is currently engaged in executing a LOCK UUO for another job, the job enters the queue associated with the core allocation resource. Because a job may share a queue with other jobs and because swapping and shuffling may be required to position the job to where it is to be locked, the actual execution time needed to complete the process of locking a job might be on the order of seconds.

When it has been established that a job can be locked, the low segment number and the high segment number (if any) are stored as flags to activate the locking routines when a swapper and shuffler are idle. The ideal position for the locked job is also stored as a goal for the locking routines. In KA10 swapping systems, the ideal position is always achieved to guarantee minimum fragmentation. In nonswapping systems, minimum fragmentation is achieved only if the ideal position does not contain an active segment (see Figure 3-1).

In swapping systems, after the job is locked in core, the locking routine determines the size of the new largest region available to unlocked jobs. This value will be greater than or equal to CORMIN. If this region is less than the old value of CORMAX, then CORMAX is set equal to the size of the new reduced region. Otherwise, CORMAX remains set to its old value.

3.2.2.4 UNLOK. AC, or CALLI AC, 120(1) – This UUO provides a mechanism for a job to unlock itself without doing a RESET UUO. The user can specify if one or both segments are to be unlocked. The call is:

```
MOVSI AC, n      ;if high segment is to be unlocked
HRRI AC, m       ;if low segment is to be unlocked
UNLOK.  AC,      ;or CALLI AC, 120
error return
normal return
```

An error return is given if the UUO is not implemented. If this is the case, a job can relinquish its locked status when either the user program executes on EXIT or RESET UUO, or the monitor performs an implicit RESET for the user. Implicit RESETS occur when

1. The user program issues a RUN UUO, or
2. The user types any of the following monitor commands: R, RUN, GET, SAVE, SSAVE, CORE 0, and any other system program-invoking command.

NOTE

If several jobs are sharing a locked high segment, the high segment is unlocked only when the SN%LOK bit is turned off for all jobs sharing the segment (i.e., when all jobs which executed the LOCK UUO have performed the unlock function) (refer to GETTAB Table 14).

On a normal return, the segment (or job) is unlocked and becomes a candidate for swapping and shuffling. Any meter points (METER.UUO) are deactivated and, if the low segment is unlocked, any real-time devices are RESET. CORMAX is increased to reflect the new size of the largest contiguous region available to unlocked jobs. However, CORMAX is never set to a greater value than its initial setting.

(1) This UUO depends on FTLOCK which is normally off in the DECsystem-1040.

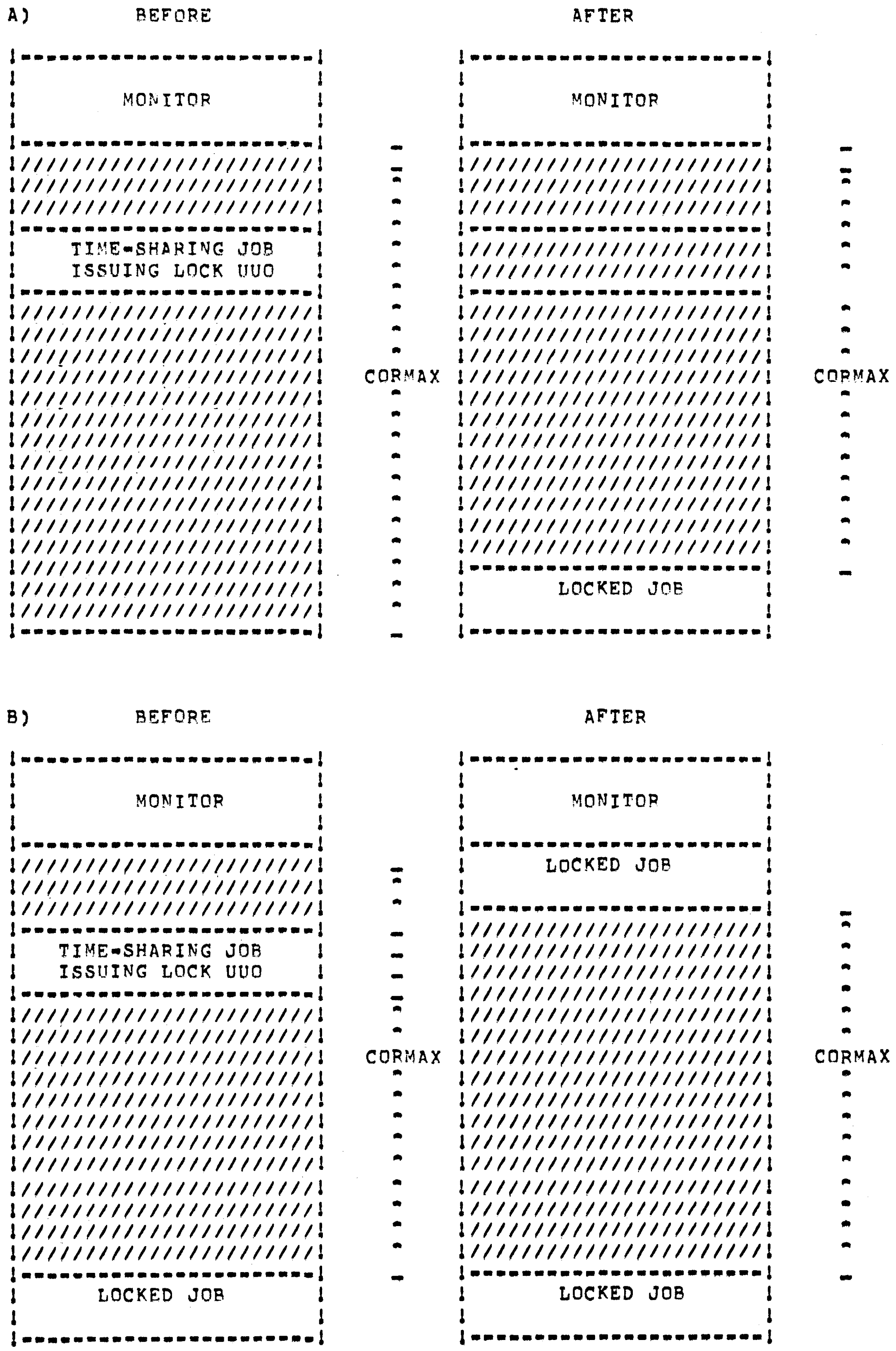
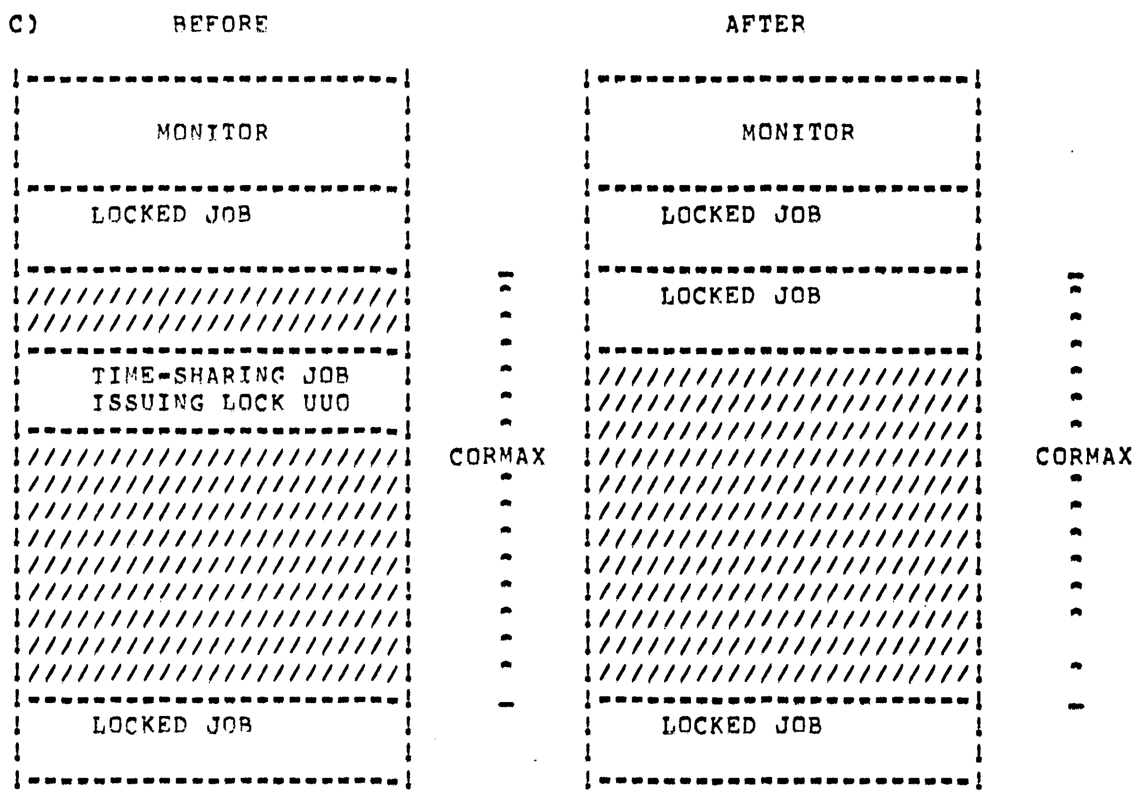


Figure 3-1 Locking Jobs In Core on KA10 Systems (Sheet 1 of 3)



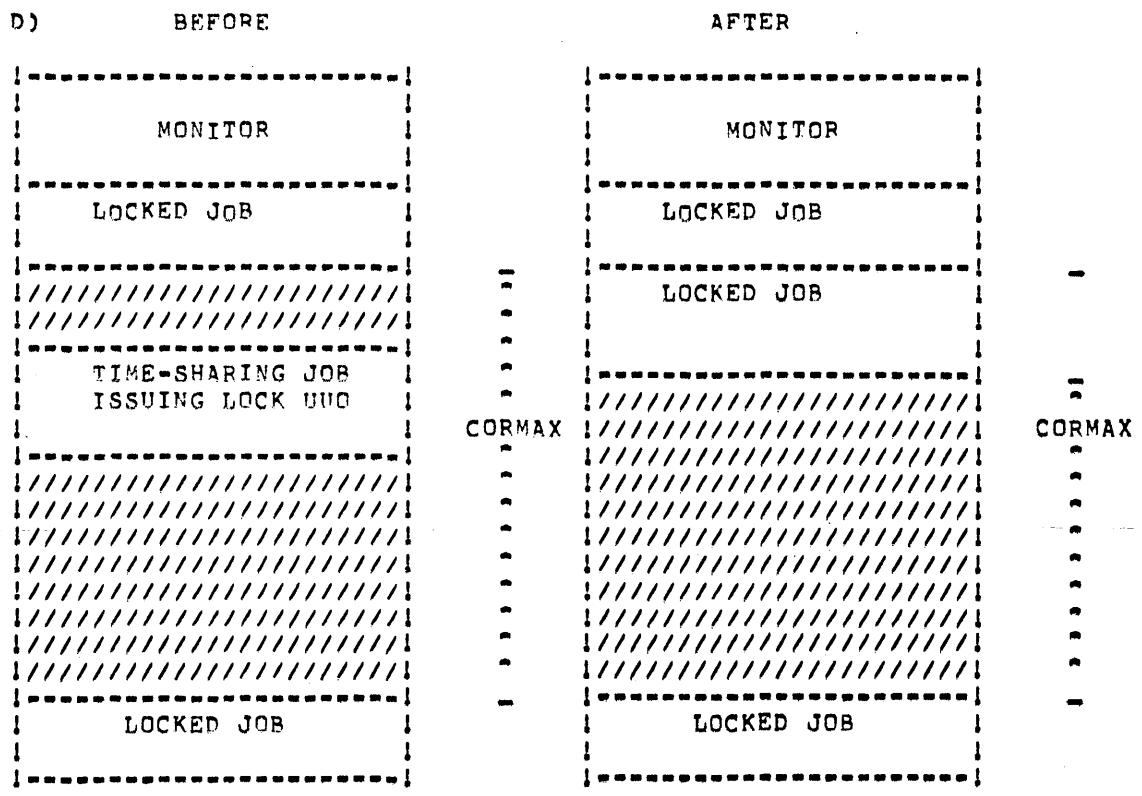


Figure 3-1 Locking Jobs In Core on KA10 Systems (Sheet 2 of 3)

```
E)  Unlikely Fragmentation Case

          BEFORE                                  AFTER
!-----------------------!           !-----------------------!
!                       !           !                       !
!        MONITOR        !           !        MONITOR        !
!                       !           !                       !
!-----------------------!     -     !-----------------------!     -
!   TIME-SHARING JOB    !     -     !///////////////////////!     -
!   ISSUING LOCK UUO    !     -     !///////////////////////!     -
!-----------------------!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!   CORMAX  !///////////////////////!   CORMAX
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!///////////////////////!     -     !///////////////////////!     -
!-----------------------!     -     !-----------------------!     -
!      LOCKED JOB       !           !      LOCKED JOB       !
!-----------------------!           !-----------------------!
!///////////////////////!           !      LOCKED JOB       !
!///////////////////////!           !                       !
!///////////////////////!           !                       !
!///////////////////////!           !-----------------------!
!///////////////////////!           !///////////////////////!
!///////////////////////!           !///////////////////////!
!-----------------------!           !-----------------------!
!      LOCKED JOB       !           !      LOCKED JOB       !
!                       !           !                       !
!-----------------------!           !-----------------------!
```

Figure 3-1   Locking Jobs In Core on KA10 Systems (Sheet 3 of 3)

3.2.3 CORE AC, or CALLI AC, 11

This UUO provides a user program with the ability to expand and contract its core size as its memory requirements change. To allocate core in either or both segments, the left half of AC is used to specify the highest user address to be assigned to the high segment and the right half is used to specify the highest user address in the low segment. The monitor will assign the smallest amount of core which will satisfy the request. If the left half of AC contains 0, the high segment core assignment is not changed. If the left half of AC is non-zero and is either less than 400000 or the length of the low segment, whichever is greater, the high segment is eliminated. If this is executed from the high segment, an illegal memory error message is printed when the monitor attempts to return control to the illegal address.

A RH of 0 leaves the low segment core assignment unaffected. The monitor clears new core before assigning it to the user; therefore, privacy of information is ensured.

The error return is given if:

1. The LH is greater than or equal to 400000 and the system does not have a two-segment capability.
2. The LH is greater than or equal to 400000 and the user has been meddling without write access privileges (refer to Paragraph 6.2.3).
3. The LH and the RH are both zero.

In swapping systems, this programmed operator returns the maximum number of 1K core blocks (all of core minus the monitor, unless an installation chooses to restrict the amount of core) available to the user. By restricting the amount of core available to users, the number of jobs in core simultaneously is increased. In non-swapping systems, the number of free and dormant 1K blocks is returned; therefore, the CORE UUO and the CORE command return the same information.

For compatibility, the KI10 also returns the number of 1K blocks available even though core is allocated in 512-word pages. The value returned is truncated to the nearest multiple of 1K (e.g., if 21 pages are available, the value returned in 10K).

The call is:

```
MOVE AC,[XWD high adr or 0, low addr or 0]
CORE AC,                                        ;or CALLI AC, 11
error return
normal return
```

The CORE UUO reassigns the low segment (if RH is non-zero) and then reassigns the high segment (if LH is non-zero). If the sum of the new low segment and the old high segment exceeds the maximum amount of core allowed to a user, the error return is given, the core assignment is unchanged, and the maximum core available to the user for high and low segments (in 1K blocks) is returned in the AC. In a nonswapping system, the number of free and dormant 1K blocks is returned.

If the sum of the new low segment and the new high segment exceeds the maximum amount of core allowed to a user, the error return is given, the new low segment is assigned, the old high segment remains, and the maximum core available to the user in 1K blocks is returned in the AC. Therefore, to increase the low segment and decrease the high segment at the same time, two separate CORE UUOs should be used to reduce the chances of exceeding the maximum size allowed to a user job. An error return is also given if a program attempts to increase the size of the low segment such that the low and high segments would overlap.

If the high segment is eliminated by a CORE UUO, a subsequent CORE UUO, in which the LH is greater than 400000, will create a new, nonsharable segment rather than re-establishing the old high segment. This segment becomes sharable after it has been:

1. Given an extension .SHR.
2. Written onto the storage device.
3. Closed so that a directory entry is made.
4. Initialized from the storage device by GET, R, or RUN commands or RUN or GETSEG UUOs.

The loader and the SAVE and GET commands use the above sequence to create and initialize new sharable segments.

A user program which expands core should compare its highest desired address with its highest legal address obtained from the Job Data Area location .JBREL (refer to Chapter 1). If the desired address is greater than the highest legal address, the program should execute a CORE UUO for the new desired address (not for the highest old legal address plus 512 or 1024). The monitor then updates .JBREL by the number of words in its basic core allocation unit (i.e., 1024 words on the KA10 processor or 512 words on the KI10 processor). Subsequent compares of the desired address and the highest legal address do not cause a CORE UUO until the next increase of core is required. If used this way, a CORE UUO will execute on both the KA10 and KI10 processors and will require less monitor CPU time because the number of CORE UUOs needed will be minimized.

The following example illustrates the method for obtaining core only when needed.

```
;SUBROUTINE TO GET CORE ONLY WHEN NEEDED
;CALL:  MOVE     T1, HIGHEST DESIRED ADDRESS
;       PUSHJ    P,CHKCOR
;       RETURN HERE UNLESS NO MORE CORE

CHKCOR: CAMG     T1,.JBREL##          ;GREATER THAN HIGHEST LEGAL ADDRESS?
        POPJ     P,                   ;NO, PRESENT CORE BIG ENOUGH.
        CORE     T1,                  ;YES, GET NEXT INCREMENT OF CORE.
          JRST     ERROR              ;NOT AVAILABLE
        POPJ     P,                   ;NEXT INCREMENT ASSIGNED.
```

3.2.4 SETUWP AC, or CALLI AC, 36

This UUO allows a user program to set or clear the hardware user-mode write protect bit and to obtain the previous setting. It must be used if a user program is to modify the high segment. The call is:

```
MOVEI AC,bit
SETUWP AC,              ;or CALLI AC, 36
error return
normal return
```

If the system has a two-register capability, the normal return will be given unless the user has been meddling without write privileges, in which case an error return will be given. A normal return is given whether or not the program has a high segment, because the reentrant software is designed to allow users to write programs for two-register machines, which will run under one-register machines. Compatibility of source and relocatable binary files is, therefore, maintained between one-register and two-register machines.

If the system has a one-register capability, the error return (bit 35 of AC=0) is given. This error return allows the user program to find out whether or not the system has a two-segment capability. The user program specifies the setting of the user-mode write protect bit in bit 35 of AC (write protect = 1, write privileges = 0). The previous setting of the user-mode write protect bit is returned in bit 35 of AC, so that any user subroutine can preserve the previous setting before changing it. Therefore, nested user subroutines, which either set or clear the bit, can be written, provided the subroutines save the previous value of the bit and restore it on returning to its caller.

3.2.5 Page Fault Handling

Whenever an executing program (on KI10 systems with the virtual memory option) references a location in a page that is not in core, the system transfers control to a page fault handler. A page fault handler determines which pages to place in core while the program is executing. A user can include his own page fault handler; or if he does not supply one, the system default page fault handler will be used.

3.2.5.1 **Default Page Fault Handler** – The default page fault handler utilizes a modified first-in/first-out (FIFO) technique. An ordered list of core resident pages is kept by age of page in physical core. Each page has an access-allowed bit, which can be set to YES or NO. Periodically, the handler will set every physical page's access-allowed bit to the NO position. A page fault will occur the next time one of these pages is referenced, that page's access-allowed bit will be changed to the YES position, and execution will continue.

By use of the age-ordered list along with a periodic check on the access-allowed bit, pages will be swapped on a modified "first-in/first-out least recently used" basis.

3.2.5.2 **Page Fault Handler Structure** – A page fault handler controls the working set, and is a part of the user's core image. If the user does not supply a page fault handler, a default handler will be read into the top of the user's address space from SYS:PFH.VMX. If a user-supplied handler is to be used, .JBPFH must point to it. .JBPFH is written in the format:

```
.JBPFH/ pfh-end ,, pfh-start
```

To provide his own page fault handler, the program must ensure that .JBPFH contains the address of its handler before the first page fault occurs. Alternatively, the user may cause the page fault handler to be obtained from his directory by ASSIGNing DSK to SYS. If the user's page fault handler is deleted through a CORE UUO, SYS:PFH.VMX will be brought into core on the next page fault.

PFH start must be of the form:

```
PFH start:  JRST START
                        PC for fault
                        page fault word
                        virtual time since page handler was first brought in
                        current page rate
            0           ; reserved
            0           ; reserved
            0           ; reserved
                        .
                        .
                        .
START:
```

The four words following PFH - start are filled in on a page fault. The page fault handler will be given control at PFH-start, the monitor will store the fault PC into PFH-start + 1, the page fault word in PFH-start + 2, virtual time since the page fault was first brought in will be stored in PFH-start + 3, and the current page rate will be stored in PFH-start + 4.

The page fault word has the following format:

Bit 0	=	1 indicates the working set has changed by the monitor or the user program without the page fault handler being given control. (PF.HCB)
Bits 1-17	=	page number causing the fault. (PF.HPN)
Bits 18-35	=	Code indicating the type of page fault (PF.HFC), either: 1 – access not allowed (the access-allowed bit has been turned off for the referenced page). (.PFHNA) 2 – page not in core (the referenced page is swapped out). (.PFHNI) 3 – monitor detected (UUO) (a page containing UUO argument is swapped out). (.PFHUU) 4 – trap after n units in virtual time (as a result of requesting virtual time traps, refer to the description of the .STTVM option of the SETUUO UUO). (.PFHTI) 5 – allocated but zero page (.PFHZI). 6 – allocated but zero after UUO. (.PFHZU)

3.2.6 PAGE. UUO, or CALLI AC, 145

The PAGE. UUO is used (on KI10 systems with the virtual memory option) to manipulate pages and the data associated with these pages. The general format for the call is:

```
MOVE AC, [XWD function, LOC]
PAGE.  AC,                     ;or CALLI AC, 145
error return
normal return
```

LOC points to an argument BLOCK. The format of the argument block varies according to the specific function involved. The following functions are available with the PAGE. UUO:

Function Code	Mnemonic	Meaning
0	.PAGIO	Swap a page in/out.
1	.PAGCD	Create/destroy a page.
2	.PAGEM	Move/exchange a page.
3	.PAGAA	Clear/set access allowed.
4	.PAGWS	Get the working set.
5	.PAGGA	Get access allowed.
6	.PAGCA	Get page accessibility.

The first four functions are used to specify one of two functions (e.g., in/out). To specify which of the two functions is desired, the user utilizes the sign bit of each word in BLOCK. A detailed description of each function follows:

Function 0 (swap a page in/out) –

causes pages, which have already been allocated, to be swapped in and added to the working set, or to be deleted from the working set in core and moved to secondary storage. The argument BLOCK is a set of entries each in the following form:

0	1	2-26	27-35
S	P		N

where: S specified whether the page is to be swapped in (0) or out (1).

P specifies whether the page is to be transferred to fast secondary storage (0) (e.g., fixed head disk) or to slow secondary storage (1) (e.g., moving head disk).

N specifies the page number to be swapped in or out.

The entries in the argument block must be passed in increasing order by page number.

Function 1 (create/destroy a page) –

causes pages to be created or destroyed. The words in argument BLOCK are of the form:

0	1	2-26	27-35
S	P		N

where: S specifies whether a page is to be created (0) or destroyed (1).

P specifies whether the page is to be created on disk (1) or added directly to the working set (0). (This applies to create only.)

N specifies the page number to be created or destroyed.

Note that if bit 1 is set for any entry, it is then assumed to be set for all entries. Arguments must be passed in increasing order by page number.

Function 2 (move/exchange a page) –

causes a page to be moved from one location in user virtual address space to another location, or causes two pages to exchange locations. The words in the argument BLOCK are of the form:

0	1-8	9-17	18-26	27-35
S		SP		DP

where: S specifies whether the specified page is to be moved (0) or exchanged with another page (1).

SP specifies the source page location.

DP specifies the destination page location.

A page cannot be moved to an already allocated page.

Function 3 (set/clear access allowed) –

causes access permission to be either set (1) or cleared (0). If a page is a part of the working set, its access bit can be turned off. When the access bit is in the off state, a page fault will occur the next time that page is accessed. The page will remain in core, so the access bit may be restored to the on state at any time. The words in the argument BLOCK are of the form:

0	1-26	27-35
S		N

where: S specifies whether the access permission is to be set (1) or cleared (0).

N specifies the page number for which access permission is to be set or cleared.

Arguments must be passed in increasing order by page number.

Function 4 (get the working set) –

determines which pages are currently a part of the working set (i.e., in core). A bit map is returned in BLOCK. N in the right half of word LOC specifies the number of words in the bit map that are to be returned. N would normally be 17 (octal) to obtain the entire bit map. Within BLOCK, the bit map is set up in the following form:

	0 — 35	
word 0		page 0-35
	.	
	.	
	.	
word 14		pages 504-511

If a bit within this bit map is set, the page associated with that bit is a part of the working set.

Function 5 (get access allowed) –

determines which pages have their access-allowed bits set. A bit map is returned in BLOCK having the same format as that returned for Function 4. If a bit is set within the bit map, the page associated with that bit is accessible.

Function 6 (get page accessability) –

determines the type of access allowed for a given page. The format of this function differs from the preceding ones. There is no argument block. Instead the contents of AC contain the necessary data in the following format:

0-17	18-35
C	N

where: C specifies the function code (i.e., 6 or .PAGCA).

N specifies the page number associated with this function.

One or more of the following bits will be returned in AC upon completion of the instruction:

Bit	Mnemonic	Meaning
0	PA.GNE	Page does not exist.
1	PA.GWR	Write access allowed.
2	PA.GAA	Access allowed (controlled by function 3).
4	PA.GAZ	Zero page (allocated by a CORE, UUO but not yet referenced).
5	PA.GCP	Can be paged out.
6	PA.GPO	Is paged out.

There are limitations on what pages may be paged out. Page zero may never be paged out, and if the high segment is sharable, none of the high segment may be paged out.

The possible error codes which may be returned in AC as a result of the PAGE. UUO are:

Code	Mnemonic	Meaning
1	PAGIA%	Illegal argument.
2	PAGIP%	Illegal page number.
3	PAGCE%	Page can't exist, but does.
4	PAGME%	Page must exist, but doesn't.
5	PAGMI%	Page must be in core, but isn't.
6	PAGCI%	Page can't be in core, but it is.
7	PAGSH%	Page is in sharable high segment.
10	PAGIO%	Paging I/O error.
11	PAGNS%	No swapping space available.
12	PAGLE%	Core limit exceeded.
13	PAGIL%	Not allowed if locked.

3.3 SEGMENT CONTROL

3.3.1 RUN AC, or CALLI AC, 35

This UUO has been implemented so that programs can transfer control to one another. Both the low and high segments of the user's addressing space are replaced with the program being called.

The call is:

```
MOVSI AC, start-adr-increment
HRRI AC, adr-of-block
RUN AC,                                ;or CALLI AC, 35
error return
[normal return is not here  but to start
address plus increment of new program]
```

The arguments contained in the six-word block are:

```
E:  SIXBIT/logical device name/
    SIXBIT/filename/            ;for  either or  both high and
                                ;low files
    SIXBIT/ext.  for low file/  ;if LH = 0, .LOW is assumed if
                                ;high  segment exists, .SAV is
                                ;assumed if high  segment does
                                ;not exist.

     0
     XWD proj.  no., prog.  no. ;if = 0,  use  current  user's
                                ;proj, prog
     XWD 0, optional core       ;RH = new highest user address
            assignment          ;to   be   assigned   to   low
                                ;segment.
                                ;LH is ignored rather than
                                ;setting high segment.
```

A user program usually will specify only the first two words and set the others to 0. The RUN UUO destroys the contents of all the user's AC's and releases all the user's I/O channels; therefore, arguments or devices cannot be passed to the next program.

The RUN UUO to certain system programs (e.g., LOGIN, LOGOUT) automatically sets the appropriate privileged bits (JACCT and JLOG). These bits are not set (or are turned off if they were set) for programs that are not privileged programs from device SYS or for programs whose starting address offset is greater than 1.. Assigning a device as SYS does not cause these bits to be set.

The RUN UUO clears all of core. However, programs should not count on this action, and must still initialize core to the desired value to allow programs to be restarted by a ↑C, START sequence without having to do I/O.

Programs on the system library should be called by using device SYS with a null project-programmer number instead of device DSK with the project-programmer number [1,4]. The extension should also be null so that the calling user program does not need to know if the call system program is reentrant or not.

The LH of AC is added to and stored in the starting address (.JBSA) of the new program before control is transferred to it. The command ↑C followed by the START command restarts the program at the location specified by the RUN UUO, so that the user can start the current system program over again.

The user is considered to be meddling with the program (refer to Paragraph 3.3.5) if the LH of AC is not 0 or 1 unless the program being run is execute-only for this job. In this case, the offset is treated as 0.

Programs accept commands from a terminal or a file, depending on how they were started, due to control by the program calling the RUN UUO. The following convention is used with all of DEC's standard system programs: 0 in LH of AC means type an asterisk and accept commands from the terminal. A 1 means accept commands from a command file, if it exists; if not, type an asterisk and accept commands from the terminal. The convention for naming system program command files is that the filename be of the form

```
###III.TMP
```

where III are the first three (or fewer if three do not exist) characters of the name of the program doing the LOOKUP, and # # # is the decimal character expansion (with leading zeroes) of the binary job number. The job number is included to allow a user to run two or more jobs under the same project-programmer number. For example,

```
009PIP.TMP
039MAC.TMP
```

Decimal numbers are used so that a user listing his directory can see the same number as the PJOB command types. These command files are temporary and may, therefore, be deleted by the KJOB program (refer to KJOB command and Appendix C in DECsystem-10 Operating System Commands).

At times it is necessary to remember the arguments that a user typed in to invoke a program (i.e., the arguments on a GET or RUN command). For example, the COBOL program needs these arguments in order to GETSEG the next overlay from the same place. In all monitors, when the program is first started, this information can be obtained from the following accumulators:

AC0	(.SGNAM)	contains the filename.
AC7	(.SGPPN)	contains the directory name.
AC11	(.SGDEV)	contains the device name.
AC17	(.SGLOW)	contains the extension of the low segment.

Note that the starting address should be changed by the program so that a ↑C, START sequence will not destroy the remembered arguments in the ACs. This information should not be used when desiring to save the current segment name (GETTAB should be used in this case), but rather when obtaining the call arguments before calling the next segment.

The RUN UUO can give an error return with an error code in AC if any errors are detected; thus, the user program may attempt to recover from the error and/or give the user a more informative message on how to proceed. Some user programs do not go to the bother of including error recovery code.

The monitor detects this and does not give an error return if the LH of the error return location is a HALT instruction. If this is the case, the monitor simply prints its standard error message for that type of error and returns the user's terminal to monitor mode. This optional error recovery procedure also allows a user program to analyze the error code received and then execute a second RUN UUO with a HALT if the error code indicates an error for which the monitor message is sufficiently informative or one from which the user program cannot recover.

The error codes are an extension of the LOOKUP, ENTER, and RENAME UUO error codes and are defined in the S.MAC monitor file. Refer to Appendix E for an explanation of the error codes.

The monitor does not attempt an error return to a user program after the high or low segment containing the RUN UUO has been overlaid. The UUO should be placed in the low segment in case the error is discovered after the high segment has been released.

To successfully program the RUN UUO for all size systems and for all system programs with a size that is not known at the time the RUN UUO is coded, it is necessary to understand the sequence of operations the RUN UUO initiates. Assume that the job executing the RUN UUO has both a low and a high segment. (It can be executed from either segment; however, fewer errors can be returned to the user if it is executed from the high segment.)

The sequence of operations for the RUN UUO is as follows:

1. Does a high segment already exist with desired name?
   If yes, go to 30.
   INIT and LOOKUP filename .SHR. If not found, go to 10.
   Read high file into top of low segment by extending it. (Here the old segment and new high segment and old high segment together may not exceed the maximum user core legally available to this job at the time of the UUO nor may it cause the total amount of virtual core assigned to all users to exceed the size of the swapping space.)

   REMAP the top of low segment replacing old high segment in logical addressing space.
   If high segment is sharable (.SHR) store its name so others can share it.
   Always go to 40 or return to user if GETSEG UUO.

10. LOOKUP filename .HGH. If not found, go to 35 or error return to user if GETSEG UUO.
    Read high file into top of low segment by extending it. (The old low segment and new high segment and old high segment together may not exceed the maximum user core legally available to this job at the time of the UUO nor may it cause the total amount of virtual core assigned to all users to exceed the size of the swapping space.)
    Check for I/O errors. If any, error return to user unless HALT in LH of return. Go to 41.

30. Remove old high segment, if any from logical addressing space. If a KI10 based system, check that the new high segment will overlap the existing low segment, if high is placed at indicated origin (if one is indicated). If it will, give an error return. .break Go to 40 or return to user if GETSEG UUO.

35. Remove old high segment, if any, from logical addressing space.
    (Go to 41.)

40. Copy vestigial job data area into job data area.
    Does the new high segment have a low file
    (LH of .JBCOR $>$ 137) ?
    If not, go to 45.

41. LOOKUP filename .SAV or .LOW or user specified extension. Error if not found. Return to user if there is no HALT in LH of error return, provided that if the CALL is from the high segment, it is still the original high segment and has not been removed from the user's addressing space. Otherwise, the monitor prints one of the following error messages:

```
?NOT A SAVE FILE
?filename.SAV NOT FOUND
?TRANSMISSION ERROR
?LOOKUP FAILURE n
?nK OF CORE NEEDED
?NO START ADR
```

and stops the job.
Reassign low segment core according to size of file or user specified core argument, whichever is larger. Previous low segment is overlaid. Read low file into beginning of low segment. Check for I/O errors. If there is an error print error message and do not return to user. If there are no errors, perform START.

45. Reassign low segment core according to larger of user's core argument or argument when file saved (RH of .JBCOR).

NOTE
To be guaranteed of handling the largest number of errors, the cautious user should remove his high segment from high logical addressing space (use CORE UUO with a one in LH of AC). The error handling code should be put in the low segment along with the RUN UUO and the size of the low segment reduced to 1K. A better idea would be to have the error handling code written once and put in a seldom used (probably nonsharable) high segment, which could be gotten in high segment using GETSEG UUO (see below) when an error return occurs to low segment on a RUN UUO.

3.3.2 GETSEG AC, or CALLI AC, 40

This UUO has been implemented so that a high segment can be initialized from a file or shared segment without affecting the low segment. It is used for shared data segments, shared program overlays, and run-time routines such as FORTRAN or COBOL object time systems. This programmed operator works exactly like the RUN UUO with the following exceptions:

1. No attempt is made to read a low file.

2. The accumulators are not preserved. The only change made to JOBDAT is to set the left half of .JBHRL to 0 (a SAVE command then saves all of the high segment) and the right half to the highest legal user address.

3. If an error occurs, control is returned to the location of the error return, unless the left half of the location contains a HALT instruction.

4. On a normal return, the control is returned to two locations following the UUO, whether it is called from the low or high segment. It should be called from the low segment unless the normal return coincides with the starting address of the new high segment.

5. User channels 1 through 17 are not released so the GETSEG UUO can be used for program overlays, such as the COBOL compiler. Channel 0 is released because it is used by the UUO.

6. .JBSA and .JBREN are zeroed if they point to a high segment that is being removed. This produces the message:

   ```
   ?NO START ADDRESS
   ```

   if a START or REENTER command is given.

Refer to steps 1 through 30 of the RUN UUO description (Paragraph 3.3.1) for details of GETSEG UUO operation.

3.3.3 REMAP AC, or CALLI AC, 37

This UUO takes the top part of a low segment and remaps it into the high segment. The previous high segment (if any) will be removed from the user's addressing space. The new low segment will be the previous low segment minus the amount remapped.

The call is:

```
MOVEI AC, highest addr in low seg
or
MOVE AC, [XWD high seg origin, low seg]        ;KI10 systems in
                                               ;low seg]
REMAP AC,                                      ;or CALLI AC, 37
error return
normal return
```

The monitor rounds up the address to the nearest core allocation unit of either 1024(10) (2000(8)) words on KA10-based systems or 512(10) (1000(8)) words on KI10-based systems. If the argument exceeds the length of the low segment, remapping will not take place, the high segment will remain unchanged in the user's addressing space, and the error return will be taken. The error return will also be taken if the system does not have a two-register capability.

Also, the error return will be given

- if an origin for the high segment is specified on KA10 based systems.
- if the specified remapping (on KI10 based systems) would cause the new high and low segments to overlap.
- if the new high segment origin plus its length would result in the high segment starting (or ending) at an address outside the program's virtual address space (>256K).

The content of AC is unchanged. The content of .JBREL (refer to Paragraph 1.2.1) is set to the new highest legal user address in the low segment. The LH of .JBHRL is set to 0 (a SAVE command then saves all of the high segment) and the RH is set to the highest legal user address in the high segment (401777 or greater or 0). The hardware relocation will be changed, and the user-mode write protect bit will be set.

This UUO is used by the LOADER to load reentrant programs, which make use of all physical core. Otherwise, the LOADER might exceed core in assigning additional core and moving the data from the low to the high segment with a BLT instruction. The GET command also uses this UUO to perform I/O into the low segment instead of the high segment.

3.3.4 Testing for Sharable High Segments

Occasionally, it is desirable for a program to determine whether its high segment is sharable. If the high segment is sharable, the program may decide not to modify itself. The following code tests the high segment whether or not

1. the system has a high segment capability, or
2. the job has a high segment.

```
HRROI T, .GTSGN         ;see if high segment is sharable
GETTAB T,               ;look at monitor .GTSGN table
JRST .+2                ;table or UUO not present
TLNN T,(SN%SHR)         ;is sharable bit on?
JRST NOTSHR             ;no, go ahead and modify here
                        ;if high segment is sharable.
```

3.3.5 Determining the High Segment Origin

It is occasionally desirable for a program to determine the origin of its high segment (i.e., the starting virtual address of the high segment within the program's address space). This information would be useful, for example, to a program that wanted to access information in the vestigial job data area or wanted to transfer control to an entry point in a high segment which had been GETSEGed. Prior to the 5.07 monitor release, the high segment origin was normally 400000 (octal) or the first available core allocation boundary above the low segment, if the low segment was larger than 128K. This assumption about the location of the high segment should no longer be made by programs. Rather, programs should determine the location of their high segment using the following procedure:

```
HRRZ      T1,.JBHRL               ;HIGHEST RELATIVE ADR IN HI SEG
JUMPE     T1,NOHIGH               ;JUMP IF NO HI SEG
HRRZ      T1,.JBREL               ;HIGHEST ADR IN LOW SEG
TRNN      T1,400000               ;LOW SEG BIGGER THAN 128K?
MOVEI     T1,377777               ;NO, ASSUME HI SEG STARTS AT 400000
MOVE      T2,[XWD -2,.GTUPM]      ;GET HI ORIGIN FROM MONITOR TABLE
GETTAB    T2,                     ;.GTUPM INDEXED BY CURRENT HI SEG NUM.
  HRLI    T2,1(T1)                ;TABLE OR UUO NOT PRESENT, USE ASSUMED
LSH       T2, -^D18               ;VALUE.    CONVERT TO ADR OF HI SEG.
ANDI      T2,777                  ;CLEAR ANY LOW BITS
MOVEM     T2,HIORGN               ;STORE  AS THE ORIGIN OF THE HI SEG
```

3.3.6 Modifying Shared Segments and Meddling

A high segment is usually write-protected, but it is possible for a user program to turn off the user write-protect bit or to increase or decrease a shared segment's core assignment by using the SETUWP or CORE UUO. These UUOs are legal from the high or low segment if the sharable segment has not been "meddled" with, unless the user has write privileges for the file that initialized the high segment. Even the malicious user can have the privilege of running such a program, although he does not have the access rights to modify the file used to initialize the sharable segment.

Meddling is defined as any of the following, even if the user has privileges to write the file which initialized the sharable segment.

1. START or CSTART commands with an argument.
2. DEPOSIT command in the low or high segment.
3. RUN UUO with anything other than a 0 or 1 in LH of AC as a starting address increment.
4. GETSEG UUO.

It is not considered meddling to perform any of the above commands or UUOs with a nonsharable program. It is never considered meddling to type ↑C followed by START (without an argument), CONT, CCONT, CSTART (without an argument), REENTER, DDT, SAVE, or E command.

When a sharable program is meddled with, the monitor sets the meddle bit for the user. An error return is given when the clearing of the user write-protect bit is attempted with the SETUWP UUO or when the reassignment of core for the high segment (except to remove it completely) is attempted with the CORE UUO. An attempt to modify the high segment with the DEPOSIT command causes the message

```
?OUT OF BOUNDS
```

to be printed. If the user write-protect bit was not set when the user meddled, it will be set to protect the high segment in case it is being shared. The command and the two UUOs are allowed in spite of meddling, if the user has the access privileges to write the file which initialized the high segment.

A privileged programmer is able to supersede a sharable program, which is in the process of being shared by a number of users. When a successful CLOSE, OUTPUT, or RENAME UUO is executed for a file with the same directory name and filename (previous name if the RENAME UUO is used) as the segment being shared, the name of the segment is set to 0. New users do not share the older version, but they do share the newer version. This requires the monitor to read the newly created file only once to initialize it. The monitor deletes the older version when all users are finished sharing it.

Users with access privileges are able to write programs that access sharable data segments via the GETSEG UUO (which is meddling) and then turn off the user write-protect bit using SETUWP UUO. With DECtape, write privileges exist if it is assigned to the job (cannot be a system tape) or is not assigned to any job and is not a system tape.

When control can be transferred only to a small number of entry points (two), which the shared program is prepared to handle, then the shared program can do anything it has the privileges to do, although the person running the program does not have these privileges.

The ASSIGN (and the DEASSIGN, DISMOUNT/REMOV, FINISH, KJOB commands if the device was previously assigned by console) command clears all shared segment names currently in use, which were initialized for the device, if the device is removable (DTA, MTA). Otherwise, new users could continue to share the old segment indefinitely, even if a new version were mounted on the device. Therefore, it is possible to update the library during regular timesharing, if the programmer has access privileges.

3.4 PROGRAM AND PROFILE IDENTIFICATION

3.4.1 SETNAM AC, or CALLI AC, 43

This UUO is used by LINK-10. The content of AC contains a left-justified SIXBIT program name, which is stored in a monitor job table. The information in the table is used by the SYSTAT program (refer to Table 3-1 in Paragraph 3.6.3.3). This UUO clears the "SYS:" program bit .JB.LSY (used by Batch), clears the execute-only bit, and outputs a SET WATCH VERSION number (refer to DECsystem-10 Operating System Commands).

3.4.2 SETUUO AC, or CALLI AC, 75(1)

This UUO is used to set various system or job parameters. To set system parameters, the user must be logged in under [1,2] or the job must be running with the JACCT bit set. Refer to the Specifications section of the DECsystem-10 Software Notebooks for a complete description of the privileged functions.

The contents of AC contain a function code in the left half and an argument in the right half. The call is:

```
MOVE AC, [XWD function, argument]
SETUUO AC,                                  ;or CALLI AC, 75
error return
normal return
```

The functions and arguments are as follows:

Function	Name	Argument
0	.STCMX	CORMAX. Privileged function.
1	.STCMN	CORMIN. Privileged function.
2	.STDAY	DAYTIME. Privileged function (FTSEDAT).
3	.STSCH	SCHED. Privileged function.
4	.STCDR	CDR (input name for this job). Not a privileged function. Right half of AC, 3 SIXBIT characters, is stored in left half of .GTSPL (FTSPL).
5	.STSPL	SPOOL for this job. Not a privileged function unless the user is unspooling devices. Bits are 31–35 of .GTSPL (FTSPL).

Bit 35	JS.PLP	line printer spooling
Bit 34	JS.PPL	plotter spooling
Bit 33	JS. PPT	paper tape punch spooling
Bit 32	JS.PCP	card punch spooling
Bit 31	JS.PCR	card reader spooling

(1) This UUO depends on FTSET which is normally off in the DECsystem-1040. If FTSET is on, individual functions depend on the other feature test switches as noted in the text.

Function	Name	Argument
6	.STWTC	WATCH for this job. Not a privileged function. Bits are bits 1–6 of .GTWCH (FTWATCH). Bit 1 JW.WDY watch time of day Bit 2 JW. WRN watch run time Bit 3 JW.WWT watch wait time Bit 4 JW.WDR watch disk reads Bit 5 JW.WDW watch disk writes Bit 6 JW.WVR watch version numbers.
7	.STDAT	DATE. Privileged function (FTSEDAT).
10	.STOPR	OPR. Privileged function.
11	.STKSY	KSYS. Privileged function (FT5UUO).
12	.STCLM	CORE limit. Privileged function (FTTLIM).
13	.STTLM	TIME limit for this job. Privileged function (FTTLIM).
14	.STCPU	CPU specification for this job. The following bits select the CPU on which the job is allowed to run. Bit 35 SP.CR0 CPU0 Bit 34 SP.CR1 CPU1 Bit 33 SP.CR2 CPU2 Bit 32 SP.CR3 CPU3 Bit 31 SP.CR4 CPU4 Bit 30 SP.CR5 CPU5
15	.STCRN	CPU runnability. Privileged function.
16	.STLMX	LOGMAX. Privileged function.
17	.STBMX	BATMAX. Privileged function.
20	.STBMN	BATMIN. Privileged function.
21	.STDFL	DSKFUL for this job. Not a privileged function. An argument of 0 (.DFPSE) causes a pause and an argument of (.DFERR) causes an error when the disk is full or the user's quota is exceeded. The current setting can be determined by issuing an argument other than 0 and 1. The value returned is either 0 or 1 depending on whether PAUSE or ERROR is set. The initial setting is ERROR.
22	.STMVM	Maximum virtual memory (GVPL). Privileged function.
23	.STMVR	Maximum virtual memory rate. Privileged function.
24	.STUVM	User virtual memory maximum (MVPL). Privileged function.
25	.STCVM	User current virtual memory maximum. ADR (address of the word that contains CVPL and CPPL). The left half of the word contains the current virtual page limit, the right half contains the current physical page limit. If either CVPL or CPPL is zero, the current value is unchanged.

Function	Name	Argument
26	.STTVM	User virtual time interrupts. Time interval equals the time interval between virtual time traps in milliseconds. This causes a code 5 page fault to the page fault handler each time "time interval" has elapsed in virtual time.
27	.STABK	Address break. On a normal return, the new address break conditions and the break address will have been set. Address conditions are: Bit 0 break on execute; Bit 1 break on read; Bit 2 break on write; Bit 3 break on MUUO. Note that 1B0+1B1+1B2+1B3 = 0 will clear the address break. If the user is enabled for address break interrupts, the software interrupt system will interrupt when an address break occurs.

The error return is given if

1. the UUO is not implemented
2. the user does not have the correct privileges for the function specified, or
3. the argument specified is invalid.

On a normal return, AC remains unchanged.

3.4.3 LOCATE AC, or CALLI AC, 62(1)

This UUO is used to change the logical station associated with the user's job. The call is:

```
MOVEI AC, station number
LOCATE AC,                          ; or CALLI AC, 62
error return
normal return
```

The station number requested is contained in AC as follows:

-1	changes the job's location to the physical station of the job's controlling terminal.
0	changes the job's location to the central station.
n	changes the job's location to remote station n.

The normal return is taken if the UUO is implemented, the station is defined, and the station is in contact. Subsequent generic device specifications are at the new station. The error return is taken if the UUO is not implemented or the specified station is illegal or not in contact.

(1) This UUO depends on FTREM which is normally off in the DECsystem-1040.

3.5 INTER-PROGRAM COMMUNICATION

3.5.1 TMPCOR AC, or CALLI AC, 44(2)

This UUO allows a job to leave several short files in core from the running of one user program or system program to the next. These files are referenced by a three-character filename and are unique to each job. All files are deleted when the job is killed. This system of temporary storage improves response time and reduces the number of disk operations. If this UUO fails, the file specification DSK:nnnNAM.TMP, where nnn is the job number and NAM is the three-character filename, should be used for temporary disk storage.

Each temporary file appears to the user as one dump mode buffer. The actual size of the file, the number of temporary files a user can have, and the total core a user can use for temporary storage are parameters determined at MONGEN time. All temporary files reside in a fixed area, but the space is dynamically allocated among different jobs and several different files for any given job.

The call is:

```
          MOVE AC, [XWD code, block]
          TMPCOR AC,                  ; or CALLI AC, 44
          error return
          normal return
          .
          .
          .
  BLOCK:  XWD NAME, 0                 ; NAME is filename
          IOWD BUFLEN, BUFFER         ; user buffer area
                                      ; (zero for no buffer)
```

The AC must be set by the user program prior to execution of the UUO and is changed by the UUO on return to a value that depends on the particular function performed. Functions of the TMPCOR UUO are presented in the following paragraphs.

3.5.1.1 CODE = 0 (.TCRFS) – Obtain Free Space – This is the only form of the UUO that does not use a two-word parameter block and, therefore, the contents of AC are ordinarily set to 0. A normal return is given (unless the UUO is not implemented), and the number of the free words available to the user is returned in AC.

3.5.1.2 CODE = 1 (.TCRRF) – Read File – If the specified file is not found, the number of free words available for temporary files is returned in AC and the error return is taken. If the specified file is found, the length of the file in words (that is, the length in BUFLEN when writing the file rounded up to the next highest multiple of four) is returned in AC, and as much of the file as possible is copied into the user's buffer. The user may check for truncation of the file by comparing the contents of AC with BUFLEN.

3.5.1.3 CODE = 2 (.TCRDF) - Read and Delete File – This function is similar to CODE = 1, except that if the specified file is found, it is deleted and its space is reclaimed.

(2) This UUO depends on FTTMP which is normally off in the DECsystem-1040.

3.5.1.4 CODE = 3 (.TCRWF) – Write File – If a file exists with the specified name, it is deleted and its space reclaimed. The requested size of the file is the value in BUFLEN rounded up to the next highest multiple of four. If there is enough space

1. The file is written.
2. The number of remaining blocks is returned in AC.
3. The normal return is taken.

If there is not enough space to completely write the file

1. The file is not written.
2. The number of free words available to the user is returned in AC.
3. The error return is taken.

3.5.1.5 CODE = 4 (.TCRRD) – Read Directory – The number of different files in the temporary file area of the job is returned in AC. An entry is made for each file in the user's buffer area until either there is no more space or all files have been listed. The error return is never taken. The user may check for truncation of the entries by comparing the contents of AC with BUFLEN. The format of a directory entry is as follows:

```
    XWD NAME, SIZE
```

where NAME is the filename and SIZE is the file length in words.

3.5.1.6 CODE = 5 (.TCRDD) – Read and Clear Directory – This function is similar to CODE = 4, except that any files in the temporary storage area of the job are deleted and their space is reclaimed.

This UUO is used by the LOGOUT program.

3.6 ENVIRONMENTAL INFORMATION

3.6.1 Timing Information

The 5.05 and later monitors use two time and two date standards. The time accounting is performed by two clocks. The APR clock, driven by the power source frequency (60 Hz in North America, 50 Hz in most other countries), is accurate over long periods of time. For this reason, it is used to keep the time of day, e.g., for the TIMER UUO. It can also be used for runtime accounting measurement (i.e., keeping track of the processor time each job uses). However, there will be some loss of accuracy since the time intervals in which a job runs are often less than the period of the APR clock.

The DK10 clock, a 100000 Hz clock, is accurate over short periods of time. It is used to perform runtime accounting, and thereby achieves greater accuracy than the APR clock.

The traditional DECsystem-10 date (returned with the DATE UUO) is a 15-bit integer. This integer is incremented by 1 each day, by 31 each month (regardless of the actual number of days in the month), and by 12*31 each year (also regardless of the actual number of days in the year). This date format is easy to resolve into year-month-day; however, the difference between two dates in this format is not necessarily the actual number of days between them.

The monitor maintains a set of GETTAB values which gives the local date and time in terms of year, month, day, hours, minutes, and seconds (GETTAB Table 11, Items 56 through 63).

For convenience, the local time (host computer time) can be converted to a universal date-time standard where the left half of the word is the day and the right half of the word is the time. This day is uniformly incremented each day (at midnight, Greenwich Mean Time) with 1 being November 18, 1858. The November date is used to be consistent with the Smithsonian Astronomical Date Standard and other computer installations and systems. (GETTAB Table 11, Item 64).

The time of day is specified as a fraction of a day allowing the 36-bit value to be in units of days with a binary point between the right and left halves. The resolution is approximately 1/3 of a second; that is, the least significant bit (bit 35) represents approximately 1/3 of a second.

3.6.1.1 **DATE AC, or CALLI AC, 14** – A 15-bit binary integer computed by the formula

date=((year-1964)x12+(month-1))x31+day=1

represents the date.

This integer representation is returned right-justified in AC.

3.6.1.2 **TIMER AC, or CALLI AC, 22** – This UUO returns the time of day, in clock ticks (jiffies) right justified in AC. A jiffy is 1/60 of a second (16.6 milliseconds) for 60-cycle power and 1/50 of a second (20 milliseconds) for 50-cycle power. The MSTIME UUO should normally be used so that the time is not a function of the cycle.

3.6.1.3 **MSTIME AC, or CALLI AC, 23** – This UUO returns the time of day, in milliseconds, right justified in AC.

3.6.2 Job Status Information

3.6.2.1 **RUNTIME AC, or CALLI AC, 27** – The accumulated running time (in milliseconds) of the job number specified in AC is returned right justified in AC. If the job number in AC is zero, the running time of the currently running job is returned. If the job number in AC does not exist, zero is returned.

3.6.2.2 **PJOB AC, or CALLI AC, 30** – This UUO returns the job number right justified in AC.

3.6.2.3 **GETPPN AC, or CALLI AC, 24** – This UUO returns in AC the project-programmer pair of the job. The project number is a binary number in the left half of AC, and the programmer number is a binary number in the right half of AC. If the program has the JACCT bit set, a skip return is given if the old project-programmer number is also logged in on another job.

3.6.2.4 **OTHUSR AC, or CALLI AC, 77** – This UUO is used to determine if another job is logged in with the same project-programmer number as the job executing the UUO. The non-SKIP return is given if

1. the UUO is not implemented, in which case the AC remains unchanged, or
2. the UUO is implemented and no other jobs are logged in with the same project-programmer number, in which case the AC contains the project-programmer number of the job executing the UUO.

The SKIP return is given if the UUO is implemented and other jobs are logged in with the same project-programmer number. The AC contains the project-programmer number of the job executing the UUO. This UUO is used by KJOB.

3.6.3 Monitor Examination

3.6.3.1 PEEK AC, or CALLI AC, 33

This UUO allows a user program to examine any location in the monitor. It is used by SYSTAT, FILDDT, and DATDMP and could be used for on-line monitor debugging. The PEEK UUO requires bit 16 (JP.SPA – examine all of core) and/or bit 17 (JP.SPM – examine the monitor) to be set in the privilege word .GTPRV.

The call is:

```
    MOVEI AC, exec address                  ;TAKEN MODULO SIZE OF MONITOR
    PEEK AC,                                ;OR CALLI AC, 33
```

This call returns with the contents of the monitor location in AC.

NOTE
On a KI10, if the address given is equal to or larger than 340000, this UUO uses the hardware memory map to fetch the word and not the physical address.

3.6.3.2 SPY AC, or CALLI AC, 42

This UUO is used for efficient examination of the monitor during time-sharing, Any number of K of physical core (not limited to the size of the monitor) is placed into the user's logical high segment. This amount cannot be saved with the monitor SAVE command (only the low segment is saved), cannot be increased or decreased by the CORE UUO (error return taken), or cannot have the user-mode write-protect bit cleared (error return taken). The call is:

```
  MOVEI AC, highest physical core location desired
  SPY AC,                                     ; or CALLI AC, 42
    error return
    normal return
```

Any program that is written to use the SPY UUO should try the PEEK UUO if the SPY UUO receives an error return. The SPY UUO requires bit 16 (JP.SPA = examine all of core) and/or bit 17 (JP.SPM = examine the monitor) to be set in the privilege word .GTPRV.

3.6.3.3 POKE. AC, or CALLI AC, 114(1)

This UUO is used by a privileged user to alter one location in the monitor at a time. The POKE. UUO requires bit 4 (JP.POK) to be set in the privilege word .GTPRV.

The call is:

```
    MOVE AC, [3, ,ADR]
    POKE. AC,                               ; or CALLI AC, 114
    error return
    normal return
```

(1) This UUO depends on FTPOKE which is normally off in the DECsystem-1040.

```
ADR:  monitor location
      old value
      new value
```

The error return is given if:

The user is not privileged; AC contains 0.

The value specified in ADR+1 as the old value is not the same as the actual value contained in the monitor location; AC contains 1.

The address specified is not a valid monitor address; AC contains 2.

3.6.3.4 GETTAB AC, or CALLI AC, 41 – This UUO provides a mechanism which will not vary from monitor to monitor for user programs to examine the contents of certain monitor locations. The call is:

```
MOVE AC, [XWD index, table number]
GETTAB AC,                          ; or CALLI AC, 41
error return
normal return
```

The left half of AC contains a job number of some other index to a table. Some job numbers may refer to high segments of programs by using arguments greater than the highest job number for the current monitor. A LH of -1 indicates the current job number. A LH of -2 references the job's high segment. An error return is given if there is no high segment or if the hardware and software are non-reentrant. The right half of AC contains a table number from the list of monitor data tables and parameters in Table 3-1. The entries in these tables are globals in the monitor subroutine COMMON. The actual values of the core addresses of these locations are subject to change and can be found in the LOADER storage map for the monitor. The complete description of these globals is found in the listing of COMMON.

The customer is allowed to add his own GETTAB tables to the monitor. A negative right half should be used to specify such customer-added tables.

An error return leaves the AC unchanged and is given if the job number or index number in the left half of AC is too high, the table number in the right half of AC is too high, or the user does not have the privilege of accessing the specified table.

A normal return supplies the contents of the requested table in AC, or a zero if the table is not defined in the current monitor.

The SYSTAT program makes frequent use of this UUO.

NOTE

Many GETTAB tables have information in the undescribed bits. This information is likely to change and should be ignored. Although the field may currently be zero, there is no reason to believe that it will always be zero.

Table 3-1
GETTAB Tables

Table Numbers (RH of AC)	Table Names	Explanation
00	.GTSTS	Job status word; index by job or segment number.
01	.GTADR	Job relocation and protection; index by job or segment number.
02	.GTPPN	Project and programmer numbers; index by job or segment number.
03	.GTPRG	User program name; index by job or segment number.
04	.GTTIM	Total run time used in units of jiffies; index by job number. The value of a jiffy can be obtained from bit 6 of the STATES word (item 17 in the .GTCNF table).
05	.GTKCT	Kilo-Core ticks of job; index by job number.
06	.GTPRV	Privilege bits of job; index by job number, refer to Paragraph 3.6.3.4.1.
07	.GTSWP	Swapping parameters of job; index by job or segment number.
10	.GTTTY	Terminal-to-job translation; index by job number.
11	.GTCNF	Configuration table; index by item number, refer to Paragraph 3.6.3.4.2.
12	.GTNSW	Nonswapping data; index by item number, refer to Paragraph 3.6.3.4.3.
13	.GTSDT	Swapping data; index by item number, refer to Paragraph 3.6.3.4.4.
14	.GTSGN	High segment table; index by job number. Bit 0 = 0, then bits 18–35 are index of high segment (if bits 18–35 = 0, then there is no high segment). Bit 0 = 1, then bits 18–35 are number of K to spy on. Bit 1 (SN%SHR) = 1 if job has a high segment that is sharable. Bit 5 (SN%LOK) = 1 if job has a high segment that is locked.
15	.GTODP	Once-only disk parameters; index by item number, refer to Paragraph 3.6.3.4.5.
16	.GTLDV	5-series monitor disk parameters; index by item number, refer to Paragraph 3.6.3.4.6.
17	.GTRCT	Disk Blocks read by job; used by DSK commands: 1. Bits 0–11 incremental blocks 2. Bits 12–35 = total blocks since start of job. Index by job number. Job 0 indicates the number of blocks swapped in.

Table 3-1 (Cont)
GETTAB Tables

Table Numbers (RH of AC)	Table Names	Explanation
20	.GTWCT	Disk blocks written by job: 1. Bits 0–11 = incremental blocks. 2. Bits 12–35 = total blocks since start of job. Index by job number. Job 0 indicates the number of blocks swapped out.
21	.GTDBS	Reserved for future.
22	.GTTDB	Reserved for future.
23	.GTSLF	Table of GETTAB addresses (GETTAB immediate); index by GETTAB table number, refer to Paragraph 3.6.3.4.7.
24	.GTDEV	Device or file structure name of sharable high segment. Index by high segment number.
25	.GTWSN	Two-character SIXBIT names for job queues; index by item numbers, refer to Paragraph 3.6.3.4.8.
26	.GTLOC	Job's logical station; index by job number.
27	.GTCOR	Physical core allocation. One bit per one K of core if system does not include LOCK UUO. Two bits per entry if system includes LOCK UUO. A non-zero entry indicates core in use.
30	.GTCOM	Table of SIXBIT names of monitor commands.
31	.GTNM1	First half of name of user in SIXBIT; index by job number.
32	.GTNM2	Last half of name of user in SIXBIT; index by job number.
33	.GTCNO	Job's charge number; index by job number.
34	.GTTMP	Job's TMPCOR pointers; index by job number.
35	.GTWCH	Job's WATCH bits; index by job number, refer to Paragraph 3.6.3.4.9.
36	.GTSPL	Job's spooling control bits; index by job number, refer to Paragraph 3.6.3.4.10.
37	.GTRTD	Job's real-time status word; index by job number.
40	.GTLIM	Job's time limit in jiffies and Batch status; index by job number. 1. Bits 1–9 (JB.LCR) = job's core limit. 2. Bit 10 = 1 (JB.LBT) if a Batch job. 3. Bit 11 = 1 (JB.LSY) if program comes from SYS. Set on R command or equivalent. Cleared on R command (or equivalent) or SETNAM UUO. 4. Bits 12–35 (JB.LTM) = job's time limit.

Table 3-1 (Cont)
GETTAB Tables

Table Numbers (RH of AC)	Table Names	Explanation
41	.GTQQQ	Timesharing scheduler's queue headers.
42	.GTQJB	Timesharing scheduler's queue that job is in; index by job number.
43	.GTCM2	Table of SET command names.
44	.GTCRS	Status of hardware taken on a crash. 0: CR.SAP = CONI APR, 1: CR.SPI = CONI PI, 2: CR.SSW = DATAI APR The remainder of the table contains the status of the various devices.
45	.GTISC	Swapper's input scan list of queues.
46	.GTOSC	Swapper's output scan list of queues.
47	.GTSSC	Scheduler's scan list of queues.
50	.GTRSP	Response counter table. Time in jiffies when user started to wait for his job to run. This time is cleared when the job is first given to the processor by the scheduler.
51	.GTSYS	System variables which are independent of CPU. Refer to Paragraph 3.6.3.4.11.
52	.GTWHY	Operator why comments in ASCIZ.
53	.GTTRQ	Total time job was in run queues whether or not it was running.
54	.GTSPS	Job status word of second processor. Bit 29 (SP.SC0) - SET CPU command can be used. Bit 35 (SP.CR0) = SET CPU UUO can be used. Bits for other processors can be obtained by shifting left 1 bit per processor.
55	.GTC0C	CPU0 CDB constants; index by item number, refer to Paragraph 3.6.3.4.12.
56	.GTC0V	CPU0 CDB variables; index by item number, to Paragraph 3.6.3.4.13.
57	.GTC1C	CPU1 CDB constants; index by item number; see .GTC0C.
60	.GTC1V	CPU1 CDB variables; index by item number; see .GTC0V.
61	.GTC2C	CPU2 CDB constants; index by item number; see .GTC0C.
62	.GTC2V	CPU2 CDB variables; index by item number; see .GTC0V.

Table 3-1 (Cont)
GETTAB Tables

Table Numbers (RH of AC)	Table Names	Explanation
63	.GTC3C	CPU3 CDB constants; index by item number; see .GTC0C.
64	.GTC3V	CPU3 CDB variables; index by item number; see .GTC0V.
65	.GTC4C	CPU4 CDB constants; index by item number; see .GTC0C.
66	.GTC4V	CPU4 CDB variables; index by item number; see .GTC0V.
67	.GTC5C	CPU5 CDB constants; index by item number; see .GTC0C.
70	.GTC5V	CPU5 CDB variables; index by item number; see .GTC0V.
71	.GTFET	Current setting of all features defined in F.MAC, index by item number, refer to Paragraph 3.6.3.4.15.
72	.GTEDN	Table of ersatz device names (e.g., NEW, LIB). The search lists of these devices and their corresponding project-programmer numbers can be obtained from the PATH UUO.
73	.GTSCN	Contains scanner response data. Refer to Paragraph 3.6.3.4.16.
74	.GTSND	Contains last send-all message. Refer to Paragraph 3.6.3.4.17.
75	.GTCMT	SET TTY command names.
76	.GTPID	Process communication ID (IPCF).
77	.GTIPC	IPCF miscellaneous data. Refer to Paragraph 3.6.3.4.18.
100	.GTUPM	Physical page number of the user page map if indexed by JOB number. High order nine bits is the virtual page number where the high segment starts in the program's address space when indexed by the high segment number.
101	.GTCMW	SET WATCH command names.
102	.GTCVL	Current virtual limit, current physical limit.
103	.GTMVL	Maximum virtual limit, maximum physical limit.
104	.GTIPA	IPCF statistics per job.
105	.GTIPP	IPCF pointers and counts.
106	.GTIPI	PID for job's [system] INFO.
107	.GTIPQ	IPCF flags and quotas per job.
110	.GTDVL	Pointer to this job's logical name table.
111	.GTABS	Address break word.
112	.GTCMP	Reserved.

Table 3-1 (Cont)
GETTAB Tables

Table Numbers (RH of AC)	Table Names	Explanation
113	.GTVM	General virtual memory data, refer to Paragraph 3.6.3.4.19.
114	.GTVRT	Paging rate for job.

3.6.3.4.1 **Entries in Table 6 – .GTPRV (Privilege Table)**–Each job has a one-word entry to indicate job privileges. The privilege bits are as follows:

Bit	Mnemonic	Meaning
1B0	JB.IPC	Job is allowed to perform IPCF privileged functions.
3B2	JP.DPR	Highest disk priority for this job.
1B3	JP.MET	Job is allowed to execute the METER.UUO.
1B4	JP. POK	Job is allowed to execute the POKE. UUO.
1B5	JP.CCC	Job is allowed to change its CPU specification via a command or UUO.
17B9	JP.HPQ	Highest high-priority queue available to this job.
1B10	JP.NSP	Job is allowed to unspool devices.
1B13	JP.RTT	Job is allowed to execute the RTTRP UUO.
1B14	JP.LCK	Job is allowed to execute the LOCK UUO.
1B15	JP.TRP	Job is allowed to execute the TRPSET UUO.
1B16	JP.SPA	Job is allowed to PEEK and SPY on all of core.
1B17	JP.SPM	Job is allowed to PEEK and SPY on the monitor.

3.6.3.4.2 **Entries in Table 11 – .GTCNF (Configuration Table)**

Item	Location	Use
0	%CNFGO	Name of system is ASCIZ.
–		
4	%CNFG4	
5	%CNDT0	Date of system in ASCIZ.
6	%CNDT1	
7	%CNTAP	Name of system device (SIXBIT).

Item	Location	Use
10	%CNTIM	Time of day in jiffies.
11	%CNDAT	Today's date (15-bit format).
12	%CNSIZ	Highest location in monitor +1.
13	%CNOPR	Name of OPR TTY (SIXBIT)
14	%CNDEV	LH is start of DDB (device-data-block) chain.
15	%CNSJN	LH=-# of high segments, RH=+# of jobs (counting NULL job).
16	%CNTWR	Non-zero if system has two-register hardware and software.
17	%CNSTS	Location describing feature switches of this system in LH, and current state in RH. Assembled according to MONGEN dialog and S.MAC: Bit 0=1 if disk system (ST%DSK) Bit 1=1 if swap system (ST%SWP) Bit 2=1 if LOGIN system (ST%LOG) Bit 3=1 if full duplex software (ST%FTT) Bit 4=1 if privilege feature (ST%PRV) Bit 5=1 if assembled for choice of reentrant or non-reentrant software at monitor load time (ST%TWR) Bit 6=1 if clock is 50 cycle instead of 60 cycle (ST%CYC) Bits 7–9 type of disk system (ST%TDS): if 0, 4-series disk system. if 1, 5-series disk system. if 2, spooled disk. Bit 10=1 if independent programmer numbers between project (INDPPN is non-zero) (ST%IND) Bit 11=1 if image mode on terminal (8-bit SCNSER) (ST%IMG) Bit 12=1 if dual processor system (ST%DUL) Bit 13=1 if multiple RIBs supported (ST%MRB) Bit 14=1 if high precision time accounting (ST%HPT) Bit 15=1 if overhead excluded from time accounting (ST%EMO) Bit 16=1 if real-time clock (ST%RTC) Bit 17=1 if built to handle FOROTS (ST%MBF) Set by the privileged operator command, SET SCHED: Bit 27=1 means no operator is present at central site (ST%NOP) Bit 28=1 means unspooling devices (ST%MSP) Bit 29=1 means assigning devices (ST%ASS) Bit 30=1 means there are no remote TTY's (ST%NRT) Bit 33=1 means only Batch jobs may LOGIN (except from CTY or OPR) (ST%BON) Bit 34=1 means no remote LOGINs (ST%NRL) Bit 35=1 means no more LOGINs except from CTY or OPR (ST%NLG)

Item	Location	Use
20	%CNSER	Serial number of PDP-10 processor. Set by MONGEN dialog.
21	%CNNSM	Number of nanoseconds per memory cycle for memory system. If the GETTAB fails, the number of nanoseconds per memory cycle is ↑D1000. Used by SYSTAT to compute shuffling time.
22	%CNPTY	PTY parameters for Batch. LH = the number of the first invisible terminal (which is one greater than the number of the CTY) RH = the number of PTY's in the system configuration.
23	%CNFRE	AOBJN word to use bit map in monitor for allocating 4-word core blocks.
24	%CNLOC	LH=0. RH=address in monitor for free 4-word core block areas. (This is never changed while monitor runs.)
25	%CNSTB	Link to STB chain for remote Batch.
26	%CNOPL	Address of the line data block (LDB) of the operator's terminal.
27	%CNTTF	Pointer to TTY free chunks.

30	%CNTTC	LH=number of TTY chunks.
		RH=address of first TTY chunk.

31	%CNTTN	Number of free TTY chunks.
32	%CNLNS	Pointer to current TTY as seen by the command decoder.
33	%CNLNP	Pointer to examine TTY line table, including remote terminals. LH=-total number of TTY lines. RH=beginning of line table.
34	%CNVER	Version of monitor. (Stored in location 137 of monitor as a save file when monitor is not running.) Bits 0–17 reserved for customer. Bits 18–23 monitor level (e.g., 5) Bits 24–29 monitor release (e.g., 7) Bits 30–35 used for internal development. If the GETTAB fails, the monitor is a version previous to 5.03.
35	%CNDSC	Pointer to data set control table. LH = -length of table. RH= beginning of control table.
36	%CNDLS	Obsolete.
37	%CNCCI	Obsolete.
40	%CNSGT	Last dormant segment which was deleted to free a segment number.

Item	Location	Use
41	%CNPOK	Address of last location changed in monitor by the POKE.UUO.
42	%CNPUC	LH=the number of the job which last successfully executed the POKE.UUO. RH=the number of successful POKE.UUOs executed.
43	%CNWHY	The reason for the last reload (SIXBIT unabbreviated operator answer). Refer to ONCE in the DECsystem-10 Software Notebooks.
44	%CNTIC	The number of clock ticks per second. This is the time-of-day clock. The number is obtained by conducting a simple experiment of monitor load time. A different clock can be used for incremental run time accounting (refer to %CNRTC below).
45	%CNPDB	The pointer to the process data block (PDB) pointer tables.
46	%CNRTC	The run time clock rate (jiffies per second). That is, the rate of the clock used to measure the run time of the job and the system statistics (null, lost, and overhead time). This is the precision of the measurement, not the units of measurement.
47	%CNCHN	The pointer to the list of channel (DF10) data blocks. LH=the address of the 1st channel data block. RH=unused.
50	%CNLMX	LOGMAX. The maximum number of jobs allowed to LOGIN.
51	%CNBMX	BATMAX. The maximum number of Batch jobs allowed to LOGIN.
52	%CNBMN	BATMIN. The guaranteed number of Batch jobs (i.e., the number of jobs reserved for Batch).
53	%CNDTM	The host computer time in universal date/time format (refer to Paragraph 3.6.1).
54	%CNLNM	LOGNUM. The number of jobs currently logged-in.
55	%CNBNM	BATNUM. The number of Batch jobs currently logged-in.
56	%CNYER	LOCYER. The year.
57	%CNMON	LOCMON. The month (Jan = 1, Feb = 2, etc.).
60	%CNDAY	LOCDAY. The local day of the month (1, 2, 3, . . .).
61	%CNHOR	LOCHOR. The local hour in 24-hour format.
62	%CNMIN	LOCMIN Minutes (0, 1, . . . ,59).
63	%CNSEC	LOCSEC. Seconds (0, 1, . . . ,59).
64	%CNGMT	Reserved.

Item	Location	Use
65	%CNDBG	Debugging status word. Bit 0=1 System debugging (ST%DBG). Bit 1=1 Reload on debug stop code (ST%RDC). Bit 2=1 Reload on job stop code (ST%RJE) Bit 3=1 No auto reloads (SP%NAR).
66	%CNFRU	Amount of free core currently in use by the monitor.
67	%CNTCM	Number of 9-bit bytes in TTY chunks.
70	%CNCVM	Customer version number.
71	%CNDVM	DEC version number.
72	%CNDFC	Number of DF10 data channels.
73	%CNRTD	Number of real time devices.
74	%CNHPQ	Number of HPQ's.
75	%CNLDB	Offset from start of TTY DDB to LDB pointer.
76	%CNMVO	Maximum vector offset for PISYS.
77	%CNMIP	Maximum priority for PISYS (currently 0).
100	%CNMER	LH: Address of MTA0, RH: offset of MTA error RPT word.
101	%CNET1	User address of EXEC's AC T1 (for DAEMON).
102	%CNLSD	Length of short DDB.
103	%CNLLD	Length of long DDB.
104	%CNLDD	Length of disk DDB.
105	%CNEXM	Address in JOBDAT of last E/D command.
106	%CNST2	Software configuration feature indicators. 1B29 ST%NSE Non-superseding ENTER exists. 1B30 ST%MSG MSGSER (MPX channel capability) included. 1B31 ST%PSI PSISER (generalized software interrupt facility) included. 1B32 ST%IPC IPCF (interprocess communication facility) included. 1B33 ST%VMS VMSER (virtual memory option) included. 1B34 ST%MER MTA error reporting included. 1B35 ST%SSP Swap space in pages.
107	%CNPIM	Minimum condition in PISYS.
110	%CNPIL	Length in internal PIT's.
111	%CNPIA	Address of JBTPIA.
112	%CNMNT	Monitor type.

Item	Location	Use
113	%CNOCR	LH: First CDR DDB, RH: offset to card count.
114	%CNOCP	CDP (same as %CNOCR above).
115	%CNPGS	Unit of core allocation.

3.6.3.4.3 Entries in Table 12 – .GTNSW (Nonswapping Data) – With the 5.05 and later monitors, no new entries will be added to the .GTNSW table because many of the parameters in this table are dependent upon the processor used and therefore are different for each processor in a multiprocessor system. GETTAB tables 51–70 exist for new parameters as well as the .GTNSW parameters.

Item	Location	Use
0		Obsolete.
–		Unspecified data.
7		
10	%NSCMX	CORMAX. Size in words of largest legal user job (Low seg+high seg).
11	%NSCLS	Byte pointer to last free block.
12	%NSCTL	Total free+dormant+idle K physical core left (virtual core).
13	%NSSHW	Job number shuffler has stopped.
14	%NSHLF	Absolute address of job above lowest hole, 0 if no job.
15	%NSUPT	Time system has been up in jiffies.
16	%NSSHF	Total number of words shuffled by system.
17	%NSSTU	Number of job using SYS if not a disk.
20	%NSHJB	Highest job number currently assigned.
21	%NSCLW	Total number of words cleared by system.
22	%NSLST	Total number of clock ticks when null job ran and other jobs wanted to but could not because: 1. Swapped out or on way in or out. 2. Monitor waiting for I/O to stop so it can shuffle or swap. 3. Job being swapped out because of expanding core.
23	%NSMMS	Size of physical memory in words.
24	%NSTPE	Total number of user parity errors (memory) since system was loaded.
25	%NSSPE	Total number of spurious (refer to Paragraph 7.7) parity errors (memory).
26	%NSMPC	Total number of multiple parity errors (memory).

Item	Location	Use
27	%NSMPA	The absolute location of the last user mode memory parity error.
30	%NSMPW	The contents of the last user mode memory parity error.
31	%NSMPP	The user PC of the last user mode memory parity error.
32	%NSEPO	Total number of PDL OVR's at UUO level in exec mode which were not recovered.
33	%NSEPR	Number of PDL OVR's at UUO level which were recovered by assigning extended list.
34	%NSNXM	Highest legal value of CORMAX.
35	%NSKTM	Count-down time for SET KSYS UUO.
36	%NSCMN	Amount of core guaranteed to be available after locking jobs in core (CORMIN).
37	%NSABC	Count of number of address breaks handled.
40	%NSABA	Contents of data switches on last address break.
41	%NSLJR	Last job that ran if different from the current job.
42	%NSACR	Accumulated CPU response. Total number of jiffies that all users waited for their jobs to initially run after either a command was issued which ran a job (program) or terminal input was given that removed the job from a TTY input wait state.
43	%NSNCR	Number of CPU responses for all users waiting for jobs to run (refer to %NSACR above). Dividing the value of %NSACR by the value of %NSNCR gives the average response time since system startup.
44	%NSSCR	Accumulated squares of the CPU response time obtained from %NSACR.

3.6.3.4.4 Entries in Table 13 – .GTSDT (Swapping Data)

Item	Location	Use
0	%SWBGH	Number of K in biggest hole in core.
1	%SWFIN	–Job number of job being swapped out, +Job number of job being swapped in.
2	%SWFRC	Job being forced to swap out.
3	%SWFIT	Job waiting to be fit into core.
4	%SWVRT	Amount of virtual core left in system in K (initially set to number of K of swapping space).

Item	Location	Use
5	%SWERC	LH=number of swap read or write errors, RH=error bits (bits 18–21 same as status bits). + number K discarded.
6	%SWPIN	–1 if job swapped in (monitors which swap process data blocks and FTPDBS = 1) (PDBs only).

3.6.3.4.5 **Entries in Table 15 – .GTODP (Once-Only Disk Parameters)**

Item	Location	Use
0	%ODSWP	Unused, contains zero in 5-series monitors.
1	%ODK4S	K of disk words set aside for swapping on all units in active swapping list.
2	%ODPRT	In-core protect time multiples size of job in K-1.
3	%ODPRA	In-core protect time added to above result after multiply.

3.6.3.4.6 **Entries in Table 16 – . GTLVD (LEVEL-D Monitor Disk Parameters)**

Item	Location	Use
0	%LDMFD	Project-programmer number UFDs only [1,1].
1	%LDSYS	Project-programmer number for device SYS [1,4]. In 4-series monitors [1,1].
2	%LDFFA	Project-programmer number for FAILSAFE [1,2].
3	%LDHLP	Project-programmer number for SYSTAT and HELP [2,5].
4	%LDQUE	Project-programmer number for spooling programs [3,3].
5	%LDSPB	1. LH=address of first PPB block. 2. RH=address of next PPB block to be scanned.
6	%LDSTR	1. LH=address of first file structure data block. 2. RH=relative address of next file structure data block, i.e., the address within the data block which points to the actual address of the next data block.
7	%LDUNI	1. LH=address of data block of first unit in system. 2. RH=relative address of data block of next unit in system.
10	%LDSWP	1. LH=address of first unit for swapping in system. 2. RH=relative address of next unit for swapping in system.
11	%LDCRN	Number of 4-word access blocks for disk systems allocated at ONCE – only time.
12	%LDSTP	Standard file protection code (057), can be changed by installation. In 4-series monitors (055).

Item	Location	Use
13	%LDUFP	Standard UFD protection code (775), can be changed by installation. In 4-series monitors (055).
14	%LDMBN	Number of monitor buffers allocated at once-only time (2). In 4-series monitors, 1.
15	%LDQUS	SIXBIT name of file structure containing 3,3.UFD for spooling and OMOUNT queues. In 4-series monitors, DSK.
16	%LDCRP	UFD used for storing system crashes. In 4-series monitors, [10,1].
17	%LDSFD	Maximum number of nested SFD's, which the monitor allows to be created.
20	%LDSPP	Protection of spooled output files (bits 0–7).
21	%LDSYP	Standard protection for files in SYS: (155) except for files with an extension of .SYS.
22	%LDSSP	Standard protection for files in SYS: with an extension of .SYS (157).
23	%LDMNU	Maximum negative argument to USETI which reads extended RIBS.
24	%LDMXT	Maximum number of blocks transferred with one I/O operation (one IOWD). Normally 100000 but can be defined at MONGEN to be smaller so that a job doing high priority disk I/O will be locked out for a shorter period of time (since it can be locked out for as long as the channel is busy).
25	%LDNEW	Project-programmer number for experimental SYS [1,5].
26	%LDOLD	Project-programmer number for library of superseded system programs [1,3].
27	%LDUMD	Project-programmer number for user mode diagnostics [6,6].
30	%LDNDB	Default number of disk buffers in a buffer ring.
31	%LDMSL	Maximum units in A.S.L.
32	%LDALG	ALGOL library ppn [5,4].
33	%LDBLI	BLISS library ppn [5,5].
34	%LDFOR	FORTRAN library ppn [5,6].
35	%LDMAC	MACRO source library ppn [5,7].
36	%LDUNV	Universal library ppn [5,17].
37	%LDPUB	Public user software library ppn [1,6].
40	%LDTED	Text Editor library ppn [5,10].
41	%LDREL	REL file library ppn [5,11].

Item	Location	Use
42	%LDRNO	RUNOFF library ppn [5,12].
43	%LDSNO	SNOBOL library ppn [5,13].
44	%LDDOC	DOC file library ppn [5,14].
45	%LDFAI	FAIL library ppn [5,15].
46	%LDMUS	Music library ppn [5,16].
47	%LDDEC	Standard DEC software ppn [10,7].

3.6.3.4.7 Entries in Table 23 – .GTSLF (GETTAB Immediate) – This table is useful for a program that uses the SPY UUO for efficiency and needs the core address of the monitor tables. Absolute location 410 in the monitor contains the address of the beginning of this table.

The format of each entry is as follows:

LH= Bits 0–8 = maximum item number in table.
Bit 9 = data may be process data.
Bit 10 = data may be segment data.
Bits 14–17 = a monitor AC.

RH=executive-mode address of table (item 0).

Examples:

```
XWD ITEM + JBTMXL, JOBSTS
XWD ITEM + TTPMXL, TTYTAB
```

3.6.3.4.8 Entries in Table 25 – .GTWSN (Two-character SIXBIT names for job queues)

Word 0

Bits 0–11 = contain the two SIXBIT character mnemonic of job state code 0.
Bits 12–23 = contain the two SIXBIT character mnemonic of job state code 1.
Bits 24–35 = contain the two SIXBIT character mnemonic of job state code 2.

Word 1

Bits 0–11 = contain the mnemonics of job state code 3.
Bits 12–23 = contain the mnemonics of job state code 4.
Bits 24–35 = contain the mnemonics of job state code 5. etc.

The job state codes for a disk system are as follows:

RN – one of the run queues.
WS – I/O wait satisfied.
TS – TTY I/O wait satisfied.
DS – disk I/O wait satisfied.
AU – disk alter UFD wait.
MQ – disk monitor buffer wait.
DA – disk storage allocation wait.
CB – disk core block scan wait.
D1 – DECtape control wait.

D2 – second DECtape control wait.
DC – data control wait.
M1 – magnetic tape control wait.
M2 – second magnetic tape control unit
CA – core allocation wait (to be locked).
IO – I/O wait.
TI – TTY I/O wait.
DI – disk I/O wait.
PI – paging I/O wait.
SL – sleep wait.
NU – null state.
ST – stop (↑C) state.
JD – DAEMON wait.

These state codes are printed by SYSTAT. Note that SYSTAT displays other codes based on analysis, such as the following:

TO – TTY output.
↑C – job stopped.
↑W – command wait.
OW – operator wait.
HB – hibernate.

3.6.3.4.9 Entries in Table 35 – .GTWCH (WATCH Table) – Each job has a one-word entry to indicate the WATCH bits. The bits for each word are as follows:

Bit	Mnemonic	Meaning
1B1	JW.WDY	Watch time of day.
1B2	JW.WRN	Watch run time.
1B3	JW.WWT	Watch wait time.
1B4	JW.WDR	Watch disk reads.
1B5	JW.WDW	Watch disk writes.
1B6	JW.WVR	Watch versions.
1B7	JW.WMT	Watch MTA statistics.
7B11	JW.WMS	Verbosity level, which is one of the following: .JWWPR=1 prefix; .JWWOL=2 one line; .JWWPO=3 prefix, first; .JWWLG=6 long, no prefix; .JWWPL=7 prefix and long
1B9	JW.CCN	Verbosity: continuation
1B10	JW.WFL	Verbosity: first
1B11	JW.WPR	Verbosity: prefix

3.6.3.4.10 Entries in Table 36 – .GTSPL (Spooling Table) – Each job has a one-word entry to indicate the spooling control bits. These bits are as follows:

Bit	Mnemonic	Meaning
35	JS.PLP	Line printer spooling.
34	JS.PPL	Plotter spooling.
33	JS.PPT	Paper tape punch spooling.
32	JS.PCP	Card punch spooling.
31	JS.PCR	Card reader spooling.
24–26	JS.PRI	Disk priority.
0–17		Input spooling filename (3 characters). Refer to Paragraph 6.3.

3.6.3.4.11 Entries in Table 51 – .GTSYS (System Wide Data) –

Bit	Mnemonic	Use
0	%SYERR	System wide hardware error count.
1	%SYCCO	Number of times COMCNT was off.
2	%SYDEL	Disabled hardware error count.
3	%SYSPC	LH=3 letter name of last STOPCD, RH = adr +1 of last STOPCD.
4	%SYNDS	Number of DEBUG STOPCD's.
5	%SYNJS	Number of job STOPCDs.
6	%SYNCP	Number of commands processed.
7	%SYSJN	Last STOPCD – job number.
10	%SYSTN	Last STOPCD – TTY name.
11	%SYSPN	Last STOPCD – program name.
12	%SYSUU	Last STOPCD – UUO
13	%SYSUP	Last STOPCD user PC.

3.6.3.4.12 Entries in Table 55 – .GTC0C (CPU0 CDB constants table) –The items in this table correspond to the items in the constants table for each processor.

CPU1	Table 57 – .GTC1C
CPU2	Table 61 – .GTC2C
CPU3	Table 63 – .GTC3C
CPU4	Table 65 – .GTC4C
CPU5	Table 67 – .GTC5C

Item	Location	Use
0	%CCPTR	LH=pointer to next CDB, or 0 if this is the last CDB. RH=unused.
1	%CCSER	APR serial number.
2	%CCOKP	If less than or equal to zero, CPU is running ok. If greater than zero, CPU has stopped running correctly. Contents of word is the number of jiffies CPU has been stopped.
3	%CCTOS	Trap offset for KA10 interrupt locations (0 or 100).
4	%CCLOG	Logical CPU name in SIXBIT (CPUn).
5	%CCPHY	Physical CPU name in SIXBIT (CPAn, CPIn, or CP6n).
6	%CCTYP	Type of processor (LH for customers, RH for DEC) 1 (.CC166) = PDP-6 2 (.CCKAX) = KA10 3 (.CCKIX) = KI10
7	%CCMPT	Relative GETTAB pointer to memory parity bad address subtable. Refer to Paragraph 3.6.3.4.14. Bits 0–8 maximum relative entry in subtable Bits 18–35 relative address of first word in subtable in CPU variable GETTAB (GT0V). If word is 0, the subtable has been conditionally assembled out of the monitor.
10	%CCRTC	Real time clock (DK10) DDB. If word is 0, there is no real time clock on this CPU.
11	%CCRTD	Real time clock DDB if high precision time accounting. If 0, there is no high precision time accounting on this CPU.
12	%CCPAR	Relative GETTAB pointer to memory parity subtable. Refer to Paragraph 3.6.3.4.14. Bits 0–8 maximum relative entry in subtable. Bits 18–35 relative address of first word in subtable in CPU variable GETTAB (.GTC0V). If word is 0, the subtable has been conditionally assembled out of the monitor.
13	%CCRSP	Relative GETTAB pointer to response subtable. Refer to Paragraph 3.6.3.4.14. Bits 0–8 maximum relative entry in subtable. Bits 18–35 relative address of first word in subtable in CPU variable GETTAB (.GTC0V).
14	%CCDKK	Number of DK10's on this CPU.

3.6.3.4.13 Entries in Table 56 – .GTC0V (CPU0 CDB Variable Table) – The items in this table correspond to the items in the variables table for each processor.

CPU1	Table 60 – .GTC1V
CPU2	Table 62 – .GTC2V
CPU3	Table 64 – .GTC3V
CPU4	Table 66 – .GTC4V
CPU5	Table 70 – .GTC5V

Item	Location	Use
5	%CVUPT	Uptime in jiffies for this CPU.
12	%CVLST	Last time in jiffies for this CPU.
14	%CVTPE	Total memory parity error words detected during all CPU sweeps on this CPU while processor was in exec or user mode. If the system halts, this location has already been updated.
15	%CVSPE	Total spurious memory parity errors detected on this CPU (i.e., errors which did not reoccur when the CPU swept through core). Can occur on a read-pause-write which rewrites memory or on a channel-detected parity not found on the sweep (refer to %CVPCS in parity subtable).
16	%CVMPC	Multiple memory parity errors for this CPU. That is, the number of times the operator pushed CONTINUE after a serious memory parity halt. LH = 1 if serious error on this bad parity (must halt). LH is cleared on CONTINUE or STARTUP.
17	%CVMPA	Memory parity address for this CPU. That is, first bad physical memory address found when the monitor swept through core after processor or channel detected first parity error.
20	%CVMPW	Memory parity word for this CPU. That is, contents of first bad word found by monitor when it swept through core after the processor channel detected first bad parity.
21	%CVMPP	Memory parity PC for this CPU. That is, PC of last memory parity (not counting sweep through core).
27	%CVABC	Address break count on this CPU.
30	%CVABA	Address break address on this CPU.
31	%CVLJR	Last job run on this CPU including the null job.
32–34		Obsolete. Refer to items 20–23 in the Response Subtable.
35	%CVSTS	Stop timesharing on this CPU. Contains job number which performed the TRPSET UUO.

Item	Location	Use
36	%CVRUN	Operator-controlled scheduling for this CPU (OPSER: SET RUN command). Bit 0 (CV%RUN)=1 do not run jobs on this CPU.
37	%CVNUL	Null time in jiffies for this CPU.
40	%CVEDI	LH=exec PC so that offending instruction can be corrected. RH=number of exec "don't care" interrupts (i.e., user enabled APR interrupts which monitor causes (AOV, FOV).
41	%CVJOB	Current job running on this CPU (0 is null job).
42	%CVOHT	Overhead time in jiffies for this CPU. Includes clock queue processing, short command processing, swapping and scheduling decisions, and software context switching. Does not include UUO execution or I/O interrupt time, since these times are not overhead.
43	%CVEVM	(KI10 only) Maximum amount of exec virtual address space to be used for mapping user segments on a LOCK UUO.
44	%CVEVU	(KI10 only) Current amount of exec virtual address space being used for mapping user segments on a LOCK UUO.
45	%CVLLC	On a dual processor system, the count of the number of times a CPU has looped in the CPU interlock while waiting for it to be relinquished by the second CPU.
46	%CVTUC	Total number of UUOs executed on this CPU from exec and user mode.
47	%CVTJC	Total number of job context switches from one job to a different job, including the null job, on this CPU.

3.6.3.4.14 **GETTAB Subtables** – Via the GETTAB mechanism, GETTAB subtables make monitor-collected data available to user programs and, at the same time, allow the installation to decide if it wants to use more monitor table space without invalidating any user programs. These subtables are included in all systems except the DECsystem-1040. However, they may be excluded by changing the appropriate conditional assembly switches with MONGEN. It is anticipated that only installations that need the core space for other uses will decide to exclude the subtables.

To reference a subtable, the user program first does a GETTAB UUO to obtain the pointer to the subtable (refer to Paragraph 3.6.3.4.12). Then the program does a second GETTAB to get the desired item in the subtable. If the pointer is zero, the desired subtable is not included in this system.

The following example illustrates the method for obtaining the accumulated response times for CPU N for all users that waited for their jobs to initially run after TTY input was given.

```
%CCRSP==XWD 13,55           ;WORD AND TABLE NUMBER FOR RESPONSE
                            ;SUBTABLE
%CVRAI==3                   ;SUBTABLE INDEX FOR ACCUMULATED TTY
                            ;INPUT UUO
                            ;RESPONSE.
.GTCOV==56                  ;GETTAB TABLE FOR CPU0 VARIABLES
    MOVEI T1, N             ;CPU NUMBER (0,1,...,5)
    LSH T1,N                ;CONSTANTS TABLE GETTAB INDEX MOVES UP
                            ;BY TWOS.
    MOVE T2,[%CCRSP]        ;RELATIVE GETTAB POINTER WORD FOR
                            ;RESPONSE
                            ;SUBTABLE FOR CPU0.
    ADD T2,T1               ;FORM GETTAB ARGUMENT FOR CPU N.
    GETTAB T2,              ;GET RELATIVE POINTER TO RESPONSE
                            ;SUBTABLE.
      JRST NONE             ;NOT THERE (MONITOR IS ONE BEFORE 5.05)
    JUMPE T2,NONE           ;IF 0, SUBTABLE NOT INCLUDED IN THIS
                            ;LOAD OF THE MONITOR.
    ADDI T2,%CVRAI          ;FORM DESIRED INDEX IN SUBTABLE WITH
                            ;RESPECT TO VARIABLE GETTAB.
    HRL T2,T2               ;RELATIVE  ADDRESS  OF   SUBTABLE   WITH
                            ;RESPECT TO VARIABLE TABLE.
    HRRI T2,.GTCOV(T1)      ;FORM PROPER GETTAB FOR CPU VARIABLES.
    GETTAB T2,              ;GET RESPONSE TIME
      JRST NONE             ;NOT THERE.  THIS SHOULD NOT HAPPEN
                            ;SINCE
                            ;ZERO TEST ON RELATIVE POINTER
                            ;FAILED.
    HERE WITH RESPONSE IN T2
```

Response Subtable

The response subtable is pointed to by %CCRSP in the constants table for each processor. This subtable is under the conditional assembly switch FTRSP. Refer to Paragraph 3.6.3.4.3 for additional response information.

Item	Location	Use
0	%CVRSO	Accumulated TTY output UUO responses. That is, the total number of jiffies users have spent waiting for their jobs to do a TTY output UUO (on CPU0) after either a command was issued which ran a job or terminal input was given that removed the job from a TTY input wait state.
1	%CVRNO	Number of TTY output UUO responses for this CPU.
2	%CVRHO	The high-order sum of the squares of TTY output UUO responses. Used for computing standard deviation.
3	%CVRLO	The low-order part of the sum of the squares of TTY output UUO responses.
4	%CVRSI	Accumulated TTY input UUO responses for this CPU. That is, the total number of jiffies users have spent waiting for thier jobs to do a TTY input UUO (on CPU0) after either a command was issued which ran a job or terminal input was given that removed the job from a TTY input wait state.

Item	Location	Use
5	%CVRNI	Number of TTY input UUO responses for this CPU.
6	%CVRHI	The high-order sum of the squares of TTY input UUO responses. Used for computing standard deviation.
7	%CVRLI	The low-order part of the sum of the squares of TTY input UUO responses.
10	%CVRSR	Accumulated CPU quantum requeue responses. That is, total number of jiffies users spent waiting for their jobs to exceed the CPU quantum on this CPU after either a command was issued which ran a job or terminal input was given that removed the job from a TTY input wait state.
11	%CVRNR	Number of CPU quantum requeue responses for this CPU.
12	%CVRHR	The high-order sum of the squares of CPU quantum requeue response. Used for computing standard deviation.
13	%CVRLR	The low-order part of the sum of the squares of CPU quantum requeue response.
14	%CVRSX	Accumulated response terminated by the first occurrence of one of the above 3 events (TTY output, TTY input, or CPU quantum requeue).
15	%CVRNX	Number of such responses in %CVRSX.
16	%CVRHX	The high-order sum of the squares of responses in %CVRSX. Used for computing standard deviation.
17	%CVRLX	The low-order part of the sum of the squares of responses in %CVRSX.
20	%CVRSC	Accumulated CPU responses on this CPU. Total number of jiffies that users waited for their jobs to run after either a command was issued which ran a job or terminal input was given that removed the job from a TTY input state.
21	%CVRNC	Number of CPU responses for all users waiting for their jobs to run. Dividing this value into the value of %CVRSC gives the average response time since the system was started.
22	%CVRHC	The high-order part of the sum of the squares of CPU responses on this CPU.
23	%CVRLC	The low-order part of the sum of the squares of CPU responses of this CPU.

Parity Subtable

The parity table is pointed to by %CCPAR in the constants table for each processor. This subtable is under the conditional assembly switch FTMEMPAR. Refer to Paragraphs 3.6.3.4.3 and 7.7 for additional parity information.

Item	Location	Use
0	%CVPLA	Highest bad memory parity address on last sweep of memory. Used to tell operator the range of bad addresses.
1	%CVPMR	Relative address (not virtual address) in the high or low segment of the last memory parity error.
2	%CVPTS	Number of parity errors on the last sweep of core. Set to 0 at beginning of the sweep.
3	%CVPSC	Number of parity sweeps by the monitor.
4	%CVPUE	Number of user-enabled parity errors. Refer to Paragraph 3.1.3.1.
5	%CVPAA	The AND of bad addresses on the last memory parity sweep.
6	%CVPAC	The AND of bad contents on the last memory parity sweep.
7	%CVPOA	The OR of bad addresses on the last memory parity sweep.
10	%CVPOC	The OR of bad contents on the last memory parity sweep.
11	%CVPCS	Number of spurious parity errors. (The APR sweep found no bad parity but the channel had requested the sweep rather than the processor). This indicates a channel memory port problem.

Bad Address Subtable

The bad address table is pointed to by %CCMPT in the constants table for each processor. This subtable is under the conditional assembly switch FTMEMPAR and contains the bad addresses on the last memory parity sweep. It is not cleared and the number of valid entries is kept in %CVPTS in the parity subtable.

3.6.3.4.15 Entries in Table 71 – .GTFET (Feature Table) – This table provides the user with a mechanism for determining the current settings of all features defined in F.MAC.

Item	Location	Use
0	%FTUUO	Bit 24 = 1 if PSISER implemented (F%PI). Bit 25 = 1 if IPCF implemented (F%IPCF). Bit 26 = 1 if control C intercept (F%CCIN). Bit 27 = 1 if JOBSTS and CTLJOB UUOs are implemented (F%PTYU). Bit 28 = 1 if PEEK UUO implemented (F%PEEK). Bit 29 = 1 if POKE. UUO implemented (F%POKE). Bit 30 = 1 if JOB continue (F%JCON).

Item	Location	Use
0 (cont)		Bit 31 = 1 if spooling supported (F%SPL). Bit 32 = 1 if job privileges supported (F%PRV). Bit 33 = 1 if DAEMON supported (F%DAEM). Bit 34 = 1 if GETTAB exists (F%GETT). Bit 35 = 1 if 2-register relocation (F%2REL).
1	%FTRTS	Real time and scheduling features Bit 26 = 1 if virtual memory (F%VM). Bit 27 = 1 if swapper (F%SWAP). Bit 28 = 1 if shuffler (F%SHFL). Bit 29 = 1 if DK10 service (F%RTC). Bit 30 = 1 if LOCK UUO implemented (F%LOCK). Bit 31 = 1 if TRPSET UUO implemented (F%TRPS). Bit 32 = 1 if real-time traps implemented (F%RTTR). Bit 33 = 1 if SLEEP UUO implemented (F%SLEE). Bit 34 = 1 if HIBER and WAKE UUOs supported (F%HIBW). Bit 35 = 1 if high priority queues supported (F%HPQ).
2	%FTCOM	Commands Bit 23 = 1 if COMPIL commands (F%CCL). Bit 24 = 1 if COMPIL-class (F%CCLX). Bit 25 = 1 if QUEUE (F%QCOM). Bit 26 = 1 if SET UUO and command (F%SET). Bit 27 = 1 if VERSION (F%VERS). Bit 28 = 1 if Batch control file commands (F%BCOM). Bit 29 = 1 if SET DAYTIME and SET DATE (F%SEDA). Bit 30 = 1 if WATCH (F%WATC). Bit 31 = 1 if FINISH and CLOSE (F%FINI). Bit 32 = 1 if REASSIGN (F%REAS). Bit 33 = 1 if E and D (F%EXAM). Bit 34 = 1 if SEND (F%TALK). Bit 35 = 1 if ATTACH (F%ATTA).
3	%FTACC	Accounting information Bit 31 = 1 if time and core limits (F%TLIM). Bit 32 = 1 if charge number (F%CNO). Bit 33 = 1 if user name (F%UNAM). Bit 34 = 1 if kilo-core-ticks accumulation (F%KCT). Bit 35 = 1 if run-time computation (F%TIME).
4	%FTERR	Error control and internal options Bit 25 = 1 if 22 bit channel (DF10C). Bit 26 = 1 if swapping process data block (F%PDBS). Bit 27 = 1 if KI10 features at startup time (F%KI10) (always 1 since 5.06). Bit 28 = 1 if METER. UUO supported (F%METR). Bit 29 = 1 if execute-only files (F%EXON).

Item	Location	Use
4 (cont)		Bit 30 = 1 if illegal instruction message checks for KI10 instructions (F%KII).
		Bit 31 = 1 if code to load BOOTS from disk (F%BOOT).
		Bit 32 = 1 if more than one swapping device (F%2SWP).
		Bit 33 = 1 if DAEMON error logging (F%EL).
		Bit 34 = 1 if multi-processor code loaded (F%MS).
		Bit 35 = 1 if memory parity error recovery (F%MEMP).
5	%FTDEB	Debugging features
		Bit 28 = 1 if response time measurement (F%RSP).
		Bit 29 = 1 if why reload code (F%WHY).
		Bit 30 = 1 if patch space left in table (F%PATT).
		Bit 31 = 1 if back-tracking information left in COMMON (F%TRAC).
		Bit 32 = 1 if monitor halts on error (F%HALT).
		Bit 33 = 1 if redundancy checking for internal errors (F%RCHK).
		Bit 34 = 1 if monitor write-protected (F%MONP).
		Bit 35 = 1 if monitor check summing (F%CHEC).
6	%FTSTR	File structure parameters
		Bit 21 = 1 if NUL device (F%NUL).
		Bit 22 = 1 if LIB/SYS/NEW (F%LIB).
		Bit 23 = 1 if disk priority transfers (F%DPRI).
		Bit 24 = 1 if append to last block (F%APLB).
		Bit 25 = 1 if append implies read (F%AIR).
		Bit 26 = 1 if generic device search (F%GRSC).
		Bit 27 = 1 if rename cross directories (F%DRDR).
		Bit 28 = 1 if SEEK UUO (F%DSEK).
		Bit 29 = 1 if super USETI/USETO (F%DSUP).
		Bit 30 = 1 if disk quotas (F%DQTA).
		Bit 31 = 1 if multiple file structures (F%STR).
		Bit 32 = 1 if 5-series UUOs (F%5UUO).
		Bit 33 = 1 if physical-only I/O (F%PHYO).
		Bit 34 = 1 if sub-file directories (F%SFD).
		Bit 35 = 1 if STRUUO functions (F%MOUN.).
7	%FTDSK	Internal disk parameters
		Bit 21 = 1 if DEBUG CB interlock (F%CBDB).
		Bit 22 = 1 if LOGIN system (F%LOGI).
		Bit 23 = 1 if disk system (F%DISK).
		Bit 24 = 1 if race-condition prevention in FILFND (F%FREE).
		Bit 25 = 1 if swap read error recovery (F%SWPE).
		Bit 26 = 1 if bad block marking (F%DBBK).
		Bit 27 = 1 if UFD compressor (F%DUFC).
		Bit 28 = 1 if disk error simulation (F%DETS).
		Bit 29 = 1 if extended RIBs supported (F%DMRB).
		Bit 30 = 1 if smaller allocation for disk core blocks (F%DSMC).

Item	Location	Use
7 (cont)		Bit 31 = 1 if allocation optimization (F%DALC). Bit 32 = 1 if disk usage statistics (F%DSTT). Bit 33 = 1 if hung disk recovery (F%DHNG). Bit 34 = 1 if disk off-line recovery (F%DBAD). Bit 35 = 1 if latency optimization (F%DOPT).
10	%FTSCN	Scanner options Bit 24 = 1 if TYPESET-10 features in DC76 (F%TYPE). Bit 25 = 1 if 2741-like terminals supported (F%2741). Bit 26 = 1 if DC76 (F%CAFE). Bit 27 = 1 if TTY BLANK command (F%TBLK). Bit 28 = 1 if page and display knowledge (F%TPAG). Bit 29 = 1 if automatic dialer supported (F%DTAL). Bit 30 = 1 if special line control (F%SCLC). Bit 31 = 1 if hardware (DC10 or DC68) scanner (F%SCNR). Bit 32 = 1 if modem control (F%MODM). Bit 33 = 1 if single scanner 630 (F%630H). Bit 34 = 1 if U.K. modem supported (F%GPO2). Bit 35 = 1 if real half-duplex terminals (F%HDPX).
11	%FTPER	I/O Parameters Bit 25 = 1 if MSGSER implemented MPX device (F%MSGS). Bit 26 = 1 if high-speed logical device search (F%HSLN). Bit 27 = 1 if CDP trouble intercept (F%CPTR). Bit 28 = 1 if CDR trouble intercept (F%CRTR). Bit 29 = 1 if CTY1 supported (F%CTY1). Bit 30 = 1 if remote station supported (F%REM). Bit 31 = 1 if LPT error recovery (F%LPTR). Bit 32 = 1 if device errors to operator (F%OPRE). Bit 33 = 1 if CDR super-image mode (F%CDRS). Bit 34 = 1 if MTA density and buffer size (F%MTSE). Bit 35 = 1 if TMPCOR area (F%TMP).

3.6.3.4.16 **Entries in Table 73 – .GTSCN (Scanner Table)** – This table allows the user a mechanism whereby he can access the scanner response data. The items and their meanings are as follows:

Item	Location	Use
0	%SCNRI	Number of RCV Interrupts
1	%SCNXI	Number of XMT Interrupts
2	%SCNEI	Number of Echo Interrupts (subset of %SCNXI)
3	%SCNMB	Maximum buffer size.
4	%SCNAL	Number of active lines.

3.6.3.4.17 **Entries in Table 74 – .GTSND (Send-all)** – The .GTSND table contains the last send-all message with the first item in this table pointing to the beginning of the message and the second item pointing to the end of the message. Items 3 through the last items contain 9-bit bytes (4 per entry) making up the text of the send-all message. Each send-all message ends with two bytes containing 001 and 000 in that order. The table entries are as follows:

Item	Use
0	Byte pointer to first byte of message.
1	Byte pointer to last byte in message.
. . .	Message text.

3.6.3.4.18 **Entries in Table 77 – .GTIPC (IPCF Miscellaneous Data)** –

Item	Mnemonic	Use
0	%IPCML	Maximum packet length.
1	%IPCSI	PID of system-wide [SYSTEM] INFO.
2	%IPCDQ	Default quota.
3	%IPCTS	Total packets sent.
4	%IPCTO	Total packets outstanding.
5	%IPCCP	PID of [SYSTEM] IPCC.
6	%IPCPM	PID mask.
7	%IPCMP	Length of PID table.
10	%IPCNP	Number of PID's now defined.
11	%IPCTP	Total PID's defined since reload.

3.6.3.4.19 **Entries in Table 113 – .GTVM (General Virtual Memory Data)**

Item	Mnemonic	Use
0	%VMSWP	Swap count.
1	%VMSCN	Scan Count.
2	%VMSIP	Count of swaps in progress.
3	%VMSLE	Count of swap list entries.
4	%VMTTL	Total virtual memory in use.
5	%VMCMX	Maximum value of %VMTTL allowed.
6	%VMRMX	Paging rate max for system.
7	%VMCON	Constant used in swap rate computation.

Item	Mnemonic	Use
10	%VMQJB	Job to requeue to PQV (–1 if all)
11	%VMRMJ	Paging rate maximum per job.
12	%VMTLF	Time of last fault.
13	%VMSPF	System page fault counts: LH = not in working set. RH = in working set.
14	%VMSW1	Address of SWPLST
15	%VMSW2	Address of SW2LST
16	%VMSW3	Address of SW3LST

3.6.4 Configuration Information

3.6.4.1 **SWITCH AC, or CALLI AC, 20** – This UUO returns the contents of the central processor data switches n AC. Caution must be exercised in using the data switches because they are not an allocated resource and are always available to all users.

3.6.4.2 **LIGHTS AC, or CALLI AC, –1** – This UUO displays the contents of AC in the console lights.

3.7 DAEMON AC, OR CALLI AC, 102(1)

This UUO requests the DAEMON program to perform a specified function for the user program. The call is:

```
          MOVE AC, [XWD length(n+1), ADR]
          DAEMON AC,                          ; or CALLI AC, 102
          error return
          normal return

     ADR: function
          arg1
          arg2
            .
            .
            .
          arg (n)
```

The length of the argument list can be zero if the number of arguments is fixed. The first word of the argument list is the code for the requested function. Non-privileged functions of the DAEMON UUO are presented in the following paragraphs. Refer to the Specifications section of the DECsystem-10 Software Notebooks for a description of the privileged functions.

(1) This UUO depends on FTDAEM which is normally off in the DECsystem-1040.

3.7.1 .DCORE Function

This function causes DAEMON to write a dump file of the job's core area. The call is:

```
ADR:  1                                  ; .DCORE function
      SIXBIT/dev/
      SIXBIT/file/
      SIXBIT/ext/
      0
      XWD ppn
      SIXBIT/SFD1/
         .
         .
         .
      SIXBIT/SFDN/
```

If an argument is omitted, the default is the same as in the DCORE command (refer to DECsystem-10 Operating System Commands).

3.7.2 .CLOCK Function

This function causes DAEMON to enter a request in the clock queue in order to awake the job after the specified number of seconds has elapsed. The UUO returns as soon as the request is entered. The HIBER UUO with no clock request (refer to Paragraph 3.1.4.2) should then be used to place the job in the sleep queue.

The call is:

```
        MOVEI AC, BLOCK
        DAEMON AC,
          JRST ERROR
        SETZ AC,
        HIBER AC,
          JRST ERROR

ERROR:  . . .                            ; simulate the DAEMON UUO
                                         ; with the SLEEP UUO.
BLOCK:  2                                ; .CLOCK function
        +seconds                         ; number of seconds to
                                         ; sleep.
```

If the job already has a request in the clock queue, the new request supersedes the current request. Thus, jobs desiring to be awakened several times should issue one request for the soonest wake time.

There is no maximum on the amount of time a job can sleep and therefore, this UUO is useful when a sleep time of more than 63 seconds is desired (the SLEEP and HIBER UUOs have an implied maximum of 63 seconds). A request specifying 0 seconds clears the job's entry in the clock queue and immediately wakes the job. Note that the resolution of the timer may be several seconds slow if the system is heavily loaded.

3.7.3 Returns

The error return is given if the UUO is not implemented, DAEMON is not running, or DAEMON cannot complete the requested function. If the UUO is not implemented or DAEMON is not running, AC remains unchanged. If DAEMON cannot complete the request, AC contains one of the following error codes:

Item	Location	Use
1	DMILF%	Illegal function.
2	DMACK%	Address check. The argument block is outside of user core or in the job data area.
3	DMWNA%	Wrong number of arguments.
4	DMSNH%	Impossible UUO failure (should never happen).
5	DMCWF%	Cannot write file. An OPEN or INIT failed.
6	DMNPV%	No privileges. An attempt was made to write in the accounting files without having the proper privileges.
7	DMFFB%	FACT format is bad.
10	DMPTH%	Invalid path specification.

The normal return is taken if the requested function is successfully completed.

3.8 REAL-TIME PROGRAMMING

3.8.1 RTTRP AC, or CALLI AC, 57(1)

The real-time trapping UUO is set by timesharing users to dynamically connect real-time devices to the priority interrupt system, to respond to these devices at interrupt level, to remove the devices from the interrupt system, and to change the PI level on which the devices are associated. The RTTRP UUO can be called from UUO level or from interrupt level. This is a privileged UUO that requires the job to have real-time privileges (granted by LOGIN) and to be locked in core (accomplished by LOCK UUO). These real-time privileges are assigned by the system manager and obtained by the monitor from ACCT.SYS. The privilege bits required are:

1. JP.LCK (Bit 14) – allows the job to be locked in core.
2. JP.RTT (Bit 13) – allows the RTTRP UUO to be executed.

WARNING

Improper use of features of the RTTRP UUO can cause the system to fail in a number of ways. Since design goals of this UUO were to give the user as much flexibility as possible, some system integrity had to be sacrificed. The most common errors are protected against since user programs run in user mode with all ACs saved. It is recommended that debugging of real-time programs not be done when system integrity is important. However, once these programs are debugged, they can run simultaneously with batch and timesharing programs.

(1) This UUO depends on FTRTTRP which is normally off in the DECsystem-1040.

Real-time jobs control devices one of two ways: block mode or single mode. In block mode, an entire block of data is read before the user's interrupt program is run. In single mode, the user's interrupt program is run every time the device interrupts. Furthermore, there are two types of block mode: fast block mode and normal block mode. These differ in response time. The response time to read a block of data in fast block mode is 6.5 sec per word and in normal block mode, 14.6 sec per word. (This is the CPU time to complete each data transfer.) In all modes, the response time measured from the receipt of the real-time device interrupt to the start of the user control program is 100 sec.

The RTTRP UUO allows a real-time job to either put a BLKI or BLKO instruction directly on a PI level (block mode) or add a device to the front of the monitor PI channel CONSO skip chain (single mode). Since the BLKI and BLKO are executed in exec mode, a KI10-based system requires that the job be mapped in exec virtual memory, in addition to being locked (refer to the LOCK UUO). When an interrupt occurs from the real-time device in single mode or at the end of a block of data in block mode, the monitor saves the current state of the machine, sets the new user virtual memory and APR flags, and traps to the user's interrupt routine. The user services his device and then returns control to the monitor to restore the previous state of the machine and to dismiss the interrupt.

In fast block mode the monitor places the BLKI/BLKO instruction directly in the PI trap location followed by a JSR to the context switcher. This action requires that the PI channel be dedicated to the real-time job during any transfers. In normal block mode the monitor places the BLKI/BLKO instruction directly after the real-time device's CONSO instruction in the CONSO skip chain (refer to Chapter 7).

Any number of real-time devices using either single mode or normal block mode can be placed on any available PI channel. The average extra overhead for each real-time device on the same channel is 5.5 sec per interrupt.

The call is:

```
        MOVEI AC, RTBLK         ; AC contains address of data block.
        RTTRP AC,               ; or CALLI AC, 57, put device on PI level.
        error return            ; AC contains an error code.
        normal return           ; PI is set up properly.
```

The data block depends on the mode used. In single mode the data block is:

```
RTBLK:      XWD PICHL, TRPADR       ;PI channel (1-6) and trap
                                    ;address.
            EXP APRTRP              ;APR trap address.
            CONSO DEV, BITS         ;CONSO chain instruction.
            0                       ;no BLKI/BLKO instruction.
```

The data block in fast block mode is:

```
RTBLK:      XWD PICHL, TRPADR       ;PI and trap address when BLKO
                                    ;done.
            EXP APRTRP              ;APR trap address.
            BLKO DEV, BLKADR        ;BLKI or BLKO instruction.
            0                       ;BLKADR points to the IOWD of
                                    ;block to be sent.
```

The data block in normal block mode is:

```
RTBLK:      XWD PICHL, TRPADR        ;channel and trap address.
            EXP APRTRP               ;APR trap address.
            CONSO DEV, @BITMSK       ;control bit mask from user
                                     ;area.
            BLKI DEV, BLKADR         ;BLKI instruction.
```

On multiprocessor systems, the real-time trap UUO applies only to the processor specified by the job's CPU specification (refer to the SET CPU command or the SET UUO). If the specification indicates more than one processor, the specification is changed to indicate CPU0. Note that the PI channel (PICHL) and processor traps (APRTRP) are only for the indicated CPU.

3.8.1.1 **Data Block Mnemonics** – The following mnemonics are used in describing the data block associated with the RTTRP UUO.

PICHL – PICHL is the PI level on which the device is to be placed. Levels 1–6 are legal depending on the system configuration. If PICHL = 0, all occurrences of the device whose device code is specified in the CONSO instruction are removed from all levels. When a device is placed on a PI level, normally all other occurrences of the device on any PI level are removed. If the user desires the same device on more than one PI level simultaneously (i.e., a data level and an error level), he can issue the RTTRP UUO with PICHL negative. This indicates to the system that any other occurrence of this device (on any PI level) is not to be removed. Note that this addition to a PI level counts as a real-time device, occupying one of the possible real-time device slots.

TRPADR – TRPADR is the location trapped to by the real-time interrupt (JRST TRPADR). Before the trap occurs, all ACs are saved by the monitor and can be overwritten without concern for their contents.

APRTRP – APRTRP is the trap location for all APR traps. When an APR trap occurs, the monitor simulates a JSR APRTRP. The user gains control from an APR trap on the same PI level that his real-time device is on. The monitor always traps to the user program on illegal memory references; nonexistent memory references, and push-down overflows. This allows the user to properly turn off his real-time device if needed. The monitor also traps on the conditions specified by the APRENB UUO (see Paragraph 3.1.3.1). No APR errors are detected if the interrupt routine is on a PI level higher than or equal to the APR interrupt level.

DEV – DEV is a real-time device code.

BITS – BITS is the bit mask of all interrupt bits of the real-time device and must not contain any other bits. If the user desires control of this bit mask from his user area, he may specify one level of indirection in the CONSO instruction (no indexing), i.e., CONSO DEV, @ MASK where MASK is the location in the user area of the bit mask. MASK must not have any bits set in the indirect or index fields.

BLKADR – BLKADR is the address in the user's area of the BLKI/BLKO pointer word. Before returning to the user, the monitor adds the proper relocation factor to the right half of the pointer word. Data can only be read into the low segment above the protected job area, i.e., above location 114.

Since the pointer word is in the user's area, the user can set up a new pointer word when the word count goes to 0 at interrupt level. This allows fast switching between buffers. When the user desires to set up his own pointer word, the right half of the word must be set as an exec virtual instead of a user virtual address. The job's relocation value is returned from both the LOCK UUO and the first RTTRP UUO executed for setting the BLKI/BLKO instruction. If this pointer word does not contain a legal address, a portion of the system might be overwritten. A check should be made to determine if the negative word count in the left half of the pointer word is too large. If the word count extends beyond the user's own area, the device may cause a nonexistent memory interrupt, or may overwrite a timesharing job. If all of the above precautions are taken, this method of setting up the pointer word is much faster and more flexible than issuing the RTTRP UUO at interrupt level.

3.8.1.2 Interrupt Level Use of RTTRP – The format of the RTTRP UUO at interrupt level is similar to the format at user level except for two restrictions:

1. AC 16 and AC 17 cannot be used in the UUO call (i.e., CALLI 16, 57 is illegal at interrupt level).
2. All ACs are overwritten when the UUO is executed at interrupt level. Therefore, the user must save any desired ACs before issuing the RTTRP UUO. This restriction is used to save time at interrupt level.

CAUTION

If an interrupt level routine executes a RTTRP UUO that affects the device currently being serviced, no additional UUOs of any kind (including RTTRP and WAKE) can be executed during the remainder of the interrupt. At this point, any subsequent UUO dismisses the interrupt.

3.8.1.3 RTTRP Returns – On a normal return, the job is given user IOT privileges. These privileges allow the user to execute all restricted instructions including the necessary I/O instructions to control his device.

The IOT privilege must be used with caution because improper use of the I/O instructions could halt the system (i.e., HALT on the KA10; CONOAPR, 0; DATAO APR, 0; CONO PI, 0 on the KA10 and KI10; and CONO PAG, 0 or DATAO PAG, 0 on the KI10). Note that a user can obtain just the user IOT privilege by issuing the RTTRP UUO with PICHL = 0.

An error return is not given to the user until RTTRP scans the entire data block to find as many errors as possible. On return, AC may contain the following error codes.

Name	Code	Value	Meaning
RTJNP%	Bit 24 = 1	4000	Job not privileged.
RTNC0%	Bit 25 = 1	2000	Not runnable on CPU0.
RTDIU%	Bit 26 = 1	1000	Device already in use by another job.
RTIAU%	Bit 27 = 1	400	Illegal AC used during RTTRP UUO at interrupt level.
RTJNL%	Bit 28 = 1	200	Job not locked in core.
RTSLE%	Bit 29 = 1	100	System limit for real-time devices exceeded.
RTILF%	Bit 30 = 1	40	Illegal format of CONSO, BLKO, or BLKI instruction.
RTPWI%	Bit 31 = 1	20	BLKADR or pointer word illegal.
RTEAB%	Bit 32 = 1	10	Error address out of bounds.
RTTAB%	Bit 33 = 1	4	Trap address out of bounds.
RTPNB%	Bit 34 = 1	2	PI channel not currently available for BLKI/BLKO's.
RTPNA%	Bit 35 = 1	1	PI channel not available (restricted use by system).

3.8.1.4 **Restrictions** –

1. Devices may be chained onto any PI channel that is not used for BLKI/BLKO instructions by the system or by other real-time users using fast block mode. This includes the APR channel. Normally PI levels 1 and 2 are reserved by the system for magnetic tapes and DECtapes. PI level 7 is always reserved for the system.

2. Each device must be chained onto a PI level before the user program issues the CONO DEV, PIA to set the device onto the interrupt level. Failure to observe this rule or failure to set the device on the same PI level that was specified in the RTTRP UUO could hang the system.

3. If the CONSO bit mask is set up and one of the corresponding flags in a device is on, but the device has not been physically put on its proper PI level, a trap may occur to the user's interrupt service routine. This occurs because there is a CONSO skip chain for each PI level, and if another device interrupts whose CONSO instruction is further down the chain than that of the real-time device, the CONSO associated with the real-time device is executed. If one of the hardware device flags is set and the corresponding bit in the CONSO bit mask is set, the CONSO skips and a trap occurs to the user program even though the real-time device was not causing the interrupt on that channel. To avoid this situation the user can keep the CONSO bit mask in his user area (refer to Paragraph 3.8.1.1). This procedure allows the user to chain a device onto the interrupt level, keeping the CONSO bit mask zero until the device is actually put on the proper PI level with a CONSO instruction. This situation never arises if the device flags are turned off until the CONO DEV, PIA can be executed.

4. The user should guard against putting programs on high priority interrupt levels which execute for long periods of time. These programs could cause real-time programs at lower levels to lose data.

5. The user program must not change any locations in the protected job data area (locations 20–114), because the user is running at interrupt level and full context switching is not performed.

6. If the user is using the BLKI/BLKO feature, he must restore the BLKI/BLKO pointer word before dismissing any end-of-block interrupts. This is accomplished with another RTTRP UUO or by directly modifying the absolute pointer word supplied by the first RTTRP UUO. Failure to reset the pointer word could cause the device to overwrite all of memory.

3.8.1.5 **Removing Devices from a PI Channel** – When PICHL=0 in the data block (see Paragraph 3.8.1.1), all occurrences of the device specified in the CONSO instruction are removed from the interrupt system. If the user removes a device from a PI chain, he must also remove the device from the PI level (CONO DEV, 0).

A RESET, EXIT, or RUN UUO from the timesharing levels removes all devices from the interrupt levels (see Paragraph 3.2.2.4). These UUOs cause a CONO DEV, 0 to be executed before the device is removed. Monitor commands that issue implicit RESETS also remove real-time devices (e.g., R, RUN, GET, CORE 0, SAVE, SSAVE).

3.8.1.6 **Dismissing the Interrupt** – The user program must always dismiss the interrupt in order to allow monitor to properly restore the state of the machine. The interrupt may be dismissed with any UUO other than the RTTRP or WAKE UUO or, on the KA10, any instruction that traps to absolute location 60. The standard method of dismissing the interrupt is with a UJEN instruction (op code 100). This instruction gives the fastest possible dismissal.

3.8.1.7 Examples

```
                    *********** EXAMPLE 1 ***********
                              SINGLE MODE


        TITLE RTSNGL - PAPER TAPE READ TEST USING CONSO CHAIN

        PIOFF=400                ;TURN PI SYSTEM OFF
        PION=200                 ;TURN PI SYSTEM ON
        TAPE=400                 ;NO MORE TAPE IN READER IF TAPE=0
        BUSY=20                  ;DEVICE IS BUSY READING
        DONE=10                  ;A CHARACTER HAS BEEN READ

PDATA:  Z                        ;LOCATION WHERE DATA IS READ INTO

PTRTST: RESET                    ;RESET THE PROGRAM
        MOVE [XWD 1,1]           ;LOCK BOTH HIGH AND LOW SEGMENTS
        LOCK                     ;LOCK THE JOB IN CORE
        JRST FAILED              ;LOCK UUO FAILED
        SETZM PTRCSO             ;MAKE SURE CONSO BITS ARE ZERO
        SETZM DONFLG             ;INITIALIZE DONE FLAG
        MOVEI RTBLK              ;GET ADDRESS OF REAL TIME DATA BLOCK
        RTTRP                    ;PUT REAL TIME DEVICE ON THE PI LEVEL
        JRST FAILED              ;RTTRP UUO FAILED
        MOVEI 1,DONE             ;SET UP CONSO BIT MASK
        HLRZ 2,RTBLK             ;GET PI NUMBER FROM RTBLK
        TRO 2,BUSY               ;SET UP CONSO BITS TO START TAPE GOING
        CONO PI,PIOFF            ;GUARD AGAINST ANY INTERRUPTS
        MOVEM 1,PTRCSO           ;STORE CONSO BIT MASK
        CONO PTR,(2)             ;TURN PTR ON
        CONO PI,PION             ;ALLOW INTERRUPT AGAIN
        MOVEI 5                  ;SET UP TO SLEEP FOR 5 SECONDS
        SLEEP
        SKIPN DONFLG             ;HAVE WE FINISHED READING THE TAPE
        JRST .-3                 ;NO GO BACK TO SLEEP
        EXIT

RTBLK:  XWD 5,TRPADR             ;PI CHANNEL AND TRAP ADDRESS
        EXP APRTRP               ;APR ERROR TRAP ADDRESS
        CONSO PTR,@PTRCSO        ;INDIRECT CONSO BIT MASK - PTRCSO
        Z                        ;NO BLKI/O INSTRUCTION
PTRCSO: Z                        ;CONSO BIT MASK
DONFLG: Z                        ;PI LEVEL TO USER LEVEL COMM.
RTBLK1: Z                        ;DATA BLOCK TO REMOVE PTR
        Z                        ;FROM PI CHANNEL
        CONSO PTR,0
        Z

TRPADR: CONSO PTR,TAPE           ;END OF TAPE?
        JRST TDONE               ;YES, GO STOP JOB
        DATAI PTR,PDATA          ;READ IN DATA WORD
        UJEN                     ;DISMISS THE INTERRUPT

APRTRP: Z                        ;APR ERROR TRAP ADDRESS
TDONE:  MOVEI RTBLK1             ;SET UP TO REMOVE PTR
        CONO PTR,0               ;TAKE DEVICE OFF HARDWARE PI LEVEL
        RTTRP                    ;REMOVE FROM SOFTWARE PI LEVEL
        JFCL                     ;IGNORE ERRORS
        SETOM DONFLG             ;MARK THAT READ IS OVER
        SETZM PTRCSO             ;CLEAR CONSO BIT MASK
        UJEN                     ;DISMISS THE INTERRUPT
```

```
  FAILED: TTCALL 3,[ASCIZ/RTTRP UUO FAILED!/]
          EXIT

          END PTRTST
```

```
                    ********** EXAMPLE 2 **********
                           FAST BLOCK MODE


        TITLE RTFBLK - PAPER TAPE READ TEST IN BLKI MODE

        TAPE=400                  ;NO MORE TAPE IN READER IF TAPE=0
        BUSY=20                   ;DEVICE IS BUSY READING
        DONE=10                   ;A CHARACTER HAS BEEN READ

BLKTST: RESET                     ;RESET THE PROGRAM
        MOVE [XWD 1,1]            ;LOCK BOTH HIGH AND LOW SEGMENTS
        LOCK                      ;LOCK THE JOB IN CORE
        JRST FAILED               ;LOCK UUO FAILED
        SETZM DONFLG              ;INITAILIZE DONE FLAG
        MOVEI RTBLK               ;GET ADDRESS OF REAL TIME DATA BLOCK
        RTTRP                     ;PUT REAL TIME DEVICE ON THE PI LEVEL
        JRST FAILED               ;RTTTP UUO FAILED
        HLRZ 2,RTBLK              ;GET PI NUMBER FROM RTBLK
        TRO 2,BUSY                ;SET UP CONO BITS TO START TAPE GOING
        CONO PTR,(2)              ;TURN PTR ON
        MOVEI 5                   ;SETUP TO SLEEP FOR 5 SECONDS
        SLEEP
        SKIPN DONFLG              ;HAVE WE FINISHED READING THE TAPE
        JRST .-3                  ;NO GO BACK TO SLEEP
        EXIT

RTBLK:  XWD 6,TRPADR              ;PI CHANNEL AND TRAP ADDRESS
        EXP APRTRP                ;APR ERROR TRAP ADDRESS
        BLKI PTR,POINTR           ;READ A BLOCK AT A TIME
        Z

POINTR: IOWD 5,TABLE              ;POINTER FOR BLKI INSTRUCTION
OPOINT: IOWD 5,TABLE              ;ORIGINAL POINTER WORD FOR BLKI
TABLE:  BLOCK 5                   ;TABLE AREA FOR DATA BEING READ
DONFLG: Z                         ;PI LEVEL TO USER LEVEL COMM.
RTBLK1: Z                         ;DATA BLOCK TO REMOVE PTR
        Z                         ;FROM PI CHANNEL
        CONSO PTR,0
        Z

TRPADR: CONSO PTR,TAPE            ;END OF TAPE?
        JRST TDONE                ;YES, GO STOP JOB
        MOVE OPOINT               ;GET ORIGINAL POINTER WORD
        MOVEM POINTR              ;RESTORE BLKI POINTER WORD
        UJEN                      ;DISMISS THE INTERRUPT

APRTRP: Z                         ;APR ERROR TRAP ADDRESS
TDONE:  MOVEI RTBLK1              ;SETUP TO REMOVE PTR
        CONO PTR,0                ;TAKE DEVICE OFF HARDWARE PI LEVEL
        RTTRP                     ;REMOVE FROM SOFTWARE PI LEVEL
        JFCL                      ;IGNORE ERRORS
        SETOM DONFLG              ;MARK THAT READ IS OVER
        UJEN                      ;DISMISS THE INTERRUPT

FAILED: TTCALL 3,[ASCIZ/RTTRP UUO FAILED!/]
        EXIT

END BLKTST
```

```
                         ********** EXAMPLE 3 **********
                               NORMAL BLOCK MODE

        TITLE RTNBLK - PAPER TAPE READ TEST IN BLKI MODE

        TAPE=400                ;NO MORE TAPE IN READER IF TAPE=0
        BUSY=20                 ;DEVICE IS BUSY READING
        DONE=10                 ;A CHARACTER HAS BEEN READ

BLKTST: RESET                   ;IO RESET
        MOVE [XWD 1,1]          ;LOCK BOTH HIGH AND LOW SEGMENTS
        LOCK                    ;LOCK THE JOB IN CORE
        JRST FAILED             ;LOCK UUO FAILED
        MOVEI RTBLK1            ;GET ADDRESS OF REAL TIME BLOCK
        RTTRP                   ;GET USER IOT PRIVILEGE
        JRST FAILED             ;UUO FAILED!
        CONO PTR,0              ;CLEAR ALL PTR FLAGS
        SETZM DONFLG            ;INITIALIZE DONE FLAG
        MOVEI RTBLK             ;GET ADDRESS OF REAL TIME DATA BLOCK
        RTTRP                   ;PUT REAL TIME DEVICE ON THE PI LEVEL
        JRST FAILED             ;RTTRP UUO FAILED
        MOVE POINTR             ;GET RELOCATED POINTER WORD FOR LATER
        MOVEM OPOINT            ;STORE FOR INTERRUPT LEVEL USE
        HLRZ 2,RTBLK            ;GET PI NUMBER FROM RTBLK
        TRO 2,BUSY              ;SET UP CONO BITS TO START TAPE GOING
        CONO PTR,(2)            ;TURN PTR ON
        MOVEI 5                 ;SET UP TO SLEEP FOR 5 SECONDS
        SLEEP
        SKIPN DONFLG            ;HAVE WE FINISHED READING THE TAPE
        JRST .-3                ;NO GO BACK TO SLEEP
        EXIT

RTBLK:  XWD 6,TRPADR            ;PI CHANNEL AND TRAP ADDRESS
        EXP APRTRP              ;APR ERROR TRAP ADDRESS
        CONSO PTR,DONE          ;WAIT ONLY FOR DONE FLAG
        BLKI PTR,POINTR         ;READ A BLOCK AT A TIME

POINTR: IOWD 5,TABLE            ;POINTER FOR BLKI INSTRUCTION
OPOINT: Z
TABLE:  BLOCK 5                 ;TABLE AREA FOR DATA BEING READ
DONFLG: Z                       ;PI LEVEL TO USER LEVEL COMM.
RTBLK1: Z                       ;DATA BLOCK TO REMOVE PTR
        Z                       ;FROM PI CHANNEL
        CONSO PTR,0
        Z

TRPADR: CONSO PTR,TAPE          ;END OF TAPE?
        JRST TDONE              ;YES, GO STOP JOB
        MOVE OPOINT             ;GET ORIGINAL POINTER LOCATION
        MOVEM POINTR            ;STORE IN POINTER LOCATION
        UJEN                    ;DISMISS THE INTERRUPT

APRTRP: Z                       ;APR ERROR TRAP ADDRESS
TDONE:  MOVEI RTBLK1            ;SET UP TO REMOVE PTR
        CONO PTR,0              ;TAKE DEVICE OFF HARDWARE PI LEVEL
        RTTRP                   ;REMOVE FROM SOFTWARE PI LEVEL
        JFCL                    ;IGNORE ERRORS
        SETOM DONFLG                ;MARK THAT READ IS OVER
        UJEN                        ;DISMISS THE INTERRUPT

FAILED: TTCALL 3,[ASCIZ/RTTRP UUO FAILED!/]
        EXIT

        END BKJTST
```

3.8.2 RTTRP Executive Mode Trapping

In special cases, the real-time user requires a faster response time than that offered by the RTTRP UUO when executed in user mode. To accommodate these cases, the user can specify a special status bit in the RTTRP UUO call, which gives the program control in exec mode (refer to Paragraph 2.1.3). Exec-mode trapping gives response times of less than 10 sec to real-time interrupts. To use this exec-mode trapping, the job must have real-time privileges (granted by LOGIN) and be locked in core (accomplished by the LOCK UUO). On KI10 based systems, the job must also be mapped contiguously in exec virtual memory (refer to the LOCK UUO). The privilege bits required are:

1. JP.TRP (Bit 15)
2. JP.LCK (Bit 14)
3. JP.RTT (Bit 13)

Several restrictions must be placed on user programs in order to achieve this level of response. On receipt of an interrupt, program control is transferred to the user's real-time program without saving ACs and with the processor in exec mode. Therefore, the user program must save and restore all ACs that are used, must not execute any UUOs, and cannot leave exec mode. This means that the programs must be self-relocating (i.e., through the use of an index or base register).

CAUTION

Improper use of the exec mode feature of the RTTRP UUO can cause the system to fail in a number of ways. Unlike the user mode feature of RTTRP, errors are not protected against since the programs run in exec mode with no ACs saved.

To specify RTTRP exec-mode trapping, bit 17 of the second word in the data block (RTBLK) must be set to 1. This implies that no context switching is to be done and that a JSR TRPADR is to be used to enter the user's real-time interrupt routine. The user program must save and restore all ACs and should dismiss the interrupt with a JRSTF @ TRPADR. This instruction must be set up prior to the start of the real-time device as an absolute or unrelocated instruction. This can be done because the LOCK UUO returns the absolute addresses of the low and high segments after the job is locked in a fixed place in memory.

The exec-mode trapping feature can be used with any of the standard forms of the RTTRP UUO: single mode, normal mode, and fast block mode.

3.8.2.1 Example –

```
        TITLE RTEXEC

        PIA=5
        DONE=10
        BUSY=20
        TAPE=400
        I=1
        AC=2
        OPDEF HIBERNATE [CALLI 72]

RTEXEC: RESET                   ;RESET THE PROGRAM
        SETZM DONFLG            ;INITIALIZE THE DONE FLAG
        MOVE AC,[XWD 1,1]
        LOCK AC,                ;LOCK THE JOB IN CORE
                                ;ABSOLUTE ADDRESS OF JOB IS RETURNED
                                ;IN AC
        JRST FAILED                ;ERROR RETURN
        HRRZS AC                   ;GET ONLY LOW SEGMENT ADDRESS
        LSH AC,9                   ;JUSTIFY ADDRESS
        MOVEM AC,INDEX             ;SAVE BASE ADDRESS FOR USE AT
                                   ;INTERRUPT LEVEL
        ADDM AC,EXCHWD             ;RELOCATE INTERRUPT LEVEL PROGRAM
        ADDM AC,JENWD              ;RELOCATE RETURN INSTRUCTION
        MOVEI AC,RTBLK             ;CONNECT REAL TIME DEVICE
        RTTRP AC,                  ;TO THE PI SYSTEM
        JRST FAILED                ;RTTRP UUO FAILED
        CONO PTR,20+PIA            ;START REAL TIME DEVICE READING
SLEEP:  MOVEI AC,^D1000            ;SLEEP
        HIBERNATE AC,              ;FOR 10 MILLISECONDS
        JRST FAILED                ;FAILED
        SKIPN DONFLG               ;IS THE INTERRUPT LEVEL PROGRAM DONE
        JRST SLEEP                 ;NO, GO BACK TO SLEEP
        EXIT                       ;YES, EXIT

RTBLK:  XWD PIA,TRPADR
        XWD 1,APRTRP               ;BIT 17 SAYS TRAP IN EXEC MODE
        CONSO PTR,DONE
        0

TRPADR: 0                          ;JSR TRPADR IS DONE UPON INTERRUPT
EXCHWD: EXCH I,INDEX               ;SET UP INDEX REGISTER
        CONSO PTR,TAPE             ;TAPE FINISHED?
        JRST TDONE(I)              ;YES, STOP THE READER
        DATAI PTR,PDATA(I)         ;NO, READ IN THE NEXT CHARACTER
RETURN: EXCH I,INDEX(I)            ;RESTORE AC'S USED
JENWD:  JRSTF @TRPADR              ;DISMISS THE INTERRUPT

APRTRP: 0                          ;APR ERRORS WILL TRAP HERE
TDONE:  CONO PTR,0                 ;TAKE THE READER OFF LINE
        SETOM DONFLG(I)            ;MARK THAT THE TAPE IS FINISHED
        JRST RETURN(I)             ;GO DISMISS THE INTERRUPT

FAILED: TTCALL 3,[ASCIZ/UUO FAILURE/]
        EXIT

DONFLG: 0                          ;FLAG TO SPECIFY END OF JOB
PDATA:  0                          ;DATA WORD
INDEX:  0                          ;BASE INDEX REGISTER

END RTEXEC
```

3.8.3 TRPSET AC, or CALLI AC, 25(1)

The TRPSET feature may be used to guarantee some of the fast response requirements of real-time users. In order to achieve fast response to interrupts, this feature temporarily suspends the running of other jobs during its use. This limits the class of problems to be solved to cases where the user wants to transfer data in short bursts at predefined times. Therefore, because the data transfers are short, the time during which timesharing is stopped is also short, and the pause probably will not be noticed by the timesharing users.

The TRPSET UUO allows the user program to gain control of the interrupt locations. If the user does not have the TRPSET privileges (JP.TRP, bit 15), an error return to the next location after the CALLI is always given, and the user remains in user mode. Timesharing is turned back on. If the user has the TRPSET privileges, the central processor is placed in user I/O mode. If AC contains zero, timesharing is turned on if it was turned off. If the LH of AC is within the range 40 through 57 of the central processor, all other jobs are stopped from being scheduled and the specified executive PI location (40–57) is patched to trap directly to the user. In this case, the monitor moves the contents of the relative location specified in the right half of AC, converts the user virtual address to the equivalent exec virtual address, and stores the address in the specified executive PI location. On a KI10-based system, this requires the user segment accessed during the interrupt be locked and mapped contiguously in the exec virtual memory (refer to the LOCK UUO). If the segment does not meet these requirements, the error return is given.

On a multiprocessor system, the TRPSET UUO applies to the processor specified by the job's CPU specification (refer to the SET CPU command or the SET UUO). If the specification indicates only CPU1, an error return is given if the job is not locked in core. When the specification indicates more than one processor, the specification is changed to indicate CPU0 (the master processor).

Thus, the user can set up a priority interrupt trap into his relocated core area. On a normal return, AC contains the previous contents of the address specified by LH of AC, so that the user program may restore the original contents of the PI location when the user is through using this UUO. If the LH of AC is not within the range 40 through 57, an error return is given just as if the user did not have the privileges. The basic call is:

```
        MOVE AC, [XWD N, ADR]
        TRPSET AC,
        ERROR RETURN
        NORMAL RETURN
        .
        .
        .
ADR:    JSR TRAP                      ;Instruction to be stored
                                      ;in exec PI location
                                      ;after relocation added to it.
TRAP:   0                             ;Here on interrupt from exec.
```

The monitor assumes that user ADR contains either a JSR U or BLKI U, where U is a user virtual address; consequently, the monitor adds a relocation to the contents of location U to make it an absolute IOWD (i.e., an exec virtual address). Therefore, a user should reset the contents of U before every TRPSET call.

A RESET UUO returns the user to normal user mode. The following instruction sequence is used to place the real-time device RTD on channel 3.

(1) This UUO depends on FTTRPSET which is normally off in the DECsystem-1040.

```
INT46:   BLKI RTD,INBLOK             ;relocation constant
                                     ;for user is added
INT47:   JSR XITINT                  ;to RH when instructions
         .                           ;are placed into 46 and 47.
         .
         .
START:   MOVEI AC,INT46
         HRLI AC,46
         TRPSET AC,
         JRST EXITR                  ;error return
         MOVE AC, [XWD 47, INT47]    ;normal return
         TRPSET AC,
         JRST EXITR                  ;error return
         .                           ;normal return
         .
         .
XITINT:  0                           ;PC saved
         . . .                       ;interrupt dismiss routine
```

To maintain compatibility between a KA10-based system and a KI10-based system, the interrupt routine should be executed in exec mode. However, for convenience, the routine can be executed in user mode in order to avoid relocation to exec virtual memory. This is possible on KA10-based systems if care is taken when dismissing the interrupt (see example below). On KI10-based systems, if there is a possibility that the interrupt may occur during the job's background processing, the interrupt routine must be executed in exec mode (and thus must be locked and exec-mapped with the LOCK UUO). In particular, if the job is executing a UUO at background level, the user of UJEN at interrupt level may cause an error. On KI10-based systems it is recommended that the TRPSET interrupt routines always be coded to run in exec mode (refer to the RTTRP UUO for programming techniques).

On KA10-based systems, the interrupt routine can be coded to run in user mode if the following procedure is observed. If the interrupt occurs while some other part of the user's program is running, the user may dismiss from the interrupt routine with a JEN @ XITINT. However, if the machine is in exec mode, a JEN instruction issued in user mode does not work because of memory relocation. This is solved by a call to UJEN (op code 100). This UUO causes the monitor to dismiss the interrupt from exec mode. In this case, the address field of the UJEN instruction is the user location when the return PC is stored (i.e., UJEN XITINT). The following sequence enables the user program to decide whether it can issue a JEN to save time or dismiss the interrupt with a UUO call.

Example (KA10-based system only):

```
XITINT:  0                           ;PC with bits in LH

         JRST 1,.+1                  ;essential instruction,
                                     ;returns machine to
                                     ;user mode.
         MOVEM AC, SAVEAC            ;save accumulator AC
         .                           ;service interrupt here
         .
         .

         MOVE AC, XITINT             ;get PC with bits
         SETZM EFLAG
```

```
        TLNN AC, 10000              ;was macnine in user
                                    ;mode at entry?
        SETOM EFLAG                 ;no
        MOVE AC, SAVEAC             ;RESTORE saved AC
        SKIPE EFLAG
        UJEN XITINT                 ;not in user mode at entry
        JEN @ XITINT

SAVEAC: 0

EFLAG:  0
```

On entering the routine from absolute 47 with a JSR to XITINT + REL (where REL. is the relocation constant), the processor enters exec mode. The first executed instruction in the user's routine must, therefore, reset the user mode flag, thereby enabling relocation and protection. The user must proceed with caution when changing channel interrupt chains under timesharing, making certain the real-time job can co-exist with other timesharing jobs.

3.8.4 UJEN (Op Code 100)

This op code dismisses a user I/O mode interrupt if one is in progress. If the interrupt is from user mode, a JRST 12, instruction dismisses the interrupt. If the interrupt came from executive mode, however, this operator is used to dismiss the interrupt. The monitor restores all accumulators, and executes JEN @ U where user location U contains the program counter as stored by a JSR instruction when the interrupt occurred.

3.8.5 HPQ AC or CALLI AC 71(1)

The HPQ UUO is used by privileged users to place their jobs in a high priority scheduler run queue. These queues are always scanned by the scheduler before the normal run queues, and any runnable job in one of these queues is executed before all other jobs in the system.

In addition, these jobs are given preferential access to sharable resources (e.g., shared device controllers). Thus, real-time associated jobs can receive fast response from the timesharing scheduler.

Jobs in high-priority queues are not examined for swap-out until all other queues have been scanned. If a job in a high-priority queue must be swapped, the lowest priority job is transferred first, and the highest priority job last. If the highest priority job is swapped, then that job is the first to be swapped in for immediate execution. Therefore, in addition to being scanned before all other queues for job execution, the high-priority queues are examined after all other queues for swap-out and before all queues for swap-in.

The HPQ UUO requires as an argument the high-priority queue number of the queue to be entered. The lowest high-priority queue is 1, and the highest-priority queue is equivalent to the number of queues that the system is built for. The call is as follows:

```
MOVE AC, HPQNUM          ; get high-priority queue number
HPQ AC,                  ; or CALLI AC, 71
error return
normal return
```

(1) This UUO depends on FTHPQ which is normally off in the DECsystem-1040.

On an error return, AC contains −1 if the user did not have the correct privileges. The privilege bits are 6 through 9 in the privilege word (.GTPRV). These four bits specify a number from 0–17 octal, which is the highest priority queue attainable by the user.

On a normal return, the job is in the desired high-priority queue. A RESET or an EXIT UUO returns the job to the high-priority queue specified in the last SET HPQ command. A queue number of 0 as an argument places the job back to the timesharing level.

3.9 METER. AC, or CALLI AC, 111(1)

This UUO provides a mechanism for system performance metering by allowing privileged users to dynamically select and collect performance statistics from the monitor. The multifunction UUO controls all aspects of the metering facility in order that the user can collect, present, or reduce data for performance analysis or can tune individual jobs or the entire system. The METER. UUO requires JP.MET (bit 3) to be set in the privilege word .GTPRV.

The general call is:

```
MOVE AC, [XWD N, ADR]
METER.AC,                          ; or CALLI AC, 111
error return
normal return
```

where

N is the number of arguments in the argument list.
ADR is the beginning of the argument list.

If N is 0, the default number of arguments depends on the particular function used. Arguments in the list can be

1. arguments for the monitor
2. values returned from the monitor, or
3. a combination of both.

The first word of the argument block is the code for the particular function. The detailed descriptions of the various functions of the METER. UUO are presented in the METER. Specification in the Software Notebooks; the following is a list of the functions available.

Function Code	Name	Description
0	.MEFCI	Initialize meter channel
1	.MEFCS	Obtain meter channel status
2	:MEFCR	Release meter channel
3	.MEFPI	Initialize meter points
4	.MEFPS	Obtain meter point status
5	.MEFPR	Release meter points

On an error return, the appropriate error code is returned in AC.

(1) This UUO depends on FTMETR which is normally off in the DECsystem-1040.

On a normal return, AC is preserved. The possible error codes returned are:

Code	Mnemonic	Meaning
1	MEILF%	Illegal function.
2	MENPV%	Not a privileged user.
3	MEIMA%	Illegal memory address.
4	MEPDL%	PDL overflow.
5	MEIAL%	Illegal argument list.
6	MEIAV%	Illegal argument value.
7	MENFC%	Not enough free core.
10	MEICT%	Illegal channel type.
11	MEIPT%	Illegal point routine type.
12	MENXP%	Non-existent point name.
13	MENXC%	Non-existent channel.
14	MEPNA%	Point not available.

CHAPTER 4
I/O PROGRAMMING

All user-mode I/O programming is controlled by monitor programmed operators. I/O is directed by

1. Associating a device and a ring of buffers with one of the user's I/O channels (INIT, OPEN).
2. Optionally selecting a file (LOOKUP, ENTER).
3. Passing buffers of data to or from the user program (IN, INPUT, OUT, OUTPUT).

Device specification may be delayed from program-generation time until program-run time because the monitor

1. Allows a logical device name to be associated with a physical device (ASSIGN or MOUNT monitor command).
2. Treats operations that are not pertinent to a given device as no-operation code.

For example: a rewind directed to a line printer does nothing, and file selection operations for devices without a filename directory are always successful.

4.1 I/O ORGANIZATION

4.1.1 Files

A file is an ordered set of data on a peripheral device. The extent of a file on input is determined by an end-of-file condition dependent on the device. For example, a file is terminated by reading an end-of-file gap from magnetic tape, by an end-of-file card from a card reader, or by depressing the end-of-file switch on a card reader (refer to Chapter 5). The extent of a file on output is determined by the amount of information written by the OUT or OUTPUT programmed operators up through and including the next CLOSE or RELEAS operator.

4.1.2 Job I/O Initialization

The monitor programmed operator

```
CALL [SIXBIT/RESET/] or CALLI 0
```

should normally be the first instruction in each user program. It immediately stops all I/O transmissions on all devices without waiting for the devices to become inactive. All device allocations made by the INIT and OPEN operators are cleared and, unless the devices have been assigned by the ASSIGN or MOUNT monitor command, the devices are returned to the monitor facilities pool. The content of the left half of .JBSA (program break) is stored in the right half of .JBFF so that the user buffer area is reclaimed if the program restarts. The left half of .JBFF is cleared. Any files that have not been closed are deleted on disk. Any older version with the same filename remains. The user-mode write-protect bit is automatically set if a high segment exists, whether it is sharable or not; therefore, a program cannot inadvertently store into the high segment. Additional functions of the RESET UUO include

1. unlocking the job if it was locked,
2. releasing any real-time devices,
3. resetting any high-priority queues set by the HPQ UUO to the value set by the HPQ command,
4. resuming timesharing if it was stopped as a result of a TRPSET UUO with a non-zero argument,
5. resetting the action of the HIBER and APRENB UUOs, and
6. clearing all PC flags except USRMOD,
7. dropping all PIDs that were to be dropped on reset.

4.2 DEVICE SELECTION

For all I/O operations, a specific device must be associated with a software I/O channel. This specification is made by an argument of the INIT or the OPEN programmed operators. The INIT or the OPEN programmed operators may specify a device with a logical name that is associated with a particular physical device by the ASSIGN or MOUNT monitor command. Some system programs, e.g., LOGOUT require I/O to specific physical devices regardless of what logical names have been assigned. Therefore, on an OPEN UUO if the sign bit of word 0 of the OPEN block is 1 (UU.PHS), the device name is taken as a physical name only, and logical names are not searched. A given device remains associated with a software I/O channel until released (refer to Paragraph 4.8.1) or until another INIT or OPEN is performed for that channel. Devices are separated into two categories: those with no filename directory (refer to Chapter 5) and those with at least one filename directory (refer to Chapter 6).

Assignable devices (i.e., non-disk and non-spooled devices) in the monitor's pool of available resources are designated as being either unrestricted or restricted. An unrestricted device can be assigned directly by any job via the ASSIGN command or INIT or OPEN UUO. A restricted device can be assigned directly only by a privileged job (i.e., a job logged in under [1,2] or running with the JACCT bit set). However, a non-privileged user can have a restricted device assigned to him indirectly via the MOUNT command. This command allows operator intervention for the selection or denial of a particular device; thus the operator can control the user of assignable devices for the non-privileged user. This is particularly useful when there are multiprogramming batch and interactive jobs competing for the same devices. The restricted status of a device is set or removed by the operator with the OPSER commands :RESTRICT and :UNRESTRICT, which use the privileged UUOs, DVRST. and DVURS. (refer to UUOPRV in the DECsystem-10 Software Notebooks).

4.2.1 Nondirectory Devices

For nondirectory devices (e.g., card reader and punch, line printer, paper-tape reader and punch, and user terminal), selection of the device is sufficient to allow I/O operations over the associated software channel. All other file specifiers, if given, are ignored. Magnetic tape, a nondirectory device, requires, in addition to the name, that the tape be properly positioned. It is advisable to use the programmed operators that select a file, so that a directory device may be substituted for a nondirectory device at run time.

4.2.2 Directory Devices

For directory devices (e.g., a DECtape and disk), files are addressable by name. If the device has a single file directory (e.g., DECtape) the device name and filename are sufficient information to determine a file. If the device has multiple file directories (e.g., disk) the name of the file directory must also be specified. These names are specified as arguments to the LOOKUP, ENTER, and RENAME programmed operators.

4.2.3 Device Initialization

The OPEN (operation code 050) and INIT (operation code 041) programmed operators initialize a device and associate it with a software I/O channel number for the job. These UUOs perform almost identical functions; the OPEN UUO is a reentrant form of INIT and is preferred for this reason. In addition to the device name, these programmed operators accept, as arguments, an initial file status and the location of the input and output buffer headers. The calls are:

```
OPEN D,SPEC                 INIT D, STATUS
error return                SIXBIT/dev/
normal return               XWD OBUF, IBUF
                            error return
      .                     normal return
      .
SPEC: EXP STATUS
      SIXBIT/dev/
      XWD OBUF, IBUF
```

The normal return is taken if a device is selected, and if the device is associated with a software I/O channel. The error return is taken if the requested device is in use, if the requested device does not exist, or if the device is restricted and has not been assigned with the MOUNT command.

The LH of word 0 of the OPEN UUO contains the following

Bit	Name	Meaning
0	UU.PHS	Sign bit. Implies physical device search.
1	UU.DEL	Disable error logging. (Used for disk diagnostics. Normally, should not be set by user.)
2	UU.DER	Disable error re-try. (Used for disk diagnostics. Normally, should not be set by user.)
3	UU.AIO	Indicates non-blocking I/O.
4	UU.IBC	Prevents the monitor from zeroing buffers after each output. (Can be used in programs to save some time.)

4.2.3.1 Data Channel – These programmed operators establish a correspondence between the device and a 4-bit channel number, D. Most of the other input/output operators require this channel number as an argument. If a device is already assigned to channel D, it is released (refer to Paragraph 4.8.1).

4.2.3.2 **Device Name** – The device name, dev, is either a logical or physical device name, with logical names taking precedence over physical names. With multiple stations, the method of device selection depends on the format of the specified SIXBIT device name.

If devn (e.g., LPT7, CDR3) is specified, the monitor attempts to select the device specifically requested.

If devSnn (e.g., CDPS14, PTPS12) is specified, the monitor attempts to select any device of the desired type at the requested station. If a device of the desired type has been previously assigned to this job at the requested station and is not INITed on another channel, it will be selected in preference to an unassigned device.

If dev (e.g., LPT, DTA) is specified, the monitor attempts to select a device of the desired type at the job's logical station. If all devices of this type are in use, the error return is taken. If no device of the desired type exists at the user's logical station, the monitor attempts to select the device at the central station. If the desired type of device has already been assigned to the job at the appropriate station (either the job's logical station or the central station) and is not INITed on another channel, it will be selected instead of an unassigned device.

In non-disk systems, if the specified device is the system device SYS, the job is placed into a system device wait queue and continues to run when SYS becomes available. In disk systems where the system device is one or more file structures, control returns immediately.

The job may pause with the message

```
?STATION nn NOT IN CONTACT
```

if the requested station is not in contact with the central station. After station nn has established contact with the central station, the user types CONTINUE for a return to job execution.

The Universal Device Index (UDX) is an 18-bit quantity that corresponds to a unique physical device in the system. (The UDX may be thought of as a "shorthand" name for that device.) No significance should be attached to the number – it is always obtained through the use of the IONDX UUO.

UDX's can be used as an argument to several UUO's as a replacement for the SIXBIT name. Using the DEVNAM UUO will convert the UDX back to a SIXBIT name. The user is cautioned against building UDX's into a program; use of the IONDX UUO is strongly recommended. (See Paragraph 4.12.7 for a complete description of IONDX.)

4.2.3.3 **Initial File Status** – The file status, including the data mode, is set to the value of the symbol STATUS. Thereafter, bits are set by the monitor and may be tested and reset by the user via monitor programmed operators. Bits 30–35 of the file status are normally set by an OPEN or INIT UUO. Refer to Table 4-3 in Paragraph 4.6.2 for the file status bits. If the data mode is not legal (refer to Chapters 5 and 6) for the specified device, the job is stopped and the monitor prints

```
ILL DEVICE DATA MODE FOR DEVICE dev AT USER addr,
```

where dev is the physical name of the device and addr is the location of the OPEN or INIT operator on the user's terminal. The terminal is left in monitor mode.

4.2.3.4 **Data Modes** – Data transmissions are either unbuffered or buffered. (Unbuffered mode is sometimes referred to as dump mode.) The mode of transmission is specified by a 4-bit argument to the INIT, OPEN, or SETSTS programmed operator. Table 4-1 summarizes the data modes.

Table 4-1
Data Modes

Octal Code	Name	Meaning
0	.IOASC	ASCII. Seven bit bytes packed left justified, five characters per word.
1	.IOASL	ASCII line. Same as 0, except that the buffer is terminated by a FORM, VT, LINE-FEED, or ALTMODE character. Differs from ASCII on TTY (half-duplex software) and PTR only.
2	.IOPIM	Packed image mode.
3–7		Unused.
10	.IOIMG	Image. A device-dependent mode. Thirty-six bit bytes. The buffer is filled with data exactly as supplied by the device.
11–12		Unused.
13	.IOIBN	Image binary. Thirty-six bit bytes. This mode is similar to binary mode, except that no automatic formatting or checksumming is done by the monitor.
14	.IOBIN	Binary. Thirty-six bit bytes. This is blocked format consisting of a word count, n (the right half of the first data word of the buffer), followed by n 36-bit data words. Checksum for cards and paper tape.
15	.IOIDP	Image dump. A device-dependent dump mode. Thirty-six bit bytes.
16	.IODPR	Dump as records without core buffering. Data is transmitted between any contiguous blocks of core and one or more standard length records on the device for each command word in the command list. Thirty-six bit bytes.
17	.IODMP	Dump one record without core buffering. Data is transmitted between any contiguous block of core and exactly one record or arbitrary length on the device for each command word in the command list. Thirty-six bit bytes.

4.2.3.5 **Buffer Header** – Symbols OBUF and IBUF, if non-zero, specify the location of the first word of the 3-word buffer ring header block for output and input, respectively. Buffered data modes utilize a ring of buffers in the user area and the priority interrupt system to permit the user to overlap computation with his data transmission. Core memory in the user's area serves as an intermediate buffer between the user's program and the device. The buffer storage mechanism consists of a 3-word buffer ring header block for bookkeeping and a data storage area subdivided into one or more individual buffers linked together to form a ring. During input operations, the monitor fills a buffer, makes that buffer available to the user's program, advances to the next buffer in the ring, and fills that buffer if it is free. The user's program follows the monitor, either emptying the next buffer if it is full or waiting for it to fill.

During output operations, the user's program and the monitor exchange roles; the user program fills the buffers and the monitor empties them. Only the headers that will be used need to be specified. For instance, the output header need not be specified, if only input is to be done. Also, data modes 15, 16, and 17 require no header.

If either of the buffer headers or the 3-word block starting at location SPEC lies outside the user's allocated core area, (1) the job is stopped and the monitor prints

ILLEGAL UUO AT USER addr

(addr is the address of the OPEN or INIT operator) on the user's termina, leaving the terminal in monitor mode.

The first and third words of the buffer header are set to zero. The left half of the second word is set up with the byte pointer size field in bits 6 through 11 for the selected device-data mode combination.

If the same device (other than disk) is INITed on two or more channels, the monitor retains only the buffer headers mentioned in the last INIT (a 0 specification does not override a previous buffer header specification). Other I/O operations to any of the channels involved act on the buffers mentioned in the last INIT previous to the I/O operations.

4.3 RING BUFFERS

4.3.1 Buffer Structure

The ring buffer (see Figure 4-1) is comprised of a buffer ring header block and buffer rings.

4.3.1.1 Buffer Ring Header Block – The location of the 3-word buffer ring header block is specified by an argument of the INIT and OPEN operators. Information is stored in the header by the monitor in response to the user execution of monitor programmed operators. The user's program finds all the information required to fill and empty buffers in the header. Bit position 0 of the first word of the header is a flag which, if 1, means that no input or output has occurred for this ring of buffers. The right half of the first word is the address of the second word of the buffer currently used by the user's program. The second word of the header contains a byte pointer to the current byte in the current buffer. The byte size is determined by the data mode. The third word of the header contains a number of bytes remaining in the buffer. A program may not use a single buffer header for both input and output, nor may a single buffer ring header be used for more than one I/O function at a time. Users cannot use the same buffer ring for simultaneous input and output; only one buffer ring is associated with each buffer ring header.

4.3.1.2 Buffer Ring – The buffer ring is established by the INBUF and OUTBUF operators, or, if none exists when the first IN, INPUT, OUT, or OUTPUT operator is executed, a 2-buffer ring is set up. The effective address of the INBUF and OUTBUF operators specifies the number of buffers in the ring. The location of the buffer ring isspecified by the contents of the right half of .JBFF in the user's job data area. The monitor updates .JBFF to point to the first location past the storage area.

All buffers in the ring are identical in structure. The right half of the first word contains the file status when the monitor advances to the next buffer in the ring (see Figure 4-2). Bit 0 of the second word of a buffer, the use bit, is a flag that indicates whether the buffer contains active data. This bit is set to 1 by the monitor when the buffer is full on input or being emptied on output, and set to 0 when the buffer is empty on output or is being filled on input. In other words, if the use bit = 0, the buffer is available to the filler; if the use bit = 1, the buffer is available to the emptier. The use bit prevents the monitor and the user's program from interfering with each other by attempting to use the same buffer simultaneously. Buffers are advanced by the UUOs and not by the user's program. The use bit in each buffer should never be changed by the user's program except by means

(1) Buffer headers may not be in the user's ACs; however, the buffer headers may be in location above .JBPFI (refer to Table 1-1 in Paragraph 1.2.1).

of the UUOs. Bits 1 through 17 of the second word of the buffer contain the size of the data area of the buffer plus 1. The size of this data area depends on the device. The right half of the third word of the buffer is reserved for a count of the number of words that actually contain data. The left half of this word is reserved for other bookkeeping purposes, depending on the particular device and the data mode.

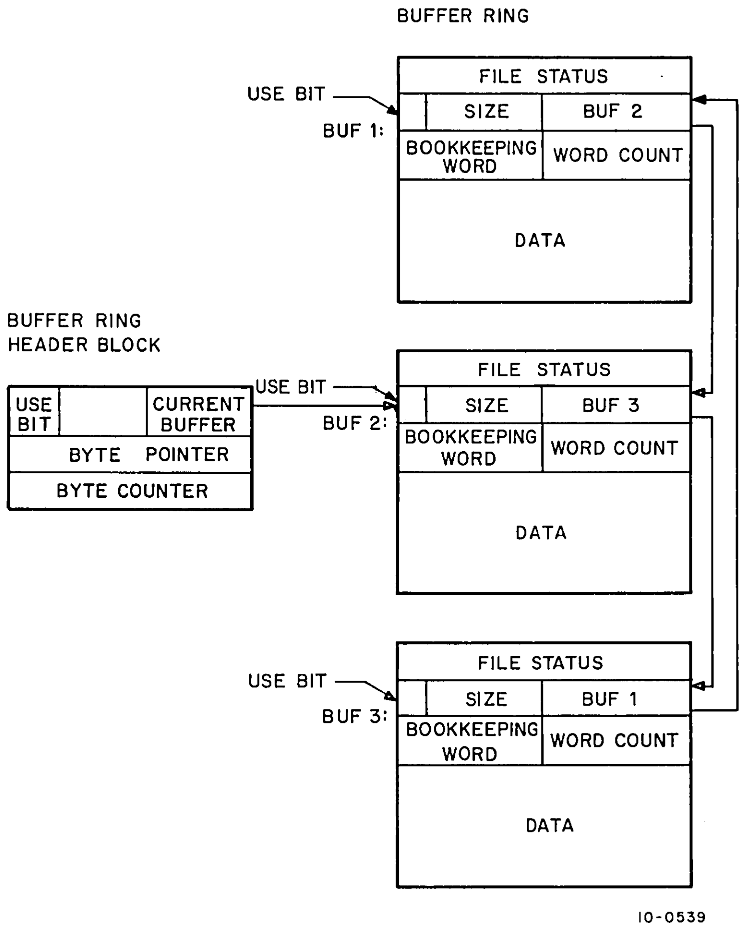


Figure 4-1 User's Ring of Buffers

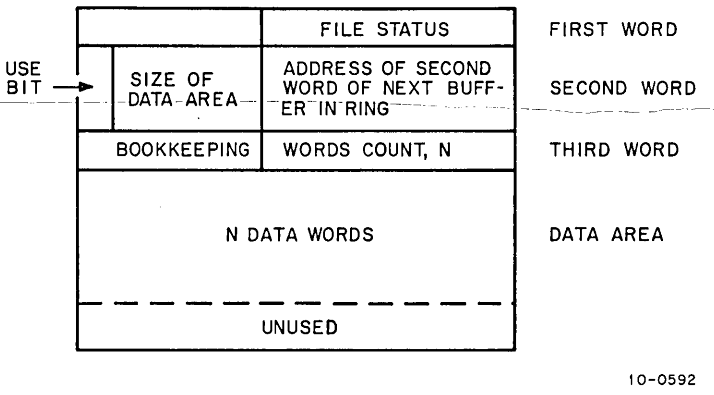


Figure 4-2 Detailed Diagram of Individual Buffer

4.3.2 Buffer Initialization

Buffer data storage areas may be established by the INBUF and OUTBUF programmed operators, or by the first IN, INPUT, OUT, or OUTPUT operator, if none exists at that time, or the user may set up his own buffer data storage area.

4.3.2.1 Monitor Generated Buffers – Each device has an associated standard buffer size (refer to Chapters 5 and 6). The monitor programmed operators INBUF D,n (operation code 064) and OUTBUF D,n (operation code 065) set up a ring of n standard size buffers associated with the input and output buffer headers, respectively, specified by the last OPEN or INIT operator on data channel D. If n = 0 on either INBUF or OUTBUF, the default number of buffers for the specified device is set up. If no OPEN or INIT operator has been performed on channel D, the monitor stops the job and prints

    I/O TO UNASSIGNED CHANNEL AT USER addr

(addr is the location of the INBUF or OUTBUF operator) on the user's terminal leaving the terminal in the monitor mode.

The storage space for the ring is taken from successive locations, beginning with the location specified in the right half of .JBFF. This location is set to the program break, which is the first free location above the program area, by RESET. If there is insufficient space to set up the ring, the monitor automatically attempts to expand the user's core allocation by 1K. If this fails, the monitor stops the job and prints

    ADDRESS CHECK FOR DEVICE dev AT USER addr

(dev is the physical name of the device associated with channel D and addr is the location of the INBUF or OUTBUF operator) on the user's terminal, leaving the terminal in monitor mode.

This message is also printed when an INBUF (OUTBUF) is attempted if the last INIT or OPEN UUO on channel D did not specify an input (output) buffer header or if input or output is attempted from a high segment.

The ring is set up by setting the second word of each buffer with a zero use bit, the appropriate data area size, and the link to the next buffer. The first word of the buffer header is set with a 1 in the ring use bit, and the right half contains the address of the second word of the first buffer.

4.3.2.2 User Generated Buffers – The following code illustrates an alternative to the use of the INBUF programmed operator. Analogous code may replace OUTBUF. This user code operates similarly to INBUF, SIZE must be set equal to the greatest number of data words expected in one physical record.

```
GO:     OPEN I,OPNBLK                     ;INITIALIZE ASCII MODE
          JRST NOTAVL                     ;THE 400000 IN THE LEFT
                                          ;HALF
        MOVE 0, [XWD 400000,BUF1+1]       ;MEANS THE BUFFER WAS NEVER
                                          ;REFERENCED.

        MOVEM 0, MAGBUF                   ;SET UP NON-STANDARD BYTE
        MOVE 0, [POINT BYTSIZ,0,35]       ;SIZE

        MOVEM 0, MAGBUF+1                 ;MAGNETIC TAPE UNIT 0
        JRST CONTIN                       ;INPUT ONLY
```

```
OPNBLK;0                                        ;GO BACK TO MAIN SEQUENCE
       SIXBIT/MTA0/                             ;SPACE FOR BUFFER RING
                                                ;HEADER
       XWD 0,MAGBUF
MAGBUF:  BLOCK 3                                ;BUFFER 1, 1ST WORD UNUSED
                                                ;LEFT HALF CONTAINS DATA
                                                ;AREA
BUF1:  0                                        ;SIZE+1, RIGHT HALF HAS
XWD SIZE+1,BUF2+1                               ;ADDRESS OF NEXT BUFFER
                                                ;SPACE FOR DATA, 1ST WORD
                                                ;RECEIVES WORD-COUNT. THUS

       BLOCK SIZE +1                            ;ONE MORE WORD IS RESERVED
                                                ;THAN IS REQUIRED FOR DATA
                                                ;ALONE
                                                ;SECOND BUFFER

BUF2:  0                                        ;THIRD BUFFER
       XWD SIZE+1,BUF3+1                        ;RIGHT HALF CLOSES THE RING
       BLOCK SIZE+1
BUF3:  0
       XWD SIZE+1,BUF1+1
       BLOCK SIZE+1
```

4.4 FILE SELECTION (LOOKUP AND ENTER)

The LOOKUP (operation code 076) and ENTER (operation code 077) programmed operators select a file for input and output, respectively. These operators are not necessary for nondirectory devices; however, it is good programming practice to always use them so that directory devices may be substituted at run time (refer to ASSIGN command). The monitor gives the normal return for a LOOKUP or ENTER to a nondirectory device; therefore, user programs can be coded in a device-independent fashion.

4.4.1 The LOOKUP Operator

LOOKUP selects a file for input on channel D.

```
        LOOKUP D,E
        error return
        normal return
              .
              .
              .
     E: SIXBIT/file/              ; FILENAME, 1 TO 6 CHARACTERS,
                                  ; LEFT-JUSTIFIED
        SIXBIT/ext/               ; FILENAME EXTENSION, 0 TO 3
                                  ; CHARACTERS, LEFT-JUSTIFIED
              –                   ; THE REMAINING WORDS IN THE
                                  ; ARGUMENT BLOCK
              –                   ; ARE IGNORED FOR NONDIRECTORY
                                  ; DEVICES.  REFER
```

```
                                        ;TO PARAGRAPH 6.1.5.1 FOR THE
                                        ;DECTAPE
                                        ;LOOKUP AND PARAGRAPH 6.2.8.1 FOR
                                        ;THE
                                        ;DISK LOOKUP.
```

If no device has been associated with channel D by an INIT or OPEN UUO, the monitor stops the job, prints

```
I/O TO UNASSIGNED CHANNEL AT USER LOC addr
```

and returns the user's terminal to monitor mode. The input side of channel D is closed if not already closed. The output side is not affected.

On DECtape, LOOKUP searches the device directory as specified by an INIT. On disk, the user's file directory as specified by the contents of location E+3 is searched. Refer to Paragraph 6.1.5.1 for details of a DECtape LOOKUP and Paragraph 6.2.8.1 for details of a disk LOOKUP.

If the device is a directory device and the file is found, the normal return is taken and information concerning the file is returned in locations E+1 through E+3. The normal return is always taken if the device associated with the channel D does not have a directory. The error return is taken if

1. the file is not found,
2. the file is found but the user does not have access to it (refer to Paragraph 6.2.3 for the description of file access codes), or
3. the device associated with channel D is a non-input device. Refer to Appendix E for the error codes returned in bits 18–35 of location E+1.

4.4.2 The ENTER Operator

ENTER selects a file for output on channel D.

```
        ENTER D, E
        error return
        normal return
        .
        .
        .
     E: SIXBIT/file/            ;FILENAME, 1 THROUGH 6
                                ;CHARACTERS, LEFT-JUSTIFIED
        SIXBIT/ext/             ;FILENAME EXTENSION, 0 THROUGH 3
                                ;CHARACTERS, LEFT JUSTIFIED
              -                 ;THE REMAINING WORDS IN THE ARGUMENT
              -                 ;ARE IGNORED FOR NONDIRECTORY DEVICES.
                                ;REFER TO PARAGRAPH 6.1.5.2 FOR THE
                                ;DECTAPE ENTER AND PARAGRAPH 6.2.8.1
                                ;FOR THE DISK ENTER.
```

If no device has been associated with channel D by an INIT or OPEN UUO, the monitor stops the job, prints

```
I/O TO UNASSIGNED CHANNEL AT USER LOC addr
```

and returns the user's terminal to monitor mode. The output side of channel D is now closed (if it was not closed); the input side is not affected. On DECtape, ENTER searches the device directory as specified by an INIT. On disk, the user's file directory, as specified by the contents of location E+3, is searched.

If the device does not have a directory, the normal return is always taken. On directory devices, if the file is found and is not being written or renamed, the file is deleted (the user must have access privileges to the file), and the storage space on the device is reclaimed. On DECtape, this deletion must occur immediately on ENTER to ensure that space is available for writing the new version of the file. On disk, the deletion of the previous version does not occur until output CLOSE time, provided bit 30 of CLOSE is 0 (refer to Paragraph 4.7.7). Consequently, if the new file is aborted when partially written, the old version remains. The normal return is taken, and the monitor makes the file entry, and records file information.

The error return is taken if:

1. The filename in location E is 0.
2. The file is found but is being written or renamed.
3. The user does not have access to the file, as supplied by the file if it exists or by the UFD if the file does not exist.
4. The device associated with channel D is a non-output device.

Refer to Paragraph 6.2.8.1 for details of a disk ENTER and Paragraph 6.1.5.2 for details of a DECtape ENTER. Refer to Appendix E for the error codes returned in bits 18–35 of location E+1.

4.4.3 RENAME Operator

The RENAME (operation code 055) programmed operator is used

1. To alter the filename, filename extension, and file access privileges.
2. To delete a file associated with channel D on a directory device.

```
        RENAME D,E
        error return
        normal return
        .
        .
        .
     E: SIXBIT/file/              ;FILENAME, 1 TO 6 CHARACTERS
        SIXBIT/ext/               ;FILENAME EXTENSION, 0 TO 3 CHARACTERS.
            -                     ;THE REMAINING WORDS IN THE ARGUMENT
            -                     ;BLOCK ARE IGNORED FOR
                                  ;NONDIRECTORY DEVICES.
                                  ;REFER TO PARAGRAPH 6.1.5.3 FOR THE
                                  ;DECTAPE RENAME AND PARAGRAPH 6.2.8.1
                                  ;FOR THE DISK RENAME.
```

If no device has been assigned with channel D, the monitor stops the job, prints

I/O TO UNASSIGNED CHANNEL AT USER LOC addr

and returns the user's terminal to monitor mode.

The normal return is given if:

1. The device is a nondirectory device.
2. If the filename specified in location E is 0, the file is deleted after all read references are completed.
3. If the file name specified in location E and the filename extension specified in the left half of location E+1 are the same as the current filename and filename extension, the access protection bits are set to the contents of bit 0 to 8 of location E + 2.
4. If the filename/filename extension specified differ from the current filename/filename extension, a search is made for the specified filename and filename extension. If a match is not found
   a. the filename is changed to the filename in location E,
   b. the filename extension is changed to the filename extension in the left half of location E+1,
   c. the access protection bits are changed to the contents of bits 0–8 of location E+2, and
   d. the access date is unchanged.

The error return is given if:

1. No file is selected on channel D.
2. The specified file is not found.
3. The file is found but is being written, superseded, or renamed.
4. The file is found but the user does not have the privileges to RENAME the file.
5. The filename/filename extension specified differ from the current filename/filename extension, a search is made for the specified filename and filename extension. If a match is found, the error return is taken.
6. The UFD is deleted.

Refer to Appendix E for the error codes returned in bits 18–35 of location E+1. Refer to Paragraph 6.1.5.3 for details of a DECtape RENAME and Paragraph 6.2.8.1 for details of a disk RENAME.

Examples

```
                    General Device Initialization

INIDEV:  0                          ;JSR HERE
         OPEN 3,OPNBLK              ;CHANNEL 3
           JRST NOTAVL              ;WHERE TO GO IF DTA5 IS BUSY

;FROM HERE DOWN IS OPTIONAL DEPENDING ON THE DEVICE AND PROGRAM
;REQUIREMENTS
```

```
            MOVE 0, JOBFF
            MOVEM 0, SVJBFF          ;SAVE THE FIRST ADDRESS OF THE BUFFER
                                     ;RING IN CASE THE SPACE MUST BE
                                     ;RECLAIMED
            INBUF 3,4                ;SET UP 4 INPUT BUFFERS
            OUTBUF 3,1               ;SET UP 1 OUTPUT BUFFER
            LOOKUP 3, INNAM          ;INITIALIZE AN INPUT FILE
              JRST NOTFND            ;WHERE TO GO IF THE INPUT FILENAME IS
                                     ;NOT IN THE DIRECTORY
            ENTER 3, OUTNAME         ;INITIALIZE AN OUTPUT FILE
              JRST NOROOM            ;WHERE TO GO IF THERE IS NO ROOM IN
                                     ;THE DIRECTORY FOR A NEW FILENAME
            ;JRST @INIDEV            ;RETURN TO MAIN SEQUENCE
OPNBLK:     14                       ;BINARY MODE
            SIXBIT/DTA5/             ;DEVICE DECTAPE UNIT 5
            XWD OBUF,IBUF            ;BOTH INPUT AND OUTPUT
OBUF:       BLOCK 3                  ;SPACE FOR OUTPUT BUFFER HEADER
IBUF:       BLOCK 3                  ;SPACE FOR INPUT BUFFER HEADER
INNAM:      SIXBIT/NAME/             ;FILE NAME
            SIXBIT/EXT/              ;FILE NAME EXTENSION (OPTIONALLY 0),
                                     ;RIGHT HALF WORD RECEIVES THE
                                     ;FIRST BLOCK NUMBER
            0                        ;RECEIVES THE DATE
            0                        ;UNUSED FOR NONDUMP I/O
OUTNAM:     SIXBIT/NAME/             ;SAME INFORMATION AS IN INNAM
            SIXBIT/EXT/
            0
            0
```

4.5 DATA TRANSMISSION

The programmed operators

```
INPUT D,E and   IN D,E
                normal return
                error return
```

Transmit data from the file selected on channel D to the user's core area. The programmed operators

```
OUTPUT D, E and OUT D, E
                normal return
                error return
```

transmit data from the user's core area to the file selected on channel D. If specified, E is the effective address of the next buffer to be written. If E is not specified, the next buffer in the sequence is implied.

If no OPEN or INIT operator has been performed on channel D, the monitor stops the job and prints

I/O TO UNASSIGNED CHANNEL AT USER addr

(addr is the location of the IN, INPUT, OUT, or OUTPUT programmed operator) on the user's terminal and the terminal is left in monitor mode. If the device is a multiple-directory device and no file is selected on channel D, bit 18 of the file status is set to 1, and control returns to the user's program. Control always returns to the location immediately following an INPUT (operation code 066) and an OUTPUT (operation code 067). A check of the file status for end-of-file and error conditions must then be made by another programmed operator. Note that to trap on a hardware write-locked device, the user should use location .JBINT (refer to Paragraph 3.1.3.2). Following an INPUT, the user program should check the word count of the next buffer to determine if it contains data. Control returns to the location immediately following an IN (operation code 056) if no end-of-file or error condition exists (i.e., if bits 18 through 22 of the file status are all 0). Control returns to the location immediately following an OUT (operation code 057) if no error condition or end-of-tape exists (i.e., if bits 18 through 21 and bit 25 are all zero). Otherwise, control returns to the second location following the IN or OUT. Note that IN and OUT UUOs are the only ones in which the error return is a skip and the normal return is not a skip.

4.5.1 Unbuffered Data Modes

Data modes 15, 16, and 17 utilize a command list to specify areas in the user's allocated core to be read or written. The effective address E of the IN, INPUT, OUT, and OUTPUT programmed operators point to the first word of the command list. Three types of entries may occur in the command list.

1. IOWD n, loc – Causes n words from loc through loc+n-1 to be transmitted. The next command is obtained from the next location following the IOWD. The assembler pseudo-op IOWD generates XWD -n, loc-1.

2. XWD 0,y – Causes the next command to be taken from location y. Referred to as a GOTO word. Up to three consecutive GOTO words are allowed in the command list. After three consecutive GOTO words, an I/O instruction must be written.

3. 0 – Terminates the command list.

Each IOWD which causes data to be transferred writes a separate record. Thus, for devices other than DECtape, the following two examples produce the same result.

```
1.  OUTPUT D, [IOWD 70, BUF1
               IOWD 70, BUF2
              Z]

2.  OUTPUT D, [IOWD 70, BUF1
              Z]

    OUTPUT D, [IOWD 70, BUF2
              Z]
```

For DECtape (where space is an important consideration), the first example writes one block, and the second writes two.

The monitor does not return program control to the user until the command list has been completely processed. If an illegal address is encountered while processing the list, the job is stopped and the monitor prints

```
ADDRESS CHECK AT USER addr
```

on the user's terminal and the terminal is left in monitor mode.

Example: Dump Output

Dump input is similar to dump output. This routine outputs fixed-length records.

```
DMPINI:   0                              ;JSR HERE TO INITIALIZE A FILE
          OPEN 0,OPNBLK                  ;CHANNEL 0
            JRST NOTAVL                  ;WHERE TO GO IF MTA2 IS BUSY
          JRST @ DMPINI                  ;RETURN

DMPOUT:   0                              ;JSR HERE TO OUTPUT THE OUTPUT AREA
          OUTPUT 0,OUTLST                ;SPECIFIES DUMP OUTPUT ACCORDING
                                         ;TO THE LIST AT OUTLIST
          STATZ 0, 740000                ;CHECK ERROR BITS
            CALL[SIXBIT /EXIT/]          ;QUIT IF AN ERROR OCCURS
          JRST @DMPOUT                   ;RETURN
DMPDON:   0                              ;JSR HERE TO WRITE AN END OF FILE
          CLOSE 0                        ;WRITE THE END OF FILE
          STATZ 0, 740000                ;CHECK FOR ERROR DURING WRITE
                                         ;END OF FILE OPERATION
            CALL [SIXBIT /EXIT/]         ;QUIT IF ERROR OCCURS
          RELEAS 0,                      ;RELINQUISH THE DEVICE
          JRST @DMPDON                   ;RETURN
OPNBLK:   16                             ;DUMP MODE
          SIXBIT /MTA2/                  ;MAGNETIC TAPE 2
          0                              ;NO RING BUFFER
OUTLST:   IOWD BUFSIZ,BUFFER             ;SPECIFIES DUMPING A NUMBER OF
                                         ;WORDS EQUAL TO BUFSIZ, STARTING
          0                              ;AT LOCATION BUFFER
                                         ;SPECIFIES THE END OF THE COMMAND
                                         ;LIST
BUFFER:   BLOCK BUFSIZ                   ;OUTPUT BUFFER, MUST BE CLEARED
                                         ;AND FILLED BY THE MAIN PROGRAM.
```

4.5.2 Buffered Data Modes

In data modes 0, 1, 10, 13, and 14 the effective address E of the INPUT, IN, OUTPUT and OUT programmed operators may be used to alter the normal sequence of buffer reference. If E is 0, the address of the next buffer is obtained from the right half of the second word of the current buffer. If E is non-zero, it is the address of the second word of the next buffer to be referenced. The buffer pointed to by E can be in an entirely separate ring from the present buffer. Once a new buffer location is established, the following buffers are taken from the ring started at E. Since buffer rings are not changed if I/O activity is pending, it is not necessary to issue a WAIT UUO.

4.5.2.1 **Input** – If no input buffer ring is established when the first INPUT or IN is executed, a 2-buffer ring is set up (refer to Paragraph 4.3.2).

Buffered input may be performed synchronously or asynchronously at the option of the user. If bit 30 of the file status is 1, each INPUT and IN programmed operator performs the following:

1. Clears the use bit in the second word of the buffer with an address in the right half of the first word of the buffer header, thereby making the buffer available for refilling by the monitor.

2. Advances to the next buffer by moving the contents of the second word of the current buffer to the right half of the first word of the 3-word buffer header.

3. Returns control to the user's program if an end-of-file or error condition exists. Otherwise, the monitor starts the device, which fills the buffer and stops transmission.

4. Computes the number of bytes in the buffer from the number of words in the buffer (right half of the first data word of the buffer) and the byte size, and stores the result in the third word of the buffer header.

5. Sets the position and address fields of the byte pointer in the second word of the buffer header, so that the first data byte is obtained by an ILDB instruction.

6. Returns control to the user's program.

Thus, in synchronous mode, the position of a device (e.g., magnetic tape), relative to the current data, is easily determined. The asynchronous input mode differs in that once a device is started, successive buffers in the ring are filled at the interrupt level without stopping transmission until a buffer whose bit is 1 is encountered. Control returns to the user's program after the first buffer is filled. The position of the device, relative to the data currently being processed by the user's program, depends on the number of buffers in the ring and when the device was last stopped.

Example: General Subroutine to Input One Character.

```
;GET -- ROUTINE TO GET ONE BYTE FROM THE INPUT FILE
;       NULLS (Ø) WILL BE DISCARDED
CALL:   JSP     A,GET
;         END-OF-FILE RETURN
;       RETURN WITH BYTE IN C

GET:    SOSGE   IB+2            ;DECREMENT THE BYTE COUNT
        JRST    GETBF           ;BUFFER EMPTY--GET ANOTHER ONE
        ILDB    C,IB+1          ;SOMETHING THERE--GET IT
        JUMPN   C,1(A)          ;RETURN IF NOT NULL
                                ;** IF NULLS ARE SIGNIFICANT, THIS
                                ;   SHOULD BE A JRST 1(A)
        JRST    C,1(A)          ;NULL--LOOP FOR ANOTHER CHARACTER

;HERE WHEN INPUT BUFFER IS EMPTY
;ASK THE MONITOR FOR THE NEXT BUFFER AND JUMP BACK
;RETURN TO USER IF END-OF-FILE

GETBF:  IN      I,              ;GET BUFFER FROM MONITOR
          JRST  GET             ;NO ERRORS OR NO EOF--JUMP BACK
        GETSTS  I,C             ;GET ERROR STATUS
        TRNN    C,74B23         ;SEE IF ANY ERRORS
        JRST    GETBFE          ;NO--GO CHECK EOF
;** INSERT ERROR ROUTINE HERE
;FOR EXAMPLE, TYPE C IN OCTAL
;WITH MESSAGE GIVING FILE NAME, ETC,
        TRZ     C,74B23         ;CLEAR ERROR BITS
        SETSTS  I,(C)           ;TELL MONITOR

GETBFE: TRNE    C,1B22          ;SEE IF END OF FILE
        JRST    (A)             ;YES--GIVE NON-SKIP RETURN
        JRST    GET             ;NO--JUMP BACK TO PROCESS DATA
```

4.5.2.2 **Output** – If no output buffer ring has been established (i.e., if the first word of the buffer header is 0), when the first OUT or OUTPUT is executed, a 2-buffer ring is set up (refer to Paragraph 4.3.2). If the ring use bit (bit 0 of the first word of the buffer header) is 1, it is set to 0, the current buffer is cleared to all zeroes, and the position and address fields of the buffer byte pointer (the second word of the buffer header) are set so that the first byte is properly stored in an IDPB instruction. The byte count (the third word of the buffer header) is set to the maximum of bytes that may be stored in the buffer, and control is returned to the user's program. Thus, the first OUT or OUTPUT initializes the buffer header and the first buffer, but does not result in data transmission.

If the ring use bit is 0 and bit 31 fo the file status is 0, the number of words in the buffer is computed from the address field of the buffer byte pointer (the second word of the buffer header) and the buffer pointer (the first word of the buffer header), and the result is stored in the right half of the third word of the buffer. If bit 31 of the file status is 1, it is assumed that the user has already set the word count in the right half of the third word. The buffer use bit (bit 0 of the second word of the buffer) is set to 1, indicating that the buffer contains data to be transmitted to the device. If the device is not currently active (i.e., not receiving data), it is started. The buffer header is advanced to the next buffer by setting the buffer pointer in the first word of the buffer header. If the buffer use bit of the new buffer is 1, the job is put into a wait state until the buffer is emptied at the interrupt level. The buffer is then cleared to zeroes, the buffer byte pointer and byte count are initialized at the buffer header, and control is returned to the user's program.

Example: General Subroutine to Output One Character

```
;PUT -- ROUTINE TO PUT ONE BYTE INTO THE OUTPUT FILE
;CALL:  MOVE     C,BYTE
;       JSP      A,PUT
;       RETURN

PUT:    SOSG      OB+2              ;ADVANCE BYTE COUNTER
        JRST      PUTBF             ;JUMP IF BUFFER FULL (OR FIRST CALL)
PUTC:   IDPB      C,OB+1            ;PUT BYTE INTO BUFFER
        JRST      (A)               ;RETURN TO CALLER

;JUMP HERE WHEN BUFFER IS FULL AND THE NEXT ONE IS NEEDED
;GIVE THE MONITOR THE BUFFER AND JUMP BACK

PUTBF:  OUT       Ø,                ;GIVE BUFFER TO MONITOR
          JRST    PUTC              ;NO ERRORS--JUMP BACK
        MOVEM     C,SAVEC#          ;ERROR--SAVE AC FOR STATUS CHECKING
        GETSTS    Ø,C               ;GET ERROR STATUS
;** INSERT OUTPUT ERROR ROUTINE HERE
;FOR EXAMPLE, TYPE C IN OCTAL
;WITH MESSAGE GIVING FILE NAME, ETC,
        TRZ      C,74B23            ;CLEAR ERROR BITS
        SETSTS   Ø,(C)              ;TELL MONITOR
        MOVE     C,SAVEC            ;RESTORE CHARACTER
        JRST     PUTC               ;JUMP BACK TO PROCESS CHARACTER
```

4.5.3 Synchronization of Buffered I/O

In some instances, such as recovery from transmission errors, it is desirable to delay until a device completes its I/O activities. The programmed operator

WAIT Channel or CALLI AD, 10

returns control to the user's program when all data transfers on channel D have finished. This UUO does not wait for a magnetic tape spacing operation, since no data transfer is in progress. An MTAPE D, 0 (refer to Paragraph 5.5.3.1) should be used to wait for the magnetic tape controller to be freed after completing spacing and I/O activity on magnetic tape. In addition, the UUO does not wait for physical I/O to the terminal to be completed; it waits only until the user's buffer is empty. Therefore, the usual motive for the WAIT UUO, error recovery, does not apply to the terminal. If no device is associated with data channel D, control returns immediately. After the device is stopped, the position of the device relative to the data currently being processed by the user's program can be determined by the buffer use bits.

4.6 STATUS CHECKING AND SETTING

The file status is a set of 18 bits (right-half word), which reflects the current state of a file transmission. The initial status is a parameter of the INIT and OPEN operators. Thereafter, bits are set by the monitor, and may be tested and reset by the user via the STATZ, STATO, and SETSTS UUO's. Table 4-3 defines the file status bits. All bits, except the end-of-file bits, are set immediately by the monitor as the conditions occur, rather than being associated with the buffer currently being used. However, the file status is stored with each buffer so that the user can determine which bufferful produced an error. The end-of-file bit is set when the user attempts to read past the last block of data (i.e., it is set on an IN or INPUT UUO for which there is no corresponding data; the previous IN or INPUT UUO obtained the end of the data). Therefore, when this bit is set, no data has been placed in the input buffer.

The programmed operators (UUO's) discussed in this section are the software equivalents of the hardware instructions CONO, CONI, CONSO, and CONSZ. A more thorough description of bits 18 through 29 for each device is given in Chapters 5 and 6 and in Appendix D.

Table 4-2
File Status Bits

Bit	Name	Meaning
18	IO.IMP	Improper mode. Attempt to write on a software write-locked tape or file structure, or a software detected redundancy failure occurred. Usually set by the monitor.
19	IO.DER	Hard device error, other than data parity error. This is a search power supply, or channel memory parity error. The device is in error rather than the data on the medium. However, the data read into core or written on the device is probably incorrect. Usually set by the monitor.
20	IO.DTE	Hard data error. The data read or written has incorrect parity as detected by hardware (or by software on CDR, PTR). The user's data is probably non-recoverable even after the device is fixed. Usually set by the monitor.
21	IO.BKT	Block too large. A block of data from a device is too large to fit in a buffer; a block number is too large for the unit; the file structure (DSK) or unit (DTA) has filled; or the user's quota on the file structure has been exceeded. Usually set by the monitor.

Table 4-2 (Cont)
File Status Bits

Bit	Name	Meaning
22	IO.EOF	End of file. The user program has requested data beyond the last record or block with an IN or INPUT UUO, or USETI has specified a block beyond the last data block of the file. When set, no data has been read into the input buffer. Usually set by the monitor.
23	IO.ACT	I/O active. The device is actively transmitting or receiving data. Always set by the monitor.
24–29		Device dependent parameters. Refer to Chapter 5 and 6 and Appendix D for detailed information about each device. Usually set by the user.
30	IO.SYN	Synchronous input. Stops the device after each buffer is filled. Usually set by the user.
31	IO.UWC	User word count. Forces the monitor to use the word count in the third word of the buffer (output only). The monitor normally computes the word count from the byte pointer in the buffer header. Usually set by the user.
32–35	IO.MOD	Data mode. Refer to Table 4-1. Usually set by the user.

4.6.1 File Status Checking

The file status (refer to Table 4-2) is retrieved by the GETSTS (operation code 062) and tested by the STATZ (operation code 063) and STATO (operation code 061) UUO. In each case, the accumulator field of the instruction selects a data channel. If no device is associated with the specified data channel, the monitor stops the job and prints

```
I/O TO UNASSIGNED CHANNEL AT USER addr
```

(addr is the location of the GETSTS, STATZ, or STATO programmed operator) on the user's terminal and the terminal is left in monitor mode.

GETSTS D,E stores the file status of data channel D in the right half and 0 in the left half of location E.

STATZ D,E skips if all file status bits selected by the effective address E are 0.

STATO D,E skips if any file status bit selected by the effective address E is 1.

4.6.2 File Status Setting

The initial file status is a parameter of the INIT and OPEN UUO's; however, the file status may be changed by SETSTS (operation code 060). Error status bits IO.ERR (IO.IMP, IO.DER, IO.DTE, and IO.BKT) must be cleared by this UUO if the user is attempting an error recovery. In addition, the SETSTS UUO can be used to clear the end-of-file bit, but this is not sufficient to clear the end-of-file condition. Further inputs will not occur until the end-of-file condition (determined by an internal monitor flag IOEND) is cleared by a CLOSE or INIT UUO.

SETSTS D,E waits until the device on channel D stops transmitting data and replaces the current file status, except bit 23, with the effective address E. If the new data mode, indicated in the right four bits of E, is not legal for the device, the job is stopped and the monitor prints

```
ILL DEVICE DATA MODE FOR DEVICE dev AT USER addr
```

(dev is the physical name of the device and addr is the location of the SETSTS UUO) on the user's terminal and the terminal is left in monitor mode. If the user program changes the data mode, it must also change the byte size for the byte pointer in the input buffer header (if any) and the byte size and item count in the output buffer header (if any). The output item count should be changed by using the count already placed there by the monitor and dividing or multiplying by the appropriate conversion factor, rather than assuming the length of a buffer. Incorrect I/O may result if a data mode change requires a different buffer length. SETSTS does not change buffer lengths. The mode specified in INIT is used to determine buffer sizes even though the buffer ring has not been created.

4.7 FILE TERMINATION

File transmission is terminated by the CLOSE D,N (operation code 070) UUO. N is usually zero, but individual options may be selected independently to control the effect of the CLOSE.

Usually a given channel is OPEN for file transmission in only one direction, and CLOSE has the effect of either direction, and CLOSE has the effect of either closing input if INPUTS have been done or closing output if OUTPUTS have been done. However, disk and DECtape may have a single channel OPEN for both INPUT and OUTPUT, in which case the first two options (described below) are useful.

In the case of the MPX device (a special pseudo-device to which one or more real devices are connected), CLOSE affects all of the devices connected to MPX.

An output CLOSE for MPX causes all buffers to be returned to the free chain. All buffers on device chains are first output and the buffer ring header is initialized as usual.

An input CLOSE for MPX causes the input buffer ring to be initialized (any remaining buffers that have not been retrieved via the IN UUO are flushed).

Table 4-3 shows the CLOSE options.

Table 4-3
CLOSE Options

Option	Meaning
CLOSE D,0	The output side of channel D is closed (bit 35=0). In unbuffered data modes, the effect is to execute a device dependent function. In buffered data modes, if a buffer ring exists, the following operations are performed: 1. All data in the buffers that has not been transmitted to the device is written. 2. Device dependent functions are performed. 3. The ring use bit (bit 0 of the first word of the buffer header) is set to 1 indicating that the buffer ring is available. 4. The buffer byte count (the third word of the buffer header) is set to 0.

Table 4-3 (Cont)
CLOSE Options

Option	Meaning
	5. Control returns to the user program when transmission is complete.
	The input side of channel D is also closed (bit 34=0). The end-of-file flag is always cleared. Further action depends on the data mode in unbuffered data modes, the effect is to execute a device dependent function. In buffered data modes, if a ring buffer exists, the following operations are performed:
	1. Wait until device is inactive.
	2. The use bit of each buffer (bit 0 of the second word) is cleared indicating that the buffer is empty.
	3. The ring use bit of the buffer header (bit 0 of the first word of the buffer header) is set to 1 indicating that the buffer ring is available.
	4. The buffer byte count (the third word of the buffer header) is set to 0.
	5. Control returns to the user program.
	On output CLOSE, the unwritten blocks at the end of a disk file are automatically deallocated (bit 33=0). On input CLOSE, the access date of a disk file is updated. Bit 32=0.
CLOSE D,1	The closing of the output side of channel D is suppressed. Other actions of CLOSE are unaffected. Bit 35=1, CL.OUT.
CLOSE D,2	The closing of the input side of channel D is inhibited; other actions of CLOSE are unaffected. Bit 34=1, CL.IN.
CLOSE D,4	The unwritten blocks at the end of a disk file are not deallocated. This capability is provided for users who specifically allocate disk space and wish to retain it. Bit 33=1, CL.DLL.
	Use of this option is meaningful with disk files only and is ignored with non-disk files.
CLOSE D,10	The updating of the access on CLOSE input is inhibited. This capability is intended for use with FAILSAFE, so that files can be saved on magnetic tape without causing the disk copy to appear as if it has been accessed. Bit 32=1, CL.ACS.
	Use of this option is meaningful with disk files only and is ignored with non-disk files.
CLOSE D,20	The deleting of the NAME block and the access tables in monitor core on CLOSE input is inhibited if a LOOKUP was done without subsequent INPUT. This bit is used by the COMPIL program to retain the core block in order to speed up the subsequent access by compilers such as FORTRAN-10. Bit 31=1, CL.NMB.
	Use of this option is meaningful with disk files only and is ignored with non-disk files.

Table 4-3 (Cont)
CLOSE Options

Option	Meaning
CLOSE D,40	The deleting of the original file, if any, is inhibited if an ENTER which creates or supersedes was done. The new copy of the file is discarded. This bit is used by the queue manager (QMANGR) to create a file or a unique name and not supersede the original file. Bit 30=1, CL.RST Use of this option is meaningful with disk files only and is ignored with non-disk files.
CLOSE D,100	The NAME block and access tables are deleted from the disk data base and the space is returned to free core. Bit 29=1, CL.DAT. Use of the option is meaningful with disk files only and is ignored with non-disk files.

Any combination of the above bit settings is legal.

Example: Terminating a File

```
DROPDV:  Ø                       ;JSR HERE
         CLOSE 3,                ;WRITE END OF FILE AND TERMINATE
                                 ;INPUT
         STATZ 3, 74ØØØØ         ;RECHECK FINAL ERROR BITS
           JRST OUTERR           ;ERROR DURING CLOSE
         RELEAS 3,               ;RELINQUISH THE USE OF THE
                                 ;DEVICE, WRITE OUT THE DIRECTORY

         MOVE Ø, SVJBFF
         MOVEM Ø, JOBFF          ;RECLAIM THE BUFFER SPACE
         JRST @ DROPDV           ;RETURN TO MAIN SEQUENCE
```

4.8 DEVICE TERMINATION AND REASSIGNMENT

4.8.1 RELEASE

When all transmission between the user's program and a device is finished, the program must relinquish the device by performing a

RELEASE D,

RELEASE (operation code 071) returns control immediately, if no device is associated with data channel D. Otherwise, both input and output sides of data channel D are CLOSEd and the correspondence between channel D and the device, which was established by the INIT or OPEN UUO's, is terminated. Any errors that occurred are recorded in the BAT block if super USETI/USETO was used with channel D. If the device is neither associated with another data channel nor assigned by the ASSIGN or MOUNT commands, it is returned to the monitor's pool of available facilities. Control is returned to the user's program.

RELEASE first causes a CONDITIONAL DISCONNECT for all devices connected to an MPX channel. The buffer rings are then initialized to their original, unused state and the I/O channel is relinquished. The channel may then be re-used (via INIT/OPEN) as an ordinary or MPX I/O channel.

4.8.2 RESDV. AC, or CALLI AC, 117

This UUO allows a user program to reset a single channel. It is similar to the RELEASE UUO except no files or buffers are closed. Files that are open on the channel are deleted; any older version with the same filename remains. All I/O transmissions on the channel are stopped, and device allocations made by the INIT or OPEN UUOs on the specified channel are cleared. The device is returned to the monitor pool unless it has been assigned by the ASSIGN or MOUNT command. The call is:

```
    MOVEI AC, channel number or
    MOVEI AC, UDX
    RESDV .AC,                              ; or CALLI AC, 117
    error return
    normal return
```

On an error return, either the AC is unchanged if the UUO is not implemented, or AC contains −1 if there is no device associated with the channel.

On a normal return, the channel is reset.

4.8.3 REASSIGN AC, or CALLI AC, 21

This UUO reassigns a device under program control to the specified job and clears the directory currently in core, but does not clear the logical name assignment. A device can be reassigned if it is assigned to the current job, or if it is both not assigned to any job and is not detached. A RELEASE UUO is performed unless the job issuing the UUO is reassigning the device to itself by specifying −1 in AC or is reassigning the device by specifying 0 in AC. If the device is restricted when it is reassigned with a 0 in AC it is returned to the restructed pool of devices and can be reassigned to a non-privileged job by a privileged job. (This is the method by which the MOUNT command is implemented.) The REASSIGN UUO will accept a UDX device specification in addition to the SIXBIT device names and channel number specifications. An error is indicated on return from the UUO if the device specified is connected to an MPX channel when the REASSIGN UUO is issued, or if any other error conditions exist. An error is also indicated if the argument of the REASSIGN UUO specifies an MPX channel itself (via a channel number or SIXBIT/MPX/ argument).

The call is:

```
    MOVE AC, job number
    MOVE AC+1, [SIXBIT/DEVICE/]             ; or MOVEI AC+1, channel number
    REASSIGN AC,                            ; or CALLI AC, 21
    return                                  ; error and normal
```

If on return the contents of AC = 0, the specified job has not been initialized. If the contents of AC+1=0, the device has not been assigned to the new job, the device is the job's controlling terminal, the logican name is duplicated, or the logical name is a physical name in the system and the job reassigning the device is either logged in under a different project-programmer number or is not the operator.

4.8.4 DEVLNM AC, or CALLI AC, 107(1)

This UUO sets the logical name for the specified device. The device can be specified with a SIXBIT device name, a channel number or a UDX. Upon call of the UUO, AC contains either the device name or the channel number associated with the device. The call is:

```
MOVE AC, [SIXBIT/dev/]              ; or MOVEI AC, channel no.
MOVE AC+1, [SIXBIT/log.name/]       ; or MOVEI AC, UDX
DEVLNM AC,                          ; or CALLI AC, 107
error return
normal return
```

On an error return, AC contains one of the following:

Name	Value	Meaning
Unchanged		UUO not implemented.
DVLNX%	-1	Non-existent device or a channel number was specified.
DVLIU%	-2	Logical name already in use.
DVLNA%	-3	Device not assigned (ASSIGN or MOUNT command not used; INIT or OPEN not done.)

On a normal return, AC and AC+1 are unchanged.

4.9 EXAMPLES

4.9.1 File Reading

The following UUO sequence is required to read a file:

OPEN	Establishes a file structure-channel correspondence (or a set of file structure-channel correspondences).
LOOKUP	Establishes a file-channel correspondence. Invokes a search of the UFD. Returns information from the file system.
INBUF	(Optional) Sets up 1 to N ring buffers in the top of core, expand core if necessary.
INPUT	Sets up a buffer ring with the default number of buffers, if no INBUF was done.
.	
.	
.	
INPUT	Requests buffers of data from the monitor.
CLOSE	Breaks file-channel correspondence.
RELEASE	Breaks device-channel correspondence.

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

4.9.2 File Writing

The following UUO sequence is required to write a file:

OPEN	Forms file structure-channel correspondence (or a set of file structure-channel correspondences).
ENTER	Forms file-channel correspondence. The monitor creates some temporary storage for interlocking and shared access purpose for the filename. No directory entry is made.
OUTPUT	
.	
.	
.	
OUTPUT	Passes buffers of data to monitor for transmission to storage device. Should not be used for the final buffer because CLOSE completes the action of ENTER.
CLOSE	Completes the action of ENTER. Adds filename to file system. Normally returns allocated, but unused, blocks to the file system.
RELEASE	Breaks device-channel correspondence.

4.9.3 File Reading/Writing

```
        TITLE   FILTRN -- SAMPLE I/O PROGRAM

;A PROGRAM THAT READS 7-BIT ASCII CHARS FROM FILE INFILE.DAT ON
;DEVICE DATA AND OUTPUTS THEM TO FILE OUTFIL.LST ON DEVICE LIST
;NOTE THAT DEVICES DATA AND LIST ARE LOGICAL NAMES.  THUS
;THE PHYSICAL NAMES ARE DETERMINED AT RUN TIME TO PROVIDE DEVICE
;INDEPENDENCE.
;BOTH INPUT AND OUTPUT FILES ARE ACCESSED SEQUENTIALLY.

START:  RESET                           ;DEVICE RESET (IN CASE PROGRAM
                                        ;  IS RESTARTED)
        OPEN    1,[     1               ;CONNECT DEVICE DATA TO PROG ON CH 1
                                        ;IN ASCII LINE MODE
                  SIXBIT /DATA/
                  XWD Ø,IBUF1]          ;IBUF1 IS THE INPUT BUFFER HEADER
          HALT  .                       ;ERROR RETURN
        OPEN    2,[     1               ;CONNECT DEVICE LIST TO CH 2 IN ASCII
                                        ;LINE MODE
                   SIXBIT /LIST/
                   XWD OBUF2,Ø]         ;OBUF2 IS OUTPUT BUFFER HEADER
          HALT  .
        LOOKUP  1,L1                    ;OPEN FILE INFILE.DAT FOR INPUT
          HALT  .                       ;ERROR RETURN
        ENTER   2,E2                    ;OPEN FILE OUTFIL.LST FOR OUTPUT
          HALT  .
        INBUF   1,3                     ;CREATE 3 INPUT BUFFERS
                                        ;SINCE NO BUFFERS SPECIFIED FOR OUTPUT
                                        ;  ON FIRST OUTPUT THE MONITOR WILL
                                        ;  MAKE THE DEFAULT NUMER

;THIS IS THE BASIC I/Ø LOOP FOR THE JOB

NEWCHR:  JSR     GET                    ;GO GET ONE INPUT CHARACTER
         JSR     PUT                    ;OUTPUT THE CHARACTER RECEIVED
         JRST    NEWCHR                 ;LOOP FOR NEXT ONE
```

```
;GET -- ROUTINE TO GET ONE CHARACTER FROM THE INPUT FILE
;IT ENDS THE PROGRAM AT INPUT END-OF-FILE

GET:     Z                          ;ENTRY/EXIT
GET1:    SOSGE   IBUF1+2            ;YES--INPUT FROM DEVICE
         JRST    GETBF
         ILDB    3,IBUF1+1          ;IF NULL, THROW IT AWAY AND GET NEXT
                                    ;  CHARACTER, THIS IS CONVENTIONAL
 FOR
                                    ;  ASCII DATA.
         JRST    @GET               ;RETURN WITH CHARACTER IN AC 3

GETBF:   IN      1,                 ;DO INPUT FROM DEVICE
           JRST  GET1               ;LOOP IF NO ERRORS AND NOT EOF
         STATZ   1,74B23            ;SEE IF ERROR READING
           HALT  .                  ;YES--GIVE UP

FINISH:  CLOSE   1,                 ;EOF--CLOSE INPUT
         CLOSE   2,                 ;CLOSE OUTPUT
         RELEAS  1,                 ;RELEASE DEVICE DATA
         RELEAS  2,                 ;RELEASE DEVICE LIST
         EXIT                       ;EXIT TO MONITOR

;PUT--ROUTINE TO PUT ONE CHARACTER ONTO THE OUTPUT

PUT:     Z                          ;ENTRY/EXIT
         SOSGE   OBUF2+2            ;IS OUTPUT BUFFER FULL?
         JRST    PUTBF              ;YES--GO OUTPUT IT
PUTC:    IDPB    3,OBUF2+1          ;PUT CHARACTER IN BUFFER
         JRST    @PUT               ;RETURN

PUTBF:   OUT     2,                 ;OUTPUT BUFFER TO DEVICE
           JRST  PUTC               ;OK, NOW STORE CHARACTER IN BUFFER
         HALT    .                  ;GIVE UP IF OUTPUT ERROR

;DATA STORAGE AREA

L1:      SIXBIT  /INFILE/           ;INPUT FILE NAME
         SIXBIT  /DAT/              ;INPUT EXTENSION
         Z                          ;PROTECTION AND CREATION DATE RETURNED
         Z                          ;INPUT DIRECTORY, Ø MEANS MY OWN

E2:      SIXBIT  /OUTFIL/           ;OUTPUT FILE NAME
         SIXBIT  /LST/              ;OUTPUT EXTENSION
         Z                          ;PROTECTION CAN GO HERE, Ø MEANS STD.
         Z                          ;OUTPUT DIRECTORY, Ø MEANS MY OWN
IBUF1:   BLOCK   3                  ;INPUT BUFFER HEADER
OBUF2:   BLOCK   3                  ;OUTPUT BUFFER HEADER
         END     START
```

4.10 NON-BLOCKING I/O

If no buffer is available in buffered data mode, the job blocks until complete. With non-blocking I/O, the monitor will not go into I/O wait but will give an error return on an IN or OUT UUO with no error bit set. (This is determined by using a STATZ, STATO or GETST.) In this case, the monitor has not completed I/O yet and the user can determine when the I/O is completed by using the software interrupt mechanism (Paragraph 3.1.3) or by re-typing the input. To use non-blocking I/O set bit 3 (UU.AIO) in the LH of word 0 of the OPEN UUO.

4.11 THE MULTIPLEXED CHANNEL FEATURE

The MPX channel is a DECsystem-10 software MPX I/O channel on which an INIT has been used for device MPX.. This special case of INIT (or OPEN), in fact, defines to the monitor (and to the user) a multiplexed channel. Without the MPX channel feature, a program is restricted to referencing 16 (1 for each software channel) simultaneously active devices. An MPX channel connects a large number of devices to one software channel, and a single program can support a large number of I/O devices simultaneously. Any job can create an MPX channel in this way, and a single job may create as many MPX channels as required within the normal constraints on the maximum number of channels per job.

To each MPX channel that the user has INITED, he "connects" those devices that he wishes to control via the MPX channel. He may connect as many devices (in any order and in an arbitrary mix of device types) to a single MPX channel so long as each device connected has the pre-defined characteristic of being controllable via the MPX channel. (The DEVTYP UUO indicates whether a device can be controlled by an MPX channel.)

From the user's point of view, I/O is performed into and out of buffers similar to the buffer ring described in Section 4.3. The buffer ring concept is slightly extended to allow the several devices connected to an MPX channel to share the same ring.

The IN and OUT UUO's are utilized in roughly the same way as required for devices other than MPX. However, the format of buffers and ring headers has been modified to provide a unique device ID (UDX) designating the source or destination of the data in each buffer.

4.11.1 Buffer Ring Extensions

For each MPX channel, one input or one output buffer ring can be defined by the user by using INIT, OPEN, INBUF, and OUTBUF in their usual way. However, the buffer ring header blocks are 4 words long for the MPX device rather than the usual 3. INIT and OPEN define the 4-word ring headers for input and output. INBUF and OUTBUF may then be used to create an arbitrary number of buffers for each ring with the buffer header in each buffer appropriately initialized. The following shows the 4-word buffer header.

Word 0	Use Bit		Current Buffer
1	Buffer Pointer		
2	Byte Counter		
3	Universal Device Index (UDX)		

The input ring contains buffers chained together in an endless fashion with pointers in each buffer header to the next buffer in the ring. As in the conventional input ring, input data is stored in consecutive buffers in the ring and retrieved in the same order for the user via the IN UUO. The MPX channel, however, also stores additional information pertaining to the data in the buffer in each buffer's 3-word header area. The 4th word of the ring header is loaded with a value identifying the specific device which stored the data.

The user must store a value identifying the device for which the data is destined. This value is stored in the 4th word of the buffer ring header before the OUT UUO is issued to output the data. With the exception of the

4th word in the buffer ring header, the MPX channel user can perform I/O operation in a way that is virtually identical to ordinary buffered I/O. Although it has no significant impact on the users, the format of the buffer rings is also modified and is a requirement when specifying the MPX device.

MPX uses buffer rings for input, but for output the format is slightly modified to form one or more device chains and a free chain.

4.11.1.1 Device Chains – Device chains are created when an OUT UUO is issued to cause a buffer of data to be output on a particular device. A control block in the monitor address space maintains pointers to the beginning of the device chains for each device. The chains are then linked via the normal buffer link pointer (the right half of the second word of each buffer) and is terminated by a zero pointer value. Using the chain for output allows the monitor to treat each device connected to an MPX channel separately.

After the device service routine empties the buffer, it is placed on a free chain available for re-use. The free chain begins with a pointer in the right half of the first word of the ring header. Buffers are linked via the normal pointer in each buffer header area, and the chain is again terminated with a pointer value of zero.

As OUT UUO's are issued, buffers are removed from the free chain and added to a device chain. The ring header is updated to the next buffer in the free chain for return to the user upon return of the OUT UUO. Buffers on a device chain are returned to the free chain by the monitor when the output has been accomplished. A facility also exists to allow the user to force an output buffer off a device chain and back to the free chain when the user wishes to abort the output.

4.11.2 I/O Modes

All I/O performed on the MPX channel is buffered I/O; that is, I/O is performed to and from buffer rings only. All buffered I/O modes are legal for MPX as long as they are legal for all of the devices connected to MPX at execution time. In addition, a new buffered I/O mode is defined for the MPX channel called Packed Image Mode (PIM).

4.11.3 Device Identification

Devices that can be controlled by an MPX channel are identified by the user in one of several ways. The various alternatives provide great flexibility in the specification of individual devices or classes of devices.

At the first level, all devices are assigned unique identifiers called the "Universal Device Index" (UDX). From the user's point of view, the assignment of a particular UDX value to a particular device is completely arbitrary.

UDX assignment for existing devices is listed under the DEVTYP UUO description.

4.11.4 UUO's

4.11.4.1 CNECT. UUO – The CNECT. UUO is used to connect and disconnect individual devices from a particular MPX channel. CNECT. can only be used for devices which can be controlled by an MPX channel. A device must be "connected" to an MPX channel before input or output can occur for that device on the MPX channel. One CNECT. must be issued for each device to be controlled by an MPX channel. The CNECT. UUO should be issued after the channel has been INITed and after any desired INBUF and OUTBUF UUO's have been issued.

CNECT. performs three basic functions:

Name	Function	Meaning
.CNCCN	1	Connect a specific device to an MPX channel.
.CNCDC	2	Equivalent to a CLOSE and disconnect.
.CNCDR	3	Equivalent to a RESET and disconnect.

The calling sequence for CNECT. is

```
        MOVEI AC, PLIST
        CNECT. AC,                    ; or CALLI AC, 130
        error return
        normal return

PLIST:  XWD OP,D
        SIXBIT /devnam/ or UDX
```

where

D is an INITed MPX channel number,
OP is the CNECT. operation code as follows:

```
OP  = 1 – .CNCCN
    = 2 – .CNCDC
    = 3 – .CNCDR
```

devnam is the SIXBIT physical, logical, or generic name of the device to be connected.
UDX, an alternate specification for the device, is the Universal Device Index for the device.

The following error codes are possible with the CNECT. UUO

Code	Name	Meaning
1	CNCNM%	The channel specified is not OPEN for device MPX:
2	CNCUD%	The device specified by PLIST+1 does not exist in the system.
3	CNCCM%	The device specified by PLIST+1 cannot be connected to device MPX.
4	CNCNF%	The monitor ran out of core to build control blocks.
5	CNCNC%	The device specified by PLIST+1 is not connected and the requested operation is conditional or unconditional disconnect.
6	CNCNO%	The channel number is in some way illegal or not open.
7	CNCII%	An invalid I/O index was specified.
10	CNCUF%	The function code is invalid.
11	CNCDU%	The device specified by PLIST+1 is already assigned, INITED or connected by this or some other job.
12	CNCSD%	The device specified by PLIST+1 is a spooled device.

4.11.4.2 **ERLST. AC, or CALLI AC, 132** – The ERLST. UUO provides the user with a list of unoperational devices connected to a specified MPX channel. In order to make processing of errors for devices on an MPX channel somewhat more efficient the UUO allows the user optionally to request a list of only those devices that have not been indicated in previous ERLST. calls.

The user provides an area of arbitrary length in core for the UUO. The UUO will store as many UDX values as will fit in the user space allowed. If more space is required, the UUO sets a flag on return to the user indicating that the list returned is incomplete.

The error return is taken if the UUO is not implemented or if the specified channel is not an INITed MPX channel.

The calling sequence is:

```
          MOVEI AC, BLOCK
          ERLST. AC,                        ; or CALLI AC, 132
          error return
          normal return

BLOCK:    # words in BLOCK, , channel # (supplied by user)
          # devices that have errors (returned by monitor)
          UDX for first device , , GETSTS for device (returned by monitor)
                                  .
                                  .
                                  .
          UDX for first device , , GETSTS for device
```

This UUO is implemented only if the monitor has the MPX option.

4.11.5 EXAMPLE

The following shows a program using MPX.

```
TITLE MPX -- SAMPLE USE OF MPX!

;***COPYRIGHT 1974, DIGITAL EQUIPMENT CORP., MAYNARD MASS, 01754***

;THIS PROGRAM CONNECTS ALL FREE TTY'S TOGETHER IN A GIANT "PARTY
 LINE".
; ANYTHING TYPED ON ANY OF THE TERMINALS WILL BE TYPED ON EVERY OTHER
; TERMINAL.

;AC USAGE
T1=1        ;TEMPS
T2=2        ; ..
T3=3        ; ..
T4=4        ; ..
C=5         ;CHARACTER (IN AND OUT)
I=6         ;INDEX TO TABLES
BP=7        ;BYTE POINTER
P=17        ;PUSH DOWN STACK

;I/O CHANNELS
MPX==1      ;CHAN FOR MPX
```

```
        SEARCH C        ;GET STANDARD SYMBOLS

;START THE PROGRAM GOING
START:  RESET
        MOVE    P,[IOWD 20,PDL]         ;SET UP PUSH DOWN POINTER
        SETZM   FIRZER                  ;CLEAR CORE SO THAT CONTROL-C
        MOVE    T1,[FIRZER,,FIRZER+1]   ; START WILL NOT LEAVE ANY
        BLT     T1,ENDZER               ; JUNK AROUND
        OPEN    MPX,OPNMPX              ;OPEN DEVICE MPX
          HALT  .                       ;OPEN ERROR
        INBUF   MPX,5                   ;GET SOME SMALL NUMBER OF
                                        ; BUFFERS FOR BOTH INPUT AND
        OUTBUF  MPX,5                   ; OUTPUT. NOTE: USING MPX WE
                                        ; MAY HAVE FEWER BUFFERS THAN
                                        ; CONNECTED DEVICES,
        MOVE    T4,[-D512,,UDXTAB]      ;POINTER TO TABLE OF CONNECTED
                                        ; DEVICES.
                                        ; THIS TABLE WILL GET 1 ENTRY
                                        ; FOR EACH TTY WE CONNECT TO
                                        ; THE MPX CHAN.
        MOVEI   T3,.UXTRM-1             ;I/O INDEX OF FIRST TTY

;LOOP TO CONNECT ALL FREE TTY'S
CNLOOP: ADDI    T3,1                    ;ADVANCE TO NEXT TTY
        MOVEI   T1,CONBLK               ;POINTER TO ARGUMENT BLOCK
        MOVEM   T3,CONDEV               ;STORE THE DEVICE NAME
        CNECT.  T1,                     ;DO THE CONNECT
          JRST  CONERR                  ;ERROR RETURN
        MOVEM   T1,(T4)                 ;STORE THE UDX RETURNED IN AC

                                        ; IN THE TABLE OF CONNECTED
                                        ; DEVICES
        AOBJN   T4,CNLOOP               ;LOOP BACK TO TRY THE NEXT TTY
;HERE ONLY IF THERE ARE 512 TTY'S AND THEY ARE ALL CONNECTED TO MPX
CONERR: CAIN    T1,CNCUD%               ;IS THIS THE LAST TTY? (THAT
                                        ; IS DID WE GET THE UNKOWN
                                        ; DEVICE ERROR?)
        JRST    MAIN                    ;YES--WE CONNECTED EVERYTHING
                                        ; WE COULD
        CAIN    T1,CNCDU%               ;IS THIS DEVICE BUSY?
        JRST    CNLOOP                  ;YES--IGNORE IT
;AT THIS POINT WE HAVE SOME UNEXPECTED ERROR CONDITION.
        HALT    .                       ;JUST DIE
;HERE IS THE MAIN LOOP OF THE PROGRAM
MAIN:   PUSHJ   P,GETLIN                ;READ A LINE INTO LINBUF
        MOVEI   I,UDXTAB                ;POINTER TO START OF TABLE
;LOOP OVER ALL TTY'S WHICH ARE CONNECTED AND SEND OUT
; THE LINE IN LINBUF
SNDLIN: MOVE    BP,[POINT 7,LINBUF]     ;SETUP BYTE POINTER
        MOVE    T1,(I)                  ;GET UDX FOR NEXT DEVICE
        JUMPE   T1,MAIN                 ;ALL DONE IF ZERO
        MOVEM   T1,OUTUDX               ;SAVE IN OUTPUT BUFFER HEADER
```

```
;OUTPUT ENTIRE LINE ON ONE TTY
SNDCHR:   ILDB      C,BP                  ;GET A BYTE
          PUSHJ     P,BYTOUT              ;OUTPUT THE BYTE
          JUMPN     C,SNDCHR              ;LOOP TILL END OF STRING
          OUTPUT    MPX,                  ;START TTY TYPING EVEN IF
                                          ; BUFFER IS NOT 100% FULL
          AOJA      I,SNDLIN              ;SEND TO NEXT TTY
;SUBROUTINE TO READ A LINE AND STORE IT IN LINBUF
GETLIN:   MOVE      BP,[POINT 7,LINBUF]   ;POINTER TO STRING
          MOVEI     I,^D78                ;MAX NUMBER OF CHARACTERS
GTLIN1:   PUSHJ     P,BYTIN               ;GET A BYTE
          IDPB      C,BP                  ;STORE IN BUFFER
          CAIE      C,.CHLFD              ;IS THIS A LINE FEED?
          SOJG      I,GTLIN1              ;NO--GO GET THE NEXT BYTE
;HERE IF LINE FEED TYPED OR WE GOT 78 CHARS
          MOVEI     C,0                   ;STORE A ZERO AS AN END OF
                                          ; STRING MARK
          IDPB      C,BP                  ; ''
          POPJ      P,0                   ;RETURN
;STANDARD SUBROUTINE TO GET 1 BYTE AND RETURN IT IN 'C'
BYTIN:    SOSGE     INCNT                 ;DECREMENT BYTE COUNT
          JRST      GETBF                 ;BUFFER EMPTY--GET ANOTHER ONE
          ILDB      C,INPTR               ;GET BYTE FROM BUFFER
          JUMPE     C,BYTIN               ;IGNORE ZERO BYTES
          POPJ      P,0                   ;RETURN
;HERE WHEN INPUT BUFFER IS EMPTY
GETBF:    IN        MPX,                  ;WAIT FOR A LINE TO BE TYPED
                                          ; ON ANY CONNECTED TTY. THIS
                                          ; USES THE FEATURE OF MPX
                                          ; WHICH CAUSES IN TO WAIT ON
                                          ; MANY DEVICES AT ONCE.
            JRST    BYTIN                 ;NO ERRORS--GET A BYTE
          HALT                            ;INPUT ERROR

;STANDARD SUBROUTINE TO WRITE 1 BYTE (FROM 'C')
;NOTE: THE UDX OF THE DEVICE TO GET THIS PIECE OF OUTPUT IS STORED IN
;         OUTUDX PRIOR TO CALLING BYTOUT
BYTOUT:   SOSG      OUTCNT                ;ROOM IN BUFFER?
          JRST      PUTBF                 ;NO--GO EMPTY THIS BUFFER
PUTC:     IDPB      C,OUTPTR              ;STORE BYTE IN OUTPUT BUFFER
          POPJ      P,0                   ;RETURN

;HERE IF BUFFER IS FULL
PUTBF:    OUT       MPX,                  ;EMPTY THIS BUFFER
            JRST    PUTC                  ;STORE DATA BYTE
          HALT                            ;OUTPUT ERROR
;STORAGE

;OPEN BLOCK FOR MPX:
OPNMPX:   EXP       .IOASC                ;ASCII MODE
          SIXBIT    /MPX/                 ;DEVICE NAME
          XWD       OBUF,IBUF             ;BUFFER RING HEADERS
```

```
;ARGUMENT BLOCK FOR CNECT. UUO
CONBLK:  XWD       .CNCCN,MPX           ;FUNCTION=CONNECT,,CHANNEL
CONDEV:  BLOCK     1                    ;NAME OF DEVICE TO CONNECT

FIRZER:  ;FIRST LOCATION TO ZERO ON STARTUP

OBUF:    BLOCK     1                    ;OUTPUT BUFFER RING HEADER
OUTPTR:  BLOCK     1                    ;BYTE POINTER TO OUTPUT BUFFER
OUTCNT:  BLOCK     1                    ;BYTE COUNT FOR OUTPUT BUFFER
OUTUDX:  BLOCK     1                    ;DEVICE TO GET THIS BUFFER

IBUF:    BLOCK     1                    ;INPUT BUFFER RING HEADER
INPTR:   BLOCK     1                    ;BYTE POINTER TO INPUT DATA
INCNT:   BLOCK     1                    ;INPUT BYTE COUNT
INUDX:   BLOCK     1                    ;WHERE THIS BUFFER CAME FROM

LINBUF:  BLOCK     ↑D80/5               ;LINE BUFFER
PDL:     BLOCK     20                   ;PUSH DOWN LIST
UDXTAB:  BLOCK     ↑D512                ;TABLE OF UDX'S
         Z                              ;ZERO TO MARK END OF TABLE
ENDZER=.-1                               ;LAST WORD TO ZERO ON STARTUP
         END       START
```

4.12 DEVICE INFORMATION

4.12.1 DEVSTS AC, or CALLI AC, 54(1)

This UUO retrieves the DEVSTS word of the device data block for an INITed device. The DEVSTS word is used by a device service routine to save the results of a CONI after each interrupt from the device. (Refer to Appendix D for the device status bits.) Devices that use the DEVSTS UUO are the following : CDR, CDP, MTA, DTA, PTR, PTP, DSK, LPT, and PLT. The DEVSTS UUO, when specifying an MPX channel (via a channel number argument or SIXBIT/MPX/), always returns a word of zeroes. It has no meaning in this case. When specifying a device controlled by a front-end, DEVSTS is also meaningless, returning a zero word.

The call is:

```
MOVEI AC, channel number of device      ; or MOVEI AC, [SIXBIT/dev/]
DEVSTS AC,                              ; or CALLI AC, 54
error return                            ; UUO not implemented for any devices
normal return                           ; AC contains the DEVSTS
                                        ; word of the DDB.
```

On return, the contents of the DEVSTS word is returned in AC. Therefore, if the device service routine does not store a CONI useless information may be returned to user. Note that an error return is not indicated if the device service routine does not use the DEVSTS word for its intended purpose. Devices with both a control and data interrupt store the controller CONI (MTS, DTS, DSK, DSK2, DPC, DPC2).

The DEVSTS UUO is not meaningful when used in asynchronous buffered I/O mode unless a WAIT UUO (see Paragraph 4.5.3) is issued first to ensure synchronization of the actual data transferred with the device status returned.

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

4.12.2 DEVCHR AC, or CALLI AC, 4

This UUO allows the user to determine the physical characteristics associated with a device name. When the UUO is called, AC must contain either the logical or physical device name as a left-justified SIXBIT quantity, or the channel number of the device as a right-justified quantity.

The call is:

```
    MOVE AC, [SIXBIT/DEV/]              ; or MOVEI AC, channel number of
                                        ; device, or MOVEI AC, UDX
    DEVCHR AC,                          ; or CALLI AC, 4
    return
```

If the device is not found or the channel is not INITed, the AC contains a zero on return. If the device is found, the following information is returned in AC:

Name	Bit	Explanation
DV.DRI	Bit 0 = 1	DECtape directory is in core. This bit is cleared by an ASSIGN or DEASSIGN to that unit.
DV.DSK	Bit 1 = 1	Device is a disk.
DV.CDR	Bit 2 = 1	Device is a card reader (DV.IN = 1) or card punch (DV.OUT = 1).
DV.LPT	Bit 3 = 1	Device is a line printer.
DV.TTA	Bit 4 = 1	TTY is controlling a job.
DV.TTU	Bit 5 = 1	TTY is in use as a user terminal (even if detached).
DV.TTB	Bit 6 = 1	Free bit left from SCNSRF.
DV.DIS	Bit 7 = 1	Device is a display.
DV. LNG	Bit 8 = 1	Device has a long dispatch table (that is, UUOs other than INPUT, OUTPUT, CLOSE, and RELEASE perform real actions).
DV.PTP	Bit 9 = 1	Device is a paper-tape punch.
DV.PTR	Bit 10 = 1	Device is a paper-tape reader.
DV.DTA	Bit 11 = 1	Device is a DECtape.
DV.AVL	Bit 12 = 1	Device is available to this job or is already assigned to this job.
DV. MTA	Bit 13 = 1	Device is a magnetic tape.
DV.TTY	Bit 14 = 1	Device is a TTY.
DV.DIR	Bit 15 = 1	Device has a directory (DTA or DSK).
DV.IN	Bit 16 = 1	Device can perform input (including MPX).
DV.OUT	Bit 17 = 1	Device can perform output (including MPX).
DV.ASC	Bit 18 = 1	Device is assigned by a console command.

Name	Bit	Explanation
DV.ASP	Bit 19 = 1	Device is assigned by program (INIT or OPEN) (including MPX).
DV.M17	Bit 20 = 1	Unbuffered one-record dump mode is legal for this device (.IODMP).
DV.M16	Bit 21 = 1	Unbuffered dump mode (more than one record) is legal (.IODMP).
DV.M15	Bit 22 = 1	Unbuffered image dump mode is legal (.IODPR).
DV.M14	Bit 23 = 1	Buffered binary mode is legal (.IOBIN).
DV.M13	Bit 24 = 1	Buffered image binary mode is legal (.IOBIN).
Bits 25 and 26 are not used.		
DV.M10	Bit 27 = 1	Buffered image mode is legal (.IOIMG).
Bits 28–32 are not used.		
DV.M2	Bit 33 = 1	Packed Image mode is legal (including MPX) (.IOPIM).
DV.M1	Bit 34 = 1	ASCII line mode is legal (.IOASL).
DV.M0	Bit 35 = 1	ASCII mode is legal (.IOASC).

DEVCHR also will accept a UDX argument and will return bits appropriate to the condition of the device selected. Note that no "device type" bits are set unless the device is, in fact, of a type that is defined for DEVCHR.

4.12.3 DEVTYP AC, or CALLI AC, 53

The device-type UUO is used to determine properties of devices. This UUO accepts, as an argument, a device name in SIXBIT or a right-justified channel number. The call is:

```
MOVE AC, [SIXBIT/dev/]              ; or MOVEI AC, channel no.
                                    ; or MOVEI AC, UDX
DEVTYP AC,                          ; or CALLI AC, 53
error return
normal return
```

The error return is given if the UUO is not implemented. In this case, the DEVCHR UUO should be used. On a normal return, if AC=0, the specified device does not exist or the channel is not INITed. If the device exists, the following information is returned in AC.

Name	Bit	Explanation
TY.MAN	Bit 0 = 1	LOOKUP/ENTER mandatory.
	Bits 1–11	Reserved for the future.
TY.AVL	Bit 12 = 1	Device is available to this job.
TY.SPL	Bit 13 = 1	Spooled on disk. (Other bits reflect properties of real device, except variable buffer size.)

Name	Bit	Explanation
TY.INT	Bit 14 = 1	Interactive device (output after each break character).
TY.VAR	Bit 15 = 1	Capable of variable buffer size (user can set his own buffer lengths).
TY.IN	Bit 16 = 1	Capable of input.
TY.OUT	Bit 17 = 1	Capable of output.
TY.JOB	Bits 18–26	Job number that currently has device INITed or ASSIGNed.
	Bits 27–28	Reserved for the future.
TY.RAS	Bit 29	Device is a restricted device (i.e., can be assigned only by a privileged job or the MOUNT command).
TY.DEV	Bits 30–35	Device type code.

Code 0 (.TYDSK)	Disk of some sort
Code 1 (.TYDTA)	DECtape
Code 2 (.TYMTA)	Magnetic tape
Code 3 (.TYTTY)	TTY or equivalent
Code 4 (.TYPTR)	Paper-tape reader
Code 5 (.TYPTP)	Paper-tape punch
Code 6 (.TYDIS)	Display
Code 7 (.TYLPT)	Line printer
Code 10 (.TYCDR)	Card reader
Code 11 (.TYCDP)	Card punch
Code 12 (.TYPTY)	Pseudo-TTY
Code 13 (.TYPLT)	Plotter
Code 14 (.TYXTC)	External task.
Code 15 (.TYMPX)	Software MPX.
Code 16 (.TYPAR)	PA611-R on DC44
Code 17 (.TYPCR)	PC-11 (R) on DC44
Code 20 (.TYPAP)	PA611-P on DC44
Code 21 (.TYLPC)	LPC-11 on DC44
Code 22 (.TYPCP)	PC-11 (P) on DC44
Codes 23–57	Reserved for Digital.
Codes 60–77	Reserved for customer.

4.12.4 DEVSIZ AC, or CALLI AC, 101

This UUO is used to determine the buffer size for a device if the user wants to allocate core himself. The DEVSIZ UUO will return the default buffer size of the MPX channel if any MPX channel is specified as a DEVSIZ argument.

If the argument of DEVSIZ (including UDX specification) is a device that is controlled by an MPX channel, DEVSIZ will return the size of a physical record for the device. If no fixed physical record size exists for the device, the default buffer size for the device (usually the same as the MPX buffer size) is returned. The call is:

```
    MOVE AC, [EXP LOC]
    DEVSIZ AC,                          ; or CALLI AC, 101
    error return
    normal return

  LOC:EXP STATUS                        ; first word of the OPEN block
  LOC+1:  SIXBIT /dev/                  ; second word of the OPEN block
```

The error return is given if the UUO is not implemented. On a normal return, AC contains one of the following values:

Name	Value	Meaning
DVSDM%	0	Device exists but the data mode is dump mode.
DVSNX%	-1	Non-existent device.
DVSIM%	-2	Illegal mode.

If the device exists and the data mode is legal, AC contains in bits 0–17 the default number of buffers, and in bits 18–35 the default buffer size (including the first three words of the buffer).

4.12.5 WHERE AC, or CALLI AC, 63(1)

This UUO returns the physical station number of the specified device. When the UUO is called, AC contains either the channel number of the device as a right-justified quantity, or the device name as a left-justified SIXBIT quantity. The call is:

```
    MOVE AC, [SIXBIT /dev/]             ; or MOVEI AC, channel no.
    WHERE AC,                           ; or CALLI AC, 63
    error return
    normal return
```

If OPR is specified as the device name, the station number at which the job is logically located is returned; if OPR is specified, the station number of the central station is returned; and if TTY is specified, the station number at which the job's TTY is located is returned.

On a normal return, the LH of AC contains the station's status, and the RH of AC contains the station number associated with the device. The station's status is represented by the following bits:

Bit 13 = 1	if the station is dial-up (.RMSDU).
Bit 14 = 1	if the station is loaded (.RMSUL).
Bit 15 = 1	if the station is in the loading procedure (.RMSUG).
Bit 16 = 1	if the station is down (.RMSUD).
Bit 17 = 1	if the station is not in contact (.RMSUN).

(1) This UUO depends on FTREM which is normally off in the DECsystem-1040.

The error return is taken if the UUO is not implemented, the specified channel is not INITed, or the requested device does not exist.

4.12.6 DEVNAM AC, or CALLI AC, 64

This UUO returns the SIXBIT physical name (in the form AAAxxx) of a device obtained through either a generic INIT/OPEN or a logical device assignment. When the UUO is called, AC contains either channel number of the device as a right-justified quantity, or the device name as a left-justified SIXBIT quantity. The call is:

```
MOVE AC, [SIXBIT /dev/]               ; or MOVEI AC, channel no.
                                      ; or UDX
DEVNAM AC,                            ; or CALLI AC, 64
error return
normal return – SIXBIT name in AC
```

The normal return is taken if the specified device is found, and AC contains the SIXBIT physical device name.

The error return is taken if the UUO is not implemented (AC is unchanged), the specified channel is not INITed, or no such device exists.

4.12.7 IONDX. AC, or CALLI AC, 127

The IONDX. UUO returns the UDX for the device name specified in the calling parameters. The parameter may be either a SIXBIT logical name or a SIXBIT physical name of the form AAAxxx.

The error return from the UUO is taken if

1. the UUO is not implemented, or
2. the device does not exist.

If the device is specified as SIXBIT/MPX/ the error return is taken. The calling sequence is:

```
MOVE AC, [SIXBIT/devnam/]             ; or MOVE AC, channel no.
IONDX. AC,                            ; or CALLI AC, 127
error return                          ; AC=0, if no such device
normal return                         ; AC=UDX
```

4.12.8 CLRST. UUO

The CLRST. UUO is used to allow a device to continue after a device error condition has occurred.

The calling sequence is:

```
MOVE AC, [XWD length , , block]
CLRST. AC,                            ; or CALLI AC, 134
error return
normal return
```

BLOCK contains:

```
     UDX          channel number or SIXBIT/device/
      0           SETSTS value
                  .
                  .
                  .
     UDX          channel number or SIXBIT/device/
      0           SETSTS value
```

This UUO is implemented only if the monitor has the MPX option.

4.12.9 MVHDR. AC, or CALLI AC, 131

The MVHDR. UUO allows a user to move a buffer ring header from one core location to another. The user may issue a MVHDR. UUO at any time after a channel has been INITed. This UUO just changes the monitor's pointer to the buffer header. MVHDR does not move anything in the user's core image.

The calling sequence of the MVHDR. UUO is:

```
     MOVEI AC, channel
     MOVE AC+1, [out-adr , , in-adr]
     MVHDR. AC,                          ; or CALLI AC, 131
     error return
     normal return
```

If the new header address is zero, the old address is unchanged. An error return is taken if the UUO has not been implemented. If the channel has not been INITed, an error return is taken. AC will be equal to one. If invalid addresses are specified, the next monitor call that references the ring header will receive an ADDRESS CHECK or an ILLEGAL UUO message.

4.12.10 SENSE AC, or CALLI AC, 133

The SENSE UUO provides information necessary for a user to diagnose and perform error recovery for a specific device. A variable length parameter list is provided to allow upwards compatibility in expansion of the information returned by the UUO.

The error return is taken if the specified device does not exist or if the UUO is not implemented.

The calling sequence is:

```
     MOVE AC, [XWD length , , addr]      ; or CALLI AC, 133
     SENSE AC,
     error return
     normal return

     addr:      UDX or
                channel number or
                SIXBIT/device
     addr+1:    length of block , , addr of block
                .
                .
                .
     block:     SIXBIT/device/
     block+1:   0 , , GETSTS information
     block+2:   DEVSTS word
```

This UUO is implemented only if the monitor has the MPX option.

CHAPTER 5
I/O PROGRAMMING
FOR NONDIRECTORY DEVICES

This chapter explains the unique features of each standard nondirectory I/O device. Each device accepts the programmed operators explained in Chapter 4, unless otherwise indicated. Table 5-1 is a summary of the characteristics of all nondirectory devices. Buffer sizes are given in octal and include three bookkeeping words. The user may determine the physical characteristics associated with a logical device name by calling the DEVCHR UUO.

Table 5-1
Nondirectory Device

Device	Name Physical	Controller Number	Unit Number	Programmed Operators	Data Modes	Buffer Size (Octal)*
Card Punch	CDP	–	CP10A	OUTPUT, OUT	A, AL, I, IB,B	35
Card Reader	CDR,CDR1	–	CR10A 461 (PDP-6)	INPUT, IN	A, AL, I, IB, B, SI	36
Console Terminal	CTY	–	LT33A, LT33B, LT35A, LT37AC 626 (PDP-6)	INPUT IN OUTPUT, OUT	A, AL, I	23
Display	DIS	–	VR30, VP10 340B, 30	INPUT, OUTPUT	ID	Dump only
Line Printer	LPT, LPT1, LPT2	–	LP10F LP10H	LP10C	OUTPUT	A, AL, I 37
			TU10 TU40 TU41			
Magnetic Tape	MTA0, MTA1, . . . ,MTA7	TM10A TM10B 516 (PDP-6)	TU20A, TU20B TU30A, TU30B	INPUT, IN OUTPUT, OUT, MTAPE	A, AL, I IB, B DR, D	203**

(*) Buffer sizes are subject to change and should be calculated rather than assumed by user programs. A DEVSIZ UUO may be employed.

(**)The buffer size for magnetic tape may be changed with the SET BLOCKSIZE command (refer to the DECsystem-10 Operating System Commands).

Table 5-1 (Cont)
Nondirectory Device

Device	Name Physical	Controller Number	Unit Number	Programmed Operators	Data Modes	Buffer Size (Octal)*
Paper-Tape Punch	PTP	–	PC09 761 (PDP-6)	OUTPUT, OUT	A, AL, I IB, B	43
Paper-Tape Reader	PTR	–	PC09 760 (PDP-6)	INPUT, IN	A, AL, I IB, B	43
Plotter	PLT, PLT1	XY10	XY10A XY10B	OUTPUT, OUT	A, AL, I IB, B	46
Pseudo TTY	PTY	–	–	INPUT, IN OUTPUT, OUT	A, AL	23
Terminal	TTY0 TTY1, . . . , TTY777	DC10 DC68A 630 (PDP-6)	LT33A, LT33B LT35A, LT37AC VT06	INPUT, IN OUTPUT, OUT TTCALL	A, AL, I	223

(*) Buffer sizes are subject to change and should be calculated rather than assumed by user programs. A DEVSIZ UUO may be employed.

5.1 CARD PUNCH

The device mnemonic is CDP; the buffer size is dependent on the data mode.

Data Mode	Buffer Size
A, AL	23(8) (20(8) data) words – 80 7-bit ASCII characters
I, IB	36(8) (33(8) data) words – 80 12-bit bytes
B	35(8) (32(8) data, 33(8) punched) words – 26 data words, word count and checksum punched.

5.1.1 Concepts

The header card is the first card of an ASCII file and identifies the card code used (refer to Appendix C). This card is not punched for data modes other than ASCII. The header card has the same punches in all columns. This punch depends on the card code used; for example, in 026, the header card has 12-2-4-8 punched in columns 1-80.

The end-of-file (EOF) card is the last of each output file. This card is punched for all data modes. The end-of-file card has a 12-11-0-1-6-7-8-9 punch in columns 1 through 80.

5.1.2 Data Modes

5.1.2.1 **ASCII, Octal Code 0** – ASCII characters are converted to card codes and punched (up to 80 characters per card). Tabs are simulated by punching from 1 to 8 blank columns; form-feeds and carriage returns are ignored.

Line feeds cause a card to be punched. All other nontranslatable ASCII characters cause a back slash to be punched. Cards can be split between buffers. Attempting to punch more than 80 columns per card causes the error bit IO.BKT (bit 21 of status word) to be set. The CLOSE will punch the last partial card and then punch an EOF card.

Cards are normally punched with ANSI card codes. Refer to Appendix C for a list of ANSI card codes.

5.1.2.2 **ASCII Line, Octal Code 1** – The same as ASCII mode.

5.1.2.3 **Image, Octal Code 10** – In image mode, each buffer contains 27 words, each of which contain three 12-bit bytes. Each byte corresponds to one card column. Since there is room for 81 columns in the buffer (3 x 27) and there are only 80 columns on a card, the last word contains only 2 bytes of data; the third byte is thrown away. If the byte size is set by the program to be 12-bit bytes (the monitor normally sets 36-bit bytes), the program must skip the last byte in the buffer. Image binary causes exactly one card to be punched for each output. A program should not force an output every 80 columns since, if the program is in spooled mode, it will waste a large amount of disk space. The CLOSE punches the last partial card and then punches an EOF card.

5.1.2.4 **Image Binary, Octal Code 13** – Same as Image.

5.1.2.5 **Binary, Octal Code 14** – Column 1 contains the word count in rows 12–3. A 7–9 punch is in column 1. Column 2 contains a checksum as described for the paper-tape reader (refer to Paragraph 5.7.1.5); columns 3 through 80 contain up to 26 data words, 3 columns per word. Binary causes exactly one card to be punched for each output. The CLOSE punches the last partial card and then punches an EOF card.

5.1.3 Special Programmed Operator Service

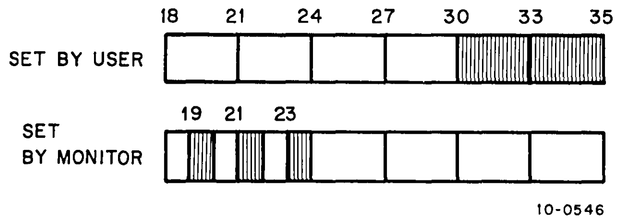
Following a CLOSE, an EOF card is punched. Columns 2 through 80 of the header card and the EOF card contain the same punches that appear in column 1 of either the header or EOF card for each file identification. These punches are ignored by the card reader service routine.

After each interrupt, the card punch stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

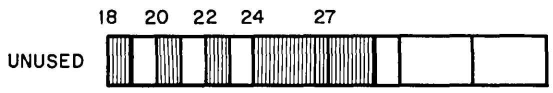
5.1.4 File Status (Refer to Appendix D)

The file status of the card punch is shown as follows.

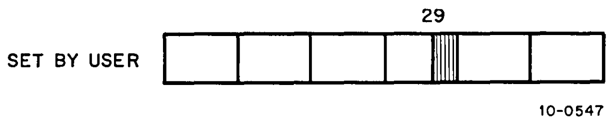
Standard Bits



Bit 19 – IO.DER	Punch error
Bit 21 – IO.BDT	Reached end-of-card with data remaining in buffer.
Bit 23 – IO.ACT	Device is active.



Device Dependent Bits



Bit 29 – IO.D29	If 1, punch ANSI card codes. If 0, punch 026 card codes

5.2 CARD READER

The card reader device mnemonic is CDR; the buffer size is 36(8) (33(8) data) words.

5.2.1 Concepts

For ASCII input, a header card can be the first card of the file and identifies the card code used (026 or ANSI standard). The header card is used only when changing from (or back to) installation standard on ASCII input. The header card must not be present with any other data modes; if present, the header card is treated as an incorrect format or read as data. Refer to Appendix C for the card codes.

An EOF card (end-of-file) has a 12-11-0-1-6-7-8-9 punch in columns 1 through 80. The EOF card has the same effect as the EOF key on the card reader. This key must be depressed or the end-of-file card must be present at the end of each input file for all data modes.

The header card codes and EOF card codes are:

EOF	12-11-0-1-6-7-8-9 (1)
026	12-2-4-8
ANSI	12-0-2-4-6-8

5.2.2 Data Modes

5.2.2.1 **ASCII. Octal Code 0** – All 80 columns of each card are read and translated to 7-bit ASCII code. Blank columns are translated to spaces. At the end of each card a carriage return/line feed is appended. As many complete cards as can fit are placed in the input buffer, but cards are not split between two buffers. Using the standard-sized buffer, only one card is placed in each buffer.

Cards are normally translated as ANSI card codes (refer to PDP-10 System Reference Manual). If a 026 header card is encountered, any following cards are translated as 026 codes (refer to Appendix C) until the 026 conversion mode is turned off. The 026 is turned off either by a RELEASE command or by an ANSI header card. Columns 2 through 80 of both of these cards are ignored.

5.2.2.2 **ASCII Line, Octal Code 1** – This mode is the same as ASCII mode.

5.2.2.3 **Image, Octal Code 10** – All 12 punches in all 80 columns are packed into the buffer as 12-bit bytes. The first 12-bit byte is in column 1. The last word of the buffer contains columns 79 and 80 as the left and middle bytes, respectively. The EOF button is processed as in ASCII mode. Cards are not split between two buffers.

5.2.2.4 **Image Binary, Octal Code 13** – This mode is the same as Image.

5.2.2.5 **Binary, Octal Code 14** – Card column 1 must contain a 7–9 punch to verify that the card is in binary format. Column 1 also contains the word count in rows 12 through 3. The absence of the 7–9 punch results in setting the IO.IMP (bit 18 of status word) flag in the card reader status word. Card column 2 must contain a 12-bit checksum as described for the paper-tape binary format. Columns 3 through 80 contain binary data, 3 columns per word for up to 26 words. Cards are not split between two buffers. The EOF button is processed the same as in ASCII mode.

5.2.2.6 **Super-Image, Octal Code 110 (2)** – Super-image mode may be initialized by setting bit 29 of the card reader's IOS word. This mode causes the 36 bits read from the I/O bus to be BLKI'd directly to the user's buffer. For this mode, the default size of the input buffer is 81 (10) words (80 (10) data words).

5.2.3 Special Programmed Operator Service

The card reader, after each interrupt, stores the results of a CONI in the DEVSTS word in the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

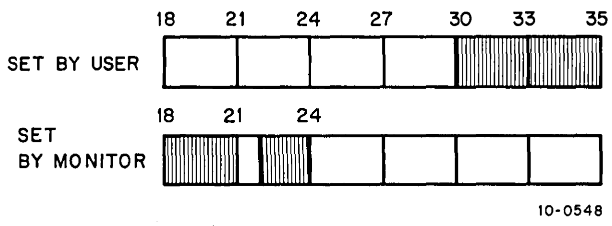
(1) These cards are symmetric in the sense that the pattern of the punches is the same if the card is turned upside down.

(2) This mode depends on FTCDRSI which is normally off in the DECsystem-1040.

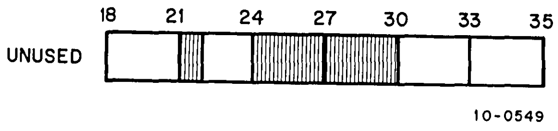
5.2.4 File Status (Refer to Appendix D)

The file status of the card reader is shown below.

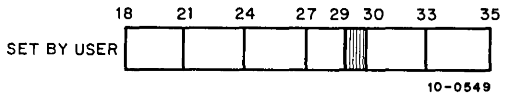
Standard Bits



Bit 18 = IO.IMP	7–9 punch absent in column 1 of a presumed binary card. The card reader is stopped.
Bit 19 = IO.DER	Photocell error, card motion error, data missed. The card reader is stopped.
Bit 20 = IO.DTE	Computed checksum is not equal to checksum read on binary card. The card reader is stopped.
Bit 22 = IO.EOF	EOF card reader or EOF button pressed.
Bit 23 = IO.ACT	Device is active.



Device-Dependent Bits



Bit 29 = IO.SIM	Super-Image mode.

5.3 DISPLAY WITH LIGHT PEN

The device mnemonic is DIS; there is no buffer because the display uses device-dependent dump mode only.

5.3.1 Data Modes

For IMAGE DUMP, Octal Code 15, an arbitrary length in the user area may be displayed on the scope. The command list format is as described in Chapter 4 with the addition for the Type 30, VR30 and VP10 display, that, if RH = 0, and LH = 0, then LH specifies the intensity for the following data (4 to 13).

5.3.2 Background

During timesharing on a heavily-loaded system, the monitor service routine for the Type 30, VR30, and VP10 guarantees a flicker-free picture on the display if the job is locked in core. To maintain this picture, the picture data must be available for the display at least every two jiffies. If the system is lightly loaded, it is not necessary to keep the job in core. When the job is swapped, a minimum amount of flicker may occur, but the job has high priority to the swapped-in again.

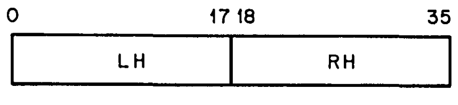
5.3.3 Display UUOs

The I/O UUOs for both displays operate as follows:

```
INIT D, 15                      ;MODE 15 ONLY
SIXBIT /DIS/                    ;DEVICE NAME
0                               ;NO BUFFERS USED
error return                    ;DISPLAY NOT AVAILABLE
normal return
CLOSE D,                        ;STOPS DISPLAY AND
   or                           ;RELEASES DEVICE AS
RELEAS D,                       ;DESCRIBED IN CHAPTER 4
```

5.3.3.1 **INPUT D, ADR** – If a light pen hit has been detected since the last INPUT command, then C(ADR) is set to the location of last light pen hit. If no light pen hit has been detected since last INPUT command, then C(ADR) is set to –1.

5.3.3.2 **OUTPUT D, ADR** – ADR specifies the first address of a table of pointers. This table is composed of pointers with the following format:

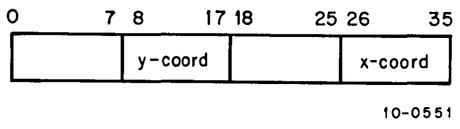


10-0550

For the Type 30, VR30 and VP10 Display:

If LH = 0 and RH = 0,	then this is the end of the command list.
If LH ≠ 0 and RH = 0,	then LH is the desired intensity for the following data or commands. The intensity ranges from 4 to 13, where 4 is the dimmest and 13 is the brightest.
If LH = 0 and RH ≠ 0,	then RH is the address of the next pointer. Successive pointers are interpreted beginning at RH.

If LH ≠ 0 and RH ≠ 0, then -LH words beginning at address RH+1 are output as data to the display. The format of the data word is the following:



For the Type 340B Display:

If RH = 0	then this is the end of the command list.
If LH = 0 and RH ≠ 0,	then RH is the address of the next pointer. Successive pointers are interpreted beginning at RH.
If LH ≠ 0 and RH ≠ 0,	then -LH words beginning at address RH+1 are output as data to the display. The format of the data word is described in the *Precision Incremental CRT Display Type 340 Maintenance Manual.*

An example of a valid pointer list for the VR-30 display is:

```
OUTPUT      D, LIST             ;OUTPUT DATA
                                ;POINTED TO BY LIST
LIST;       XWD     5, Ø        ;INTENSITY 5 (DIM)
            IOWD    1, A        ;PLOT A
            IOWD    5,SUBP1     ;PLOT SUBPICTURE 1
            XWD     13,Ø        ;INTENSITY 13 (BRIGHT)
            IOWD    1,C         ;PLOT C
            IOWD    2,SUBP2     ;PLOT SUBPICTURE 2
            XWD     Ø,LIST1     ;TRANSFER TO LIST 1


LIST1:      XWD     1Ø,Ø        ;INTENSITY 1Ø (NORMAL)
            IOWD    1,B         ;PLOT B
            IOWD    1,D         ;PLOT D
            XWD     Ø,Ø         ;END OF COMMAND LIST
            OUTPUT  D, LIST     ;OUTPUT DATA
                                ;POINTED TO BY LIST
A:          XWD     6,6         ;Y=   6, X=6
B:          XWD     7Ø,1Ø5      ;Y=  7Ø, X=1Ø5
C:          XWD   1Ø5,7Ø        ;Y= 1Ø5, X=7Ø
D:          XWD  1ØØØ,2ØØ       ;Y=1ØØØ, X=2ØØ

SUBP1:      BLOCK   5           ;SUBPICTURE 1
SUB2;       BLOCK   2           ;SUBPICTURE 2
```

An example of a valid pointer list for the Type 340B Display is:

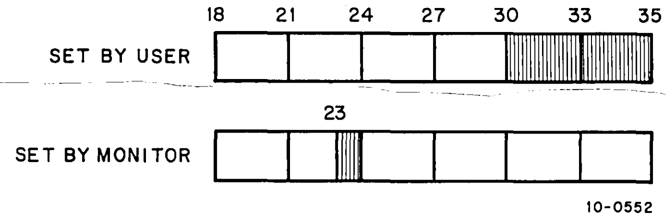
```
        OUTPUT D, LIST        ;OUTPUT DATA POINTED
                              ;TO BY POINTER IN LIST

LIST:   IOWD   1,A            ;SET STARTING POINT TO (6,6)
        IOWD   5,SUBP1        ;DRAW A CIRCLE
        IOWD   1,C            ;SET   STARTING    POINT    TO
                              (70,105)
        IOWD   5,SUBP1        ;DRAW A CIRCLE
        IOWD   1,B            ;SET   STARTING    POINT    TO
                              (105,70)
        IOWD   2,SUBP2        ;DRAW A TRIANGLE
        IOWD   0,LIST1        ;TRANSFER TO LIST1

LIST1:  IOWD   1,D            ;SET STARTING POINT TO
                              ;(100,-200)
        IOWD   5,SUBP1        ;DRAW A CIRCLE
        IOWD   1,A            ;SET STARTING POINT TO (6,6)
        IOWD   2,SUBP2        ;DRAW A TRIANGLE
        XWD    0,0            ;STOP

A:      X=6    Y=6
B:      X=105  Y=70
C:      X=70   Y=105
D:      X=1000 Y=-200

SUBP1:  BLOCK  5              ;DRAW A CIRCLE
SUBP2:  BLOCK  2              ;DRAW A TRIANGLE
```

The example shows the flexibility of this format. The user can display a subpicture by setting up a pointer. He can also display the same subpicture in many different places by setting up pointers to the subpicture, each preceded by a pointer to commands for the display to reset its coordinates.

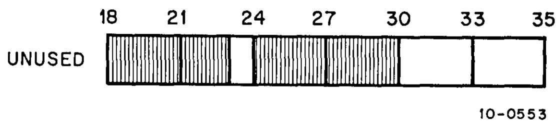
5.3.4 File Status (See Appendix D)

The file status of the display is shown below.

Standard Bits



Bit 23 = IO.ACT	Device is active



Device-Dependent Bits – None

5.4 LINE PRINTER

The device mnemonic is LPT; the buffer size is 37(8) (36(8) data) words.

5.4.1 Data Modes

5.4.1.1 **ASCII. Octal Code 0** – ASCII characters are transmitted to the line printer exactly as they appear in the buffer. Refer to the PDP-10 System Reference Manual for a list of the vertical spacing characters.

5.4.1.2 **ASCII Line, Octal Code 1** – This mode is exactly the same as ASCII and is included for programming convenience. All format control must be performed by the user's program; this includes placing a RETURN, LINE-FEED sequence at the end of each line.

5.4.1.3 **Image, Octal Code 10** – This mode is the same as ASCII mode.

5.4.2 Special Programmed Operator Service

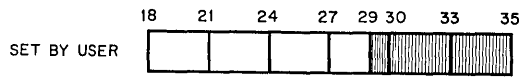
The first output programmed operator of a file and the CLOSE at the end of a file cause an extra form-feed to be printed to keep files separated.

After each interrupt, the line printer stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

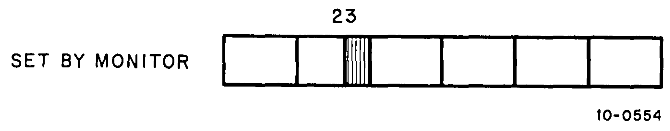
5.4.3 File Status (See Appendix D)

The file status of the line printer is shown below.

Standard Bits



Bit 29 = IO.SFF	Suppress FORM FEEDS on an OPEN or RELEASE



Bit 23 = IO.ACT	Device is active.

Device-Dependent Bits – None

5.5 MAGNETIC TAPE

Magnetic tape format for the DECsystem-10 is industry compatible. The tapes are unlabeled, 7- or 9-channel; 200, 556, or 800 bpi. The device mnemonic is MTAx (MTA0, MTA1, etc.) and the buffer size is 203(8) (200(8) data) words. (Refer to the *System Reference Manual,* Section 6 for more specific information on the DECsystem-10 magnetic tape system).

The user may change the density and/or blocksize of a magnetic tape by using the SET DENSITY and SET BLOCKSIZE commands. (Refer to the *Operation System Commands Manual.*)

As far as the user is concerned, the tape contains only records and EOF marks signalling the end of the record or the end of the file. A file consists of an integral number of physical records, separate from each other by inter-record gaps (an area on tape where no data is written). There may or may not be more than one logical record in each physical record. Write and read operations on files are performed sequentially. An EOF mark consists of a record containing a 17(8) (for 7-channel tapes) or a 23(8) (for 9-channel tapes). EOF marks are used in the following manner:

1. An EOF mark follows every file.
2. Two EOF marks follow a file if that file is the last or only file on the tape. (A double EOF is also known as an end-of-tape or EOT).
3. No EOF mark precedes the first file on a tape.

When an output file is closed the I/O service routine automatically writes two EOF marks and backspaces over one of them. If another file is opened, the second EOF mark is written over leaving one EOF mark between files. At the end of the in-use portion of the tape, a double EOF (defined as the logical end-of-tape) appears.

Normally, all data is written with odd parity, 800 bpi unless changed by the installation. A maximum of 200(8) words per record is read or written if the monitor has set up the buffer ring. If the user builds his own buffers (using SET BLOCKSIZE), a maximum of 4094 words may be specified. The word count is not written on tape. If an I/O error occurs or an end-of-tape is reached, reading ahead ceases on input and output is terminated.

5.5.1 Data Modes

The following table shows the data modes available to magnetic tape users:

Mode	Octal Code	Meaning
ASCII	0	Data written on magnetic tape appears exactly as it appears in the buffer. No processing of any kind is performed by the service routine. Parity checking by the magnetic tape system is sufficient assurance that the data is correct.
ASCII Line	1	Same as ASCII.
Image	10	The mode is the same as ASCII, but data consists of 36-bit words.

Mode	Octal Code	Meaning
Image Binary	13	Same as Image
Binary	14	Same as Image
Dump records (DR)	16	Data is in the form of standard, fixed-length records, (128 words is the standard unless changed by the installation when generating its monitor or specified by the user with the SET BLOCKSIZE command). Records read into or written from the user's core area are unbuffered. Control for read or write operations must be via a command list (described in Chapter 4, Unbuffered Data Modes) in core memory. For input operations, a new record is read for each word in the command list (except GOTO words); if the record terminates before the command word is satisfied, the service routine reads the next record. If the command word runs out before the record terminates, the remainder of the record is ignored. For each output command word, exactly enough standard-length records are followed by one short record to write all of the words on the tape. If an I/O error occurs or the EOT is reached, no additional commands are retrieved from a dump mode command list, and I/O is terminated. When the EOF is read, the user receives the standard EOF return (the error return from the IN UUO) and the IO.EOF bit is set in the file status word. (This bit can be retrieved with the GETSTS UUO.) The EOF character is read into the user's buffer. The next INPUT or IN UUO will read the next record on tape.
Dump (D)	17	Variable-length records are read into or written from anywhere in the user's core area without regard to the buffering scheme. Control for read or write operations must be via a command list (described in Chapter 4, Unbuffered Data Modes) in core memory. For input operations a new record is read for each word in the command list (except GOTO words); if the record terminates before the command word is satisfied, the service routine skips to the next command word. If the command word runs out before the record terminates, the remainder of the record is ignored. For each output command word, exactly one record is written. Handling of EOF mode is the same as Dump Records (DR) as described above.

5.5.2 Magnetic Tape UUO's

5.5.3 Special Programmed Operator Service (UUO's)

There are several UUO's that are available for magnetic tape users to perform certain functions. They are discussed in the following paragraphs.

5.5.3.1 MTAPE UUO – The MTAPE UUO provides functions such as rewind, backspace record, backspace file, and 9-channel tape initialization. The format is:

```
MTAPE D, FUNCTION
```

where D is the device channel number on which the magnetic tape unit is initialized. FUNCTION is selected according to Table 5-2.

Table 5-2
MTAPE Functions

Symbol	Function	Action
MTWAT.	0	No operation. Waits for spacing and I/O to finish.
MTREW.	1	Rewinds to load point.
MTEOF.	3	Writes EOF.
MTSKR.	6	Skips one record.
MTBSR.	7	Backspaces one record.
MTEOT.	10	Spaces to logical end-of-tape. Terminates at either two consecutive EOF marks or at the end of the first record beyond EOT marker.
MTUNL.	11	Rewinds and unloads.
MTBLK.	13	Writes 3 inches of blank tape.
MTSKF.	16	Skips one file. Causes a series of "skip record" operations.
MTBSF.	17	Backspaces files. Causes a series of "backspace record" operations.
MTDEC.	100	Initializes for Digital-compatible 9-channel tape.*
MTIND.	101	Initializes for industry-compatible, 9-channel tape.**
MTLTH.	200	Reserved for future use.

*Digital-compatible mode writes (or reads) 36 data bits in five frames of a 9-track magnetic tape. The tape can be any density or parity and is not industry-compatible. This mode is in effect until a RELEASE D, or a MTCHR D, is executed.

**Industry-compatible mode writes (or reads) 32 data bits in four frames of a 9-track magnetic tape and ignores the low-order four bits of a word. It must be 800 bpi density and odd parity.

MTAPE waits for the magnetic tape unit to complete the action in progress; bits 18–25 of the status word are then cleared, the indicated function is initiated (including no operation) and control is immediately returned to the user's program. It is important to remember that the I/O service routine can be reading several blocks ahead of the user's program when performing buffered input/output. MTAPE affects only the physical position of the tape and does not change the data that has already been read into the buffers. Therefore, an INPUT UUO or OUTPUT UUO following an MTAPE UUO may not retrieve the buffer containing the block requested. However, a single buffer ring retrieves the expected block since the device must stop after each INPUT UUO or OUTPUT UUO. Alternatively, if bit 30 (IO.SYN) of the file status word is set via the INIT UUO or the SETSTS UUO, the device stops after each buffer is filled on an INPUT or OUTPUT. Thus, the MTAPE will apply to the buffer supplied on the next INPUT or OUTPUT.

MTAPE functions must be followed by MTAPE 0 if subsequent operations depend on the completion of the MTAPE function. If this is not done, subsequent input and output UUO's are ignored until the magnetic tape control is freed. This problem occurs frequently in programs that issue a REWIND command at the beginning of the program. The tape may actually be positioned to its beginning, but the processing of the MTAPE function may cause the first input to be ignored.

Issuing a backspace file command to a magnetic tape unit moves the tape in the reverse direction until the tape has:

1. Passed the EOF mark.

2. Reached the beginning of the tape.

The end of the backspace file operation positions the tape heads either immediately in front of an EOF mark or at the beginning of the tape. In most cases, it is desirable to skip forward over this file up to the beginning of the file. In this case, giving a "skip file" command would skip the entire first file on the tape, stopping at the beginning of the second file rather than leaving the tape positioned at the beginning of the first file. Therefore, a correct sequence for "backspace file" would be:

```
MTBSF. MT,          ; Backspace file
MTWAT. MT,          ; Wait for completion
STATO MT,4000       ; Beginning of tape?
MTSKF. MT,          ; No, skip over file mark
```

Since it is necessary to wait after the MTBSF. (backspace file) instruction to ensure that the move is completed before testing to see whether or not this is the beginning of the tape, the instruction WAIT MT cannot be used for this purpose. The WAIT MT instruction waits only for the completion of I/O transfer operation, and "backspace file" is a spacing operation not an I/O transfer operation.

The device service routine must wait until the magnetic tape control is free before processing the MTAPE. MT,0, which tells the tape control to do nothing. Thus, the service routine achieves the waiting period necessary for the completion of the previous operation and the proper positioning of the tape. The following sequence shows an incorrect file backspace:

```
MTBSF. MT,          ; Backspace file
WAIT MT,            ; Wait for completion
STATO MT, 4000      ; Beginning of tape?
MTSKF. MT,          ; No, skip over file mark
```

5.5.3.2 MTAPE D, 11 Rewind and Unload (UNLOAD) – This UUO initializes all automatic error reporting. Therefore, reel-specific errors can be summarized regardless of the method used to change reels. An entry into the system error log file will be written that includes:

drive number (MTxn)
SIXBIT/REELID/
number of words read since the last UNLOAD
number of words written since the last UNLOAD
number of soft-read errors since the last UNLOAD
number of hard-read errors since the last UNLOAD
number of soft-write errors since the last UNLOAD
number of hard-write errors since the last UNLOAD

These numbers will be output on both the operator's and the user's terminals in the following format:

```
[MTxn/REELID READ (W/H/S) = a/b/c WRITE (W/H/S) = d/e/f]
```

Where:	a =	words read
	b =	hard-read errors
	c =	soft-read errors
	d =	words written
	e =	hard-write errors
	f =	soft-write errors

Whenever a=b=c=0, the information on READ will not be printed.
Whenever d=e=f=0, the information on WRITE will not be printed.

To prevent this message from being printed type:

```
SET    WATCH    NO    MTA
```

5.5.3.3 **MTCHR. AC, or CALLI AC, 112**(1) –This UUO enables the user to obtain a set of data from which the current state of a specified magnetic tape drive can be determined. The call is:

```
MOVE AC, [XWD +n,LOC]
or
MOVE AC, [SIXBIT/DEV/]  ; (This maintains compatibility with
                        ; pre-601/507 monitors.)
or
MOVEI AC, channel number
MTCHR, AC,
error return
normal return
```

LOC is a left-justified, SIXBIT physical or logical device name. On normal return the monitor returns values in the first N locations after LOC as follows:

Name	Word	Meaning
.MTRID	1	SIXBIT/REELID/
.MTWRD	2	Words read.
.MTWWT	3	Words written.
.MTSRE	4	Soft-read errors.
.MTHRE	5	Hard-read errors.
.MTSWE	6	Soft-write errors.
.MTHWE	7	Hard-write errors.
.MTTME	10	Total media errors since last unload.
.MTTDE	11	Total device errors since system loaded.
.MTTUN	12	Total unloads since system loaded.
.MTNFB	13	Number of files from beginning of tape.
.MTNRF	14	Number of records from last EOF.
.MTICC	15	Initial error CONI MTC.

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

Name	Word	Meaning
.MTICS	16	Initial error CONI MTS.
.MTFCC	17	Final error CONI MTC.
.MTFCS	20	Final error CONI MTS.
.MTTRY	21	Number of retrys to resolve last error.

An error return is taken if:

1. The specified device is not a magnetic tape (i.e., not MTXn.).
2. The specified device is not present.
3. The MTCHR. UUO is not implemented.

If the specified device is not a magnetic tape or is not present, a -1 value is returned to the AC. If the UUO is not implemented, the contents of AC are not changed.

A normal return to AC will contain the following information:

Word, Bit	Mnemonic	Contents
0-17	MT.AWC	The actual word count for the last record read or written.
18-26	MT.CRC	If a 9-channel drive is being used, these bits will contain the last Cyclic Redundancy Character (CRC).
27-29	MT.NCR	The number of characters read from the tape into the last addressed word location in the buffer during the last read operation.
31	MT.7TR	Indicates 7-track tape.
32	MT.WLK	The transport write-locked indicator bit; if this bit is 1, the transport is write-locked.
33-35	MT.DEN	Any of the following single-digit tape density (i.e., bits per inch) identifiers:

Name	Function	Meaning
.MTDN2	1	200 bpi
.MTDN5	2	556 bpi
.MTDN8	3	800 bpi
.MTD16	4	1600 bpi
	5	Reserved for future use.

In determining the value of the density identifier to be returned to bits 33–35 of the AC, the monitor examines the file status bit initialized by the INIT UUO and will return any INIT-specified density identifier. If density was not specified by INIT, the monitor then determines if the user specified density using the SET DENSITY command and returns any user-specified density identifier to the AC. If the SET DENSITY command was not used, the monitor returns the system default identifier to the AC. If no density is specified by INIT, the GETSTS UUO will return a 0 to bits 33–35 of AC. If GETSTS is used, the system default density identifier is not returned.

5.5.4 Nine-Channel Tapes

Nine-channel magnetic tape may be written and read in two ways: Digital-compatible format and industry-compatible format. Using an MTAPE CH. 101 automatically sets the density at 800 bits (eight-bit bytes) per inch with odd parity. The monitor sets up buffer headers, when necessary, in the usual manner according to the I/O mode of the device. In order to operate on eight-bit bytes, the user must insert the byte size in the byte pointer before the first IN UUO or OUT UUO.

5.5.4.1 **Digital-Compatible Mode** – Most DECsystem-10 magnetic tapes will be written in Digital-compatible mode which allows old 7-channel user programs to read and write 9-channel tapes with no modification. Digital-compatible mode writes 36 data bits in five bytes of a nine-track magnetic tape, can be any parity and density and is not compatible with other systems. The software mode is specified in the usual manner during initialization or with a SETSTS UUO and user-mode I/O is the same as 7-track magnetic tape.

For the data word in core, there are five magnetic tape bytes per 36-bit word with parity bits unavailable to the user. Bits are written on tape as shown below. Bits 30 and 31 are written twice and tracks 8 and 9 of byte 5 contain 0. On reading, parity bits and tracks 8 and 9 of byte 5 are ignored. The OR of bits (B30) is read into bit 30 of the data word, the OR of bits (B31) is read into bit 31.

Data Word On Tape

Tracks

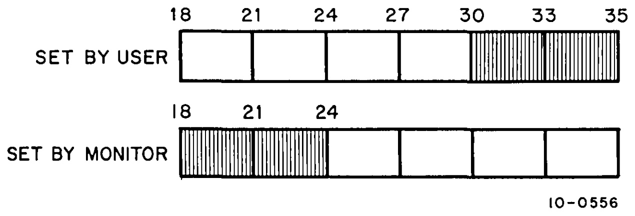
9	8	7	6	5	4	3	2	1
B0	B1	B2	B3	B4	B5	B6	B7	P
B8	B9	B10	B11	B12	B13	B14	B15	P
B16	B17	B18	B19	B20	B21	B22	B23	P
B24	B25	B26	B27	B28	B29	(B30)	(B31)	P
0	0	(B30)	(B31)	B32	B33	B34	B35	P

P = Parity
BN = Bit N in core.

5.5.5 File Status (Refer to Appendix D)

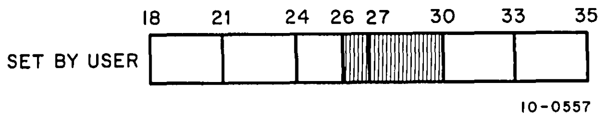
The file status of the magnetic tape is shown below.

Standard Bits

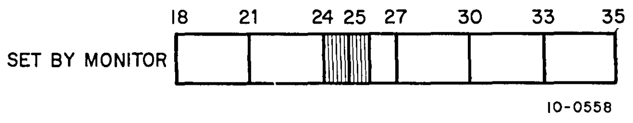


Bit 18 – IO.IMP	Unit was write-locked when output was attempted, or illegal operation was specified to the magnetic-tape control.
Bit 19 – IO.DER	Data was missed, tape is bad, or transport is hung.
Bit 20 – IO.DTE	Parity error.
Bit 21 – IO.BKT	Record read from tape exceeds buffer size.
Bit 22 – IO.EOF	EOF mark encountered. A 17(8) (for 7-channel tapes) or a 23(8) (for 9-channel tapes) appears in buffer.
Bit 23 – IO.ACT	Device active.

Device Dependent Bits



Bit 26 – IO.PAR	I/O parity. 0 for odd parity, 1 for even parity. Odd parity is preferred. Even parity should be used only when creating a tape to be read in binary coded decimal (BCD) on another computer.
Bit 27–28 – IO.DEN	I/O density, 00 = System standard. Defined at MONGEN time and can be changed with the SET DENSITY command. 01 = 200 bpi 10 = 556 bpi 11 = 800 bpi
Bit 29 – IO.NRC	I/O no read check. Suppress automatic error correction if bit 29 is 1. Normal error correction repeats the desired operation 10 times before setting an error status bit.



Bit 24 – IO.BOT	I/O beginning of tape. Unit is at beginning of tape mark.
Bit 25 – IO.EOT	I/O tape end. Physical end of tape mark encountered.

5.6 PAPER-TAPE PUNCH

The device mnemonic is PTP; the buffer size is 43(8) (40(8) data) words.

5.6.1 Data Modes

5.6.1.1 **ASCII, Octal Code 0** – The eighth hole is punched when necessary in order to make even parity. Tape-feed without the eighth hole (000) is inserted after form-feed. A rubout is inserted after each vertical or horizontal tab. Null characters (000) appearing in the buffer are not punched.

5.6.1.2 **ASCII Line, Octal Code 1** – The mode is the same as ASCII mode. Format control must be performed by the user's program.

5.6.1.3 **Image, Octal Code 10** – Eight-bit characters are punched exactly as they appear in the buffer with no additional processing.

5.6.1.4 **Image Binary, Octal Code 13** – Binary words taken from the output buffer are split into six 6-bit bytes and punched with the eighth hole punched in each line. There is no format control or checksumming performed by the I/O routine. Data punched in this mode is read back by the paper-tape reader in the IB mode.

5.6.1.5 **Binary, Octal Code 14** – Each bufferful of data is punched as one checksummed binary block as described for the paper-tape reader. Several blank lines are punched after each bufferful for visual clarity.

5.6.2 Special Programmed Operator Service

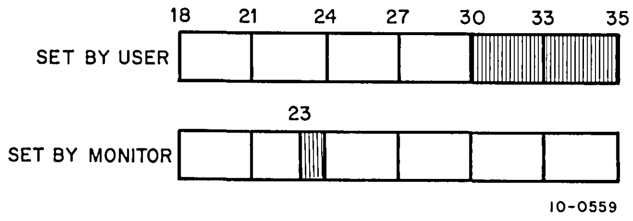
The first output programmed operator of a file causes approximately two fanfolds of blank tape to be punched as leader. Following a CLOSE, an additional fanfold of blank tape is punched as trailer. No EOF character is punched automatically.

After each interrupt, the paper-tape punch stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

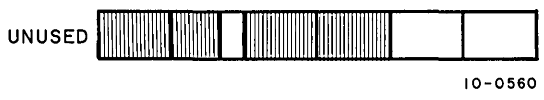
5.6.3 File Status (Refer to Appendix D)

The file status for the paper-tape punch is shown below.

Standard Bits



Bit 23 – IO.ACT Device is active.



Device Dependent Bits – None.

5.7 PAPER-TAPE READER

The device mnemonic is PTR; the buffer size is 43(8) (40(8) data) words.

5.7.1 Data Modes (Input Only)

NOTE
To initialize the paper-tape reader, the input tape must be threaded through the reading mechanism and the FEED button must be depressed.

5.7.1.1 **ASCII, Octal Code 0** – Blank tape (000), RUBOUT (377), and null characters (200) are ignored. All other characters are truncated to seven bits and appear in the buffer. The physical end of the paper tape serves as an EOF, but does not cause a character to appear in the buffer.

5.7.1.2 **ASCII Line, Octal Code 1** – Character processing is the same as for ASCII mode. The buffer is terminated by LINE FEED, FORM, or VT.

5.7.1.3 **Image, Octal Code 10** – There is no character processing. The buffer is packed with 8-bit characters exactly as read from the input tape. Physical end-of-tape is the EOF indication but does not cause a character to appear in the buffer.

5.7.1.4 **Image Binary, Octal Code 13** – Characters not having the eighth hole punched are ignored. Characters are truncated to six bits and packed six to the word without further processing. This mode is useful for reading binary tapes having arbitrary blocking format.

5.7.1.5 **Binary, Octal Code 14** – Checksummed binary data is read in the following format. The right half of the first word of each physical block contains the number of data words that follow and the left half contains half a folded checksum. The checksum is formed by adding the data words using 2's complement arithmetic, then splitting the sum into three 12-bit bytes and adding these using 1's complement arithmetic to form a 12-bit checksum. The data error status flag (refer to Table 4-3 in Paragraph 4.6.2) is raised if the checksum miscompares. Because the checksum and word count appear in the input buffer, the maximum block length is 40. The byte pointer, however, is initialized so as not to pick up the word count and checksum word.

Again, physical end of tape is the EOF indication, but does not result in putting a character in the buffer.

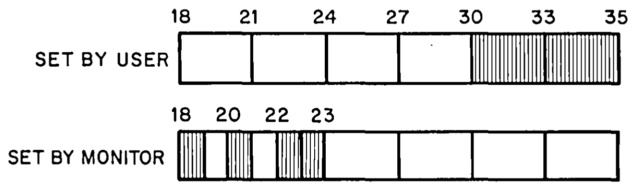
5.7.2 Special Programmed Operator Service

After each interrupt, the paper-tape reader stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

5.7.3 File Status (Refer to Appendix D)

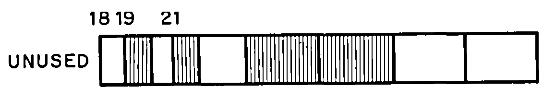
The file status of the paper-tape reader is shown below.

Standard Bits



10-0561

Bit 18 – IO.IMP	Binary block is incomplete.
Bit 20 – IO.DTE	Bad checksum in binary mode.
Bit 22 – IO.EOF	Physical end-of-tape is encountered. No character is stored in the buffer.
Bit 23 – IO.ACT	Device is active.

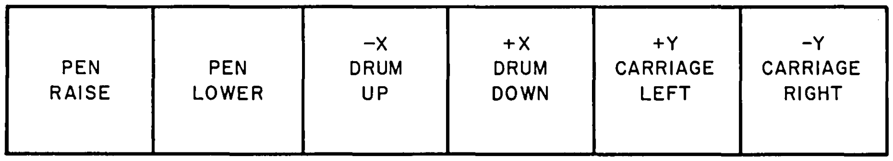


10-0562

Device dependent bits – None.

5.8 PLOTTER

The device mnemonic is PLT; the buffer size is 43(8) (40(8) data) words. The plotter takes 6-bit characters with the bits of each character decoded as follows:



10-0563

Do not combine PEN RAISE or LOWER with any of the position functions. (For more details on the incremental plotter, refer to the PDP-10 System Reference Manual.)

5.8.1 Data Modes

5.8.1.1 **ASCII, Octal Code 0** – Five 7-bit characters per word are transmitted to the plotter exactly as they appear in the buffer. The plotter is a 6-bit device; therefore, the leftmost bit of each character is ignored.

5.8.1.2 **ASCII Line, Octal Code 1** – This mode is identical to ASCII mode.

5.8.1.3 **Image, Octal Code 10** – Six 6-bit characters per word are transmitted to the plotter exactly as they appear in the buffer.

5.8.1.4 **Image Binary, Octal Code 13** – This mode is identical to Image mode.

5.8.1.5 **Binary, Octal Code 14** – This mode is identical to Image mode.

5.8.2 Special Programmed Operator Service

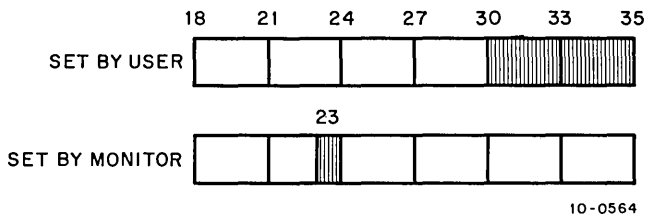
The first OUTPUT operator causes the plotter pen to be lifted from the paper before any user data is sent to the plotter. The CLOSE operator causes the plotter pen to be lifted after all user data is sent to the plotter. These two pen-up commands are the only modifications the monitor makes to the user output file.

After each interrupt, the plotter stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

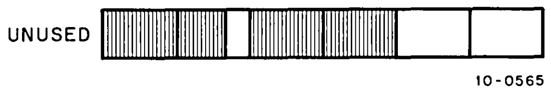
5.8.3 File Status (Refer to Appendix D)

The file status of the plotter is shown below.

Standard bits



Bit 23 – IO.ACT Device is active.



Device Dependent Bits – None.

5.9 PSEUDO-TTY

The device mnemonic is PTY0,PTY1, . . . ,PTYn. (The number of pseudo-TTYs is specified when the monitor is generated for a specific installation.) The buffer size is 23(8) (20(8) data) words.

5.9.1 Concepts

Each job in the DECsystem-10 is usually initiated by a user at a physical terminal. Except in the case of a DETACH operation, the job remains under the control of the user's terminal until it is terminated by either the KJOB command or the LOGOUT UUO. For each physical terminal there is a block of core in the monitor, containing information about the physical terminal and including two buffers as the link between the physical terminal and the job. It is through these buffers that the terminal sends input to the job, and the job returns output to the terminal.

Sometimes it is desirable to allow a job in the DECsystem-10 to be initiated by a program instead of by a user. Since a program cannot use a physical terminal in the way a user can, some means must be provided in the monitor for the program to send input to and accept output from the job it is controlling. The monitor provides this capability via the pseudo-TTY (PTY). The PTY is a simulated terminal and is not defined by hardware. Like hardware-defined terminals, each PTY has a block of core associated with it. This block of core is used by the PTY in the same manner as a hardware-defined terminal uses its block of core. Figure 5-1 shows the parallel between a hardware-defined terminal and a software-defined PTY.

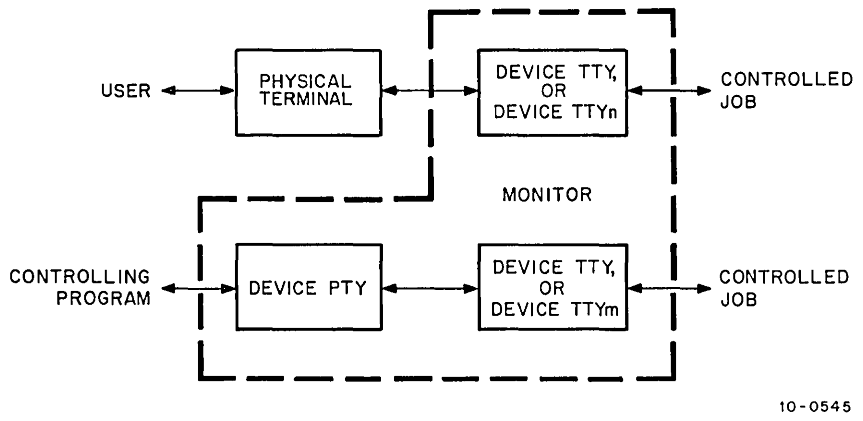


Figure 5-1 Pseudo-TTY

The controlling program, most commonly the batch processor, uses the PTY in the same way a user uses a physical device. It initiates the PTY, inputs characters to and waits for output from the PTY, and closes the PTY using the appropriate programmed operators. The job controlled by the program performs I/O to the PTY as though the PTY were a physical terminal.

A controlled job may go into a loop and not accept any input from its associated buffer; therefore, it is not possible for the controlling program to simply rely on waiting for activity in the controlled job. A controlling program may also wish to drive more than one controlled job, and be able to respond to any of these jobs; therefore, the controlling program cannot wait for any particular PTY. For these two reasons, the PTY differs from other devices in that it is never in an I/O wait state. Timing is accomplished by the HIBER UUO and the status bits of the PTY.

5.9.2 The HIBER UUO

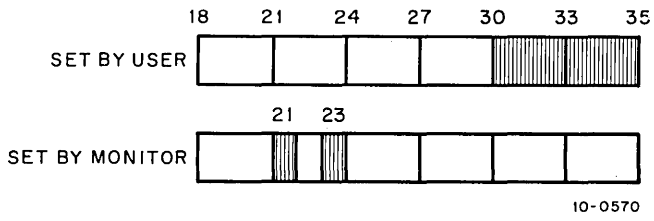
The HIBER UUO (refer to Paragraph 3.1.4.2) allows the controlling program to temporarily suspend its operation until either there is activity in the controlled job or the specified amount of sleep time runs out, whichever occurs first. If bit 12 in the AC is set in the HIBER UUO call, any PTY activity since the last HIBER UUO causes the controlling program to be awakened. If no PTY activity occurs before the limit of sleep time is reached, the controlling program is activated, and it checks the controlled job's run time or other criteria to determine whether the job should be interrupted. If the job should be interrupted, the controlling program may output two control-C characters to stop the job. (A timesharing user stops a running job in the same way.) If the job should not be interrupted, the controlling program should repeat the HIBER UUO.

If bit 12 in AC is not set, unnecessary delays might result if activity occurred on a PTY while the controlling job was sleeping. To avoid these delays, a check is made when a PTY status bit changes to determine if the controlling program is in a sleep. If it is, the sleep time is cleared so the controlling program can service the PTY.

5.9.3 File Status (Refer to Appendix D)

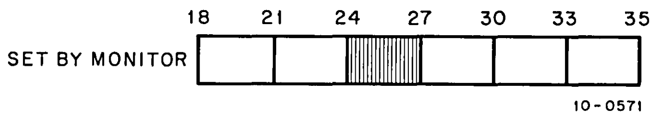
The file status of the pseudo-TTY is shown below.

Standard Bits



Bit 21 – IO.BKT	
Bit 23 – IO.ACT	Device is active.

Device Dependent Bits



Bit 24 – IO.PTI	Job is in a TTY input wait. The controlling job should perform an OUTPUT to the PTY.
Bit 25 – IO.PTO	The TTY buffer has output to be read by an INPUT from the PTY.
Bit 26 – IO.PTM	Any characters typed into the TTY buffer (by OUTPUT to the PTY) are read by the monitor command decoder instead of by the controlled job (i.e., the controlled job is in monitor mode).

5.9.4 Special Programmed Operator Service

5.9.4.1 OUT, OUTPUT UUOs – The first OUTPUT operation after an INIT or OPEN causes the special actions of the RELEASE UUO (refer to Paragraph 5.9.4.3) and then the following normal output operations.

1. Characters from the controlling program's buffer ring are placed in the input buffer of the TTY linked to the PTY.
2. The IO.PTI bit is cleared.
3. The IO.PTM bit is set or cleared as determined by the state of the TTY.

The following are exceptions to the normal output actions:

1. NULLS (ASCII 000) are discarded.
2. If more OUTPUTs are performed than are accepted by the controlled job and if the limit on this excess is exceeded, the IO.BKT bit is set and the remainder of the controlling program's buffer is discarded.
3. Lower case characters sent to the controlling job are translated to upper case if the appropriate bit in the TTY is set.

5.9.4.2 IN, INPUT UUOs – Characters are read from the output buffer of the TTY and are placed in the buffer ring of the controlling program. If there are no characters to read, an empty buffer is returned. The INPUT UUO does not cause a WAIT.

All the available characters are passed to the controlling program. If there are more characters to read than can fit in the buffer of the controlling program, the IO.PTO bit remains set and another INPUT should be done. If the output buffer of the TTY is exhausted by the INPUT UUO, the IO.PTO bit is cleared.

5.9.4.3 RELEASE UUO – The RELEASE UUO causes the following special actions:

1. Any characters in the output buffer of TTY are discarded.
2. If the controlled job is still attached to TTY, it is detached.
3. The PTY is disassociated from the software channel.

CAUTION

Haphazard use of the PTY and subsequent RELEASE operations may leave detached jobs tying up core and other system resources.

5.9.4.4 JOBSTS UUO – This UUO provides status information about devices TTY and/or the controlled job in order to allow complete and accurate checking of a controlled job.

The call is:

```
MOVEI AC, user channel number          ; or MOVNI AC, Job number
JOBSTS AC,                             ; or CALLI AC, 61
error return
normal return
```

When the UUO is called, AC contains a number n specifying the job and/or the TTY to be checked. If n is from 0 to 17, the specified TTY and job are those currently INITed on the user's channel n. If n is negative, the job to be checked is job number (-n).

The error return is given if one of the following is true:

1. the UUO is not implemented. If this is the case, check the I/O status word.
2. n is out of range.
3. there is no PTY INITed on channel n.

Otherwise, the normal return is given and AC contains the following status information:

Name	Bit	Explanation
JB.UJA	Bit 0 = 1	Job number is assigned.
JB.ULI	Bit 1 = 1	Job is logged in.
JB.UML	Bit 2 = 1	TTY is at monitor level.
JB.UOA	Bit 3 = 1	TTY output is available.
JB. UDI	Bit 4 = 1	TTY is at user level and in input wait, or TTY is at monitor level and can accept a command. In other words, there is no command awaiting decoding or being delayed, the job is not running, and the job is not stopped waiting for operator device action.
JB.UJC	Bit 5 = 1	JACCT is set. In particular, ↑C↑C will not work.
	Bits 6–17	Reserved for the future.
JB.UJN	Bits 18–35	Job number being checked or 0 if no job number is assigned.

5.9.4.5 CTLJOB UUO – This UUO is used to determine the job number of the program (job) that is controlling the specified job, if any.

The call is:

```
MOVE AC, job number              ;-1 means user's job
CTLJOB AC,                       ;or CALLI AC, 65
error return
normal return
```

On a normal return, AC contains the job number of the program (job) that is controlling the controlled job. If AC = 1, the specified job is not being controlled via a PTY.

An error return is given if the UUO is not implemented or the job number is too large.

5.10 TERMINALS

Communication between the user and the DECsystem-10 can be accomplished by use of a terminal. Commands, programs or data may be sent directly to the computer by means of a terminal. Each terminal is assigned a TTY number, such as TTY1 or TTY2 (the maximum number is 512). The console terminal (the terminal connected directly to the DECsystem-10 processor) is known as the CTY. The standard buffer size for terminal input and output is 23(8) (20(8) data) words. The terminal user may communicate with the operator and other users by means of the SEND or PLEASE commands (see Operating System Commands).

A terminal (under timesharing) may be in monitor mode or user mode. In monitor mode, each line the user types is sent to the monitor command language interpreter.

The execution of certain commands (as noted in the following examples) places the terminal in user mode. When the terminal is in user mode, it becomes simply an I/O device for that user. In addition, user programs use the terminal for two purposes. The user program will either accept user command strings from the terminal or use the terminal as a direct I/O device.

Example (terminal dialogue):

```
monitor mode     .R PIP                      monitor command

user mode        *DSK:PROG1.MAC←TTY:         user command string

                 THIS IS FILE 1 ↑Z           user program using
                                             terminal as input
                                             device

                 *↑C
monitor mode     .R MACRO                    monitor command

user mode        *TTY: ←DSK:PROG1            user command string

                       .                     user program using
                                             terminal
                       .                     as an output device
                 assembly listing
                       .
                       .
```

When the system is started, each terminal is in monitor mode ready for users to log in. However, if the system becomes fully loaded (i.e., the maximum number of jobs that the system is set to handle has been initiated), then any unused terminals from which access is requested will receive the message JOB CAPACITY EXCEEDED.

A time-sharing user types ↑C to stop a user program and return the terminal to monitor mode. If the user program is waiting for input from the terminal, the user needs to type only one ↑C to return the terminal to monitor mode; otherwise, he must type two ↑C's. Because of this procedure, the user knows that his program is not waiting for input if there is no response from the monitor after one ↑C. Certain commands cause the user program to start running or to continue but leave the terminal in monitor mode. (Refer to the Operating System Commands Manual.)

Control-T (↑T) causes the terminal to print status information pertaining to the current user job. The status information returned is:

1. incremental day time
2. incremental run time
3. incremental disk reads

4. incremental disk writes
5. program name
6. core size
7. job state
8. program counter

Control-R (↑R) retypes the current input line after all rubout processing. For example, if a user types in a line incorrectly, then makes correction using the RUBOUT key, the corrected line may be retyped in its entirety by typing ↑R. An example of this is:

```
SET TTQ/Q/Y  N0/0/O ↑ R
SET TTY NO
```

Control-R will issue a carriage return/line feed before printing the corrected input line.

Control-U (↑U) causes the deletion of the current input line, back to the last break character. The system responds with a carriage return, line feed so that the line may be typed again. Once a break character has been typed, line-editing features (↑U and RUBOUT) can no longer be used on that line, except when running TECO.

Control-O (↑O) temporarily suppresses output to the terminal. This action is useful when a program begins output of a long message which does not interest the user. If he does not want to wait for his terminal to finish printing the message, he can stop the output in one of two ways. He can type two control-C's but this action will also stop execution of the program. Alternatively, the user can type ↑O and the program will continue to execute but its output will not be printed on the terminal. The system responds with a carriage return, line feed sequence. Output is restored to the terminal when one of the following conditions occurs:

1. The executing program requests input from the terminal.
2. The program terminates and returns control to the monitor.
3. The user types ↑C to return to the monitor.
4. The user types another ↑O.

At remote stations, the effect of the ↑O may be somewhat delayed.

The type-ahead technique may be employed by the experienced timesharing user at a terminal. This means that the user does not have to wait for the completion of one command before he can begin another. For example, if two operations are desired from the monitor, the request for the second operation can be typed before receiving the period after completion of the first.

More specific information on terminals may be found in the SCNSER Specification in the Software Notebooks, and in the System Reference Manual, Section 3.3.

On half-duplex terminals, the user may type Control-O to stop unwanted output. To return to the monitor during output, type any character until output stops; then type Control C.

Programs waiting for terminal output are awakened before the output buffer is empty, causing them to be swapped in sooner and preventing pauses. Programs waiting for terminal input will be awakened when input is received.

5.10.1 Data Modes

ASCII (American Standard Code for Information Interchange) is a standard character set encoded in 7 bits (8 bits including a parity bit). The ASCII set consists of 128 characters, 33 of which are non-printing control characters. The following table describes how the characters are handled.

000	NULL	Ignored on input; suppressed on output.
001	↑A	No special action.
002	↑B	No special action.
003	↑C	Not passed to program. The user's terminal is switched to monitor mode the next time input is requested by the program. Two successive ↑Cs cause the terminal to be immediately switched to monitor mode. Performs a ↑U and a ↑O. For user program control of ↑C, refer to Paragraph 3.1.3.2.
004	↑D (EOT)	Not echoed; therefore, typing in a control-D (EOT) does not cause a full-duplex data phone to hang up.
005	↑E (WRU)	No special action.
006	↑F	No special action.
007	↑G (Bell)	Echoes as Bell and is a break character.
010	↑H (Backspace)	Echoes as backspace.
011	↑I (TAB)	Echoes as a TAB or an equivalent number of spaces. Refer to the SET TTY TAB command.
012	↑J (Linefeed)	Echoes as a linefeed and is a break character.
013	↑K (Vertical tab)	Echoes as a vertical tab or four linefeeds. Refer to the SET TTY FORM command.
014	↑L (Form)	Echoes as a FORMFEED or eight linefeeds. Refer to the SET TTY FORM command.
015	↑M (Carriage return	Passed to program if terminal is in a paper-tape input mode; otherwise, supplies a linefeed echo, is passed to program as a CR and LF, and is a break character due to the LF.
016	↑N	No special action.
017	↑O	Not passed to program. Complements output suppression bit allowing users to turn output on or off. INPUT, INIT, and OPEN clear the output suppression bit. This bit is also cleared by any other INPUT-class operation, such as DDTIN and TTCALLS 0, 2, 4, and 5, by input test TTCALLS 13 and 14, and by returning to monitor command level via ↑C or EXIT operations. Echoed as ↑O followed by carriage return/linefeed.
020	↑P	No special action.

021	↑Q (XON)	Starts paper-tape mode if .TTY TAPE command has been given; refer to Paragraphs 5.10.8 and 5.10.9.
022	↑R	Retype the line currently being input, including the effect of any edits to the line.
023	↑S (XOFF)	Ends paper-tape mode; refer to Paragraphs 5.10.8 and 5.10.9.
024	↑T	Gives job status and timing information.
025	↑U	Deletes input line back to last wakeup character. Echoed as ↑U followed by a carriage return/linefeed; is a break character. Passed to program if special editor mode is true.
026	↑V	No special action.
027	↑W	No special action.
030	↑X	No special action.
031	↑Y	No special action.
032	↑Z	Acts as EOF on TTY input. Echoes as ↑Z followed by carriage return/linefeed. Is a break character.
033	↑[(ESC)	The standard ASCII escape. Echoed as $; is a break character.
034	↑\	No special action.
035	↑]	No special action.
036	↑↑	No special action.
037	↑←	No special action.
040–137		Printing characters, no special action.
140–174		Lower case ASCII; translated to upper case, unless lower case mode is on. Echoes as upper case if translated to upper case.
175 and 176		Old versions of altmode; converted to the standard escape (033) unless in special editor mode (INIT or TRMOP. UUO) or no altmode conversion is specified (TRMOP. UUO or SET TTY NO ALT command).
177		RUBOUT or DELETE: 1. Completely ignored if in paper-tape mode (XON). 2. Break character, passed to program if either DDT mode or special editor mode is true. 3. Otherwise (ordinary case) causes a character to be deleted for each rubout typed. All the characters deleted are echoed between a single pair of backslashes. If no characters remain to be deleted, echoes as a carriage return/linefeed.

On output, all characters are typed just as they appear in the output buffer with the exception of TAB, VT, and FORM, which are processed the same as on type-in. Programs should avoid sending ↑D, because it may hang up certain data sets.

Image mode (octal code 10) is legal for TTY input and output except for pseudo-TTY's (refer to Paragraph 5.9). Image mode is especially convenient for users of display devices, light pens, etc. since any sequence of input characters is allowed. The user must use the ASSIGN command before the INIT command can be used in image mode. (The user's own TTY is always assigned by logging in.) An attempt to do input to an unassigned terminal results in an error return. Since any sequence of characters must be allowed, Control-C and Control-Z may not cause their usual functions. If the user program accepts all characters, and does not release the terminal from image mode, no user input will release the user from this state. The terminal would effectively become dead to the system. Because of this situation, an image input state is defined. The image input state begins when the program starts waiting as a result of an INPUT UUO in image mode. It ends when the program executes any non-image mode terminal output operation. If no output is desired, a TTCALL UUO can be executed to output a null character. If no input characters are received for 10 seconds the EOF is forced. After another 10 seconds, the image input state is terminated by the monitor and a Control-C is simulated. If the user should be in this situation, he should stop typing until the Control-C appears.

5.10.2 Model 2741 Terminals

The DECsystem-10 provides support for users of several versions of Model 2741 terminal through use of a DC76 Communications Interface. The DC76 converts the 2741 character codes to ASCII.

The 2741 terminals have both upper and lower case characters, but no control characters. It operates in half-duplex mode only. The two 2741 keyboards are shown on the following page.

NOTE

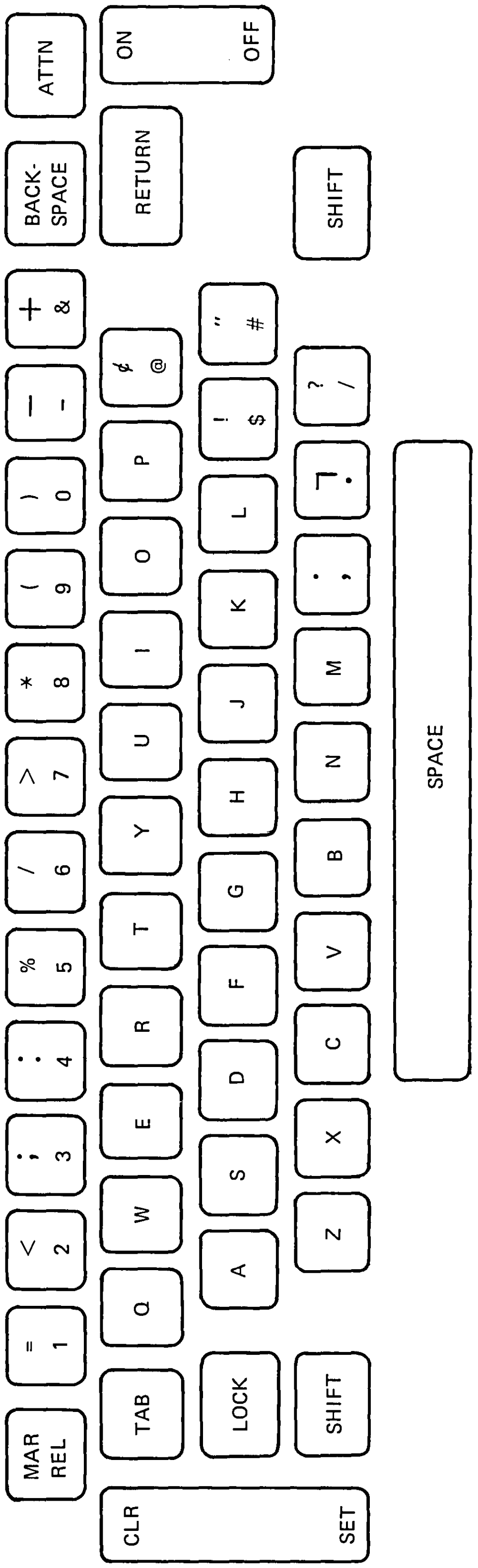
Most 2741 terminals do not have a circumflex key labeled as (∧) and a (⅂) (sometimes ±) must be used. Control characters are obtained by typing the circumflex key and then the corresponding alphabetic character.

The following shows the required character set:

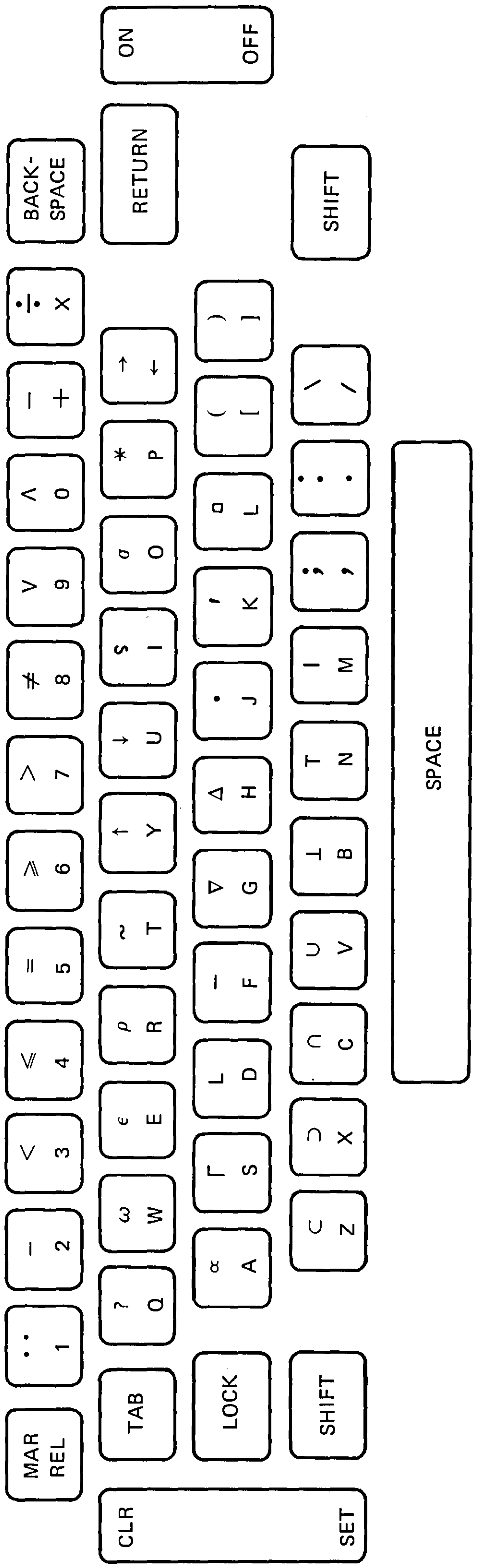
2741 Octal Code	Character
00	Space
13	EOA (vertical tab)
16	Shift
17	EOT
35	Index (line feed)
55	Carriage return
56	Backspace
57	Null

The following shows how to generate special characters:

To Generate	Type
↑	↑↑
escape	↑$



10-1281



10-1282

To Generate	Type
left square bracket	[or ↑(or ↑<
right square bracket	] or ↑) or ↑>
left angle bracket	< or ↑[
right angle bracket	> or ↑]
backslash	↑/
034 file separator	↑4
035 group separator	↑5
036 record separator	↑6
037 unit separator	↑7
left braces	↑3
vertical bar	↑1
right braces	↑2
tilde	↑–
accent grave	↑'

It is strongly recommended that the terminal have a break feature (ATTN), but it is not required. The ATTN key unlocks a locked keyboard, enabling the user to type and locks an unlocked keyboard enabling output to be typed out. The DC76 recognizes that a terminal is a 2741 through automatic baud recognition (the 2741 baud rate is 134.5).

5.10.2.1 **User Interface** – Alphanumeric characters (ASCII characters 40–176) will appear to be handled in the same way as with a Model 33 type terminal. (For instance, striking the capital "A" key on the 2741 will transmit an ASCII 101).

A special set of commands are utilized for Model 2741 terminals. (Refer to the Operating System Commands Manual for complete information.) SET TTY DEBREAK tells the system that the terminal has a feature that allows the computer to lock the keyboard and start output. This feature is useful for TECO or DDT, where the user does not hit carriage return prior to a response from the computer.

The SET TTY ELEMENT # command changes the typing element. (This command also sets TTY NO LC.) The elements available are

987	APL correspondence
029	Standard correspondence
087	Call 360 BASIC
963	Extended binary
938	BCD
988	APL (EBCD)

SET TTY TIDY command specifies that every character occupies one print position. The terminal normally types out characters such that they appear on the page the same way the user types them in. For example [prints out as ↑<. In TIDY mode, [prints out as <.

On input, lower-case alphanumeric characters are translated to upper-case by the monitor unless the SET TTY LC command is given.

CAUTION: Because these terminals are local copy devices, the characters input may print as lower case even when the program is receiving them as upper case.

When the monitor command "SET TTY LC" is given or SEM (Special Editor Mode) is set by the program, lower-case alphanumeric characters will not be modified on input.

Backspace (010 octal) will be processed in the same way (except in APL mode) that a rubout is processed, except it will echo as a backspace.

The monitor will assume tab stops are set in the standard positions (1, 9, 17, 25, etc.). If the tabs are set to any other place, an incorrect operation will result.

The following non-ASCII characters on the EBCD (938) type ball are considered to be stylized versions of ASCII characters:

cent sign (¢)	backslash \
lozenge (#)	vertical bar |
plus-or-minus (±)	circumflex ↑

If the circumflex character is followed by any other non-alphabetic character, the circumflex is ignored and only the non-alphabetic character is put into the buffer. (These translations do not occur when APL mode is in effect.)

Occasionally, a terminal will become hung (a transmission error occurs on a line control character). When this happens, switching the terminal quickly from REMOTE to LOCAL (or ON to OFF) will usually clear up the problem. It is important not to confuse this with slow system response.

5.10.3 DDT Submode(1)

To allow a user's program using buffered I/O and the DDT debugging program to use the same terminal without interfering with one another, the TTY service routine provides the DDT submode. This mode does not affect the TTY status if it is initialized with the INIT operator. It is not necessary to use INIT to perform I/O in the DDT submode. I/O in DDT mode is always to the user's terminal and not to any other device.

In the DDT submode, the user's program is responsible for its own buffering. Input is usually one character at a time, but if the typist types characters faster than they are processed, the TTY routine supplies buffers full of characters at the same time.

To input characters in DDT mode, use the sequence

```
MOVEI AC,BUF
CALL AC, [SIXBIT/DDTIN/]
```

BUF is the first address of a 21-word block in the user's area. The DDTIN operator delays, if necessary, until one character is typed in. Then all characters (in 7-bit packed format) typed in since the previous occurrence of DDTIN are moved to the user's area in locations BUF, BUF+1, etc. The character string is always terminated by a null character (000). RUBOUTS are not processed by the service routine but are passed on to the user. The special control character ↑U has no effect. Other characters are processed as in ASCII mode.

To perform output in DDT mode, use the sequence

```
MOVEI AC,BUF
CALL AC,[SIXBIT /DDTOUT/]
```

(1) The usage described in this section is obsolete; new programs should use the TTCALL UUO (refer to Paragraph 5.10.3).

BUF is the first address of a string of packed 7-bit characters terminated by a null (000) character. The TTY service routine delays until the previous DDTOUT operation is complete, then moves the entire che acter string into the monitor, begins outputting the string, and restarts the user's program. Character processing is the same as for ASCII mode output.

5.10.4 TTCALL UUO 051

The TTCALL UUO is used to extend the capabilities of the terminal. The TTCALL operations are performed for a physical terminal (not a logical name TTY) and most operations reference the terminal controlling the job which executed the UUO. (There are exceptions, such as in the case of GETLCH.)

The general form is

```
TTCALL AC, ADR
```

The AC field describes the particular function desired, and the argument (if any) is contained in ADR. ADR may be an AC or any address in the low segment above the job data area (137). It may be in high segment for AC fields 1 and 3. The functions are:

AC Field	Mnemonic*	Action
0	INCHRW	Input character and wait
1	OUTCHR	Output a character
2	INCHRS	Input character and skip
3	OUTSTR	Output a string
4	INCHWL	Input character, wait, line mode
5	INCHSL	Input character, skip, line mode
6	GETLCH	Get line characteristics
7	SETLCH	Set line characteristics
10	RESCAN	Reset input stream to command
11	CLRBFI	Clear type-in buffer
12	CLRBFO	Clear type-out buffer
13	SKPINC	Skip if a character can be input
14	SKPINL	Skip if a line can be input
15	IONEOU	Output as an image character
16–17		(Reserved for future use)

*The TTCALL mnemonics are defined in a separate MACRO assembler table, which is scanned if an undefined OP CODE is found. If the symbol is found in the TTCALL table, it is defined as if it had appeared in an appropriate OPDEF statement, for example:

```
TYPE:  OUTCHR CHARAC
```

If OUTCHR is undefined, it will be assembled as though the program contained the statement:

```
OPDEF OUTCHR [TTCALL 1,]
```

This facility is available in MACRO V.44 and later.

INPUT and INPUT TEST operations (TTCALLs 0, 2, 4, 5, 13 and 14) also clear the effect of the previous ↑O type in.

INCHRW ADR or TTCALL 0, ADR – This inputs a character into the low-order seven bits of location ADR. If there is no character yet typed, the program waits.

OUTCHR ADR or TTCALL 1, ADR – This outputs the character in location ADR to the user's terminal. Only the low order seven bits of the contents of ADR are used; the remaining bits need not be zeroes.

If there is no room in the output buffer, the program waits until room is available. ADR may be in high segment.

INCHRS ADR or TTCALL 2, ADR – This is similar to INCHRW, except that it skips on a successful return, and does not skip if there is no character in the input buffer; it never puts the job into a wait.

```
TTCALL 2,ADR
 JRST  NONE
JRST   DONE
```

OUTSTR ADR or TTCALL 3, ADR – This outputs a string of characters in ASCIZ format:

```
TTCALL 3,MESSAGE
MESSAGE: ASCIZ /TYPE THIS OUT/
```

ADR may be in high segment.

INCHWL ADR or TTCALL 4, ADR – This is the same as INCHRW, except that it decides whether or not to wait on the basis of lines rather than characters; as such, it is the preferred way of inputting characters, because INCHRW causes a swap to occur for each character rather than each line (compare DDT and PIP input). In other words, INCHWL returns the next character in the line if a break character has been typed. (1) If a break character has not been typed, INCHWL waits. Repeated uses of INCHWL return each of the successive characters of the line.

Note that a control-C character in the input buffer is sufficient to satisfy the condition of a pending line. Therefore, when the input is done, the control-C is interpreted and the job is stopped. This definition of a line also applies to TTCALL 5, and TTCALL 14,.

INCHSL ADR or TTCALL 5, ADR – This is the same as INCHRS, except that its decision whether to skip is made on the basis of lines rather than characters.

GETLCH ADR, or TTCALL 6, ADR – This takes one argument, from location ADR, and returns one word, also in ADR. The argument is a number, representing a TTY line. Bits 18 and 19 of the line number are ignored since terminal numbers begin at 200000. If the argument is negative, the line number controlling the program is assumed. If the line number is greater than those defined in the system, a zero answer is returned.

The normal answer format is as follows:

(1) If the input buffer becomes nearly filled, the waiting-of-line condition is satisfied even though no break character appears. This is true of all line-mode input operations.

Name	Bit	Meaning
GL.ITY	0	Line is a pseudo TTY.
GL.CTY	1	Line is the CTY.
GL.DSP	2	Line is the display console.
GL.DSL	3	Line is the dataset data line.
	4	Obsolete.
GL.HDP	5	Line is half-duplex.
GL.REM	6	Line is a remote TTY.
GL.RBS	7	Line is at a remote station.
GL.LIN	11	A line has been typed in by the user.
	12	Obsolete.
GL.LCM	13	Lower case input mode is on.
GL.TAB	14	Terminal has tabs.
GL.LCP	15	Terminal input is not echoed, because device is local copy.
GL.PTM	16	Control Q (paper-tape) switch is on.
	17	Obsolete.
	18-35	200000 + line number.

SETLCH ADR or TTCALL 7, ADR – This allows a program to set and clear some of the bits for GETLCH. They may be changed only for the job's controlling TTY. Bits 13, 14, 15, and 16 can be modified. Bits 18 and 19 of the line number argument are ignored.

Example:

```
SETO        AC,0
GETLCH      AC
TLZ         AC,GL,TAB
TLO         AC,GL,LCM
SETLCH      AC
```

RESCAN or TTCALL 10, 0 – This is intended for use only by the COMPIL program. It causes the input buffer to be rescanned from the point where the last command began. If bit 35 of E is 1, the error return is given if there is a command in the input buffer. If the input buffer is empty, the skip return is given. Obviously, if the UUO is executed after the first input, the RESCAN may no longer be in the buffer. ADR is not used, but it is address checked.

CLRBFI or TTCALL 11, 0 – This causes the input buffer to be cleared as if the user had typed a number of Control u's. It is intended to be used when an error has been detected (e.g., if a user did not want anything that he might have typed ahead to be executed).

CLRBFO or TTCALL 12, 0 – This causes the output buffer to be cleared as if the user had typed CONTROL O. It should be used rarely, since most users want to see all output up to the point of an error.

SKPINC or TTCALL 13, 0 – This skips if the user has typed at least one character. It does not skip if no characters have been typed; however, it never inputs a character. It is useful for a compute-bound program that wants to occasionally check for input and, if any, go off to another routine (such as the FORTRAN operating system) to actually do the input.

SKPINL or TTCALL 14, 0 – This is the same as SKPINC, except that a skip occurs if the user has typed at least one line.

IONEOU ADR or TTCALL 15, E – This outputs the low-order eight bits of the contents of E as an image character.

5.10.5 GETLIN AC, or CALLI AC, 34

This UUO returns the SIXBIT physical name of the terminal that the job is attached to:

The call is:

```
    GETLIN AC,                          ;or CALLI AC,34
```

The name is returned left justified in the AC. If the job issuing the UUO is currently detached, the left half of AC contains a 0 on return. The right half of AC contains the right half of the physical name of the terminal to which the job was most recently attached. Therefore, by testing the left half of AC, jobs can determine if they are attached to a terminal.

Example:

```
    CTY or TTY3 or TTY30
```

This UUO is used by the LOGIN program to print the TTY name.

5.10.6 TRMNO. AC, or CALLI AC, 115(1)

This UUO is used to obtain the number of the terminal currently controlling a particular job. This terminal number can then be used as the argument to the GETLCH (refer to Paragraph 5.10.3.7) and TRMOP. (refer to Paragraph 5.10.6) UUOs.

The call is:

```
    MOVE AC, job number
    TRMNO. AC,                          ; or CALLI AC, 115
    error return
    normal return
```

On a normal return, the right half of AC contains the universal I/O index (.UXxxx) for the terminal. The range of values is 200000 to 200777 octal. The symbol .UXTRM (octal value 200000) is the offset for the terminal indices.

On an error return, if the AC is unchanged, the UUO is not implemented. If the AC contains zero, one of three errors occurred:

1. The job is currently detached and, therefore, no terminal is controlling it.
2. The job number is unassigned; i.e., there is no such job.
3. The job number is out of range and therefore illegal.

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

The particular error condition can be determined from the JOBSTS UUO (refer to Paragraph 5.9.4.4). For example,

```
MOVEI AC, number
TRMNO. AC,
     JRST .+2
JRST OK
JUMPN AC, not implemented
MOVNI AC, number
JOBSTS AC,
     JRST illegal number
JUMPL AC, detached
JRST no job assigned.
```

5.10.7 TRMOP. AC, or CALLI AC, 116(1)

This UUO allows the user to control, examine, and modify information about any terminal connected to the system. Many of the functions of this UUO are extensions to the TTCALL input and output functions (refer to Paragraph 5.10.3). Certain functions are privileged, or require that the user have the terminal ASSIGNed. Generally, any function is legal for the terminal on which the job issuing the UUO is running. In addition, any READ or SKIP function is legal for any terminal if the job issuing the UUO

1. has the privilege bit JP.SPM set,
2. is running with the JACCT bit set, or
3. is logged in as [1,2].

A SET or output function is legal for any terminal if the job

1. has the privilege bit JP.POK set,
2. is running with the JACCT bit set, or
3. is logged-in as [1,2].

The call is:

```
           MOVE AC, [XWD N, ADR]
           TRMOP. AC,                    ; or CALLI AC, 116
           error return
           normal return

ADR:       function code
ADR+1:     universal I/O index (UDX)
```

ADR is the address of the argument block and N is the length (N must be at least 2). The first word of the argument block contains the code for the requested function. The second word contains the universal I/O index of the terminal to be affected (.UXTRM + line number). This index is in the same format as returned by the TRMNO. UUO (refer to Paragraph 5.10.5). Remaining arguments in the argument block depend on the particular function used.

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

Function codes are defined within the following ranges:

0000-0777	Perform a specific action.
1000-1777	Read a parameter.
2000-2777	Set a parameter.
3000-3777	Reserved for DEC customers.

The functions within the range 0000-0777 are as follows:

.TOSIP	1	Skip if terminal input buffer is not empty.
.TOSOP	2	Skip if terminal output buffer is not empty.
.TOCIB	3	Clear terminal input buffer.
.TOCOB	4	Clear terminal output buffer.
.TOOUC	5	Output normal mode character from ADDR+2 to terminal.
.TOOIC	6	Output image mode (8-bit) character from ADR+2 to terminal.
.TOOUS	7	Output ASCIZ string to terminal from address at ADR+2.
.TOINC	10	Input character from terminal to AC, normal mode.
.TOIIC	11	Input character from terminal to AC, image mode (not yet implemented).
.TODSE	12	Enable modem for outgoing call.
.TODSC	13	Enable and place outgoing call on modem with dialer. Phone number of up to 17 digits is stored in 4-bit bytes in ADR+2 and ADR+3 and is terminated by a 17 byte. If caller must wait for a second dial tone (e.g., after dialing a 9), a 16 byte results in a 5 second wait.
.TODSF	14	Hang up modem (i.e., disconnect call).
.TORES	15	Do a rescan.
.TOSTE	16	Set the TTY element from ADDR+2
.TOEAD	17	Enable automatic baud detection

The READ (1000-1777) and SET (2000-2777) functions are parallel; i.e., if function 1002 reads a particular parameter, then function 2002 sets the same parameter. Values for the READ functions are returned in AC; arguments to the SET functions are given in ADR+2. One-bit quantities are not range-checked; instead bit 35 of ADR+2 is stored. The following description of the READ function codes indicate if there is a corresponding SET function code.

Read Code	Range	Description	Corresponding SET
1000	1 bit	Output in progress (.TOOIP)	No
1001	1 bit	Terminal at monitor mode (.TOCOM)	No
1002	1 bit	Paper tape mode (.TOXON)	Yes

Read Code	Range	Description	Corresponding SET
1003	1 bit	Lower case (if set, no lower case) (.TOLCT).	Yes
1004	1 bit	Slave switch (.TOSLV).	Yes
1005	1 bit	Tab switch (if 0 = spaces, if 1 = tab) (.TOTAB).	Yes
1006	1 bit	Form switch (if 0 = linefeeds, if 1 = formfeeds) (.TOFRM).	Yes
1007	1 bit	Local copy switch (if set, no echo) (.TOLCP).	Yes
1010	1 bit	Free CR-LF switch (if set, no CR-LF) (.TONFC).	Yes
1011	0 to 377	Horizontal position of carriage (.TOHPS).	No
1012	16. to 200.	Carriage width (.TOWID).	Yes
1013	1 bit	TTY GAG bit (if set, NO GAG) (.TOSND).	Yes
1014	1 bit	Half-duplex line (.TOHLF)	Yes, privileged
1015	1 bit	Remote line (.TORMT).	Yes, privileged
1016	1 bit	Display terminal (.TODIS).	Yes, privileged
1017	0 to 3	Filler class (.TOFLC).	Yes
1020	1 bit	Paper tape enabled (.TOTAP).	Yes
1021	1 bit	Paged display mode (also set and cleared by SET TTY PAGE) (. .TOPAG).	Yes
1022	1 bit	Suspended output (need XON to resume) also set by XOFF, formfeed or page size exceeded, if paged display mode (.TOSTP). Not implemented.	Yes
1023	0 to 63	Page size (number of lines) (also set by SET TTY PAGE) (.TOPSZ). Not implemented.	Yes
1024	0 to 63	Page counter (number of lines output this page) (.TOPCT).	Yes
1025	1 bit	Suppress blank lines on output (0 = normal output and 1 = suppress multiple linefeeds and vertical tabs to linefeeds (also set and cleared by SET TTY BLANK) (.TOBLK).	Yes

Read Code	Range	Description	Corresponding SET
1026	1 bit	Suppress ALTmode conversion on input (0 = 175 and 176 converted to 033 and 1 = no conversion) (also set and cleared by SET TTY ALT) (.TOALT).	Yes
1027	1 bit	APL mode (.TOAPL).	Yes
1030	*	Receive Speed (.TORSP).	Yes
1031	*	Transmit Speed (.TDTSP).	Yes
1032	1 bit	Debreak (.TODBK).	Yes
1033	1 bit	Line is 2741 (.TO274).	Yes, privileged
1034	1 bit	TIDY (.TOTDY).	No
1035	1 bit	AUTO CR value. If non-zero, the first space after COL n is converted to a carriage return. (The value of n = 16 to 200). (.TOACR).	Yes

(*)This is a four-bit field that contains an octal code corresponding to the speed desired according to the following table:

Code	Speed
1	50
2	75
3	110
4	134.5
5	150
6	200
7	300
10	600
11	1200
12	1800
13	2400
14	4800
15	9600
16	External A
17	External B

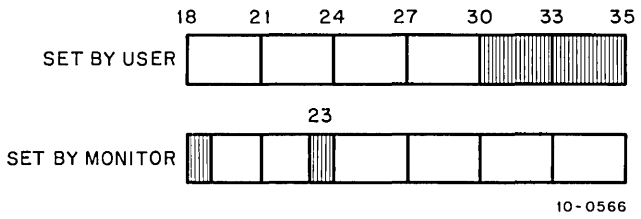
On an error return, AC is either unchaged or contains an error code.

AC	Name	Meaning
Unchanged		UUO is not implemented.
0		The requested function is not implemented.
1	TOPRC%	User is not privileged to perform this function.
2	TORGB%	Argument is out of range.
3	TOADB%	Argument list length or address is illegal.
4	TOIMP%	Dataset activity to a non-dataset terminal.
6	TODIL%	Subfunction failed (e.g., call not properly completed from dialer).
7	TOTNA%	Terminal not available.

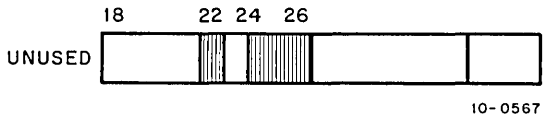
5.10.8 File Status (Refer to Appendix D)

The file status of the terminal is shown below.

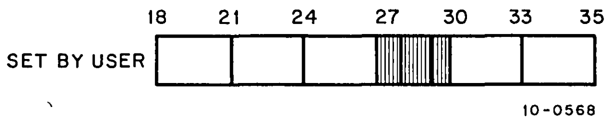
Standard Bits



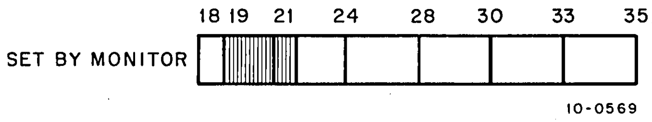
Bit 18 = IO.IMP	TTY is not assigned to a job (for image mode input processing).
Bit 23 = IO.ACT	Device is active.



Device Dependent Bits



Bit 27 – IO.TEC	This bit causes 001 through 037, 175, and 176 (octal) to echo the character exactly as received by the monitor. THERE IS NO SPECIAL ECHO (E.G., $ OR ↑X).
Bit 28 – IO.SUP	Suppresses echoing on the terminal.
Bit 29 – IO.SEM	Special editor mode. Pass all characters except lower case and ↑C. Lower case is controlled by the SET TTY LC command and corresponding TRMOP. UUO function.



Bit 19 – IO.DER	Ignore interrupts for three-fourths of a second.
Bit 20 – IO.DTE	Echo failure has occurred on output.
Bit 21 – IO.BKT	Character was lost on typein.

5.10.9 Paper-Tape Input from the Terminal (Full-Duplex Software)

Paper-tape input is possible from a terminal equipped with a paper-tape reader that is controlled by the XON (↑Q) and XOFF (↑S) characters. When commanded by the XON character, the terminal service reads paper tapes, starting and stopping the paper tape as needed, and continuing until the XOFF character is read or typed in. While in this mode of operation, any RUBOUTS will be discarded and no free line feeds will be inserted after carriage returns. Also, TABS and FORMFEEDS will not be simulated on a Teletype Model 33 to ensure output of the reader control characters. To use paper tape processing, the terminal with a paper-tape reader must be connected by a full-duplex connection and only ASCII paper tapes should be used.

The correct operating sequence for reading a paper tape in this way is as follows:

```
.R PIP↵
*DSK:FILE←TTY:↑Q↵
THIS IS WHAT IS ON TAPE
MORE OF THE SAME
LAST LINE ↑Z
*↑C
```

5.10.10 Paper-Tape Output at the Terminal (Full-Duplex Software)

Paper-tape output is possible on any terminal-mounted paper-tape punch, which is controlled by the TAPE, AUX ON (↑R) AND AUX OFF (↑T) characters. The punch is connected in parallel with the keyboard printer and, therefore, when the punch is on, all characters on the keyboard are punched on tape.

LT33B or LT33H Teletypes can have the reader and punch turned off and on under program control. When commanded by the AUX ON character, the TTY service punches paper tapes until the AUX OFF character is read or typed in. The AUX OFF character is the last character punched on tape.

When writing programs to output to the terminal paper-tape punch, the user should punch several inches of blank tape before the AUX OFF character is transmitted. This last character may then be torn off and discarded.

CHAPTER 6
I/O PROGRAMMING FOR DIRECTORY DEVICES

This character explains the unique features of the standard directory devices. Each device accepts the programmed operators explained in Chapter 4, unless otherwise indicated. Table 6-1 is a summary of the characteristics of the directory device. Buffer sizes are given in octal and include three bookkeeping words. The user may determine the physical characteristics associated with a logical device name by calling the DEVCHR UUO (refer to Paragraph 4.10.2).

Table 6-1
Directory Devices

Device	Physical Name	Controller Number	Unit Number	Programmed Operators	Data Modes	Buffer Sizes (Octal*)
DECtape	DTA0, DTA1, . . . , DTA7 DTB0, DTB1, . . . , DTB7**	TD10 551 (PDP-6)	TU55 555(PDP-6)	INPUT, IN OUTPUT OUT LOOKUP, ENTER MTAPE, USETF, USETO, USETI UTPCLR	A, AL, I B, IB DR, D	202
Fixed Head Disk	DSK, FHA, FHA0, . . . , FHA3 DSK, FSA, FSA0, . . . , FSA7	RC10 RH10	RD10 RM10B RS04	INPUT, IN OUTPUT, OUT LOOKUP, ENTER RENAME, SEEK USETO, USETI	A, AL, I B, IB DR, D	203

*Buffer sizes are subject to change and should be calculated rather than assumed by user programs. A DEVSIZ UUO may be employed.
**Recognized if dual DECtape controller is supported.

Table 6-1 (Cont)
Directory Devices

Device	Physical Name	Controller Number	Unit Number	Programmed Operators	Data Modes	Buffer Sizes (Octal*)
Disk Pack	DSK, DPA, DPA0, . . . , DPA7	RP10	RP01 RP02 RP03	INPUT, IN OUTPUT, OUT LOOKUP, ENTER RENAME, SEEK USETO, USETI	A, AL, I B, IB DR, D	203

*Buffer sizes are subject to change and should be calculated rather than assumed by user programs. A DEVSIZ UUO may be employed.

6.1 DECTAPE

The device mnemonic is DTA0, DTA1, . . . , DTA7; the buffer size is 202 (octal) words (177(8) user data, 200(8) transferred). On systems with dual DECtape controllers, the drives on the second controller have the mnemonic DTB0, DTB1, . . . , DTB7.

6.1.1 Data Modes

Two hundred words are written. The first word is the link plus word count. The following 177 (octal) words are data supplied to and from user programs.

6.1.1.1 Buffered Data Modes – Data is written on DECtape exactly as it appears in the buffer and consists of 36-bit words. No processing or checksumming of any kind is performed by the service routine. The self-checking of the DECtape system is sufficient assurance that the data is correct. Refer to Paragraph 6.1.2 for further information concerning blocking of information.

6.1.1.2 Unbuffered Data Modes – Data is read into or written from anywhere in the user's core area without regard to the standard buffering scheme. Control for read or write operations must be via a command list in core memory. The command list format is described in Chapter 4. On the KI10, if the IOWD list is modified as the result of I/O performed (i.e., an INPUT UUO reads into the IOWD list) and the word count of any of the IOWDs read into the list is greater than the following value:

(maximum word count specified in original list -2)/512+2

then the job is stopped and the monitor types

ADDRESS CHECK AT USER adr

File-structured dump mode data is automatically blocked into standard-length DECtape blocks by the DECtape service routine. Each block read or written contains 1 link word plus 1 to 177(8) data words. Unless the number of data words is an exact multiple of the data portion of a DECtape block (177(8)), the remainder of the last block written after each output programmed operator is wasted. The input programmed operator must specify the same number of words that the corresponding output programmed operator specified to skip over the wasted fractions of blocks.

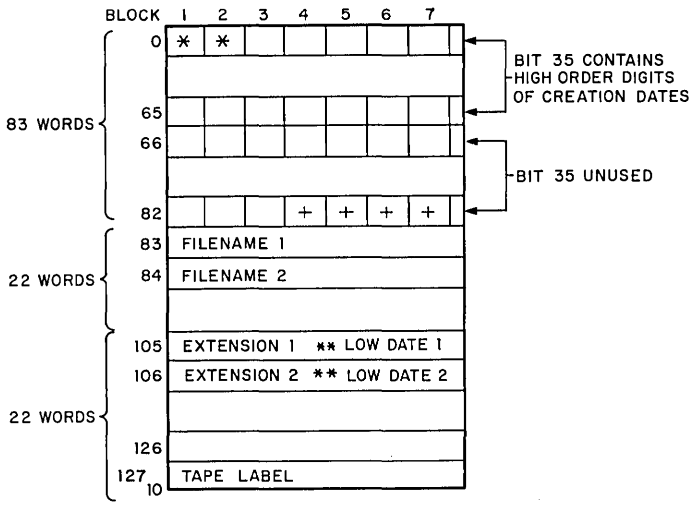
6.1.2 DECtape Format

A standard reel of DECtape consists of 578 (1102(8)) pre-recorded blocks each capable of storing 128 (200(8) 36-bit words of data. Block numbers that label the blocks for addressing purposes are recorded between blocks. These block numbers run from 0 to 1101(8). Blocks 0, 1, and 2 are normally not used during timesharing and are reserved for a bootstrap loader. Block 100(10) (144(8)) is the directory block, which contains the names of all files on the tape and information relating to each file. Blocks 3(10) through 99(10) (1-143(8)) and 101(10) through 577(10) (145-1101(8)) are usable for data.

If, in the process of DECtape I/O, the I/O service routine is requested to use a block number larger than 1101(8) or smaller than 0, the monitor sets the IO.BKT flag (bit 21) in the file status and returns.

6.1.3 DECtape Directory Format

The directory block (block 100(10)) of a DECtape contains directory information for all files on that tape; a maximum of 22 files can be stored on any one DECtape (see Figure 6-1).



NOTES:

* Reserved for system, contains 36 as does block 144_8 for the directory.

** For zero-compressed files, this area holds the number of 1K blocks (-1) needed to load the file (up to 64K).

+ Represents blocks 1102 through 1105, which are not available contains 37_8.

10-0572

Figure 6-1 DECtape Directory Format

The first 83 words (0 through 82 (decimal)) of the directory block contain slots for blocks 1 through 577 on a DECtape. Each slot occupies five bits (seven slots are stored per word) and represents a given block on the DECtape. Each slot contains the number of the file (1-26 (octal)) occupying the given block. This allows for 581 slots (83 words x 7 slots per word). The four extra slots represent nonexistent blocks 1102 through 1105 (octal).

Bit 35 of the first 66 words (0 through 65 (decimal)) of the directory block contain the high order three bits of the 15-bit creation date of each file on the DECtape. (Note that the low order 12 bits of the creation date of each file are contained in words 105 through 126(decimal)). This split format allows for compatibility among monitors and media as old as 1964. The high order 3 bits of the 15-bit creation date for file 1 are contained in bit 35 of words 0, 22, and 44. Word 44 contains the first (most significant) digit; word 22 contains the second and word 0 contains the third. The high order digits for file 2 are contained in bit 35 of words 1, 23 and 45 with the digits in the same order as described for file 1. The high order digits for the remaining files are organized in the same fashion.

Words 83 through 104 (decimal) of the directory block contain the filenames of the 22 files that reside on the DECtape. Words 83 contains the filename for file 1, word 84 contains the filename for file 2, filenames are stored in SIXBIT code.

The next 22 words of the directory block (words 105 through 126(10)) primarily contain the filename extensions and the low order part of the creation dates of the 22 files that reside on the DECtape, in the same relative order as their filename. The bits for each word are as follows:

Bits 0 – 17(10)	The filename extension in SIXBIT code.
Bits 18 – 23(10)	Zero.
Bits 24 – 35(10)	The low order 12 bits of the date on which the file was created. (Note that the high order digits are encoded in bit 35 of words 0 through 65(10). The creation date is computed with the following formula: ((year-1964) * 12 + (month-1)) * 31 + day -1.

Word 127(10) of the directory block is the tape label.

The message

BAD DIRECTORY FOR DEVICE DTAn: EXEC CALLED FROM USER LOC n

occurs when any of the following conditions are detected:

1. A parity error occurred while reading the directory block.
2. No slots are assigned to the file number of the file.
3. The tape block, which may be the first block of the file (i.e., the first block for the file encountered while searching backwards from the directory block), cannot be read.

Ordinary user programs never manipulate DECtape directories explicitly since the LOOKUP and ENTER programmed operators (refer to Paragraphs 6.1.5.1 and 6.1.5.2) automatically record all necessary entries in the directory for the user. These programmed operators have all the capability needed to process the name and creation date of a file. However, a small number of special purpose programs do process directories by explicit action rather than using the LOOKUP and ENTER operators. For such programs, the following examples illustrate methods for:

1. assembling the 15-bit creation date, and

2. storing the 15-bit creation date. The number of the file (an integer from 1 to 22) is in register P1 and the directory block begins at location DIRECT.

Example 1 Special Purpose Assembly of the Creation Date

```
DPB      T1, [POINT 12, DIRECT+ ↑D104 (P1), 35] ;SAVE LOW PART
MOVEI    T2, 1                                  ;SET UP TO MARK LOW BIT
ANDCAM   T2, DIRECT-1 (P1)                      ;CLEAR DIRECTORY BIT
TRNE     T1, 1B23                               ;IF BIT IN DATE SET,
IORM     T2, DIRECT-1 (P1)                      ;SET DIRECTORY BIT
ANDCAM   T2, DIRECT+ ↑D21 (P1)                  ;
TRNE     T1, 1B22                               ;REPEAT FOR EACH BIT IN
IORM     T2, DIRECT+ ↑D21 (P1)                  ;HIGH PART OF DATE
ANDCAM   T2, DIRECT+ ↑D43 (P1)                  ;
TRNE     T1, 1B21                               ;
IORM     T2, DIRECT+ ↑D43 (P1)                  ;
```

Example 2 Special Purpose Storage of the Creation Date

```
LDB     T1, [POINT 12, DIRECT+ ↑D104 (P1), 35]  ;GET LOW PART
MOVEI   T2, 1                                   ;SET UP TO TEST LOW BIT
TDNE    T2, DIRECT-1 (P1)                       ;IF SET IN DIRECTORY
TRO     T1, 1B23                                ;THEN SET BIT IN DATE
TDNE    T2, DIRECT+ ↑D21 (P1)                   ;REPEAT FOR EACH BIT IN
TRO     T1, 1B22                                ;HIGH PART OF DATE
TDNE    T2, DIRECT+ ↑D43 (P1)                   ;
TRO     T1, 1B21                                ;
```

6.1.4 DECtape File Format

A file consists of any number of DECtape blocks.

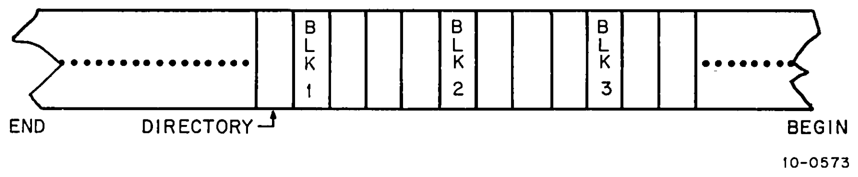


Figure 6-2 Format of a File on Tape

Each block contains the following:

Word 0	Left half	The link. The link is the block number of the next block in the file. If the link is zero, this block is the last in the file.
	Right half	Bits 18 through 27; the block number of the first block of the file. Bits 28 through 35; a count of the number of words in this block that are used (maximum 177(8)).
Words 1 through 177(8)		Data packed exactly as the user placed in his buffer or in dump mode files, the next 177 words of memory.

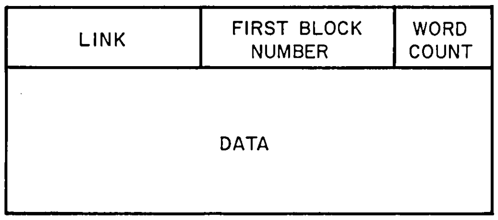


Figure 6-3 Format of a DECtape Block

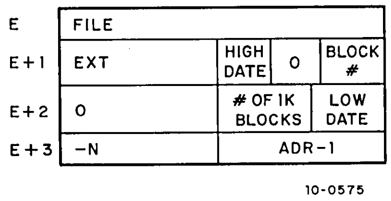
6.1.4.1 **Block Allocation** – Normally, blocks are allocated by starting with the first free block nearest the directory and going backwards to the front of the tape (block 0). When the end of the tape is reached, the direction of the scan is reversed. Blocks are not written contiguously; rather, they are separated by a spacing factor. This allows the drive to stop and restart to read the next block of the file without having to back up the tape. The spacing factor is normally four, but for dump mode and UGETF followed by an ENTER, the spacing factor is two (refer to Paragraph 6.1.6.3).

6.1.5 I/O Programming

DECtape is a directory device; therefore, file selection must be performed by the user before data is transferred. File selection is accomplished with LOOKUP and ENTER UUOs. The UUO format is as follows:

UUO D, E

where D specifies the user channel associated with this device, and E points to a four-word parameter block. The parameter block has the following format:



where

FILE is the filename in SIXBIT ASCII.

EXT is the filename extension in SIXBIT ASCII.

HIGH DATE contains the high order 3 bits of the creation date.

BLOCK # is the number of the first block of the file.

# of 1K blocks is the number of blocks needed to load the file if the file is a zero-compressed file (bits 18–23).

LOW DATE contains the low order 12 bits of the date on which the file was originally created (bits 24–35). The format is the same as that used by the DATE UUO.

-N is the negative word length of the zero-compressed file.

ADR-1 is the core address of the first word of the file minus 1.

Location E + 3 is used for zero-compressed files.

6.1.5.1 **LOOKUP D, E** – The LOOKUP programmed operator sets up an input file on channel D. The contents of location E and E + 1 (left half) are matched against the filenames and filename extensions in the DECtape directory. If no match is found, the error return is taken (refer to Appendix E). If a match is found, locations E + 1 through E + 3 are filled by the monitor, and the normal return is taken (refer to Table 6-2). Refer to Section 4 of Paragraph 6.2.8.1 for sample code for assembling the 15-bit creation date.

Table 6-2
LOOKUP Parameters

On Call			On Return		
Parameter	Use*	Contents	Parameter	Use*	Contents
E	A	SIXBIT /FILE/	E	V	SIXBIT /FILE/
E + 1	A	SIXBIT /EXT/	E + 1	V	LH = SIXBIT /EXT/ RH = high order 3 bits of 15-bit creation date (Bits 18–20) unused (Bits 21–25) first block # (Bits 26–35)
E + 2	I	–	E + 2	V	LH = 0 RH = zero. (Bits 18–23)** low order 12 bits of 15-bit creation date (Bits 24–35)**
E + 3	I	–	E + 3	V	IOWD LENGTH, ADR**

*A = argument from user program, V = value from monitor, I = ignored.
**For zero-compressed files only.

The first block of the file is then found as follows:

1. The first 83 words of the DECtape directory are searched backwards, beginning with the slot immediately prior to the directory block, until the slot containing the desired file number is found.

2. The block associated with this slot is read in and bits 18 through 27 of the first word of the block (these bits contain the block number of the first block of the file) are checked. If the bits are equal to the block number of this block, then this block is the first block; if not, then the block with that block number is read as the first block of the file.

6.1.5.2 ENTER D, E – The ENTER programmed operator sets up an output file on channel D. The DECtape directory is searched for a filename and filename extension that match the contents of location E and the left half of location E + 1. If no match is found and there is room in the directory, the monitor records the information in location E through E + 2 in the DECtape directory (refer to Table 6.3). An error return is given if there is no room in the directory for the file (refer to Appendix E). Refer to Paragraph 6.2.8.3 for a special note on error recovery. If a match is found, the new entry replaces the old entry, the old file is reclaimed immediately, and the monitor records the file information. This process is called superseding and differs from the process on disk in that, because of the small size of DECtape, the space is reclaimed before the file is written rather than after. Refer to Section 4 of Paragraph 6.2.8.1 for sample code for setting the 15-bit creation date.

Table 6-3
ENTER Parameters

On Call			On Return		
Parameter	Use*	Contents	Parameter	Use*	Contents
E	A	SIXBIT /FILE/	E	V	SIXBIT /FILE/
E + 1	A	LH = SIXBIT /EXT/ RH = high order 3 bits of 15-bit creation date (bits 18–20).	E + 1	V	LH = SIXBIT /EXT/ RH = high order 3 bits of 15-bit creation date (bits 18–20).
E + 2	A	RH = low order 12 bits of desired 15-bit creation date or 0. (0 implies current date).	E + 2	V	RH = low order 12 bits of 15-bit creation date (bits 24–35).
E + 3	I	–	E + 3	I	–

*A = argument from user program, V = value from monitor, I = ignored.

6.1.5.3 RENAME D, E – The RENAME programmed operator alters the filename or filename extension of an existing file, or deletes the file directory from the DECtape associated with channel D. If location E contains a 0, RENAME deletes the directory entry of the specified file; otherwise, RENAME searches for the file and enters the information specified in location E and E + 1 into the DECtape directory (refer to Table 6-4). RENAME is preceded by a LOOKUP or an ENTER, to select the file that is to be RENAMEd, and a CLOSE. The error return is given if a LOOKUP or ENTER has not been done (refer to Appendix E). Refer to Paragraph 6.2.8.3 for a special note on error recovery.

Table 6-4
RENAME Parameters

On Call			On Return		
Parameter	Use*	Contents	Parameter	Use*	Contents
E	A	SIXBIT /FILE/ or 0	E	V	SIXBIT /FILE/
E + 1	A	LH = SIXBIT /EXT/ RH = high order 3 bits of 15-bit creation date (bits 18–20).	E + 1	V	LH = SIXBIT /EXT/ RH = high order 3 bits of 15-bit creation date (bits 18–20).
E + 2	A	RH = low order 12 bits of 15-bit creation date or 0 (0 implies current date).	E + 2	V	RH = low order 12 bits of 15-bit creation date (bits 24–35).
E + 3	I	–	E + 3	I	–

*A = Argument from user program, V = value from monitor, I = ignored.

Unlike on disk, a DECtape RENAME works on the last file LOOKUPed and ENTERed for the device, not the last file for this channel. The UUO sequence required to successfully RENAME a file on DECtape is as follows:

```
LOOKUP      D,E
CLOSE D,
RENAME      D,E1
```

or

```
ENTER       D,E
CLOSE D,
RENAME      D,E1
```

6.1.5.4 **INPUT, OUTPUT, CLOSE, RELEASE** – When performing nondump input operations, the DECtape service routine reads the links in each block to determine what block to read next and when to raise the EOF flag.

When an OUTPUT is given, the DECtape service routine examines the left half of the third word in the output buffer (the word containing the word count in the right half). If this half contains -1, it is replaced with a 0 before being written out, and the file is thus terminated. If this half word is greater than 0, it is not changed and the service routine uses it as the block number for the next OUTPUT. If this half word is 0, the DECtape service routine assigns the block number of the next block for the next OUTPUT.

For both INPUT and OUTPUT, block 100 (the directory) is treated as an exceptional case. If the user's program gives

```
USETI D, 144(8)
```

to read block 100, it is treated as a 1-block file.

The CLOSE operator places a -1 in the left half of the first word in the last output buffer, thus terminating the file.

The RELEASE operator writes the copy of the directory, which is normally kept in core onto block 100, but only if any changes have been made. Certain console commands, such as KJOB or CORE 0, perform an implicit RELEASE of all devices and, thus, write out a changed directory even though the user's program failed to give a RELEASE.

6.1.6 Special Programmed Operator Service

Several programmed operators are provided for manipulating DECtape. These UUOs allow the user to manipulate block numbers and to handle directories.

6.1.6.1 USETI D, E – The USETI programmed operator sets the DECtape on channel D to input block E next. Since the monitor reads as many buffers as it can on INPUT, it is difficult to determine which buffer the monitor is processing when the USETI is given. Therefore, the INPUT following the USETI may not obtain the buffer containing the block specified. However, if a single buffer ring is used, the desired block is retrieved since the device must stop after each INPUT. Alternatively, if bit 30 (IO.SYN) of the file status word is set via an INIT, OPEN, or SETSTS UUO, the device stops after each bufferful of data on an INPUT so that the USETI will apply to the buffer supplied by the next INPUT.

6.1.6.2 USETO D, E – The USETO programmed operator sets the DECtape on channel D to output block E next. With multiple-buffered I/O, the output following the USETO may not apply to the buffer containing the specified block, since the monitor transfers as many buffers as possible with each OUTPUT. Therefore, a single buffer ring should be used, or bit 30 (IO.SYN) of the file status word should be set. Refer to Paragraph 6.1.6.1.

6.1.6.3 UGETF D, E – The UGETF programmed operator places the number of the next free block of the file in the user's location E.

If UGETF is not preceded by an ENTER, the monitor modifies its algorithm in the following manner:

1. the first block is written nearest the front of the tape instead of nearest the directory.
2. the spacing factor is changed to 2 instead of 4 so that very large programs can fit almost entirely in a forward direction.

If no LOOKUP or ENTER has been done, UGETF returns a -1. If a LOOKUP has been done, UGETF gives the same results as if an ENTER has been done. UGETF returns a block number; it neither marks the directory nor sets a particular block to be written, and is a no-op for anything except DTA.

6.1.6.4 UTPCLR AC, or CALLI AC, 13 – The UTPCLR programmed operator clears the directory of the DECtape on the device channel specified in the AC field. A cleared directory has zeroes in the first 83 words except in the slots related to blocks 1, 2, and 100(10) and nonexistent blocks 1102 through 1105(8). Only the directory block is affected by UTPCLR. This programmed operator is a no-operation if the device on the channel is not a DECtape.

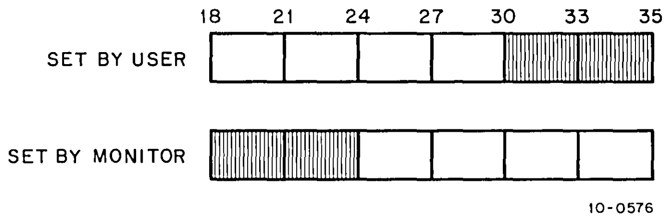
6.1.6.5 MTAPE D, 1 and MTAPE D, 11 – MTAPE D, 1 rewinds the DECtape and moves it into the end zone at the front of the tape. MTAPE D, 11 rewinds and unloads the tape, pulling the tape completely onto the left-hand reel, and clears the directory-in-core bit. These commands affect only the physical position of the tape, not the logical position. When either is used, the user's job can be swapped out while the DECtape is rewinding; however, the job cannot be swapped out if an INPUT or OUTPUT is done while the tape is rewinding.

6.1.6.6 **DEVSTS UUO** – After each interrupt, the DECtape service routine stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

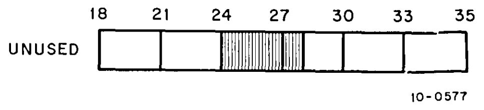
6.1.7 File Status (Refer to Appendix D)

The file status of the DECtape is shown on the next page.

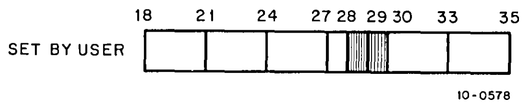
Standard Bits



Bit 18 – IO.IMP	An attempt was made to read block 0 in nonstandard dump mode.
Bit 19 – IO.DER	Data was missed.
Bit 20 – IO.DTE	Parity error.
Bit 21 – IO.BKT	Block number is too large or tape is full on OUTPUT.
Bit 22 – IO.EOF	EOF mark encountered on input. No special character appears in buffer.
Bit 23 – IO.ACT	Device is active.



Device Dependent Bits



Bit 28 – IO.SSD DECtape is in semi-standard I/O mode. The setting of this bit is recognized only if bit 29 (nonstandard I/O mode) is on. Semi-standard mode is similar to nonstandard mode except.

1. block numbers are checked for legality, and

2. the tape is started in the same direction as it was previously going.

3. dead reckoning is done.

Bit 29 – IO.NSD	DECtape is in a nonstandard I/O mode format as opposed to standard-I/O mode. No file-structured operations are performed on the tape. Blocks are read or written sequentially; no links are generated (output) or recognized (input). The first block to be read or written must be set by a USETI or USETO. In nonstandard I/O mode, up to 200(8) words per block are read or written as user data (as opposed to the standard mode of 1 link plus word count followed by 177(8) words). No dead reckoning is used on a search for a block number as the tape may be composed of blocks shorter than 200 words. The ENTER, LOOKUP, and UTPCLR UUOs are treated as no-ops. Block 0 of the tape may not be read or written in dump mode if bit 29 is on, because the data must be read in a forward direction and block 0 normally cannot be read forward.

6.1.8 Important Considerations

When positioning to a desired block on DECtape, the technique of dead reckoning is used. This means that the DECtape service routine starts the DECtape spinning and computes the time it should take to reach the desired block. Meanwhile, the service routine performs a service for another user, if any, and then returns just before the computed time has elapsed. If the desired block has not been reached, this process is repeated until it is successful. This technique is used to keep the controller free for other uses while the DECtape is spinning.

When an attempt is made to write on a write-locked tape or to access a drive that has no tape mounted, the message

DEVICE DTAn OPERATOR zz ACTION REQUESTED

is given to the user. When the situation has been rectified, CONT may be typed to proceed. However, if this message is output because of an attempt to write on a write-locked tape and any operation that causes a RESET to be performed (e.g., a GET or RUN command) is then executed, a RELEASE will be done on the DECtape. This RELEASE causes any attempt to write the directory to output the same message. To avoid the second output of the message, the user should ASSIGN the DECtape again thus causing the DECtape service routine not to write the directory on the RELEASE.

The DECtape service routine reads the directory from a tape the first time it is required to perform a LOOKUP, ENTER, or UGETF; the directory image remains in core until a new ASSIGN command is executed from the console. To inform the DECtape service routine that a new tape has been mounted on an assigned unit, the user uses an ASSIGN command. The directory from the old tape can be transferred to the new tape, thus destroying the information on that tape unless the user reassigns the DECtape transport every time he mounts a new reel.

Although DECtape is a file-structured block device, there is a limit to the number of files that may be opened simultaneously on a single DECtape. A given DECtape may be OPENed or INITed on two software channels (maximum) at the same time, once for INPUT and once for OUTPUT. An attempt to INIT on two channels for INPUT or two channels for OUTPUT generates no error indication, and only the most recent INIT is effective. This restriction explains why the following examples do not work.

Example:

```
.R FILCOM
*TTY:=DTA1:P1,DTA1:P2
```

FILCOM accepts the command string but the comparison does not work because the DECtape cannot be associated with the input side of two software channels at the same time.

Example 2:

```
.R MACRO
*DTA1:BIN,DTA1:LST←DTA1:PROG
```

MACRO accepts the command string but does not produce the desired results because a single DECtape cannot be associated with the output side of two software channels at the same time. However, the following example works, because only one file is opened for reading and one file for writing.

```
.R MACRO
*DTA1:BIN=DTA1:SOURCE
```

6.2 DISK

The device mnemonic is DSK, FHA, DPA; the buffer size is 203(8) (200(8) data) words.

6.2.1 Data Modes

6.2.1.1 **Buffered Data Modes** – Data is written on the disk exactly as it appears in the buffer. Data consists of 36-bit words.

CAUTION

All buffered mode operations utilize a 200 octal word data buffer. Attempts to set up non-standard buffer sizes are ignored. In particular, attempting to use buffer sizes smaller than 200 words for input result in data being read in past the end of the buffer destroying what information was there (e.g., the buffer header of the next buffer).

6.2.1.2 **Unbuffered Data Modes** –Data is read into or written from anywhere in the user's core area without regard to the normal buffering schemes. Control for read or write operations must be via a command list in core memory. The command list format is described in Chapter 4. The disk control automatically measures dump data into standard-length disk blocks of 200 octal words. Unless the number of data words is an exact multiple of the standard length of a disk block (200 words) after each command word in the command list, the remainder of that block is wasted.

6.2.2 Structure of Disk Files

The file structures of a disk system minimize the number of disk seeks for sequential or random access during either buffered or unbuffered I/O. The assignment of physical space for data is performed automatically by the monitor when logical files are written or deleted by user programs. Files may be any length, and each user may have as many files as he wishes, as long as disk space is available and the user has not exceeded his logged-in quota. Users or their programs do not need to give initial estimates of file length or number of files. Files may be simultaneously read by more than one user at a time, thus allowing data sharing. A new version of a file may be recreated by one user while other users continue to read the old version, thus allowing for smooth replacement of shared programs and data files. Finally, one user may selectively update portions of a file, rather than create a new one.

6.2.2.1 **Addressing by Monitor** – The file structure described in this section is generally transparent to the user, and a detailed knowledge of this material is not essential for effective user-mode use of the disk. One set of disk-independent file handling routines in the monitor services all disks and drums. This set of routines interprets and operates upon file structures, processed disk UUOs, queues disk requests, and makes optimization decisions. The monitor deals primarily with logical units within file structures and converts to physical units in the small device-dependent routines just before issuing I/O commands. All queues, statuses, and flags are organized by logical unit rather than by physical unit. The device-dependent routines perform the I/O for specific storage devices and translate logical block numbers to physical disk addresses.

All references made to disk addresses refer to the logical or relative addresses used by the system and not to any physical addressing scheme involving records, sectors, or tracks, that may pertain to a particular physical device. The basic unit that may be addressed is a logical disk block, which consists of 200(8) 36-bit words.

6.2.2.2 **Storage Allocation Table (SAT) Blocks** – Unique to each file structure is a file named SAT.SYS. This file reflects the current status of every addressable block on the disk. Only the monitor can modify the contents of SAT.SYS as a result of file creation, deletion, or space allocation, although this file may be read by any user. The SAT file consists of bits indicating both the portion of file storage in use and the portion that is available. To reduce the size of SAT.SYS, each bit can be used to represent a contiguous set of blocks called a cluster. Monitor overhead is decreased by assigning and releasing file storage in clusters of blocks rather than single blocks.

If a particular bit is on, it indicates that the corresponding cluster is bad or nonexistent or has been allocated to a file. It may or may not contain data (i.e., files may contain allocated but unwritten clusters). If the bit is off, it indicates that the corresponding cluster is empty, or available to be written on.

It is recommended that cluster sizes should evenly divide blocks on a unit. In the 5.03 and later monitors, the refresher truncates to the largest number of full clusters. With truncation, the last few blocks are not included in the addressing space, but may be used for swapping; therefore, they are not part of SWAP.SYS even though they are in the swapping space. In addition, any bad blocks in the extra blocks are not included in SWAP.SYS.

6.2.2.3 **File Directories** – A directory is a file which contains as data pointers to other files on the disk. There are three levels of directories in each file structure:

1. The master file directory (MFD).
2. The user file directories (UFDs).
3. The sub-file directories (SFDs).(1)

(1)Sub-file directories depend on FTSFD which is normally off in the DECsystem-1040.

The master file directory consists of two-word entries; the entries are the names of the user file directories on the file structure. The first word of each entry contains the project-programmer number of the user. The left half of the second word of each entry contains the mnemonic UFD in SIXBIT and the right half contains a pointer to the first cluster of the user file directory (see Figure 6-4). The main function of the master file directory is to serve as a directory of individual user file directories. A continued MFD is the MFDs on all file structures in the job's search list.

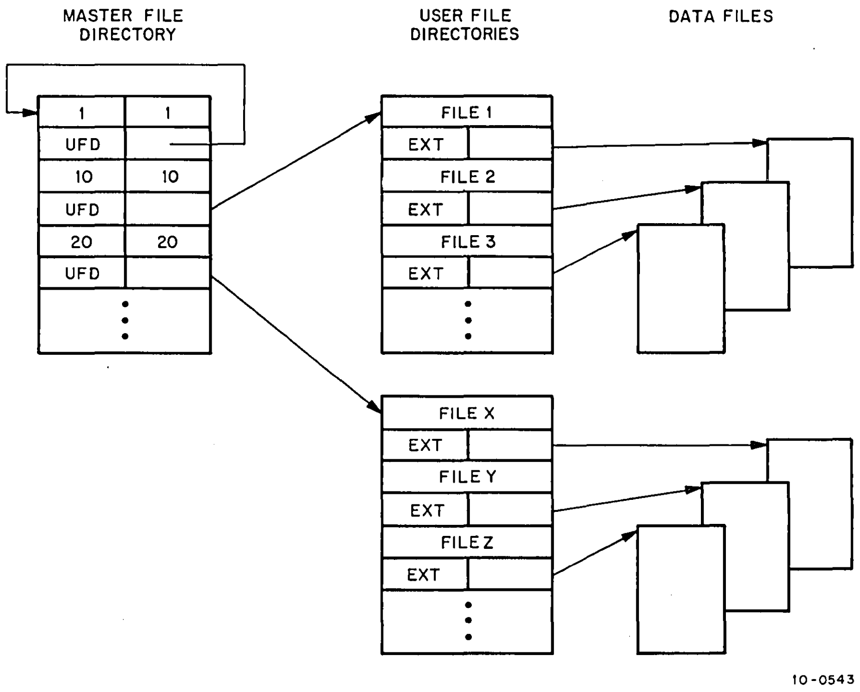


Figure 6-4 Basic Disk File Organization for Each File Structure

The entries within a user file directory are the names of files existing in a given project-programmer number area within the file structure. The first word of each entry contains the filename in SIXBIT. The left half of the second word contains the filename extension in SIXBIT, and the right half contains a pointer to the first cluster of the file (see Figure 6-4). This pointer specifies both the unit and the super-cluster of the file structure in which the file appears. The right half of the directory entry is referred to as a compressed file pointer (CFP). A continued UFD is all the UFDs for the same project-programmer number on all file structures on the job's search list.

When the user is logged-in, each file structure for which he has a quota contains a UFD for his project-programmer number. Each UFD contains the names of all the user's files for that file structure only. UFDs are created only by privileged programs (i.e., LOGIN in response to a LOGIN command, and OMOUNT in response to a MOUNT command). A user is not prevented from attempting to read a file in another user's UFD on a file structure for which he does not have a UFD. Whether or not the user is successful depends on the protection specified for the file being referenced.

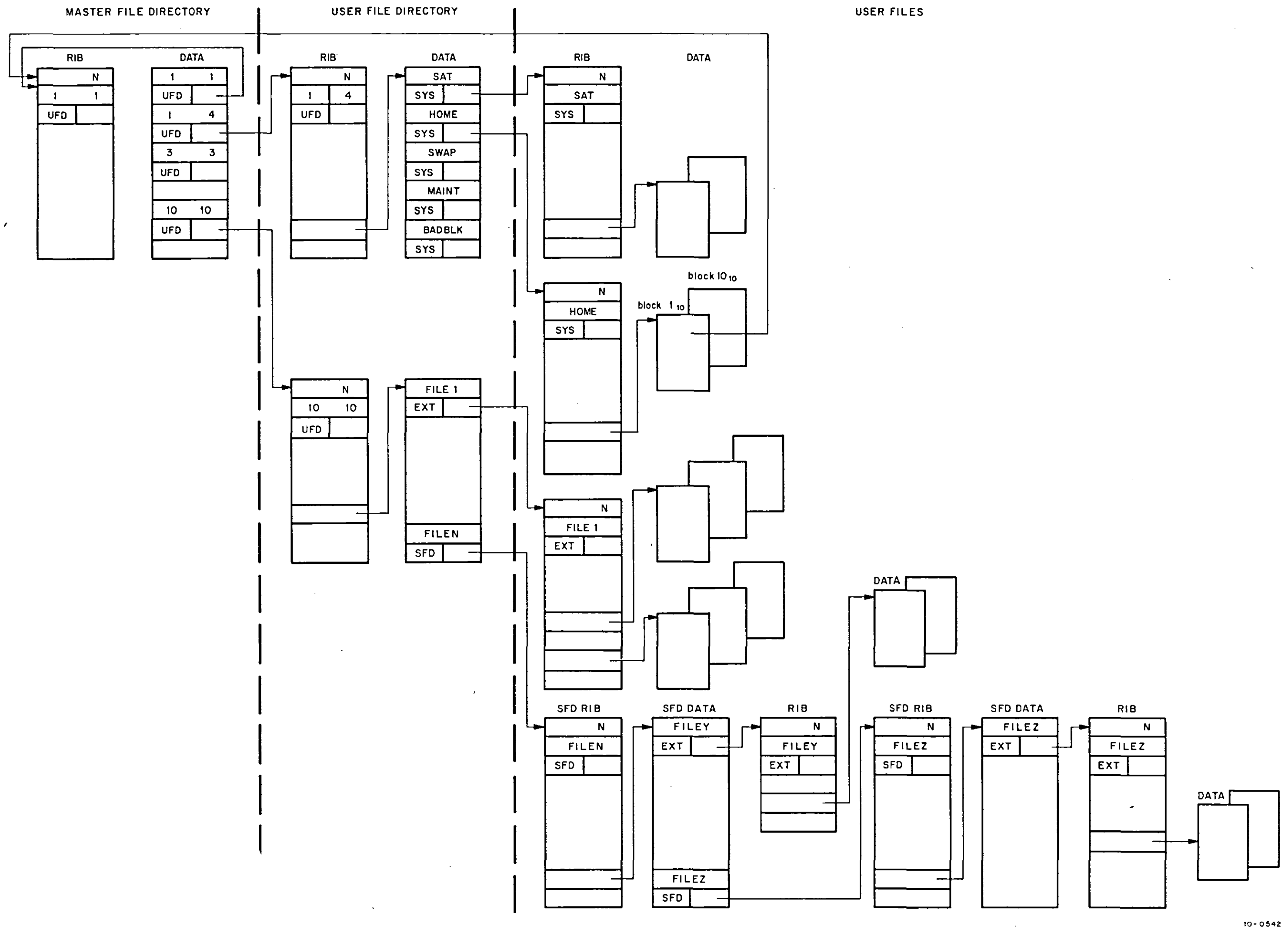


Figure 6-5 Disk File Organization

As an entry in the user file directory, the user can include a sub-file directory (SFD). The sub-file directory is similar to the other types of directories in that it contains as data all the names of files within the directory. This directory is pointed to by a UFD or a higher-level SFD nested in any arbitrary tree structure. The maximum number of nested SFDs allowed is defined via a MONGEN question and can be obtained from a GETTAB table (GETTAB table .GTLVD, item 17). Files can be written or read in SFDs nested deeper than the maximum but SFDs cannot be created. (There is an absolute maximum of six, including the UFD.) Unlike UFDs, a sub-file directory can be created by any program. A continued SFD, or sub-directory, is all of the SFDs on all file structures in the job's search list with the same name and path.

This third level of directory allows groups of files belonging to the same user to be separate from each other. This is useful when organizing a large number of files according to function. In addition, simultaneous batch runs of the same program for a single user can use the same filenames without conflicting with each other. As long as the files are in different sub-file directories, they are unique.

A file is uniquely identified in the system by a file structure name, a directory path, a filename and an extension. The directory path is an ordered list of directory names, starting with a UFD, which uniquely specifies a directory without regard to a file structure. The PATH. UUO is used to set or read the default directory path for a job (refer to Paragraph 6.2.9.1). Default paths can be a job's UFD, an SFD in a job's UFD, a UFD different from the job's UFD, or an SFD in another UFD. If a default path is not specified, it is the job's UFD. The notation FILE.EXT [PPN,A,B,. . . ,N] designates the file named FILE.EXT in the UFD [PPN] in the SFD N, which is in the SFD. . . , which is in the SFD A. The path to the file named FILE.EXT is [PPN,A,B, . . . ,N].

To improve disk access and core searching times, only UFD names are kept in the MFD (project-programmer number 1,1). All system programs and monitor file structure files are contained in another project-programmer number directory called the system library. For convenience both to users typing commands and to user programs, device name SYS is interpreted as the system library; therefore, no special programming is required to read as a specified file from device SYS. In command strings, the abbreviation SYSx: represents the system library on file structure DSKx: i.e., SYSA: represents the system library on DSKA.

6.2.2.4 **File Format** – All disk files (including directories) are composed of two parts:

1. pure data.

2. Information needed by the system to retrieve this data.

Each data block contains exactly 200(8) words. If a partially filled buffer is output to the disk by a user, a full block is written with trailing zeros filling to make 200(8) words. A partial block input later appears to have a full 200(8) data words. Word counts associated with individual blocks are not retained by the system except in the case of the last block of the file.

There are three links in the chain by which the system references data on the disk. This chain is transparent to the user, who might look on the directory as having four-word entries analogous to DECtapes. The first link is the two-word directory entry that points to the second link, the retrieval information block (RIB). The RIB, in turn, points to the third link, the individual data blocks of the file (see Figure 6-5).

The retrieval block contains all the pointers to the entire file. Retrieval information associated with each file is stored and accessed separately from the data; therefore, system reliability is increased because the probability of destroying the retrieval information is reduced. System performance is improved because the number of positionings necessary for random access is reduced.

For recovery purposes, a copy of the retrieval information block is written immediately after the last data block of the file when a CLOSE is completed. If the first RIB is lost or bad, the monitor can recover by allowing a recovery program to use the second RIB; therefore, a data file of n blocks has two additional overhead blocks: relative block 0, containing the primary RIB; and a relative block n + 1, containing the redundant RIB (refer to Appendix H).

6.2.3 Access Protection

Nine bits of the retrieval information of a file are used to indicate the protection of that file. This protection is necessary because the disk is shared by many users, each of whom may desire to keep certain files from being written on, read, or deleted by other users. The nine bits are divided into three classes because the users are divided into three categories:

1. the owner of the file.
2. the users with the same project number as the owner, and
3. all other users.

Ordinarily, the owner of a file is any user whose programmer number is the same as the programmer number of the UFD containing the file, regardless of whether the two project numbers match. Therefore, in order to maintain only one owner for each file, the installation should not assign the same programmer number to different users, no matter how many projects the installation has. A user working on more than one project, but having the same programmer number, can reference all his files as an owner under each of his project-programmer numbers.

However, some installations may decide that a user is the owner of a file only when both the project and programmer numbers under which the user is logged in match the pair identifying the UFD. If this is the case, the same programmer number can be assigned to different users in different projects. This allows the task of assigning programmer numbers to be delegated to project leaders without concern for duplication since the project numbers will be different from one project to another. However, a user working on more than one project cannot have the same owner access to all the files that he has written.

The definition of the owner of a file is specified at monitor generation time with MONGEN (INDPPN). No matter how the installation defines an owner, project numbers 0 to 7 are always independent of the project-programmer number (i.e., a user with a project number from 0 to 7 is considered the owner of all files with that project number).

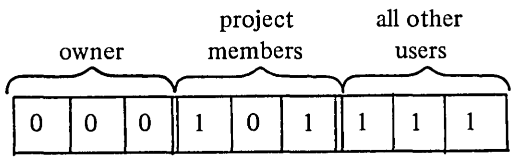
A member of the owner's project is any user whose logged-in project number is the same as the owner's, regardless of his programmer number.

The three bits associated with each category of users are encoded as follows:

Code	Access Protection
7	Greatest protection, which means no access privileges. However, the owner may LOOKUP the file so that he can change the protection to a less restrictive code via a RENAME. Thus, for the owner, this code is equivalent to codes 6 and 5.

Code	Access Protection
6	Execute-only. This disables user meddling and examining (DUMP, DCORE, D, E, SAVE, SSAVE, START n, CSTART n, DDT, COREn) with the error message ?ILLEGAL WHEN EXECUTE ONLY. An error return is given on a LOOKUP to an execute-only file to all users except the owner of the file.
5	Read, execute
4	Append, read, execute
3	Update, append, read, execute.
2	Write, update, append, read, execute
1	Rename, write, update, append, read, execute
0	Change protection, rename, write, update, append, read, execute.

The following example illustrates the 9-bit protection field of a file that has a protection of 057.



This code means:

1. The owner has complete privileges (code 0).
2. The project members have read and execute privileges (code 5).
3. All other users have no access privileges (code 7).

The greatest protection a file can have is 7, and the least is 0. Usually, the owner's field is 0 or 1. However, it is always possible for the owner of a file to change the access protection associated with the file even if the owner-protection is not set to 0. Thus, codes 0 and 1 are equivalent when they appear in the owner's field. Access protection can be changed by executing a RENAME UUO or by using the PROTECT monitor command as follows:

```
PROTECT FILE.ext <nnn> ↵
```

When an ENTER UUO specifies a protection code of 000 and the file does not exist, the monitor substitutes the standard protection code as defined by the installation. The normal system standard is 057. This protection prevents users in different projects from accessing another user's files; however, a standard protection of 055 is recommended for in-house systems where privacy is not as important as the capability of sharing files among projects. No program should be coded to assume knowledge of the standard protection. If it is necessary to use this standard, it should be obtained through the GETTAB UUO.

To preserve files with LOGOUT, a protection code of 1 in the owner's field should be associated with the files. LOGOUT preserves all files in a UFD for which the protection code for the owner is greater than zero. The PRESERVE monitor command can be used to obtain a protection code of 1 in the owner's field.

6.2.3.1 UFD and SFD Privileges – The protection code associated with each file completely describes the access rights to that file independently of the protection code of the UFD. UFDs and SFDs may be read in the same manner as files but cannot be written explicitly, because they contain RIB pointers to particular disk blocks. For UFD and SFD privileges, users are divided into the same three categories as for files. Each category has three independent bits:

Bit	Access Privileges
4	Allow LOOKUPS in UFD or SFD.
2	Allow CREATEs in UFD or SFD.
1	Allow the UFD or SFD to be read as a file.

The owner is permitted to control access to his own UFD and SFD. It is always legal for the owner to issue a RENAME to change the protection of his directories. Any program can create or delete SFDs; however, only privileged programs are allowed to create, supersede, or delete a UFD. The monitor checks for the following types of privileged programs.

1. Jobs logged in under project-programmer number [1,2] (FAILSAFE).
2. Jobs running with the JACCT bit set in JBTSTS (LOGIN, LOGOUT).

Privileged programs are allowed to:

1. Create UFDs (and SFDs).
2. Delete UFDs (and SFDs).
3. Set privileged LOOKUP, ENTER, and RENAME arguments.
4. Ignore file protection codes.

UFD and SFD privileges are similar with the exception being that SFDs can be RENAMEd and deleted by both privileged programs and the owner of the SFD if his protection byte is 7.

6.2.4 Disk Quotas(1)

Each project-programmer number in each file structure is associated with the quotas that limit the number of blocks that can be stored under the UFD in the particular file structure. The quotas are:

1. Logged-in quota.
2. Logged-out quota.

When the user logs in, he automatically starts using his logged-in quota. Because this is not a guaranteed amount of space, the user competes with others for it. The logged-out quota is the amount of space that the user must be within in order to log off the system. Normally, the logged-out quota is less than or equal to the logged-in quota, so that the user must delete temporary files.

If a user exceeds his logged-in quota, the monitor types the following message:

```
[EXCEEDING QUOTA ON Fs]
```

(1) Quota checking depends on FTDQTA which is normally off in the DECsystem-1040.

where fs is the name of the file structure. The message appears in square brackets (like the TECO core expansion message) to suggest a warning rather than an error. Unlike most monitor messages, this message indicates that the user program may continue to run, and the console remains in user mode. The user program can no longer create or supersede files (ENTER gives an error return). Files already ENTERed are allowed to continue for a specified number of blocks. This amount is called the overdrawn amount and is a parameter of the file structure. The overdrawn amount specifies the number of blocks by which the logged-in UFD may exceed its logged-in quota. When the user exceeds the overdrawn amount, the IO.BKT bit is set, and further OUTPUTs are not allowed. A CLOSE operates successfully, including the writing of the last buffers and the RIBs.

When the user logs in, the LOGIN program reads the logged-in quota from the file AUXACC.SYS for all public file structures in which the user is allowed to have a UFD. This information is passed to the monitor where it is kept in core. If the quota has changed since the user last logged in, LOGIN updates (or creates) the RIB of each UFD with the new quotas.

6.2.5 Simultaneous Access

In its core area, the monitor maintains two 4-word blocks called access blocks. These blocks control simultaneous access to a single file by a number of user channels. All active files have access blocks that contain file status information. The access blocks ensure that a maximum of one user channel supersedes or updates a given file at a given time.

6.2.6 File Structure Names

Each file structure has a SIXBIT name specified by the operator at system initialization time. This name can consist of four or less alphanumeric characters and must not duplicate any device, unit, or existing file structure name or its abbreviation. The recommended names for the file structures in the public pool are DSKA, DSKB, . . . ,DSKN (in order of decreasing speed).

When a specific file structure is INITed (e.g., DKSA), LOOKUP and ENTER searches are restricted to that file structure. Usually a channel is INITed with the generic name DSK, in which case all file structures in the active search list of the job are searched (refer to Paragraph 6.2.7).

6.2.6.1 Logical Unit Names – When a single file structure name is specified, the set of all the units in that file structure is implied; however, it is possible to specify a particular logical unit within a file structure (e.g., DSKA0, DSKA1, DSKA2 are three logical units in the file structure DSKA). The monitor deals with file structures rather than with individual units; therefore, when reading files, specifying a logical unit within a file structure is equivalent to specifying the file structure itself. The monitor locates the file regardless of which unit it is on within a file structure. However, in writing a file, the monitor uses the logical unit name as a guide in allocating space and will, if possible, write the file on the unit specified. In this way, a user can apportion files among different units for increased throughput.

6.2.6.2 Physical Controller Class Names – In addition to DSK, single file structure names (DSKA), and logical unit names (DSKA0), it is possible to specify a class of controllers. If the system has one controller of the type specified, the result is the same as if the user had specified the physical controller name. The controller classes supported by DEC are:

DR (future drum), FH, DP, FS

6.2.6.3 **Physical Controller Names** – It is possible to specify any of the units on a particular controller. The monitor relates that name to the file structures, which contain at least one unit on the specified controller. More than one file structure may be specified when a physical controller name is used. The controllers that DEC supports are:

DRA, DRB (future drum), FHA, FHB, DPA, DPB, FSA, FSB

6.2.6.4 **Physical Unit Names** – When a physical controller name is specified, all units on that controller are implied. It is possible to specify a physical unit name on a particular controller. The physical unit names that DEC supports are:

DRA0, DRB0	Reserved for future drum (RX10).
FHA0, . . . , FHA3	Mixture or Burroughs fixed-head disks (RD10) and Bryant drums (RM10B) on RC10 control.
FHB0, . . . , FHB3	Mixture of Burroughs fixed-head disks (RD10) and Bryant drums (RM10B) on second RC10 control.
FSA0, . . . , FSA7	RS04 disk on RH10.
DPA0, . . . , DPA7	Mixture of RP02 and RP03 disk packs on RP10 control.
DPB0, . . . , DPB7	Mixture of RP02 and RP03 disk packs on second RP10 control.

6.2.6.5 **Unit Selection on Output** – If the user specifies a file structure name on an ENTER, the monitor chooses the emptiest unit on the file structure which does not currently have an open file (UFDs are not considered opened) for the job. This selection improves disk throughput by distributing files for a particular job on different units. For example, in a MACRO assembly with two output files and one input file, it is probable that the monitor would allocate the output files on units separate from each other and from the input file. If this were the only job running, there would be almost no seeks. Therefore, to take advantage of this, programs should LOOKUP input files before ENTERing output files.

6.2.6.6 **Abbreviations** – Abbreviations may be used as arguments to the ASSIGN command and the INIT and OPEN UUOs. The abbreviation is checked for a first match when the ASSIGN, INIT, or OPEN is executed. The file structure or device eventually represented by the particular abbreviation depends on whether a LOOKUP or ENTER follows. A LOOKUP applies to as wide a class of units as possible, whereas an ENTER applies to a restricted set to allow files to be written on particular units at the user's option. For example, consider the following configuration:

File Structure		**Physical Unit**
DSKA	=	FHA0, FHA1, FHA2
DSKB	=	FHB0, FHB1
DSKC	=	DPA0, DPA1, DPA2, DPA3
DSKD	=	DPB0, DPB1, DPB2
PRVA	=	DPB3

Table 6-5 shows the file structures and units impiled by the various names and abbreviations.

Table 6-5
File Structure Names

Argument Supplied to ASSIGN, MOUNT, INIT, OPEN	File Structures or Units Implied LOOKUP	ENTER
D, DS, DSK	Generic DSK according to job search list (refer to Paragraph 6.2.7).	
P, PR, PRV, PRVA	PRVA	PRVA
F, FH, FHA	DSKA, DSKB	FHA0
FHB	DSKB	FHB0
FHA0	DSKA	FHA0
FHB0	DSKB	FHB0
DP	DSKC, DSKD, PRVA*	DSKC
DPA	DSKC	DSKC
DPB	DSKD, PRVA*	DSKD
DPA0	DSKC	DPA0
DPB2	DSKD	DPB2
DPB3	PRVA	PRVA

*Only if user has done a MOUNT.

6.2.7 Job Search List

To a user, a file structure is like a device; that is, a file structure or a set of file structures may be specified by an INIT or OPEN UUO or by the first argument of the ASSIGN or MOUNT command. A console user species a file structure by naming the file structure and following it with a colon.

There is a flexible naming scheme that applies to file structures; however, most user programs INIT device DSK, which selects the appropriate file structure, unless directed to do otherwise by the user. The appropriate file structure is determined by a job search list. A job search list is divided into the two parts:

1. an active search list (usually referred to as the job search list), and
2. a passive search list.

The active search list is an ordered list of the file structures that are to be searched on a LOOKUP or ENTER when device DSK is used. The passive search list is an unordered list of file structures maintained by the monitor for LOGOUT time. At this time, LOGOUT requires that the total allocated blocks on each UFD in both the active and passive search lists be below the logged-out quota. Each job has its own active search list (established by LOGIN) with file structures in the order that they appear in the administrative control file AUXACC.SYS. Thus, a user has a UFD for his project-programmer number in each file structure in which LOGIN allows him to have files. With the MOUNT command, mounted file structures may be added to the active search list. The following is an example of a search list:

```
     DSKB, DSKA, FENCE, DSKC
```

DSKB and DSKA comprise the active search list. These file structures are represented by generic name DSK for this job. DSKC is the name of a file structure that was previously in the active search list. FENCE represents the boundary between the active and passive search list.

Each file structure in a job search list may be modified by setting one of two flags with the JOBSTR UUO:

1. Do not create in this structure if just generic DSK is specified.
2. Do not write in this structure.

Setting the "do not create" flag indicates that no new files are to be created on this file structure unless explicitly stated. For example, if the "don't create" flag is set

```
     DSKA: FOO ←
```

allows FOO to be created on DSKA, but

```
     DSK: FOO ←
```

does not. For LOOKUPs on device DSK, the monitor searches the structures in the order specified by the job search list. For ENTERs when the filename does not exist (creating, see below), the file is placed on the first file structure in the search list that has space and does not have the "do not create" flag set. For ENTERs when the filename already exists on any file structure in the search list (superseding, see below), the file is placed on the same structure that contains the older file. If the write-lock bit is set for the file structure, a write-lock error (ERWLK%) is given on the supersede. Because superseding is treated differently from creating, a user may explicitly place a file on a particular file structure, for example, a fast one with the do not create bit set, so that subsequent supersedes will remain on that file structure even though generic DSK is used.

6.2.8 User Programming

Three types of writing on the disk may be distinguished. If a user does an ENTER with a filename which did not previously exist in his UFD, he is said to be creating that file. If the filename previously existed in his UFD, he is said to be superseding that file; the old version of the file stays on the disk (and is available to anyone who wants to read it) until the user does the output CLOSE. At the time of the CLOSE, the user's UFD is changed to point to the new version of the file and the old version is either deleted immediately or marked for deletion later if someone is currently reading it; the space occupied by deleted files is always reclaimed in the SAT tables (refer to Paragraph 6.2.2.2). Finally, if a user does a LOOKUP followed by an ENTER (the order is important) on the same filename on the same user channel, he will be able to modify selected blocks of that file, using USETO and USETI UUOs (refer to Paragraph 6.2.9.2) without creating an entirely new version; this third type of writing, called updating, eliminates the need to copy a file when making a small number of changes. A LOOKUP followed by an ENTER and OUTPUT (in that order) writes the output at the beginning of the file. To append information to the file, a USETI -1 is used before the output.

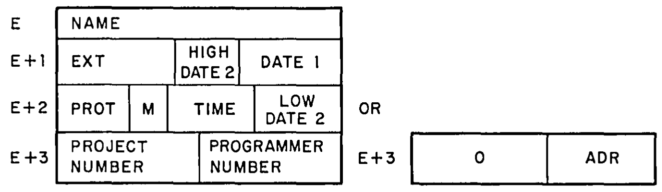
As a standard practice, user programs should read, create, and supersede (new file with same filename) files on different user channels. However, for compatibility with DECtapes, it is possible to read and create, or read and supersede, two files on the same user channel as long as all OUTPUTs and the CLOSE output are done before the LOOKUP and the first input, or vice versa. In other words, a CLOSE UUO is required between successive LOOKUPS and ENTERs unless updating is intended.

The actual file structure of the disk is generally transparent to the user. In programming I/O on the disk, a format analogous to that of DECtapes is used; that is, the user assumes a 4-word directory entry similar in form to the first four words of retrieval information. The UUO format is approximately the same as for DECtapes:

UUO D,E

Where UUO is an I/O programmed operator, and D specifies the user channel associated with this device. E points either to a 4-word directory entry or an extended argument block in the user's program.

6.2.8.1 **Four-word Arguments for LOOKUP, ENTER, RENAME UUOs** – The 4-word argument block has the following format:



10-0593

where

NAME is the filename in SIXBIT, or, if a UFD, is the project number in the left half and the programmer number in the right half.

EXT is the filename extension in SIXBIT ASCII.

HIGH DATE 2 contains the high order 3 bits of the date on which the file was originally created (bits 18–20).

DATE 1 is the data that the file was last referenced (RENAME, ENTER, or INPUT) in the format of the DATE UUO (bits 21–35).

PROT is the protection code for the file (bits 0–8).

M is the data mode (ASCII, binary, dump) (bits 9–12).

TIME is the time that the file was originally created, represented as the number of minutes past midnight of the creation date (bits 13–23).

LOW DATE 2 is the low order 12 bits of the date (in the same format as the DATE UUO) on which the file was originally created (bits 24–35).

NOTE

The 2-part format for DATE 2 (creation date) is used to maintain compatibility with monitors and media as old as 1964.

The programmed operators (UUOs) operate as follows:

1. ENTER UUO – ENTER D, E causes the monitor to store the 4-word directory entry for later entry into the proper UFD or SFD when user channel D is closed or released.

NAME	The filename must be nonzero; otherwise, an error return results.
EXT	The filename extension may be zero; if so, the monitor leaves it as zero.
HIGH DATE 2	If a nonzero date is obtained by concatenating the high order 3 bits in this field with the low order 12 bits in LOW DATE 2, then the monitor uses that value as the creation date for the file. If the date is zero, the monitor supplies the high order three bits from the 15-bit value representing the current date.
DATE 1	The date may be zero, in which case the monitor substitutes the current date. The date must not be in the future; if this is so, the current date is used.
PROT	If the protection code is 0, the monitor substitutes the installation standard as specified at MONGEN time. If the protection code is 0 and this ENTER is superseding a file, the protection of the new file is copied from the old file. RENAME may be used to change the protection after a file has been completely written and when it is being closed.
M	The data mode is supplied by the monitor. It was set by the user in the last INIT or SETSTS UUO on channel D.
TIME, LOW DATE 2	If these are 0, and bits 18–20 of E + 1 are zero the monitor supplies the current date and time as the creation date and time for the file. The high order digits of the creation date overflow to bits 18–20 of E + 1 (HIGH DATE 2). If either is nonzero, the monitor uses the HIGH DATE 2 supplied by the user in E + 1 and the TIME and LOW DATE 2 supplied in E + 2. Thus, files may be copied without changing the original creation time and date.
PROJECT NUMBER PROGRAMMER NUMBER	If this word is 0, the file will be written in the default directory. (For example, if the default path is [10, 10, A], the file will be written in SFD A which is contained in [10,10] .UFD.) The default path is determined by the PATH. UUO (refer to Paragraph 6.2.9.1). If a default path has not been specified via the PATH. UUO, it is the job's UFD (i.e., the project-programmer number under which the user is logged in).
	If this word is a project-programmer number, the file will be written in the UFD specified (i.e., sub-directories will not be scanned). This allows the program to write in the disk area under which the job is logged in although the default directory is different. Note that it is generally not possible to create (ENTER) files in another user's area

of the disk, because UFDs are usually protected from all but the owner when creating files.

If this word is XWD 0, ADR, the file will be written according to the path specified by ADR. The argument block beginning at ADR is the same as in the PATH. UUO (refer to Paragraph 6.2.9.1) except that the first two arguments (ADR and ADR + 1) are ignored. The scan switch (ADR + 1) is not needed since if the file is found in the specified directory, it will be superseded, and if not found, it will be created at the end of the path of the specified directory, even if a file with the same name appears in an upper-level directory. A path specification in the ENTER block overrides any default path specification given in the PATH. UUO.

With certain types of error returns peculiar to the disk, the right half of E + 1 is set to a specific number to indicate the error that caused the return. For example, if the extension UFD is specified and bit 18 (RP.DIR) of the file status word is not set, the right of E + 1 is set to 2 (protection failure). Refer to Paragraph 6.2.8.3 for a special note on error recovery. Refer to Appendix E for the error codes returned on the ENTER UUO.

When an ENTER is executed by the monitor on a file that exists, a new file by that name is written, and those bits in the SAT blocks that correspond to the blocks of the old file are zeroed when the CLOSE (or RELEAS) UUO is executed provided that bit 30 of the CLOSE is 0 (refer to Paragraph 4.7.7). Space is thereby retrieved and available to other users after the new file has been successfully written. If a file structure is INITed on channel D, the monitor maximizes the job's throughput by selecting the emptied unit for which the job has no opened files (refer to Paragraphs 6.2.6.5 and 6.2.6.6).

2. LOOKUP UUO – LOOKUP D, E causes the monitor to read the appropriate UFD or SFD. If a later version of the file is being written, the old version pointed to by the UFD is read.

NAME	The same as on an ENTER.
EXT	The same as on an ENTER.
DATE 1, PROT, M, TIME, LOW and HIGH DATE 2	These arguments are ignored. The monitor returns these quantities to the user in E + 1 and E + 2.
PROJECT NUMBER PROGRAMMER NUMBER	If this word is 0, the file will be read from the user's default directory path. The entire path is searched only if the scan switch is set via the PATH, UUO (refer to Paragraph 6.2.9.1). If a default path has not been specified, it is the project-programmer number under which the user is logged in. If a project-programmer number is specified (i.e., sub-directories will not be scanned). Thus, it is possible to read files in another user's directories, provided the file's protection mask permits reading and the UFD permits LOOKUPs. If this word is XWD 0, ADR, the file will be read according to the path specified by ADR. The argument block beginning at ADR is the same as in the

PATH. UUO except that the first argument is ignored and the second argument, if 0, uses the default value of the scanned switch (refer to the PATH. UUO). A path specification in the LOOKUP block overrides any default path specification given in the PATH. UUO.

The monitor returns the negative word count (or positive block count for files larger than 2(17) words) in the LH of E + 3, 0 in RH of E + 3 when the 4-word argument block is given. As a result, the monitor treats a negative project-programmer number as if it were 0; however, this will not always be true; therefore, programs must be written to either clear E + 3 before doing a LOOKUP, ENTER, or RENAME or set E + 3 to the desired project-programmer number. In the future, a negative project-programmer number may be used to indicate SIXBIT alphabetic characters for project and programmer initials.

The numbers placed in the RH of E + 1 on an error return have a significance analogous to that described for the ENTER UUO (refer to Appendix E).

If the file is currently being superseded, the old file is used.

3. RENAME UUO – RENAME D, E is used to alter the filename, the filename extension and/or protection of a file, or to delete a file from the disk. This UUO can be used to change the name of an SFD, but an attempt to change the extension or project-programmer number associated with an SFD, the name, extension, or project-programmer number associated with a UFD, or the project programmer number of a device with an implied project-programmer number (e.g., SYS:, NEW:, OLD:) results in a protection error. To RENAME a file, a LOOKUP or ENTER must first be done to identify the file for the RENAME UUO. Locations E through E + 2 are as described for ENTER. If E + 3 = 0, there is no change in the directory of the file. If E + 3 is the default project-programmer number, the file is renamed in that UFD. If E + 3 has a different project-programmer number than the one in which the file is LOOKUPed or ENTERed (i.e., E + 3 is not the default project-programmer number), the monitor deletes the directory entry from the old directory (UFD or SFD) and inserts the directory entry into the specified UFD, provided the user has the privileges to delete files from the old directory, and to create files in the new UFD. (This is an efficient way to move a file from one UFD to another, since no I/O needs to be done on the data blocks of the file.) If E + 3 = XWD 0, ADR, the file is renamed into a new SFD or UFD according to the path specified by ADR. (Refer to the PATH. UUO.) Therefore, the only way to RENAME a file into a SFD different from the one which it is in is to give an explicit path via an argument block.

A CLOSE is optional because RENAME performs a CLOSE. However, a CLOSE should not be issued between a LOOKUP and RENAME if the file is not in the default path or cannot be obtained from the default path by scanning because CLOSE erases all memory of the path of a file. If a CLOSE is performed and the file is not in the default path, the RENAME returns the FILE NOT FOUND error. In addition, disk accesses are minimized if a CLOSE does not precede a RENAME.

RENAME enters the information specified in E through E + 2 into the retrieval information and proper directory. If the contents of E is zero, RENAME has the effect of deleting the file. Although only a privileged job can delete a UFD, any job can delete an SFD. If the directory is not empty or if a job is currently using the directory, the RENAME returns the DIRECTORY NOT EMPTY error. (Refer to Appendix E for the error codes.) Refer to Paragraph 6.2.8.3 for a special note on error recovery.

When issuing a RENAME UUO, the user must ensure that the status at locations E through E + 3 are as he desires. An ENTER or LOOKUP must have preceded the RENAME; therefore, the contents of E through E + 3 will have been altered, or filled if the E is the same for all UUOs.

4. Examples – The sample code below can be used to assemble the 15-bit creation date of a disk (or DECtape) file in register T1 after a successful LOOKUP. The four-word argument block begins at location E.

```
HRRZ        T1, E+2                  ; GET LOW-ORDER PART
LDB         T2, [POINT 3, E+1, 20]   ; GET HIGH-ORDER PART
DPB         T2, [POINT 6, T1, 23]    ; MERGE THE TWO PARTS
```

Using a zero in the date fields as an ENTER causes the Monitor to substitute the current date. The following sample code illustrates setting the 15-bit creation date in the four-word ENTER argument block from the value in register T1.

```
DPB         T1, [POINT 12, E+2, 35]  ; STORE LOW-ORDER PART
ROT         T1, -↑D12                ; POSITION HIGH PART
DPB         T1, [POINT 3, E+1, 20]   ; STORE HIGH-ORDER PART
```

6.2.8.2 **Extended Argument for LOOKUP, ENTER, RENAME UUOs** – A number of quantities have been added to the existing four-word block. The user program may specify exactly the number of words in the argument block. If the left half of E is 0 and the right half of E is three or greater, the right half of E is interpreted as the count of the number of words which follow. If the right half of E is less than three, a file-not-found return is given because the user program is not supplying enough arguments. Allowed arguments supplied by the user program are returned by the monitor as values. If the user program supplies arguments that are not allowed, the monitor ignores these arguments and supplies values on return. Table 6-6 indicates the arguments that may be supplied by a user program.

Table 6-6
Extended LOOKUP, ENTER, and RENAME Arguments

Rel. Loc	Symbol	Lookup	Create Supers	Update Rename	Arguments and Value
0	.RBCNT	A	A	A	Count of arguments following
1	.RBPPN	A0	A0	A0	Directory name (project-programmer no.) or pointer
2	.RBNAM	A	A	A	Filename in SIXBIT
3	.RBEXT	A	A	A	File extension (LH)
		V	A0	A	High order 3 bits of 15-bit creation date (bits 18–20). Access date (bits 21–35)
4	.RBPRV	V	A0	A	Privilege (bits 0–8)
		V	V	A	Mode (bits 9–12)
		V	A0	A	Creation time (bits 13–23)
		V	A0	A	Low order 12 bits of 15-bit creation date (bits 24–35)
5	.RBSIZ	V	V	V	Length of file in data words written (+no. words)
6	.RBVER	V	A	A	Octal version number (36 bits)

Table 6-6 (Cont)
Extended LOOKUP, ENTER, and RENAME Arguments

Rel. Loc	Symbol	Lookup	Create Supers	Update Rename	Arguments and Value
7	.RBSPL	V	A	A	Filename to be used in output spooling.
10	.RBEST	V	A	A	Estimated length of file (+no. blocks)
11	.RBALC	V	A	A	Highest relative block number within the file allocated by user or monitor to file.
12	.RBPOS	V	A	A	Logical block no. of first block to allocate within F.S.
13	.RBFT1	V	A	A	Future nonprivileged argument – reserved for DEC
14	.RBNCA	V	A	A	Nonprivileged argument reserved for customer to define
15	.RBMTA	V	A1	A1	Tape label if on backup tape
16	.RBDEV	V	V	V	Logical unit name on which the file is located
17	.RBSTS	V	A1	A1	1. LH=Combined status of all files in UFD 2. RH=Status of this file
20	.RBELB	V	V	V	Bad logical block within error unit
21	.RBEUN	V	V	V	1. LH=Logical unit no. within F.S. of bad unit (0 , , , N). 2. RH=No. of consecutive blocks in bad region
22	.RBQTF	V	A1	A1	(UFD-only) FCFS logged-in quota in blocks
23	.RBQTO	V	A1	A1	(UFD-only) logged-out quota in blocks
24	.RBQTR	V	A1	A1	(UFD-only) reserved logged-in quota
25	.RBUSD	V	A1	A1	(UFD-only) no. of blocks used at last logout
26	.RBAUT	V	A1	A1	Author project-programmer number (creator, updater or superseder)
27	.RBNXT	V	A1	A1	Next file structure name if file continued
30	.RBPRD	V	A1	A1	Predecessor file structure name if file continued

A = Argument (supplied by privileged or nonprivileged user program) and returned by monitor as a value.
A0 = Argument like A with the addition that a 0 argument causes the monitor to substitute a default value.
V = Value (returned by monitor) cannot be set even by privileged program, monitor ignores argument.
A1 = Argument if privileged program (ignored if nonprivileged).

Table 6-6 (Cont)
Extended LOOKUP, ENTER, and RENAME Arguments

Rel. Loc	Symbol	Lookup	Create Supers	Update Rename	Arguments and Value
31	.RBPCA	V	A1	A1	Privileged argument word reserved for each customer to define as he wishes.
32	.RBUFD	V	V	V	Logical block number within F.S. (not cluster no.) of the RIB of the UFD in which the name of this file appears.
33	.RBFLR	V	V	V	Relative block number in file of first block in RIB
34	.RBXRA	V	V	V	Extended RIB address
35	.RBTIM	V	V	V	Creation date in universal date-time standard (refer to Paragraph 3.6).

A = Argument (supplied by privileged or nonprivileged user program) and returned by monitor as a value.
A0 = Argument like A with the addition that a 0 argument causes the monitor to substitute a default value.
V = Value (returned by monitor) cannot be set even by privileged program, monitor ignores argument.
A1 = Argument if privileged program (ignored if nonprivileged).

The following explanation is a more complete description of the terms used in Table 6-6.

.RBCNT	LH=unused (must be zero). RH=number of arguments following. If bit 18 is set on ENTER, it is a non-superseding ENTER.

.RBPPN	LH=octal project number (right-justified).
	RH=octal programmer number.
	The project-programmer number is of the UFD in which the file is to be LOOKedUP, ENTERed, or RENAMEd. To LOOKUP the MFD, .RBPPN must contain a 1 in the left half and a 1 in the right half indicating that the filename (.RBNAM) is to be LOOKedUP in project 1, programmer 1's UFD (the MFD).

.RBNAM	SIXBIT filename, left justified with trailing nulls. If the MFD or UFD is being LOOKedUP, ENTERed, or RENAMEd, this location contains the project-programmer number. If a SFD is being LOOKedUP, ENTERed, or RENAMEd, this location contains the directory name. The argument can be 0 only on a RENAME, in which case the file is deleted. If the filename is not left justified on ENTER, most programs are unsuccessful on a subsequent LOOKUP. The monitor cannot left-justify the argument because it may be an octal project-programmer number.
.RBEXT	LH=SIXBIT filename extension, left justified with trailing nulls. Null extensions are discouraged because they convey no information. If the extension is not left justified on ENTER, most programs are unsuccessful on a subsequent LOOKUP. RH, bits 18–20 = high order 3 bits of 15-bit creation date (RB.CRX), bits 21–35 = access date in standard format (RB.ACD). If an error return is given, bits 18–35 are set to an error code by the monitor before the error (no skip) return is taken. Refer to Paragraph 6.2.8.3 for a special note on error recovery.

.RBPRV	Bits 0–8 = protection codes. (RB.PRV) Bits 9–12 = data mode in which file is created. (RB.MOD) Bits 13–23 = creation time in minutes since midnight (RB.CRT) Bits 24–35 = low order 12 bits of 15-bit creation date in standard format (RB.CRD)
.RBSIZ	Written length of file. The word is the positive number of words written in the file. For extended arguments, this word is never used for project-programmer numbers. (The four-word block remains compatible so that LH = - number of words in file, RH=0.) This argument is ignored, and a value is always returned.
.RBVER	Octal version number like the contents of location 137 in the job data area. LH=patch level (A=1, B–2, etc.) Set by monitor except in the case of privileged programs. RH=octal version number, never converted to decimal. This argument is accepted, except on a LOOKUP. If a user program wishes to increase the version number by 1 on each UPDATE, it should add 1 to location E + 6 between the LOOKUP and the ENTER.
.RBSPL	Filename to be used to label the output on a device which is being spooled. The filename is taken from the ENTER to the device, or is 0 if an ENTER was not done.
.RBEST	Estimated length of file in positive number of blocks. On an ENTER, FILSER uses this value as the number of blocks to allocate for the file. If requested # of blocks can't be allocated, partial allocation will be performed, but no error return will be given. .RBALC will always contain, on a UUO return, the actual number of blocks allocated.
.RBALC	Number of contiguous 128-word blocks, N, to be allocated to the file on an ENTER or RENAME. This number includes the RIBS of the file. N is equivalent to the last relative block number of the file. A 0 means do not change allocation instead of deallocating all the blocks of the file. All of the data blocks can be deallocated by superseding the file and doing no outputs before the CLOSE. This argument can be used to allocate additional space onto the end of the file, deallocate previously allocated but unwritten space, or truncate written data blocks. The smallest unit of disk space that the monitor can allocate is a cluster of 128-word blocks. Typically small devices use a cluster size of 1 block. If N is not the last block of a cluster, the monitor rounds up, thereby adding a few more blocks than the user requested. If N is too large, the partial allocation error (17) is given; however, you may still write to the file.

NOTE

To create a file of pre-specified length, do an extended ENTER with .RBEST set and .RBALC equal to zero. To create a file of pre-specified length with contiguous blocks, do an extended ENTER with .RBALC set and .RBEST equal to zero. After an ENTER, .RBALC always contains the accurate allocated file length.

.RBPOS	Logical block number, L, of the first block to be allocated for a new group of clusters appended to the file. A logical block number is specified with respect to the entire file structure. Logical block numbers begin with logical block number 0. This feature combined with DSKCHR UUO allows a user program to allocate a file with respect to tracks and cylinders for maximum efficiency when the program runs alone. Because SAT blocks, swapping space, and bad blocks are scattered throughout a file structure, programs using this feature must be prepared to handle such contingencies. It is discouraged for any programs to depend on blocks actually used for allocation to operator without errors.
.RBFT1	Future nonprivileged argument reserved for DEC.
.RBNCA	Nonprivileged argument reserved for customer definition.
.RBMTA	A 36-bit tape label if file has been put on magnetic tape. If allocated space is 0, then file was deleted from disk when it was copied on magnetic tape. Argument is accepted only from privileged programs; otherwise, it is ignored.
.RBDEV	The logical name of the unit on which the file is located. Ignored as an argument, returned as a value.
.RBSTS	File status word

LH=status of UFD Bit 0=1 (RP.LOG) if the user is logged in and set by LOGIN. LOGOUT clears this bit.

RH=status of file.

Bit 18=1 (RP.DIR) if file is a directory file; needed to protect the system from a user who might try to modify a directory file. The protection error is given if extension UFD is given on an ENTER or RENAME and this bit is not set.

Bit 19=1 (RP.NDL) if file cannot be deleted, renamed, or superseded, even by a privileged program or by a user logged in under [1,2].

Bit 21=1 (RP.NFS) if file should not be dumped by FAILSAFE because certain files are needed before FAILSAFE can run.

Bit 22=1 (RP.ABC) if file always has bad checksum (because the monitor never recomputes the checksum) e.g., SWAP.SYS, SAT.SYS.

Bit 25=1 (RB.NQC) if file is a non-quota checked file.

Bit 26=1 (RP.CMP) if UFD compressing.

Bit 27=1 (RB.FCE) if file contains a checksum error.

Bit 28=1 (RB.FWE) if file contains a write error.

Bit 32=1 (RP.BFA) if file is bad because of a FAILSAFE restore.

Bit 33=1 (RP.CRH) if file was closed after a crash.

Bit 35=1 (RP.BDA) if file is bad because of damage assessment.

.RBSTS (cont)	The following bits appear in both the LH and RH of this location: Bit 11 (RP.URE) = 1 if any file in the UFD has had a hard data error while reading. Bit 29 (RP.FRE) = 1 if this file has had a hard data error while reading. (The IO.DTE bit has been set.) An entry is made in the BAT block so that the bad region is not reused. Bit 10 (RP.UWE) = 1 if any file in this UFD has had a hard data error while writing. Bit 28 (RP.FWE) = 1 if this file has had a hard data error while writing. (The IO.DTE bit has been set.) An entry is made in the BAT block so that the bad region is not reused. Bit 9 (RP.UCE) = 1 if any file in this UFD has had a software checksum error or a redundancy check error. Bit 27 (RP.FCE) = 1 if this file has had a software checksum error or a redundancy check error. (The IO.IMP bit has been set.) NOTE **Device errors (IO.DER) are not flagged in the file status word because they refer to a device and disappear when a device is fixed.**
.RBELB	Logical block number within the unit on which last date error (IO.DTE) occurred, as opposed to block within file structure. Set by the monitor in the RIB on a CLOSE when the hardware detects either a hard bad parity error or a search error while reading or writing the file. Device errors, checksum, and redundancy errors are not stored here. This argument is ignored, and a value is returned.
.RBEUN	LH=logical unit number within file structure on which last bad region was detected. RH=number of bad blocks in the last-detected bad region. The bad region may extend beyond the file. This argument is ignored, and a value is returned.
.RBQTF	Meaningful for UFD only. Contains first-come-first-served logged-in quota. This quota is the maximum number of data and RIB blocks that can be in this directory in this structure while the user is logged in. The UFD and its RIB are not counted. Argument is ignored unless it is from a privileged program.
.RBQTO	Meaningful for UFD only. Contains logged-out quota. This quota is the maximum number of data and RIB blocks that can be left in this directory in this file structure after the user logs off. LOGOUT requires the user to be below this quota to log off. LOGIN stores these quotas in the RIB of the UFD, so that LOGOUT does not have to scan ACCT.SYS at LOGOUT time to find the quota. Argument is ignored unless it is from a privileged program.
.RBQTR	Meaningful for UFD only. (Reserved for the future.) Contains reserved logged-in quota. This quota is the guaranteed number of blocks the user has when he logs in. Argument is ignored unless it is from a privileged program.
.RBUSD	Meaningful for UFD only. Contains number of data and RIB blocks used in this directory in this file structure by the user when he last logged off. LOGIN reads this word so that it does not have to LOOKUP all files in order to set up the number of blocks the user has written. LOGIN sets bit 0 of the file status word (.RBSTS) and LOGOUT clears it in order to indicate whether LOGOUT has stored the quantity. Argument is ignored unless it is from a privileged program.

.RBAUT	Contains project-programmer number of the creator or superseder of the file, as opposed to owner of file. Usually the author and the owner are the same. Only when a file is created in a different directory are these different. This argument is used by Batch for validating queue entries in other directories. Argument is ignored unless it is from a privileged program.
.RBNXT	Reserved for future.
.RBPRD	Reserved for future.
.RBPCA	Privileged argument reserved for customer definition.
.RBUFD	The logical block number (not cluster number) in the file structure of the RIB of the UFD in which the name of this file appears.
.RBFLR	The relative block number of the file to which the first pointer of this RIB points. It is used for multiple RIBs (i.e., 0 for prime RIB).
.RBXRA	The extended RIB address (logical unit number and cluster address of next RIB in a multiple-RIB file).
.RBTIM	The date and time of creation of the file in the universal date-time standard (refer to Paragraph 3.6). That is, the LH contains the date and the RH contains the time as a fraction of a day.

6.2.8.3 **Error Recovery for ENTER and RENAME UUOs** – Error codes for the LOOKUP, ENTER, and RENAME UUOs are returned in the right half of location E + 1 of the four-word argument block and in the right half of location E + 3 (.RBEXT) in the extended argument block. This means that the error code overwrites the high order three bits of the creation date and the entire access date. Since the vast majority of programs recover from these errors either by aborting or by reinitializing the entire argument block, this overwriting of data does not cause any problems. However, a small number of programs may attempt recovery by fixing just the incorrect part of the argument block and then retrying the UUO. These programs should always restore the right half of location E + 1 before retrying an ENTER or a RENAME UUO. (In order to eliminate problems for programs recovering from errors for files with zero creation dates, which is the most common case, error codes are restricted to a maximum of 15 bits even though the entire right half of E + 1 is used. In addition, the 5.06B and later monitors force access dates to be greater than or equal to the creation date, but never greater than the current date.)

6.2.9 Special Programmed Operator Service

The following are special programmed operator service UUOs.

6.2.9.1 **PATH. AC, or CALLI AC, 110(1)** – This UUO sets or reads the default directory path, or reads the current directory path on a channel. The call is:

```
MOVE AC, [XWD n, ADR]
PATH. AC,
error return
normal return
```

(1) This UUO depends on FTSFD which is normally off in the DECsystem-1040.

```
    ADR:       arg
               scan switch
               ppn
               SFD(1) name
               SFD(2) name
                 .
                 .
                 .
ADR+n-1:       0
```

The first word of the argument block contains one of the following:

C(ADR)=SIXBIT device name, or XWD 0, D(2)
: Return the current path for the specified device or channel D.

C(ADR)=XWD JOB, –1
: Return the default directory path.

C(ADR)=–2
: Define the default directory path.

C(ADR)=–3
: Define the additional path to be searched when a file is not found in the user's directory path.

C(ADR)=XWD JOB, –4
: Return the additional path to be searched when a file is not found in the user's directory path.

If the left half of ADR is a job number N and the right half of ADR is –1 or –4, the returned values are for either

1. job N if 0<N< the highest legal job number, or
2. the current job if N is outside the above range (i.e., N<0 or N> the highest legal job number).

When defining a path within a UFD (C(ADR) = –2), ADR+1 is the scan switch, ADR+2 is the default project-programmer number, and the remainder of the argument block up to the first zero word defines the default path. The scan switch determines whether or not the monitor scans for the file on a LOOKUP. If the switch is 1, the monitor examines the specified directory only; higher level directories are not searched. If the switch is 2, the following occurs:

1. The monitor searches the UFD or SFD specified by the path (either explicit or default path). If the file is found, the scan is terminated.
2. If the file is not found, the monitor backs up one directory along the path and continues the scan (i.e., it scans the directory in which the current SFD appears). The scan is terminated when the UFD is searched or when the file is found.

Scanning allows directories to be nested since any file not found in the current SFD is obtained automatically from a higher level directory. This is useful when a user has a default directory in use containing files he is currently working on and a higher level directory containing checked-out routines. Since SFDs are continued across file structures but the depth of the nesting of directories is not necessarily the same on each file structure, each scan searches the file structures that are:

(1) This UUO depends on FTSFD which is normally off in the DECsystem-1040.
(2) Note that this function of the PATH. UUO is available even if FTSFD is turned off.

1. in the job's search list and

2. have SFDs to the depth specified in the path.

The file structures are searched in the same order as they appear in the search list.

On an ENTER, the scan switch is ignored; if the file is found in the specified directory, it will be superseded. If the file is not found, it will be created at the end of the path in the specified directory whether or not a file with the same name appears in a higher level directory.

When defining the additional path to be used after the user's directory path is searched (C(ADR)=–3), ADR+1 indicates if SYS (bit 35 = 1) or experimental SYS (bit 34 = 1) is to be scanned, and ADR+2 is the project-programmer number to be used for a user library. These locations are used as follows. If the file is not found in the user's directory path on a LOOKUP DSK:, the directory specified in ADR+2 is searched for the file. This directory must be a UFD and allows users with different directory paths to share a common directory of files. If the file is not found in the library and if bit 35 of ADR+1 is set, the system library (SYS: [1,4]) is searched. In addition on a LOOKUP SYS:, if bit 34 of ADR+1 is set, the directory area [1,5] is searched before the system library area [1,4]. The [1,5] area is called the experimental SYS area (NEW:) and can be used to separate software that is near the end of the development and testing stages from the standard system software on the system library [1,4].

When returning a path, ADR+1 contains the following:

bits 34 and 35	the scan switch
bit 33=1	if experimental SYS (NEW:) is searched
bit 32=1	if SYS is searched
bit 31=1	if there is a user library
bit 30=1	if the user-supplied project-programmer number is to be ignored on a LOOKUP or ENTER UUO and the implied project-programmer of the device is to be used (e.g., [1,4] if SYS; [1,5] if NEW). The implied project-programmer number is returned in ADR+2.
bits 27–29	the type of search list:

0	a non-standard search list (e.g., DSKA)
1	job search list
2	ALL search list
3	SYS search list

and ADR+2 through ADR+n–1 is the path. If the path is less than n–1 words, a zero word is stored at the end. If ADR contains a device name or channel number when the UUO is called, the file structure name or ersatz device name is returned in ADR depending on the name specified (e.g., SYS is returned only if C(ADR) = SYS and the job does not have a device with the logical name SYS). If a LOOKUP or ENTER has been done on the specified device or channel number, the following is returned in the argument block.

ADR:	the SIXBIT name of the file structure or ersatz device.
ADR+1:	the scan switch.
ADR+2:	the actual project-programmer number associated with the file.
ADR+3:	the actual path of the file.
.	
.	
ADR+m	0 the end of the path if m <n–1.

If no LOOKUP or ENTER has been done, the following is returned:

ADR:	SIXBIT DSK or ersatz device name.
ADR+1:	the scan switch.
ADR+2:	the job's default project-programmer number (or the project-programmer number of the ersatz device).
ADR+3:	the default path to the file.
.	
.	
ADR+m:	0 the end of the path if m <n–1.

On an error return,

AC is unchanged if the UUO is not implemented. (SFD remains a reserved extension, but all SFD code disappears.) The GETTAB which returns the maximum number of SFDs allowed returns 0 or fails. The default path is the user's project-programmer number.

AC is 0 if the device or channel number does not represent a disk.

AC is –1 if an SFD in the path specification is not found.

Examples

1. This example sets the default path to [27,235,SUB] with no scanning in effect.

```
        MOVE 1, [XWD 5, A]
        PATH. 1,
        error
        normal

A:      -2
        1
        27,235
        SUB
        0
```

2. Refer to Figure 6-6. The path plus filename for file A is X.MAC [10,63]. The path plus filename for file B is Y.CBL [14,5]. The path plus filename for file C is Z.ALG [14,5,M].

3. Refer to Figure 6-7. The job's search list is DSKA/N, DSKB, DSKC, and the default path is [PPN, A, B, C, D].

   a. LOOKUP DSK: with no matches scans in order; DSKA:D (.SFD), DSKA:C, DSKB:C, DSKA:B, DSKB:B, DSKA:A, DSKB:A, DSKA:PPN (.UFD), DSKB:PPN, DSKC:PPN.

   b. LOOKUP DSK: FILE2 finds DSKA: FILE2 [PPN, A, B, C].

   c. LOOKUP DSKB: FILE2, or LOOKUP DSKC: FILE2 fails.

   d. ENTER DSK: FILE9 receives an error since no file structure has both the no-create bit off and the directory structure [PPN, A, B, C, D].

   e. ENTER DSKA: FILE1 creates the file at the end of the path on DSKA (the file designated by (FILE1) in diagram).

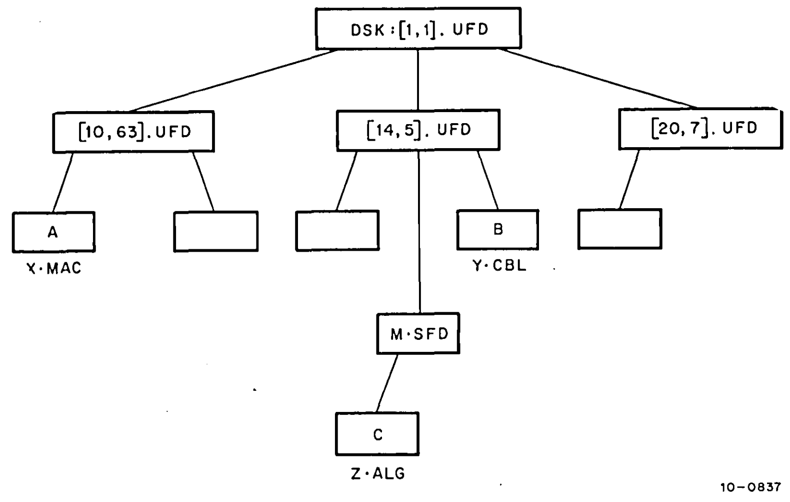


Figure 6-6 Directory Paths on a Single File Structure

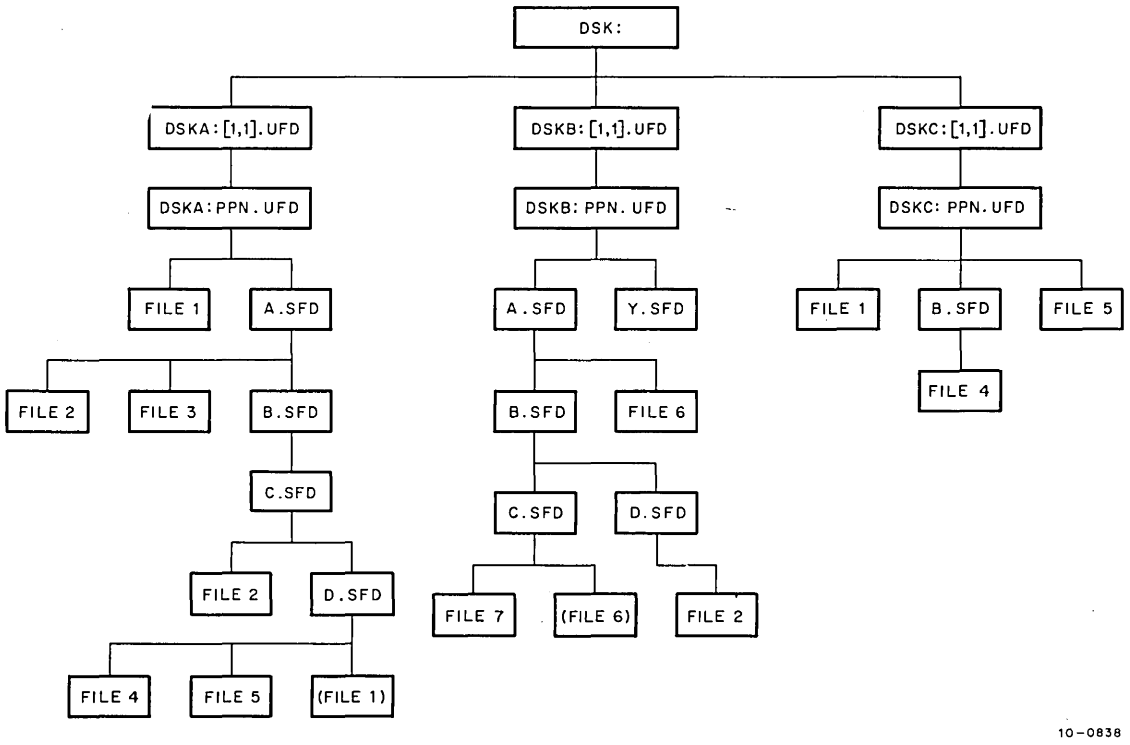


Figure 6-7 Directory Paths on Multiple File Structures

The default path is [PPN, A, B, C]:

a. ENTER DSK: FILE6 creates DSKB: FILE6 [PPN, A, B, C] (the file designated by (FILE6) in diagram).

b. ENTER DSK: FILE2 supersedes FILE2 in DSKA: [PPN, A, B, C].

c. LOOKUP DSK: FILE4 fails.

d. ENTER DSK: FILE7 supersedes FILE7 in DSKB: [PPN, A, B, C].

4. The user defines the following path.

```
        MOVE 1, [XWD 5, A]
        PATH. 1
        error
        MOVE 1, [XWD 3, B]
        PATH. 1,
        error
```

A:	–2	Define the default directory path.
	2	Scanning is in effect.
	10,63	The UFD [10,63].
	NAME	The SFD [NAME]
	0	The default path is [10,63,NAME].
B:	–3	Define an additional path.
	3	Both experimental SYS and SYS are searched.
	10,7	The user library is [10,7].

If the user is logged in as [10,10] and does a LOOKUP DSK: FILTST, the following directories are searched in order:

[NAME,SFD]	
[10,63.UFD]	job's search list.
[10,7.UFD]	
[1,5.UFD]	system's search list.
[1,4.UFD]	

If the user is logged in as [10,10] and does a LOOKUP DSK: PRJFIL [10,155], the following directories are searched:

[10,155.UFD]	
[10,7.UFD]	job's search list.
[1,5.UFD]	
[1,4.UFD]	system's search list.

6.2.9.2 USETI and USETO UUOs – The function of these UUOs is to notify the disk service routines that a particular relative block (instead of the next block in sequence) is to be used on the following INPUT or OUTPUT on the specified channel. USETI and USETO do not perform I/O; they simply change the current position of the file. Note that each INPUT or OUTPUT also logically advances the file; therefore, to reread or rewrite the same block a USETI (or USETO) must be given before each INPUT (or OUTPUT). On a USETO, the monitor will write out all buffers whose use bit is on (FULL BUFS) before advancing the file.

Since the monitor reads (or writes) as many buffers as it can on INPUT (OUTPUT), it is difficult to determine which buffer the monitor is processing when the USETI (USETO) is given. Thus, the INPUT (OUTPUT) following the USETI (USETO) may not read (write) the buffer containing the block specified with the USETI (USETO). However, a single buffer ring reads (writes) the desired block since the device must stop after each INPUT (OUTPUT). Alternatively, if bit 30 of the status word (IO.SYN) is set via an INIT, OPEN, or SETSTS UUO, the device stops after each bufferful of data on an INPUT (OUTPUT) so that the USETI (USETO) will apply to the buffer supplied on the next INPUT (OUTPUT). The calls are:

USETI D, N and USETO D, N

where D is the channel number, and N designates a block relative to the beginning of the file. N can be in the following ranges:

N	Block Represented
1–777777(8)	Blocks of the file
0	Prime (1st) RIB
–2, ... ,–10(8)	Extended (2nd to the 8th) RIB(1)
–1	Last block accessed (USETO) or end-of-file (USETI).

Note that the 18-bit effective address used for N is interpreted as both an unsigned positive integer and a signed (2's complement) integer. This is required since, with extended RIBs, there can be more than 377777(8) (largest positive signed integer) blocks in a file. The exact interpretation of N depends upon the context of the USETI/USETO (i.e., reading, writing, updating).

When reading or writing a file, USETI precedes an INPUT and USETO precedes an OUTPUT (i.e., USETI is illegal for a non-privileged program unless a LOOKUP has been done, and USETO is illegal for a non-privileged program unless an ENTER has been done). However, there are special cases when updating a file (both a LOOKUP and an ENTER have been done) when USETI may be followed by an OUTPUT and USETO may be followed by an INPUT. The action performed on a USETI or USETO depends on the value of N.

When N is a block number less than or equal to the current size of the file in blocks (i.e., N is a block that has been previously written), USETI or USETO points to block N in order to read or write that block on the next INPUT or OUTPUT.

When N is a block number greater than the current size of the file in blocks, USETI followed by an INPUT receives the end-of-file return (e.g., if the file is five blocks long, USETI with n=7 receives the end-of-file return). On a USETO followed by an OUTPUT' the monitor allocates the intervening blocks, writes zeroes in the first new block up to block N–1, and then writes block N. For example, if the file is two blocks long, USETO with N=4 writes zeroes in block 3 and the data on the OUTPUT in block 4. If the number of blocks requested cause the disk to be filled or the user's quota to be exceeded, as many blocks as allowed will be allocated and the IO.BKT bit will be set in the status word. In addition, in update mode, USETI followed by an OUTPUT appends the data to the end of the file (i.e., makes the file larger). USETO followed by an INPUT allocates and zeroes the first new block up to block N–1 and then receives the end-of-file return.

When N=0 on reading, writing, and updating, USETI and INPUT read the prime RIB, and USETO and OUTPUT receive the IO.BKT error. In addition, in update mode, USETO and INPUT read the prime RIB, and USETI and OUTPUT receive the IO.BKT error.

(1) The number of extended RIBs allowed on the system can be changed with MONGEN and can be obtained from a GETTAB table (.GTLVD, item 23). Extended RIBs depend on FTMRIB which is normally off in the DECsystem-1040.

When N=–2 to –10(8), a USETI and INPUT read the indicated extended RIB (–2 is the 2nd RIB, . . . , –10(8) is the 8th RIB). USETO followed by an OUTPUT attempts to allocate a large number of blocks (since N is interpreted as an unsigned integer) and, therefore, is not recommended because the user's disk quota will probably be exceeded.

When N=–1, USETO and OUTPUT rewrite the last block in which I/O was performed. USETI and INPUT receive the end-of-file return. In addition, in update mode, USETI followed by OUTPUT appends the data to the end of the file, and USETO and INPUT read the last block in which I/O was performed.

The user can append data to the last block of an append-only file by specifying a USETO followed by an OUTPUT to the last block(1). The monitor then reads the block (of N words) into a monitor buffer, copies words N+1 through 200 from the user's buffer into the monitor buffer, and rewrites the block. The current length of the block can be obtained from the LOOKUP/ENTER block. It is not necessary to read the last block of the file before appending to it because the data already existing in the block is not changed.

When appending data to the last block of a file, the IO.BKT bit is set and no output is done if

1. Any block before the last block is written.
2. The last block already contains 200 words.
3. Fewer words are written than the current size of the block.

If the last block is written with a buffer-mode OUTPUT, the size of the last block becomes 200 words and, therefore, cannot be appended to.

Append-only files can be read only if FTAIR is on. Note that BASIC stores data at the beginning of files that it must read and, therefore, to run BASIC, FTAIR must be turned on.

All uses of USETI and USETO for the disk without a prior LOOKUP UUO or ENTER UUO being issued on the channel will cause an illegal instruction trap. The job currently being performed will stop and the monitor will print the following line on the controlling terminal.

```
?ILLEGAL UUO AT USER addr
```

The terminal at this point will enter into the monitor mode of operation.

6.2.9.3 SEEK UUO(2) – This UUO, when used in conjunction with USETI and USETO, allows user programs control over the time at which positioning operations occur. Following a USETI or USETO, positioning is to the cylinder containing the requested relative block within a file.

The call is:

```
SEEK AC,                ; or CALLI D, 56
return
```

D specifies a software channel number. The SEEK UUOs are honored by the monitor only if the unit for which they are issued is idle. If the unit is in any other state, the SEEK UUO is a no-operation.

(1)This feature depends on FTAPLB, which is normally off in the DECsystem-1040. Therefore, a new block must be written in order to append to a file.
(2)This UUO depends on FTDSEK which is normally off in the DECsystem-1040.

SEEK UUOs issued for public file structures are treated in the same way as private file structures. This allows users to debug programs using a public disk pack and later run the same programs using a private disk pack.

The following is the proper UUO sequence for issuing a SEEK.

For output

a. USETO to select a block (relative or actual)
b. SEEK to request positioning
c. computations
d. OUTPUT to request actual output

For input

a. USETI to select a block (relative or actual)
b. SEEK to request positioning
c. computations
d. INPUT to request actual input.

6.2.9.4 RESET UUO – This UUO causes files that are in the process of being written, but have not been CLOSEd or RELEASed, to be deleted; the space is reclaimed. If a previous version of the file with the same name and extension existed, it remains unchanged on the disk (and in the UFD). If the programmer wishes to retain the newly created file and to delete the older version, he must CLOSE or RELEASE the file before doing a RESET UUO.

6.2.9.5 DEVSTS UUO – After each interrupt, FILSER stores the results of a CONI in the DEVSTS word of the device data block. The DEVSTS UUO is used to return the contents of the DEVSTS word to the user (refer to Paragraph 4.10.1).

6.2.9.6 CHKACC UUO – The CHKACC UUO provides a consistent and uniform method of determining whether or not a file may be accessed. User programs should not make assumptions about the access rights to a file, but should employ CHKACC to insure that access is permitted. This is especially true for privileged programs which are constrained by the access privileges of a non-privileged project-programmer number for which they may be performing a task. For instance, LPTSPL must check the access rights of the user issuing a PRINT command to verify that the user is actually allowed to read the file.

The right to access a file is determined by:

1. The type of access desired (e.g., read).
2. The project-programmer number of the user desiring access to the file.
3. The project-programmer number of the directory in which the file resides.
4. The protection field of the file or the protection field of the directory.

Note that access to a file is not dependent upon the filename. However, the filename is needed if a LOOKUP must be performed (e.g., to obtain the protection field of the file).

The type of access to be checked is represented by one of the following codes:

0	.ACCPR	Change protection.
1	.ACREN	Rename.
2	.ACWRI	Write.
3	.ACUPD	Update.
4	.ACAPP	Append.
5	.ACRED	Read.
6	.ACEXO	Execute only.
7	.ACCRE	Create in UFD.
10	.ACSRC	Read directory as file.

The format of the call to CHKACC is:

```
          MOVEI AC, CHKLOC
          CHKACC AC,                    ; or CALLI AC, 100
          error return
          normal return
              .
              .
              .
CHKLOC:   BYTE(18)ACCESS(9)Directory-Protection(9)File-Protection
          directory PPN
          user's PPN
```

where:

ACCESS is the code for the type of access desired.

DIRECTORY-PROTECTION is the 9-bit protection field for the directory containing the file (see Paragraph 6.2.3.1).

FILE-PROTECTION is the 9-bit protection for the file (see Paragraph 6.2.3).

DIRECTORY PPN is the project/programmer number of the directory (UFD) containing the file.

USER'S PPN is the project/programmer number of the user desiring access to the specified file.

The error return is taken if the UUO is not implemented. On a normal return, AC is set to zero if access is allowed, and –1 if otherwise.

For functions 0 through 6 the monitor will ignore the DIRECTORY-PROTECTION, and for functions in 7 and 10, the monitor will ignore the FILE-PROTECTION.

The following sample code checks to see if user [36,402] has access rights to the file specified as PRIVAT.TXT [1206, 124].

```
        MOVEI   AC,.ACRED               ;GET CODE FOR "READ FILE"
        HRLM    AC,CHKLOC               ;STORE TYPE OF ACCESS DESIRED
        LOOKUP  CH,LKPBLK               ;LOOKUP PRIVAT.TXT [1206,124]
        JRST    ERROR                   ;ERROR RETURN WHEN FILE CANNOT BE
                                        ;FOUND
        LDB     AC,[POINT 9, FILPRO, 8] ;GET FILE'S PROTECTION FIELD
        HRRM    AC,CHKLOC               ;STORE PROTECTION CODE
        MOVE    AC,FILPPN               ;GET PPN OF DIRECTORY
        MOVEM   AC,CHKLOC+1             ;STORE DIRECTORY PPN
        MOVE    AC,[XWD 36,402]         ;GET USER'S PPN
        MOVEM   AC,CHKLOC+2             ;SAVE USER'S PPN
        MOVEI   AC,CHKLOC               ;SET UP FOR CHKACC
        CHKACC  AC,                     ;GET ACCESS RIGHTS FROM MONITOR
        JRST    NOTIMP                  ;ERROR RETURN WHEN UUO NOT IMPLE-
                                        ;MENTED
        JUMPE   AC,ALLOWD               ;ACCESS IS ALLOWED IF AC CONTAINS 0
NOACCESS:          .                    ;ELSE IF AC CONTAINS -1 ACCESS
                   .                    ;IS NOT PERMITTED
                   .
LKPBLK:
FILNAM: SIXBIT/PRIVAT/
FILEXT: SIXBIT/TXT/
FILPRO: 0
FILPPN: XWD 1206, 124
CHKLOC: BLOCK 3
```

6.2.9.7 STRUUO AC, or CALLI AC, 50 – This UUO manipulates file structures and is intended primarily for monitor support programs.

The call is:

```
MOVE AC, [XWD N, LOC]
STRUUO AC,                  ; or CALLI AC, 50
error return                ; AC contains an error code
normal return               ; AC contains status information
```

N is the number of words in the argument list starting at location LOC. For the functions with a fixed length argument list, N may be 0.

The first word of the argument list specifies the function to be performed. Function 0 (.FSSRC) is the only unprivileged function; the remaining functions are available only to jobs logged-in under [1,2] or to programs running with the JACCT bit set. (Refer to the Specifications section of the DECsystem-10 Software Notebooks for a complete description of the privileged functions and their appropriate error codes.)

The present functions are as follows:

Function	Name	Argument
0	.FSSRC	Define a new search list for this job. This is the only unprivileged function.
1	.FSDSL	Define a new search list for any job or for the system. Privileged function.

Function	Name	Argument
2	.FSDEF	Define a new file structure. Privileged function.
3	.FSRDF	Redefine an existing file structure. Privileged function.
4	.FSLOK	Prevent any further new INITs, ENTERs, or LOOKUPs. Privileged function.
5	.FSREM	Remove file structure from system. Privileged function.
6	.FSULK	Test and set UFD interlock. Privileged function.
7	.FSUCL	Clear UFD interlock. Privileged function.
10	.FSETS	Simulate disk hardware errors. Privileged function.

```
          MOVE AC, [XWD N, LOC]
          STRUUO AC,
          error return
          normal return

LOC:      0                          ;.FSSRC
LOC+1:    first file structure name
LOC+2:    0
LOC+3:    status bits
LOC+4:    second file structure name
LOC+5     0
LOC+6:    status bits
  .
  .
  .
```

The argument list consists of word triplets, which specify the new search list in order to replace the current search list. The current search list may be determined with the JOBSTR UUO. The first word contains a left-justified file structure name in SIXBIT. The second word is not used at present. The third word contains the following status bits:

Bit 0 =	1 if software write-protection is requested for this file structure.
Bit 1 =	1 if files are not to be created on this file structure unless the specific file structure is specified in an ASSIGN command or in an INIT or OPEN UUO.

The user may use the MOUNT command to add a new file structure name to his search list. The MOUNT program

1. Requests the file structure to be mounted (if it is not already mounted).
2. Creates a UFD for the user if he has a logged in quota in file SYS: QUOTA.SYS on that file structure.

A user cannot create files on a file structure unless he or the project-programmer number specified has a UFD on that file structure. However, by using the .FSSRC function, the user may add a file structure name to his search list if the file structure is mounted and either the user has a UFD for that file structure or he does not want to write on that file structure. If the user attempts to delete a file structure name from his search list by the .FSSRC function, the monitor moves the file structure name from the active search list to the passive search list. The DISMOUNT command must be used to remove the file structure from the active or passive search list. The DISMOUNT command causes the mount count to be decremented, signifying that the user is finished with the file structure, and checks that the user has not exceeded his logged out quota on the file structure.

Table 6-7
.FSSRC Error Codes

Symbol	Code	Explanation
FSILF%	0	Illegal function code.
FSSNF%	1	One or more file structures not found.
FSSSA%	2	One or more file structures single access only.
FSILE%	3	Illegal entry in list.
FSTME%	4	Too many entries in search list.
FSUNA%	5	Unit not available.
FSPPN%	6	PPN does not match.
FSMCN%	7	Mount count greater than one.
FSNPV%	10	Not a privileged user.
FSFSA%	11	Structure already exists.
FSILL%	12	Illegal argument list length.
FSUNC%	13	Unable to complete UUO.
FSNFS%	14	System full of file structures.
FSNCS%	15	Insufficient free core for data blocks.
FSUNF%	16	Illegal unit.
FSRSL%	17	File structure is repeated in a search list definition.

6.2.9.8 **JOBSTR AC, or CALLI AC, 47(1)** – This UUO returns the next file structure name in the job's search list along with other information about the file structure. Programs like DIRECT use this UUO to list a user's directory correctly and specify in which file structure the files occur, as well as the order in which they are scanned.

The call is:

```
MOVE AC, [XWD N, LOC]
JOBSTR AC,                        ; or CALLI AC, 47
error return
normal return
```

LOC is the address of the N-word argument. When the UUO is called, the first word should be one of the following:

1. –1 to return the first file structure name in the search list.
2. a file structure name to return the next file structure following the specified name.

(1) In the DECsystem-1040, FTSTR is normally off so that there is only one file structure on the system. However, this UUO is implemented and returns the file structure name or –1.

3. 0 to return the file structure name immediately following the FENCE. (Refer to Paragraph 6.2.7.

On normal return, the first word contains:

1. the first file structure name in the search list if −1 was specified.
2. the next file structure name appearing after the specified name or after the FENCE (if 0 was specified).
3. 0 if the item after the specified name is the FENCE.
4. −1 if there are no more file structure names in the search list, or the search list is empty.

The second word contains 0 (reserved for a future argument), and the third word contains status bits. Current status bits are:

Bit 0 = 1	if software write protection is in effect for this job.
Bit 1 = 1	if files are not to be created on this file structure, when a multiple file structure name is specified in an INIT or OPEN UUO. Files can be created if a specific file structure or physical unit is specified.

The following is an example of reading a job's search list.

```
        SETOM LOC         ;place -1 in LOC to get 1st
                          ;name in search list.
LOOP:   MOVEI   AC,LOC    ;set up AC.
        JOBSTR AC,        ;do the UUO.
        JRST ERROR        ;error return
        MOVE    AC,LOC    ;get file structure name returned.
        JUMPE   AC,FENCE  ;jump if it is the FENCE.
        AOJE    AC,END    ;jump if end of search list (-1).
        .
        .                 ;LOC has next file structure name
        .
        .
        JRST LOOP         ;repeat with next file structure name.
LOC:    -1                ;file structure name.
        0                 ;reserved for future use.
        0                 ;status bits.
```

6.2.9.9 GOBSTR AC, or CALLI AC, 66 – This UUO returns successive file structure names in the search list of either an arbitrary job or the system. The GOBSTR UUO is a generalization of the JOBSTR UUO (see Paragraph 6.2.9.8). It is a privileged UUO unless information being requested is either about the system search list or the jobs logged in under the same project-programmer number as the calling job's number. For example, the KJOB program needs information about the search lists of jobs logged in under the same project-programmer number as the job logging out. The privilege bits required are either JP.SPA (bit 16) or JP.SPM (bit 17) of the privilege word (.GTPRV).

The call is:

```
MOVE AC, [XWD N, LOC]
GOBSTR AC,                    ; or CALLI AC, 66
error return                  ; AC contains an error code
normal return
```

When the UUO is called, AC specifies the length (N) and address (LOC) of an argument list. N may be 0, 3, 4, or 5 where N = 0 has the same effect as N = 3. The status word is used or returned only if N = 5. The argument list is as follows:

```
LOC:  job number                      ;job whose search
                                      ;list is desired.
      XWD proj, prog                  ;project-programmer
                                      ;number of above job.
      SIXBIT /file structure name/    ;or -1 or 0.
      0                               ;currently unused.
      Status                          ;status bits are the same
                                      ;as in JOBSTR UUO.
```

If the job number = -1, the number of the job issuing the UUO is used. If the job number = 0, the given project-programmer number is ignored and the system search list is used. When the given project-programmer number is -1, the project-programmer number of the job issuing the UUO is used. On a normal return, the next file structure in the specified search list is returned in LOC + 2. If there are no more file structures in the search list, -1 is returned in this location.

On an error return, AC contains one of the following error codes:

Code	Mnemonic	Meaning
3	DFGIF%	If LOC+2 is not 0, –1, or a file structure name in job's search list.
6	DFGPP%	If job number (LOC) and project-programmer number (LOC+1) do not correspond.
10	DFGNP%	If job issuing the UUO is not privileged.
12	DFGLN%	If the length specified for the argument list is not valid.

6.2.9.10 **SYSSTR AC, or CALLI AC, 46** – This UUO provides a simple mechanism to obtain all the file structure names in the system. The proper technique to access all files in all UFDs is to access the MFD on each file structure spearately. Monitor support programs use this UUO to access all the files in the system.

The call is:

```
MOVEI AC, 0                    ;or MOVE ac, [SIXBIT/FSNAME/]
SYSSTR AC,                     ;or CALLI AC, 46
error return
normal return
```

An error return is given if either

1. The UUO is not implemented
2. The argument is not a file structure name.

On a normal return, the next public or private file structure name in the system is returned in AC. A return of 0 in the AC on a normal return means that the list of file structure names has been exhausted. If 0 is specified as an argument, the first file structure name is returned in AC. The argument cannot be a physical disk unit name or a logical name.

6.2.9.11 **SYSPHY AC, or CALLI AC, 51(1)** – This UUO returns all physical disk units in the system. The SYSPHY UUO is similar to the SYSSTR UUO (see Paragraph 6.2.9.10).

The call is:

```
MOVEI AC, 0 or the last unit name returned by previous
SYSPHY
SYSPHY AC,                    ; or CALLI AC, 51
error return                  ; not implemented or not a physical disk
normal return                 ; unit name
```

On the first call AC should be 0 to request the return of the first physical unit name. On subsequent calls, AC should contain the previously returned unit name.

An error return is given if AC does not contain a physical disk unit name as zero. On a normal return, the next physical unit name in the system is returned in AC. A return of 0 in AC indicates that the list of physical units has been exhausted.

6.2.9.12 **DEVPPN AC, or CALLI AC, 55(1)** – This UUO allows a user program to obtain the project-programmer number associated with a disk device. The device argument given can be a logical device name, a physical device name, or one of the special devices called ersatz devices. (Refer to DECsystem-10 Operating System Commands for the list of system devices.)

When the UUO is called, AC must contain either the device name as a left-justified SIXBIT quantity, or the channel number of the device as a right-justified quantity.

The call is:

```
MOVE AC, [SIXBIT /DEV/]       ; or MOVEI AC, channel number
DEVPPN AC,                    ; or CALLI AC, 55
error return
normal return
```

The error return is taken if:

1. The UUO is not implemented; therefore, the contents of AC remain the same on return. In this case, obtain the appropriate project-programmer number as follows:
   a. For the user's area, use the GETPPN UUO (refer to Paragraph 3.6.2.3).
   b. For the special ersatz devices, use the default project-programmer numbers appearing in the following list:

(1) This UUO depends on FT5UUO which is normally off in the DECsystem-1040.

Device	Project-programmer Number
ALG:	[5,4]
ALL:	USER'S
BAS:	[5,1]
BLI:	[5,5]
COB:	[5,2]
DMP:	[5,11]
DOC:	[5,14]
DSK:	User's
FAI:	[5,15]
FOR:	[5,6]
HLP:	[2,5]
LIB:	Set by each user
MAC:	[5,7]
MUS:	[5,16]
MXI:	[5,3]
NEW:	[1,5]
OLD:	[1,3]
REL:	[5,11]
RNO:	[5,12]
SNO:	[5,13]
SYS:	[1,4]
TED:	[5,10]
UNV:	[5,17]

2. The device does not exist or the channel is not INITed; therefore, zero is returned in AC.

3. The device is not a disk; the user's project-programmer number is returned in AC.

If a legal device is specified, the normal return is given and the project-programmer number associated with the device is returned in AC. However, if the user has device NEW: enabled in his search list and device SYS: is given as the argument to the DEVPPN UUO, the project-programmer number returned is [1,5].

The following is an example for reading a UFD if either device SYS: or the user's area is specified.

```
          MOVEI   A,16                ;GET MFD PROJECT-PROGRAMMER NUMBER
          GETTAB  A,                  ;NO CHANGE IF NO GETTAB
            MOVE  A,[1,,1]            ;  IN CASE OF LEVEL C
          MOVEM   A,MFDPPN            ;STORE MFD DIRECTORY NUMBER

          MOVE    A,DEVNAM            ;GET DEVICE NAME TYPED BY USER
          MOVEM   A,MODE+1            ;STORE FOR OPEN
          DEVPPN  A,                  ;GET PROJECT-PROGRAMMER NUMBER
            JRST  GETPPX              ;  NOT IMPLEMENTED OR NO SUCH DEVICE

;BACK HERE WITH IMPLIED PPN IN A

GOTPPN:   MOVEM   A,PPN               ;STORE PPN IMPLIED BY DEVICE NAME

          OPEN    I,MODE              ;TRY TO OPEN DEVICE
            JRST  ERROR               ;NOT AVAILABLE
          LOOKUP  I,PPN               ;TRY TO LOOKUP UFD
            JRST  ERROR               ;NOT THERE
          IN      I,                  ;READ FIRST BLOCK
            JRST  USEIT               ;GO DO USEFUL WORK
          JRST    ERROR               ;ERROR OR END OF FILE

;HERE IF DEVPPN FAILS

GETPPX:   CAMN    A,[SIXBIT /SYS/]    ;SEE IF DEVICE NAME SYS:
          JRST    GETPPS              ;YES--GO HANDLE SYS:
          GETPPN  A,                  ;NO--GET OWN PPN
            JFCL                      ;(IN CASE OF JACCT)
          JRST    GOTPPN              ;OK--PROCEED ABOVE

GETPPS:   MOVE    A,[1,,16            ;FIND SYS:  PPN
          GETTAB  A,                  ;FROM MONITOR TABLES
            MOVE  A,[1,,1]            ;(IN CASE OF LEV. C)
          JRST    GOTPPN              ;OK--PROCEED ABOVE

MODE:     14                ;BINARY READ
          0                 ;DEVICE NAME
          0,,INBUFH         ;BUFFER HEADER

PPN:      0                 ;DIRECTORY NAME
          SIXBIT /UFD/      ;EXTENSION
          0
MFDPPN:   1,,1              ;LOOKUP UFD IN MFD
```

6.2.9.13 **DSKCHR AC, or CALLI AC, 45** – The disk characteristics UUO provides necessary information for allocating storage efficiently on different types of disks. Most programs are able to use the generic device name DSK rather than special disk names; however, this UUO is needed by special monitor support programs.

This UUO accepts, as arguments, names of file structures (e.g., DSKA), types of controllers (e.g., DP), controllers (e.g., DPA), logical units (e.g., DSKA3), physical disk units (e.g., DPA3) or logical device names (e.g., ALPHA). If the argument in LOC specifies more than one unit, the values returned in AC are for the first unit of the specified set. If the argument specifies more than one file structure (i.e., DSK or logical device name for disk), the first unit of the first file structure is returned.

The call is:

```
        MOVE AC, [XWD+N,LOC]          ;N is the number of locations
                                      ;of arguments and values starting
                                      ;at location LOC

        DSKCHR AC,                    ;or CALLI AC, 45
        error return                  ;not a disk
        normal return
```

On a normal return, AC contains status information in the left half and configuration information in the right half. The left half bits have been chosen so that the normal state is 0.

Name	Bit	Explanation
DC.RHB	Bit 0 = 1	The monitor must reread the home block before the next operation to ensure that the pack ID is correct. The monitor sets this bit when a disk pack goes off-line.
DC.OFL	Bit 1 = 1	The unit is off-line.
DC.HWP	Bit 2 = 1	The unit is hardware write-protected.
DC.SWP	Bit 3 = 1	The unit belongs to a file structure that is write-protected by software for this job.
DC.SAF	Bit 4 = 1	The unit belongs to a single-access file structure.
DC.ZMT	Bit 5 = 1	The unit belongs to a file structure with a mount count that has gone to zero (i.e., no one is using the file structure). Available in 5.02 monitors and later.
	Bit 6 = 1	Reserved for the future.
DC.STS	Bits 7 & 8	Unit status.
.DCSTD	=01	The unit is down.
.DCSTN	=10	No pack is mounted.
.DCSTD	=11	Reserved for the future.
.DCSTP	=00	A pack is mounted.
DC.MSB	Bit 9 = 1	The unit has more than on SAT block.
DC.NNA	Bit 10 = 1	The unit belongs to a file structure for which the operator has requested no new INITs, LOOKUPs, or ENTERs; set by privileged STRUUO function.
DC.AWL	Bit 11 = 1	The file structure is write-locked for all jobs.
	Bit 12–14	Reserved for future expansion.
DC.TYP	Bits 15–17	The code identifies which type of argument was passed to the monitor in location LOC.

Name	Bit	Explanation
DC.DCN	Bits 18–20	Data channel number that software believes hardware is connected to; first data channel is 0.
DC.CNT	Bits 21–26	Controller types:
.DCCFH	=1	FH (Burroughs disk, Bryant drum) controller RC10
.DCCDP	=2	DP (Memorex disk packs) controller RP10
DC.CNN	Bits 27–29	Controller number; first controller of each type starts at 0 (e.g., DPA = 0, DPB = 1)
DC.UNT	Bits 30–32	Unit type; a controller-dependent field used to distinguish various options of a unit on its controller.

If bits 21–26 and bits 30–32 then type is

1	0	RD10 Burroughs disk (.DCUFD)
1	1	RM10B Bryant drum (.DCUFM)
2	1	RP02 disk pack (.DCUD2)
2	2	RP03 disk pack (.DCUD3)

DC.UNN	Bits 33–35	Physical unit number within controller; first unit is 0.

The user program supplies in location LOC a left-justified, SIXBIT disk name which may be one of the following:

.DCTDS	0	generic disk name
.DCTAB	1	subset of file structures because of file structure abbreviation
.DCTFS	2	file structure name
.DCTUF	3	unit within a file structure
.DCTCN	4	controller type
.DCTCC	5	controller
.DCTPU	6	physical disk unit name

or a logical name for one of the above assigned by the ASSIGN or MOUNT monitor command.

On a normal return, the monitor returns values in the following locations:

LOC	(.DCNAM)	The argument name.
LOC+1	(.DCUFT)	The number of blocks left of the logged in job quota before the UFD of the job is exhausted on the unit specified in LOC. If negative, the UFD is overdrawn. If the negative number is 400000 000000, the UFD has not been accessed since LOGIN; therefore, the monitor does not know the quota.
LOC+2	(.DCFCT)	The number of blocks on a first-come first-served basis left for all users in the file structure.
LOC+3	(.DCUNT)	The number of blocks left for all users on the specified unit.
LOC+4	(.DCSNM)	The file structure name to which this unit belongs.

LOC+5	(.DCUCH)	Characteristic sizes 1. Bits 0–8 are the number of blocks/cluster (DC.UCC). 2. Bits 9–17 are the number of blocks/track (DC.UCT). 3. Bits 18–35 are the number of blocks/cylinder (DC.UCY) (see Appendix F).
LOC+6	(.DCUSZ)	The number of 128-word blocks on the specified unit.
LOC+7	(.DCSMT)	The mount count for the file structure. The mount count is the number of jobs that have done a MOUNT command for this file structure without executing a DISMOUNT command; it is a use count.
LOC+10	(.DCWPS)	The number of words containing data bits per SAT block on this unit.
LOC+11	(.DCSPU)	Number of SAT blocks per unit.
LOC+12	(.DCK4S)	Number of K allocated for swapping.
LOC+13	(.DCSAJ)	Zero if none or more than one job has this file structure mounted. XWD –1, ,n if only job n has file structure mounted bit it is not single access. XWD 0, , n if job has file structure mounted and it is single access.
LOC+14	(.DCULN)	The unit's logical name (e.g., DSKB0).
LOC+15	(.DCUPN)	The unit's physical name (e.g., DPA0).
LOC+16	(.DCUID)	The unit's ID (e.g., 2RP003).
LOC+17	(.DCUFS)	The first logical block used for swapping on this unit.

6.2.9.14 DISK. AC, or CALLI AC, 121 – The DISK. UUO is a general-purpose call designed for setting and examining parameters of the disk and file systems. Its present function allows the user to assign a priority for disk operations (data transfers and head positionings) either for a user I/O channel or for his job (all I/O channels). Therefore, when a disk operation is initiated, the request with the highest priority is selected. If there is more than one request with the same priority, the one most satisfying disk optimization is chosen (refer to Chapter 8).

The range of permissible disk priorities is –3 to +3 with 0 being the normal timesharing priority. Thus, a job can request a lower than normal priority (e.g., when the job is a background job). The maximum priority (greater than 0) that the user is allowed to assign is set by bits 1 and 2 (JP.PRI) of the privilege word .GTPRV.

The call is:

```
        MOVE AC, [XWD function, ADR]
        DISK. AC,                        ;or CALLI AC, 121
        error return
        normal return
```

The error returns are:

0	UUO not implemented	
–1	DUILF%	Illegal function
–2	DUILP%	Illegal priority

The present function is:

Function	Name	Description
0	.DUPRI	Set the disk priority

ADR contains, in the right half, the desired priority (–3 to +3) and in the left half, one of the following:

LH (ADR) = n	Sets the priority for channel n (n is from 0 to 17)
LH (ADR) = –1	Sets the priority for all channels OPENed by the job.
LH (ADR) = –2	Sets the priority for the entire job.

When a priority is set for a channel, it overrides any priority set for the job and remains in effect until the channel is RELEASed. When set for the job, the priority remains in effect until reset by another DISK. UUO or the SET DSKPRI command (refer to DECsystem-10 Operating System Commands).

6.2.9.15 Simultaneous Supersede and Update – Files that may be simultaneously superseded or updated by several different users should be treated with care. The problem arises when one user has a copy of information to be superseded by another user. For example, file F contains a count of the number of occurrences of a certain event. The count is 10 at a given time. When two users observe separate instances of the event, each tries to increment the count.

Supersede – Incorrectly

```
        Job 1                   Job 2

LOOKUP A, F
                         LOOKUP C, F
READ COUNT (=10)         READ COUNT (=10)
ADD 1 (=11)              ADD 1 (=11)
                               .
                               .
ENTER B, F                     .
WRITE OUT (=11)          ENTER D, F           (Fail)
CLOSE B,                       .
                         ENTER D, F           (Succeed)
                         WRITE OUT (=11)
                         CLOSE D,
```

In this example, job 2 ignored job 1's increment.

Supersede – Correctly

Job 1	Job 2	
ENTER B, F		
LOOKUP A, F		
	ENTER D, F	(Fail)
INPUT A, (=10)		
ADD1 (=11)	.	
OUTPUT B, (=11)	.	
CLOSE B,	.	
	ENTER D, F	(Succeed)
	LOOKUP C, F	
	INPUT C, (=11)	
	ADD1 (=12)	
	OUTPUT D, (=12)	
	CLOSE D,	

In this example, both jobs performed the ENTER FIRST; therefore, incorrect copies were not made and the increment of each job was recorded properly.

The similar problem with an update can be avoided by never using the information returned by the LOOKUP:

Job 1	Job 2	
LOOKUP A, F		
INPUT A,	LOOKUP B, F	
	INPUT B,	
ENTER A, F		
OUTPUT	ENTER B, F	(Fail)
CLOSE	Here any information from the LOOKUP and INPUT must be discarded.	

6.2.10 File Status (Refer to Appendix D)

The file status of the disk is shown below:

Bit 18 = IO.IMP

1. INPUT UUP attempted on a read-protected file.
2. INPUT UUO when no LOOKUP was done (or super-USETI/USETO previously attempted by nonprivileged user)
3. OUTPUT UUO when no ENTER was done (or super-USETI/USETO previously attempted by nonprivileged user)
4. Software-detected checksum error
5. Software-detected redundancy error in SAT block or RIB, or

	6. Buffered mode I/O attempted after super-USETI/USETO.
	7. OUTPUT UUO attempted on a write-locked unit.
Bit 19 = IO.DER	Search error, power supply failure.
Bit 20 = IO.DTE	Disk or data channel parity error. Checksum failure on INPUT.
Bit 21 = IO.BKT	1. Quota is exhausted (past overdrawn)
	2. File structure is exhausted.
	3. RIB is full.
	4. Super-USETI/USETO block is too large for the file structure.
	5. More than 777777 blocks were read with one super--USETI/ USETO.
	6. Block number specified is too low for writing in a file that has an append protection code (4). The block number must be greater than the current highest block number of the file. Not set on a USETI or USETO.
	7. A super-USETI or USETO was issued by a non-privileged program.
Bit 22 = IO.EOF	EOF encountered on INPUT. No special character appears in the buffer.
Bit 23 = IO.ACT	Device is active.
Bit 29 = IO.WHD	Write disk pack headers

6.2.11 Disk Packs

A disk pack system combines disk and the DECtape features. Some packs (similar to individual DECtapes) are designed to be private, assignable, and removable. The other packs make up part or all of the public disk storage area where system programs and user files are stored. These disk packs belong to file structures in the storage pool and cannot be assigned to any single user. The system library and shared on-line storage are maintained, and swapping storage is assigned within the public disk pack area.

The only distinction between public and private packs is that private packs are intended to be removed from the system during regular operation. Public packs usually stay on-line all the time. However, the file structure format for public and private disk packs is identical.

User programs can exercise much greater control over private packs. For example, a program may attempt to position the arms of disk packs in anticipation of future I/O (refer to Paragraph 6.2.9.3). This capability is useful to a program that is aware of the contents of a disk and is able to use this information to optimize positioning. The program may also specify the position of files on the disk by using the allocate arguments of the extended LOOKUP, ENTER, and RENAME UUOs.

Private packs may be accessed by more than one job (multi-access) or restricted to only one job (single access). To access a private file structure, the user must type the MOUNT monitor command. If the private file structure is already mounted, on-line, and multi-access, the user receives an immediate response and may start using the private pack. When the user is finished using the private file structure, he should type the DISMOUNT monitor command. If no other job is using the file structure, a message is typed to the operator informing him that the drives belonging to the file structure are free.

6.2.11.1 Removable File Structures – All file structures are designed as if they could be removed from the system; therefore, disk packs are handled the same as other types of disks.

6.2.11.2 Identification – Disk packs have identifying information written on the home block, a block on every unit identifying the file structure to which the unit belongs and its position within the file structure. Part of this information is the pack ID, a one- to six-character SIXBIT name uniquely identifying the disk pack. The MOUNT and OMOUNT programs check that the operator has mounted the proper packs by comparing the pack ID in the home block with the information stored in the system administration file STRLST.SYS.

6.2.11.3 IBM Disk Pack Compatibility – The data format of IBM disk packs has variable-length sectors and no sector headers. DEC format has fixed-length sectors (128 words) and specially written sector headers. Latency optimization is employed to improve system throughput (refer to Paragraph 8.3). DEC's significantly simpler hardware controller is used without reducing user capabilities.

To transfer data from an IBM pack system to a DECpack system, a simple program in a higher-level language should be written for both machines. The program then reads the IBM disk pack on the IBM computer and writes the files onto magnetic tape. The magnetic tape is then transferred to a DEC computer and read by another program, which writes the files onto the DEC RP01, RP02, or RP03 packs.

6.3 SPOOLING OF UNIT RECORD I/O ON DISK

Devices capable of spooling (card reader, line printer, card punch, paper-tape punch, and plotter) have an associated bit in the job's .GTSPL word (refer to Paragraph 3.6.3.4.10). If this bit is on when the device is ASSIGNed or INITed, the device is said to be in spool mode. While in this mode, all I/O for this device is intercepted and written onto the disk rather than onto the device. System spooling programs later do the actual I/O transfer to the device.

Spooling allows more efficient use of the device because users cannot tie it up indefinitely. In addition, since the spooling devices are generally slow and the jobs that are to be spooled are usually large, the jobs do not spend unnecessary time in core.

6.3.1 Input Spooling

If a LOOKUP is given after the INIT of the card reader, it is ignored and an automatic LOOKUP is done on the first INPUT, using the filename given in the last SET CDR command and the filename extension of .CDR. (This action is also taken if no LOOKUP is given.) If the automatic LOOKUP fails, the INPUT returns with bit 21 (IO.BKT) and bit 22 (IO.EOF) on. After every automatic LOOKUP, the name in the input-name counter .GTSPL (refer to Paragraph 3.6.3.4.10) is incremented so that the next automatic LOOKUP will use the next filename in order.

The ordering of the input names in .GTSPL is as follows:

QAA, . . . , QAZ, QBA, . . . , QBZ, . . . RAA, . . . , RAZ, . . . ZZZ

The next name after ZZZ begins with the SIXBIT character after Z (i.e., [AA]).

6.3.2 Output Spooling

If an ENTER is done, the filename specified is stored in the RIB in location .RBSPL so that the output spooler can label the output. Therefore, programs should specify a filename, if possible.

If an ENTER is not done, an automatic ENTER is given, using a filename in the general form

xxxyyy.zzz

where xxx is a 3-character name manufactured by the monitor to make the 9-character name unique.

yyy is

1. an appropriate station number Snn if a generic device name is INITed, or
2. a unit number if a specific unit is INITed.

zzz is the generic name of the device-type (LPT, CDP, PTP, or PLT).

Output spooling should not concern the user because all requests are queued when the user logs off the system. The files are moved to the output queues before the logged-out quota is computed.

CHAPTER 7 INTER-PROCESS COMMUNICATION FACILITY

7.1 INTER-PROCESS COMMUNICATION FACILITY (IPCF)

The Inter-Process Communication Facility (IPCF), a feature of the DECsystem-10 Monitor (5.07 and later), provides a capability for communication between jobs running on the system. This communication is accomplished by the use of three UUO's: IPCFS., IPCFR., and IPCFQ. (Refer to Paragraphs 7.1.6, 7.1.7, and 7.1.8 for complete descriptions of these UUO's.)

Jobs communicate by sending "packets" of information (using the IPCFS. UUO) that contain a destination and a return address, some flags, and data. The receiver of a packet can find out if a packet has been sent (IPCFQ.) and retrieve it (IPCFR.).

Each job sending a packet declares a symbolic name and acquires a Process ID (PID). (The name/PID relationship is similar to that of the assembly language label/address relationship.) A PID is a concise, unique identifier for the sender and receiver and is associated with both the symbolic name and the job number. The job acquires this PID through the [SYSTEM] INFO facility of IPCF which may be used to find out other information: names associated with other PID's, PID's for other names, etc.

When receiving a packet, a job will have a "mailbox" in the form of a short linear FIFO queue. Packets from a sender (or senders) are put in this queue and remain until the receiving job retrieves them. Many applications require a more complex queueing structure; this can be built within the receiver's program.

A typical example of the use of IPCF might be a program running a special I/O device such as a photo-composition machine. The program takes disk files as input, performs some character manipulation and produces output on the photo-composition machine. The program runs continuously and whenever it finishes with one disk file, it waits until another is provided. In this example, any job in the system could, using IPCF, send the names of files to be output and any instruction. Return messages might indicate the length of time required to output the requested file, report completion of the task or list accounting charges.

More complex communication is possible using IPCF, but the example described is indicative of the process. IPCF will most likely be used for communication between user jobs and special system jobs, but is available for general use.

Note that IPCF is not directly accessible at the monitor command level and has no connection with the SEND command.

Additional information on the basic concepts of inter-process communication is contained in Process Communication Pre-Requisites or the IPC Set-Up Revisited, M.J. Spier, Proceedings of the 1973 Sagamore Computer Conference on Parallel Processing, pp. 79–88.

A sample program illustrating the use of IPCF is shown in Paragraph 7.1.10.

7.1.1 Packets

A packet consists of 36-bit words that are passed between jobs in order to accomplish an IPCF communication. A packet contains a four-word descriptor block (containing flags, the sender's PID, the receiver's PID, the length of the packet and a pointer to the start of the data portion of the packet) and data (a message). Figure 7-1 shows a sample layout of a packet.

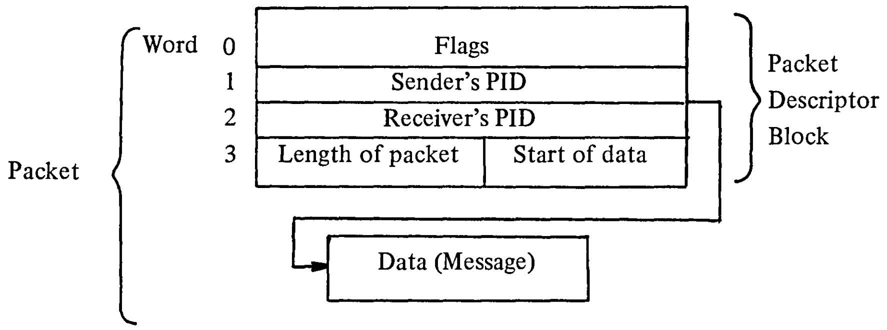


Figure 7-1 Sample Layout of a Packet

On systems with the virtual memory option (6.01 monitor and later), the message portion of a packet can consist of either words or one page. (A page contains 512 decimal or 1000 octal words.)

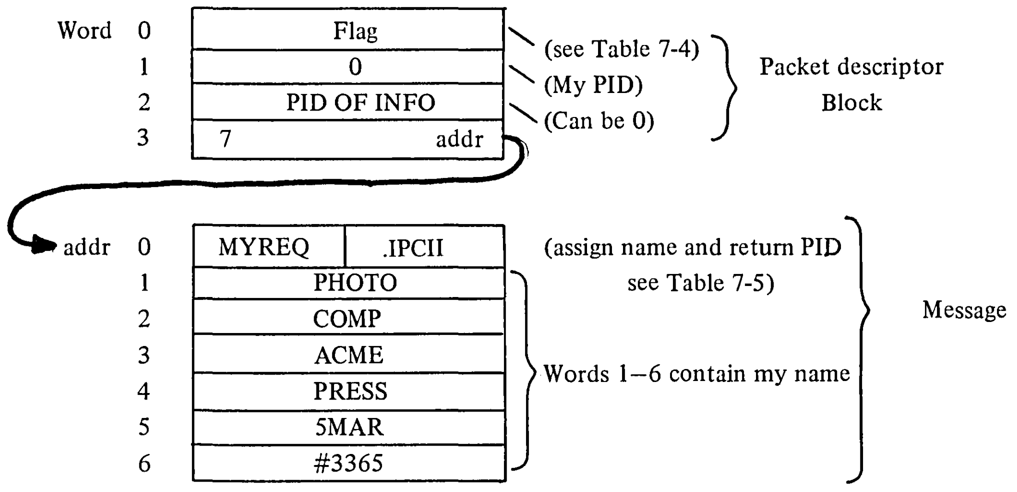
The maximum length of the message portion of a non-page packet may be found by referring to the %IPCML (.GTIPC 0, , 77) entry of the GETTAB UUO table. (Typically, the maximum length is set to approximately 12 words in order to limit monitor storage.) If large amounts of data are to be sent, the message portion of the packet may be used as a pointer to a file containing the data.

7.1.2 Process ID (PID)

A PID is a 36-bit value that substitutes for a user-declared symbolic name. The PID serves as a destination or source address for a packet and remains assigned to the name as long as the user wishes to use that name. The association between a PID and a name is always released when the job logs off the system or through a request to [SYSTEM] INFO. Alternatively, the job may request that the association be freed when a RESET UUO is executed. After a PID is released, the same value is not re-used. This protects against any messages being sent to the wrong job by accident.

The user acquires a PID by declaring a name (i.e., by notifying [SYSTEM] INFO of this name) and requesting that a PID be assigned to the name. The name cannot duplicate other names in use at the same installation and has certain restrictions. (See Paragraph 7.1.9 for details.) Figure 7-2 shows a sample request to INFO to get a PID.

When using the page mode option (virtual memory monitors), ADDR will be a page number (1–511). In most uses of IPCF, the PID and job number may be used interchangeably, but this is not recommended. The fact that the PID is unique ensures the validity of the source and destination addresses of the packet. For instance, if the job number is used instead of a PID and the intended receiver has logged out, the job that receives the packet may not be the intended receiver.



Currently, each PID has only one name associated with it, but each job may have several PID's. Jobs with the special IPCF privilege can assign PID's; ordinary jobs can get a PID only through requests to [SYSTEM]INFO.

If the job sends a packet and specifies the sender's PID as 0, it indicates the sender is the originator of the request. If the sender's PID is associated with another job, a duplicate of any answer will be sent to the PID specified.

7.1.3 Queue

The monitor keeps a linear queue (the "mailbox") for each job using IPCF. The queue holds a packet (or packets) until the job is ready to retrieve the packet. The queue is not created until another job sends an IPCF packet to the job and does not occupy any space until that time.

The maximum number of packets allowed in a queue at any one time is determined by a "receive" quota that may be set at each installation for each user. (If no quota is set by the installation, the standard default is five.)

The receiver should always endeavor to empty his queue promptly to avoid losing (because of a full queue) packets sent to him. In addition, each outstanding packet occupies monitor space which may become exhausted even if the receive quota is not exceeded.

7.1.4 [SYSTEM]INFO

The [SYSTEM]INFO facility acts as a central information utility for IPCF and performs several functions connected with names and PID's. [SYSTEM]INFO will, on request, assign a PID, find a name associated with a PID, assign a name, or drop PID's associated with names.

The IPCFS. UUO is used to send a packet to INFO with the message portion of the packet containing the request. This request must be in the format shown in Table 7-1.

The PID of [SYSTEM]INFO may be obtained by sending a request to the IPCF Controller [SYSTEM]IPCC. (See Paragraph 7.1.5 for a complete description of IPCC.) It is usually not necessary to determine INFO's PID since a destination PID of zero implies INFO is the destination.

Table 7-1
[SYSTEM] INFO Request Format
(Message Portion of Packet)

Offset	Content
0	CODE, ,FUNCTION
1	PID of job to receive duplicate copy of response (or 0)
2-7	FUNCTION Argument

CODE	A user-declared quantity that will enable the user to associate an answer with a request. If no answer is expected, it is not necessary to use a CODE and the CODE field should contain a zero.
FUNCTION	One of seven operations that a user may request [SYSTEM] INFO to perform.

FUNCTION and FUNCTION argument are shown in Table 7-3.

Any answer from [SYSTEM] INFO will be in the form of a packet sent to the requester with the message portion of the packet in the same format as the request. The following shows the response format:

Offset	Content
0	CODE, ,FUNCTION (copied from the request)
1	Response

7.1.5 IPCF Controller ([SYSTEM] IPCC)

The IPCF Controller ([SYSTEM] IPCC) supports a number of functions and will, on request, enable (or disable) a job for receiving packets, give the PID of [SYSTEM] INFO, create a [SYSTEM] INFO, destroy a PID, create a PID or set a send/receive quota for a job. Table 7-4 shows all of the [SYSTEM] IPCC functions.

To send a request to [SYSTEM] IPCC, a packet is sent (using the IPCFS. UUO) with the message portion of the packet in the format as shown below.

Offset	Content
0	CODE, ,FUNCTION
1-n	FUNCTION argument

CODE	A user-declared quantity that will enable the user to associate an answer with a request. If no answer is expected, it is not necessary to use a CODE and the CODE field should contain a zero.
FUNCTION	One of several operations that a user may request [SYSTEM] IPCC to perform.

FUNCTION and FUNCTION argument are shown in Table 7-4.

The PID of IPCC is obtained by referring to the %IPCCP (.GTIPC 5 , , 77) entry of the GETTAB table.

The request to IPCC should be long enough for any reply to fit into the same space. (The maximum length of a request to IPCC is defined at monitor generation time.) The format of the reply from [SYSTEM]IPCC is shown below.

Offset	Content
0	CODE, ,FUNCTION (copied from the request)
1-n	Response

7.1.6 IPCFS. UUO or CALLI AC, 143

The IPCFS. UUO is used to send an IPCF packet. Each packet has a four-word descriptor block in the following format:

Offset	Name	Meaning
0	.IPCFL	Flags (See Table 7-2)
1	.IPCFS	Sender's PID
2	.IPCFR	PID of intended receiver
3	.IPCFP	Message length, ,address of message

.IPCFS may be a PID, a job number or zero.

.IPCFR may be a PID, a job number or may be zero if the intended receiver is [SYSTEM]INFO.

When the appropriate "indirect bits" are set in word 0, .IPCFS and .IPCFR contain the address of the location where the PID is to be found, rather than the PID itself.

On systems with the virtual memory option, an IPCF user may specify "page mode" by setting a flag in word 0 of the packet descriptor block. If this flag is set (Bit 19, IP.CFV), the message length (.IPCFP) should always be specified as octal 1000 and the address of the message should be a page number (1–511).

If there is room in the receiver's queue, for a packet being sent, it is put in the queue. If there is no room, the UUO will take the error return (not block). Even when the UUO gives the successful return, there is no guarantee that the message has been received, and the sender should always code to be able to handle a return packet indicating that the packet that was sent was not delivered. This non-delivery message might be generated if the receiver dropped his PID or logged out before the packet was received. Non-delivery is indicated (on a return message) if the IP.CFM field in word 0 of the packet descriptor block is set to 1.

The form of an IPCFS. call is:

```
MOVE AC, [XWD N,LOC]
IPCFS. AC,                              ;or CALLI AC, 143
error return
normal return
```

N is the number of words in the packet descriptor block at LOC (must be four)
LOC is the location (word address) of the packet descriptor block

On an error return, an error code will be either in the AC or in the flag field (bits 24–29, IP.CFE) of the packet descriptor block. (See Table 7-8 for a list of error codes.)

Using the page mode option (a page is sent), the page is removed from the user's addressing space and if an attempt is made to reference it afterwards, an illegal memory reference (page fault) error will result.

Example:

```
            MOVE     T1,[4,,LOC]        ;LOAD SIZE,,ADR OF DESC, BLOCK
            IPCFS.   T1,                ;SEND THE MESSAGE
              POPJ   P,                 ;ERROR-RETURN WITH CODE IN T1
            JRST     .POPJ1##           ;GOOD RETURN
                .
                .
                .
    LOC:    IP.CFR           ;INDIRECT RECEIVER
            0                ;SEND FROM US
            PIDHIM           ;TO PID IN PIDHIM
            ^D8,,MSG         ;SEND 8 WORDS AT MSG
```

7.1.7 IPCFR. UUO or CALLI AC, 142

The IPCFR. UUO is used to receive an IPCF packet. Each packet has a four-word descriptor block in the followint format:

Offset	Name	Meaning
0	.IPCFL	Flags (see Table 7-2)
1	.IPCFS	Sender's PID
2	.IPCFR	Receiver's PID (filled in by sender)
3	.IPCFP	Message length, ,address

.IPCFS will be a PID or job number.

.IPCFR will be a PID or job number.

.IPCFP specifies the length and location of a block of core (or a page number) in which to receive the packet from the input queue.

The format of the call is:

```
MOVE AC, [XWD N, LOC]
IPCFR. AC,                    ; or CALLI, 142
error return
normal return
```

N is the number of words in the packet descriptor block at LOC (must be four)

LOC is the location of the packet descriptor block.

On systems with the virtual memory option, an IPCF user may specify "page mode" by setting a flag in word 0 of the packet descriptor block. If this flag is set (bit 19, IP.CFV), the message length (.IPCFP) should always be specified as octal 1000 and the address should be a page number (1–511). If the packet to be received is in page mode, and the packet descriptor block of IPCFR. UUO doesn't have bit 19 set, doesn't specify the length as 1000 or doesn't specify a page number for the address, an error will result. When a page is received, it is put in the user's addressing space and then may be referenced.

The user should "reserve" pages in his addressing space to receive packets. (Refer to the PAGE UUO for information on creating and deleting a page in the address space.)

The user also specifies in his call whether or not to block if no packet is in the input queue (bit 0, IP.CFB in word 0 of the packet descriptor block). If the process blocks, then it is placed in the monitor's SLEEP queue with a HIBER-style wakeup condition of IPCF.

Any job can send any message to any other job. Therefore, it is important that the receiver be able to discard "junk mail". In examining for "junk mail", the user can

1. use the IPCFQ. UUO to check the sender (to see if he wants to receive "mail" from that sender)
2. use the IPCFQ. UUO to check the length of the packet (to see if he wants a packet of that length)
3. check the message and if not interested, simply ignore the message (or any request).

If the packet is too big to receive and bit 4 of word 0 (IP.TTL) is set, as much of the packet as will fit in the space specified will be received and the rest of the packet will be lost. If the IPCFR. UUO is issued, the block specified to receive the packet is not long enough and IP.TTL is not set, the packet will remain in the queue and the error return will be taken. A simple method for discarding an unwanted packet is to set IP.TTL and specify a length of zero.

On a successful return, the AC will contain an "associated variable" (LH= length is words, RH=flags from packet descriptor block) for the following entry (the top packet) in the queue. If the queue is now empty the associated variable will be zero. (This associated variable is the same as that of the IPCF interrupt and should be used to update the IPCF receive status.)

Any job that is disabled for receiving packets may still receive any packets already in the queue but will appear to be disabled to any user attempting to send.

7.1.8 IPCFQ. UUO or CALLI AC, 144

The IPCFQ. UUO is used to "query" the status of the input queue and returns information in the packet descriptor block about the next packet in the queue.

The format of the packet descriptor block is:

Offset	Name	Meaning
0	.IPCFL	Flags for top packet in queue (see Table 7-2)
1	.IPCFS	Sender's PID
2	.IPCFR	Receiver's PID
3	.IPCFP	Length of top packet, ,length of queue

The format of the call is:

```
        MOVE AC, [XWD N,LOC]
        IPCFQ. AC,                      ; or CALLI AC, 144
        error return
        normal return
```

N is the number of words in the packet descriptor block (must be four)

LOC is the location of the packet descriptor block.

Error returns are shown in Table 7-4.

IPCFQ. never blocks but only reads out the status of the caller's receive queue.

7.1.9 USING IPCF

The following flow chart shows the general process of sending and receiving a packet.

The user should keep in mind that there are two levels in the send/receive transaction: the UUO level and the message level. The UUO level invokes setting up the UUO call with the correct packet descriptor block. For instance, if the user specifies "page mode" in word 0 of the flag field, the "start of data" in the right half of word 3 should be a page number. The message level involves a special format only if the request is to [SYSTEM] INFO. For instance, the function must be inserted according to Tables 7-3 and 7-4 and the proper format for the name sent to INFO must be followed.

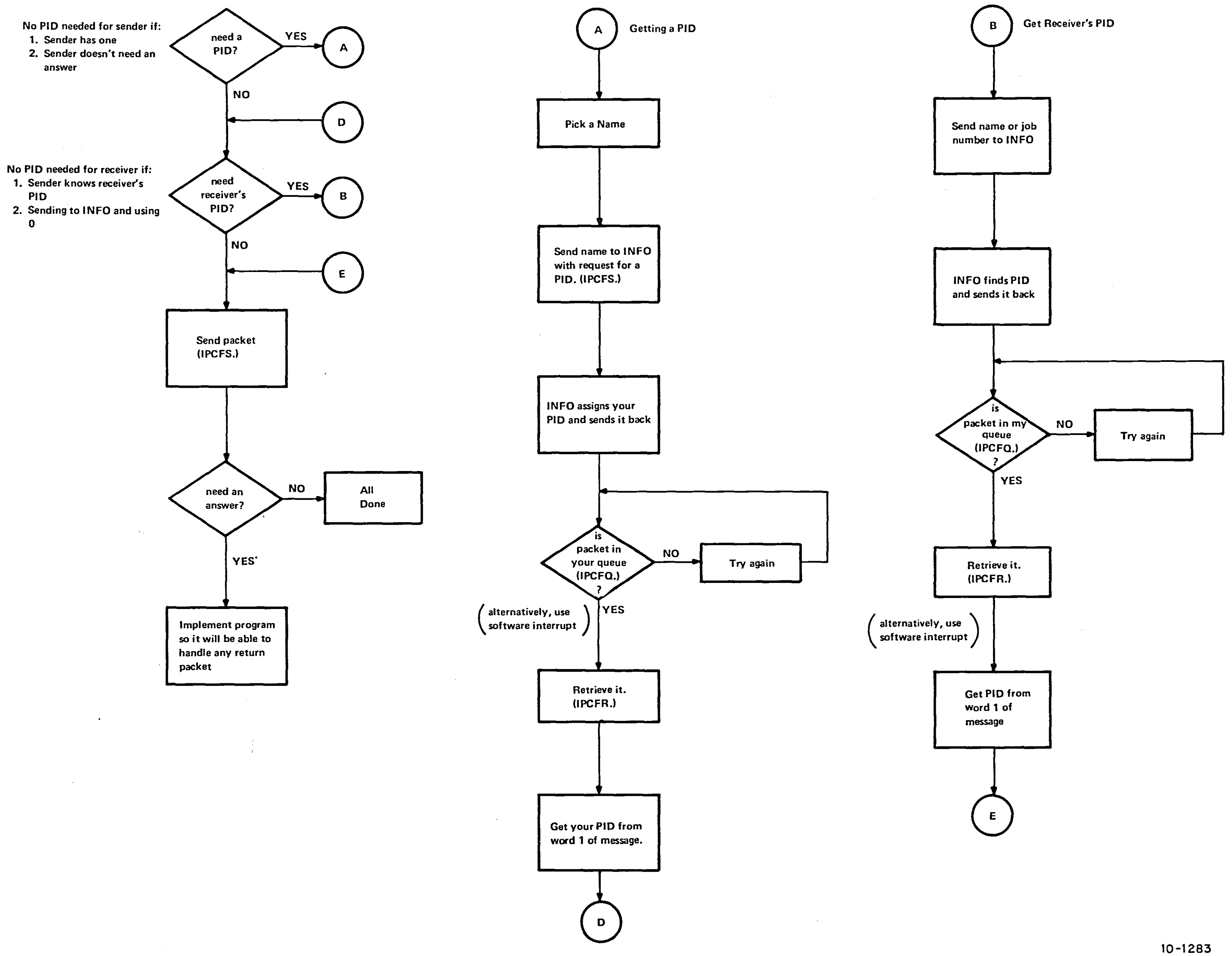
There are also two levels of PID quotas. The monitor keeps a PID table of all PID's currently in use. [SYSTEM] INFO keeps a list of the PID's currently assigned to each user and the PID quota. (Currently, each job's quota of PID's is 2). The user who does not expect to receive an answer from his request is not required to have a PID.

The send and receive quotas may be set (by the system administrator) for all users at an installation or for certain users (using the .IPCSQ function in a request to IPCC). The send quota for a job may be set at zero or "unlimited".

If the IPCF user is enabled for receiving a software interrupt, he will receive an interrupt when a packet is put into his receive queue. (For more information on the Software Interrupt System, refer to Paragraph 3.1.3). If the IPCF user is not enabled to receive a software interrupt, he must check (every few milliseconds) to see if the packet has been put into the queue.

It is possible to give any job the privileges normally associated with [SYSTEM] INFO. This would usually be done to create a private network controller such as a transaction processing control program. Privileges are invoked by programs setting the privilege bit (bit 18 of word 0 of the packet descriptor block, IP.CFP). A privileged job may create or drop a PID.

[SYSTEM] INFO may be set up as a public or private INFO. All users on a system would have access to the public INFO but only certain jobs would have access to the private INFO. If a request is made to IPCC for the PID of INFO, the job will get the PID of the INFO it has access to. If using the private INFO, zero is the default PID and a privileged job can find out the PID of the public INFO (and use it) by referring to the %IPCSI (.GTIPC 1 , , 77) with the GETTAB UUO.



No PID needed for sender if:
1. Sender has one
2. Sender doesn't need an answer
need a PID?
YES
A
NO
D
No PID needed for receiver if:
1. Sender knows receiver's PID
2. Sending to INFO and using 0
need receiver's PID?
YES
B
NO
E
Send packet (IPCFS.)
need an answer?
NO
All Done
YES*
Implement program so it will be able to handle any return packet
A
Getting a PID
Pick a Name
Send name to INFO with request for a PID. (IPCFS.)
INFO assigns your PID and sends it back
is packet in your queue (IPCFQ.) ?
NO
Try again
YES
alternatively, use software interrupt
Retrieve it. (IPCFR.)
Get your PID from word 1 of message.
D
B
Get Receiver's PID
Send name or job number to INFO
INFO finds PID and sends it back
is packet in my queue (IPCFQ.) ?
NO
Try again
YES
Retrieve it. (IPCFR.)
alternatively, use software interrupt
Get PID from word 1 of message
E

10-1283

Table 7-2
Packet Descriptor Block Flags

Bit	Name	Meaning	Related UUO
0	IP.CFB	Don't block	IPCFR.
1	IP.CFS	Indirect sender's PID	IPCFS.
2	IP.CFR	Indirect receiver's PID	IPCFS.
3	IP.CFO	Allows one "send" above quota	IPCFS.
4-17	Reserved for future use (must be zero).		
18	IP.CFP	Request is privileged(*)	IPCFS.
19	IP.CFV	Page mode – indicates the message is a page. For a receiver, this bit must be set for the top packet in the queue if it is in page mode. An error is returned on a receive if this bit is not set to correspond to the top message in the queue.	
20-23	Reserved for future use. (Must be 0)		
24-29	IP.CFE	Error code field. See Table 7-5 for a list of error codes.	IPCFR. IPCFQ. IPCFS.
30-32	IP.CFC	System and sender code. (Privileged) .IPCCC 1 = Send by IPCC .IPCCF 2 = Sent by public INFO .IPCCP 3 = Sent by private INFO	IPCFR. IPCFS. IPCFQ.
33-35	IP.CFM	Special message return. (Privileged) .IPCFN If = 1, packet not delivered. If = 0, normal delivery. If the packet is undeliverable, the packet is sent back to the sender with this field set to 1.	IPCFR. IPCFS. IPCFQ.

Table 7-3 describes the functions for a request to [SYSTEM] INFO. Unless specifically stated, the PID and job number can be used interchangeably. If the request sent to [SYSTEM] INFO is for action to be performed for another job, the requester must be privileged and any answer will be sent to the affected job.

All requests to INFO contain in word 1 the PID (or job number) to receive a duplicate copy of a successful answer. If word 1 = 0, the answer is sent only to the sender of the request.

(*)The monitor will allow the sender/receiver to set this bit only if the job has the IPCF privilege. This bit indicates that the associated packet has a privileged request. If the receiver sets this bit (and has the IPCF privilege) then IPCFR. and IPCFQ. will return the setting of the bit in any reply. If not set, then the bit will be zero when the packet is copied to the user's queue. If the job is not privileged and this bit is set, an error is returned.

The symbolic name is limited to 30 characters and cannot contain any control characters except TAB (octal code 11). In order to initiate communication between jobs, there should be a mutual understanding between the two jobs of the symbolic names to be used. This frees the communications procedure from any dependencies on system characteristics (such as job numbers) that might change between executions.

Examples:

```
[SYSTEM]PHOTOCOMP
FILEPROCESSOR[10,1521]
PHOTOCOMP[SYSTEM]
TEST PROGRAM['ANY',151]
```

In order to prevent a malicious or careless user from assigning a name that you want, a small restriction is placed on the kinds of names that may appear within square brackets. The only things that may appear are:

```
[PROJ.#, PROG.#]
['ANY', PROG.#]
['ANY', 'ANY']
[PROJ.#, 'ANY']
[SYSTEM]
```

where PROJ.# and PROG.# must be the numbers under which the job is currently running.

A job may specify [SYSTEM] as part of the name only if the job is privileged (the JACCT bit is set), is running under [1,2] or has the IPCF privileges. When trying to find the PID of a name, the name must be specified exactly as it appears, character for character.

Table 7-3
[SYSTEM]INFO Functions

Function	Name	Description	Function Argument
1	.IPCIW	Find PID for the name contained in the the function argument	ASCIZ of name
2	.IPCIG	Find name for the PID contained in the function argument	PID
3	.IPCII	Assign the name contained in the function argument to the job number making this request. (This name is dropped when a RESET UUO is done by the job.)	ASCIZ of name
4	.IPCIJ	Assign the name contained in the function argument to the job number making this request. (This name is dropped on LOGOUT.)	ASCIZ of name
5	.IPCID**	Drop the PID contained in the function argument.	PID or job number
6	.IPCIR**	Drop all PID's that were created (by .IPCII) for the job number in the function argument.	Job number

Table 7-3 (Cont)
[SYSTEM]INFO Functions

Function	Name	Description	Function Argument
7	.IPCLQ	Drop all PID's associated with the job number contained in function argument.	Job number
10-14	Reserved for future use.		
15	.IPCIS	Sent by IPCC. If word 0 = 0, ,15 a RESET was done by this job If word 0 = −1, ,15 a LOGOUT was done by this job	

**This is a privileged function.

NOTE
When sending a packet to INFO, a 0 can be specified as the receiver's PID. Functions 5, 6 and 7 are privileged unless the requester is the "owner" of the job.

Table 7-4 describes the functions for a request to [SYSTEM]IPCC. Unless specified otherwise, the job number and PID may be used interchangeably.

The user is normally enabled to received packets when the job is logged in or after sending a packet to IPCC.

All requests to IPCC contain in word 1 the PID (or job number) to receive a duplicate copy of a successful answer. If word 1 = 0, the answer is sent only to the sender of the request.

Table 7-4
IPCC Functions

Function	Name	Description	Function Argument
1	.IPCSE	Enable user's ability to receive packets.	PID of job to be enabled
2	.IPCSD	Disable user's ability to receive packets.	PID of job to be disabled
3	.IPCSI	Asks for the PID of [SYSTEM]INFO	Word 1: PID of job. Word 2: PID of [SYSTEM]INFO returned by IPCC.
4	.IPCSF	Create a [SYSTEM]INFO. (Privileged)	Word 1: PID of job to set it for. Word 2: PID given to INFO-returned to requester
5	.IPCSG	Destroy a PID (Privileged)	Word 1: PID to be destroyed
6	.IPCSC	Create a PID (Privileged)	Word 1: Bit 0 = 0 permanent PID = 1 delete on RESET Remainder of word 1 contains job number to be associated with the PID created. Word 2: PID created (answer)

Table 7-4 (Cont)
IPCC Functions

Function	Name	Description	Function Argument
7	.IPCSQ	Set send and receive quota (Privileged)	Word 1: PID of job to set it for [illegible] Word 2: LH = 0 (reserved) RH = quota bits 18–26 = send quota bits 27–35 = receive quota
10	.IPCSO	Change the job number associated with a PID (*) (Privileged)	Word 1: PID Word 2: new job number
11	.IPCSJ	Find the job number of a PID	Word 1: PID Word 2: answer (job number)
12	.IPCSP	Find one or more PID's of a job number.	Word 1: job number (cannot be PID) Word 2: PID ('s) with a zero at the end of the list
13	.IPCSR	Find send and receive quota of a job number.	Word 1: job number Word 2: answer (same form as function 7)
14	.IPCSW	Unblock a job from RESET. (Sent to IPCC by INFO)**	job number

15	.IPCSS	Indicates to INFO whether a job was RESET or logged out.	Word 1: RH = job number
			LH = 0 indicates RESET
			LH = 1 indicates logged out

(*)This function may be useful in systems work in the case where two system processes perform the same function. Using .IPCSO would allow one of them to be "turned off".

(**)This is a privileged function.

Table 7-5
Error Codes

Value	Where Returned	Mnemonic	Reason
1	AC	IPCAC%	Address Check
2	AC	IPCNL%	Length of packet descriptor block not specified as 4
3	AC	IPCNP%	No packet in receive queue
4	Reserved		
5	AC	IPCTL%	Data too long for user's buffer. (Not enough room specified in an IPCFR. UUO.)

Table 7-5 (Cont)
Error Codes

Value	Where Returned	Mnemonic	Reason
6	AC or IP.CFE	IPCDU%	Destination unknown. (Receiver's PID is invalid.)
7	AC	IPCDD%	Destination disabled.
10	AC	IPCRS%	No room in sender's quota. (May use IP.CFO)
11	AC	IPCRR%	No room in receiver's quota. (Queue is filled.)
12	AC	IPCRY%	No room in system for packet.
13	AC	IPCUP%	Unknown page on send. Duplicate page on receive.
14	AC or IP.CFE	IPCIS%	Sender's invalid PID.
15	AC or IP.CFE	IPCPI%	Privilege insufficient.
16	IP.CFE	IPCUF%	Unknown function.
17	IP.CFE	IPCBJ%	Bad job number.
20	IP.CFE	IPCPF%	PID table full.
21	AC	IPCPR%	Page requested, page not in top of queue.
22	AC	IPCIE%	Paging I/O error.
70	AC	IPCCU%	[SYSTEM] INFO has an unknown, internal error.
71	IP.CFE	IPCCF%	[SYSTEM] IPCC request failed.
72	IP.CFE	IPCFF%	[SYSTEM] INFO failed to complete a request to assign a PID or name.
73	IP.CFE	IPCBP%	PID quota exceeded.
74	IP.CFE	IPCBP%	Unknown PID*.
75	IP.CFE	IPCDN%	Duplicate name.
76	IP.CFE	IPCNN%	Unknown name.
77	IP.CFE	IPCEN%	Name has illegal characters. (Square brackets not used properly.)

*If [SYSTEM] INFO should crash and restart, all existing PID's will be lost.

7.1.10 IPCF Example

```
;EXAMPLE INITIALIZATION OF ANY IPCF USER
;CALLED WITH A BLOCK OF SIX WORDS FROM NAME

;       CONTAINING AN ASCIZ STRING TO BE
;       SIGNED OUT BY THIS PROCESS
;       IF ERROR, NON-SKIP WITH T1=ERROR CODE
;       SKIP RETURN IF SUCCESSFUL

IPCINI: PUSHJ   P,.SAVE4##      ;PRESERVE P1-4
        MOVEI   T1,.IPCII       ;SIGN OUT UNTIL RESET
        MOVEM   T1,NAME-2       ;SAVE AS FUNCTION
        SETZM   NAME-1          ;CLEAR WHO WANTS ANSWER
        MOVE    T1,[ 4,,[ 0             ;NOFLAGS
                          0             ;SEND FROM US
                          0             ;SEND TO [SYSTEM]INFO
                          ^D8,,NAME-2]] ;POINT TO ARGUMENT
        IPCFS.  T1,             ;SEND REQUEST
          POPJ  P,              ;ERROR, GIVE UP WITH CODE IN T1

;NOW BLOCK AND WAIT FOR AN ANSWER
;NOTE, THAT JUNK MUST BE DISCARDED

INILP2: MOVE    T1,[4,,P1]      ;POINT TO ARGUMENT BLOCK
        MOVEI   P1,0            ;
        MOVEI   P1,0            ;CLEAR FLAGS
        SETZB   P2,P3           ;ZERO ARG BLOCK
        MOVE    P4,[^D8,,DBLK]  ;POINT TO DATA
        IPCFR.  T1,             ;RECEIVE
          POPJ  P,              ;GIVE UP IF FAIL RETURNING ERROR IN T1
        MOVE    T1,DBLK         ;GET FUNCTION CODE
        LDB     T2,[POINT 3,P1,32]  ;GET SENDER'S CODE
        CAIE    T2,.IPCCF       ;SEE IF FROM SYSTEM [SYSTEM]INFO
        CAIN    T2,.IPCCP       ; OR IF FROM LOCAL [SYSTEM]INFO
        CAIE    T1,.IPCII       ;YES--SEE IF INFO NAME MATCH
        JRST    INILP2          ;NO--TRY AGAIN
        LDB     T1,[POINT 6,P1,29]  ;GET MESSAGE ERROR CODE
        JUMPN   T1,.POPJ##      ;ERROR IF SET, RETURN TO CALLER IN T1
        MOVE    T1,DBLK+1       ;GET PID ASSIGNED
        MOVEM   T1,PIDUS        ;SAVE FOR TRANSACTIONS
        JRST    .POPJ1##        ;GIVE OK RETURN

;ROUTINE TO IDENTIFY A RECEIVER
;CALLED WITH NAME OF RECEIVER IN SIX WORDS
;       FROM NAME IN ASCIZ
;       NON-SKIPS IF ERROR WITH CODE IN T1
;               .GT.0 IS IPCSER ERROR CODE
;               -1 IF RECEIVER UNKNOWN
;SKIP RETURNS WITH PID IN PIDHIM
```

```
IDRCVR: PUSHJ   P,.SAVE4##         ;PRESERVE P1-4
        MOVEI   T1,.IPCIW          ;ASK WHO IS
        MOVEM   T1,NAME-2          ;SAVE AS FUNCTION
        SETZM   NAME-1             ;CLEAR WHO WANTS ANSWER
        MOVE              T1,[ 4,,[ 0     ;INDIRECT RECEIVER
                          0               ;SEND FROM US
                          0               ;SEND TO [SYSTEM]INFO
                          ^D8,,NAME-2]] ;POINT TO ARGUMENT
        IPCFS.  T1,                ;SEND REQUEST

IDRLP2: MOVE    T1,[4,,P1]         ;POINT TO ARGUMENT BLOCK
        MOVEI   P1,0               ;CLEAR FLAGS
        SETZB   P2,P3              ;ZERO ARG BLOCK
        MOVE    P4,[^D8,,DBLK]     ;POINT TO DATA
        IPCFR.  T1,                ;RECEIVE
          POPJ  P,                 ;FIVE UP IF FAIL WITH ERROR IN T1
        MOVE    T1,DBLK            ;GET FUNCTION CODE
        LDB     T2,[POINT 3,P1,32]  ;GET SENDER'S CODE
        CAIE    T2,.IPCCF          ;SEE IF FROM SYSTEM [SYSTEM]INFO
        CAIN    T2,.IPCCP          ; OR IF FROM LOCAL [SYSTEM]INFO
        CAIE    T1,.IPCIW          ;SEE IF INFO NAME MATCH
        JRST    IDRLP2             ;NO--TRY AGAIN
        LDB     T1,[POINT 6,P1,29]  ;ISOLATE ERROR CODE
        JUMPN   T1,.POPJ##         ;IF SET, ERROR--RETURN IN T1
        SKIPN   T1,DBLK+1          ;GET PID ASSIGNED
        GVERR$  -1                 ;IF NOT SET, ERROR
        MOVEM   T1,PIDHIM          ;SAVE FOR TRANSACTIONS
        JUST    .POPJ1##           ;GIVE OK RETURN

;ROUTINE TO SEND A MESSAGE OF 8 WORDS IN MSG
;IT IS SENT TO THE PID IN PIDHIM
;NON-SKIP ON ERROR WITH CODE IN T1
;SKIP IF OK

SNDMSG: MOVE    T1,[ 4,,[ IP.CFR         ;INDIRECT RECEIVER
                          0               ;SEND FROM US
                          PIDHIM          ;SEND TO HIM
                          ^D8,,MSB]]      ;POINT TO DATA
        IPCFS.  T1,                ;SEND
          POPJ  P,                 ;ERROR--RETURN WITH CODE IN T1
        JRST    .POPJ1##           ;GOOD

;ROUTINE TO BLOCK UNTIL A MESSAGE IS RECEIVED
;IT CAN HANDLE UP TO 8 WORDS, STORED IN MSG
;NON-SKIP RETURNS IF ERROR WITH ERROR IN T1
;SKIPS WITH T1=LENGTH AND WITH SENDER IN PIDHIM

RCVMSG: PUSHJ   P,.SAVE4##         ;PRESERVE P1-4
        MOVE    T1,[4,,P1]         ;POINT TO ARGUMENT BLOCK
        MOVEI   P1,0               ;CLEAR FLAGS
        SETZB   P2,P3              ;ZERO ARG BLOCK
        MOVE    P4,[^D8,,MSG ]     ;POINT TO DATA AREA
        IPCFR.  T1,                ;BLOCK WAITING
          POPJ  P,                 ;ERROR, GIVE UP WITH ERROR CODE IN T1
        MOVEM   P2,PIDHIM          ;STORE SENDER
        HLRZ    T1,P4              ;GET ACTUAL LENGTH
        JRST    .POPJ1##           ;GOOD RETURN

;ROUTINE TO ISSUE A FATAL IPCF ERROR MESSAGE AND START OVER
;ENTERRED WITH ERROR CODE IN T1
```

```
IPCERR: MOVM    T2,T1             ;GET POSITIVE FORMAT
        TLNE    T2,-1             ;SEE IF STUFF IN LEFT HALF
        MOVEI   T1,0              ;YES--UUO MUST NOT BE IMPLEMENTED
        CAIL    T1,INFERR         ;SEE IF INFO ERROR
        CAILE   T1,77             ; (RANGE INFERR TO 77)
        JRST    IPCER1            ;NO--TRY NORMAL IPCF ERRORS
        SUBI    T1,INFERR-MAXERR-1 ;YES--REMOVE TABLE OFFSET
        JRST    IPCER2            ;AND ISSUE MESSAGE
IPCER1: CAILE   T1,MAXERR         ;SEE IF ERROR WE UNDERSTAND
        JRST    UNKERR            ;NO--GO HANDLE SEPARATELY
IPCER2: OUTSTR  @ERRTBL(T1)       ;OUTPUT TEXT (***TEMP***)
        JRST    FINERR            ;FINISH UP

UNKERR: OUTSTR  [ASCIZ \? UNKNOWN IPC ERROR CODE \]
        PUSHJ   P,.TOCTW##        ;ISSUE IN OCTAL

FINERR: OUTSTR  [ASCIZ \
\]
        EXIT

;TABLE OF ERROR MESSAGES

        DEFINE M($MES),<
        [ASCIZ \? $MES\]
>
        M       UNKNOWN RECEIVER
ERRTBL: M       IPCF NOT IMPLEMENTED
        M       ADDRESS CHECK
        M       UUO BLOCK NOT LONG ENOUGH
        M       NO PACKET IN QUEUE
        M       PAGE IN USE
        M       DATA TOO LONG FOR BUFFER
        M       DESTINATION UNKNOWN
        M       DESTINATION DISABLED
        M       SENDING QUOTA EXCEEDED
        M       RECEIVING QUOTA EXCEEDED
        M       SYSTEM STORAGE EXCEEDED
        M       UNKNOWN PAGE (SEND), EXISTING PAGE (RECEIVE)
        M       INVALID SENDER
        M       INSUFFICIENT PRIVILEGES
        M       UNKNOWN FUNCTION
        M       BAD JOB NUMBER
        M       PID TABLE FULL
        M       PAGE REQUESTED WITH NON-PAGE PACKET NEXT
        M       PAGING I/O ERROR
MAXERR==.<ERRTBL-1>  ;HIGHEST KNOWN ERROR CODE
        M       INFO HAD INTERNAL ERROR
        M       INFO RAN INTO AN IPCF REJECTION
        M       INFO FAILED TO COMPLETE AN ASSIGN
        M       INFO RAN OUT OF PID'S
        M       INFO COULD NOT IDENTIFY THE PID
        M       INFO FOUND A DUPLICATE NAME
        M       INFO KNEW OF NO SUCH NAME
        M       INFO DETERMINED THAT NAME HAS ILLEGAL CHARACTERS
INFERR==100-<.-<ERRTBL+MAXERR+1>>  ;FIRST INFO ERROR

;LITERALS

        XLIST
        LIST
        RELOC

;IMPURE STORAGE

OFFSET: BLOCK   1       ;CCL START CODE
ORGFF:  BLOCK   1       ;ORIGINAL .JBFF,,.JBREL

ZCOR:!                  ;START OF AREA TO CLEAR
PDLST:  BLOCK   LN$PDL+2 ;PUSH-DOWN LIST
        BLOCK 2
NAME:   BLOCK   6       ;TRANSMISSION NAME
ENAME==,-1
FLSR:   BLOCK   1       ;1=SEND, 2=RECEIVE

PIDUS:  BLOCK   1       ;PID OF US
PIDHIM: BLOCK   1       ;PID OF OTHER GUY

DBLK:   BLOCK   8
MSG:    BLOCK   8
EMSG==,-1
EZCOR==,-1

        END     IPCFEX
```

CHAPTER 8
MONITOR ALGORITHMS

8.1 JOB SCHEDULING

The number of jobs that may be run simultaneously must be specified in creating the DECsystem-10 Monitor. Up to 127 jobs may be specified. Each user accessing the system is assigned a job number.

In a multiprogramming system all jobs reside in core, and the scheduler decides what jobs should run. In a swapping system, jobs exist on an external storage device (usually disk or drum) as well as in core. The scheduler decides not only what job is to run but also when a job is to be swapped out onto the disk (drum) or brought back into core.

In a swapping system, jobs are retained in queues of varying priorities that reflect the status of the jobs at any given moment. Each job number possible in the system resides in only one queue at any time. A job may be in one of the following queues:

1. Run queues – for runnable jobs waiting to execute. (There are three run queues of different levels of priorities.)
2. I/O wait queue – for jobs waiting while doing I/O.
3. I/O wait satisfied queue – for jobs waiting to run after finishing I/O.
4. Sharable device wait queue – for jobs waiting to use sharable devices.
5. TTY wait queue – for jobs waiting for input or output on the user's console.
6. TTY wait satisfied queue – for jobs that completed a TTY operation and are awaiting action.
7. Stop queue – for processes that have been completed or aborted by an error and are awaiting a new command for further action.
8. Null queue – for all job numbers that are inactive (unassigned).

Each queue is addressed through a table. The position of a queue address in a table represents the priority of the queue with respect to the other queues. With certain queues, the position of a job determines its priority with respect to the other jobs in the same queue. For example, if a job is first in the queue for a sharable device, it has the highest priority for the device when it becomes available. However, if a job is in a I/O wait queue, it remains in the queue until the I/O is completed. Therefore, in an I/O wait queue, the job's position has no significance. The status of a job changes each time it is placed into a different queue. Each job, when it is assigned to run, is given a quantum time. When the quantum time expires, the job ceases to run and moves to a lower priority run queue. The activities of the job currently running may cause it to move out of the run queue and enter one of the wait queues. For example: When a currently running job begins input from a DECtape, it is placed in the I/O wait queue, and the input is started. A second job is set to run while the input of the first job proceeds. If the second job then decides to access a DECtape for an I/O operation, it is stopped because the DECtape control is busy, and it is put in the queue for jobs waiting to access the DECtape control. A third job is set to run. The input operation of the first job finishes, making the DECtape control available to the second job. The I/O operation of the second job is initiated, and the job is transferred from the device wait queue to the I/O wait queue. The first job is transferred from the I/O wait queue to the highest priority run queue. This permits the first job to preempt the running of the third job. When the quantum time of the first job becomes zero, it is moved into the second run queue, and the third job runs again until the second job completes its I/O operations.

Data transfers also use the scheduler to permit the user to overlap computation with data transmission. In unbuffered modes, the user supplies an address of a command list containing pointers to relative locations in the user area to and from which data is to be transferred. When the transfer is initiated, the job is scheduled into an I/O wait queue where it remains until the device signals the scheduler that the entire transfer has been completed.

In buffered modes, each buffer contains a use bit to prevent the user and the device from using the same buffer at the same time (refer to Paragraph 4.3). If the user overtakes the device and requires the buffer currently being used by the device as his next buffer, the user's job is scheduled into an I/O wait queue. When the device finishes using the buffer, the device calls the scheduler to reactivate the job. If the device overtakes the user, the device is stopped at the end of the buffer and is restarted when the user finishes with the buffer.

Scheduling occurs at each clock tick (1/60th or 1/50th of a second) or may be forced at monitor level between clock ticks if the current job becomes blocked (unrunnable). The asynchronous swapping algorithm is also called at each clock tick and has the task of bringing a job from disk into core. This function depends on

1. The core shuffling routine, which consolidates unused areas in core to make sufficient room for the incoming job.

2. The swapper, which creates additional room in core by transferring jobs from core to disk.

Therefore, when the scheduler is selecting the next job to be run, the swapper is bringing the next job to be run into core. The transfer from disk to core takes place while the central processor continues computation for the previous job.

8.2 PROGRAM SWAPPING

Program swapping is performed by the monitor on one or more units of the system independent of the file structures that may also use the units. Swapping space is allocated and deallocated in clusters of 1K words on a KA10 (Pages on a KI10); this size is the increment size of the memory relocation and protection mechanism. Directories are not maintained, and retrieval information is retained in core. Most user segments are written onto the swapping units as contiguous units. Swapping time and retrieval information is, therefore, minimized. Segments are usually read completely from the swapping unit into core with one I/O operation. The swapping space on all units appears as a single system file, SWAP.SYS, in directory SYS in each file structure. This file is protected from all but privileged programs by the standard file protection mechanism (refer to Paragraph 6.2.3).

The reentrant capability reduces the demands on core memory, swapping space, swapping channel, and storage channel; however, to reduce the use of the storage channel, copies of sharable segments are kept on the swapping device. This increases the demand for swapping space. To prevent the swapping space from being filled by user's files and to keep swapped segments from being fragmented, swapping space is preallocated when the file structure is refreshed. The monitor dynamically achieves the space-time balance by assuming that there is no shortage of swapping space. Swapping space is never used for anything except swapped segments, and the monitor keeps a single copy of as many segments as possible in this space. (The maximum number of segments that may be kept may be increased by individual installations but is always at least as great as the number of jobs plus one.) If a sharable segment on the swapping space is currently unused, it is called a dormant segment. An idle segment is a sharable segment that is not used by users in core; however, at least one swapped-out user must be using the segment or it would be a dormant segment.

Swapping disregards the grouping of similar units into file structures; therefore, swapping is done on a unit basis rather than a file structure basis. The units for swapping are grouped in a sorted order, referred to as the active swapping list. The total virtual core, which the system can allocate to users, is equal to the total swapping space preallocated on all units in the active swapping list. In computing virtual core, sharable segments count only once, and dormant segments do not count at all. The monitor does not allow more virtual core to be granted than the system has capacity to handle.

When the system is started, the monitor reads the home blocks on all the units that it was generated to handle. The monitor determines from the home blocks which units are members of the active swapping list. This list may be changed at once-only time. The change does not require refreshing of the file structures, as long as swapping space was preallocated on the units when they were refreshed. All of the units with swapping space allocated need not appear in the active swapping list. For example, a drum and disk pack system should have swapping space allocated on both drum and disk packs. Then, if the drum becomes inoperable, the disk packs may be used for swapping without refreshing. Users cannot proceed when virtual core is exhausted; therefore, FILSER is designed to handle a variety of disks as swapping media. The system administrator allocates additional swapping space on slower disks and virtually eliminates the possibility of exhausting virtual core; therefore, in periods of heavy demand, swapping is slower for segments that must be swapped on the slower devices. It is also undesirable to allow dormant segments to take up space on high-speed units. This forces either fragmentation on fast units or swapping on slow units; therefore, the allocation of swapping space is important to overall system efficiency.

The swapping allocator is responsible for assigning space for the segment the swapper wants to swap out. It must decide

1. Onto which unit to swap the segment.
2. Whether to fragment the unit if not enough contiguous space is available.
3. Whether to make room by deleting a dormant segment.
4. Whether to use a slower unit.

The units in the active swapping list are divided into swapping classes, usually according to device speed. For simplicity, the monitor assumes that all the units of class 0 are first followed by all the units of class 1. Swapping classes are defined when the file structures are refreshed and may be changed at once-only time.

When attempting to allocate space to swap out at a low or high segment, the monitor performs the following:

Step	Procedure
1	The monitor looks for contiguous space on one of the units of the first swapping class.
2	The monitor looks for noncontiguous space on one of the units in the same class.
3	The monitor checks whether deleting one or more dormant segments would yield enough contiguous or noncontiguous space.

If all of these measures fail, the monitor repeats the process on the next swapping class in the active swapping list. If none of the classes yields enough space, the swapper begins again and deletes enough dormant segments to fragment the segment across units and classes. When a deleted segment is needed again, it is retrieved from the storage device.

8.3 DEVICE OPTIMIZATION

8.3.1 Concepts

Each I/O operation on a unit consists of two steps: positioning and data transferring. To perform I/O, the unit must be positioned, unless it is already on a cylinder or is a non-positioning device. To position a unit, the controller cannot be performing a data transfer.

If the controller is engaged in a data transfer, the positioning operation of moving the arm to the desired cylinder cannot begin until the data transfer is complete.

The controller reads the sector headers to ensure that the heads actually moved to the correct cylinder. If they did not, the software recalibrates the positioner by moving it to a fixed place and beginning again. Finally, the data is transferred to or from the desired sectors. To understand the optimization, the transfer operation includes verification, searching, and actual transfer. The time from the initiation of the transfer operation to the actual beginning of the transfer is called the latency time. The channel is busy with the controller for the entire transfer time; therefore, it is important for the software to minimize the latency time.

The FILSER code, the routines that queue disk requests and make optimization decisions, handles any number of channels and controllers and up to eight units for each controller.(1) Optimization is designed to keep:

1. As many channels as possible performing data transfers at the same time.
2. As many units positioning on all controllers, which are not already in position for a data transfer.

Several constraints are imposed by the hardware. A channel can handle only one data transfer on one control at a time. Furthermore, the control can handle a data transfer only on one of its units at a time. However, the other units on the control can be positioning while a data transfer is taking place provided the positioning commands were issued prior to the data transfer. Positioning requests for a unit on a controller that is busy doing a data transfer for another of its units must be queued until the data transfer is finished. When a positioning command is given to a unit through a controller, the controller is busy for only a few microseconds; therefore, the software can issue a number of positioning commands to different units as soon as a data transfer is complete. All units have only one positioning mechanism that reaches each point; therefore, only one positioning operation can be performed on a unit at the same time. All other positioning requests for a unit must be queued.

The software keeps a state code in memory for each active file, unit, controller, and channel, to remember the status of the hardware. Reliability is increased because the software does not depend on the status information of the hardware. The state of a unit is as follows:

I	Idle; No positions or transfers waiting or being performed.
SW	Seek Wait; Unit is waiting for a control to become idle so that it can initiate positioning (refer to Paragraph 6.2).

(1) Disk latency optimization depends on FTDOPT which is normally off in the DECsystem-1040. If this switch is off, all requests are handled on a first-come first-served basis.

S	Seek; Unit is positioning in response to a SEEK UUO; no transfer of data follows.
PW	Position Wait; Unit is waiting for control to become idle so that it can initiate positioning.
P	Position; Unit is positioning; transfer of data follows although not necessarily on this controller.
TW	Transfer Wait; Unit is on cylinder and is waiting for the controller/channel to become idle so that it can transfer data.
T	Transfer; Unit is transferring; the controller and channel are busy performing the operation.

Table 8-1 lists the possible states for files, units, controllers, and channels.

Table 8-1
Software States

File*	Unit	Controller	Channel
I	I	I	I
	SW		
	S		
PW	PW		
P	P		
TW	TW		
T	T	T	T

*Cannot be in S or SW state because SEEKs are ignored if the unit is not idle.

8.3.2 Queueing Strategy

When an I/O request for a unit is made by a user program because of an INPUT or OUTPUT UUO, one of several things can happen at UUO level before control is returned to the buffer-strategy module in UUOCON, which may, in turn, pass control back to the user without rescheduling. If an I/O request requires positioning of the unit, either the request is added to the end of the position-wait queue for the unit if the control or unit is busy, or the positioning is initiated immediately. If the request does not require positioning, the data is transferred immediately. If the channel is busy, the request is added to the end of the transfer-wait queue for the channel. The control gives the processor an interrupt after each phase is completed. Optimization occurs at interrupt level when a position-done or transfer-done interrupt occurs.

8.3.2.1 **Position-Done Interrupt Optimization** – Data transfer is started on the unit unless the channel is busy transferring data for some other unit or control. If the channel is busy, the request goes to the end of the transfer-wait queue for that channel.

8.3.2.2 **Transfer-Done Interrupt Optimization** – When a transfer-done interrupt occurs, all the position-done interrupts inhibited during the data transfer are processed for the controller, and the requests are placed at the end of the transfer-wait queue for the channel. All units on the controller are then scanned. The requests in the position-wait queues on each unit are scanned to see the request nearest the current cylinder. Positioning is begun on the unit of the selected request. All requests in the transfer-wait queue for all units on the channel that caused the interrupt are then scanned and the latency time is measured. The request with the shortest latency time is selected, and the new transfer begins.

8.3.3 Fairness Consideration

When the system selects the best task to run, users making requests to distant parts of the disk may not be serviced for a long time. The disk software is designed to make a fair decision for a fixed percentage of time. Every n decisions, the disk software selects the request at the front of the position-wait or transfer-wait queue and processes it, because that request has been waiting the longest. The value of n is set to 10 (decimal) and may be changed by redefining symbols with MONGEN.

8.3.4 Channel Command Chaining

8.3.4.1 Buffered Mode – Disk accesses are reduced by using the chaining feature of the data channel. Prior to reading a block in buffered mode, the device independent routine checks to see if there is another empty buffer, and if the next relative block within the file is a consecutive logical block within the unit. If both checks are true, FILSER creates a command list to read two or more consecutive blocks into scattered core buffers. Corresponding decisions are made when writing data in buffered mode and, if possible, two or more separate buffers are written in one operation. The command chaining decision is not made when a request is put into a position-wait or transfer-wait queue; instead, it is postponed until the operation is performed, thus increasing the chances that the user program will have more buffers available for input or output. The default size of the channel command list is 20 decimal words and can be changed by redefining CCWMAX with MONGEN.

8.3.4.2 Unbuffered Mode – Unbuffered modes do not use channel chaining and, therefore, read or write one command word at a time. Each command word begins at the beginning of a 128-word block. If a command word does not contain an even multiple of 128 words, the remaining words of the last block are not read, if reading, and are written with zeroes, if writing.

8.4 MONITOR ERROR HANDLING

The monitor detects a number of errors. If a hardware error is detected, the monitor repeats the operation three times on a search error, ten times on a data error; then recalibrates, repositions, and tries three or ten more times. This entire cycle will be repeated ten times. If the failure occurs eleven times in a row, it is classified as a hard error. If the operation succeeds after failing one to ten times, it is a soft error.

8.4.1 Hardware Detected Errors

Hardware detected errors are classified either as device errors or as data errors. A device error indicates a malfunction of the controller or channel. A data error indicates that the hardware parity did not check (the user's data is probably bad).

A device error sets the IO.DER bit in the channel status word, and a data error sets the IO.DTE bit.

Disk units may have imperfect surfaces; therefore, a special non-timesharing diagnostic program, MAP, is provided to initially find all the bad blocks on a specified unit. The logical disk addresses of any bad regions of one or more bad blocks are recorded in the bad allocation table (BAT) block on the unit. The monitor allocates all storage for files; therefore, it uses the BAT block to avoid allocating blocks that have previously proven bad.

The MAP program writes two copies of the BAT block because the BAT block might be destroyed. If the MAP program is not used, the monitor discovers the bad regions when it tries to use them and adds this information to the BAT block. However, the first user of the bad region loses that part of his data.

A hard data error usually indicates a bad surface; therefore, the monitor never returns the bad region to free storage. This results in the bad region causing an error only once. The bad unit and the logical disk address are stored in the retrieval information block (RIB) of the file when the file is CLOSEd or RESET and the extent of the bad region is determined. The origin and length of the bad region is stored in the bad allocation table (BAT) block.

8.4.2 Software Detected Errors

The monitor makes a number of software checks on itself. It checks the folded checksum (refer to Appendix H) computed for the first word of every group and stored in the retrieval pointer. The monitor also checks for inconsistencies when comparing locations in the retrieval information block with expected values (filename, filename extension, project-programmer number, special code, logical block number, block number of directory RIB). The monitor checks for inconsistencies in the storage allocation table block when comparing the number of free clusters expected with the number of zeroes. A checksum error or an inconsistency error in the SAT block or RIB normally indicates that the monitor is reading the wrong block. When these errors occur, the monitor sets the improper mode error bit (IO.IMP) in the user channel status word and returns control to the user program.

8.5 DIRECTORIES

8.5.1 Order of Filenames

In 5.02 and earlier monitors, the names of newly created files are appended to the directory if the directory does not contain more than 64 filenames. If the directory contains more than 64 filenames, a second block is used for the new filenames. When filenames are deleted from the first block, entries from the second block are not moved into the first. When additional new files are created, their names are added to the end of the first block of the directory instead of the end of the directory. Thus, the order of the filenames in the directory may not be according to the date of creation.

In 5.03 and later monitors, if FTDUFD = 1, files are always entered in the directory in the order in which they are created. In the DECsystem-1040, FTDUFD is normally off, indicating that the order of filenames is the same as in the 5.02 and earlier monitors.

8.5.2 Directory Searches

Table space in core memory is used to reduce directory searching time. The JBTPPB table contains pointers to a list of four-word blocks for the user's project-programmer number, one block for each file structure on which the user has a UFD.

Four-word name and access blocks contain copies of LOOKUP information for recently-accessed files and may reduce disk accesses to zero or one directory read for a LOOKUP on a recently-active file. Recent LOOKUP failures are also kept in core, but are deleted when space is needed.

8.6 PRIORITY INTERRUPT ROUTINES

8.6.1 Channel Interrupt Routines

Each of the seven PI channels has two absolute locations associated with it in memory: 40+2n and 41+2n, where n is a channel number (1-7). When an interrupt occurs on a channel, LOC 40+2n is executed to the first of the two associated locations (unless an interrupt on a higher priority channel is being processed). For fast service of a single device, the first location contains either a BLKI or BLKO instruction. For service of more than one device on the same channel, the first location contains a JSR to location CHn in the appropriate channel interrupt routine. The JSR ensures that the current state of the program counter is saved.

Each channel interrupt routine (mnemonic name, CHn, where n is the channel number) consists of three separate routines:

CHn:	The contents of the program counter is saved in location CHn. CHn+1 contains a JRST to the first device service routine in the interrupt chain.
SAVn:	The routine to save the contents of a specified number of accumulators. It is called from the device service routines with a JSR.
XITCHn:	The routine to restore saved accumulators. Device service routines exit to XITCHn with a POPJ PDP, if SAVn was previously called.

8.6.2 Interrupt Chains

Each device routine contains a device interrupt routine DEVINT where DEV is the three-letter mnemonic for the device concerned. This routine checks to determine whether an interrupt was caused by device DEV. The interrupt chain of a given channel is a designation for the logical positioning of each device interrupt routine associated with that channel.

The monitor flow of control on the interrupt level through a chain is illustrated below. Channel 5 is used in the example.

```
Monitor Routine          Relevant Code                  Explanation

  Absolute             52/JSR CH5                     ; control transferred here
  Locations            53/                            ; on interrupt

  CHAN5                CH5: 0                         ; contents of PC saved here
                          JRST PTPINT                 ; control transfers to
                                                      ; first link in interrupt
                                .                     ; chain

                       PTPINT:  CONSO PTP,PTPDON      ; if PDP done bit is
  PTPSER                  JRST LPTINT                 ; on, PTP was cause
                                 .                    ; of interrupt –
                                 .                    ; otherwise, go to
                                 .                    ; next device
```

Monitor Routine	Relevant Code	Explanation
	LPTINT: CONSO LPT,LPTLOV+LPTERR+LPTDON	
LPTSER	JEN @ CH5	; three possible bits
	.	; may indicate that
	.	; LPT caused interrupt
	.	

When a real-time device is added to the interrupt chain (CONSO skip chain) by a RTTRP UUO (refer to Paragraph 3.8.1), the device is added to the front of the chain. After putting a real-time device on Channel 5 in single mode (refer to Paragraph 3.8.1), the chain is as follows:

Monitor Routine	Relevant Code	Explanation
Absolute	52/JSR CH5	; control transferred here
Locations	53/	; on interrupt
CHAN5	CH5 0	; contents of PC saved here
	JRST RDTINT	; control transfers to first
		; link in interrupt chain
RTDEV	RTDINT: CONSO RTD,BITS	
	JRST PTPINT	
	JRST <context switcher and dispatch for real-time interrupts>	
	PTPINT: CONSO PTP,PTPDON	; if PTP done bit is
PTPSER	JRST LPTINT	; on, PTP was cause
	.	; of interrupt –
	.	; otherwise, go to
	.	; next device.
	LPTINT: CONSO LPT, LPTLOV+LPTERR+LPTDON	
LPTSER	JEN @ CH5	; three possible bits
	.	; may indicate that
	.	; LPT caused interrupt
	.	

After putting a real-time device on channel 5 in normal block mode (refer to Paragraph 3.8.1), the chain is as follows:

Monitor Routine	Relevant Code	Explanation
Absolute	52/JSR CH5	; control transferred here
Locations	53/	; on interrupt
CHAN5	CH5: 0	; contents of PC saved here
	JRST RTDINT	; control transfers to first
		; link in interrupt chain

Monitor Routine	Relevant Code	Explanation
RTDEV	RTDINT;CONSO RTD,BITS	
	JRST PTPINT	
	BLKI RTD,POINTR	
	JRST <context switcher>	
	JEN @ CH5	
	PTPINT: CONSO PTP,PTPDON	; if PTP done bit is
PTPSER	JRST LPTINT	; on, PTP was cause
	.	; of interrupt –
	.	; otherwise, go to
	.	; next device
	LPTINT: CONSO LPT, LPTOV+LPTERR+LPTDON	
LPTSER	JEN @ CH5	; three possible bits
	.	; may indicate that
	.	; LPT caused interrupt.

After putting a real-time device on channel 6 in fast block mode (refer to Paragraph 3.8.1), the chain is as follows:

Monitor Routine	Relevant Code	Explanation
Absolute	54/BLKO RTD,POINTR	; control transferred
Locations	55/JSR CH6	; here on interrupt
CHAN6	CH6: 0	; contents of PC saved
	JRST <context switcher>	; control transfers to
		; context switcher.

The exec mode trapping feature can be used with any of the standard forms of the RTTRP UUO; single mode, normal block mode, and fast block mode. The following examples illustrate the chain when used with each of the three modes.

Single Mode (Exec Mode)

Monitor Routine	Relevant Code	Explanation
Absolute	52/JSR CH5	; control transferred here
Locations	53/	; on interrupt
CHAN5	CH5: 0	; contents of PC saved here
	JRST RDTINT	; control transfer to first
		; link in interrupt chain
RTDEV	RTDINT: CONSO RTD BITS	
	JRST PTPINT	
	JSR TRPADR	
	JEN @ CH5	

Single Mode (Exec Mode) (Cont)

	PTPINT: CONSO PTP,PTPDON	; if PTP done bit is
PTPSER	JRST LPTINT	; on, PTP was cause
	.	; of interrupt –
	.	; otherwise, go to
	.	; next device
	LPTINT: CONSO LPT, LPTLOV+LPTERR+LPTDON	
LPTSER	JEN @ CH5	; three possible bits
	.	; may indicate that
	.	; LPT caused interrupt
	.	

Normal Block Mode (Exec Mode)

Monitor Routine	Relevant Code	Explanation
Absolute	52/JSR CH5	; control transferred here
Locations	53/	; on interrupt
CHAN5	CH5: 0	; contents of PC saved here
	JRST RTDINT	; control transfers to first
		; link in interrupt chain
RTDEV	RTDINT: CONSO RTD, BITS	
	JRST PTPINT	
	BLKI RTD, POINTR	
	JSR TRPADR	
	JEN @ CH5	
	PDPINT: CONSO PTP,PTPDON	; if PTP done bit is
PTPSER	JRST LPTINT	; on, PDP was cause
	.	; of interrupt –
	.	; otherwise, go to
	.	; next device
	LPTINT: CONSO LPT,LPTLOV+LPTERR+LPTDON	
LPTSER	JEN @ CH5	; three possible bits
	.	; may indicate that
	.	; LPT caused interrupt.
	.	

Fast Block Mode (Exec Mode)

Monitor Routine	Relevant Code	Explanation
Absolute	54/BLKO RTD,POINTR	; control transferred here
Locations	55/ JSR CH6	; on interrupt

Fast Block Mode (Exec Mode) (Cont)

```
CHAN6          CH6: : 0                        ; contents of PC saved here
                 JRST RDTINT                   ; control transfers to first
                                               ; link in interrupt chain

RTDEV          RTDINT: JSR TRPADR
                 JEN @ CH6
```

8.7 MEMORY PARITY ERROR ANALYSIS, REPORTING AND RECOVERY(1)

The memory parity error analysis and recovery software allows the machine to run with PARITY STOP off, thereby gaining increased CPU speed (10% more on the KA10 processor and 100% more on the KI10 processor), better error reporting, and improved failsafe recovery. The analysis software considers its goals to be

1. Never jeopardize the system or the user program by allowing it to continue with bad data from memory.
2. Always maintain the running of the system with the maximum number of users as possible as long as there is no possibility of violating the integrity of the system or the user program.

In either case, complete information is printed for the operator so that he can reconfigure the memories and reload the system when necessary. Additional information is recorded on the disk by DAEMON for field service in order that the cause of the error can be located and fixed.

8.7.1 Description of Analysis

The error analysis software differentiates between user mode and executive mode when a parity error occurs. If the processor is executing in user mode and the user is enabled for parity trapping (refer to Paragraph 3.1.3.1), control is transferred to the user's routine. Otherwise, the execution of the user's job is stopped and the user receives the error messages

```
?ERROR IN JOB n
?MEM PAR ERR AT USER PC nnnnnn
```

Simultaneously, a request is made for the lowest priority channel routine to sweep through core in order to locate all words with bad memory parity, in case there is more than one word. During the sweep, all locations with bad parity are rewritten, so that subsequent references usually will not receive a parity error. After the sweep of core is completed, all jobs (including the current job) with parity errors in their low segments receive the above ERROR IN JOB message. All jobs with errors in their high segments are swapped out if the high segment has the hardware user-mode write protect bit set, since a copy exists on the swapping space. In this case recovery occurs for all jobs sharing the high segment except for the currently running job. If the high segment is not write protected for a job (so that there is no copy on the disk), if the high segment is locked, or if one of the sharing job's low segments is locked, all jobs sharing the high segment are stopped and receive an error message since no recovery is possible. In addition, the segment name is cleared so that new users will receive a new copy from the file system on a R, RUN, or GET command or a RUN or GETSEG UUO.

If the processor is in executive mode when the error occurs, the analysis procedure depends on the value of the PC. Two conditions are recognized as not being harmful:

1. a parity error during the PI 7 sweep of memory.

(1)This feature depends on FTMEMPAR which is normally off in the DECsystem-1040.

2. a parity error during the storing of data words around the location of a channel-detected memory parity error.

If the PC is at the BLT instruction which moves user core to facilitate core allocation, the bad word is determined from the BLT pointer. If the pointer is in the protected part of the job data area, this area is cleared so the monitor will not attempt to use the bad words, since they contain executive mode addresses. In either case, the user's job is stopped and an error message is output to the user. In addition, the memory sweep procedure is invoked to find additional words with bad parity.

If the PC is in executive mode location and there are no PIs in progress, the UUO is run to completion, the current user receives an error message, and the memory sweep procedure is invoked. If the sweep routine detects bad parity in an address within the monitor or detects no words with bad parity (because they have been rewritten on a read-pause-write instruction), the routine prints on the CTY (instead of OPR),

```
?EXEC PARITY HALT
n MEM PAR ERRS FROM aaaaaa TO bbbbbb ON CPUn FOR JOBx [program]
```

and then HALTS. This message is printed without using the interrupt system in order to maximize the chances of the message being output. Although the operator can attempt to continue the system by pushing the CONT console switch, this is not a recommended operator procedure (e.g., the monitor may have incorrect data thereby causing more damage). (Refer to MEMPAR in Notebook 8 of the DECsystem-10 Software Notebooks for complete operator instructions on memory parity error recovery.)

If a PI is in progress when the parity error is detected, a sweep of core is made at the high priority APR PI level. If a word with bad parity is discovered in the monitor area or no parity errors are found, the monitor prints the above message to the operator and halts. The finding of words without bad parity is considered serious because the read-pause-write class instructions rewrite memory before the parity interrupt occurs so that the parity error is usually corrected. In this case, the operator receives the message

```
?0 MEM PAR ERRORS
```

On all recoverable or non-recoverable parity errors, the operator receives on either OPR or CTY a message similar to the following:

```
?n MEM PAR ERRORS FROM aaaaaa TO bbbbbb ON CPUn for JOBx [program]
```

preceded by five bells. This alerts him to potential problems and gives him the necessary information for reconfiguring the memories. In addition, the operator is notified of the jobs that have been stopped in case they are crucial to the operation of the system. If they are, he can take appropriate action to restart them.

If the DF10 channel detects a memory parity error while reading for file I/O from memory, the user's job is not stopped and the user does not receive an error message. Instead, the error is treated as a device error and the IO.DER error bit is set. However, the operator receives the message

```
?n MEM PAR ERRS FROM aaaaaa TO bbbbbb ON CHANNEL n
```

where n is the logical channel number starting with the fastest device as defined by MONGEN. For example, the fastest disk unit is on the first channel and the magnetic tape TM10B control is on the last channel.

If the DF10 channel detects a memory parity error while swapping a job out of core, the user's job is stopped and the user receives the following error message:

```
?ERROR IN JOB n
?SWAP OUT CHN MEM PAR ERR
```

The operator receives the message

```
?m MEM PAR ERRS FROM aaaaaa TO bbbbbb ON CHANNEL n for JOB x [prog].
```

If the error is detected in a high segment on the swap out, all jobs using the high segment receive the error message. The high segment name is cleared so that new users will receive a new copy of the segment from the file system.

On all parity errors detected by the processors or the channels, DAEMON is awakened to correct the information stored by the monitor's analysis routine. DAEMON writes this information in the hardware log file on the disk for the use of field service in diagnosing and solving the problem.

APPENDIX A DECTAPE COMPATIBILITY BETWEEN DEC COMPUTERS

The following chart illustrates the ability to read the indicated tapes with a suitable program. In general, the standard software of machines of one family will not read tapes written by the standard software of machines of a different family.

The standard tapes of the PDP-1, PDP-4, PDP-6, PDP-7, PDP-9, PDP-10, PDP-11, and PDP-15 consist of 578 blocks of 128 36-bit words (256 18-bit words). The standard tapes of the PDP-15 and the PDP-8 family consist of 4096 blocks of 129 12-bit words (43 36-bit words).

Read by / Written by	PDP-1 550,550-A And 555, TU55, TU56	PDP-4 550 And 555, TU55, TU56	PDP-5 552 And 555,TU55, TU56	PDP-6 551 And 555,TU55 TU56	PDP-7 550-A And 555,TU55, TU56	PDP-8 552,TC01 And 555,TU55, TU56	PDP-8/I,L TC01,TC08 And TU55,TU56	PDP-8/E TC08-P, TD8E And TU55, TU56	LINC-8 And Optional Converter And LINCtape Drive	PDP-9 TC02 And TU55, TU56	PDP-10 TD10 And TU55,TU56	PDP-11 TC11 And TU56	PDP-12 TC12 And TC12-F TU55, TU56	PDP-15 TC02,TC15 And TU55,TU56
PDP-1	A	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z
PDP-4	Z	A	D	D	A	D	D	D	E	D	D	D	E	D
PDP-5	Z	D	A	B	C	A	A	A	E	A	A	A	E	A
PDP-6	Z	D	A	A	C	A	A	A	E	A	A	A	E	A
PDP-7	Z	A	C	C	A	C	C	C	E	C	C	C	E	C
PDP-8	Z	D	A	B	C	A	A	A	E	A	A	A	E	A
PDP-8/I,L	Z	D	A	B	C	A	A	A	E	A	A	A	E	A
PDP-8/E	Z	D	A	B	C	A	A	A	E	A	A	A	E	A
LINC-8 & Converter	Z	E	E	B	E	E	E	E	A	E	E	E	A	E
PDP-9	Z	D	A	A	C	A	A	A	E	A	A	A	E	A
PDP-10	Z	D	A	A	C	A	A	A	E	A	A	A	E	A
PDP-11	Z	D	A	B	C	A	A	A	E	A	A	A	E	A
PDP-12 & TC12-F	Z	E	E	B	E	E	E	E	A	E	E	E	A	E
PDP-15	Z	D	A	A	C	A	A	A	E	A	A	A	E	A

KEY:		
A	=	Can be done.
B	=	Can be done only by ignoring indicated checksum errors.
C	=	Can be done with programmed checksum.
D	=	Can probably be done as in (C) except that PDP-4 is too slow for calculating the exclusive-or checksum in line; calculations must be done before writing and after reading.
E	=	Program and optional hardware exist to convert to and from LINCtape format. Standard PDP-12 and LINC-8 tapes are in LINCtape format which is incompatible. DECtapes must be formatted on another machine before writing on PDP-12 or LINC-8.
Z	=	No information available.

NOTES:

1. PDP-8/S cannot use DECtape. Classic LINC only uses LINCtape which is incompatible with DECtape.
2. The PDP-6 and 10 (and probably other machines) cannot find the first or last block when searching from the end zone.
3. The PDP-9 and -15 software writes data in reverse order in blocks which are written while moving in the reverse direction.

APPENDIX B
WRITING REENTRANT USER PROGRAMS

B.1 DEFINING VARIABLES AND ARRAYS

The LOADER simplification makes it somewhat more difficult to define variables and arrays. The easiest way to define variables and arrays, so the resulting relocatable binary can be loaded on a one- or two-segment machine, is to put them all in a separate subprogram as internal global symbols using Block 1 and Block N pseudo-ops. All other subprograms refer to this data as external global locations. Most reentrant programs have at least two subprograms, one for the definition of low segment locations and one for instructions and constants for the high segment. (This last subprogram must have either a HISEG pseudo-op or a TWOSEG pseudo-op followed by RELOC 400000.) Programs are self-initializing; therefore, they clear the low segment when they are started although the monitor clears core when it assigns it to a user.

Block 1 and Block N pseudo-ops cause the LOADER to leave indications in the job data area (LH of JOBCOR) so a monitor SAVE command will not write the low segment. This is advantageous in sharable programs for two reasons. It reduces the number of files in small DECtape directories (the maximum is 22 files). Also, I/O is accomplished only on the first user's GET that initializes the high segment, but not on any subsequent user's GETs for either the high or low segment.

B.2 EXAMPLE OF TWO-SEGMENT REENTRANT PROGRAM

```
LOW SEGMENT SUBPROGRAM:

TITLE LOW - EXAMPLE OF LOW SEGMENT SUB-PROGRAM
      JOBVER=137
      LOC     JOBVER
      3                  ;VERSION 3
      RELOC   0
      INTERNAL LOWBEG,DATA,DATA1,DATA2,TABLE,TABLE1

LOWBEG:
DATA:    BLOCK  1
DATA1:   BLOCK  1
DATA2:   BLOCK  1

TABLE:   BLOCK  10
TABLE1:  BLOCK  10
LOWEND=.-1               ;LAST LOCATION TO BE CLEARED
      END

HIGH SEGMENT SUBPROGRAM:

TITLE HIGH - EXAMPLE OF HIGH SEGMENT SUB-PROGRAM
      HISEG                ;OR TWOSEG
```

```
                                          ;RELOC 400000
          EXTERN   LOWBEG,LOWEND
          T=1
   BEGIN: SETZM    LOWEG           ;CLEAR DATA AREA

          MOVEI    T,LOWBEG+1
          HRLI     T,LOWBEG
          BLT      T,LOWEND
          MOVE     T,DATA1         ;COMPUTE
          ADDI     1,1
          MOVEM T, DATA2
            .
            .
            .
         END       BEGIN           ;STARTING ADDRESS
```

B.3 CONSTANT DATA

Some reentrant programs require certain locations in the low segment to contain constant data, which does not change during execution. The initialization of this data happens only once after each GET, instead of after each START; therefore, programmers are tempted to place these constants in the subprogram that contains the definitions of the variable data locations. This action requires the SAVE command to write the constants out and the GET command to load the constants again; therefore, the constant data should be moved by the programs from the high segment to the low segment when the rest of the low segment is being initialized. The exception is when the amount of code and constants in the high segment needed to initialize the low segment constants take up too much room in the high segment. In this case, it is best to have I/O in the low segment on each GET. A rule to follow in deciding between this segment core space and the low segment GET I/O time is: put the code in the high segment if it does not put the high segment over the next 1K boundary.

B.4 SINGLE SOURCE FILE

A second way of writing single save file reentrant programs is to have a single source file instead of two separate ones. This is more convenient, although it involves conditional assembly and, therefore, produces two different relocatable binaries. A number of system programs have been written this way. The idea is to have a conditional switch which is 1 if a reentrant assembly and 0 if a non-reentrant assembly.

```
DEMO - DEMO ONE SOURCE REENTRANT PROGRAM -V002  MACRO 44,0,4 14:30  2-APR-71 PAGE 1
DEMO

                        TITLE DEVO - DEMO ONE SOURCE REENTRANT PROGRAM -V002

000137                          LOC <JOBVER=137>
000137  000000 000002           EXP     002             ;VERSION NUMBER
000000'                         RELOC

                                INTERN  JOBVER,PURE

                        IFNDEF PURE,<PURE==1>           ;ASSUME REENTRANT IF PURE UNDEFINED
400000'                         IFN PURE,<TWOSEG>       ;TELL LOADER TO EXPECT TWO SEGMENTS
400000'                         IFN PURE,<RELOC 400000> ;START OF HIGH SEGMENT RELOCATION

400000' 047000 000000   BEG:    RESET                   ;RESET ALL I/O
400001' 200000 400007'          MOVE    0,[DATAB,,DATAB+1]
400002' 402000 000000'          SETZM   DATAB           ;NOW CLEAR DATA REGION
400003' 251000 000203'          BLT     0,DATAE-1       ;UP TO LAST LOCATION
400004' 000000 400004'          '
400005' 000000 400005'          '
400006' 000000 400006'          '

000000'                 IFN PURE,<RELOC>                ;SET RELOCATION COUNTER TO LOW SEGMENT

000000'                 DATAB:                          ;FIRST LOCATION CLEARED ON STARTUP
000000'                 DATA:   BLOCK   1
000001'                 TABLE:  BLOCK   ^D128
000201' 000000 000201'          '
000202' 000000 000202'          '
000203' 000000 000203'          '
000204'                 DATAE:                          ;END OF DATA AREA

400007'                 IFN PURE,<RELOC>                ;BACK TO HIGH SEGMENT
400007'                         LIT                     ;PUT LITERALS IN HIGH SEGMENT
400007' 000000' 000001'
                400000          END     BEG

NO ERRORS DETECTED

HI-SEG.  BREAK IS 400010
PROGRAM BREAK IS 000204

2K CORE USED
```

APPENDIX C
CARD CODES

Table C-1
ANSI Card Codes

ASCII Character	Octal Code	Card Punches	ASCII Character	Octal Code	Card Punches
NULL	00	12-0-9-8-1	CTRL-↑	36	11-9-8-6
CTRL-A	01	12-9-1	CTRL-←	37	11-9-8-7
CTRL-B	02	12-9-2	SPACE	40	
CTRL-C	03	12-9-3	!	41	12-8-7
CTRL-D	04	9-7	"	42	8-7
CTRL-E	05	0-9-8-5	#	43	8-3
CTRL-F	06	0-9-8-6	$	44	11-8-3
CTRL-G	07	0-9-8-7	%	45	0-8-4
CTRL-H	10	11-9-6	&	46	12
TAB	11	12-9-5	'	47	8-5
LF	12	0-9-5	(	50	12-8-5
VT	13	12-9-8-3	)	51	11-8-5
FF	14	12-9-8-4	*	52	11-8-4
CR	15	12-9-8-5	+	53	12-8-6
CTRL-N	16	12-9-8-6	,	54	0-8-3
CTRL-O	17	12-9-8-7	–	55	11
CTRL-P	20	12-11-9-8-1	.	56	12-8-3
CTRL-Q	21	11-9-1	/	57	0-1
CTRL-R	22	11-9-2	0	60	0
CTRL-S	23	11-9-3	1	61	1
CTRL-T	24	9-8-4	2	62	2
CTRL-U	25	9-8-5	3	63	3
CTRL-V	26	9-2	4	64	4
CTRL-W	27	0-9-6	5	65	5
CTRL-X	30	11-9-8	6	66	6
CTRL-Y	31	11-9-8-1	7	67	7
CTRL-Z	32	9-8-7	8	70	8
ESCAPE	33	0-9-7	9	71	9
CTRL-\	34	11-9-8-4	:	72	8-2
CTRL-]	35	11-9-8-5	;	73	11-8-6

Table C-1 (Cont)
ANSI Card Codes

ASCII Character	Octal Code	Card Punches	ASCII Character	Octal Code	Card Punches
<	74	12-8-4	↑∧	136	11-8-7
=	75	8-6	←	137	0-8-5
>	76	0-8-6	\-	140	8-1
?	77	0-8-7	a	141	12-0-1
@	100	8-4	b	142	12-0-2
A	101	12-1	c	143	12-0-3
B	102	12-2	d	144	12-0-4
C	103	12-3	e	145	12-0-5
D	104	12-4	f	146	12-0-6
E	105	12-5	g	147	12-0-7
F	106	12-6	h	150	12-0-8
G	107	12-7	i	151	12-0-9
H	110	12-8	j	152	12-11-1
I	111	12-9	k	153	12-11-2
J	112	11-1	l	154	12-11-3
K	113	11-2	m	155	12-11-4
L	114	11-3	n	156	12-11-5
M	115	11-4	o	157	12-11-6
N	116	11-5	p	160	12-11-7
O	117	11-6	q	161	12-11-8
P	120	11-7	r	162	12-11-9
Q	121	11-8	s	163	11-0-2
R	122	11-9	t	164	11-0-3
S	123	0-2	u	165	11-0-4
T	124	0-3	v	166	11-0-5
U	125	0-4	w	167	11-0-6
V	126	0-5	x	170	11-0-7
W	127	0-6	y	171	11-0-8
X	130	0-7	z	172	11-0-9
Y	131	0-8	{	173	12-0
Z	132	0-9	|	174	12-11
[	133	12-8-2	}	175	11-0
\	134	0-8-2	~	176	11-0-1
]	135	11-8-2	DEL	177	12-9-7

NOTE
The ASCII character ESCAPE (octal 33) is also CTRL-[on a terminal.

The ASCII characters } and ~ (octal 175 and 176) are treated by the monitor as ALT-MODE and are often considered the same as ESCAPE.

APPENDIX D
DEVICE STATUS BITS

Table D-1
Device Status Bits

Device	Function	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
CDP	SETSTS												ANSI		User Word Count	Data Mode			
	GETSTS		Punch Error		Data when EOC reached		I/O Active												
CDR	SETSTS												Super Image Mode	Sync Input		Data Mode			
	GETSTS	No 7-9 Punch	Data Missed	Binary Check-sum Error		EOF card EOF button	I/O Active												
DIS	SETSTS															Data Mode			
	GETSTS						I/O Active												
DSK	SETSTS												Write Head-ers	Sync Input	User Word Count	Data Mode			
	GETSTS	Write Lock	Search Error	Disk Parity Error	Block No. Too Large	End of File	I/O Active												

Table D-1 (Cont)
Device Status Bits

Device	Function	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
DTA	SETSTS											Semi-Standard I/O Mode	Non-structured Dump Mode	Sync Input	User Word Count	Data Mode			
	GETSTS	Write Lock	Data Missed	Parity Error	Block No. Too Large	End of File	I/O Active												
LPT	SETSTS												Suppress Form Feeds		User Word Count	Data Mode			
	GETSTS						I/O Active												
MTA	SETSTS									Write Even Parity	Tape Density		No Retry	Sync Input	User Word Count	Data Mode			
	GETSTS	Write Lock Illegal Operation	Data Missed	Parity Error	Record Too Long	End of File	I/O Active	Load Point Rewinding	End Point										
PLT	SETSTS														User Word Count	Data Mode			
	GETSTS						I/O Active												
PTP	SETSTS														User Word Count	Data Mode			
	GETSTS						I/O Active												
PTR	SETSTS													Sync Input		Data Mode			
	GETSTS	Block Incomplete		Checksum Error		End of Tape	I/O Active												

Table D-1 (Cont)
Device Status Bits

Device Function	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
PTY SETSTS GETSTS				Block No. Too Large		I/O Active	PTY Wait	TTY Re-sponse	Monitor Mode						Data Mode			
TTY SETSTS										Echo of $ Sup-press	Echo Sup-press	Full Char-acter Set	Sync Input	User Word Count	Data Mode			
GETSTS	TTY Not Assig-ned for image mode input	Ignore Inter-rupt	Echo Fail-ure	Char-acter Lost		I/O Active												

Note 1: SETSTS UUO may set all bits except Bit 23 and GETSTS UUO may return all bits (18-35); however, the two are separated to show those bits normally set by the user program on INIT, OPEN, or SETSTS as distinct from those normally set by the monitor (GETSTS).

Note 2: Unused bits should always have the value 0.

Note 3: Refer to the appropriate device sections in Chapters 5 and 6 for the complete description of each status bit.

APPENDIX E
ERROR CODES

The error codes in Table E-1 are returned in AC on RUN and GETSEG UUOs, in the right half of location E + 1 on 4-word argument blocks of LOOKUP, ENTER, and RENAME UUOs, and in the right half of location E + 3 on extended LOOKUP, ENTER, and RENAME UUOs. The codes are defined in the C.MAC file.

Table E-1
Error Codes

Symbol	Code	Explanation
ERFNF%	0	File not found, illegal filename (0,*), filenames do not match (UPDATE), or RENAME after a LOOKUP failed.
ERIPP%	1	UFD does not exist on specified file structures. (Incorrect project-programmer number.)
ERPRT%	2	Protection failure or directory full on DTA.
ERFBM%	3	File being modified (ENTER, RENAME).
ERAEF%	4	Already existing filename (RENAME) or different filename (ENTER after LOOKUP) or supersede (on a non-superseding ENTER).
ERISU%	5	Illegal sequence of UUOs (RENAME with neither LOOKUP nor ENTER, or LOOKUP after ENTER).
ERTRN%	6	1. Transmission, device, or data error (RUN, GETSEG only). 2. Hardware-detected device or data error detected while reading the UFD RIB or UFD data block. 3. Software-detected data inconsistency error detected while reading the UFD RIB or file RIB.
ERNSF%	7	Not a saved file (RUN, GETSEG only).
ERNEC%	10	Not enough core (RUN, GETSEG only).
ERDNA%	11	Device not available (RUN, GETSEG only).
ERNSD%	12	No such device (RUN, GETSEG only).
ERILU%	13	Illegal UUO (GETSEG only). No 2-register relocation capability.

Table E-1 (Cont)
Error Codes

Symbol	Code	Explanation
ERNRM%	14	No room on this file structure or quota exceeded (overdrawn quota not considered).
ERWLK%	15	Write-lock error. Cannot write on file structure.
ERNET%	16	Not enough table space in free core of monitor.
ERPOA%	17	Partial allocation only.
ERBNF%	20	Block not free on allocated position.
ERCSD%	21	Cannot supersede an existing directory (ENTER).
ERDNE%	22	Cannot delete a non-empty directory (RENAME).
ERSNF%	23	Sub-directory not found (some SFD in the specified path was not found).
ERSLE%	24	Search list empty (LOOKUP or ENTER was performed on generic device DSK and the search list is empty).
ERLVL%	25	Cannot create a SFD nested deeper than the maximum allowed level of nesting.
ERNCE%	26	No file structure in the job's search list has both the no-create bit and the write-lock bit equal to zero and has the UFD or SFD specified by the default or explicit path (ENTER on generic device DSK only).
ERSNS%	27	GETSEG from a locked low segment to a high segment which is not a dormant, active, or idle segment. (Segment not on the swapping space.)

Table E-2 shows the IPCF Error Returns.

Table E-2
IPCF Error Returns

Mnemonic	Code	Meaning
IPCAC%	1	;ADDRESS CHECK
IPCNL%	2	;NOT LONG ENOUGH
IPCNP%	3	;NO PACKET IN RECEIVE QUEUE
IPCIU%	4	;PAGE IN USE (VM)
IPCTL%	5	;DATA TOO LONG FOR USER'S BUFFER
IPCDU%	6	;DESTINATION UNKNOWN (RECEIVER'S PID)
IPCDD%	7	;DESTINATION DISABLED
IPCRS%	10	;NO ROOM IN SENDER'S QUOTA
IPCRR%	11	;NO ROOM IN RECEIVER'S QUOTA
IPCRY%	12	;NO ROOM IN SYSTEM STORAGE
IPCUP%	13	;UNKNOWN PAGE ON SEND; DUPLICATE PAGE ON RECEIVE (VM)
IPCIS%	14	;INVALID SEND PID

Table E-2 (Cont)
IPCF Error Returns

Mnemonic	Code	Meaning
IPCPI%	15	;PRIV INSUFFICIENT
IPCUF%	16	;UNKNOWN FUNCTION
IPCBJ%	17	;BAD JOB NUMBER
IPCPF%	20	;PID TABLE FULL
IPCPR%	21	;PAGE REQUESTED, NORMAL NEXT
IPCIE%	22	;PAGING I/O ERROR
IPCFU%	70	;[SYSTEM] INFO HAS AN UNKNOWN, INTERNAL ERROR
IPCCF%	71	;[SYSTEM] IPCF REQUEST FAILED
IPCFF%	72	;[SYSTEM] INFO FAILED TO COMPLETE AN ASSIGN
IPCQP%	73	;PID QUOTA EXCEEDED
IPCBP%	74	;BAD (UNKNOWN) PID
IPCDN%	75	;DUPLICATE NAME
IPCNN%	76	;NO SUCH NAME
IPCBN%	77	;NAME HAS ILLEGAL CHARACTERS

APPENDIX F
COMPARISON OF DISK-LIKE DEVICES

Table F-1
Disk Devices

Device Name	Fixed-Head Disk	Drum	Removable Disk Pack(s)	
Manufacturer	Burroughs	Bryant	Memorex, ISS	
Device Type	RD10	RM10B	RP02	RP03
Controller	RC10	RC10	RP10	RP10
Maximum Disks per Controller	4	4	8	8
Maximum Controllers per System	2	2	3	3
Hardware Mnemonic	DSK	DSK	DPC	DPC
Software Mnemonic	FHA, FHB	FHA, FHB	DPA, DPB, DPC	DPA, DPB, DPC
Capacity Minimum (X10**6 words)	.5	.345	5.2	10.4
Maximum (1 control) (X10**6 words)	2	1.38	41.4	82.8
Blocks/Track	20	30	10	10
Blocks/Cylinder	4000	2700	200	400
Blocks/Unit	4000	2700	40000	80000
Rotational Speed (rpm)	1800	3600	2400	2400
Revolution Time (msec)	33	17	25	25
128-Word Blocks/ Revolution	20	30	10	10
Transfer Rate μs word	13	4.3	15	15

Table F-1 (Cont)
Disk DEvices

Device Name	Fixed-Head Disk	Drum	Removable Disk Pack(s)	
Manufacturer	Burroughs	Bryant	Memorex, ISS	
Device Type	RD10	RM10B	RP02	RP03
Controller	RC10	RC10	RP10	RP10
Seek Time				
Average (msec)	0	0	50	50
Minimum (msec)	0	0	20	20
Maximum (msec)	0	0	80	80
Swapping Times (msec)		(includes 30 ms verify)		
1K	25	13	84	84
4K	73	27	144	144
10K	154	54	256	264
25K	358	120	589	589

NOTE

Although the Bryant drum is a drum in every sense, its software mnemonic is still FHA because it is connected to the system through the fixed head disk control.

APPENDIX G
MAGNETIC TAPE CODES

Table G-1
ASCII Codes and BCD Equivalents

ASCII	Character Symbol	BCD	ASCII	Character Symbol	BCD
040	blank	20	074	<	76
041	!	52	075	=	13
042	”	17	076	>	16
043	#	32	077	?	72
044	$	53	100	@	57
045	%	77	101	A	61
046	&	35	102	B	62
047	’	14	103	C	63
050	(	34	104	D	64
051	)	74	105	E	65
052	*	54	106	F	66
053	+	60	107	G	67
054	,	33	110	H	70
055	-	40	111	I	71
056	.	73	112	J	41
057	/	21	113	K	42
060	0	12	114	L	43
061	1	01	115	M	44
062	2	02	116	N	45
063	3	03	117	O	46
064	4	04	120	P	47
065	5	05	121	Q	50
066	6	06	122	R	51
067	7	07	123	S	22
070	8	10	124	T	23
071	9	11	125	U	24
072	:	15	126	V	25
073	;	56	127	W	26

Table G-1 (Cont)
ASCII Codes and BCD Equivalents

ASCII	Character Symbol	BCD	ASCII	Character Symbol	BCD
130	X	27	134	\	36*
131	Y	30	135	]	55
132	Z	31	136	↑	ILLEGAL
133	[	75	137	—	37

*Code used for all illegal codes.

When converting from ASCII to BCD, the following is done for ASCII codes 000-037 and 140-177:

000	ignored.
001-010	same as ASCII 134.
011	same as ASCII 040.
012-014	constitutes end of line.
015	ignored.
016-031	same as ASCII 134.
032	end of file.
033-037	same as ASCII 134.
140	same as ASCII 134.
141-172	same as ASCII 101-132.
173-176	same as ASCII 134.
177	ignored.

APPENDIX H
FILE RETRIEVAL POINTERS

Sequential and random file access are handled more efficiently by the monitor if all the information describing the file can be kept in core at once. To understand this effect, it is necessary to know how the monitor accesses files.

With each named file, UFD, and MFD, the monitor writes a special block containing necessary information needed to retrieve the data blocks that constitute the file. This block is called a retrieval information block, or RIB.

Retrieval pointers in the RIB describe contiguous blocks of file storage space called groups. Each pointer occupies one word and has one of three forms:

1. A group pointer
2. An EOF pointer
3. A change of unit pointer.

H.1 A GROUP POINTER

A group pointer has three fields:

1. A cluster count
2. A folded checksum
3. A cluster address within a unit. The width of each field may be specified at ONCE-only time; therefore, the same code can handle a wider variety of sizes of devices.

The cluster count determines the number of consecutive clusters that can be described by one pointer. The folded checksum is computed for the first word of the first block of the group. Its main purpose is to catch hardware or software errors when the wrong block is read. The folded checksum is not a check on the hardware parity circuitry. The size of the cluster address field depends on the largest unit size in the file structure and on the cluster size. A cluster address is converted to a logical block address by multiplying the number of blocks per cluster.

H.1.1 Folded Checksum Algorithm

This algorithm takes the low order n-bit byte, repeatedly adds it to the upper part of the word, and then shifts. The code is:

```
LOOP:   ADD     T1,T
        LDB     T,LOW ORDER N BITS OF T1
        LSH     T1,-N                       ;RIGHT SHIFT BY N BITS
        JUMPN   T1,LOOP
        DONE                                ;ANSWER IN T
```

This scheme eliminates the usual overflow problem associated with folded checksums and terminates as soon as there are no more bits to add.

H.2 END-OF-FILE POINTER

The EOF is indicated by a zero word.

H.3 CHANGE OF UNIT POINTER

A file structure may comprise more than one unit; therefore, the retrieval information block must indicate which unit the logical block is on. Because a file can start on one device and move to another, a method of indicating a change from one unit to another in the middle of the file is necessary. To show this movement, a zero count field indicates that the right half of the word specifies a change in unit. A zero count field contains a unit number with respect to the file structure. The first retrieval pointer, with respect to the RIB, always specifies a unit number. Bit 18 is 1 to guarantee that the word is non-zero; otherwise, it might be confused with an EOF pointer.

H.4 DEVICE DATA BLOCK

The monitor keeps a copy of up to six retrieval pointers in core at once. Therefore, if a file is allocated in six or less contiguous blocks (i.e., described in six or less pointers), all of the retrieval information can be kept in core and no additional accesses to the RIB are necessary.

H.5 ACCESS BLOCK

For each active file, the monitor keeps eight words of storage called an access block. These access blocks remain dormant in monitor core after a file is closed and are reclaimed only when the core space is needed. Therefore, if a 4-word LOOKUP is done after a file has been active, access to the UFD and RIB blocks will not require I/O.

INDEX

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