ComputerAutomation

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REAL-TIME EXECUTIVE (RTX)

USER'S MANUAL

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REVISION HISTORY

Revision	Issue Date	Comments
A0		Original issue.
A1 to E6		Misc. RTX/IOX updates.
F0	November 1976	Adds Magnetic Tape Intelligent Cable, Storage Module Disk, and IEEE Intelligent Cable IOX Handlers. Adds block diagrams for IOB, UAT, DIB and CIB. Adds IOX Handler listing.
F2	April 1977	Adds File Manager to IOX, and overall documentation cleanup.

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PART I

REAL-TIME EXECUTIVE (RTX)

SECTION 1

INTRODUCTION TO RTX

This section presents an overview of Computer Automation's Real Time-Executive (RTX) program which operates on all ALPHA-16 and LSI processors. The following discussion is concerned with three basic questions:

1. What is RTX?
2. When should RTX be used?
3. What does an application program look like?

1.1 WHAT IS RTX?

RTX is a modular package of service routines that handles both the overhead functions and the scheduling services associated with a real-time environment. Modular construction allows you to select only the portions of RTX required for your application. Real-time environment means that if your application requires that certain tasks be performed at selected intervals or in response to an external signal or event, then RTX will manage the orderly interruption and resumption of your program. RTX does all the overhead functions to maintain and direct the execution of your application during both normal and real-time processing.

RTX is also a powerful multi-task executive that controls all tasks of the overall application. These tasks include priority scheduling, response and assignment, interrupt servicing, and communication among RTX tasks and user-developed handlers. Overall task control:

1. Allows the application program to be designed as a number of either inter-related or subordinate tasks. The nature of the application determines the task relationships. RTX will completely handle the switching from task to task as required.

2. Allows the application program to dynamically define (and redefine) the priority level of the various tasks in the application using RTX service routines. This is a software priority which is then used by the RTX scheduler function to direct the sequence of task execution.

3. Allows RTX priority scheduling, response and assignment to share the computer among tasks with equal priority. When all tasks of the highest priority are temporarily waiting for some event to occur, the next highest priority level is scheduled in the same manner.

4. Allows response to interrupts, as generated, because the user provides the interrupt instructions which transfer control to an interrupt service routine. This interrupt service routine will save status (using an RTX function), perform the necessary instructions to assure no data loss, and then restore status (using an RTX function). This routine can also cause a lower priority routine to be

cheduled if additional processing of the interrupt data is required; the lower priority routine can be temporarily deferred until any higher priority tasks have had their turn at executing.

• Allows the various tasks in the application to communicate between themselves (or with RTX) through RTX communication routines. These routines allow a task to uniquely identify the communication request and then post it. Posting consists of presenting information to, or requesting information from, another task. This facility may be used to operate simply as a signaling device, or it may be as complex as both a signaling and parametric (pointer-passing) function.

ll of these RTX features combine to produce a multi-tasking, real-time scheduling xecutive that is, despite its small size, the most powerful and easy to use system f its kind on the market. Figure 1-1 illustrates a typical example of RTX.

.2 WHEN SHOULD RTX BE USED?

he most significant reason for using RTX is that your application program requires a ea ime environment. Real-time environments are found in many circumstances, ar ng from high speed data acquisition to occasional sampling of an electro- e nical device such as a relay. The basic criterion is that a need exists for the pplication to communicate with some external device or event in a time-dependent anner. If this criterion is met, then RTX is a suitable vehicle for defining the elationship between the external device or event and the application programming asks which control and service that device or event. Some of the more obvious pplications are:

. ommunications
    - Message Switching
    - Store-and-Forward
    - Networks
    - Reservation Systems

. Process Control
    - Plant Operations
    - Flow Monitoring
    - Equipment Direction
    - X-Y Positioning
    - Petro-chemical Applications

3. Data Acquisition
    - Test cells, such as automotive or airframe/aircraft
    - Traffic Control
    - Instrumentation Control
    - Source Data Entry
    - Oil Field Data Monitoring

4. Medical Data Processing
    - EKG/EEG Analysis
    - Patient Monitoring
    - Cardiac Monitoring
    - Patient Billing

5. Security Systems
   - Plant/Facility Security
   - X-Ray Security Systems
   - Video Transmission Systems

6. Financial Transactions
   - Point-of-Sale
   - Automatic Banking
   - Inventory Control

1.3 WHAT DOES AN APPLICATION PROGRAM LOOK LIKE?

RTX allows the user to construct his application in modules. These modules are then combined with RTX during the loading process to produce the final application program. The user may choose any arrangement of his program into modules that suit his needs. Figure 1-1 shows a general diagram of this type of arrangement. This modularity concept applies not only to the user's application, but also to RTX itself. The RTX package is simply a library of separate subroutines which may be referenced by the user's modules; certain of the RTX subroutines in turn reference others, and the linking of all required modules (performed by the LAMBDA loader or by the OS:LNK program) results in a configuration consisting of only those modules needed for the application. Figure 1-2 shows how the modules and user programs are loaded into memory and the size of the individual RTX modules. Keep in mind that the only RTX modules actually loaded for a given program will be the ones required by the particular program.

1.4 DEFINITIONS

1. Activity: A task which has been initialized (via BEGIN: for example) and is receiving support from RTX.

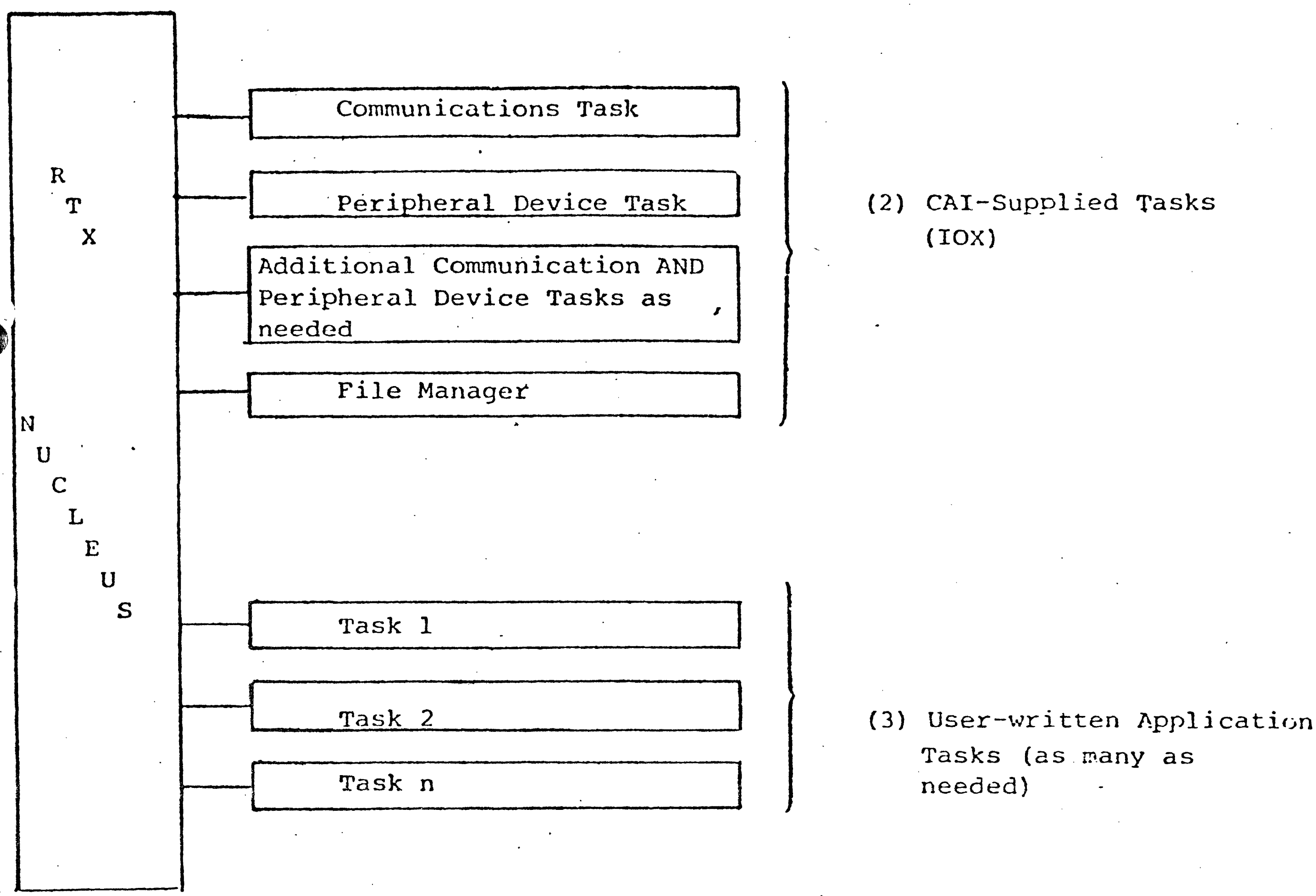
2. Common Subroutines: Subroutines which may be used by two or more different activities concurrently. These require special coding to provide reentrant capability.

3. Coordination Number: A decimal integer used to identify a task to RTX. It is analagous to a telephone number in that it is used to "connect" a task to another task or to the DELAY: process.

4. Interrupt Data Processing: That portion of code that processes the data obtained by an Interrupt Service routine.

5. Interrupt Service: That portion of code that must be executed immediately after the interrupt occurs (so as not to lose data). It should be limited to only that code which is necessary to assure no data loss.

6. Inter-Task Coordination: A method for tasks to communicate and pass parameters using two 16-bit computer words. These words may contain any information, such as a table address, a pointer to a list of values, or a value itself.



(1) RTX Nucleus provides control, scheduling, priority handling.
(2) CAI-supplied tasks provide handlers for I/O (such as printers, tapes, etc.,), for communications (such as BISYNC, ASYNC, etc.), and others.
(3) The user need only supply tasks which perform his application's work, while utilizing the CAI-supplied software for support.

Figure 1-1. Typical Example of RTX

ADDRESS	MEMORY	MODULE SIZE	
:0000	Literals and Interrupts	Scratch Pad = :100	
:00FF	User - Mainline (i.e., RTX Initialization), Tasks, Data/Work Areas and Interrupt Service Routines	User Programs	
	IOX - TTY, Line Printer, CRT and Paper Tape Tables and Drivers	:200+	RTX/IOX Library Segment 1
	IOX - Card Reader and Mag Tape Tables and Drivers	:180+	RTX/IOX Library Segment 1
	IOX - Disk Tables and Drivers	:260+	RTX/IOX Library Segment 1
	IOX Scheduler	:A0	RTX/IOX Library Segment 1
	RTX Nucleus RTX:, BEGIN:, END:, ..., List Pinters and Scheduler	:C0	RTX/IOX Library Segment 1
	Debug (ZBG)	:2D4	RTX/IOX Library Segment 2
	IOX Controls IONIT:, EOR:, EOF:, SIO:, ..., SINT:, IO: and EOFCK:	:290	RTX/IOX Library Segment 2
	RTX Services DECPR:, DELAY:, GET:, PUT:, ..., SUBR:, SUBX:, INTG: and RTOSZ:	:130	RTX/IOX Library Segment 2
:nFFF	File Manager	:600	RTX/IOX Library Segment 2

Figure 1-2. RTX Software Configuration

7. Main Line: A short initializing sequence which resets all task table pointers, and then begins one or more tasks. (Tasks may also be begun by other tasks, or upon an interrupt from an external device.)

8. Priority: A software defined method for assigning (and re-assigning) the relative importance of a task to RTX.

9. Re-entrant Programs: A program specifically written such that it may be directly entered by more than one program, concurrently. Under RTX, this is necessary only if two or more Interrupt Service routines require immediate use of the same program. For example, Interrupt Service A calls routine C. While C is executing, Interrupt Service B becomes active and also calls routine C. If C were not re-entrant, this second call to C would replace the return address at C's entry point, causing the return address for routine A to be lost.

10. Task: A program or set of programs which operate to perform a specific function within the real-time application.

11. Work Area: An area of storage dedicated to table space for RTX. This table contains all the necessary information for RTX to perform its functions. Its usage is dynamic and is dependent upon the maximum concurrent usage of RTX functions.

SECTION 2

RTX ORGANIZATION

RTX is basically a collection of functions (subroutines) and a user-supplied work area, which are linked to the user's Mainline sequence and tasks prior to execution. Each RTX function may be called as a subroutine by the user as it is needed, to perform a specific job. (See below for descriptions and calling sequences of these functions.) RTX also includes a task scheduler (SCHED:) which is used to execute the task of highest priority. The priority of a task is defined when the task is begun, and may be changed by the task, using the SETPR:, INCPR:, and DECPR: functions. Priorities may range from 1 to 8191, with larger numbers representing the higher priority.

The scheduler maintains a "Ready" list of each task in order of priority. The highest priority task is executed until it suspends itself by calling any of the following RTX functions:

DELAY:	(unless altering or cancelling a previous delay)
GET:	(if no corresponding PUT: yet, and not a cancel call)
SUBR:	(if the common subroutine is busy)
PAUSE:	(essentially reschedules the pausing task at the same priority)
IO:	(BEGINs, at I/O completion time, the normal or abnormal return at the same priority)
SETPR:	(if the new priority is lower than that of another task)
DECPR:	(if the new priority is lower than that of another task)

Once the task has been suspended, RTX executes the new highest priority task. The rule for determining the highest of equal priority tasks is, "first in - first out". Thus, if a task suspends itself, it thereby becomes "last in" within its priority.

In addition to the user-invoked suspends listed above, occurrence of an interrupt will cause a task to be suspended, if the new priority is higher than that of the current task. An interrupt is defined to be:

1. A hardware (external) interrupt, with INTQ: or INTAC: attached, or

2. A software (internal) interrupt:

   a DELAY: expiring
   a PUT: which satisfies an outstanding GET:
   a SUBX, UNLK:, or UNPR:, with a higher priority task waiting

In addition, an Input Output Executive package (IOX) is available, which may be linked to run in conjunction with RTX. Its function is to perform I/O operations to the standard CAI I/O devices (teletype, high speed paper tape reader and punch, card reader, magnetic tape units, and disk) and resolve confilicts of concurrent I/O [illegible]lization.

A File Manager operates in conjunction with IOX. It enables the user to communicate with data files by name, independent of the physical medium storing the file. Requests for access are made through IOX using Logical Units (LUNs).

2.1 WORK AREA (USER BLOCKS)

The user must supply a contiguous work area for RTX to build its tables. The address and length of this work area is specified in the call to the RTX: function. It is grouped by RTX into blocks of five words each, and there must be at least two of these blocks (10 words) reserved; otherwise an error return will be made from the initialization routine. Table 2-1 gives a list of the RTX functions which allocate a[illegible] de-allocate this area. The left hand column denotes the number of blocks allo-c[illegible]d (+) or de-allocated (-) by the function in the right-hand column. The user [illegible]st supply sufficient work area for the maximum number of five-word blocks which may be allocated at any one time.

2.2 RTX FUNCTIONS:

2.2.1 Initialize Work Area (RTX:)

Calling Sequence:

```
N          EQU        (NUMBER OF TASK BLOCKS)
WKAREA     RES        N+N+N+N+N,0       AREA FOR BLOCKS

           JST        RTX:
           DATA       N                 # OF CONCURRENT ACTIVITIES
           DATA       WKAREA
           ERROR      RETURN            WORK AREA EXCEEDED
           NORMAL     RETURN
```

Returns With:

```
INTERRUPTS ENABLED
OVERFLOW RESET
WORD MODE
A REGISTER --- CURRENT RTX REVISION NUMBER IN ASCII
X REGISTER --- CURRENT RTX REVISION NUMBER IN ASCII
```

This subroutine is called in the user's Mainline sequence to initialize the working area of RTX. The work area is broken into N blocks of five words each, which are then used by the remainder of RTX during system operation. The number N must be large enough to allow for all concurrent activities. Work area overflow will cause a jump to the RTX: routine's error return at any subsequent time during the running of the program, not just during the call to RTX:.

NOTE

A call to this subroutine causes activation of the RTX Scheduler. Upon return, the calling program (normally the user's Mainline sequence) is thenceforth considered a task with a priority of 8172.

In addition to initializing the work area, the RTX: subroutine can also reset all I/O tables, if desired; this feature will insure restartability of a user's program. The feature may be referenced in the user program, if restart capability is required; otherwise it may be omitted, thereby shortening the overall length of the program. (Upon initial loading, I/O reset is not required before execution.)

To include this feature in the RTX: subroutine, simply reference the module "IONIT:" in the Mainline sequence; either of the following directives:

```
IONIT: REF
    or
LOAD IONIT:
```

will serve this purpose.

2.2.2 Initiate New Task (BEGIN:)

Calling Sequence:

```
JST       BEGIN:
DATA      (*) START ADDRESS OF NEW TASK
DATA      PRIORITY OF NEW TASK
```

Returns With:

```
INTERRUPTS --- ENABLED
OV --- UNCHANGED
A REGISTER --- UNCHANGED
X REGISTER --- UNCHANGED
```

NOTE

When the new task starts executing, the A and X registers will contain the values at the time of the JST to BEGIN:, OV will be reset, and the computer will be in word mode.

This subroutine is called to initiate a new task. The task is scheduled and BEGIN: then exits to the task Scheduler. This means that the calling program will not receive control back immediately if the new ("begun") activity is of higher priority, or if another task of higher priority is ready to begin execution.

Table 2-1. User Blocks for RTX Functions

No. of Blocks	Function
+1	RTX:
+1	BEGIN:
-1	END:
0	PAUSE:
+1	PUT: (If a new, unique PUT: and no corresponding GET: is waiting for it)
0	PUT: (If a new unique PUT: and the corresponding GET: is already waiting for it)
0	PUT: (To change the information in a previous PUT:)
-1	PUT: (To cancel an outstanding PUT:)
0	GET: (If a new, unique GET: and no corresponding PUT: is waiting for it)
-1	GET: (If a new, unique GET:, and the corresponding PUT: is already waiting for it)
-1	GET: (To replace a previous task currently waiting for a PUT: with the current task; the new GET: must be called with the same coordination number as the task to be replaced)
-1	GET: (To cancel an outstanding GET:)
0	DELAY: (To initiate a new delay)
0	DELAY: (To change the length of an outstanding delay)
-1	DELAY: (To cancel an outstanding delay)
0	INTSV:
0	INTRS:
+1	INTAC:
+1	INTQ:
+1	SUBR: (If the common subroutine is not already in use)
0	SUBR: (If the common subroutine is already in use)

Table 2-1. User Blocks For RTX Functions (Continued)

No. of Blocks	Function
-1	SUBX: (If no other tasks are waiting to use the common subroutine)
0	SUBX: (If one or more tasks are waiting to use the common subroutine)
+1	PROT: (If the facility is not already protected)
0	PROT: (If the facility is already protected)
-1	UNPR: (If no other tasks are waiting to protect the facility)
0	UNPR: (If one or more tasks are waiting to protect the facility)
+1	LOCK: (If the facility is not already locked)
0	LOCK: (If the facility is already locked)
-1	UNLK: (If no other tasks are waiting to LOCK: the facility)
-1	ABORT: (In addition, -1 for each resultant SUBX: call where no other tasks are waiting to use the common subroutine, and -1 for each resultant UNPR: and UNLK: call where no other tasks are waiting to PROT: or LOCK: the facility)
0	GETPR:
0	SETPR:
0	INCPR:
0	DECPR:
0	IOREL:
0	IOWAT:
3 or 4	IO: (as follows:) +1 For the immediate return +1 For scheduling +1 For setting a watchdog timer +1 If I/O completes before scheduling completes

NOTE

Priorities are integers from 0 (lowest) to 8191 (highest). Users should limit priority to less than 7000 because certain RTX functions use those of 7000 and higher.

.2.3 Terminate Current Task (END:)

Calling Sequence:

```
JST      END:
```

he current task may terminate itself with a call to END:. No arguments are required nd control will not return.

NOTE

The Mainline sequence (as a result of the JST to RTX:) has a priority of 8172. This sequence should begin other necessary tasks and then terminate itself by a call to END:. If it does not terminate, no tasks of a lower priority can execute.

.2.4 Suspend Current Task (PAUSE:)

Calling Sequence:

```
JST      PAUSE:
```

Returns With:

```
INTERRUPTS --- ENABLED
STATUS --- UNCHANGED
A REGISTER --- UNCHANGED
X REGISTER --- UNCHANGED
```

This subroutine is called by a program which desires to allow other tasks at the same priority level to get service. This is useful if a program is unusually long or is a closed loop. PAUSE: is essentially similar to a BEGIN:, END: pair, but is less demanding on work area space in RTX.

NOTE

Programs which loop indefinitely are permissible, but should be used carefully since they will block execution of all activities of a lower priority. Tasks should begin in response to a stimulus, generate the appropriate reaction, and end.

2.2.5 Coordination Numbers

Before discussing GET:, PUT:, and DELAY: the concept of coordination number must be understood. A coordination number is a 16-bit value which is supplied as an argument to GET:, PUT:, DELAY:, PROT:, UNPR:, LOCK:, UNLK:, IO: and IOREL:. This number serves to identify the activity so that it may be referenced by a later call.

For GET:, PUT: AND DELAY:, the same coordination number used in the same type of call supersedes the previous call. The negative (2's complement) of a coordination number cancels the previous call. FORTRAN uses the following coordination numbers, and the designer should avoid their re-use:

F:RBPG address (for LOCK:)
:FFDC (for LOCK:)

In addition, all DELAYs performed in IOX and COMX use memory addresses as coordination numbers. These memory addresses fall within the IOX or COMX boundaries, or their associated tables (CIB's). Thus, it is strongly suggested that the system designer follow this practice, and use as coordination numbers, only memory addresses of locations within his program. Basically, it is the system designer's responsibility to allocate coordination numbers so that no conflicts arise.

NOTE

Zero has no separate identifiable two's complement, and therefore a coordination number of zero should not be used.

2.2.6 Inter Task Coordination (PUT:/GET:)

These two facilities are generally used together as a pair. In general, PUT: passes 32 bits (the A and X registers) to a GET:. Coordination numbers are used to insure proper reference. There are no timing restrictions on associated PUT:/GET: pairs. (If a task calls GET: before another task has made the corresponding PUT: call, the GETting task will suspend until the PUT: is made.)

PUT:

Calling Sequence:

```
JST       PUT:
DATA      COORDINATION NUMBER
```

Returns With:

INTERRUPTS --- ENABLED
STATUS --- UNCHANGED
A REGISTER --- UNCHANGED
X REGISTER --- UNCHANGED

This subroutine is called to do one of three things:

1. Pass 32 bits to another task; call PUT: with the same (positive) coordination number which will be used in the call to GET;

. Change the information in a previous PUT:; call PUT: with the same coordination number used previously.

. Delete an outstanding PUT:; call PUT: with the 2's complement of the coordination number of the PUT: to be deleted.

NOTE

> If a PUT: is issued before the associated GET: is called, one block is used from the work area in RTX. If the GET: is called first no additional demands are made on the work area.

ET:

Calling Sequence:

```
JST       GET:
DATA      COORDINATION NUMBER
```

Returns With:

```
INTERRUPTS --- ENABLED
STATUS --- UNCHANGED
A REGISTER --- FROM ASSOCIATED PUT
X REGISTER --- FROM ASSOCIATED PUT
```

his subroutine is called for one of three reasons:

. To obtain 32 bits (A and X registers) from another task: call GET: with the positive coordination number to be used with PUT:.

. To delete a task currently in a GET: waiting for the associated PUT:; call GET: with the 2's complement of the coordination number.

. o replace a task currently waiting for a PUT: with the current task; call GET: with the same coordination number as the task to be replaced.

ft GET: is called, control will not be returned until the associated PUT: is ssued.

.2.7 Delay Current Task (DELAY:) (Requires Real-Time Clock Option)

Calling Sequence:

```
JST       DELAY:
DATA      # OF TICKS ON THE CLOCK FOR DELAY
DATA      COORDINATION NUMBER
```

Returns with:

```
INTERRUPTS --- ENABLED
STATUS --- UNCHANGED
```

If deleting or changing an outstanding delay:

A REGISTER --- UNCHANGED
X REGISTER --- UNCHANGED

If actually executing a delay:

A REGISTER --- COORDINATION NUMBER
X REGISTER --- UNDEFINED

This subroutine is called for one of three reasons:

1. To delay the current task for a specified period of time. (The number of ticks referred to above is the number of time interrupts from the Real-Time Clock. These interrupts normally occur every 10 msec but may be changed by a jumper wire. (See the appropriate ALPHA-16 or ALPHA LSI Computer Reference Manual). For this call, supply a currently unused positive coordination number.

2. To delete an outstanding delay. A call to DELAY: with the 2's complement of the coordination number of any current delay will delete the delay request (and the task that called it). This is useful for deleting a watchdog routine.

3. To change an outstanding delay. A call to DELAY: with the coordination number of a currently active delay will change the outstanding delay. This is equivalent to deleting a task in a delay and immediately starting the same task with a new delay.

SECTION 3

INTERRUPT PROCESSING

Most interrupt service routines can be divided into two sections. First, the recognition that the requesting device usually has an immediate need which will result in data being lost if it is not met. Second, a subsequent need to perform some processing upon that data. In the case of output, the device may not continue to operate at full speed if its request is not answered within a certain interval. After meeting this very high-speed requirement, the need for continued rapid servicing diminishes considerably, until the next request is made.

RTX provides two alternative methods for interrupt service. One is the INTQ: service, which combines the functions of saving status, queueing or scheduling of support tasks, and then dismissing the interrupt since it has been honored. The second is to use the INTSV:, INTAC:, and INTRS: services to provide each of those three functions separately. Use of these three functions is described below.

Upon receiving control after an interrupt, the interrupt handler should immediately call INTSV:, to preserve the register status. When control returns, the handler may utilize the registers as required. Processing, at this point, should be restricted to the very high speed "lost data" requirements. The handler may then schedule other activities, by calling INTAC:, with the start address and priority as arguments. Processing is ended for this phase, by issuing a call to INTRS:, which resumes processing. Normally, the newly scheduled activity will have a high priority. Note, however, that the programmer may assign this priority, as distinct from those systems where the hardware has the device priorities wired in. When the scheduled processing activity receives control, it will be considered a normal activity, and may make use of all RTX functions. Interrupts will be enabled, so that other devices which require service may receive control during their "lost data" intervals, after which the System Scheduler will return control to the highest priority processing program.

The A and X register are passed between the scheduling and the scheduled routines, so that word or byte transfer devices can pass the data itself to the processing programs. After the processing program has finished its task, it may terminate, or it may schedule other responding tasks.

By using INTSV: and INTRS: to save and restore status, the user is relieved of one of the most important and error-prone types of coding. With INTAC:, he can schedule routines which are normal, interruptable programs, and which can utilize all of RTX's capabilities.

Note that the INTSV:, INTRS:, INTAC:, and INTQ: routines are necessary only for the user who is using RTX in conjunction with his own special (non-standard) device and has written his own interrupt handler for it. The RTX I/O Executive (IOX), discussed in Chapter 2 of this manual, contains the necessary I/O handler routines for the standard CAI-supplied I/O devices (card reader, teletype, high speed paper tape punch and reader, magnetic tape, disk and floppy disk). These standard handlers within IOX make use of the INTQ: routine internally.

3.1 SAVE ENVIRONMENT (INTSV:)

Calling Sequence:

```
JST      INTSV:      INTERRUPTS MUST BE DISABLED
DATA     *PLOC       LOCATION OF ENTRY POINT TO INTERRUPT ROUTINE
```

Returns With:

```
INTERRUPTS---STILL DISABLED
STATUS---OV RESET, WORD MODE
A REGISTER---SAVED P REGISTER
X REGISTER---UNCHANGED
```

his subroutine must be called by an interrupt subroutine to save the current nvironment.

.2 ESTORE ENVIRONMENT (INTRS:)

Calling Sequence:

```
JST      INTRS:
---      DOES NOT RETURN
```

his subroutine is called by an interrupt subroutine to exit. If RTX was interrupted, ontrol is returned to RTX. Otherwise, task control is moved to the block at the top f t scheduler ready chain and the system Scheduler is entered.

. INITIATE A NEW TASK FROM AN INTERRUPT SUBROUTINE (INTAC:)

Calling Sequence:

```
JST      INTAC: (MUST BE IN WORD MODE)
DATA     (*) START ADDRESS
DATA     PRIORITY
```

eturns With:

```
INTERRUPTS---UNCHANGED
OV---INDETERMINATE
A REGISTER---DESTROYED
X REGISTER---DESTROYED
```

3.4 INTERRUPT SERVICE AND QUEUE TASK (INTQ:)

This service may be used in place of the INTSV:, INTRS:, INTAC:, sequence. It is functionally identical to the combination of those three services when they are used as follows:

```
SUBENT      ENT
            JST     INTSV:            SAVE ENVIRONMENT
            DATA    *PLOC
            JST     INTAC:            QUEUE "TASKC" AT "PRIOR"

            DATA    TASKC, PRIOR

            JST     INTRS:            DISMISS INTERRUPT AND GO TO RTX
                                      SCHEDULER
```

The advantage to using INTQ: is that it is faster; i.e., it shortens the period of time during which interrupts are disabled.

Calling Sequence:

```
            JST     INTQ:
            DATA    $,0,0,0           CALLING LOCATION, 3 TEMPS REQUIRED

            DATA    TASK-ADDRESS      FOR TASK WHICH IS QUEUED
            DATA    PRIORITY          FOR QUEUED TASK
            DATA    A-REGISTER        VALUE PASSED TO QUEUED TASK IN A
            DATA    X-REGISTER        VALUE PASSED TO QUEUED TASK IN X
            DATA    P-LOC             LOCATION OF SAVED P-REGISTER AT
                                      TIME OF INTERRUPT
```

Returns With:

DOES NOT RETURN. QUEUES TASK FOR SCHEDULER AND DISMISSES INTERRUPT.

ample Usage

1. Interrupt for End-of-Block

```
EOBENT      ENT                       VECTORED INTERRUPT
            JST     INTQ:
            DATA    $,0,0,0
            DATA    TASKB,PRIORB,0,0,EOBENT
```

2. Interrupt for Data (Input) Ready

```
DATENT    ENT                     VECTORED INTERRUPT
          SIN     3               BLOCK BYTE MODE
          STA     AREG            SAVE A-REG
          INA     ADDR,FCN        INPUT THE DATA VALUE
          EMA     AREG            RESTORE PROPER A-REG AND PASS INPUT
                                  VALUE TO QUEUED TASK
          JST     INTQ:
          DATA    $,0,0,0
          DATA    TASKA,PRIORA
AREG      DATA    0               A-REG VALUE FOR TASK
XREG      DATA    0               X-REG VALUE FOR TASK
          DATA    DATENT          RETURN POINTER FROM INTERRUPT
```

3.5 COMMON SUBROUTINES (REENTRANCE)

Normally, different activities are independent of each other. However, it is not unusual to have two unrelated programs use the same utility subroutines, therefore defining a "common" subroutine. One example would be mathematical functions library routines. Rather than duplicating copies in each using program, a single copy is loaded, and entered with subroutine calls (JST instructions). If control is within the common subroutine when an interrupt occurs, and another program gains control and re-calls the subroutine, the second call will destroy the return location of the first. When control finally returns to the middle of the interrupted subroutine (clearing the interrupt), it will complete its execution, and again return to the second caller. The original caller never sees control come back. The later caller gets two returns from one call. This dilemma is referred to as the common subroutine problem, and it occurs in any system which allows interrupt processing. It is solved in different ways. Most simply, common subroutines can be forbidden. Alternatively, push-down stacks are utilized, scratch storage is forbidden, (except in the stack), and the programming task is made significantly more imposing.

RTX has implemented an alternative solution to this problem, that of a "shared" facility. In our context a shared facility is a body of code which may be called concurrently from more than one task. In this sense, a shared facility is then common to several tasks.

The implementation consists of two services which are contained in RTX. These are:

SUBR: To initiate the execution of a shared facility
SUBX: To return from a shared facility

To illustrate usage of these services, consider the following example. If the subroutine CUP is a common subroutine to two tasks (named COFFEE and TEA), then it is possible that an interrupt could occur which causes task COFFEE to execute before task TEA Finished. This means that subroutine CUP could be entered from COFFEE before it completed the processing due to its prior entry from TEA. In this case, subroutine CUP is in common usage. It is designated as a shared facility and must be esigned to accomodate that condition. The method here is to use the following sequence of code in both COFFEE and TEA whenever it is desired to call subroutine CUP:

```
        JST     SUBR:           ACTUALLY CALL SUBR: SERVICE
        DATA    CUP             NAME OF COMMON SUBROUTINE
```

instead of the usual method

```
        JST     CUP
```

NOTE

NEVER call a common subroutine directly; that is, with a JST name. ALWAYS call a common subroutine using

```
        JST     SUBR:           CALL THE SUBR: SERVICE
        DATA    NAME            NAME OF COMMON SUBROUTINE
```

(or using the LOCK: or PROT: routines described below).

3.6 WRITING COMMON SUBROUTINES

The rules for writing a common subroutine are very simple. They apply to the subroutine exit instruction. There are two rules:

1. Instead of the traditional RTN instruction, use a JMP to the location directly before the subroutine entry point.

2. In the location directly before the subroutine entry point, place a JST SUBX:.

Use of these two rules will allow an orderly exit from the common subroutine. In our previous example, subroutine CUP looks like this:

```
                NAM     CUP
                EXTR    SUBX:
                JST     SUBX:
CUP             ENT                     ENTRY TO COMMON ROUTINE CUP
                JMP     CUP-1           EXIT COMMON ROUTINE
```

When SUBR: and SUBX: are used, all subsequent calls to the common subroutine are "locked out" until the current call to the subroutine has completed and the jump to SUBX: has been made. Then, each subsequent call (made while the common subroutine was busy) is completed in priority order.

If this procedure is not followed, the system behavior will appear to be very erratic. Although the system will probably correct itself, when the doubly-returned task finally terminates, one activity has been lost, and one has been duplicated, probably incorrectly. If the user understands this section thoroughly, he can have the convenience of library subroutines, without the difficulty of accidental re-entry.

3.7 CALL A COMMON SUBROUTINE (SUBR:)

This subroutine is called by a user task to schedule a subroutine which may be used by more than one task.

NOTE

This subroutine does not return directly to the calling program. It exits through the Scheduler (SCHED:).

Calling Sequence:

```
JST     SUBR:
DATA    (*) ADDRESS OF COMMON SUBROUTINE
```

Enters Subroutine With:

```
INTERRUPTS---ENABLED
STATUS---UNCHANGED
A REGISTER---UNCHANGED
X REGISTER---UNCHANGED
```

NOTE

The return address put in the entry point of the common subroutine is the location following the data in the above call. That is, it appears to the subroutine as if it were called from the location of its address (Not the location of the "JST SUBR:").

3.8 EXIT FROM COMMON SUBROUTINE (SUBX:)

This subroutine is called from within a common subroutine to return to the calling task.

NOTE

This subroutine does not return directly to the calling program. It exits through the Scheduler (SCHED:).

Calling Sequence

```
          JST       SUBX:
SUB       ENT
                    where:    SUB is the entry point of the common
                              subroutine.  This call must immediately
                              precede the entry so that RTX can keep
                              its chains straight.
          JMP       SUB-1     RETURN
```

Returns to calling task with:

INTERRUPTS--ENABLED
STATUS---UNCHANGED
A REGISTER---UNCHANGED
X REGISTER---UNCHANGED

NOTE

Each SUBR: call made <u>must</u> have a corresponding call made to SUBX: once the routine has completed. If a call to END: (to terminate the calling task) is made from within a subroutine called by SUBR:, all other tasks will be permanently denied the user of that routine. To terminate a task from within a SUBR'd subroutine, the ABORT: routine should be used.

3.9 PROTECT A FACILITY (PROT:)

PROT: is called by a user's subroutine to protect itself from usage by other tasks. It is in a way similar to SUBR: in that reentrance to a common subroutine is prevented during its usage; however, in SUBR:, the determination to protect the subroutine is made by the <u>calling program</u>, while in PROT:, the determination is made by the subroutine itself.

Calling sequence:

```
            DATA    0
SUB         ENT
            JST     PROT:
            DATA    $-3
```

The call to PROT: <u>must</u> be the first instruction following the entry point. The temp cell SUB-1 is used by PROT: to store the contents of SUB (the return address from the caller). Note that exiting from the routine SUB must be done via the return address in SUB-1, not the address in SUB.

Returns with:

INTERRUPTS---ENABLED
STATUS---UNCHANGED
A-REGISTER---UNCHANGED
X-REGISTER---UNCHANGED

PROT: may be called more than once using the same coordination number by the same task. However, a <u>different</u> task is effectively locked out of the subroutine until it is released by executing a call to UNPR:.

NOTE

The INTRS: and INTQ: subroutines contain logic to preclude task-switching caused by an interrupt occuring immediately before a JST LOCK: or JST PROT: instruction. This involves checking the interrupted instruction to see if it is a JST LOCK: or JST PROT:. This check is effective only if the instruction is a JST indirect through a base page pointer to LOCK: or PROT:; that is, an :F9xx instruction. To insure this protection feature, reference LOCK: or PROT: by means of an EXTR directive, rather than a REF directive. This also implies that if EXTR directives are used in conjunction with the LPOOL directive, then an EXTR LOCK: or EXTR PROT: must be accompanied by a SPAD LOCK: or SPAD PROT: directive to insure that the pointer remains in the base page.

3. RELEASE A PROTECTED FACILITY (UNPR:)

UNPR: is called by a common subroutine to delete its protected condition caused by a previous call to PROT:

Calling Sequence:

```
            JST       UNPR:
            DATA      Coordination Number
```

Returns with:

```
      INTERRUPTS---ENABLED
      STATUS---UNCHANGED
      A-REGISTER---UNCHANGED
      X-REGISTER---UNCHANGED
```

In effect, RTX treats the address of a common subroutine (as used in SUBR: and SUBX:) as a coordination number. These are shared with the coordination numbers used by PROT: and UNPR:. That is, the list in which the common subroutine addresses are saved for SUBR: is the same list that saves the coordination numbers for PROT: and LOCK:. Results will be unpredictable (and probably disastrous) if the coordination number used by PROT:, UNPR:, LOCK: or UNLK: is also the address of a common subroutine (called by SUBR:).

Because RTX maintains a single list for PROT: and LOCK: coordination numbers and SUBR: common subroutine addresses, an alternative method for writing common subroutines exists. The rules for this type of common subroutine are:

1. Instead of the standard "RTN SUB" instruction, use a "JMP SUB-2".

2. In the 2 locations directly before the subroutine entry point, place:

```
      JST        SUBX:
      RES        1
```

3. In the two locations immediately following the subroutine entry point, place:

```
JST         PROT:
DATA        SUB-1
```

4. Because PROT: moves the return address from SUB to SUB-1, references to parameters must be made through SUB-1, rather than SUB. For example, a typical routine, that adds the arguments presented to it and returns the sum in the A register, would normally be coded as follows:

Calling Sequence:

```
                JST         ADDM
                DATA        3
                DATA        4

ADDM            ENT
                LDA         *ADDM
                IMS         ADDM
                ADD         *ADDM
                IMS         ADDM
                RTN         ADDM
```

NOTE

This may not be used as a common subroutine because it has no protection from re-entrance.

Using the SUBR: common subroutine feature, the routine would appear as follows:

Calling Sequence:

```
                JST         SUBR:
                DATA        ADDM
                DATA        3
                DATA        4

                JST         SUBX:
ADDM            ENT
                LDA         *ADDM
                IMS         ADDM
                ADD         *ADDM
                IMS         ADDM
                JMP         ADDM-1
```

The alternative method, using the PROT: common subroutine feature, is as follows:

Calling Sequence:

```
                JST       ADDM
                DATA      3
                DATA      4

                JST       SUBX:
                RES       1
      ADDM      ENT
                JST       PROT:
                DATA      ADDM-1
                LDA       *ADDM-1
                IMS       ADDM-1
                ADD       *ADDM-1
                IMS       ADDM-1
                JMP       ADDM-2
```

The advantages of the last example, using the PROT:/SUBX: sequence, are:

1. The calling sequence is shorter than that calling SUBR: (the standard JST SUB is used).

2. The burden for insuring that the subroutine is common (re-entrance protected) lies solely with the subroutine writer, not the subroutine caller.

3. If the subroutine is capable of stacking multiple return addresses (not shown in this example), the subroutine is then recursive, and may call itself. (Note that if recursive, SUBX: should only be called on the last return (use RTN SUB-1 for all returns but the last)).

3.11 LOCK OUT A FACILITY (LOCK:)

LOCK: was designed for use by Real Time FORTRAN, and is similar to PROT:. The only difference between them is that the return address from the subroutine is stored in the location following the coordination number, instead of the location in front of the entry point, e.g.:

Calling Sequence:

```
      SUB       ENT
                JST       LOCK:
                DATA      Coordination Number
                DATA      0            (Return address stored here)
```

Returns With:

INTERRUPTS---ENABLED
STATUS---UNCHANGED
A-REGISTER---UNCHANGED
X-REGISTER---UNCHANGED

The JST to LOCK: does not need to be placed immediately following the subroutine entry point, although JST to PROT: does.

The user should reference the LOCK: or PROT: subroutine with an EXTR directive, rather than a REF directive. See the note in the PROT: description regarding this.

Note that the PROT:/SUBX: example shown above does not apply to LOCK:.

3.12 UNLOCK A LOCKED FACILITY (UNLK:)

UNLK: is similar to UNPR:. However, UNLK: permits the common subroutine to complete processing, then returns control to the calling task, while UNPR: returns through the Scheduler to the Ready list for the next task on the list.

3.13 ABORT A TASK (ABORT:)

ABORT: is called from within a common subroutine to terminate the task which called the subroutine.

In addition to performing the END: function, ABORT: also deletes any PROT:, LOCK: or SUBR: conditions previously set by the aborted task.

Calling Sequence:

```
JST           ABORT:
```

ABORT: exits to the scheduler (SCHED:).

NOTE

> The duration of an ABORT: call is significantly longer than an END: call, and therefore it should be called only if in a common subroutine, or in a PROTected or LOCKed condition.

3.14 OBTAIN CURRENT PRIORITY (GETPR:)

Calling Sequence:

```
JST           GETPR:
```

Returns With:

INTERRUPTS---ENABLED
STATUS---UNCHANGED
A REGISTER CONTAINS TASK PRIORITY
X REGISTER---UNCHANGED

The subroutine is called to get the current priority of a task. It is usually called so that a task's priority may be restored after it is temporarily altered.

3. SET TASK PRIORITY (SETPR:)

Calling Sequence:

```
LDA            DESIRED PRIORITY
JST            SETPR:
```

Returns With:

```
INTERRUPTS---ENABLED
STATUS---OV RESET, WORD MODE
A REGISTER---UNCHANGED
X REGISTER---UNCHANGED
```

This subroutine is called whenever a task desires to alter its priority.

3.16 INCREMENT TASK PRIORITY (INCPR:)

Calling Sequence:

```
JST            INCPR:
```

Returns With:

```
INTERRUPTS---ENABLED
STATUS---UNCHANGED
A REGISTER---UNCHANGED
X REGISTER---UNCHANGED
```

This subroutine will increment the priority of the calling task by 1. No range checking is performed.

3.17 DECREMENT TASK PRIORITY (DECPR:)

Calling Sequence:

```
JST            DECPR:
```

Returns With:

```
INTERRUPTS---ENABLED
STATUS---UNCHANGED
A REGISTER---UNCHANGED
X REGISTER---UNCHANGED
```

This subroutine will decrement the calling task's priority by 1. No range checking is performed.

SECTION 4

ADDITIONAL RTX FEATURES

4.1 RTX DEBUG FEATURE (ZBG)

The standard CAI DEBUG program is included in the RTX library tape (Segment 1) under the name ZBG. (Detailed descriptions of DEBUG are included in LSI-2 AutoMagic, CA document 96045-00, or LSI-3/05 AutoMagic, CA document 93001-00). When this module is linked, Relocation Register RF points to the RTX Linked list pointers for use with Z function; the corresponding length required by the Z function is set to five words, which is the length of each block used in the RTX Linked lists. When displaying a particular list with the Z function, the first printed line is not an entry in the list, but simply the pointer to the top of the list, followed by the next four higher words in memory; this first line may therefore be ignored.

There are eight lists maintained by RTX, and the pointers to the top of each of these lists reside within the RTX nucleus in eight consecutive memory locations, in the following order:

0RF	Pointer to the list of tasks awaiting execution (READY)
1RF	Pointer to the list of INTQ: and INTAC: tasks awaiting execution (FIFO)
2RF	Pointer to the list of tasks currently awaiting completion of a DELAY (DLYCH)
3RF	Pointer to the list of common subroutines currently requested (COMN)
4RF	Pointer to the list of tasks currently awaiting I/O execution (IOCH)
5RF	Pointer to the list of tasks awaiting a PUT: response to a requested GET: (GETCH)
6RF	Pointer to the list of PUT: requests awaiting a GET: response (PUTCH)
7RF	Pointer to the list of currently unused blocks (FREE)

The following is a description of the contents and manipulation of a user block within each of the lists:

1. READY List (RF) Ready to Run (used by BEGIN:)

   RTX maintains a list of all tasks which are ready to execute in the READY list. This list is sorted into priority order, so that RTX simply executes the task at the top of the list. The format for a READY block is as follows:

Word	Contents
0	Word address pointer to next block entry in the list. (The last element in the list contains a zero).
1	Bits 15-3. Task priority number. Bits 2-0. (LSI-2 only) Bit 2. EIN indicator, for reference only. (RTX always allows interrupts.) Bit 1. BYTE mode indicator upon next resumption of task. Bit 0. OVerflow indicator upon next resumption of task.

Word	Contents
	Bits 2-0. (LSI-3/05 only)
	Bit 2. BYTE mode indicator upon next resumption of task.
	Bit 1. OVerflow indicator upon next resumption of task.
	Bit 0. Unused
2	P register contents upon next resumption of task.
3	A register contents upon next resumption of task.
4	X register contents upon next resumption of task.

2. FIFO list (1RF) Ready to Run (used by INTAC: and INTQ:)

In order to avoid the problems of interrupting a linked list processor, INTQ; and INTAC: put the entries for their tasks in the FIFO list. (BEGIN: operates directly on the READY list). The RTX scheduler (which is never run as an interrupt routine) empties the FIFO list into the READY list and sorts the READY list. The format of a FIFO block is the same as a READY block.

3. DLYCH List (2RF) Delay (used by DELAY:)

A call to DELAY: (with a unique positive coordination number) causes the block for the currently executing task to be deleted from the READY list and put on top of the DLYCH list. The format of a DLYCH block is as follows:

Word	Contents
0	Word address pointer to next block in the list.
1	Status & Priority. Same as READY list entry.
2	The P register. Points to address of return from DELAY:
3	The coordination number.
4	Working number of ticks left in Delay.

Upon return, the A register will contain the coordination number. The X register will contain the number of Real Time Clock "ticks" remaining (normally zero).

4. COMN List (3RF) Common Subroutine (used by SUBR:, SUBX:, LOCK:, UNLK:, PROT:, UNPR:)

A call to SUBR:, LOCK: or PROT: causes the COMN list to be searched for a block for the common subroutine. If none is found, a block is deleted from the FREE list and put on top of the COMN list. The format for a COMN block is as follows:

Word	Contents
0	Pointer to the next block in the list
1	Busy flag (zero = not busy)
2	Pointer to the block of the highest priority task waiting to use the common subroutine (0 = no task waiting)
3	Address of the common subtoutine (or coordination number)
4	Unused

If SUBR: is called and a block for the common subroutine is found with the Busy flag set, the block for the currently executing task is deleted from the READY list, and inserted into a secondary list pointed to by Word 2 above. At the same time, the P register is set so that the task will again call SUBR: when RTX next executes the task.

5. IOCH List (4RF) I/O Suspend (used by IOX:, Fortran Interface)

A call to IO: or IOWAT: when the busy flag is set in the IOB, or a Fortran call for I/O when no parameter block is currently available, will cause the task block to be deleted from the READY list and put on the top of the IOCH list. The P register is set so the task will repeat the call when RTX next executes the task. The format of an IOCH block is the same as for a READY block. The IOCH list is emptied into the READY list each time any I/O completes.

6. GETCH List (5RF) Get (used by GET:)

A call to GET: with a unique positive coordination number (and no matching PUT: yet) causes the block for the currently executing task to be deleted from the READY list and put on top of the GETCH list.

Word	Contents
0	Pointer to next block in the list
1	Status & Priority (same as Ready)
2	P register. Points to return from GET:
3	Coordination No.
4	Unused

When the associated PUT: is done, the block is deleted from the GETCH list, the A and X register contents are stored into words 3 and 4, and the block is inserted into the READY list in priority order.

7. PUTCH List (6RF) Put (used by PUT:)

A call to PUT with a unique positive coordination number (and no waiting GET:) causes a block to be deleted from the FREE list (see below) and added to the top of the PUTCH list. The format for a PUTCH block is as follows:

Word	Contents
0	Pointer to next block in the list
1	Unused
2	A register contents to be passed
3	Coordination No.
4	X register contents to be passed

When the associated GET is processed, the block is deleted from the PUTCH list and put on top of the FREE list.

8. FREE List (7RF) Available Storage

This list is initialized to contain the entire work space during a call to RTX:. As blocks are required, they are taken from the top of the FREE list. As blocks are no longer required, they are deleted from the appropriate list and put onto the tail of the FREE list. A FREE block has no specific format. It will simply contain data from the function which last used the block.

4.2 PROGRAM LOADING WITH ZBG

ZBG resides in the RTX library; to make use of ZBG, it is necessary to include a

```
     ZBG              REF
```

instruction within the user's program. Thus ZBG is entered immediately upon execution, and may then be used to breakpoint through the mainline sequence and any particular task.

4.3 POWER-FAIL, AUTO-RESTART (PWRFL:)

If the computer being used has the Power Fail option, the user may utilize the RTX program module which provides service for that device. The loader will cause the routine to be loaded if the user has a REF to PWRFL:. He must, however, not actually call that program at execution time. Instead, if a power failure begins, the interrupt hardware will force control into that routine, saving the computer's register st[illegible]s, and halt, to prevent loss of information from core storage. When the power is restored, the program will schedule a user-supplied routine, which must be named PWRUP:, and must occur in a NAM directive. Re-initiation of the activity which was in process (at the time of the power failure) will also be scheduled and control will be passed to the system Scheduler.

RTX will schedule PWRUP: as a task at priority 8184 with the contents of the A register nonzero if the power failure was detected. If power failure was not detected (e.g., the computer was halted), RTX will transfer control to PWRUP: with the contents of the A register equal to zero. Note that RTX cannot resume the activity in progress at the time of the power failure if the power failure was not detected.

4.4 TELETYPE INPUT/OUTPUT

RTX provides decimal, octal, and hexadecimal I/O on the standard Teletype, by using a software interface to CAI's Teletype Utility Package (TUP). The calls and usage are identical to the standard version.

TUP also provides the capability to read and print strings of text, (for headings, labels, etc.), and this capability is retained in the RTX version.

Refer to the standard TUP documentation (#96014) for a complete description of each routine. Additionally, a specific limitation exists with respect to TUP usage through RTX:. TUP must not be called concurrently by more than one task, because TUP itself calls subroutines within it with JST instructions, and these subroutines are not protected from re-entrance.

TUP resides on the RTX Segment 2 library tape, and its routines should be referenced with the REF or EXTR directive.

4.5 LSI-3/05 SOFTWARE CONSOLE ROUTINE (CNSOL3)

The LSI-3/05 version of RTX includes CNSOL3, the Software Console Routine, which may be linked by a reference to CNSOL3 in the user program module. Usage of the Software Console Routine is described in the LSI-3/05 Software Manual (90-20010-00).

SECTION 5

RTX OPERATING PROCEDURES

1. Assemble each of your application program modules. Be sure to reference each RTX function that a module uses in either an EXTR or a REF directive.

2. When you have a useful object tape for each of your modules, you are ready to create the executable application program. This requires that you first load LAMBDA, the relocating, linking loader.

Using LAMBDA, force load the initializer task module of your application.

Then using LAMBDA, load the remainder of your group of application program modules. You can use the Selective Load feature of LAMBDA to include only the modules your program actually requires.

5. Still using LAMBDA, selectively load the RTX Library object modules from the two RTX Library Tapes (70-93300-01 and 70-93300-02).

NOTE

If the user program does not reference PROT: and LOCK:, LAMBDA and OS:LNK will declare these subroutines as undefined. This declaration can be ignored since INTRS: and INTQ: (loaded after PROT: and LOCK:) check to see if a call to either subroutine is the next instruction after an interrupt is serviced.

NOTE

When operating under the IOX File Manager, disk devices must be labeled prior to their use. Labeling is done with the stand-alone program, RTX File Label Utility (tape Nos. 70-93324-40A1 and -41A1). Subsection II/5.3 gives a complete description of this utility.

6. Start execution of your program so that the initializer module (Mainline Sequence) or ZBG, if used, is executed first.

Section 6

A SAMPLE RTX PROGRAM - RTX DEMO

6.1 PROGRAM DESCRIPTION

The RTX Demo Program (00-93300-13) demonstrates the basic functions of RTX in a simple, straightforward manner. It consists of three main tasks (TASK1, TASK2, TASK3). The function of each of these tasks is to delay a specific amount of time, and then call a routine to output a message to the teletype. The message consists of the task name followed by the elapsed time in seconds since the start of the program.

An actual user's application of RTX might very well use the interrupt from some external device to initiate a task. This example simulates the effect of three such devices which interrupt every 5, 7, and 11 seconds, respectively; that is, the delays themselves simulate external devices.

Each task delays a different amount of time than the other tasks, before printing.

```
TASK1 delay:   5 seconds
TASK2 delay:   7 seconds
TASK3 delay:  11 seconds
```

Thus TASK1 will output

```
"TASK1 0005"
"TASK1 0010"
"TASK1 0015"
etc.
```

TASK2 will output

```
"TASK2 0007"
"TASK2 0014"
"TASK2 0021"
etc.
```

And TASK3 will output

```
"TASK3 0011"
"TASK3 0022"
"TASK3 0033"
        etc.
```

Because of teletype timing, each message takes more than one second to complete. Thus the three tasks will contend with each other for the use of the teletype.

In addition, a fourth task called "IOTASK" outputs the actual teletype messages. This task is begun by each of the three main tasks whenever their delays expire, at the following various priorities:

TASK1 begins IOTASK at priority 5
TASK2 begins IOTASK at priority 7
TASK3 begins IOTASK at priority 11

This means that if TASK1 and TASK3 both begin IOTASK at the same time (which they will, at 55 seconds), TASK3's message will be output first, since its priority to begin IOTASK is higher than TASK1's.

To be more specific, and to demonstrate the priority sequence more fully, the actual teletype output after 55 seconds appears as:

TASK3 0055, TASK2 0056, TASK1 0055,...because each message takes slightly more than one second to print, thus causing the following sequence:

TIME	ACTION
55 seconds after start	TASK1 and TASK3 both begin IOTASK with a "55 seconds" message. Since TASK3 has the higher priority, its message is printed first.
56 seconds after start	TASK2 begins IOTASK with a "56 seconds" message. TASK3's "55 seconds" message is still printing, and TASK1's "55 seconds message" is queued up. Since TASK2 has a higher priority than TASK1, the TASK2 "56 seconds" message gets output when TASK3's message completes.
57+ seconds after start	TASK1's "55 seconds" message is output after TASK2's "56 seconds" message is completed.

After 80 seconds, the teletype listing should appear as:

```
TASK1 0005, TASK2 0007, TASK1 0010, TASK3 0011
TASK2 0014, TASK1 0015, TASK1 0020, TASK2 0021, TASK3 0022
TASK1 0025, TASK2 0028, TASK1 0030, TASK3 0033
TASK2 0035, TASK1 0035, TASK1 0040, TASK2 0042, TASK3 0044
TASK1 0045, TASK2 0049, TASK1 0050, TASK3 0055
TASK2 0056, TASK1 0055, TASK1 0060, TASK2 0063, TASK1, 0065, TASK3 0066
TASK2 0070, TASK1 0070, TASK1 0075, TASK3 0077
TASK2 0077, TASK1 0080,
```

(TASK3's message contains carriage return and line feed control characters).

6.2 PROGRAM MODULE FUNCTIONS

Let us now examine the RTX functions used in this program (refer to the flowchart in figure 6-1 and the program listing at the end of this section). There are six basic modules comprising the program:

BEGIN	TASK3
TASK1	IOTASK
TASK2	ADD1

6.2.1 BEGIN (Initialize and Begin Tasks)

The program start occurs at the BEGIN section of the flowchart. The first step is to initialize RTX. This is performed using the RTX: function to define the maximum number of RTX tasks which may be in concurrent operation and the required table space for RTX management of those tasks. If insufficient table space is found or other peculiarities occur during initialization, the error return is taken. In our example, we halt the computer to remedy the problem. Using the BEGIN: function of RTX defines the task name (TASK1, TASK2 and TASK3 in our example) and its software priority number (100 for each in our example).

No other tasks have begun their activity at this point. This is because the first task following the RTX: call (the initialization sequence itself) is automatically scheduled at the highest software priority. When the END: function is called, this task is deleted and the Scheduler can then schedule the other tasks in relation to their priority.

Since the three tasks all have priority 100 and priority 100 is the highest active priority value, the Scheduler will arrange each task in sequence according to the order in which it was initiated by the BEGIN: call, and will then start execution of the first task in that sequence. The sequence is determined by a first-in, first-out rule. Therefore, TASK1 executes until it requests an RTX service which causes it to be suspended.

When the task is re-scheduled (on completion of one of the above function calls), it is put back in sequence at the end of all other equal priority tasks.

This type of organization allows for true priority scheduling within an application, while also allowing the tasks themselves to be executed, interrupted, and resumed in an orderly fashion.

6.2.2 TASK1 (Delay 5 seconds, Then Output Name and Elapsed Time)

When TASK1 is begun, it first performs a five second delay. This is done by a call to DELAY: with parameters of 500 (number of 10 millisecond real time clock "ticks" to delay) and 1 (a specific coordination number for this particular task's delay calls). The coordination number is necessary mainly for identifying a delay to be changed or deleted; however, it is also required when beginning a new delay, as in this example. When the delay is completed, control is returned to TASK1, which then calls the subroutine ADD1, which increments the elapsed time in the TASK1 message by five seconds. Note that ADD1 is called via SUBR:, because it is a common subroutine used by all three tasks, and is not re-entrant; thus SUBR: prevents another task from entering ADD1 until this call is completed.

Upon return from ADD1, the message is ready for output to the teletype. This is done by a call to BEGIN: to initialize the common task called "IOTASK," which in turn makes the actual call to the I/O executive (IOX) to perform the output. Note that "IOTASK" is a task, not a subroutine; this means that TASK1 may now continue with its next 5-second delay while the I/O is in progress rather than upon its completion, which would invalidate the elapsed time count. Also, the initiation of the common task is made with a priority of 5. IOTASK is also initiated by TASK2 and TASK3, with priorities of 7 and 11 respectively, so that a predictable ordering of outputs is achieved when two or three tasks are vying for the teletype at the same time.

6.2.3 TASK2 (Delay 7 Seconds, Then Output Name and Elapsed Time)

TASK2 is identical to TASK1 in its logical functioning. The only difference between them is in the parameters passed in their calls to DELAY:, ADD1, and IOTASK. TASK2 calls DELAY: with a 7 second count and a coordination number of 2 (to differentiate it from TASK1's delay call). The common subroutine ADD1 is called to increment the elapsed time by seven instead of five, and the common task IOTASK is begun at a higher priority (7).

6.2.4 TASK3 (Delay 11 Seconds, Then Output Name and Elapsed Time)

TASK3 is similar to TASK1 and TASK2. TASK3 calls DELAY: with an 11 second count and a coordination number of 3. It calls ADD1 to increment the count by eleven, and begins IOTASK at priority 11.

6.2.5 IOTASK (Call IOX To Output A Message On The Teletype)

IOTASK is a common task begun as a task by BEGIN: calls in TASK1, TASK2 and TASK3. Upon entry, the X register contains an address pointer to the I/O Information Block (IOB) of the calling task. A call is then made to the IOX package (at its entry point named IO:) passing the IOB address as a parameter. An error status from the I/O operation will cause the computer to halt. Otherwise, the task terminates itself with a call to END:.

6.2.6 ADD1 (Common Subroutine To Increment The Elapsed Time for Printing)

ADD1 is a common subroutine called by TASK1, TASK2 and TASK3 prior to printing their messages. Upon entry, the A register contains the amount by which to increment the elapsed time tally, which is pointed to by an address in the X register. The routine performs the addition, and then returns to the calling task through SUBX:. This is because the subroutine was called via SUBR: to avoid re-entrance.

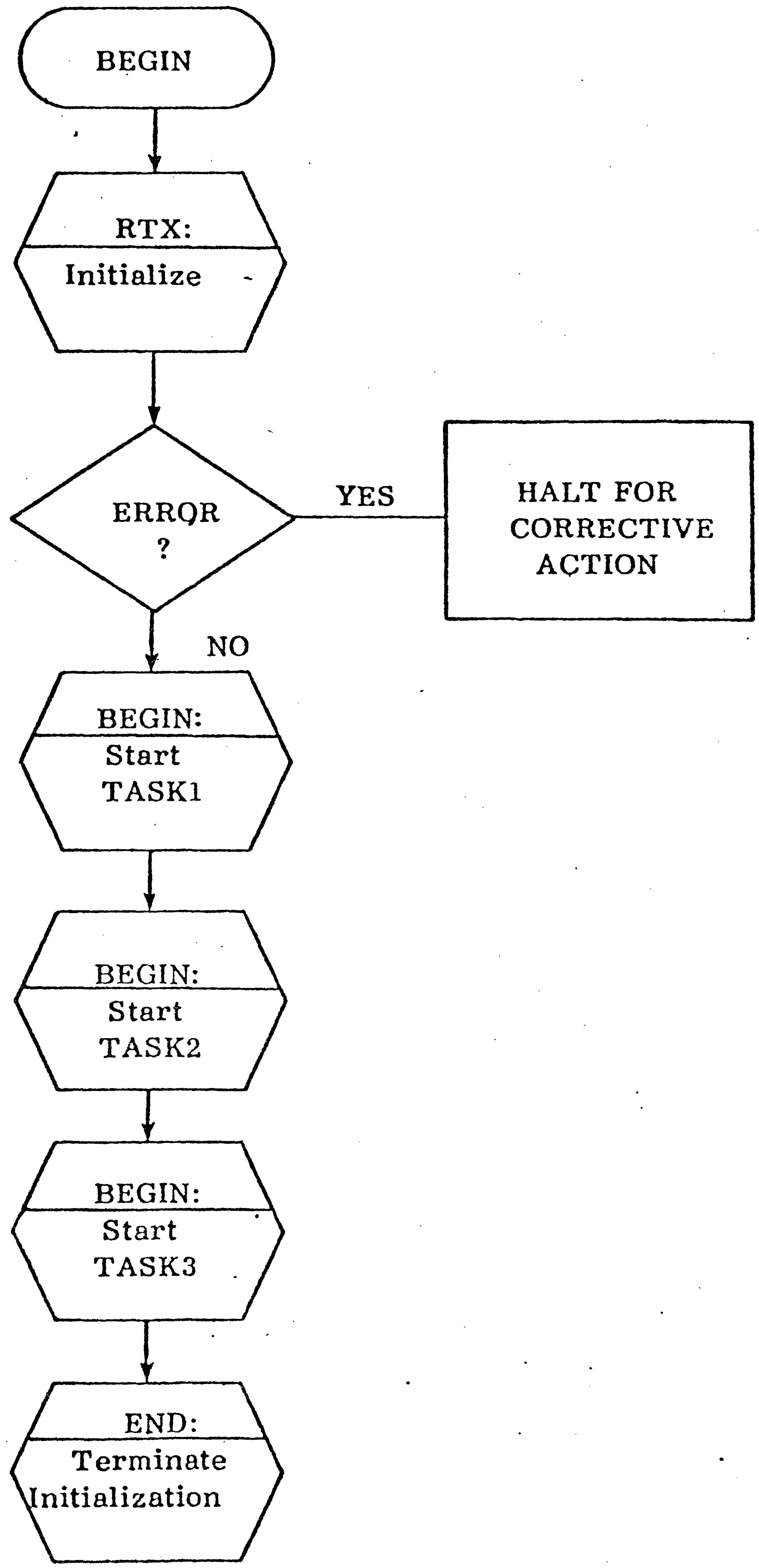


Figure 6-1. RTX Demo Program - Flow Diagram (Sheet 1)

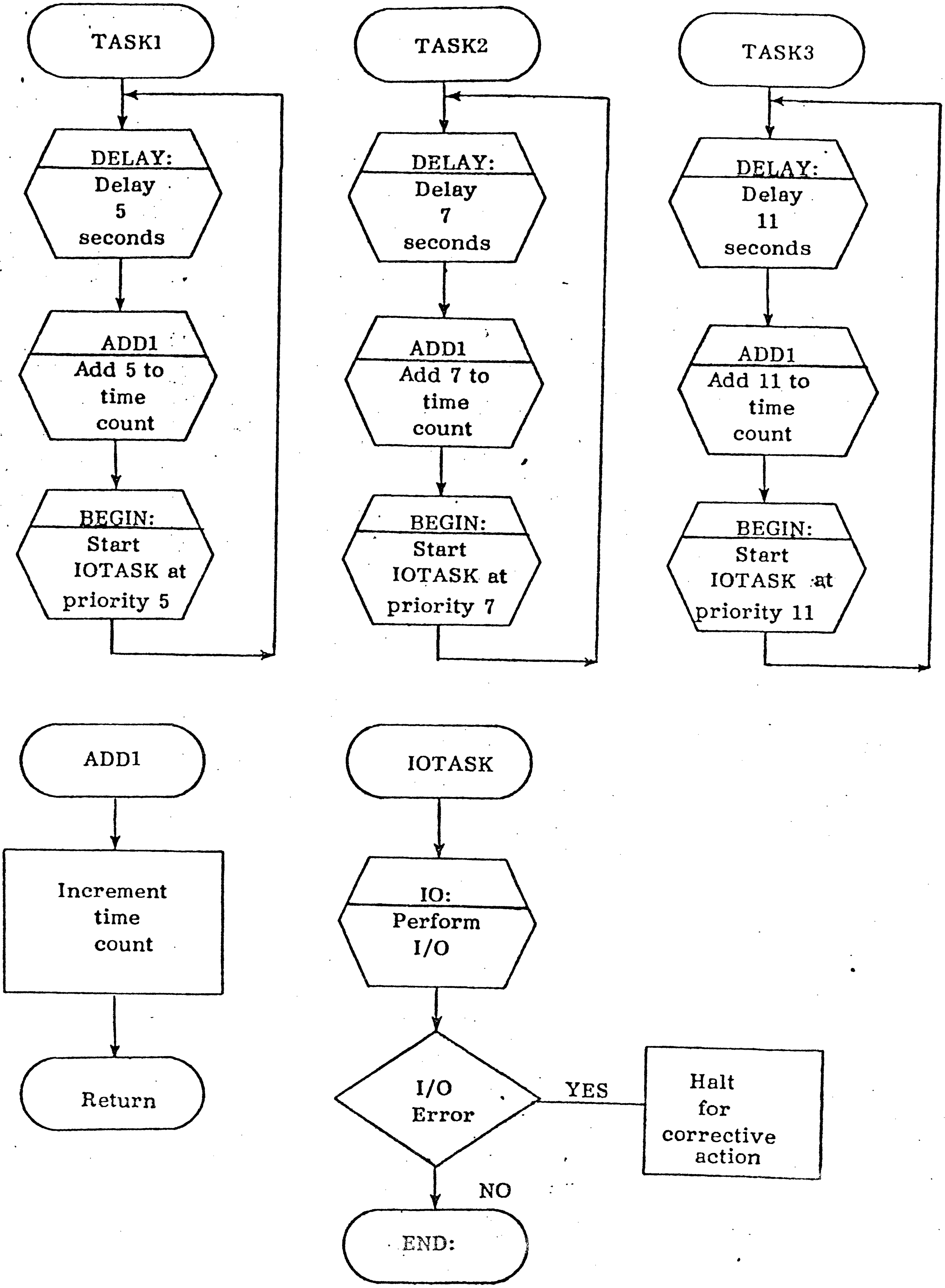


Figure 6-1. RTX Demo Program - Flow Diagram (Cont'd)

```
0002       0000            IFF    LSI305
0004                       ENDC
0008                 *  THIS PROGRAM CONCURRENTLY EXECUTES THREE (3)
0009                 *  TASKS (TASK1, TASK2, & TASK3) WHICH DELAY
0010                 *  THEMSELVES FOR 5, 7, & 11 SECONDS RESPECTIVELY
0011                 *  AND THEN TYPE OUT THEIR IDENTIFICATION FOLLOWED
0012                 *  BY THE NUMBER OF SECONDS THAT HAVE ELAPSED
0013                 *  SINCE THE PROGRAM WAS STARTED.  THE THREE TASKS
0014                 *  ARE ALL RUNNING AT THE SAME PRIORITY AND CALL
0015                 *  A COMMON SUBROUTINE TO UPDATE THE NUMBER OF
0016                 *  SECONDS IN THEIR OUTPUT MESSAGES.  A COMMON
0017                 *  TASK (IOTASK) IS THEN QUEUED TO OUTPUT THE
0018                 *  APPROPRIATE MESSAGE.  THIS TASK IS QUEUED
0019                 *  AT THREE (3) DIFFERENT PRIORITIES (TASK1=5,
0020                 *  TASK2=7, & TASK3=11) SO THAT, FOR EQUAL TIMES,
0021                 *  THE MESSAGES SHOULD APPEAR IN THE FOLLOWING
0022                 *  ORDER:  TASK3, TASK2, TASK1.
0023                 *
0024  000D                     NAM    PWRUP:
0025  00F5                     NAM    I:UAT
0026                           EXTR   RTX:,BEGIN:,END:
0027                           EXTR   SUBR:,SUBX:,DELAY:,IO:
0028                           EXTR   PAUSE:
0029       0000                IFF    LSI305
0030                           EXTR   D:TY00
0031                           ENDC
0035       0014       NOACTS   EQU    20
0036  0000                     REL    0
0037       0000       BEGIN    EQU    $
0038  0000 B000 B0B0           LDA    ='00'     RESET
0039  0001 9A89 008B           STA    T1        .
0040  0002 9A89 008C           STA    T1+1      . ALL
0041  0003 9AA3 00A7           STA    T2        .
0042  0004 9AA3 00A8           STA    T2+1      . ELAPSED
0043  0005 9ABD 00C3           STA    T3        .
0044  0006 9ABD 00C4           STA    T3+1      . TIMES
```


ComputerAutomation

```
0045  0007 F900 0000            JST    RTX:      START RTX
0046  0008 0014                 DATA   NOACTS    NUMBER OF ACTIVITIES
0047  0009 000E                 DATA   WRAREA    RTX BUFFER AREA
0048  000A 0800                 HLT
0049  000B F266 0072            JMP    START     GO START INITIALIZE ROUTINE
0050  000C            PWRFL:  REF              FORCE LOAD THE POWER FAIL
0051                  *                         ROUTINE
0052  000D F900 0000  PWRUP:  JST    END:      IGNORE POWER UP RESTART TASK
0053  000E 0000       WRAREA  RES    NOACTS+NOACTS+NOACTS+NOACTS+NOACTS,0
```

```
                          *
                          *       INITIALIZE TASKS
                          *
0072 F900 0000    START   JST     BEGIN:
0073 007C                 DATA    TASK1      START TASK 1
0074 0064                 DATA    100        PRIORITAET VON TASK 1
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * *   * * * * * * *
                          *
0075 F900 0000            JST     BEGIN:
0076 0098                 DATA    TASK2      START TASK 2
0077 0064                 DATA    100
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * *   * * * * * * *
                          *
0078 F900 0000            JST     BEGIN:
0079 00B4                 DATA    TASK3
007A 0064                 DATA    100
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * *   * * * * * * *
                          *
007B F900 0000            JST     END:       HALT INITIALIZE ROUTINE
```

```
                          *
 007C F900 0000   TASK1   JST     DELAY:     WAIT FOR
 007D 01F4                DATA    500,1      5 SECONDS
 007E 0001
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                          *
 007F C705                LAM     5          5 TIMES THROUGH ADD
 0080 E000 008B           LDX     =T1        POINTER TO NUMBER
 0081 F900 0000           JST     SUBR:      CALL COMMON SUBROUTINE
 0082 00DA                DATA    ADD1       TO ADD IN BCD
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                          *
 0083 E000 008E           LDX     =IOB1      ADDRESS OF IOB1
 0084 F900 0000           JST     BEGIN:     START COMMON TASK
 0085 00CF                DATA    IOTASK,5   TO DO I/O (PRIORITY IS 5)
 0086 0005
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                          *
 0087 F60B 007C           JMP     TASK1      KEEP GOING
                          *
                          * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                          *
      0088        BUFF1   EQU     $
 0088 D4C1                TEXT    'TASK1 '
 0089 D3CB
 008A B1A0
 008B B0B0        T1      TEXT    '0000'
 008C B0B0
 008D ACA0                TEXT    ', '
      008E        IOB1    EQU     $          IOB BLOCK
 008E 0000                DATA    0,0,0,0
 008F 0000
 0090 0000
```


ComputerAutomation

```
       0091 0000
0107   0092 C3CF          DATA    'CO'      LUN
0108   0093 0005          DATA    5         FUNC CODE (UNFORMATTED WRT)
0109   0094 000C          DATA    12        MESSAGE BYTE LENGTH
0110   0095 0088          DATA    BUFF1     MSG BUFFER
0111   0096 0000          DATA    0,0
       0097 0000
```


ComputerAutomation

```
                         *
    0098 F900 0000  TASK2  JST    DELAY:    WAIT FOR
    0099 02BC              DATA   700,2     7 SECONDS
    009A 0002
                         *
                         * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
    009B C707              LAM    7         7 TIMES THROUGH ADD
    009C F000 00A7         LDX    =T2       POINTER TO NUMBER
    009D F900 0000         JST    SUBR:     CALL COMMON SUBROUTINE
    009E 00DA              DATA   ADD1      TO ADD IN BCD
                         *
                         * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
    009F F000 00AA         LDX    =IOB2     ADDRESS OF IOB BLOCK
    00A0 F900 0000         JST    BEGIN:    START COMMON TASK
    00A1 00CF              DATA   IOTASK,7  TO DO I/O (PRIORITY IS 7)
    00A2 0007
                         *
                         * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
    00A3 F603 0098         JMP    TASK2     KEEP GOING
                         *
                         * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
         00A4       BUFF2  EQU    $
    00A4 D4C1              TEXT   'TASK2 '
    00A5 D3CB
    00A6 B2A0
    00A7 B0B0       T2     TEXT   '0000'
    00A8 B0B0
    00A9 ACA0              TEXT   ', '
         00AA       IOB2   EQU    $         IOB BLOCK
    00AA 0000              DATA   0,0,0,0
    00AB 0000
    00AC 0000
```

```
        00AD 0000
0142    00AE C3CF          DATA   'CO'      LUN
0143    00AF 0005          DATA   5         FUNC CODE (UNFORMATTED WRT)
0144    00B0 000C          DATA   12        MESSAGE BYTE LENGTH
0145    00B1 00A8          DATA   BUFF2     MSG BUFFER
0146    00B2 0000          DATA   0,0
        00B3 0000
```

```
                        *
 0084 F900 0000   TASK3  JST    DELAY:   WAIT FOR
 0085 044C               DATA   1100,3   11 SECONDS
 0086 0003
                        *
                        * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                        *
 0087 C70B               LAM    11       11 TIME THROUGH ADD
 0088 E900 00C3          LDX    =T3      POINTER TO NUMBER
 0089 F900 0000          JST    SUBR:    CALL COMMON SUBROUTINE
 008A 000A               DATA   ADD1     TO ADD IN BCD
                        *
                        * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                        *
 008B E000 00C5          LDX    =IOB3    ADDRESS OF IOB
 008C F900 0000          JST    BEGIN:   START COMMON TASK
 008D 00CF               DATA   IOTASK,11 TO DO I/O (PRIORITY IS 11)
 008E 000B
                        *
                        * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                        *
 008F F608 0084          JMP    TASK3    KEEP GOING
                        *
                        * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                        *
      00C0        BUFF3  EQU    $
 00C0 D4C1               TEXT   'TASK3 '
 00C1 D3CB
 00C2 B3A0
 00C3 B0B0        T3     TEXT   '0000'
 00C4 B0B0
      00C5        IOB3   EQU    $        IOB BLOCK
 00C5 0000               DATA   0,0,0,0
 00C6 0000
 00C7 0000
 00C8 0000
```

```
0176  00C9 C3CF          DATA   'CO'      LUN
0177  00CA 0006          DATA   6         FUNC CODE (ASCII WRITE)
0178  00CB 000A          DATA   10        MESSAGE BYTE LENGTH
0179  00CC 00C0          DATA   BUFF3     MESSAGE BUFFER ADRESS
0180  00CD 0000          DATA   0,0
      00CE 0000
```

```
                          *
                          *  THIS IS THE COMMON TASK "IOTASK" QUEUED
                          *  BY TASK1, TASK2 AND TASK3 SO THAT THEY WILL
                          *  NOT BE DELAYED WAITING FOR THE COMPLETION
                          *  OF THE I/O.  NOTE THAT THE IOX PACKAGE (IO:)
                          *  IS USED.
                          *
          00CF            IOTASK EQU    $        COMMO. TASK ENTRY POINT
     00CF 6803                   SIN    2        AVOID INTERRUPTS HERE
     0000 FA01 0002              STX    IOB      STORE IOB ADDRESS INTO CALL
     0001 F900 0000              JST    IO:      CALL IOX
     0002 0000            IOB    DATA   $-$      IOB ADDRESS STORED HERE
     0003 F900 0000              JST    END:     IMMEDIATE RETURN
     0004 0000                   NOP             IGNORE ERROR RETURN
     0005 F900 0000              JST    END:     TERMINATE THE COMMON TASK
```

```
                       *
                       *   THIS IS THE COMMON SUBROUTINE CALLED BY TASK1,
                       *   TASK2, AND TASK3 TO UPDATE THE NUMBER OF
                       *   ELAPSED SECONDS IN THE APPROPRIATE OUTPUT
                       *   MESSAGE. ALL TASKS CALLING THIS SUBROUTINE
                       *   HAVE THE SAME PRIORITY, SO THE CALL TO PAUSE:
                       *   WILL CAUSE SOME ATTEMPTS AT RE-ENTRY.
                       *
0006 0F00              NEXT  SWM
0007 0A18 00F0               IMS    COUNT     DONE?
0008 F206 000F               JMP    LX        NO, CONTINUE LOOP
0009 F900 0000               JST    SUBX:     YES, RETURN FROM COMMON
                       *                    SUBROUTINE
000A 0800              ADD1  ENT              ENTRY POINT
000B 9A14 00F0               STA    COUNT
000C 1328                    LLX    1         BYTE ADDRESS OF NUMBER
000D C203                    AXI    3         ADDRESS OF LEAST
                       *                    SIGNIFICANT DIGIT
000E EA12 00F1               STX    SAVEX     SAVE IT
000F C704              LX    LAM    4         DO ONLY 4 DIGITS
00F0 9A11 00F2               STA    FOUR
00E1 E20F 00F1               LDX    SAVEX     GET ADDRESS OF LSD
00E2 0E00                    SBM
00E3 B400 0000         ADD2  LDAB   @0        GET DIGIT
00F4 F900 0000               JST    PAUSE:    ALLOW RE-ENTRY ATTEMPT
00F5 0150                    IAR              ADD ONE (1)
00E6 9C00 0000               STAB   @0        PUT IT BACK
00E7 C0BA                    CAI    '9'+1     WAS IT '9'?
00E8 F201 00EA               JMP    $+2       YES, GOTTA DO NEXT DIGIT
00E9 F613 0006               JMP    NEXT      NO, CHECK FOR DONE
00FA C6B0                    LAP    '0'       CHANGE TO ZERO ('0')
00FB 9C00 0000               STAB   @0        PUT IN DIGIT
00FC 00A8                    DXR              POINT TO PREVIOUS DIGIT
00ED 0A04 00F2               IMS    FOUR      BUMP FOUR DIGIT COUNT
00FF F60B 00E3               JMP    ADD2      DO NEXT DIGIT
00EF F619 0006               JMP    NEXT      CONTINUE
```

```
PAGE  0012  03/30/77   11:25:?7      RTX DEMO PROGRAM 93300/01-13E1
MACRO2 (A2) SI= DEMOS    BO=              [SI=2 RTX DEMO 400-93300-13E1]

0234   00F0 0000          COUNT   DATA    0
0235   00F1 0000          SAVEX   DATA    0
0236   00F2 0000          FOUR    DATA    0
```

```
                        *
                        *  THIS IS THE UNIT ASSIGNMENT TABLE REQUIRED
                        *  BY IOX.  THERE IS ONLY ONE ENTRY, SINCE ONLY
                        *  ONE I/O DEVICE (TTY) IS USED IN THE
                        *  PROGRAM.
                        *
           00F3         UATTOP EQU    $            TOP OF UAT
      00F3 C3CF                DATA   'CO'         LUN
           0000                IFF    LSI3C5
      00F4 0000                DATA   D:TY00       DIB ADDRESS FOR STD TTY
                               ENDC
      00F5 FFFC         I:UAT  DATA   UATTOP-$-2   LENGTH OF UAT
                        *
           0000                END    BEGIN

0000  ERRORS
0000  WARNING
```

PART II

THE INPUT/OUTPUT EXECUTIVE (IOX)

SECTION 1

IOX GENERAL DESCRIPTION

IOX is a subsystem of RTX which operates under RTX control, and provides the user with a complete, modular method of input/output device management and support. Application programming is faster since time-consuming input/output programming for standard peripherals and communications devices need no longer be done by the user. Since IOX is open-ended, the user can add capability for virtually any kind of device unique to his application and program it under IOX control. All I/O performed by IOX is interrupt-driven and allows other tasks in the system to execute even though I/O is in progress.

Working in conjunction with IOX is the File Manager that enables the user to communicate with data files by name, independent of the physical medium storing the file. Requests for file access are made through IOX using Logical Units (LUNs).

IOX can perform one operation at a time for each peripheral device. Operations requiring the use of the same device are done in I/O task priority order (i.e., the highest priority request is honored whenever the device is available to be used). Operations performed on different devices are done concurrently. All calls to IOX specify a Logical Unit (LUN) on which to perform the I/O rather than physical units. This feature allows a program to be debugged using one set of I/O assignments and executed using another.

IOX satisfies the following I/O requirements of the system:

1. Selects the proper commands for communicating with external devices.

2. Processes device interrupts in the following manner:

   a. Saves the status of the currently executing task.

   b. Determines the task priority of the interrupt. (Must it be serviced immediately or can it wait for the completion of a higher priority task and if so, is the higher priority task ready for execution?)

   c. Determines whether the task processing the interrupt is a re-entrant task, or that the interrupt may not be serviced until each prior interrupt has been fully processed.

   d. Determines which of the I/O tasks awaiting execution has the highest priority, then restores the CPU status to the environment of that highest priority and gives control to that task.

   e. Ensures that no task may access a device while it is controlled (dedicated) by another task.

   f. Ensures that the interrupt system is not disabled for a period of time which would prevent a high speed device from performing I/O successfully.

1.1 GENERAL DESCRIPTION

Because of the likelihood of having several similar devices attached to the computer (including identical units) in a real time environment, IOX has been designed to make it easy to support several similar devices (differing only by device address) using "shareable" code. IOX requires some space for flags, device addresses, etc. Since the types of flags depend on the device, as well as the interface to which the device is connected (there may be more than one device per controller), IOX maintains flags in two separate locations depending on whether the information is unique to the device or to the controller. In order to utilize the minimum space in memory for these flags and temporary cells, and to facilitate the allocation of these cells, IOX does most of its interfacing by means of tables which define the type of device and interface to which it is connected.

IOX is primarily concerned with four tables:

IOB	Input Output Block
UAT	Unit Assignment Table
DIB	Device Information Block
CIB	Controller Information Block

(These tables are more fully described in section 2 (IOB and UAT) and section 4 (DIB and CIB). The <u>IOB</u> is created by the user (task) and resides within the calling task. It contains the Logical Unit Name or Number (LUN) as well as specifications for the I/O operation to be performed.

The <u>UAT</u> is also created by the user. It is a series of two-word entries, each of which equates the LUN (specified in the IOB) to a specific device.

The <u>DIB</u> and <u>CIB</u> are tables which are used in communication between IOX and a particular handler. IOX contains within it DIB's and CIB's for each standard device. Additionally, the user may create his own tables if he desires; for example, he may reserve an extent on a disk by specifying its boundaries in his own disk DIB, or he may create a DIB and CIB (and a handler) for a non-standard device.

In general, the usage of these tables by IOX is as follows: The user constructs the IOB within his program and calls IOX, giving as the sole argument the address of this IOB. IOX must then transfer control to the handler associated with this request. To do so, it first obtains the logical unit number (LUN) from within the IOB, and compares it to each entry in the UAT until a match is found. The UAT is simply a list of each possible Logical Unit Name/Number (LUN), associated with the address of the DIB which defines the device assigned to that LUN. Thus for each LUN the UAT contains a pointer to the appropriate DIB. In turn, each DIB contains a pointer to the CIB which defines the interface to which the device is connected. Finally, the CIB contains a jump table which points to the particular handlers (procedures) for processing the specific request. Therefore, given an IOB and a UAT, IOX can find the procedure to handle the request made in the IOB.

The following steps are performed during a normal call from the user to IOX:

1. The user calls IOX carrying the word address (may be indirect) of his IOB.

2. IOX examines the status within the IOB. If the IOB is busy (from a previous call to IOX), the calling task is suspended and control is passed to the RTX task scheduler.

3. If the IOB is not busy, it is then flagged as busy, and the UAT is searched to find a LUN which matches the LUN in the IOB. If not found, an abnormal return is made to the caller after setting the "Invalid LUN" status bit in the IOB.

4. If a matching UAT entry is found, the correct DIB is located (the DIB is referenced within the UAT entry) and the requested function code is compared to the permissible function code(s) within the DIB. If the requested function code is found to be illegal, an abnormal return is made to the caller after setting the "Error" status bit in the IOB.

5. IOX next queues the I/O request with any previously pending I/O requests for the requested device according to the priority of the calling task and passes control to its internal I/O scheduling routine.

6. The scheduling routine then monitors the request queue in each DIB; whenever it becomes physically possible to begin an I/O request (the I/O device is available and no higher priority request is pending), the scheduler calls the appropriate I/O handler routine (driver) according to the handler entry address within the CIB.

7. In general, the I/O handler routine will set up the required interrupt locations, select the device, and initiate a watchdog timer, and then return control to the I/O scheduler.

8. The I/O scheduler continues monitoring the I/O request queues and calling the applicable I/O handler routine(s) until each DIB has been examined once. Then the I/O scheduler terminates with a call to END:.

9. When an end-of-block I/O interrupt occurs, it causes a return to the I/O handler which initiated the I/O operation. The handler will normally at this time, call an end-of-block routine within IOX, which stores the I/O status and record count into the IOB, releases the device from dedication (if desired), returns to the calling task through either the normal or the abnormal return location, depending on the status, and begins the I/O scheduler.

10. If an I/O error should cause the watchdog timer to expire prior to I/O completion, it causes a return to the applicable handler, which will then normally execute an initialize function to the device, store an "Unresponsive Device" status into the IOB and return to the caller's abnormal return location.

1.2 CALLING SEQUENCES

The three entry points to IOX are:

IO:	To perform an I/O operation or special function
IOREL:	To release a dedicated device
IOWAT:	To wait for completion of an I/O operation

ac of these entries requires a parameter list (IOB). IOB format is described in etail in section 2. The IOB specifies the type and mode of operation, data area, ata length, and the Logical Unit Name/Number. It also provides room for status nformation to be returned to the calling task. All calls to IOX return with the egisters as follows:

A Register	Undefined
X Register	Pointing to the IOB
OV Register	Undefined
Word Mode	
LSI Console Data Register	Unchanged

he format of a call to IOX to perform an I/O operation is:

```
JST      IO:       Call the IOX perform I/O routine
DATA     (*)IOB    Address of the Input/Output Block
---                Immediate Return
---                Operation complete---abnormal return
---                Operation complete---normal return
```

ot that there are three exits from IO: -- two are always taken. As soon as the e est is processed, IOX BEGIN:'s a new task whose starting address is the immediate eturn location. When the I/O operation is completed, IOX returns to either the bnormal or normal return depending on the success of the operation. Having an mmediate exit as well as a complete exit from IOX provides the user with the option f concurrently executing his program while the I/O is in progress. If he does not ish to continue execution until the I/O has completed, he simply codes:

```
 T       END:
```

n he location of the Immediate Return.

lternatively, if a certain amount of concurrent processing can take place during the /O operation, the immediate return location should contain a jump to the processing outine. When the intermediate processing has finished, and it is necessary to await /O completion before continuing, a call to the IOWAT: routine is made, as in the ollowing example:

```
        JST     IO:       Initiate the I/O operation
        DATA    (*)IOB    IOB address
        JMP     TAG       Immediate return - continue processing
        JST     END:      Ignore complete return
        JST     END:      Ignore complete return
TAG     EQU     $
        .
        .                 Concurrent processing
        .                 during I/O
        .
        JST     IOWAT:    Wait until I/O completion
        DATA    (*)IOB:   IOB address
        ---               Operation complete - abnormal return
        ---               Operation complete - normal return
```

ote that a call to END: must be made at the "complete" returns from the call to IO:, n order to terminate the I/O task. One of these two returns will be made if I/O o tes before the call to IOWAT: is executed.

NOTE

> A call to IO: is equivalent to a call to BEGIN: (see chapter 1, RTX Functions) with a starting address of the immediate return and a priority of the task which calls IO: except that the new task is queued <u>before</u> all tasks of equal priority.

An abnormal return may result due to the following:

- LUN not in UAT
- Illegal Operation Request
- Device Error
- File Mark Input
- End-of-Device

A normal exit will result from all other conditions.

1.3 DEVICE DEDICATION

If desired, the user may dedicate a device to specific IO: calls only. Word 3 of the IOB provides the capability of establishing a specific (non-zero) coordination number for an I/O call. Once such a call has established the dedication of a device, all future I/O requests for that device will be held off (queued) until the device is released, unless they contain the established coordination number.

A device is released from dedication by a call to the IOREL: subroutine, as follows:

```
JST     IOREL:
DATA    (*)IOB
---     Return
```

On return the A register will be zero if the device was released; otherwise, one or more of the following A register bits will be set:

Bit 0 set:	the LUN entry in the IOB could not be found in the UAT.
Bit 1 set:	the IOB contains a coordination number of zero.
Bit 2 set:	the coordination number in the DIB does not match the coordination number in the IOB and no queued IOB has a matching coordination number.

1.4 LOADING

The user is supplied with two standard relocatable object segments, each residing on two separate paper tapes:

Segment 1 (paper tape 70-93300/1-01):

This segment contains the following program modules, in the order shown:

1. Character I/O Drivers
2. Card Reader Drivers
3. Magnetic Tape Drivers
4. Disk Drivers

5. I/O Scheduler
6. RTX Nucleus
7. ZBG
8. CNSOL3 (if LSI-3 version)

Segment 2 (paper tape 70-93300/1-02):

This segment contains, in the following order:

1. IOX Control
2. RTX Services

In addition to these two modules, the user will require:

1. An RTX Mainline sequence, which makes a call to RTX: to initialize the RTX environment, and to BEGIN: for each task he wishes to initiate immediately.

2. One or more "task" programs to be run simultaneously under RTX (See chapter 1, RTX Description)

3. Special device handler program(s) and the associated DIB and CIB tables, for use in communicating with any device(s) for which a standard handler does not currently exist in IOX (see section 3, I/O Handler Organization below). These handler programs are not necessary if using only the standard devices (teletype, CRT, high speed paper tape reader and punch, line printer, card reader, magnetic tape, disk, floppy disk).

NOTE

> The user's special DIB's will each contain a CHAN directive to permit chaining to the other DIB's referenced during linking. The user who does not have an OS system will need version D0 or higher of the OMEGA assembler in order to correctly assemble the DIB tables, because lower versions do not recognize the CHAN directive.

4. A Unit Assignment Table module (UAT) containing entries for each I/O unit to be accessed (see section 2, UAT Description).

The user may either load each module using LAMBDA, or produce a binary tape via the OS Link Editor. The order of input of the object modules is as follows:

1. User's main line sequence.
2. User's various tasks.
3. Unit Assignment Table (UAT).
4. Special user-coded DIBs and CIBs, if any.
5. User-coded I/O handlers, if any.
6. RTX/IOX tape, Segment 1.
7. RTX/IOX tape, Segment 2.

The RTX/IOX tapes, Segments 1 and 2, are organized in library format. Each routine on these tapes is loaded conditionally until the last module of the tape is read. The routines are organized so that only one pass through the loader is necessary.

NOTE

Fortran tasks to be run under RTX control require additional library modules to be linked. Refer to the Fortran Operations Manual for a complete description.

1.5 RESTARTABILITY

In general, if some I/O error occurs during execution for which the operator wishes to abort the program, it may not be restartable if the abort condition (e.g., the operator halts the processor through the console) occurs during the period of any I/O request (either pending or being serviced). This is because various "busy" flags within the I/O tables must be reset upon restarting the program. To insure resetting of these flags, reference the "IONIT:" module from the Mainline sequence (see chapter 1, section 2: description of the RTX: initialization routine).

SECTION 2

IOB AND UAT ORGANIZATION

The IOB (Input/Output Block) is created by the user and resides within the calling task. It contains the Logical Unit Name or Number (LUN) as well as specifications for the I/O operation to be performed.

The UAT is also created by the user. It is a series of two-word entries, each of which equate the LUN (specified in the IOB) to a specific device.

The following IOB description applies to all standard IOX handlers. The description is annotated to include File Manager functions. IOB organization for non-standard handlers (for example, the IEEE Intelligent Cable Handler) is described in Section 7.

2.1 INPUT/OUTPUT BLOCK (IOB) - 10 WORDS

The IOB must be set up by the user within his own program. Word 0 is temporary storage and will be destroyed by IOX each time IO: is called. Words 1 and 2 are set to the device name by IO:. Words 3-7 are parameters passed by the user on calls to IO:. Words 5 (bits 8-15) and 8 contain information returned to the user from IOX. Word 9 is used only on devices which support direct access I/O (i.e., disk, floppy disk). (Note that IOB tables are not required for Fortran tasks. Refer to the Fortran Operations Manual). Figure 2-1 illustrates the IOB configuration.

Sample IOB's are included in TASK1, TASK2, and TASK3 of the RTX Demo Program. Refer to Chapter 1, Section 6.

Word 0 — Temporary Storage for Use by IOX. This word is used by IOX as a pointer to queue requests for each device. It must NOT be altered by the user.

Word 1 — Device Type (Two ASCII Characters). This word is set by IO:. It contains the two character mnemonic for the device type.

Word 2 — Device Number. This word is set by IO:. By convention it contains two ASCII digits (0-9) and is used to distinguish between multiple devices of the same type.

CAUTION

Words 1 and 2 are used for temporary storage during calls to IO: and are only valid after one of the complete exits has been taken. These locations must not be changed when the busy bit in word 5 is set.

INPUT/OUTPUT BLOCK

<table>
<tr><th>Standard Name*</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th>word</th></tr>
<tr><td></td><td colspan="16">CHAIN POINTER (RESERVED FOR USE BY IOX)</td><td>0</td></tr>
<tr><td>IDT</td><td colspan="16">DEVICE TYPE</td><td>1</td></tr>
<tr><td>ICUN or ITCB</td><td colspan="16">DEVICE NUMBER</td><td>2</td></tr>
<tr><td></td><td colspan="16">COORDINATION NUMBER</td><td>3</td></tr>
<tr><td>ILUN</td><td colspan="16">LOGICAL UNIT NAME/NUMBER</td><td>4</td></tr>
<tr><td>ISTA,IOP</td><td>BUSY</td><td>ERROR</td><td>NO I/O</td><td>BAD LUN</td><td>FORM</td><td>DEV. UN-RESP</td><td colspan="2">DEVICE POS.</td><td>INT. USE</td><td colspan="2">RES.</td><td>SO</td><td colspan="2">OP CODE</td><td colspan="2">OP MOD.</td><td>5</td></tr>
<tr><td>IRCNT</td><td colspan="16">REQUESTED COUNT</td><td>6</td></tr>
<tr><td>IBUFF</td><td colspan="16">BUFFER ADDRESS</td><td>7</td></tr>
<tr><td>IACNT</td><td>FLAG</td><td colspan="15">ACTUAL COUNT/PROMPT CHARACTERS</td><td>8</td></tr>
<tr><td>[illegible]AA</td><td colspan="16">DIRECT ACCESS ADDRESS</td><td>9</td></tr>
</table>

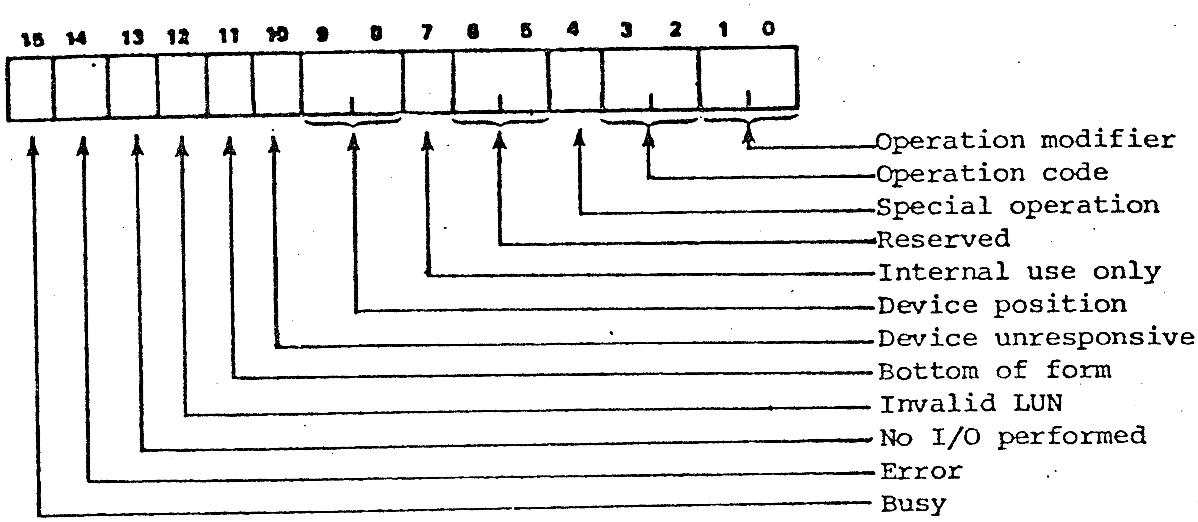
Figure 2-1. IOB Configuration

* refer to the I/O Handler listing at the end of Section 3.

Word 3 I/O Coordination Number. This word is supplied by the user to coordinate his I/O requests. If this word is non-zero, the device on which the call is being made will be dedicated to the coordination number supplied. When a device is dedicated to a specific coordination number, only those requests with matching numbers will be honored. All others will be queued until the device is released. If device dedication is not required, this word should be set to zero.

Word 4 Logical Unit Name/Number (LUN). This word is supplied by the user and it describes the Logical Unit on which the I/O should take place. Although the LUN may be any 16-bit value, by convention all negative numbers are considered to be ASCII character pairs (e.g., SI, LO). All positive numbers are considered to be FORTRAN unit numbers (e.g., 5,6,10).

Word 5 Status, Function Code. This word uses the following format:



Bits 15-8 Status returned to the user by IOX. The breakdown of bits is as follows:

Bit 15 Busy (the operation has not been completed)

Bit 14 Error (an unrecoverable error has occurred); or bit 11 or 12 is set for the File Manager.

Bit 13 No I/O performed (e.g., LUN is assigned to dummy device, device cannot perform the requested operation, LUN not in assignment table, Read or Write with zero (0) count).

Bit 12 Invalid LUN (LUN cannot be found in Unit Assignment Table); or File Manager access mode error.

Bit 11	Bottom of form (listing device only); or File Manager end of medium, directory full, directory error, device not labeled or partition busy.
Bit 10	Device unresponsive (the device has not responded to the request in a reasonable length of time); not used by the File Manager.
Bits 9 and 8	Position of device: 00 Indeterminate 01 Beginning of device 10 File mark found 11 End of device (disk and Magnetic tape only). For tape, the EOT reflective marker was encountered. For disk, the last sector in the extent was accessed. This status does not necessarily mean that no data was transferred.
Bit 7	This bit is for INTERNAL use only. Initialize to zero and do not ALTER.
Bits 6 and 5	Reserved for future expansion
Bits 4-0	Requested Function Code. This is supplied by the user and defines the operation to be performed on the device. The breakdown of bits is as follows:
Bit 4	Special Operation - If this bit is set, bits 3-0 are ignored. This is to allow users to supply drivers for devices which perform special functions.
Bits 3 and 2	Operation Code 00 Read 01 Write 10 Position 11 Function
Bits 1 and 0	Operation Modifier - These bits define the specific type of operation to be performed. Their meaning depends on the operation code. (Some operation modifiers vary for certain Handlers. These differences are noted accordingly.)

For read:		File Manager
00	Direct Access (MTIC only, Read Reverse)	Random Access
01	Unformatted, Sequential	Sequential
10	Formatted ASCII, Sequential	Sequential
11	Formatted Binary, Sequential	Sequential

For write:		File Manager
00	Direct Access	Random Access
01	Unformatted, Sequential	Sequential
10	Formatted ASCII, Sequential	Sequential
11	Formatted Binary, Sequential	Sequential

For position:		File Manager
00	Absolute, Records	No change
01	Absolute, Files	No change
10	Relative, Records	No change
11	Relative, Files	No change

For function:		File Manager
00	Write File Mark	No change
01	Punch leader	Reserved
10	MTIC only, Control Edit; Line Printer only, Eject to Top-of-Form	Set file deleted bit in DIB
11	MTIC only, Control Erase	Update directory (New files only)

Word 6

Requested Count. This word is supplied by the user to specify the I/O length, which is defined as follows:
For read or write functions, this word is the number of bytes to be transmitted (1 to 65,535). (If the operation is Write Formatted ASCII, IOX will alter the requested count to remove trailing blanks before calling the handler. This is done with an intermediate counter. IOB Word 6 is not altered.)

For relative record or relative file positioning, this word is the number of records or files to skip. (A positive count means skip forward, a negative count means skip backward).

For absolute record or absolute file positioning, this word is the actual record or file number to skip to. (For MTIC Handlers, the unit is rewound and placed offline if this word is equal to minus one.)
NOTE: Positioning a file to absolute -1 (file marks or records) is a close file operation for the File Manager (refer to Section 5.1.3).

Word 7

Buffer Address. This word is supplied by the user to specify the start address of the I/O buffer. Note that this address is always a word address and that indirect addressing is not allowed.

Word 8

Actual Count/Prompt Characters. This word is returned to the user by the File Manager. It contains the number of records or files actually skipped (for relative position), the actual record or file skipped to (for absolute position), or the actual record length in bytes (for read or write). The File Manager will NOT read more bytes into the user's buffer than requested, but will continue to count characters to establish the physical record length.

On devices which are capable of prompting, this word is used to hold up to two prompt characters.

NOTE

Word 8 contents will be assumed to be prompt characters if negative (bit 15 set). Bits 7-0 not equal to zero indicate two prompt characters; bits 7-0 equal to zero indicate only one prompt character (in bits 15-8).

Word 9 Direct Access Address. This word is the direct access data address within the device (current record number), for devices capable of supporting direct access. For sequential access, this word will be incremented to the current logical record number after each access. For random access, the user stores the logical record number here.

2.2 UNIT ASSIGNMENT TABLE (UAT)

The Unit Assignment Table is not part of the standard IOX library; it must be "tailor-made" by the user for the particular configuration of devices he requires. Figure 2-2 illustrates the UAT configuration.

UNIT ASSIGNMENT TABLE

15 0	word
LOGICAL UNIT NAME/NUMBER	0
DIB ADDRESS	1
LOGICAL UNIT NAME/NUMBER	2
DIB ADDRESS	3
LOGICAL UNIT NAME/NUMBER	N-2
DIB ADDRESS	N-1
TABLE LENGTH = -(N + 2)	N

Figure 2-2. UAT Configuration

The UAT is a table of two-word entries for each logical unit which can be referenced in calls to IOX, plus a terminating word containing the UAT word length. The first word of the entry is the Logical Unit Name/Number (LUN) which is referenced in the user's IOB. It may be any value from 0 to 65535.

The second word of the entry is the address of the corresponding DIB table.

The last word in the table is the count word. It is a negative quantity representing the number of words in the table, plus one; that is, two words for each entry, plus the count word itself, plus one. Thus, if there exist four two-word entries, the contents of the count would be minus 10, or -(4 x 2 + 1 + 1). The count word must be the last word in the table, and must be labeled I:UAT, because this is the name used by IOX when referencing the UAT. (Refer to the sample UAT at the end of this section).

2.3 STANDARD DIB NAMES

The following table shows the DIB names for all devices for which standard and non-standard handlers exist within IOX. The label is to be used as the second word of the UAT entry for each device the user wishes to include.

	Non-DIO	Fortran Non-DIO	DIO	Fortran DIO
Teletype Console	D:TY00	D:TYF0	D:TY0D	D:TYFD
Teletype Keyboard	D:TK00	D:TKF0	D:TK0D	D:TKFD
Teletype Tape Reader	D:TR00	D:TR00	D:TR0D	D:TR0D
Teletype Punch	D:TP00	D:TP00	D:TP0D	D:TP0D
CRT Console	D:TY00	D:TYF0	D:TV0D	--
CRT Keyboard	D:TK00	D:TKF0	D:TV0D	--
High Speed Paper Tape Reader	D:PR00	D:PR00	D:PR0D	D:PR0D
High Speed Paper Tape Punch	D:PP00	D:PP00	D:PP0D	D:PP0D
Centronics Line Printer	D:LP00	D:LPF0	D:LP0D	D:LPFD
Tally Line Printer	D:LP10	D:LPF1	--	--
Data Products Line Printer	D:LP20	D:LPF2	--	--
Card Reader	D:CR00	D:CR00	D:CR0D	D:CR0D
Disk (43 series, fixed platter), unit 0	D:DK00	D:DKF0	--	--
Disk (43 series, fixed platter), unit 1	D:DK02	D:DKF2	--	--
Disk (43 series, fixed platter), unit 2	D:DK04	D:DKF4	--	--
Disk (43 series, fixed platter), unit 3	D:DK06	D:DKF6	--	--
Disk (43 series, removable platter), unit 0	D:DK01	D:DKF1	--	--
Disk (43 series, removable platter), unit 1	D:DK03	D:DKF3	--	--
Disk (43 series, removable platter), unit 2	D:DK05	D:DKF5	--	--
Disk (43 series, removable platter), unit 3	D:DK07	D:DKF7	--	--
Storage Module Disk, unit 0 (cylinders 0-201)	D:SM00	D:SMF0	--	--
Storage Module Disk, unit 0 (cylinders 202-403)	D:SM01	D:SMF1	--	--
Floppy Disk, unit 0	D:FD00	D:FDF0	--	--
Floppy Disk, unit 1	D:FD01	D:FDF1	--	--
Floppy Disk, unit 2	D:FD02	D:FDF2	--	--
Floppy Disk, unit 3	D:FD03	D:FDF3	--	--
Magnetic Tape, unit 0	D:MT00	D:MT00	D:MC00	--
Magnetic Tape, unit 1	D:MT01	D:MT01	D:MC01	--
Magnetic Tape, unit 2	D:MT02	D:MT02	D:MC02	--
Magnetic Tape, unit 3	D:MT03	D:MT03	D:MC03	--
IEEE Intelligent Cable	--	--	D:IE0D	--

2.4 SAMPLE UAT

When creating the UAT, the user must declare I:UAT in a NAM directive, and any of the Standard DIB names in an EXTR directive, e.g.:

```
                NAM          I:UAT
                EXTR         D:CR00, D:LP00, D:TK00, D:LPF0
UATTOP          DATA         'CR'                Card Reader Entry
                DATA         D:CR00
                DATA         'LP'                Centronics Line Printer Entry
                DATA         D:LP00
                DATA         'CI'                Command Input Entry
                DATA         D:TK00
                DATA         'CO'                Command Output Entry
                DATA         D:TK00
                DATA         5                   FORTRAN Unit 5
                DATA         D:CR00
                DATA         6                   FORTRAN Unit 6
                DATA         D:LPF0
I:UAT           DATA         UATTOP-I:UAT-2      Table Length
```

SECTION 3

I/O HANDLER ORGANIZATION

The purpose of an I/O handler routine is to set up and execute the actual I/O instructions (normally interrupt-driven Auto-I/O instructions) necessary to perform an input or output operation to a specified device. The I/O operation and the Logical Unit Name/Number are specified in the user's IOB, and the I/O must be performed within the constraints of the device as specified in the CIB and DIB. (These tables are described fully in section 4.) A listing of the Character-oriented I/O handler is included at the end of this section.

3.1 THE STANDARD HANDLERS

Each standard IOX handler is described below. Refer to Section 7 for descriptions of non-standard handlers and to Publication No. 93325-00 for the A/D, D/A Handler.

3.1.1 Character-oriented Device Handler (non-Fortran)

This handler performs I/O, according to specifications within the applicable CIB, for the teletype, high speed reader and punch, and line printer. (A complete listing of this handler is found at the end of this section.)

3.1.2 Fortran List Device Handler

This handler exists for I/O to the teletype console, teletype keyboard and line printer when used as a list output device under Fortran. It differs from the previously described handler in that it recognizes and processes Fortran carriage control characters; i.e., a "1" character as the first print character signifies top-of-form, and a '0' signifies double spacing before printing. (A top-of-form function to the teletype consists of six consecutive line feeds).

Note that the Fortran task does not use an IOB, but rather Fortran I/O statements; these are passed through the Fortran/RTX I/O Interface routine which sets up an internal IOB for the user, according to the DIB's he has included in his Unit Assignment Table. The Fortran I/O handler is entered because the third character of the device name in DIB Words 5 and 6 is an "F"; thus "LPF0" will be processed by the Fortran handler, and "LP00" will be processed by the standard character handler.

3.1.3 Card Reader Handler

The card reader handler is similar to the standard character handler except that input characters are converted to ASCII before returning.

3.1.4 Magnetic Tape Handler

The Magnetic tape handler processes I/O for magnetic tape devices, and will perform read, write, write end-of-file and reposition functions.

3.1.5 Disk and Storage Module Disk Handler (Non-Fortran)

The IOX disk handler allows the RTX user to communicate with the disk. The communication takes place through IOX and the standard calling sequence is used.

The user calls the IOX disk handler by making a standard call to IOX with an IOB which contains a LUN assigned to a disk DIB. The op-code must be either read-direct access or write-direct access.

Data Formats

The IOX disk handler supplies no formatting information of its own. It just reads (or writes) the number of bytes requested by the user. The length of each "record" is unknown (supplied by calling program) and therefore the disk handler is unable to read variable length records without some form of external formatting routines.

The IOX disk handler can support multiple "extents" on each disk and can allow access to them as if each were a separate disk unit. Extents are simply regions on the disk which may be defined by the user to be handled separately. Without any outside action by the user, IOX will process contiguous records throughout the extent. Each record contains the number of bytes requested in the I/O call, and each record starts at the beginning of a sector. Therefore, for fixed length records, each extent may be considered as a sequential file.

In order to allow "direct access", each sector has a "relative sector number". The user may direct the IOX disk handler to process a particular record by initializing IOB Word 9 (IOB Direct Access Address) in the IOB used for the I/O call. At the completion of each request, this address is appropriately incremented by the IOX disk handler so that the next request will process the next record. If the record contains 1-512 bytes, the address will be incremented by one; 513-1024 bytes, the address will be incremented by two; etc. Note that the relative sector number and relative record number may not agree (in fact they will not agree if the records are larger than 512 bytes).

Extents are defined in the disk DIB's. The standard Disk DIB's (DK00 and DK01) define an extent as an entire platter (200 cylinders, 2 heads). The user who wishes to utilize several extents on a single platter may do so by creating his own disk DIB's, using the following variables within each DIB to define the parameters of the desired extent:

a. The number of sectors per track (may be less than the physical number).

b. The starting sector number (when added to the number of sectors per track must be less than or equal to the physical number per track).

c. The number of heads per cylinder (may be less than the physical number).

d. The starting head number (when added to the number of heads per cylinder must be less than or equal to the physical).

e. The number of cylinders the extent occupies.

f. The starting cylinder (when added to the number of cylinders must be equal to or less than the physical).

g. The drive number.

The IOX disk handler does not check for validity of the resulting sector, head, and cylinder numbers. It assumes that the dimensions and offsets supplied in the DIB are valid. This allows the user to take advantage of the "flag" bits described in the Disk Interface Manual.

Contiguous sectors occur in the following sequence:

a. Consecutive sectors on a single track (up to the number of sectors per track).

b. The same sectors on the next head (up to the number of heads per cylinder).

c. The same sectors and heads on the next cylinder (up to the number of cylinders).

The disk handler requires four additional words (five if under Fortran) in the DIB which are not required for the other handlers. These are DIB words 11-14, (11-15 if under Fortran) and are described in section 4.

3.1.6 Floppy Disk Handler (Non-Fortran)

An "extent" on a floppy disk is constructed as described for the disk handler, taking into account the size limitations in the number of cylinders, heads, and sectors:

Cylinders per Floppy Disk platter = 77 (00-76)
Heads per platter = 1 (single surface)
Sectors per track = 26 (00-25)
Words per sector = 64

There exists within RTX a standard Floppy Disk DIB (D:FD00) whose extent is defined as an entire platter. The user may define his own DIB's as described in the disk handler description.

3.1.7 Disk, Storage Module Disk, and Floppy Disk Handler (Fortran)

Fortran tasks require a certain minimum amount of file management to be performed by the disk handler. The Fortran disk handler differs from the standard disk handler as follows:

a. The random access address within the IOB is maintained by the Fortran disk handler itself, rather than the user, since the Fortran task does not create its own IOB.

b. The Fortran disk handler can write and recognize an end-of-file mark. This is a 2-character ASCII record comprised of "/*" characters.

The determination as to whether a Fortran or a non-Fortran disk handler is to be used is made on the basis of the device name in Words 5 and 6 in the DIB. If the third character is an "F", it signifies Fortran, and the Fortran disk handler is used.

In addition, a sixteenth word (Word 15) is required in a Fortran DIB. This word is used for storage of the current relative record number, which would normally be maintained in IOB Word 9. Since the Fortran user does not have access to the IOB, the Fortran/RTX I/O Interface routine keeps this information in the DIB.

.1.8 Magnetic Tape Intelligent Cable (MTIC) Handler

The MTIC handler controls data transfers between Pertec or Pertec-compatible formatters and tape transports and the central processor. The handler performs read, write, write filemark, rewind and offline, control edit, control erase, and reposition functions.

3.? I/O HANDLER REQUIREMENTS

he user may write his own handler routine for any type of I/O device he wishes. The equirements for any I/O handler to be run under control of IOX are as follows:

.. Since all I/O under RTX must be done under interrupts, the word and block interrupt locations must be set up prior to I/O.

. . time-out sequence must be included to avoid the possibility of the device "hanging-up" indefinitely without completing its operations. The real time clock, via the RTX DELAY: call is normally used for this purpose.

NOTE

> The user must not attempt to manipulate the real time clock by any means other than through the DELAY: call, as this will adversely affect the operation of RTX.

:. Once I/O is initiated, the handler should pass control back to the IOX scheduler. This permits other I/O operations to be executed simultaneously if requested.

!. The I/O handler should resume control upon either an end-of-block interrupt or upon watchdog time-out, to check the status and return to the caller at either the normal or the abnormal return location.

Several IOX- internal subroutines (described below) currently exist to aid the standard handlers in accomplishing the above requirements. The user-written handler may use any of these routines he wishes. The names of any of these routines must be declared in EXTR or REF directives within the user's handler.

3.2.1 SINT: (Set up an Instruction at the Word Interrupt Location)

Calling sequence:

```
EXTR      SINT:
.
.
.
LDX       CIB Address
JST       SINT:
DATA      :XXXX
```

Returns with:

```
INTERRUPTS---UNCHANGED
STATUS---UNCHANGED
A-REGISTER---UNDEFINED
X-REGISTER---UNCHANGED
```

Where :XXXX represents a constant which is added to CIB Word 1 to form an interrupt instruction:

SINT: does the following:

1. It determines the word interrupt location of the device. This address must reside in CIB Word 21.

2. It calculates and stores an instruction into the word interrupt location. The actual instruction stored is the arithmetic sum of (contents of CIB Word 1) + (:XXXX), where :XXXX may be any positive or negative value.

NOTE

The standard CIB's contain a "SEL DA,7" instruction in word 1.

3. Preparation is then made for a subsequent call by the handler to the SIO: routine (the handler need not call SIO:, however). This preparation consists of transferring the contents of DIB Word 8 into CIB Word 12.

(In the standard DIB's Word 8 will contain various function codes which are required for SELECT instructions in order to initiate an Auto I/O sequence during the SIO: routine. If the specific handler does not call SIO:, DIB Word 8 need not be preset.)

3.2.2 SIO: (Start I/O and Watchdog Timer)

Calling sequence:

```
EXTR      SIO:
.
.
.
LDA       DPTR
LDX       CIB address
JST       SIO:
```

Returns with:

Does not return directly; if the INTP: subroutine is used, a return will ultimately be made in the following state:

INTERRUPTS---ENABLED
STATUS---WORD MODE OV RESET
A-REGISTER---UNDEFINED
X-REGISTER---CIB Address

DPTR is an address pointer to a two-word information block:

Word 1: Positive number of bytes to be transferred.
Word 2: Word address of I/O buffer.

(Note that the standard handlers use CIB Words 26 and 27 for this information).

The SIO: routine does the following:

1. Negates the byte count pointed to by the A register, and stores it into the Word interrupt location plus one.

2. Shifts the Buffer address pointed to by the A register to the left by one bit (converts to a byte address), then decrements the byte address and stores it into the word interrupt location plus two.

NOTE

(Steps 1 and 2 above complete the three-word Auto I/O sequence. The AIN/AOT instruction itself may be generated by a call to SINT:)

3. Calculates the delay count required for the watchdog timer, as follows (assume a ten millisecond Real Time Clock rate):

   a. The negative byte count created in step 1 is loaded into the A register.
   b. The contents of CIB Word 20 are stored in-line and executed as an instruction.
   c. The contents of the A register are then negated (converted to positive) and incremented by 1000.

Steps a, b and c above compute the number of RTC "ticks" (normally 10 milliseconds each) to delay during the I/O operation. Since the number is constructed beginning with the byte count (step a) and incremented by 1000 (step c) the minimum delay possible is ten seconds, plus ten milliseconds for each data byte to be transferred. The purpose of step b is to permit a larger delay, if necessary. For example, CIB Word 20 can be set up by the user, when constructing the CIB prior to execution, to be a shift instruction (e.g., "LLA 1") which would double the value in the A register, and thus cause a twenty millisecond delay for each data byte(plus the ten second constant). Note that the instruction in CIB Word 20 is executed before the byte count in the A register has been converted from negative to positive, and before the constant 1000 is added. If the minimum delay (ten seconds, plus 10 milliseconds for each byte to be transferred) is adequate, then the instruction in CIB Word 20 should be zero (a no-op instruction). It is the responsibility of the user when creating the CIB table for his handler to determine how large a delay is required to permit completion of an I/O operation, and thus what instruction (normally LLA K, where K must be determined) is to be stored into CIB Word 20.

4. Sets up and executes the following I/O instructions:

SEL DA,X	Handler-determined function
SEL DA,5	Set word transfer mask
SEL DA,6	Set block transfer mask
SEL DA,Y	Handler-determined function

X and Y represent the function codes in bits 15 through 13 and 12 through 10, respectively, of CIB Word 12. (These function codes were originally copied from DIB Word 8 in a prior call to SINT:.) Note that if Select instructions of function X and/or Y are not required by the device, they can be organized in the DIB so that X=5 and Y=6, so that each is executed twice, or they can be set to a function code which has no meaning to the device, if such a code exists.

NOTE

If these function codes are all zero, it indicates an operation under Distributed I/O.

If the device uses function codes 5 and 6 for other purposes than to set the transfer masks, the user may wish to perform the Select functions within the handler itself, rather than calling SIO:.

5. Once the Select instructions have been executed, a call to RTX DELAY: is made, carrying the calculated delay time described in step 3 above.

If the Watchdog Timer expires before an end-of-block interrupt occurs, the instruction in CIB Word 1 (normally "SEL DA 7") is executed to disable interrupts for the device, and the "Error" and "Device Unresponsive" status bits are set in the DIB, and control is then passed to the EOR: routine at EORST:.

NOTE

SIO: does not set up the end-of-block interrupt location. This must be done in the handler.

3.2.3 INTP: (End of Block Interrupt Return Point)

The INTP: routine cancels the watchdog timer upon end-of-block interrupt, and passes Control to the return address of SIO:. Thus INTP: is an extension of SIO:, and is intended to be used only in conjunction with SIO:.

To call INTP: at end-of-block, the handler should, prior to calling SIO:, set up the following sequence at the end-of-block interrupt location:

```
    JST     *$+1
    DATA    TAG
```

Example:

```
            EXTR    INTQ:,INTP:
    TAG     ENT
            JST         INTQ:
            DATA    $,0,0,0
            DATA    INTP:,8180,0
            DATA    CIB Address
            DATA    TAG
```

where TAG is a short calling sequence to the RTX INTQ: subroutine, which points to INTP: as the task to be queued.

(The user should first familiarize himself with the RTX INTQ: description in chapter 1 RTX Functions).

The above description is the method used by the standard I/O handlers for end-of-block interrupts. For this purpose, the first 12 words of the applicable CIB may be used to contain the calling sequence to INTQ:.

For example, the following is a representation of the first twelve locations within the CIB for the line printer:

```
        C : L P Ø --- L I N E   P R I N T E R

 LOC  INST ADDR  LABEL  MNEM OPERAND  COMMENT
 ØØØØ                   NAM  C:LPØ
                             EXTR INTQ:,INTP:,I:READ,I:RITE,I:FUN
                 *
                    * * * * * * * * * * * * * * * * * * * * * * *
                    *
      ØØØ4       DA     EQU  4
      ØØ42       INTAD  EQU  :42
                    *
                    * * * * * * * * * * * * * * * * * * * * * * *
                    *
 ØØØØ                   REL  Ø
      ØØØØ       C:LPØ  EQU  $
 ØØØØ Ø8ØØ       CIB    ENT
 ØØØ1 4Ø27              SEL  DA,7     SELECT --- FC = 7
 ØØØ2 F9ØØ              JST  INTQ:
 ØØØ3 ØØØ3              DATA $,Ø,Ø,Ø,INTP:,818Ø,Ø,CIB,CIB
 ØØØ4 ØØØØ
 ØØØ5 ØØØØ
 ØØØ6 ØØØØ
 ØØØ7
 ØØØ8 1FF4
 ØØØ9 ØØØØ
 ØØØA ØØØØ
 ØØØB ØØØØ
```

Note that the end-of-block interrupt location contains a JST into the CIB itself; Word 1 of the CIB is the SEL DA,7 instruction used by the SIO: routine. It is also executed at end of block, thus serving as a convenient method to turn off the interrupt masks following an I/O operation.

Following this instruction is a JST to INTQ: followed by the required parameters, of which INTP: is the task to be executed. Note also that this sequence will automatically cause the X register to be loaded with the CIB address upon entry to INTP:.

3.2.4 WAIT: (End of Record Delay Routine)

Calling sequence:

```
LDX          CIB Address
JST          WAIT:
```

Returns with:

```
INTERRUPTS---ENABLED
STATUS---UNCHANGED
A-REGISTER---UNDEFINED
X-REGISTER---CIB Address
```

The WAIT: routine utilizes the delay length specified in DIB Word 7 to delay a sufficient length of time at end-of-record to ensure that the device is physically ready to perform the next I/O request. (Generally, one character time is sufficient for this delay.)

The routine loads the delay count from DIB Word 7 depending on the I/O instruction at the Word interrupt location; i.e., if bit 13 of the I/O instruction is on, it is assumed to be an output instruction, and bits 0-7 of DIB Word 7 are used as the delay count. If bit 13 of the I/O instruction is off, it is assumed to be an input instruction, and bits 8-15 of DIB Word 7 are used as the delay count. Once the delay count is established, a call to RTX DELAY: is made; upon return from the delay, the routine exits to the caller.

3.2.5 EOFQ: (End of File Check Routine)

Once an end-of-block interrupt has occurred, EOFQ: may be called as follows:

```
LDX          CIB Address
JMP          EOFQ:
```

This routine does the following:

1. Examines the first two input characters in the buffer to determine whether they are '/*'
2. If so, control is passed to the EOF: routine.
3. If not, control is passed to the EOR: routine.

:.2.6 EOF: (End of File Routine)

ing sequence:

```
LDX             CIB Address
JMP             EOF:
```

'he EOF: routine is entered when it has been determined that an end-of-file has been ncountered (the routine EOFQ: may be used to determine this).

'he routine stores a zero value into CIB Word 28, loads the A register with an end-of-ile status, and transfers control to the EOR: routine at EORST:.

.2.7 EOR: (End of Record Routine)

:al ng sequence:

```
LDX             CIB Address
JMP             EOR:
```

'his routine is entered when the handler has completed the requested I/O operation and ishes to return to the calling task.

'he routine loads the A register with the current status from CIB Word 32, and con-in s at EORST:.

;.2.8 EORST: (Alternate Entry Point to EOR:)

EORST: and EOR: are alternate entry points to the same end-of-record routine. The ifference between the two is that EOR: loads the I/O status word into the A register rom the CIB. EORST: assumes that the status is already in the A register.

:al ng sequence:

```
LDX             CIB Address
LDA             I/O status (from handler)

JMP             EORST:
```

'he routine does the following:

. It copies the actual transfer count of the I/O operation from the CIB into Word 8 of the IOB.

:. It stores the status of the I/O operation (in the A register upon entry) into bits 15-8 of IOB Word 5.

:. It performs an RTX BEGIN: call, passing as a parameter the normal or abnormal return address of the caller, depending on the status. The abnormal return address is taken if any of bits 9, 10, 11, or 14 are set in word 5 of the IOB.

. It calls WAIT: to perform an end-of-record delay.

5. It loads CIB Word 1 (assumed to be "SEL DA,7), masks off the low order two bits (to make it a SEL DA,4 or initialize instruction) and executes it in-line.

6. It empties the IOCH (I/O suspend) list into the READY list.

7. It then transfers to the IOX request scheduler routine to check to see if another request is pending for any device on the controller just used.

3.2.9 FETCH: (Input one character from an I/O device)

Calling sequence:

```
EXTR      FETCH:
.
.
.
LDA            CIB Address
JST            FETCH:
```

Returns with:

INTERRUPTS---ENABLED
STATUS---UNCHANGED
A-REGISTER---CONTAINS INPUT BYTE
X-REGISTER---UNCHANGED

The FETCH: routine calls WAIT: to wait one character time, then calls SIO: to perform a one-character I/O operation. Upon input of the character, it is checksummed, and the subroutine exits back to the caller.

The following assumptions are made by FETCH:.

1. The handler has previously zeroed out the checksum word (CIB Word 13) at the start of the record.

2. There exists in CIB words 34 through 37 the following sequence:

```
DATA      $+1            Pointer to byte count
DATA      1              Byte count (1 character)
DATA      $+1            Buffer address
DATA      0              One-character input buffer
```

which are required for FETCH:'s call to SIO:.

Upon return from FETCH:, the input character is in CIB word 37 as well as in the A register, and the cumulative checksum is in CIB word 13.

3.2.10 BUFFQ: (Store input character into buffer)

Calling sequence:

```
EXTR      BUFFQ:
.
.
.
LDX       CIB Address
JST       BUFFQ:
```

Returns with:

INTERRUPTS---ENABLED
WORD MODE
OVERFLOW---RESET (unless buffer filled)
A-REGISTER---CONTAINS INPUT BYTE
X-REGISTER---UNCHANGED

T BUFFQ: routine is designed to be used following a call to FETCH:, in that it moves CIB word 37 (stored into by FETCH:) into the user's buffer. The step-by-step procedure is:

1. The overflow register is reset.

2. The actual transfer count (CIB Word 28) is incremented.

3. The actual transfer count is compared to the requested count (CIB word 26).

4. If the actual count is greater (indicating that the buffer is already full), the buffer address (CIB Word 27) is incremented and the subroutine exits.

5. If the actual count is less, CIB Word 37 is copied into the user's buffer pointed to by CIB Word 27. Then Word 27 is incremented and the subroutine exits.

6. If the actual count is equal (indicating that this character will cause the buffer to be full), overflow is set and CIB Word 37 is copied into the user's buffer pointed to by CIB Word 27. Then Word 27 is incremented and the subroutine exits.

3.2.11 UNRES: (Unresponsive Device Routine)

Calling sequence:

```
EXTR      UNRES:
.
.
.
LDX       CIB Address
JMP       UNRES:
```

3.2.12 IORTN: (Return to I/O Scheduler)

Calling sequence:

```
     EXTR      IORTN:
     .
     .
     .
     LDX       CIB Address
     JMP       IORTN:
```

In practice, an I/O handler is a subroutine with an abnormal calling sequence (a JMP instruction is used, rather than a JST). This is because I/O handlers are only "called" from one location, and thus the return is known. This return address is IORTN:. Therefore, once an I/O operation has been initiated, a jump to IORTN: must be made. Note that if the SIO: routine is called, it will exit to IORTN:.

3.3 CHARACTER-ORIENTED DEVICE HANDLER LISTING

The following listing illustrates the standard Character-oriented Device Handler (non-Fortran) written for an LSI-2 processor. The code also includes a table of equates used by RTX, its subexecutives, and its library modules, as well as a listing of the TTY console DIB (D:TY00) and TTY CIB (C:TY0). CONCORDANCE listings provide an alphabetized map of all symbols.

```
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *      THE EQUATES CONTAINED IN THIS ASSEMBLY
                 *      ARE USED BY RTX AND ITS SUBEXECUTIVES AND
                 *      ITS LIBRARY MODULES
                 *
                 *      IT MUST BE ASSEMBLED AND THE SYMBOL TABLE
                 *      GENERATED BE PASSED TO THE RTX MODULE
                 *      BEING ASSEMBLED
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *      EQUATES COMMON TO SEVERAL BLOCK TYPES
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
      0000       CHAIN  EQU   0        POINTER TO NEXT BLOCK
      0001       PRI    EQU   1        PRIORITY (BITS 15-3)
      0003       CN     EQU   3        COORDINATION NUMBER
      0002       QUEUE  EQU   2        TOP OF QUEUE
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *      T C B   E Q U A T E S
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
      0001       STAPRI EQU   PRI      STATUS (BITS 0-2) & PRIORITY (BITS 15-3)
      0002       PREG   EQU   2        PROGRAM REGISTER
      0003       AREG   EQU   3        ACCUMULATOR REGISTER
      0004       XREG   EQU   4        INDEX REGISTER
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *      I O B   E Q U A T E S
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
PAGE  0002  09/01/76  09:46:43   94500-10 RTX, IOX        EQUATES
MACRO2 (A2) SI= MACROS  BO=        RTXEQU  ---  EQUATES USED IN RTX

0039                       *
0040       0001      IDT     EQU     1         DEVICE TYPE
0041       0002      ICUN    EQU     2         UNIT NUMBER
0042       0002      ITCB    EQU     2         ADDRESS OF USER'S TCB
0043       0004      ILUN    EQU     4         LOGICAL UNIT NAME/NUMBER
0044       0005      ISTA    EQU     5         STATUS
0045       0005      IOP     EQU     5         OP-CODE
0046       0006      IRCNT   EQU     6         REQUESTED COUNT
0047       0007      IBUFF   EQU     7         BUFFER ADDRESS
0048       0008      IACNT   EQU     8         ACTUAL COUNT TRANSMITTED
0049       0009      IDAA    EQU     9         DIRECT ACCESS ADDRESS
```

```
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *      C  I  B     E Q U A T E S
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
      0000       CBOR   EQU   0          BEGINNING OF RECORD FLAG
      0001       CSEL7  EQU   1          SELECT  FC = 7
      0004       CTMP1  EQU   4          TEMP CELL 1
      0005       CTMP2  EQU   5          TEMP CELL 2
      0006       CTMP3  EQU   6          TEMP CELL 3
      0007       CEBTSK EQU   7          END OF BLOCK TASK POINTER
      0009       CNEWA  EQU   9          A REGISTER FOR EBTSK
      000A       CNEWX  EQU   10         X  REGISTER FOR EBTSK
      000C       CFUN   EQU   12         TEMP CELL FOR I/O INSTRUCT
      000D       CCSUM  EQU   13         CHECKSUM           TEMP
      000E       REWCNT EQU   14
      000F       CJTBL  EQU   15         JUMP TABLE
      0013       CSPLOP EQU   19         POINTER TO SPECIAL OP PROC
      0014       CDEL   EQU   20         DELAY MODIFICATION
      0015       CINTR  EQU   21         POINTER TO INTERRUPT ADDRE
      0016       EXCESS EQU   22
      0017       CEOF   EQU   23
                 *
                 *      FILLED FROM IOB
                 *
      0018       CIOB   EQU   24         IOB POINTER
      0019       COP    EQU   25         OPERATION CODE
      001A       CRCNT  EQU   26         REQUESTED COUNT
      001B       CBUFF  EQU   27         BUFFER ADDRESS
      001C       CTCNT  EQU   28         TRANSFER COUNT
      001D       CDAA   EQU   29         DIRECT ACCESS ADDRESS
                 *
                 *      FILLED FROM DIB
                 *
      001E       CDIB   EQU   30         DIB POINTER
```


Computer Automation

```
          001F          CFUN1  EQU     31          TEMP CELL 2 FOR FUNCTIONS
                        *
                        *      TEMP STORAGE USED BY IOX AND ITS DRIVERS
                        *
          0020          STATUS EQU     32          DEVICE STATUS WORD
          0021          CRTN   EQU     33          RETURN ADDRESS FROM I:SIO
          0022          CDCHN  EQU     34          START OF DATA CHAIN
          0023          CDCHN1 EQU     CDCHN+1
          0024          CDCHN2 EQU     CDCHN+2
          0025          CDCHN3 EQU     CDCHN+3
```

```
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *     D I B   E Q U A T E S
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
        0001     DCIB    EQU    1        CIB POINTER
        0004     DSW     EQU    4        DEVICE SPECIFICATION WORD
        0005     DT      EQU    5        DEVICE TYPE
        0006     DCUN    EQU    6        CONTROLLER & UNIT NUMBERS
        0007     DDEL    EQU    7        END OF BLOCK DELAY TIMES
        0008     DFUN    EQU    8        FUNCTION CODES & FLAGS
        0009     DULS    EQU    9        UPPER LIMITS
        000A     DERRC   EQU    10       ERROR COUNTER
        000B     DSTRT   EQU    11       DIO START ADDRESSES & MODES
        000B     DSECT   EQU    11       VERIFY FLAG, DRIVE #, STARTING SECTOR
        000C     DHEAD   EQU    12       SECTORS/TRACK & STARTING HEAD
        000D     DCYL    EQU    13       SECTORS/CYLINDER & STARTING CYLINDER
        000E     DEOD    EQU    14       NUMBER OF SECTORS IN FILE
        000F     DCSECT  EQU    15       FORMATTED SECTOR NO
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *     INTERRUPT BLOCK  E Q U A T E S
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
        0000     NTAIO   EQU    0        I/O INSTRUCTION
        0001     NTCNT   EQU    1        COUNT FOR AUTO I/O
        0002     NTBUFF  EQU    2        BUFFER ADDRESS - 1
        0004     NTEOB   EQU    4        END-OF-BLOCK INTERRUPT
        0005     NTEOBA  EQU    5        ADDRESS FOR EOB INSTRUCTION
                 *
                 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                 *
                 *     MISCELLANEIOUS EQUATES
                 *
```

```
                * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                *
      001D      ARROW  EQU    29         BACKARROW FLAG SAME AS CDA
      0003      EORMSK EQU    3          END OF RECORD MASK
      0004      EOFMSK EQU    4          END OF FILE MASK
      4000      I:ERR  EQU    :4000
      0800      I:BOP  EQU    :800
      0400      I:RES  EQU    :400
      0200      I:EOF  EQU    :200
      0100      I:BOD  EQU    :100       BEGINNING OF DEVICE STATUS BIT
      0300      I:EOD  EQU    :300
      2000      I:NOIO EQU    :2000
      4000      ERROR  EQU    :4000
      001F      OPMSK  EQU    31
      0080      IOREL  EQU    :80
      0003      EORTYP EQU    3
      0004      PROMPT EQU    4
      0008      EOFTYP EQU    8
      0000             IFF    LSI305
      0005      IOREQ  EQU    5
                       ENDC
```

```
                         MACRO   LLL
                         IFF     LSI305
                         LLL::   :180,#1-1
                         ENDC
                         IFT     LSI305
                         REPT    #1
                         LLL:
                         ENDC
                         ENDM

                         MACRO   LLL:
                         LLX     1
                         RLA     1
                         ENDM
      0010               FORM    LLL::,12,4
                         MACRO   INISTF     CIB INTERRUPT & DEVICE ADDRESS STUFF
                         SPACE   1
                 DA      EQU     #1         DEFINE DEVICE ADDRESS
                 INTAD   EQU     #2         DEFINE INTERRUPT ADDRESS (DATA)
                         ABS     INTAD      ORG TO AUTO I/O LOCATION
                         DATA    0,0,0
                         ABS     INTAD+4    ORG TO END-OF-BLOCK INTERRUPT
                         JST     *$+1       GO TO CIB FOR
                         DATA    CIB        . END OF BLOCK
                         REL     0          ORG TO RELATIVE ZERO (0)
                         SPACE   1
                         ENDM

                         MACRO   SINT       GENERATE CALL TO SETUP INTERRUPTS
                         JST     SINT:      CALL SUBROUTINE
                         IFF     #1(S)
                         DATA    :3800      MAKES STOP
                         NOTE    U,FIRST.PARAMETER
                         ENDC
                         IFF     #2(I)
                         IFF     #2(O)
```

```
                 DATA    :3800     MAKES STOP
                 NOTE    U,SECOND.PARAMETER
                 ENDC
                 ENDC
                 IFT     LSI305
                 IFT     #2[I]
                 DATA    #3+:40F9
                 ENDC
                 IFT     #2[0]
                 DATA    #3+:60F9
                 ENDC
                 ENDC
                 IFF     LSI305
                 IFT     #2[I]
                 DATA    #3+:13F9
                 ENDC
                 IFT     #2[0]
                 DATA    #3+:23F9
                 ENDC
                 ENDC
                 ENDM

                 MACRO   CIB
                 TITL    'RTX/IOX CHARACTER I/O DRIVERS 93302-1XE0
                 TITL    C:#1...CONTROLLER.INFORMATION.BLOCK
                 NAM     C:#1
                 EXTR    SCH:,INTQ:,INTP:
                 XDEF    #4
                 XDEF    #5
                 XDEF    #6
                 INTSTF  #2,:#3
         CIB     EQU     $
         C:#1    DATA    SCH:
                 IFT     LSI305
                 SEA     DA%1+1
                 ENDC
```

```
                  IFF     LS1305
                  SEL     DA%1+1
                  ENDC
                  JST     INIQ:
                  DATA    $,0,0,0,INIP:,8180,0,C:#1,C:#1,0,0,0
                  XREF    #4
                  XREF    #5
                  DATA    0
                  XREF    #6
                  DATA    0
                  LLA     #7
                  DATA    INTAD
                  RES     12,0
                  DATA    $+1,1,$+1,0
                  END
                  ENDM
                  MACRO   DIB
                  TITL    'RTX/IOX CHARACTER I/O DRIVERS 93302-1XE0
                  TITL    D:#1...DEVICE.INFORMATION.BLOCK
                  NAM     D:#1
                  EXTR    C:#3
         D:#1     CHAN    X::
                  DATA    C:#3,0,0,:#4
                  TEXT    #2
                  DATA    0,:#5,:#6,0,:#7
                  END
                  ENDM
                  MACRO   XDEF
                  IFF     #1(0)
                  EXTR    I:#1
                  ENDC
                  ENDM
                  MACRO   XREF
                  IFF     #1(0)
                  DATA    I:#1
                  ENDC
```

```
0326                    IFT     #1[0]
0327                    DATA    0
0328                    ENDC
0329                    ENDM
0330                    SAVE
0331                    END

0000  ERRORS
0000  WARNING
```

```
                    *
                    * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
     0000                  NAM    D:TY00
                           EXTR   C:TY0
                    *
                    * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
     0000           D:TY00 CHAN   X::
     0001 0000             DATA   C:TY0,0,0,:5066,'TY','00'
     0002 0000
     0003 0000
     0004 5066
     0005 D409
     0006 B0B0
     0007 020C             DATA   :20C,:A6E,:4800,0
     0008 0A6E
     0009 4800
     000A 0000
                           END

0000  ERRORS
0000  WARNING
```

```
X     0000  C:TY0       0129  0134
N     0133  D:TY00      0128
U     0000  X::         0133
0136 SOURCE LINES
```

```
0251  0000                      NAM     C:TYO
0252                            EXTR    INTQ:,INIP:,I:READ,I:RITE,I:FUN
0253                            EXTR    SCH:

0254  0002                      INISTF 7,2
0254+ 0002 0000
0254+ 0003 0000
0254+ 0004 0000
0254+ 0006
0254+ 0006 F907 0007
0254+ 0007 0000
0254+ 0000

0255       0000         C:TYO   EQU     $
0256  0000 0000         CIB     DATA    SCH:
0257       0000                 IFF     LSI305
0258  0001 403F                 SEL     DA,7      SELECT --- FC = 7
0259                            ENDC
0263  0002 F900 0000            JST     INTQ:
0264  0003 0003                 DATA    $,0,0,0,INTP:,8180,0,CIB,CIB
      0004 0000
      0005 0000
      0006 0000
      0007 0000
      0008 1FF4
      0009 0000
      000A 0000
      000B 0000
0265  000C 0000                 RES     3,0
0266  000F 0000                 DATA    I:READ,I:RITE,0,I:FUN,0
      0010 0000
      0011 0000
      0012 0000
      0013 0000
0267  0014 1353                 LLA     4
0268  0015 0002                 DATA    INTAD
```

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```
0269  0016 0000          RES     12,0
0270  0022 0023          DATA    $+1,1,$+1,0
      0023 0001
      0024 0025
      0025 0000
0271                     END

0000  ERRORS
0000  WARNING
```

```
N    0255  C:TYO     0251
     0256  CIB       0264  0264
U    0000  DA        0258  0261
X    0000  I:FUN     0252  0266
X    0000  I:READ    0252  0266
X    0000  I:RITE    0252  0266
U    0000  INTAD     0268
X    0000  INTP:     0252  0264
X    0000  INTQ:     0252  0263*
U    0000  LSI305    0257  0260
X    0000  SCH:      0253  0256
0271 SOURCE LINES
```

```
        0000                MACH    0         MUST WORK ON LSI AND ALPHA/NM-16
                      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                      *
                      *     ORIGINATING NAMES
                      *
                      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                      *
   0000                     NAM     I:READ    INPUT REQUEST
   0074                     NAM     I:RITE    OUTPUT REQUEST
   0085                     NAM     I:FUN     SPECIAL FUNCTIONS PROCESSOR
   0083                     NAM     RITE2     OUTPUT END OF RECORD (CR,LF,ETC)
                      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                      *
                      *     EXTERNAL NAMES
                      *
                      * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                      *
                            EXTR    BEGIN:    BEGIN TASK SERVICE
                            EXTR    END:      END TASK SERVICE
                            EXTR    SUBR:     BEGIN COMMON SUBROUTINE
                            EXTR    SUBX:     END COMMON SUBROUTINE
                            EXTR    DELAY:    DELAY SERVICE ROUTINE
                            EXTR    EOF:      END OF FILE TASK
                            EXTR    EOR:      END OF RECORD TASK
                            EXTR    EORST:    SET STATUS AND END OF RECORD
                            EXTR    SINT:     SET INTERUPTS TASK
                            EXTR    SIO:      START I/O
                            EXTR    CKSUM:    COMPUTE CHECKSUM TASK
                            EXTR    FETCH:    GET CHARACTER
                            EXTR    EOFCK:    CHECK FOR END-OF-FILE
                            EXTR    BUFFQ:    PUT BYTE INTO BUFFER
                            EXTR    WAIT:     WAIT FOR DEVICE
                            EXTR    EOFQ:     CHECK FOR ASCII EOF ('/*')
```

```
                         * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
                         *      THIS ROUTINE WILL PROCESS ANY REQUESTS
                         *      TO INPUT FROM A CHARACTER DEVICE.
                         *
                         *      ALL REQUESTED WILL BE ISSUED FOR ONE (1)
                         *      CHARACTER AT A TIME.
                         *      IF THE TRANSFERRED COUNT CONTAINED IN THE
                         *      CIB IS NEGATIVE THE DEVICE WILL BE
                         *      PROMPTED WITH THE CHARACTER OR CHARACTERS
                         *      CONTAINED IN THE CTCNT.
                         *
                         * * * * * * * * * * * * * * * * * * * * * * * * * * *
                         *
0000                            REL     0
          0000           I:READ EQU     $
                         *
0000 B41B 001B                  LDA     @CBUFF
0001 1350                       LLA     1
0002 9C0E 000E                  STA     @REQCNT   SAVE FOR A RESTART
                         *
          0003           RFA2   EQU     $         R E S T A R T
                         *
0003 9C1B 001B                  STA     @CBUFF    SET BUFFER ADDRESS TO BYTE
0004 C601                       LAP     1
0005 9C23 0023                  STA     @CDCHN1   SET BYTE COUNT TO ONE
0006 0110                       ZAR
0007 9C1D 001D                  STA     @ARROW    CLEAR BACK ARROW FLAG
0008 9C1C 001C                  STA     @CTCNT    CLEAR TRANSFER COUNT
0009 B416 0016                  LDA     @EXCESS   PROMPT CHARACTERS
000A 308E 0019                  JAP     RFAX      IF NONE
000B 1357                       LLA     8         CHECK FOR #
000C 2101 000E                  JAZ     $+2       IF ONLY ONE
000D C601                       LAP     1         TWO PROMPT CHARACTERS
000E 0150                       IAR               ADJUST COUNT
000F 9C04 0004                  STA     @CTMP1    PUT IN MINI-IOB
```


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```
0010 C608                LAP     IACNT
0011 8C18 0018           ADD     @CIOB       ADDRESS OF PROMPT CHARACTERS
0012 9C05 0005           STA     @CTMP1+1 PUT IN MINI-IOB
0013 FBDC 00F0           SINT    STANDARD,OUTPUT,0
0014 23F9
0015 0030                TXA                 CIB ADDRESS
     0000                IFF     LSI305
0016 8ADA 00F1           ADD     =CTMP1      ADDRESS OF MINI-IOB
                         ENDC
0017 FBDA 00F2           JST     SIO:        DO OUTPUT
0018 FBDA 00F3           JST     WAIT:       FOR DELAY.
     0019         RFAX   EQU     $
0019 FBD6 00F0           SINT    STANDARD,INPUT,0
001A 13F9
001B C607                LAP     7           OP CODE MASK
001C 8419 0019           AND     @COP        MASK OFF OP CODE
001D D203 0021           CMS     TWO         COMPARE TO TWO
001E F203 0022           JMP     UNFMTI      UNFORMATTED
001F F234 0054           JMP     BININ       BINARY
0020 F20C 002D           JMP     RFA3        FORMATTED ASCII
0021 0002         TWO    DATA    2           CONSTANT TWO (2)
                  *
                  *
                  *      TITL UNFMTI --- UNFORMATTED INPUT
                  *
     0022         UNFMTI EQU     $
                  *
0022 FBD1 00F4           JST     FETCH:      GET NEXT CHARACTER
0023 FBD1 00F5           JST     BUFFQ:      GO PUT INTO BUFFER
0024 3242 0022           JOR     UNFMTI      GO GET NEXT CHARACTER
0025 F3D0 00F6           JMP     EOR:        END OF RECORD
```

```
                              *
          0026                RFA10   EQU     $
                              *
     0026 FBCC 00F3                   JST     WAIT:
     0027 B40E 000E                   LDA     @REQCNT
     0028 F625 0003                   JMP     RFA2      GO RESTART
                              *
          0029                RFA4    EQU     $         MAYBE GOOD
                              *
     0029 9C1D 001D                   STA     @ARROW    SET FLAG
     002A C0DF                        CAI     :DF       IS IT BACK ARROW?
     002B F220 004C                   JMP     RFA9      YES, BACK UP
     002C FBC8 00F5                   JST     BUFFQ:    PUT INTO BUFFER
                              *
          002D                RFA3    EQU     $         L O O P
                              *
     002D FBC6 00F4                   JST     FETCH:    GET CHARACTER
     002E FBC8 00F7                   JST     EOFCK:    IF FILE MARK, GOODBYE
     002F A2C8 00F8                   IOR     =:80
     0030 9C25 0025                   STA     @CDCHN3   HIGH-ORDER BIT ON
     0031 C0FF                        CAI     :FF       IS IT RUBOUT?
     0032 F605 002D                   JMP     RFA3      YES, IGNORE IT
     0033 D2C5 00F9                   CMS     =:8D      HOW ABOUT A CARRIAGE RETURN?
     0034 F607 002D                   JMP     RFA3      TOO SMALL
     0035 F60C 0029                   JMP     RFA4      GOT A LIVE ONE
                              *
                              *       FOUND CARRIAGE RETURN
                              *
```

```
                          *
                          *       FOUND CARRIAGE RETURN
                          *
     0036 C604                    LAP     PROMPT     PROMPTABLE BIT
     0037 841F 001F               AND     @CFUN1     IS IT?
     0038 210C 0045               JAZ     RFA1       IF NOT, GET OUT
     0039 C603                    LAP     EORMSK     MASK FOR EOR TYPE
     003A 841F 001F               AND     @CFUN1     GET EOR TYPE
     003B C002                    CAI     2          IS IT CR/LF ?
     003C F201 003E               JMP     $+2        YES, ECHO LINE FEED
     003D F207 0045               JMP     RFA1       NO, FORGET LINE FEED
     003E FBB4 00F3               JST     WAIT:      DO A HICCUP
     003F FBB0 00F0               SINT    STANDARD,OUTPUT,0
     0040 23F9
     0041 B250 0092               LDA     CRLF+1     LINE FEED
     0042 9C25 0025               STA     @CDCHN3    DATA CHARACTER
     0043 B422 0022               LDA     @CDCHN     POINER TO MINI-IOB
     0044 FBAD 00F2               JST     SIO:       OUTPUT
                          *
          0045            RFA1    EQU     $          CHECK FOR VALID RECORD
                          *
     0045 BC1D 001D               EMA     @ARROW     CORRECTION FLAG
     0046 C0DF                    CAI     :DF        LAST CHARACTER BACK ARROW
     0047 F621 0026               JMP     RFA10      YES, DO IT OVER
     0048 B40E 000E               LDA     @REQCNT    RESTART ADDRESS
     0049 13D0                    LRA     1          MAKE IT WORD
     004A 9C1B 001B               STA     @CBUFF
     004B F3AE 00FA               JMP     EOFQ:      CHECK FOR END OF FILE
                          *
          004C            RFA9    EQU     $          BACK ARROW FOUND
                          *
     004C B41C 001C               LDA     @CTCNT     CURRENT COUNT
     004D 2160 002D               JAZ     RFA3       IF AT BEGINNING
     004E 00D0                    DAR                DOWN ONE
     004F 9C1C 001C               STA     @CTCNT     RESTORE IT
     0050 B41B 001B               LDA     @CBUFF     * *
```

```
0594  0051 00D0            DAR              * DECREMENT BUFFER ADDRESS
0595  0052 9C1B 001B       STA     @CBUFF   * *
0596  0053 F626 002D       JMP     RFA3     GO GET NEXT
```

```
                          *       READ A BINARY RECORD
                          *       FIND THE RECORD HEADER
          0054            BININ   EQU     $
     0054 FB9F 00F4               JST     FETCH:    GET A CHARACTER
     0055 C0FF                    CAI     :FF       IS IT A RUBOUT
     0056 F202 0059               JMP     $+3       YES GO GET BYTE COUNT
     0057 FB9F 00F7               JST     EOFCK:    CHECK FOR /*
     0058 F604 0054               JMP     BININ
                          *
                          *       GET THE BYTE COUNT
                          *
     0059 0110                    ZAR
     005A 9C0D 000D               STA     @CCSUM    CLEAR THE CHECKSUM
     005B FB98 00F4               JST     FETCH:    GET FIRST CHARACTER
     005C 1357                    LLA     8         SHIFT TO HIGH ORDER BYTE
     005D 9C1D 001D               STA     @CDAA     SAVE IN TEMP CELL
     005E FB95 00F4               JST     FETCH:    GET SECOND CHARACTER
     005F A41D 001D               IOR     @CDAA     MERGE THE TWO BYTES
     0060 3101 0062               JAN     $+2       NOT AN END OF FILE
     0061 F399 00FB               JMP     EOF:      AN END-OF-FILE
                          *
                          *       READ THE INPUT DATA
                          *
     0062 0310                    NAR
     0063 9C0E 000E               STA     @REQCNT   SAVE REQUIRED COUNT
                          *
          0064            NEXT1   EQU     $         GET NEXT ONE
                          *
     0064 FB8F 00F4               JST     FETCH:    GO GET NEXT BYTE
     0065 FB8F 00F5               JST     BUFFQ:    GO QUEUE INTO BUFFER
     0066 DC0E 000E               IMS     @REQCNT   INCREMENT NUMBER OF BYTES
     0067 F603 0064               JMP     NEXT1
                          *
                          *       PERFORM CHECKSUM
                          *
     0068 C6FF                    LAP     :FF
```

```
0634  0069 840D 000D        AND    @CCSUM    MASK OFF LOW ORDER BITS
0635  006A 9C1D 001D        STA    @CDAA     SAVE RECORD CHECKSUM
0636  006B F888 00F4        JST    FETCH:    FIRST BYTE
0637  006C 1357             LLA    8         SHIFT TO HIGH ORDER BYTE
0638  006D 9C0E 000E        STA    @REQCNT   SAVE
0639  006E F885 00F4        JST    FETCH:    SECOND CHARACTER
0640  006F A40E 000E        IOR    @REQCNT   MERGE TWO BYTES
0641  0070 941D 001D        SUB    @CDAA     SUBTRACT COMPUTED CHECKSUM
0642  0071 2101 0073        JAZ    $+2       IF EVERYTHING OK
0643  0072 B289 00FC        LDA    =ERROR    ERROR CODE
0644  0073 F389 00FD        JMP    EORST:    ERROR EXIT
```

```
0649                     * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
0650                     *
0651                     *       THIS ROUTINE WILL PROCESS ANY REQUESTS
0652                     *       TO OUTPUT TO A CHARACTER DEVICE.
0653                     *
0654                     *       AFTER THE REQUEST HAS BEEN STARTED, CONTROL
0655                     *       WILL BE RETURNED TO THE IO SCHEDULER
0656                     *
0657                     * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
0658                     *
0659       0074          I:RITE EQU    $
0660                     *
0661  0074 FB78 00F0            SINT   STANDARD,OUTPUT,0
0661+ 0075 23F9
0662  0076 B41A 001A            LDA    @CRCNT    REQUESTED COUNT
0663  0077 9C1C 001C            STA    @CTCNT    SET TRANSFERED COUNT
0664                     *
0665                     *  WHAT WAS REQUEST
0666                     *
0667  0078 C603                 LAP    3
0668  0079 8419 0019            AND    @COP      MASK OFF OP-CODE
0669  007A 9C19 0019            STA    @COP      REPLACE NEW ONE
0670  007B C003                 CAI    3         IF BINARY
0671  007C F21E 009B            JMP    RITE10    FORMATTED BINARY
0672  007D 0030                 TXA
0673       0000                 IFF    LSI305
0674  007E 8A7F 00FE            ADD    =CRCNT    ADDRESS OF DATA CHAIN
0675                            ENDC
0679                     *
0680       007F          RITE1  EQU    $         QUIT TUIT
0681                     *
0682  007F FB72 00F2            JST    SIO:      START I/O
0683  0080 B419 0019            LDA    @COP
0684  0081 C001                 CAI    1         IF UNFORMATTED
0685  0082 F373 00F6            JMP    EOR:      GO TO END OF RECORD
0686                     *
```

```
0687                         *       OUTPUT TRAILER RECORD
0688                         *
0689       0083              RITE2   EQU     $
0690  0083 FB6F 00F3                 JST     WAIT:     WAIT AWHILE
0691  0084 C603                      LAP     EORMSK    END OF RECORD MASK
0692  0085 841F 001F                 AND     @CFUN1    MASK OFF THE EOR FLAG
0693  0086 9C1B 001B                 STA     @CBUFF
0694  0087 8A08 0090                 ADD     EORBAD    ADD START OF BUFFER ADDRESS
0695  0088 BC1B 001B                 EMA     @CBUFF    PUT IT AND PICK UP EOR FLAG
0696  0089 1300                      LRA     1
0697  008A 0150                      IAR               CORRECT # OF CHARACTERS
0698  008B 9C1A 001A                 STA     @CRCNT    PUT INTO DATA CHAIN
0699  008C 0030                      TXA
0700       0000                      IFF     LSI305
0701  008D 8A70 00FE                 ADD     =CRCNT    DATA CHAIN ADDRESS
0702                                 ENDC
0706                         *
0707       008E              LEAVE   EQU     $         CALL SIO: AND GO TO EOR:
0708                         *
0709  008E FB63 00F2                 JST     SIO:      START I/O
0710  008F F366 00F6                 JMP     EOR:      ALL DONE
0711  0090 0091              EORBAD  DATA    CRLF
0712  0091 8D8A              CRLF    DATA    :8D8A,:8A8D,:8D8A,:A08D
      0092 8A8D
      0093 8D8A
      0094 A08D
0713  0095 0000              NULLS   DATA    0,0,0
      0096 0000
      0097 0000
0714  0098 FF00              EOF1    DATA    :FF00,0
      0099 0000
0715  009A AFAA              EOF2    TEXT    '/*'
0716                         *
0717       009B              RITE10  EQU     $         FORMATTED BINARY
0718                         *
0719  009B 0110                      ZAR
```

```
009C 9C0D 000D          STA    @CCSUM    CLEAR THE CHECKSUM BYTE
009D B214 00B2          LDA    RHEDAD    RECORD HEADER TASK
009E FB53 00F2          JST    SIO:      START I/O
009F FB53 00F3          JST    WAIT:     WAIT AWHILE
                 *
     00A0        RITE11 EQU    $         OUTPUT BYTE COUNT
                 *
00A0 B41A 001A          LDA    @CRCNT    REQUESTED COUNT
00A1 9C25 0025          STA    @CDCHN3   PUT INTO CIB
00A2 C602               LAP    2         TRANSFER COUNT
00A3 9C23 0023          STA    @CDCHN1   PUT INTO DATA CHAIN
00A4 B422 0022          LDA    @CDCHN    DATA CHAIN ADDRESS
00A5 FA2E 00D4          JST    I:OCS     GO COMPUT CHECKSUM
00A6 FB48 00F2          JST    SIO:      START I/O
00A7 FB48 00F3          JST    WAIT:     WAIT AWHILE
                 *
     00A8        RITE12 EQU    $         OUTPUT BINARY RECORD
                 *
00A8 0030               TXA
     0000               IFF    LSI305
00A9 8A54 00FE          ADD    =CRCNT    DATA CHAIN ADDRESS
                        ENDC
00AA FA29 00D4          JST    I:OCS     COMPUTE CHECKSUM
00AB FB46 00F2          JST    SIO:      START I/O
00AC FB46 00F3          JST    WAIT:     WAIT A BIT
                 *
     00AD        RITE13 EQU    $         OUTPUT CHECKSUM
                 *
00AD C6FF               LAP    :FF
00AE 840D 000D          AND    @CCSUM    MASK OFF CHECKSUM
00AF 9C25 0025          STA    @CDCHN3   PUT INTO CIB
00B0 B422 0022          LDA    @CDCHN    DATA CHAIN ADDRESS
00B1 F623 008E          JMP    LEAVE     LEAVE BECAUSE YOU'RE DONE
00B2 00B3        RHEDAD DATA   RHEAD
00B3 0005        RHEAD  DATA   5,NULLS+1
00B4 0096
```

```
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
                    *      THIS ROUTINE WILL PROCESS THE SPECIAL
                    *      FUNCTIONS REQUESTED FOR THE I/O DEVICES
                    *
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
      00B5          I:FUN  EQU    $
                    *
00B5 FB3A 00F0             SINT   STANDARD,OUTPUT,0
00B6 23F9
00B7 C60F                  LAP    :F
00B8 8419 0019             AND    @COP      MASK OFF OP CODE
00B9 9C19 0019             STA    @COP
00BA C00C                  CAI    :C        IF A C
00BB F203 00BF             JMP    FMARK     JMP TO WRITE FILE MARK
00BC C00D                  CAI    :D        IF A D
00BD F208 00C6             JMP    PLEAD     JMP TO PUNCH LEADER
00BE F337 00F6             JMP    EOR:      GO TO END OF RECORD
                    *
      00BF          FMARK  EQU    $         WRITE FILE MARK
                    *
00BF B41F 001F             LDA    @CFUN1    SPECIAL FLAGS
00C0 1302                  LRA    3         MOVE EOF BIT TO OV
00C1 B20F 00D1             LDA    SEOF      '/*' FILE MARK
00C2 3201 00C4             JOR    $+2
00C3 F644 007F             JMP    RITE1     IF THAT'S IT, DUIT TUIT
00C4 B612 00B2             LDA    FEOF      RUBOUT-NULL-NULL
00C5 FB2C 00F2             JST    SIO:      WRITE IT
                    *
      00C6          PLEAD  EQU    $         PUNCH LEADER
                    *
00C6 C714                  LAM    20
00C7 9C16 0016             STA    @EXCESS   SET COUNT FOR 20 TIMES
00C8 FB2A 00F3             JST    WAIT:     WAIT A BIT
00C9 B204 00CE             LDA    LEADER    ADDRESS OF LEADER CHAIN
```

```
0794   00CA F827 00F2          JST    SIO:       OUTPUT 6 NULLS
0795   00CB DC16 0016          IMS    @EXCESS    ARE WE DONE
0796   00CC F604 00C8          JMP    $-4        NO
0797   00CD F328 00F6          JMP    EOR:       JMP END OF RECORD
0798   00CE 00CF        LEADER DATA   $+1,6,NULLS
       00CF 0006
       00D0 0095
0799        00B2        FEOF   EQU    RHFDAD
0800   00D1 00D2        SEOF   DATA   $+1,2,EOF2
       00D2 0002
       00D3 009A
```

II/3-41

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```
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
                    *       THIS ROUTINE WILL SEARCH THRU THE OUTPUT
                    *       DATA CHAIN AND CREATE THE CHECKSUM FOR
                    *       THE ENTIRE CHAIN
                    *
                    *       CALLING SEQUENCE:
                    *
                    *       JST    I:OCS
                    *
                    *       A  REGISTER MUST CONTAIN THE ADDRESS OF
                    *             THE FIRST PORTION OF THE CHAIN
                    *             THE CHECKSUM IS TO BE COMPUTED
                    *       X  REGISTER MUST CONTAIN THE CIB ADDRESS
                    *
                    *       RETURN STATUS:
                    *
                    *       A REGISTER CONTAINS A 8 BIT CHECKSUM
                    *       X  REGISTER  UNCHANGED
                    *       STATUS:
                    *             OVERFLOW --- RESET
                    *             REMAINDER IS UNCHANGED
                    *
                    *       THE COMPUTED CHECKSUM IS PLACED BACK IN
                    *       THE CIB
                    *
                    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
                    *
0004 0800           I:OCS   ENT
0005 9A18 00EE              STA    TMP3      SAVE DATA CHAIN ADDRESS
0006 EA16 00ED              STX    TMP2      SAVE CIB ADDRESS
0007 B40D 000D              LDA    @CCSUM    CHECKSUM BYTE
0008 9A0A 00E3              STA    I:OCS5    INITIALIZE CHECKSUM
0009 B314 00EE              LDA    *TMP3     NUMBER OF BYTES IN RECORD
000A 0310                   NAR
000B 9A13 00EF              STA    COUNT     SET BYTE COUNTER
```

```
0838  00DC DA11 00EE              IMS     TMP3      BUMP CHAIN POINTER
0839  00DD E310 00EE              LDX     *TMP3     BUFFER ADDRESS
0840  00DE 1328                   LLX     1         SET TO BYTE ADDRESS
0841                        *
0842       00DF             I:OCS4 EQU    $         COMPUT CHECKSUM FOR NEXT
0843                        *
0844  00DF 0E00                   SBM               SET BYTE MODE
0845  00E0 B400 0000              LDAB    @0        LOAD OUTPUT BYTE
0846  00E1 0F00                   SWM               SET WORD MODE
0847  00E2 F81C 00FF              JST     CKSUM:    GO COMPUTE CHECKSUM
0848  00E3 0000             I:OCS5 DATA   $-$       CHECKSUM DATA CELL
0849  00E4 0128                   IXR               INCREMENT BUFFER ADDRESS
0850  00E5 DA09 00EF              IMS     COUNT     INCREMENT COUNT DONE
0851  00E6 F607 00DF              JMP     I:OCS4    NOT DONE
0852                        *
0853       00E7             I:OCS9 EQU    $         ALL DONE SO CLEAN HOUSE
0854                        *
0855  00E7 B604 00E3              LDA     I:OCS5    COMPUTED CHECKSUM
0856  00E8 E204 00ED              LDX     TMP2      RESTORE X REGISTER
0857  00E9 9C0D 000D              STA     @CCSUM    PUT CHECKSUM IN CIB
0858  00EA B203 00EE              LDA     TMP3
0859  00EB 00D0                   DAR               RESTORE A REGISTER
0860  00EC F718 00D4              RTN     I:OCS     R E T U R N
0861  00ED 0000             TMP2  RES     1,0
0862  00EE 0000             TMP3  RES     1,0
0863  00EF 0000             COUNT RES     1,0
0864       0010                   LPOOL
      00F0 0000
      00F1 0004
      00F2 0000
      00F3 0000
      00F4 0000
      00F5 0000
      00F6 0000
      00F7 0000
      00F8 0080
```

```
      00F9 008D
      00FA 0000
      00FB 0000
      00FC 4000
      00FD 0000
      00FE 001A
      00FF 0000
0865                    END

0000  ERRORS
0000  WARNING
```

```
U   0000  ARROW     0488* 0539* 0579*
X   0000  BEGIN:    0444
    0600  BININ     0516  0605
X   0000  BUFFQ:    0457  0526* 0542* 0627*
U   0000  CBUFF     0478  0484* 0584* 0593  0595* 0693* 0695*
U   0000  CCSUM     0610* 0634  0720* 0752  0833  0857*
U   0000  CDAA      0613* 0615  0635* 0641
U   0000  CDCHN     0574  0731  0754
U   0000  CDCHN1    0486* 0730*
U   0000  CDCHN3    0549* 0573* 0728* 0753*
U   0000  CFUN1     0563  0566  0692  0780
U   0000  CIOB      0498
X   0000  CKSUM:    0454  0847*
U   0000  CUP       0513  0668  0669* 0683  0771  0771*
    0863  COUNT     0837* 0850*
U   0000  CRCNT     0662  0674  0677  0698* 0701  0704  0727  0740
                    0743
    0712  CRLF      0572  0711
U   0000  CTCNT     0489* 0589  0592* 0663*
U   0000  CTMP1     0496* 0499* 0503  0506
U   0000  D         0500  0511  0571  0661  0768
X   0000  DELAY:    0448
X   0000  END:      0445
    0714  EOF1
    0715  EOF2      0800
X   0000  EOF:      0449  0617
X   0000  EOFCK:    0456  0547* 0604*
X   0000  EOFQ:     0459  0585
X   0000  EOR:      0450  0528  0685  0710  0776  0797
    0711  EORBAD    0694
U   0000  EORMSK    0565  0691
X   0000  EORST:    0451  0644
U   0000  ERROR     0643
U   0000  EXCESS    0490  0791* 0795*
    0799  FEOF      0785
X   0000  FETCH:    0455  0525* 0546* 0601* 0611* 0614* [illegible]* [illegible]*
                    0639*
```

```
     0778  FMARK    0773
N    0766  I:FUN    0436
     0830  I:OCS    0732* 0745* 0860
     0842  I:OCS4   0851
     0848  I:OCS5   0834* 0855
     0853  I:OCS9
N    0476  I:READ   0434
N    0659  I:RITE   0435
U    0000  IACNT    0497
U    0000  INPUT    0511
     0798  LEADER   0793
     0707  LEAVE    0755
U    0000  LSI305   0502  0505  0645  0673  0676  0700  0705  0734
                    0742
     0624  NEXT1    0629
     0713  NULLS    0757  0798
U    0000  OUTPUT   0500  0571  0661  0768
     0788  PLEAD    0775
U    0000  PROMPT   0562
U    0000  REQCNT   0480* 0534  0582  0622* 0628* 0634* 0640
     0577  RFA1     0564  0569
     0531  RFA10    0581
     0482  RFA2     0535
     0544  RFA3     0517  0551  0553  0590  0596
     0537  RFA4     0554
     0587  RFA9     0541
     0510  RFAX     0491
     0757  RHEAD    0756
     0756  RHEDAD   0721  0799
     0680  RITE1    0784
     0717  RITE10   0671
     0725  RITE11
     0736  RITE12
     0749  RITE13
N    0689  RITE2    0437
     0800  SEOF     0782
X    0000  SIN1:    0452
```

```
X    0000  SIU:      0453  0508* 0575* 0682* 0709* 0722* 0733* 0746*
                     0786* 0794*
U    0000  STANDA    0500  0511  0571  0661  0768
X    0000  SUBR:     0446
X    0000  SUBX:     0447
     0861  TMP2      0832* 0856
     0862  TMP3      0831* 0835  0838* 0839  0858
     0518  TWO       0514
     0523  UNFMTI    0515  0527
X    0000  WAIT:     0458  0509* 0533* 0570* 0690* 0723* 0734* 0747*
                     0792*
0865 SOURCE LINES
```

SECTION 4

DIB AND CIB DESCRIPTIONS

The DIB and CIB are tables which are used in communication between IOX and a particular I/O handler or the File Manager.

The following DIB and CIB descriptions apply to all standard IOX handlers. DIB and CIB descriptions for non-standard handlers (for example, the IEEE Intelligent Cable handler) are included in Section 7 and for the File Manager, in Section 5.

4.1 DEVICE INFORMATION BLOCK (DIB) - 11 TO 18 WORDS

Words 0 to 10 are used by all IOX device handlers. Words 11 to 17 are used by specific handlers and the File Manager.

Figure 4-1 illustrates the DIB configuration.

DEVICE INFORMATION BLOCK

STANDARD NAME *	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0							word	
CHAIN	DIB CHAIN ADDRESS							0	
DCIB	CIB ADDRESS							1	
QUEUE	USED BY IOX TO QUEUE REQUESTS							2	
CN	COORDINATION NUMBER							3	
DSW	DEVICE SPECIFICATION WORD							4	
DT	DEVICE NAME							5	IOB Words 1 and 2
D[illegible]N	CONTROLLER NUMBER			UNIT NUMBER				6	
[illegible]DEL	INPUT RTC TICKS			OUTPUT RTC TICKS				7	
DFUN	FUNCTION CODE	FUNCTION CODE	FUNCTION CODE	FUNCTION CODE	FILE MARK	PF	END OF RECORD	8	
DULS	MAX BYTES-ASCII			MAX BYTES-BINARY				9	
D[illegible]RC	HARDWARE ERROR COUNT (except MTIC)							10	
	ADDITIONAL WORDS USED BY SPECIFIC HANDLERS							11 … 17	

* refer to the I/O Handler listing at the end of Section 3.

Figure 4-1. DIB Configuration

4.2 REGULAR DIB CONFIGURATION (ALL HANDLERS) - WORDS 0 TO 10

Word 0 — Chain pointer to next DIB (CHAN directive). Last DIB contains 0. The DIB CHAN operand is X::.

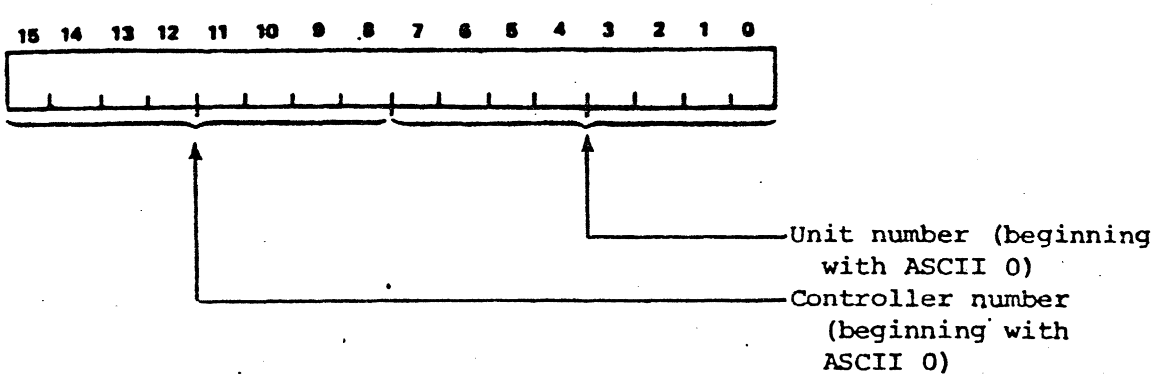
Word 1 — Associated CIB address. (See list of standard CIB names at the end of Section 4.)

Word 2 — Used by IOX as a pointer to queue requests for this DIB. Initialize to zero.

Word 3 — Device coordination number. Initialize to zero.

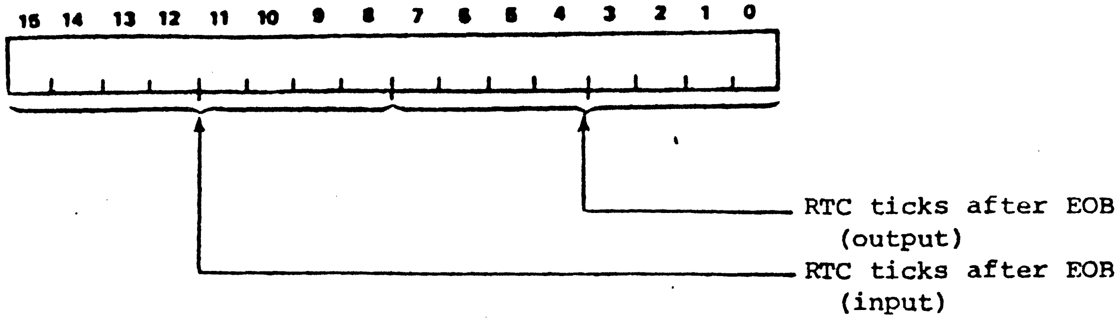
Word 4 — Device Specification Word (DSW). Each of the 16 bits corresponds to the equivalent binary value described for bits 0-3 of IOB Word 5 (opcode); e.g., if the device is capable of reading Formatted ASCII (which function, if requested by the IOB, would appear as 0010 in bits 0-3 in IOB Word 5) then bit 2 should be set on in the DSW. If the device can punch leader (1101 in bits 0-3 in IOB Word 5), then bit 13 (:D) should be set on in the DSW.

Word 5 and 6 — Device Name. These words are copied into IOB words 1 and 2, respectively, upon finishing a call to IO:. These words contain four ASCII characters. Word 5 contains the first two characters which specify the device ("CR" for card reader, for example). Word 6 uses the following format for the third and fourth characters:



For Fortran tasks using the teletype or lineprinter as a list device with carriage control character recognition, or for a disk with end-of-file capability, the third character of the device name must be an "F", to serve as a flag that the Fortran handler is to be used.

Word 7 This word uses the following format:



Bits 8-15. A binary value representing the number of Real-Time Clock ticks to delay after an end-of-block interrupt for an input operation, before the device is considered available for the next I/O operation.

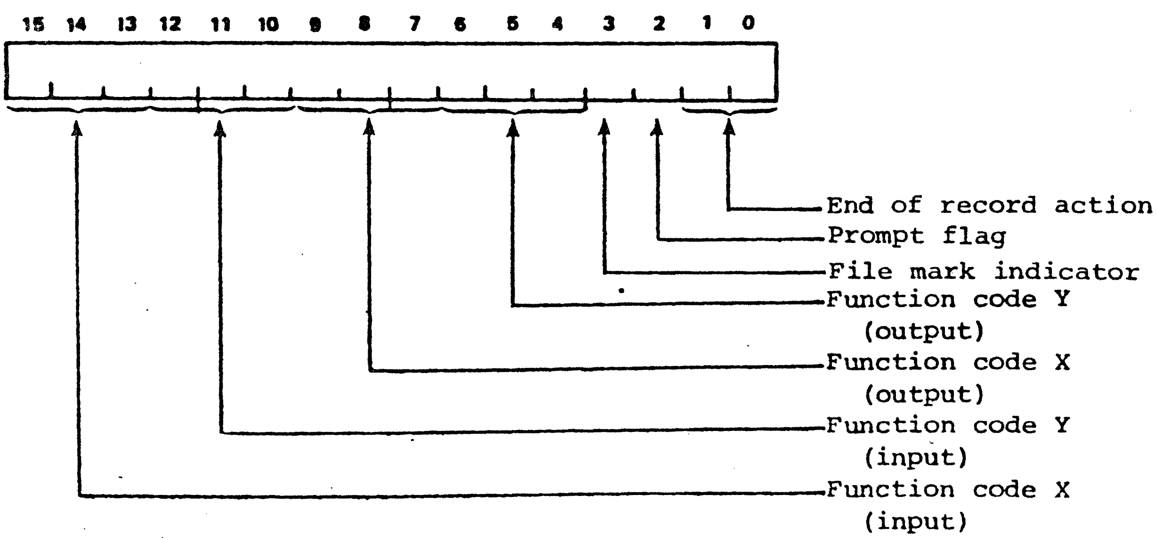
Bits 0-7. A binary value representing the number of Real-Time Clock ticks to delay after an end-of-block interrupt for an output operation, before the device is considered available for the next I/O operation.

Word 8 This word contains function codes which are executed in Select instructions to initiate an I/O operation if SIO: is called.

The order of execution of the Select instruction within SIO: is:

```
SEL      DA,X
SEL      DA,5
SEL      DA,6
SEL      DA,Y
```

This word uses the following format:



Bits 13-15. Contains function code X in the above sequence, for an input operation.
Bits 10-12. Contains function code Y in the above sequence, for an input operation.

Bits 7-9. Contains function code X in the above sequence, for an output operation.
Bits 4-6. Contains function code Y in the above sequence, for an output operation.

Bit 3. A flag signifying the type of file mark to be used for the device.

1 = slash/asterisk
0 = rubout/nll/null

Bit 2. A flag signifying whether the device is to be prompted before an input operation.

1 = Prompt the device
0 = Do not prompt the device

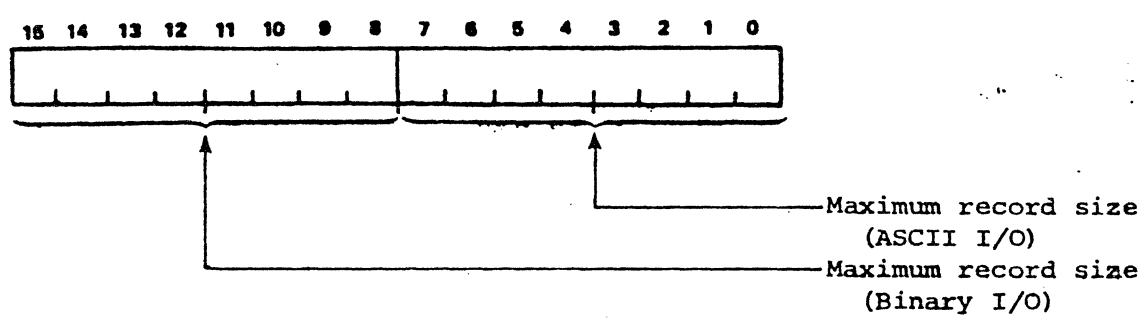
Bits 0-1. These bits represent the end of record action to be taken for Formatted ASCII output:

00 = Output carriage return only
01 = Output line feed only
10 = Output carriage return and line feed
11 = Output space and carriage return

NOTE

Word 8 is set to zero for Distributed I/O and Disk DIB's.

Word 9 This word uses the following format:



Bits 8-15. Maximum record size (in bytes) for formatted ASCII I/O operations. (Zero signifies unlimited record size.)

Bits 0-7. Maximum record size (in bytes) for binary I/O operations. (Zero signifies unlimited record size.)

Word 10 Cumulative hardware error count (must be incremented by the individual handler). Initialize to zero.

NOTE

Word 10 is used differently by the Magnetic Tape Intelligent Cable DIB. See the additional DIB configurations section.

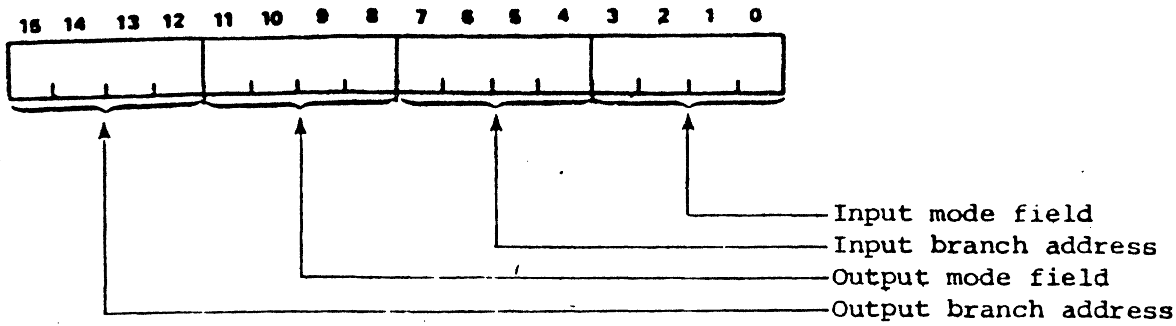
4.3 ADDITIONAL DIB CONFIGURATIONS - UP TO 18 WORDS

The following DIB configurations require additional words which are not required in the regular DIB configuration.

4.3.1 Distributed I/O DIB

15 14 13 12	11 10 9 8	7 6 5 4	3 2 1 0	word
REGULAR DIB CONFIGURATION				0–10
OUTPUT BRANCH ADDRESS	OUTPUT MODE FIELD	INPUT BRANCH ADDRESS	INPUT MODE FIELD	11

Word 11 DIO command fields. This word uses the following format:

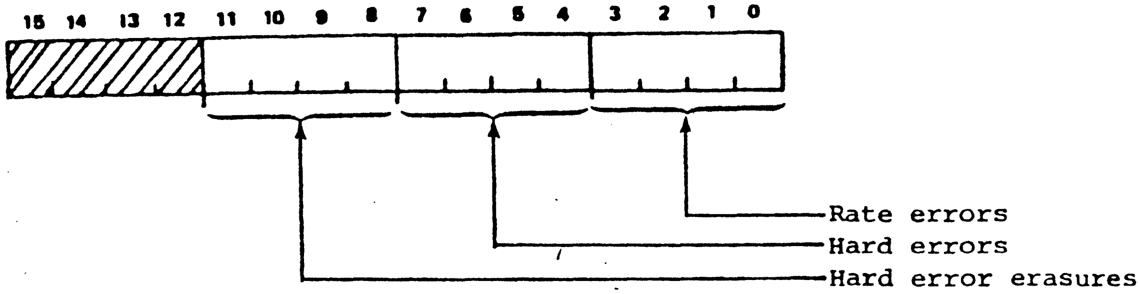


Bits 15-12. Branch Address Field of DIO Command Word for output.
Bits 11-8. Mode Field of DIO Command Word for output.
Bits 7-4. Branch Address field of DIO Command Word for input.
Bits 3-0. Mode Field of DIO Command Word for input.

4.3.2 Magnetic Tape Intelligent Cable DIB

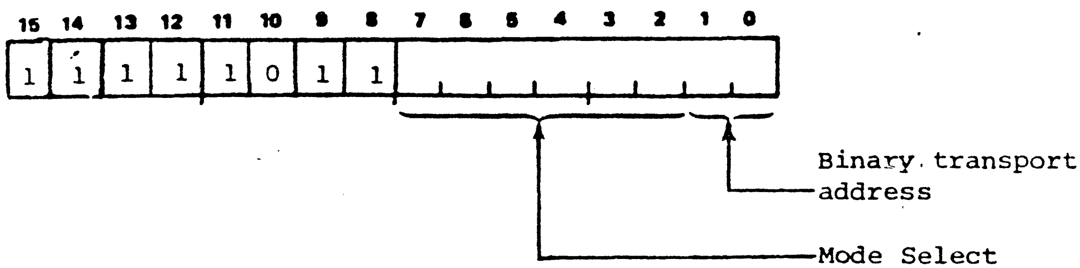
<table>
<tr><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th>word</th></tr>
<tr><td colspan="16">REGULAR DIB CONFIGURATION</td><td>0
9</td></tr>
<tr><td colspan="4">NOT USED</td><td colspan="4">HARD ERROR ERASURES</td><td colspan="4">HARD ERRORS</td><td colspan="4">RATE ERRORS</td><td>10</td></tr>
<tr><td colspan="8">:FB</td><td colspan="7">0</td><td>TRANS ADDR</td><td>11</td></tr>
<tr><td colspan="16">MINIMUM RECORD LENGTH</td><td>12</td></tr>
</table>

Word 10 Three MTIC error counters. This word uses the following format:



Bits 11-8. The number of erasures due to hard errors.
Bits 7-4. The number of hard errors. This counter is reset whenever an erasure occurs.
Bits 3-0. The number of rate errors. This counter is reset whenever a hard error occurs.

Word 11 Basic mode select word. This word uses the following format:



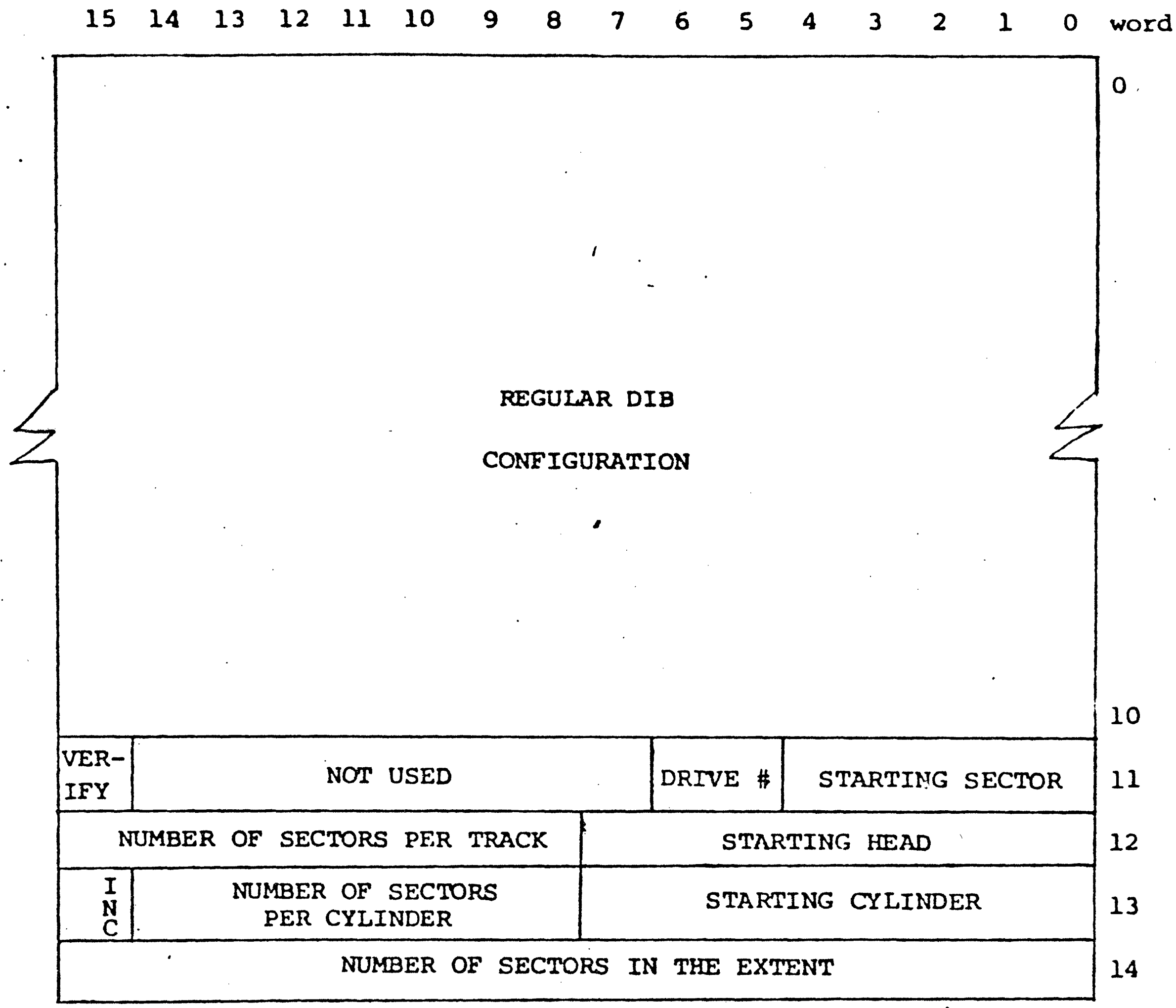
Examples - :FB00 indicates transport 0
:FB03 indicates transport 3

Word 12 This word contains the minimum record length (in bytes). Records smaller than this byte count are considered noise records. CIB word 35 must specify the word address of a buffer with a size greater than or equal to the minimum record length. The standard minimum record length for the MTIC handler is 12 bytes.

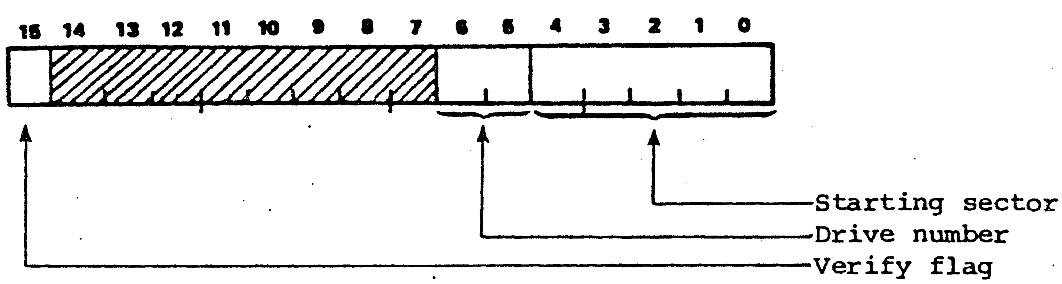
Write requests with a byte count less than the minimum record length will have additional characters appended to the record until the byte count equals the contents of word 12. Blanks are appended to ASCII records and zeros are appended to Binary records.

Read request will return only the number of characters requested.

4.3.3 Disk DIB



Word 11 This word uses the following format:



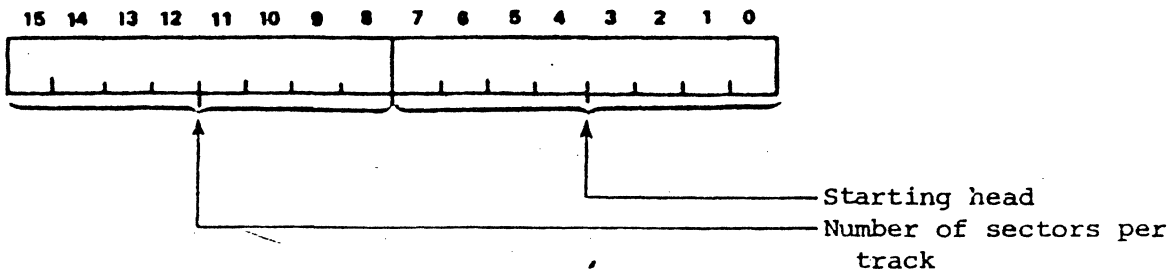
Bit 15. Verify flag
If this bit is set, a verify operation will be performed after each write. Two additional attempts will be made to re-write the record before the error bit in the status is set.

Bits 14-7. Not used.

Bits 6-5. Drive Number
This is the number of the drive attached to the controller. Its range is from 0 through 3 inclusive.

Bits 4-0. Starting Sector
This is the sector number where the extent is to start. Its range is from 0 through the number of physical sectors -1 per track.

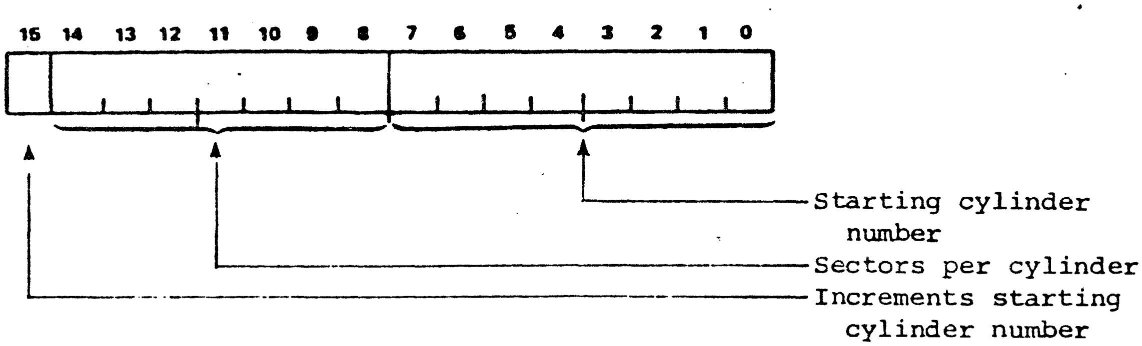
Word 12 This word uses the following format:



Bits 15-8. Number of Sectors per Track
This number defines the number of sectors on each track that this extent is to occupy. The sum of the number and the starting sector may not exceed the physical number of sectors per track.

Bits 7-0. Starting Head
This number defines the starting head number of the extent. Its range is from 0 through the number of heads -1 on the disk drive.

rd 13 This word uses the following format:



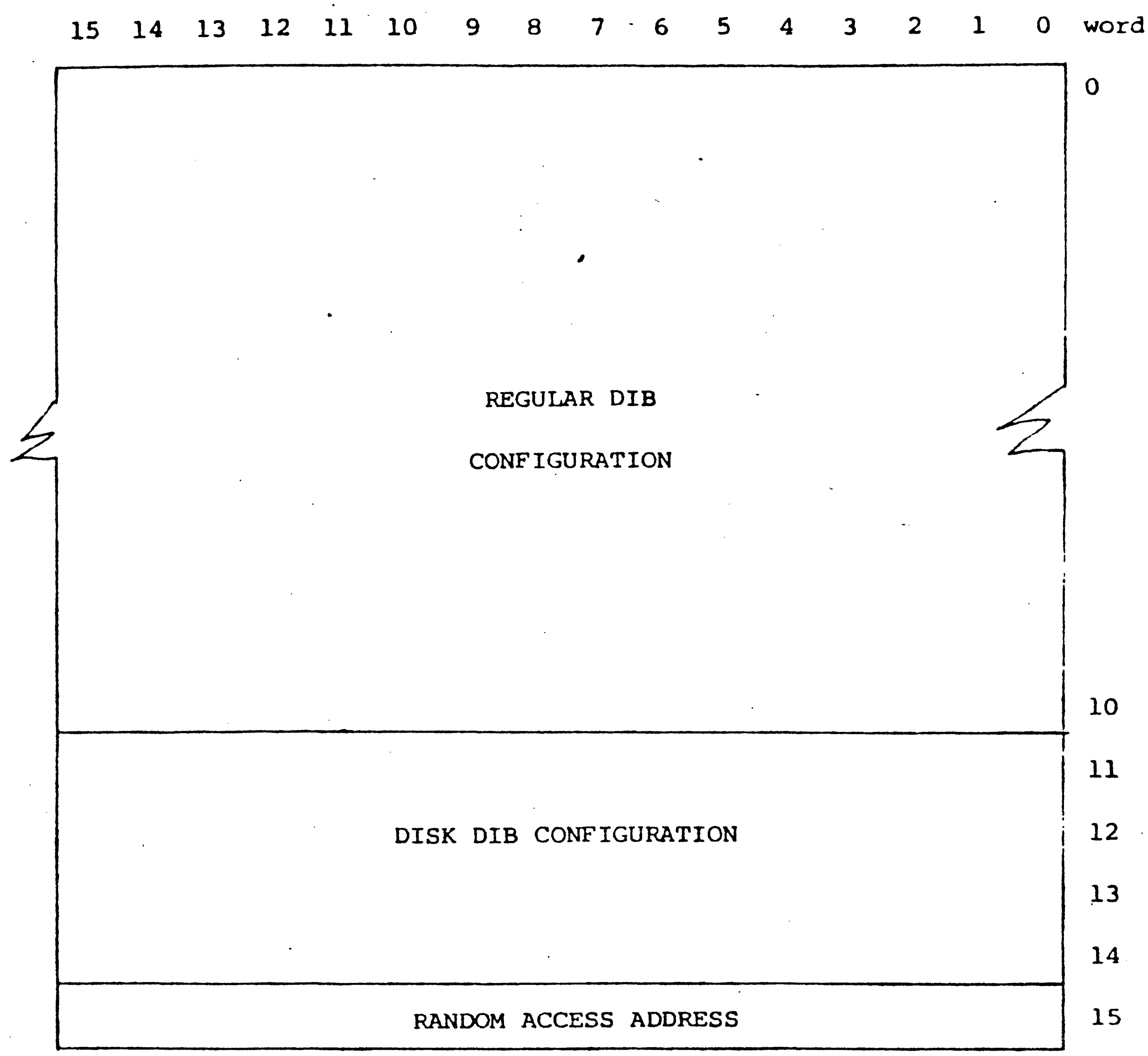
Bit 15. If this bit is set, the contents of bits 7-0 are incremented by 256.

Bits 14-8. Number of Sectors per Cylinder
This number equals the number of sectors per cylinder times the number of read/write heads. This is the maximum value of any extent.

Bits 7-0. Starting cylinder
This number is the first cylinder that the extent is to occupy.

Word 14 Number of Sectors in the Extent
This number is used to detect the end of the extent and to allow the IOX disk handler to set the end-of-device status if access to the last sector of the extent or beyond is requested. This number is equal to the number of cylinders times the number of heads per cylinder times the number of sectors per track.

4.3.4 Fortran Disk DIB



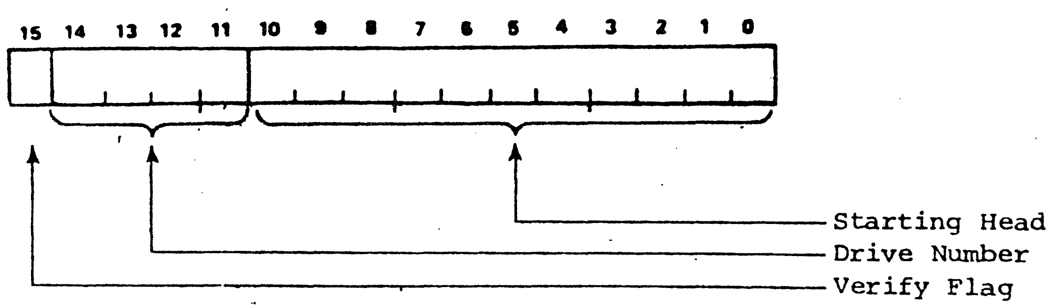
Word 15 Random Access Address
This word provides a location other than the user's IOB to store the record number.

.3.5 Storage Module Disk DIB (Fortran and Non-Fortran)

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 word

			10
VER-IFY	DRIVE NUMBER	STARTING HEAD	11
STARTING SECTOR NUMBER			12
STARTING CYLINDER			13
NUMBER OF SECTORS			14
RECORD NUMBER (FORTRAN ONLY)			15
NUMBER OF SECTORS PER TRACK			16
NUMBER OF SECTORS PER CYLINDER			17

Word 11 This word uses the following format:



Bit 15. Verify Flag
If this bit is set, a verify operation will be performed after each write. Two additional attempts will be made to re-write the record before the error bit in the status is set.

Bits 14-11. Drive Number
This is the number of the drive attached to the controller. Its range is from 0 to 15 inclusive.

Bits 10-0. Starting Head
This number defines the starting head number of the extent. Its range is from 0 through the number of heads -1 on the disk drive.

Word 12 Bits 15-0. Starting Sector
This is the sector number where the extent is to start. Its range is from 0 through the number of physical sectors -1 per track.

Word 13 Bits 15-0. Starting Cylinder
This number defines the starting cylinder number of the extent. Its range is from 0 through the number of physical cylinders -1 on the disk drive.

Word 14 Bits 15-0. Number of Sectors
This number is used to detect the end of the extent to allow the IOX Storage Module handler to set the end-of-device status if access to the last sector of the extent or beyond is requested. This number is equal to the number of heads per cylinder times the number of sectors per track.

Word 15 Bits 15-0. Fortran Record Number
This word is only required for Fortran to provide a location other than the user's IOB to store the record number.

Word 16 Bits 15-0. Number of Sectors per Track
This number defines the number of sectors on each track that this extent is to occupy. The sum of this number and the starting sector number may not exceed the physical number of sectors per track.

Word 17 Bits 15-0. Number of Sectors per Cylinder
This number defines the number of sectors on each cylinder that this extent is to occupy. It is numerically equal to the number of sectors per track times the number of heads per cylinder. Note that the number of heads per cylinder plus the starting head number must not exceed the physical number of heads on the drive.

SAMPLE DISK DIB

This DIB defines an extent on disk unit 0 of cylinders 0 through 10, heads 2 and 3, sectors 0-11; that is, all sectors of the first eleven cylinders of the removable platter:

```
                NAM         D:DKXX          DIB NAM
                EXTR        C:DK0           CIB Reference
*
D:DKXX          EQU         $
                CHAN        X::             Chain link to other DIB's
                DATA        C:DK0           CIB Address
                DATA        0               IOX temp cell
                DATA        0               Coordination number
                DATA        :0011           DSW: Direct access Read/Write
                DATA        'DK, 'XX'       Device name
                DATA        0               EOB delay (none required)
                DATA        0               FC's, flags (none required)
                DATA        0               Max record size
                DATA        0               Error count
                DATA        0               Drive 0, starting sector 0
                DATA        :C02            Sectors per track = 12
*                                           Starting head number = 2

                DATA        :1800           Sectors per cylinder = 24
*                                           Starting cylinder number = 0
                DATA        :108            Sectors per extent = 264
                                            (24 sectors x 11 cylinders)
```

CONTROLLER INFORMATION BLOCK (CIB) - 38 WORDS (47 WORDS FOR STORAGE MODULE DISK)

he CIB is used for storing and/or transferring information between IOX and the I/O andler. Words 15-19 must contain the described information upon initial entry to OX. Words 22-31 have data stored in them while in IOX. All other words are used by le standard I/O handlers and IOX routines, but may not be required by the user's pecially written handler. Figure 4-2 illustrates the CIB configuration.

ich B location and its usage is described below:

0 — Temp cell. Set to zero by the scheduler to be used for beginning of record flag. Set to -1 by IORTN: or SIO:. Set to a number greater than zero by an interrupt.

rd 1 — Temp cell. If the subroutine SIO: or EORST: is called, this word should contain a SEL DA, 7 instruction where DA=the device address of the device being accessed.

rds 2-11 — Temp cells. CIB's for standard I/O handlers contain a calling sequence to the RTX INTQ: routine, which is executed upon an end-of-block interrupt. (See INTQ: description.)

rd 12 — Temp Cell. The special function codes from DIB Word 8 are stored here by SINT:, and used by SIO: in setting up the I/O select instruction sequence.

CONTROLLER INFORMATION BLOCK

Standard Name*	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
CBOR	TC FOR SIO:--BEGINNING OF RECORD FLAG	0
CSEL7	TC FOR SIO: OR EORST: SEL DA,7	1
	JST INTQ:	2
	DATA $ CALLING LOC	3
CTMP1	DATA 0 TEMP 1	4
CTMP2	DATA 0 TEMP 2	5
CTMP3	DATA 0 TEMP 3	6
CEBTSK	DATA TASK ADDRESS	7
	DATA PRIORITY FOR QUEUED TASK	8
CNEWA	DATA AREG	9
CNEWX	DATA XREG	10
	DATA P-LOC CIB ADDRESS	11
CFUN	TC FOR SINT: AND SIO:--FUNCT. CODES (DIB wd 8)	12
CCSUM	TC FOR CHECKSUM	13
REQCNT	TC	14
CJTBL	ENTRY POINT TO READ	15
	ENTRY POINT TO WRITE	16
	ENTRY POINT TO POSITION	17
	ENTRY POINT TO FUNCTION	18
CSPLOP	ENTRY POINT TO SPECIAL OPERATION	19
CDEL	TC FOR SIO:--WATCHDOG TIMER INSTR.	20
CINTR	TC FOR SINT: AND SIO:--DEVICE WORD INTERRUPT ADDR.	21
EXCESS	TC FOR IOX--PROMPT CHARS (IOB wd 8)	22
CEOF	TC FOR IOX--EOF, AND FOR MAG TAPE--RETRY CTR	23
CIOB	TC FOR IOX--IOB ADDR	24
COP	TC FOR IOX SCHED--OP CODE AND STATUS (IOB wd 5)	25
CRCNT	TC FOR IOX SCHED--REQUESTED COUNT (IOB wd 6)	26
CBUFF	TC FOR IOX SCHED--BUFFER ADDR (IOB wd 7)	27
CTCNT	TC FOR IOX--ACTUAL BYTE COUNT	28
CDAA	TC FOR IOX SCHED--DIRECT ACCESS ADDR (IOB wd 9)	29
CDIB	TC FOR IOX SCHED--DIB ADDR AND BUSY FLAG	30
CFUN1	TC FOR IOX SCHED--FUNCT. CODES (DIB wd 8)	31
STATUS	TC FOR EOR:--STATUS	32
CRTN	TC FOR SIO: AND WAIT:--RETURN ADDRESSES	33
CDCHN	DATA $+1 POINTER TO BYTE COUNT	34
CDCHN1	DATA 1 BYTE COUNT	35
CDCHN2	DATA $+1 BUFFER ADDRESS	36
CDCHN3	DATA 0 1 CHAR INPUT BUFF	37

NOTE:
TC = Temp Cell

*refer to the I/O Handler listing at the end of Section 3.

Figure 4-2. CIB Configuration

Word 13	Temp Cell. Used by the standard I/O handlers for a checksum storage cell.
Word 14	Temp Cell.
Words 15-18	IOX requires these words to be set up as a jump table to various entry points in the I/O handler, as follows:

Word 15	Entry point to READ.
Word 16	Entry point to WRITE.
Word 17	Entry point to POSITION.
Word 18	Entry point to FUNCTION.

If any of the above functions have no meaning to the handler, the corresponding cell (Words 15-18) should be zero.

Word 19	Entry point to SPECIAL OPERATION. If the handler does not perform a special operation, this word should be zero.
Word 20	Temp Cell. This cell is assumed by SIO: to be an instruction (e.g., LLA or NOP) to be used in calculating the watchdog timer. (See SIO: routine description.)
Word 21	Temp Cell. SINT: and SIO: routines expect this word to contain the device's word interrupt address.
Word 22	Temp Cell. Used by IOX to store prompt characters from IOB Word 8, if any.
Word 23	Temp Cell. Used by IOX character handler in checking for end of file, and by the magnetic tape handler as a retry counter.
Word 24	Temp Cell. IOX scheduler routine stores IOB address here.
Word 25	Temp Cell. IOX scheduler routine stores IOB Word 5 (op code and status) here.
Word 26	Temp Cell. IOX scheduler routine stores IOB Word 6 (requested count) here.
Word 27	Temp Cell. IOX scheduler routine stores IOB Word 7 (buffer address) here.
Word 28	Temp Cell. Used by IOX routines to count actual byte transfers.
Word 29	Temp Cell. IOX scheduler routine stores IOB Word 9 (direct access address) here, if any.
Word 30	Temp Cell. IOX scheduler routine stores DIB address here, and later uses it for a busy flag. (If non-zero, IOX assumes the device to be busy.)
Word 31	Temp Cell. IOX scheduler routine stores DIB Word 8 (function codes) here.

Word 32 Temp Cell. Used by FOR: routine for storage of status.

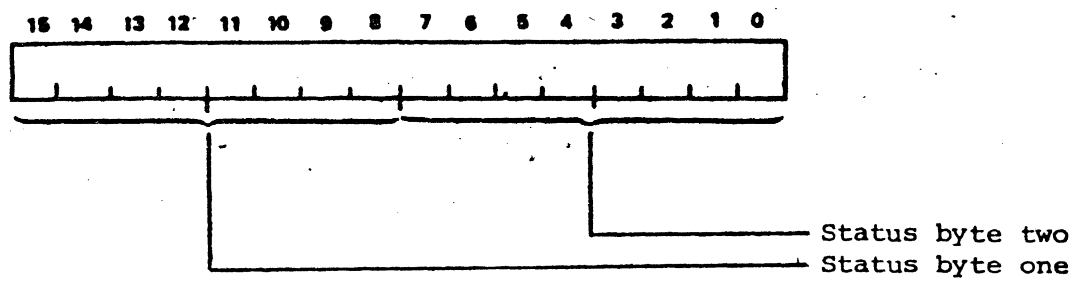
Word 33 Temp Cell. Used by the SIO: and WAIT: routines to store their return addresses.

Words 34-37 Temp Cells. Used by the standard I/O handlers as a byte count/buffer address/1-character buffer sequence for 1-character I/O calls to SIO:. (See FETCH: description.)

NOTE

MTIC Handlers use CIB words 34 and 35 in the following manner:

Word 34 Temp Cell. Used to store the MTIC Hardware Status. This word uses the following format:



Word 35 Minimum Record Length Buffer Address. This word contains a word address of a buffer with a size greater than or equal to DIB word 12.

4.6 STANDARD CIB NAMES

The following table shows the CIB names for all devices for which standard and non-standard handlers exist within IOX. The label is to be used as the second word of the associated DIB(s). (A table of DIB names is shown in section 2 - Unit Assignment Table description.)

	Non-DIO	Fortran Non-DIO	DIO	Fortran DIO
Teletype	C:TYO	C:TYF	C:TYD	C:TYFD
CRT	C:TYO	C:TYF	C:TVD	--
High Speed Paper Tape Reader	C:PRO	C:PRO	C:PRD	C:PRD
High Speed Paper Tape Punch	C:PPO	C:PPO	C:PPD	C:PPD
Line Printer	C:LPO	C:LPF	C:LPD	C:LPFD
Card Reader	C:CRO	C:CRO	--	--
Disk	C:DKO	C:DKF	--	--
Storage Module Disk	C:SMO	C:SMFO	--	--
Floppy Disk	C:FDO	C:FDO	--	--
Magnetic Tape	C:MTO	C:MTO	C:MCO	--
IEEE Intelligent Cable	--	--	C:IEOD	--

SECTION 5

FILE MANAGER

The File Manager provides directory and data management for file-oriented devices. The devices supported by the File Manager are the moving head disk and the floppy disk. It operates as a driver working in conjunction with RTX/IOX. By using the File Manager, an application program may communicate directly with the data files by name, independent of the physical medium storing the file.

All requests for file access are made through IOX (IO:) using Logical Units (LUNs). The File Manager calls standard IOX device drivers using Logical Units for the required physical I/O. LUN assignments for files as well as LUNs for use by the File Manager for physical I/O are made in the Unit Assignment Table (UAT). (See Section 2, IOB and UAT Organization.) File information (name, file attributes, etc.) is contained in a Device Information Block (DIB) for that file. The file DIB is not to be confused with the device DIB described in Section 4 although the first ten words are the same. The file DIB is described in this section.

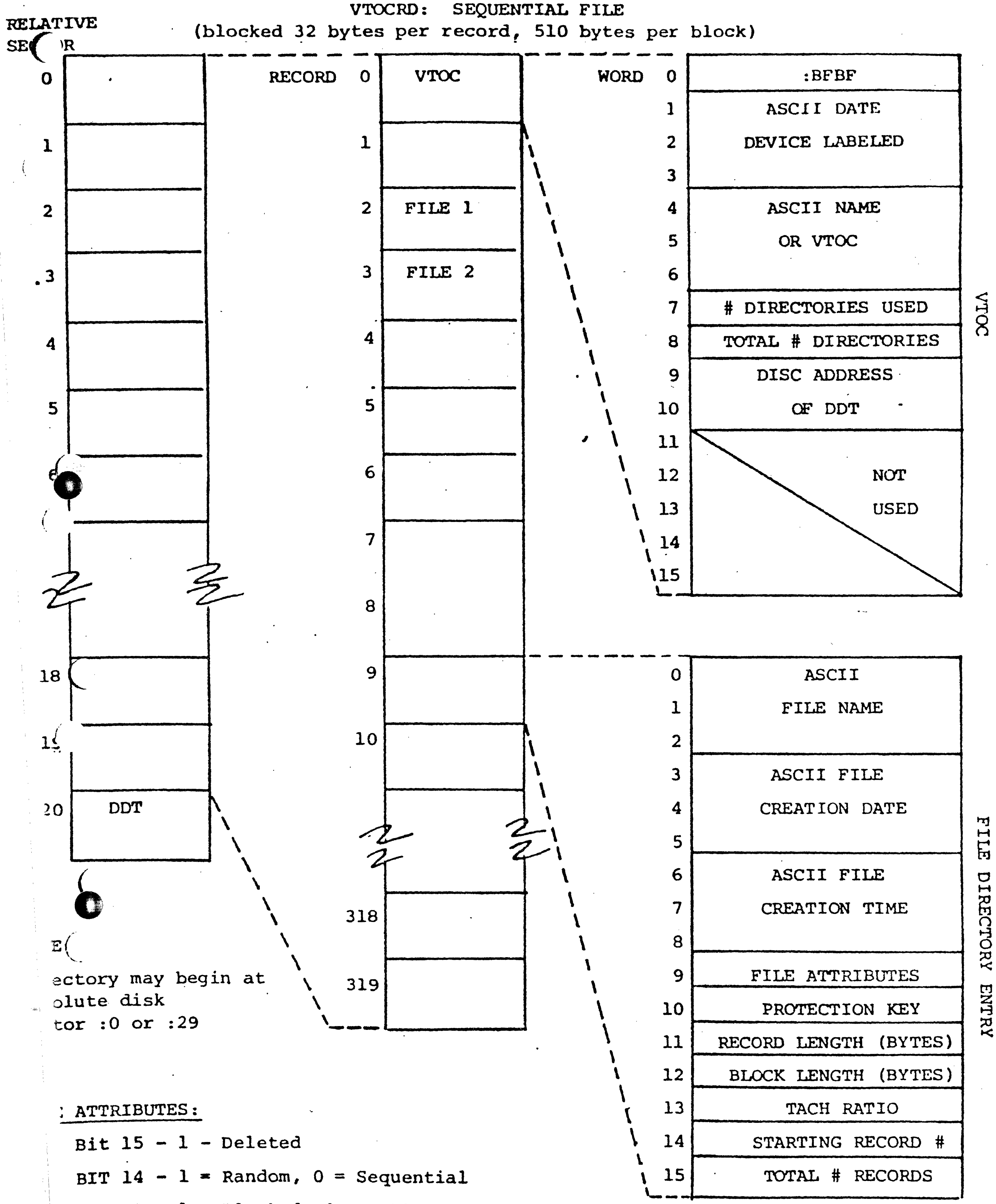
The File Manager requires that all File-oriented devices be labeled prior to use. This involves the creation of a Volume Table of Contents (VTOC) and directories on each individual unit to allow later file processing by name. Do not confuse "labeling" with the "formatting" of disk packs; the latter must be done with stand-alone programs before labeling. The RTX File Label Utility (93324-40A1 and -41A1) is a stand-alone program for labeling file-oriented devices. The device labeled using this utility is compatible with the Computer Automation OS file format.

5.1 FILE ORGANIZATION

File organization in the File Manager is compatible with the Computer Automation OS file format. Any file-oriented device accessed through the File Manager must contain a directory. The directory describes by name all data files which reside on the device. The physical medium containing a directory and files is called a Volume. The first entry in the directory is the Volume Table of Contents (VTOC). This entry contains information for the File Manager as well as volume name and creation date. The remainder of the directory is segmented into file description entries, one for each file on that volume. An entry contains the file name, creation date and time, and File Manager information such as record size, block size and file length. See Figure 5-1 for directory structure. Figure 5-2, the Disk Descriptor Table, defines the disk partition limits.

For disk volumes, multiple new file writes are supported through disk partitioning. The disk is divided into as many as eight partitions, each of which may have a new file open. If a file extends past the end of a partition, the file is linked to the next available partition. File linkage is supported for forward sequential reading or for positioning only (in either direction). Any number of old files may be open. (See Figure 5-3 for file linkage.)

VTOCRD: SEQUENTIAL FILE
(blocked 32 bytes per record, 510 bytes per block)



E(
ectory may begin at
olute disk
tor :0 or :29

: ATTRIBUTES:

Bit 15 - 1 - Deleted

BIT 14 - 1 = Random, 0 = Sequential

BIT 13 - 1 = Blocked, 0 = Unblocked

FILE LINKED FLAG

Figure 5-1. Disk Directory Structure

WORD		PARTITION
0	LAST PHYSICAL SECTOR	1
1	NUMBER IN PARTITION	
2		2
3		
4		3
5		
6		4
7		
8		5
9		
10		6
11		
12		7
13		
14		8
15		
16	NEXT RELATIVE RECORD (ACTUAL)	1
17	NEXT RELATIVE RECORD (WORKING)	
18		2
19		
20		3
21		
22		4
23		
24		5
25		
26		6
27		
28		7
29		
30		8
31		

NOTE:
Entry is zero if that partition does not exist

Figure 5-2. Disk Description Table (DDT) in Volume Table of Contents

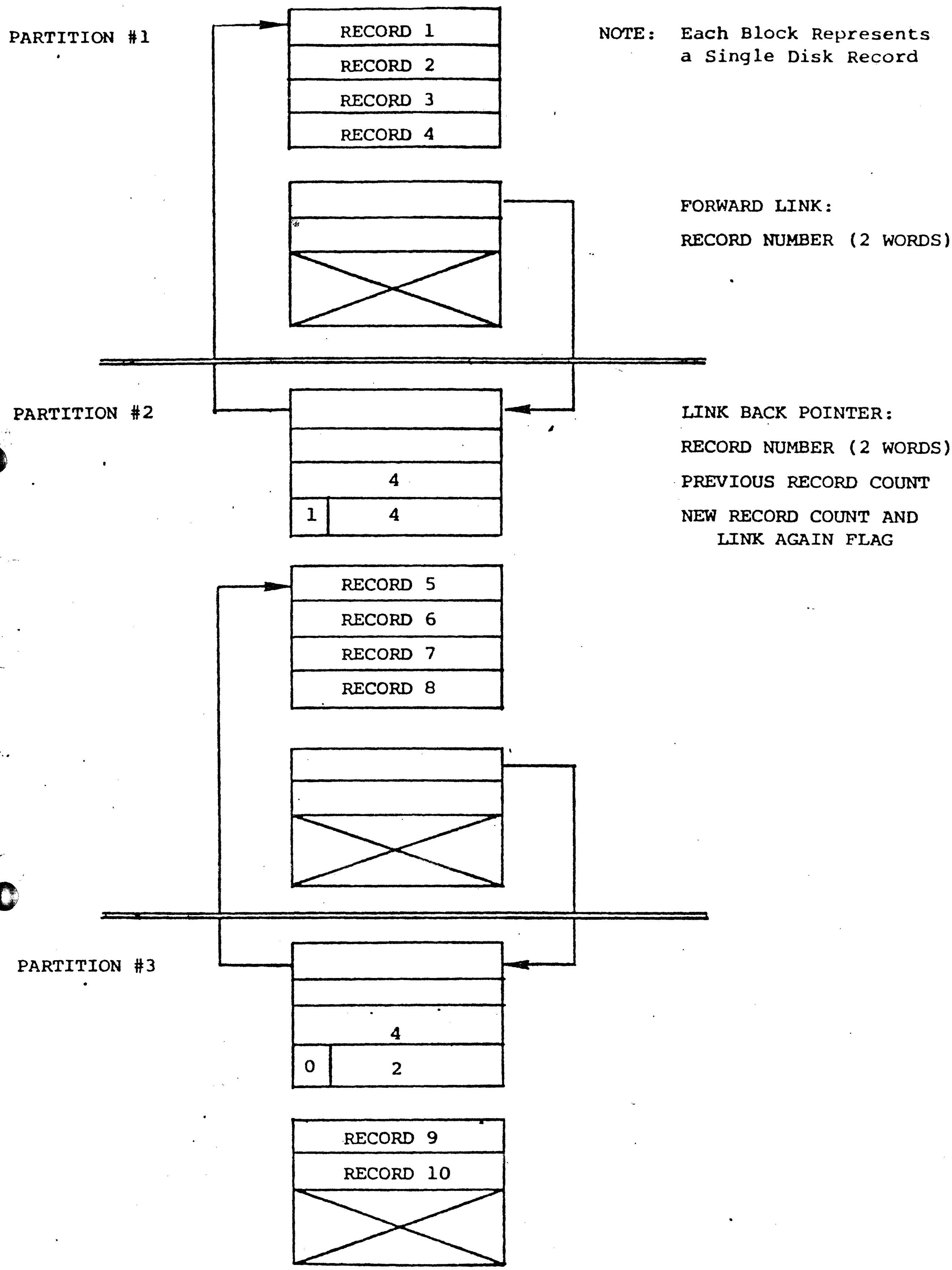


Figure 5-3. Disk File Linkage

5.1.1 Sequential File Access

Sequential file processing is available to the user on the moving head disk and the floppy disk. Sequential files are uniquely ordered by the File Manager: Given logical record N, the next READ request will always return logical record N+1. A READ or WRITE operation automatically advances the file to the next logical record. However, records may be accessed out of order by using the POSITION operation.

The File Manager provides automatic blocking and deblocking of logical records under sequential access. All I/O requests access a single logical record whose position in the physical record is controlled by the File Manager and need not be known by the user.

If the data security bit is set in the DIB, every sequential WRITE operation on that file will cause a directory update on the disk.

For blocked files, the user must provide a record buffer and a blocking buffer. The size and address of each is in the appropriate DIB and IOB. The record buffer may be smaller than the file record size; however, the blocking buffer must be the block size plus two bytes.

Only a record buffer is required for unblocked files. The record buffer may be smaller than the file record size. The user MUST reserve a word (two bytes) at address BUFFER -1 that is required for use by the File Manager.

Random Access

With the File Manager, random access file processing is available only for disk devices. Random files are accessed by physical records; automatic blocking/deblocking is not provided. A random file must reside within a single partition. The number of data bytes contained in each record is fixed at 512. The medium-capacity disk sector size is 512 bytes. When using a floppy disk, four sectors are used for each random file record; each sector has 128 bytes.

Although the record size of a random file is fixed, any number of bytes may be read or written. The specified record number is relative to the beginning of the file.

NOTE

> The record number is used to test for end-of-file. If more than 512 bytes are written, the sector(s) beyond the end-of-file will be destroyed.

To access a file in the random mode, the file must have been created as a random file. When a new file is opened with the random file type bit set in the DIB, a random file is created. When closed, the file size is equal to the largest relative record number accessed +1.

5.1.2 File Opening and Closing

The File Manager provides automatic file opening. On the first access (read, write, position, function) of the file, the File Manager will attempt to open the file. If the file name is found in the directory, the open and first access is completed. If the file name is not found, a new file is created. When creating a new file, the partition number for placement of the file may be specified in the DIB. If not supplied (zero), the File Manager will use the partition having the largest unused space. Position to absolute file -1 to close the file.

5.1.3 File Positioning

File positioning is provided for use with sequential files. It allows the user to access logical records out of sequence. There are four basic types of positioning. With each type of positioning a count is specified by the user in the Input/Output Block (IOB word 6). (The IOB is defined in Section 2.)

Note that counting of records or file marks begins at zero. See Figure 5-4 for examples of sequential file positioning.

1. Absolute by file mark. The count is the number of file marks to skip from the beginning of the file. The next READ or WRITE will access the logical record following the file mark. Note that a position to absolute zero is equivalent to a rewind. Positioning a file to absolute -1 will close the file. If the count exceeds the number of file marks in the file, an "end-of-media" status is returned with the file positioned after the last logical record.

2. Absolute by logical record. The count is the number of logical records to skip from the beginning of the file (the count must be positive). If a file mark is encountered before the count is exhausted, a "file-mark-found" status is returned and the file is left positioned at the file mark. If the end-of-file is encountered before the count is exhausted, an "end-of-file" status is returned and the file is left positioned after the last logical record.

3. Relative by file marks. The count is the number of file marks to skip from the current file position. A positive count means skip forward; a negative count means skip backwards. While skipping forward, if the end-of-file is encountered, and "end-of-file" status is returned and the file is left positioned after the last logical record. In like manner, when skipping backward, a "beginning-of-file" status is returned and the file is positioned at the first logical record.

4. Relative by logical record. The count is the number of logical records to skip from the current file position. While skipping forward, if a file mark is encountered, a "file-mark-found" status is returned and the file is positioned at the file mark.

   For backwards skips, if a file mark is found, a "file-mark-found" status is returned and the file is positioned after the file mark. As with relative positioning by file marks, the File Manager will not allow the position to go beyond the beginning and end of file limits.

With a normal completion, the actual number of records/file marks skipped is returned to the user in IOB word 8. For an error completion, the count returned is the number successfully skipped when the error occurred. For a retry, the requested count should be set to the REQUESTED count in the IOB minus the ACTUAL count.

5.1.4 File Functions

The File Manager provides the functions described below. They are set by the user in the IOB (see Section 2).

Write File Mark	This function writes a sequential record (blocked or unblocked) that contains a :80 in the first byte. When read, this record will cause a file-mark-found status to be returned. Note that this is a data separator, not an end-of-file.
Delete File	This function sets the file-deleted bit in the file DIB and in the directory when the file is closed. Note that this does not free the space on the file device; it only enables a new file to be created with the same name.
Update Directory	This function causes the directory to be updated with the current end of file. This function is valid only for new files. This enables the user to secure the data without performing a close on the file.

TE: The number indicates the count supplied by the user.

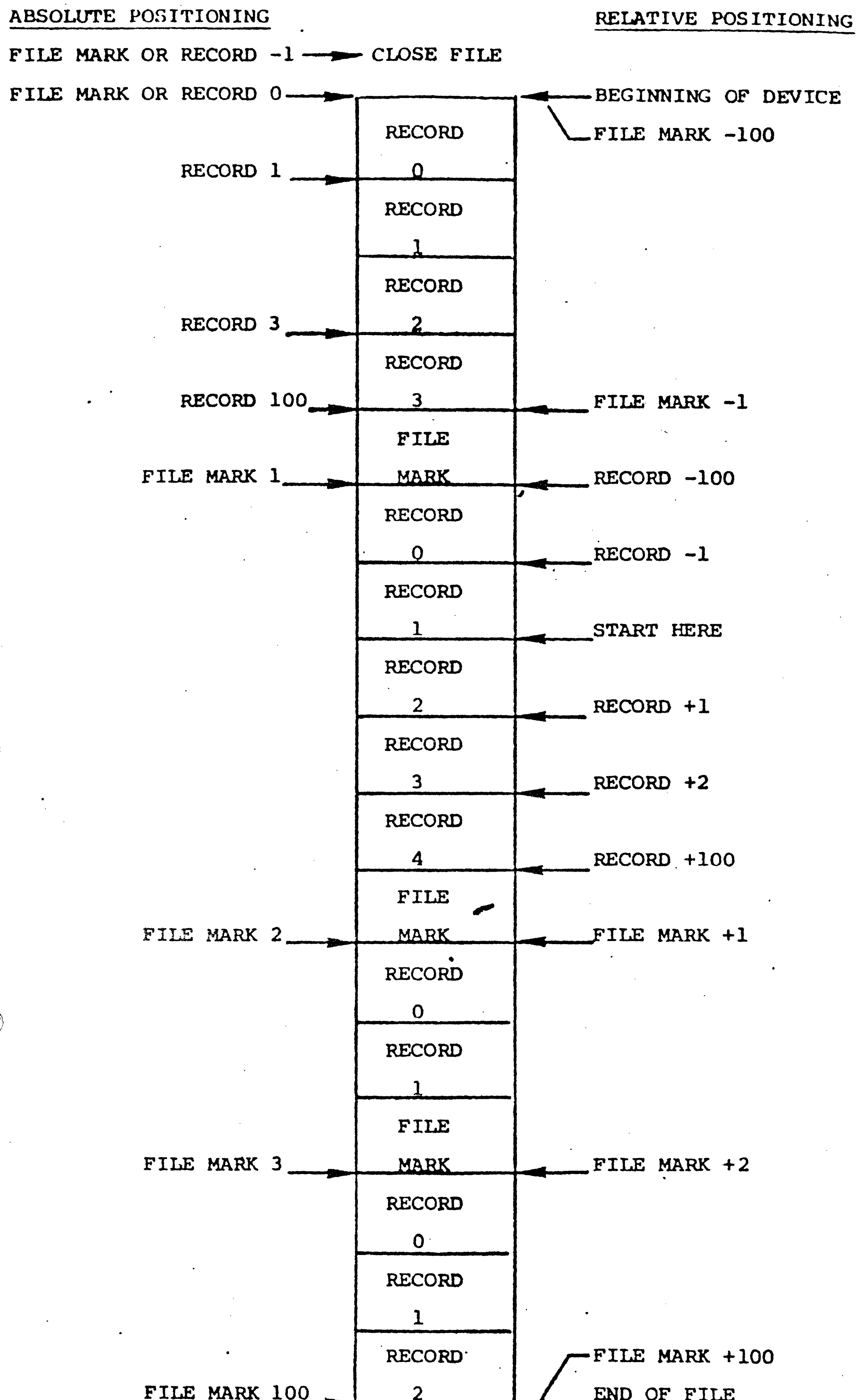


Figure 5-4. Sequential File Positioning Examples

5.2 TABLE ORGANIZATION

The File Manager may be considered as a "dummy" IOX driver in that it is a "data" driver as opposed to a device driver. The File Manager is only concerned with the data contained on the device and not the device itself. Since the File Manager is independent of the file device, it calls a standard IOX device driver to access data n the device. These calls are made to IO: using the logical units associated with the device.

Since the File Manager operates under IOX as a driver, it requires the same type driver tables (i.e. DIBs and CIBs). If the File Manager was equated to a device driver, then a VTOC (directory) would be equivalent to a device controller, and a file would be equivalent to a device unit. The File Manager requires that one CIB for each VTOC, and one DIB for each file be concurrently active (open).

A device containing a VTOC to be accessed by the File Manager must have a unique logical unit associated with it. This logical unit is contained in the File Manager CIB for that VTOC and is used to access the device.

Each File Manager DIB must have a logical unit associated with it. This logical unit is used by the user to access the file described by the DIB.

Logical unit associations are made in the Unit Assignment Table (UAT). A description of the UAT, as well as of the Input/Output Block (IOB) that contains the LUN, is given in Section 2.

Figure 5-5 gives an example of a table configuration. In this example, the file device is a moving head disk with two platters (unit 0 and unit 1). Each unit contains an independent Volume Table of Contents (VTOC) and file directory for that unit.

The standard IOX moving head disk driver requires one controller information block (CIB) C:DKO and two device information blocks (DIBs) D:DK00 and D:DK01 for disk units 0 and 1 respectively.

The File Manager requires two CIBs, C:FM0 and C:FM1, for VTOC 1 and VTOC 2, respectively. Since three files are to be active (open) concurrently, three DIBs are required: D:FM00 for FILE 1, D:FM01 for FILE 2 and D:FM02 for FILE 3.

Each file device (VTOC) has a logical unit associated with it which is used by the File Manager to access the device (LUN X for VTOC 1 and LUN Y for VTOC 2).

The user accesses the files through a standard IOX call to IO: using the logical unit associated with the file DIB. (LUN A for FILE 1, LUN B for FILE 2 and LUN C for FILE 3.

5.2.1 File Device Information Block (DIB)

The first ten words of the Device Information Block (DIB) have essentially the same functions for the File Manager as they have for IOX. These standard functions are described in Section 4, DIB and CIB Descriptions. The functions for words 10 through are given below. (Refer to Figure 5-6.)

Words 0-6	Standard for IOX.
Words 7-9	Standard for IOX, but <u>must</u> be set to zero for File Manager.

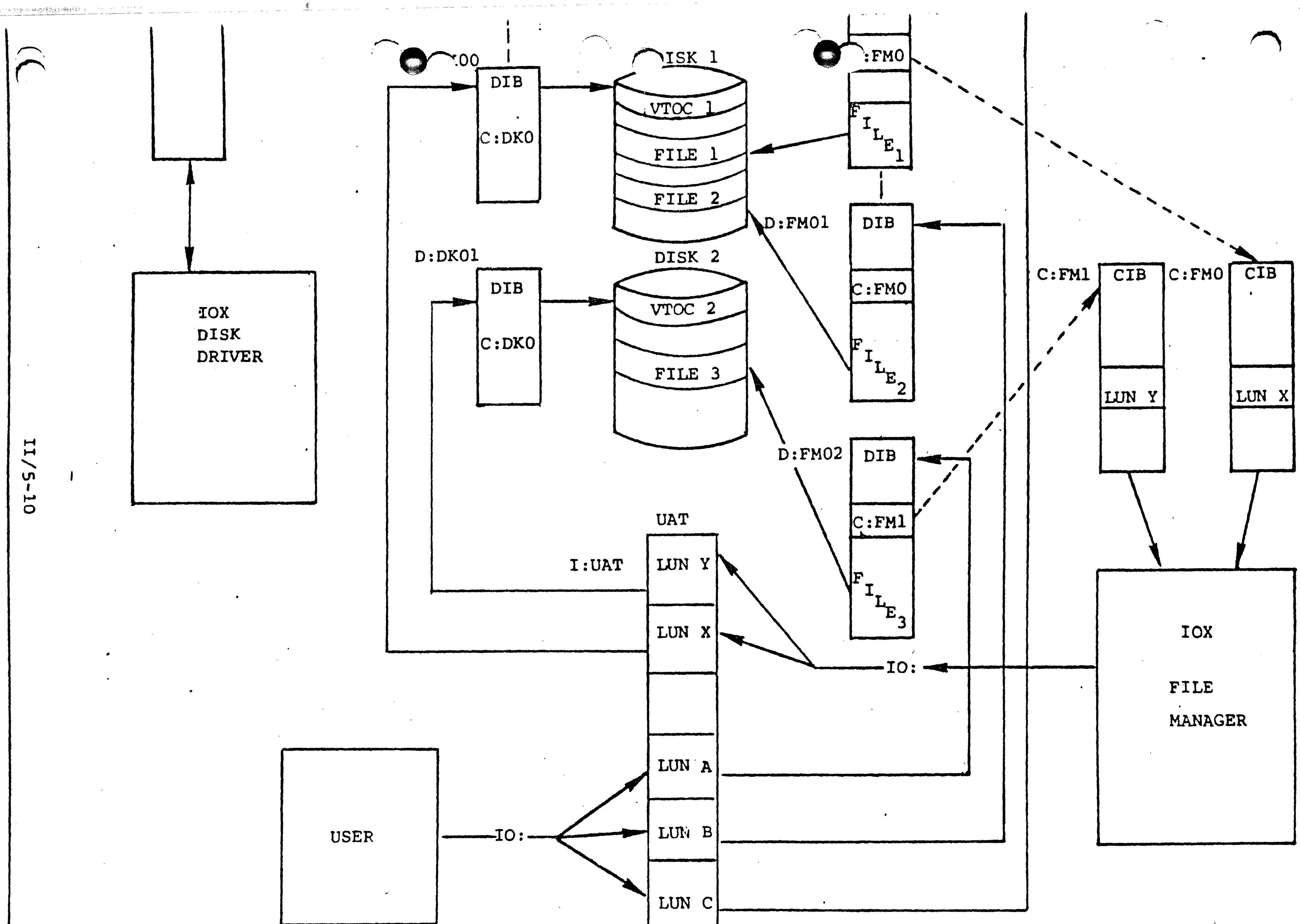


Figure 5-5. Table Organization

Word	Contents	Label
0–9	STANDARD FOR IOX	
10	PHYSICAL I/O ERROR STATUS	DHST
11	FILE STATUS WORD	DFST
12–14	FILE NAME	DFNAM
15	RELATIVE RECORD NUMBER	DRRN
16	ABSOLUTE RECORD NUMBER	DARN
17	RECORD SIZE	DRS
18	BLOCK SIZE	DBKS
19	PHYSICAL RECORDS PER BLOCK	DPRB
20	PHYSICAL RECORD NUMBER	DPRN
21	TOTAL RECORDS	DTREC
22	DIRECTORY ENTRY NUMBER	DDEN
23	CURRENT BLOCK ADDRESS	DCBA
24	BLOCKING BUFFER ADDRESS	DBBA
25	LAST PHYSICAL RECORD	DLPR
26	COMPLETION STATUS	DCST

Figure 5-6. DIB Definition when Used with the File Manager

Word 10 — Physical I/O error status. The status (word 5) of the physical I/O IOB is stored here after each operation.

Word 11 — File Status word. For old files, all bits are supplied by the File Manager from the directory; therefore, all bits of word 11 are initialized to zero. When creating a new file, those bits flagged with an asterisk (*) must be supplied by the user before the first access. The data security bit may be modified at any time to enable or disable this function. After the first access of a file (new or old), if the file delete bit (15) is set, the file will be deleted when the file is closed. Bits 15-13 correspond to the file attribute bits in the directory entry and are transferred to the entry when a new file is closed.

Bit 15. 0 = keep file, 1 = delete file

Bit 14*. 0 = sequential file, 1= random file

Bit 13*. 0 = unblocked records, 1 = blocked records

Bit 12. 0 = file closed, 1 = file open

Bit 11. 0 = file open for sequential access
1 = file open for random access

Bit 10. 0 = old file, 1 = new file

Bit 9. 0 = current block not modified
1 = current block modified (blocked files only)

Bit 8. Data security bit. When set the directory is updated after each sequential write (unblocked files) or after a block is written (blocked files).

Bit 7. 0 = file not linked, 1 = file linked

Bits 6-4. Reserved for future expansion.

Bits 3-0*. Partition number. For old files, contains the number. For new files, specifies where the new file is to be created. If zero, the available partition with the greatest unused space is used and its number is stored here.

Words 12-14* — ASCII file name. Supplied by the user.

Word 15 — Relative record number. Relative to the beginning of the current file segment for linked files. With unlinked files, this word is the same as the absolute record number.

Word 16 — Absolute record number. The current file position relative to the beginning of the file. Note that the first record is record zero.

Word 17* — Record size in bytes. Set to 512 for random files. Supplied by user for new files.

* Information supplied by user.

Word 18*	Block size in bytes. Used for blocked files only. Supplied by user for new files.
Word 19	Number of physical records/block. Contains the number of 512 byte physical records required for a file block (blocked files) or record (unblocked files). Supplied by the file manager. Referred to as "tach ratio" under CAI OS.
Word 20	Physical record number of first record in file. Supplied by the File Manager.
Word 21	Total records in the file. For linked files, contains total records in current segment. Supplied by the file manager.
Word 22	Directory entry number for this file. Supplied by the file manager.
Word 23	Current block address. Contains the physical record number of the last block read. Supplied by the File Manager.
Word 24*	Blocking buffer address, (Word address, no indirect). Supplied by user when accessing blocked files. Buffer size must be block size plus 2 bytes. Not required for unblocked or random files.
Word 25	Last physical record in partition. For new files, contains the last available record number. Not used for old files. Supplied by the File Manager.
Word 26	Completion status. Cleared upon entry into file manager and set when operation is complete. A bit is active when it is set to 1.

Bit 15. Physical I/O error. An abnormal status was returned from physical I/O. The detail physical I/O status (DHST) word in the DIB contains word 5 of the CIB IOB used for the physical I/O.

Bit 14. Device not labeled. A valid VTOC identifier was not found. This error can only occur during a file open.

Bit 13. Directory full. No unused entries are available in the directory for the creation of a new file.

Bit 12. Directory error. An error was returned from physical I/O during a direction read or write. Detail physical I/O status (DHST) word in DIB is set. This error can occur during a file open, close, or directory update.

Bit 11. End of Media. The end of a partition was reached during write on a new file. It is valid for both sequential and random access modes.

Bit 10. Partition(s) busy. The required partition for a new file creation already has a new file currently open, (partition is busy), or required partition is full. If no partition was specified, then all partitions are busy.

* Information supplied by user.

Bit 9-8. Reserved for future expansion.

Bit 7. Access mode error. A sequentail access was made on a ramdom file or a random access was made on a sequential file. The access type did not match file type in a new file open.

Bits 6-2. Reserved for future expansion.

Bit 1. Unable to close. Indicates a close was in process when an error occurred (file remains open).

Bit 0. Unable to open. Indicated an open was in progress when an error occurred, (file remains closed).

.2 Manager Controller Information Block (CIB)

The Controller Information Block (CIB) is used for storing and/or transferring information between the File Manager and the IOX I/O handler. Words 15-19 must contain the described information upon initial entry to the File Manager (actually to IOX). igure 5-7 illustrates the CIB configuration. The functions of each CIB word are described below. Word 0, words 15-19 and words 24-33 are defined the same for the File Handler as they are for IOX.

Word 0	SIO: beginning of record flag.
Words 1-10	IOB used by the File Manager for physical I/O; includes user-supplied LUN for the file device (IOB word 4 = CIB word 5). All other data in IOB is supplied by the File Manager. The IOB status word is transferred to the DIB physical I/O error status word after each IO: call.
Word 11	Number of physical sectors per physical record (supplied by the File Manager).
Word 12	Physical sector address of Volume Table of Contents (VTOC). Initialize to zero. The File Manager determines the VTOC address (0 or :29) on first open.
Word 13	Address of Disk Descriptor Table (DDT) (supplied by the File Manager after first open). This is a physical record address.
Word 14	Open/close buffer address. This word contains the word address (no indirection) of a 256-word buffer supplied by the user. This buffer is used by the File Manager for directory searching during open or close processing.
Words 15-18	Entry point jump table.

Word 15	Read	FM:REA
Word 16	Write	FM:WRT
Word 17	Position	FM:POS
Word 18	Function	FM:FUN

Word 19	Special operation entry point. Not used; set to zero.
Word 20	Current direction record number during open, or operation code during position/function processing (supplied by the File Manager).
Word 21	Number of directory entries used during open, or absolute file position count during position processing (supplied by the File Manager).
Word 22	Number of directory entries available during open or current file position during position processing. Supplied by the File Manager.

Word	Contents	Label
0	SIO: BEGINNING OF RECORD FLAG	DBOR
1	PHYSICAL I/O	
	IOB	
10		
11	NUMBER OF SECTORS/RECORD	CSPR
12	VTOC ADDRESS	CVTOC
13	DDT ADDRESS	CDDT
14	OPEN/CLOSE BUFFER	COCB
*15	STANDARD	CJTB
*17	FOR	
*18	CIB	
*19		
20	CURRENT DIRECTORY RECORD	CCDR/CPFC
21	DIRECTORY ENTRIES USED	CVND/CAPC
22	DIRECTORY ENTRIES AVAILABLE	CVDA/CCPC
23	PARTITION BUSY FLAGS	CPBS
*24		
*25		
*26		
*27	STANDARD	
*28	FOR	
*29	CIB	
*30		
*31		
*32		
*33		
34	SUBROUTINE LEVEL 5	CR:xxx WHERE
35	RETURN LEVEL 4	
36	ADDRESS LEVEL 3	xxx = SUBROUTINE NAME
37	SAVE LEVEL 2	
38	AREA LEVEL 1	
39	FILE LINKAGE	CLKBF
40	BUFFER	
41		
42		

Figure 5-7. CIB Definition When Used With the File Manager

Word 23	Partition busy flags. Each partition on disk is represented by a single bit. The bit position is equal to the partition number. With a maximum of 8 partitions numbered 1-8, only bits 1-8 are used. Bits 0 and 9-15 are unused. A partition busy flag is set when a new file is open in that partition and cleared when it is closed. Only one new file may be open in any one time. Supplied by the File Manager.
*Words 24-33	Standard CIB definition.
Words 34-38	Subroutine return address save area.

Word 34	Level 5 subroutines:	FM:PS FM:FN
Word 35	Level 4 subroutines:	FM:RE FM:WR FM:OP FM:CL
Word 36	Level 3 subroutines:	FM:DM FM:EOF
Word 37	Level 2 subroutines:	FM:WBK FM:RBK FM:RLK FM:RLR
Word 38	Level 1 subroutines:	FM:PIO

Words 39-42	Buffer for processing partition file linkage.

5.3 RTX FILE LABEL UTILITY

The RTX File Label Utility is a stand-alone program for labeling file-type devices. The RTX/IOX File Manager requires that all file-type devices be labeled prior to use. This involves the creation of a Volume Table of Contents (VTOC) and directories on each individual unit to allow later file processing by name. Do not confuse "labeling" with "formatting" of disk packs; the latter must be done with stand-alone programs before labeling. The labeled device is compatable with Computer Automation OS File Format.

5.3.1 Environment

The Label Utility requires an LSI-2 or LSI-3/05 CPU with a minimum of 4K words of memory. The tape numbers (binary paper tape) are 93324-40A1 and -41A1 for LSI-2 and LSI-3/05, respectively.

5.3.2 Program Operation

After loading and executing, the Label Utility halts with P=:0100 and waits for the user to specify TTY I/O type:

1. Standard option board TTY, set Sense switch OFF.

2. DIO TTY, set Sense switch ON.

To continue execution, depress RUN after setting the desired I/O Option. The Label Program will then query the user for its variable information. When responding, certain keys on the keyboard have special functions.

1. <u>Return.</u> The Return key indicates the end of a line of input and causes a carriage return and line feed to be generated.

2. <u>Back arrow (←).</u> The back arrow causes the previous character input to be replaced by the next character typed. Multiple characters may be replaced by typing the appropriate number of back arrows followed by the correction characters.

3. <u>Back arrow (←)/Return.</u> A back arrow followed immediately by Return causes the entire current line to be ignored and replaced by the next line input. The Return causes a carriage return and line feed to be generated.

NOTE

> An invalid response to a query will result in the query being repeated.

The Label Utility begins with the first query:

    DATE? (MMDDYY)

The user should respond with a Volume Identification. It must consist of one to six characters, normally alphanumeric, although any characters are allowed.

    Example: Feb. 4, 1977 would be input as 020477.

    TIME? (HHMMSS)

Enter the current time of day (hours, minutes, seconds). This time is saved in the VTOC. This time is NOT incremented by a real-time clock. This is a 24 hour clock.

Example: 1:23 PM would be input at 132300.

    VOLUME NAME?

The user should respond with a Volume Identification. It must consist of 1-6 characters, normally alphanumeric, although any characters are allowed.

    TYPE AND UNIT NUMBER?

The response is a two-character specifier of the physical device which is to be labeled. The specifiers are:

DEVICE	SPECIFIER
Moving Head Disk, Unit 0	D0
Moving Head Disk, Unit 1	D1
Moving Head Disk, Unit 2	D2
Moving Head Disk, Unit 3	D3
Floppy Disk, Unit 0	F0
Floppy Disk, Unit 1	F1
Floppy Disk, Unit 2	F2
Floppy Disk, Unit 3	F3

    DOES xx CONTAIN OS?

If the device to be labeled (xx) contains a copy of the Computer Automation Operation System (OS) the user responds with "YES". Otherwise, the user's response is "NO", causing the next query to be suppressed. OS must be on the device before labeling.

SAVE OS?

If an operating system exists on the Unit and is to be saved, the user responds with "YES", otherwise "NO".

f the device to be labeled is a disk, the next query is:

NUMBER OF PARTITIONS? (1-8)

The user now selects the number of partitions (1-8) into which the disk is to be divided and enters that value. Only the first digit entered is used. The number of partitions selected is the limit to the number of new files which may be open simultaneously (new file creation).

The labeling process then begins. When successfully completed, the following message is output:

LABEL COMPLETE

I the selected device is off-line, not ready, write protected, or othewise mal ctions during the labeling process, the following message is output:

HARDWARE ERROR
RETRY?

If the user responds with "YES", the program will retry the label process. If the device still fails, the error message is repeated. If the user responds with "NO", the labeling process is aborted and the Program continues with the next query.

LABEL MORE?

user is offered the option of labeling another device or terminating the process. A "YES" response will cause a restart with the query "VOLUME NAME?". If the user wishes to change the date and time and continue, the response is "NO". A "NO" response will halt the CPU. Depressing RUN will restart the program at the beginning. At this point, a new I/O option may be selected.

NOTE

The restart entry point is :0101. The LSI 3/05 version contains a software console routine for restarting (CNSOL3).

```
                    *
                    *       UNIT ASSIGNMENT TABLE
                    *
         0001       NEW     EQU     1         NEW FILE LOGICAL UNIT
         0002       OLD     EQU     2         OLD FILE LOGICAL UNIT
         0003       PIO     EQU     3         PHYSICAL I/O LOGICAL UNIT
                            SAVE
                    *
    0006                    NAM     I:UAT
                            EXTR    D:FM0
                            EXTR    D:FM1
                            EXTR    D:DK01
         0000       UATTOP  EQU     $
    0000 0002               DATA    OLD       OLD FILE LOGICAL UNIT
    0001 0000               DATA    D:FM0     OLD FILE DTB
    0002 0001               DATA    NEW       NEW FILE LOGICAL UNIT
    0003 0000               DATA    D:FM1     NEW FILE DTB
    0004 0003               DATA    PIO       PHYSICAL I/O LOGICAL UNIT
    0005 0000               DATA    D:DK01    PHYSICAL I/O LOGICAL UNIT
    0006 FFF8       I:UAT   DATA    UATTOP-$-2
                            END

0000 ERRORS
0000 WARNING
```

```
                       *
                       *         RTX MAINLINE CODE
                       *
0000                             NAM    MAIN
                                 EXTR   TASK
                                 EXTR   RTX:
                                 EXTR   BEGIN:
                                 EXTR   END:
     000A              N         EQU    10        NUMBER OF WORKING BLOCKS
     0000              MAIN      EQU    $
0000 FB07 0008                   JST    RTX:      INITIALIZE RTX
0001 000A                        DATA   N
0002 000B                        DATA   WKAREA
0003 0800                        HLT              ERROR
0004 FB04 0009                   JST    BEGIN:    START TASK
0005 0000                        DATA   TASK
0006 0064                        DATA   100       AT PRIORITY 100
0007 FB02 000A                   JST    END:
     0003                        LPOOL
0008 0000
0009 0000
000A 0000
000B 0000              WKAREA    RES    5*N,0     RTX WORK AREA
     0000                        END    MAIN

0000   ERRORS
0000   WARNING
```

```
                         *
                         *        APPLICATION PROGRAM. THIS COPIES EVERY THIRD RECORD FORM
                         *        THE EXISTING FILE "OLD" (BLOCKED 72,510) TO A NEW
                         *        FILE "NEW" (UNBLOCKED, 80 BYTE RECORDS).
                         *
0000                              NAM    TASK
0033                              NAM    DATE:
0036                              NAM    TIME:
                                  EXTR   IO:
                                  EXTR   END:
     0000                TASK     EQU    $
0000 C648                         LAP    72       RECORD BUFFER SIZE IN BYTES
0001 9A43 0045                    STA    IOB+6    SET UP BYTE COUNT IN IOB
0002 C602                         LAP    OLD      LOGICAL UNIT OF FILE "OLD"
0003 9A3F 0043                    STA    IOB+4
0004 C601                         LAP    :0001    OPCODE FOR SEQUENTIAL READ
0005 9A3E 0044                    STA    IOB+5
0006 FB32 0039                    JST    IO:      READ A RECORD FROM FILE "OLD"
0007 003F                         DATA   IOB      THE FIRST READ WILL OPEN THE FILE
0008 FB31 003A                    JST    END:
0009 F213 001D                    JMP    CHECK    ABNORMAL RETURN, TEST FOR END OF FILE
                         *
000A C601                         LAP    NEW      LOGICAL UNIT FOR FILE "NEW"
000B 9A37 0043                    STA    IOB+4    SET UP IOB
000C C605                         LAP    :0005    OPCODE FOR SEQUENTIAL WRITE
000D 9A36 0044                    STA    IOB+5
000E FB2A 0039                    JST    IO:      WRITE THE RECORD TO FILE "NEW"
000F 003F                         DATA   IOB      THE FIRST WRITE WILL CREATE A NEW FILE
0010 FB29 003A                    JST    END:     AND OPEN IT
0011 F20E 0020                    JMP    ERROR    ABNORMAL RETURN
                         *
0012 C602                         LAP    OLD      LOGICAL UNIT OF FILE "OLD"
0013 9A2F 0043                    STA    IOB+4    SET UP IOB
0014 C60A                         LAP    :000A    OPCODE FOR POSITION RELATIVE RECORDS
0015 9A2E 0044                    STA    IOB+5
0016 C602                         LAP    2        FORWARD RECORD COUNT TO SKIP
```

```
0017 9A2D 0045          STA    IOB+6
0018 FB20 0039          JST    IO:       SKIP TWO RECORDS ON FILE "OLD"
0019 003F               DATA   IOB
001A FB1F 003A          JST    END:
001B F201 001D          JMP    CHECK     ABNORMAL RETURN, TEST FOR END OF FILE
001C F61C 0000          JMP    TASK      GO BACK TO READ ANOTHER RECORD
                  *
     001D         CHECK EQU    $
001D B226 0044          LDA    IOB+5     GET IOB COMPLETION STATUS
001E 821C 003B          AND    =:0200    TEST FOR FILE MARK FOUND OR END OF FILE
001F 3102 0022          JAN    DONE      YES, COPY COMPLETE
                  *                       NO, SOME OTHER ERROR OCCURED
     0020         ERROR EQU    $
0020 0800               HLT              ERROR HALT
0021 F601 0020          JMP    $-1
                  *
     0022         DONE  EQU    $         COPY COMPLETE, CLOSE FILES
                  *
0022 C701               LAM    1         COUNT = -1
0023 9A21 0045          STA    IOB+6     SET UP IOB
0024 C609               LAP    :0009     OPCODE FOR POSITION ABSOLUTE FILES
0025 9A1E 0044          STA    IOB+5
0026 C602               LAP    OLD       LOGICAL UNIT OF FILE "OLD"
0027 9A1B 0043          STA    IOB+4
0028 FB10 0039          JST    IO:       CLOSE READ FILE "OLD"
0029 003F               DATA   IOB
002A FB0F 003A          JST    END:
002B F60B 0020          JMP    ERROR     ABNORMAL RETURN
                  *
002C C601               LAP    NEW       LOGICAL UNIT OF FILE "NEW"
002D 9A15 0043          STA    IOB+4     SET UP IOB
002E FB0A 0039          JST    IO:       CLOSE WRITE FILE "NEW"
002F 003F               DATA   IOB
0030 FB09 003A          JST    END:
0031 F611 0020          JMP    ERROR     ABNORMAL RETURN
                  *
```

```
0121  0032 F807 003A         JST    END:      ALL DONE
0122  0033 CDCD       DATE:  TEXT   'MMDDYY'
      0034 C4C4
      0035 D9D9
0123  0036 C8C8       TIME:  TEXT   'HHMMSS'
      0037 CDCD
      0038 D3D3
0124       0006              LPOOL
      0039 0000
      003A 0000
      003B 0200
      003C
      003D
      003E
0125                  *
0126                  *      INPUT OUTPUT BLOCK (IOB)
0127                  *
0128  003E 0000       IOB    DATA   0,0,0,0,$-$,$-$,$-$,BUFFER,0,0
      0040 0000
      0041 0000
      0042 0000
      0043 0000
      0044 0000
      0045 0000
      0046 004A
      0047 0000
      0048 0000
0129       004A       BUFFER EQU    $+1
0130  0049 0000              DATA   0         REQUIRED FOR UNBLOCKED FILES
0131  004A 0000              RES    36,0      72 BYTE RECORD BUFFER
0132                         END

0000  ERRORS
0000  WARNING
```

```
      0000                NAM   C:FM0
                          EXTR  FM:REA
                          EXTR  FM:WRT
                          EXTR  FM:POS
                          EXTR  FM:FUN
*
           0000   C:FM0   EQU   $            FILE MANAGER CTB
      0000 0000           RES   5,0
      0005 0003           DATA  PIO          PHYSICAL I/O LOGICAL UNIT
      0006 0000           RES   8,0
      000E 0028           DATA  OCBUF        OPEN/CLOSE BUFFER ADDRESS
      000F 0000           DATA  FM:REA       READ ENTRY POINT
      0010 0000           DATA  FM:WRT       WRITE ENTRY POINT
      0011 0000           DATA  FM:POS       POSITION ENTRY POINT
      0012 0000           DATA  FM:FUN       FUNCTION ENTRY POINT
      0013 0000           RES   24,0
*
      0028 0000   OCBUF   RES   256,0        OPEN/CLOSE BUFFER
                          END

0000  ERRORS
0000  WARNING
```

```
PAGE  0001  03/11/77  15:36:32     EXAMPLE FILE MANAGER APPLICATION
MACRO2 (A2) SI= EX:S    BO=               ** FILE DTB **

                      *
                      *         OLD FILE DTB. DEVICE STATUS WORD IS SET TO ALLOW FILE READ
                      *         OR POSITION OPERATIONS ONLY.
                      *
      0000                      NAM     D:FMO
                                EXTR    C:FMO
                      *
      0000            D:FMO     CHAN    X::
      0001 0000                 DATA    C:FMO     FILE MANAGER CTB ADDRESS
      0002 0000                 RES     2,0
      0004 0F0F                 DATA    :0F0F     DEVICE STATUS WORD
      0005 C6CD                 TEXT    'FM00'     DEVICE NAME
      0006 B0B0
      0007 0000                 RES     4,0
      000B 0000                 DATA    :0000     FILE STATUS WORD
      000C CFCC                 TEXT    'OLD    '  FILE NAME
      000D C4A0
      000E A0A0
      000F 0000                 RES     9,0
      0018 001C                 DATA    BRUF      BLOCKING BUFFER ADDRESS
      0019 0000                 RES     3,0
                      *
      001C 0000       BRUF      RES     510+2/2,0 BLOCKING BUFFER, SIZE = BLOCK SIZE+2 BYTES
                                END

0000  ERRORS
0000  WARNING
```

```
                           *
                           *       NEW FILE DIB. DEVICE SPECIFICATION WORD IS SET TO ALLOW
                           *       ANY FILE OPERATION. THE FILE IS UNBLOCKED WITH 80 BYTE RECORDS.
                           *       NO BLOCKING BUFFER IS REQUIRED.
                           *
0000                               NAM    D:FM1
                                   EXTR   C:FM0
                           *
0000                       D:FM1   CHAN   X::
0001 0000                          DATA   C:FM0     FILE MANAGER CIB ADDRESS
0002 0000                          RES    2,0
0004 FFFF                          DATA   :FFFF     DEVICE STATUS WORD
0005 C6CD                          TEXT   'FM01'     DEVICE NAME
0006 B0B1
0007 0000                          RES    4,0
000B 0000                          DATA   :0000     FILE STATUS WORD
000C CEC5                          TEXT   'NEW    '  FILE NAME
000D D7A0
000F A0A0
000F 0000                          RES    2,0
0011 0050                          DATA   80        RECORD SIZE
0012 0000                          DATA   0         BLOCK SIZE (UNBLOCKED)
0013 0000                          RES    5,0
0018 0000                          DATA   0         BLOCKING BUFFER ADDRESS (NONE REQUIRED)
0019 0000                          RES    3,0
                           *
                                   END

0000 ERRORS
0000 WARNING
```

SECTION 6

DEVICE-DEPENDENT CONSIDERATIONS

The device-dependent functions of IOX are the responsibility of the individual device handlers. Initially IOX performs all parameter validation and error checking before control is transferred to the appropriate device handler. The device handler will execute the data transfer and perform the device testing. Note that the bit configuration for each function (bits 3-0 of IOB word 5) is listed below each operation in parentheses.

6.1 STANDARD CHARACTER DEVICE HANDLERS

6.1.1 Line Printer (LP)

Write (formatted ASCII) (0110)	Outputs up to 132 (or less if the printer is not that wide) characters.
Write file mark (1100)	Outputs /* in columns 1 and 2.
All other function codes	No I/O

6.1.2 Teletype Keyboard (TK)

Write (formatted ASCII) (0110)	Outputs up to 72 characters. Carriage return, line feed are appended to the end of each record.
Write (unformatted) (0101)	Outputs up to 65,535 characters exactly as in the user's buffer.
Read (formatted ASCII (0010)	Inputs from the keyboard until a carriage return is read. Standard character editing is active.
Read (unformatted) (0001)	Inputs from the keyboard until the number of characters requested is input.
Write File Mark (1100)	/* is output followed by carriage return, line feed.
All other function codes	No I/O

6.1.3 Teletype Console (TY) (implies tape reader or keyboard for input, whichever is ready)

Write (formatted ASCII) (0110)	Outputs up to 72 characters. Carriage return and line feed are appended to the end of each record.
Write (unformatted) (0101)	Outputs up to 65,535 characters exactly as in the user's buffer.
Read (formatted ASCII) (0010)	Inputs (from the tape reader, if ready, otherwise from the keyboard) until a carriage return is read. Standard character editing is active.
Read (unformatted) (0001)	Inputs (from the tape reader, if ready; otherwise from the keyboard) until the requested number of characters is input.
Write File mark (1100)	/* is output, followed by carriage return, line feed.
All other function codes	No I/O

.1 Teletype Reader (TR)

Read (formatted ASCII) (0010)	Inputs up to 256 ASCII characters from the reader (does NOT echo on printer) until a carriage return is read. Standard character editing is active.
Read (unformatted) (0001)	Inputs from the reader (does NOT echo on printer) until the number of characters requested is input.
Read (formatted binary) (0011)	Reads one binary record and checks the checksum. If a checksum error is detected, the error status will be set.
All other function codes	No I/O

1. Teletype Punch (TP)

Write (formatted ASCII) (0110)	Outputs up to 256 ASCII characters. Carriage return line feeds are supplied at the end of each record.
Write (formatted binary) (0111)	Outputs up to 65,535 bytes in IOX binary format.
Write (unformatted) (0101)	Outputs up to 65,535 bytes exactly as in the user's buffer.
Write File Mark (1100)	Outputs Rubout-Null-Null on the paper tape.
Punch Leader (1101)	Outputs 12 inches of leader.
All other function codes	No I/O

.1.6 Card Reader (CR)

Read (formatted ASCII) (0010)	One card will be read. The maximum number of bytes transferred is 80. If the first two columns contain /* an end-of-file is assumed.
Read (formatted binary) (0011)	To be specified . . . if the first two columns contain /* an end-of-file is assumed.
All other function codes	No I/O

6.1.7 High Speed Reader (PR)

Read (formatted ASCII) (0010)	Inputs from the reader until a carriage return is read. Standard character editing is active.
Read (unformatted) (0001)	Inputs from the reader until the number of characters requested is input.
Read (formatted binary) (0011)	Reads one binary record and checks the checksum. If the checksum is in error the error status is set.
All other function codes	No I/O

6.1.8 High Speed Punch (PP)

Write (formatted ASCII) (0110)	Outputs up to 256 ASCII characters. Carriage return line feeds are supplied at the end of each record.
Write (formatted binary) (0111)	Outputs up to 65,535 bytes in the IOX binary format.
Write (unformatted) (0101)	Outputs up to 65,535 bytes exactly as in the user's buffer.
Write File Mark (1100)	Outputs Rubout, Null, Null on the paper tape.
Punch Leader (1101)	Outputs 12 inches of leader.
All other function codes	No I/O

6.2 FORTRAN LIST DEVICE HANDLER

6.2.1 Line Printer (LPF)

Write (formatted ASCII) (0110)	Outputs up to 132 characters, preceded by a carriage control character ("1" = top of form, "0" = double upspace, any other = single upspace).

Write file mark (1100)	Outputs "/*" in columns 1 and 2.
All other function codes	No I/O

6.2.2 Teletype Keyboard (TKF)

Write (formatted ASCII) (0110)	Outputs up to 72 characters, preceded by carriage control character ("1" = top of form = 6 upspaces, "0" = double upspace, any other = single upspace).
Write (unformatted) (0101)	Outputs up to 65,535 characters exactly as in the user's buffer.
Read (formatted ASCII) (0010)	Inputs from the keyboard until a carriage return is read. Standard character editing is active.
Read (unformatted) (0101)	Inputs from the keyboard until the number of characters requested is input.
Write File Mark (1100)	/* is output followed by carriage return, line feed.
All other function codes	No I/O

6.2 Teletype Console (TYF)(implies tape reader or keyboard for input, whichever is ready)

Write (formatted ASCII) (0110)	Outputs up to 72 characters, preceded by carriage control character ("1" = top of form = 6 upspaces, "0" = double upspace, any other = single upspace).
Write (unformatted) (0101)	Outputs up to 65,535 characters exactly as in the user's buffer.
Read (formatted ASCII) (0010)	Inputs (from the tape reader, if ready, otherwise from the keyboard) until a carriage return is read. Standard character editing is active.
Read (unformatted) (0001)	Inputs (from the tape reader, if ready; otherwise from the keyboard) until the requested number of characters is input.
Write File mark (1100)	/* is output, followed by carriage return, line feed.
All other function codes	No I/O

6.3 MAGNETIC TAPE HANDLER

6.3.1 Magnetic Tape (MT)

Write (formatted ASCII, formatted binary, or unformatted) (0110, 0111, or 0101)	Outputs 1 to 65535 bytes as a single record.
Read (formatted ASCII, formatted binary, or unformatted) (0010, 0011, or 0001)	Inputs one record up to 65,535 bytes. If the actual record is longer than the requested number of bytes, only the requested number will be input. If the actual record is shorter than the requested input, only the actual number of bytes are input. Up to ten retries will be made in the event of a parity error before an error status is returned to the caller.
Position Relative Records (1010)	Skips the number of records in the requested count. A positive count indicates forward skips. A negative count indicates backward skips. If a file mark is encountered during the positioning, the operation is terminated, and the number of records actually skipped (not including the file mark) is returned along with an end-of-file status. The tape is left positioned prior to the file mark (the file mark is never actually crossed and movement is effectively bounded within a pair of file marks). If an end of tape or beginning of tape marker is found during positioning, the operation is te terminated with the actual count returned and an end-of-device status.
Position Relative Files (1011)	Skips the number of file marks in the requested count. A positive count indicates forward skips. A negative count indicates backward skips. Upon return, the tape is positioned past the last file mark skipped. If an end-of-tape or beginning-of-tape mark is encountered, the operation is terminated with the actual skip count returned, along with the appropriate end-of-device status.
Position Absolute Records (1000)	The tape is first rewound to load point, then skipped forward the number of records requested. The requested count must be positive. If the count is zero, the tape is left at load point.
Position Absolute Files (1001)	The tape is first rewound, then skipped forward the number of files requested. The requested count must be positive. If the count is zero, the tape is left at load point.
Write File Mark (1100)	A write file mark function is issued to the tape unit.
All other operations	No I/O

6.4 DISK, STORAGE MODULE DISK, AND FLOPPY DISK HANDLER

6.4.1 Disk (DK), Storage Module Disk (SM), and Floppy Disk (FD)

Write Direct Access (0100)	Writes to the disk the number of bytes specified by the user in IOB Word 6, to the relative record number specified in IOB Word 9. Upon completion of the operation, this record number is incremented.
Read Direct Access (0000)	Reads from the disk the number of bytes specified by the user in IOB Word 6, from the relative record number specified in IOB Word 9. Upon completion of the operation, this record number is incremented.
All other function codes	No I/O

NOTE

The Floppy Disk Handler supports only one floppy disk controller. The handler must not be used concurrently with a storage module disk controller.

The Storage Module Disk Handler supports only one storage module disk controller. The handler must not be used concurrently with a floppy disk controller.

6.4.2 Fortran Disk (DKF), Storage Module Disk (SMF), and Floppy Disk (FDF)

Write (formatted ASCII, formatted binary) (0110 or 0111)	Outputs to the disk the number of bytes specified by the user, to the relative record number maintained in DIB Word 15. Upon completion of the operation, this record number is incremented and stored into IOB Word 9.
Read (formatted ASCII, formatted binary) (0010 or 0011)	Inputs from the disk the number of bytes specified by the user, from the relative record number maintained in DIB Word 15. Upon completion of the operation, this record number is incremented and stored into IOB Word 9.
Position Relative Records (1010)	The requested count (positive or negative) is added to the current relative record number maintained in DIB Word 15. (No actual I/O occurs). The new record number is also copied into IOB Word 9. If the resultant relative record number is greater than the highest sector number in the extent, the highest sector number is stored, and the end-of-device status is returned. If the resultant relative record number is negative, a zero (representing the first record of the extent) is stored, and a beginning-of-device status is returned.

Position Absolute Records (1000)

The requested count (which represents the actual record number to be positioned to), is stored into DIB Word 15 and IOB Word 9. No actual I/O occurs. If the record number is greater than the highest sector number in the extent, the highest sector number is stored, and the end-of-device status is returned. If the record number is negative, a zero (representing the first record of the extent) is stored, and a beginning-of-device status is returned.

Write File Mark (1100)

A two character record containing "/*" is written into the record pointed to by the Relative Record Count, then this count is incremented and copied into IOB Word 9.

All other function codes

No I/O.

NOTE

The Floppy Disk Handler supports only one floppy disk controller. The handler must not be used concurrently with a storage module disk controller.

The Storage Module Disk Handler supports only one storage module disk controller. The handler must not be used concurrently with a floppy disk controller.

6.5 MAGNETIC TAPE INTELLIGNET CABLE (MTIC) HANDLER

Write forward (ASCII or Binary) (0110 or 0111)

Outputs 1 to 65,535 bytes as a single record. Records containing a byte count less than the minimum record length (DIB word 12) will have additional characters appended to the record until the byte count is equal to the minimum record length. Blanks are appended to ASCII records and zeros are appended to Binary records.

During write operation error recovery, the tape is backspaced one record and another write is attempted. Up to ten retries are made in the event of a rate error (processor workload error). Up to three retries are made in the event of a hard error (tape error); subsequently, a fixed length erase function is used to erase the hard error region and three more retries are executed. This erase procedure is executed up to ten times, at which point an error status is returned. (Note: Hard error recovery is modified if the Control Edit function is on. Refer to the Control Edit description.)

Error counts for each type of recovery are returned to DIB word 10.

Read (forward, reverse) (ASCII, Binary), Read Reverse (0010, 0011, 0000)	Inputs one record up to 65,535 bytes. If the actual record is longer than the requested number of bytes, only the requested number is input. If the actual record is shorter than the requested input, only the actual number of bytes are input. Up to ten retries are made before an error status is returned.
Position Relative Records (1010)	Skips the number of records in the requested count. A positive count indicates forward skips. A negative count indicates backward skips. If a file mark is encountered during the positioning, the operation is terminated, and the number of records actually skipped (not including the file mark) is returned along with an end-of-file status. The tape is left positioned prior to the file mark (the file mark is never actually crossed and movement is effectively bounded within a pair of file marks). If an end of tape or beginning of tape marker is found during positioning, the operation is terminated with the actual count returned with an end-of-device status.
Position Relative Files (1011)	Skips the number of file marks in the requested count. A positive count indicates forward skips. A negative count indicates backward skips. Upon return, the tape is positioned past the last file mark skipped. If an end-of-tape or beginning-of-tape mark is encountered, the operation is terminated with the actual skip count returned with the appropriate end-of-device status.
Position Absolute Records (1000)	The tape is first rewound to load point, then skipped forward the number of records requested. The requested count must be positive. If the count is zero, the tape is left at load point. If the count is minus one, the unit is placed offline.
Position Absolute Files (1001)	The tape is first rewound, then skipped forward the number of files requested. The requested count must be positive. If the count is zero, the tape is left at load point. If the count is minus one, the unit is placed offline.
Write File Mark (1100)	A write file mark function is issued to the tape unit.
Control Edit (1110)	This function causes the formatter to implement special head positioning to allow record updating.

NOTE

Control Edit needs to be used with caution because of possible "tape creep". Refer to the Distributed I/O System User's Manual, Publication No. 91-53629-00B2, for a more detailed explanation.

Control Edit requires five calls to IO:. Call one positions the tape at the end of the record to be updated. (An inter-record gap containing an erasure or noise record might be found between the end of this record and the beginning of the next record.) Call two sets the edit function on. Call three performs a skip or read reverse function for the current record. Call four performs a write forward function for the new record. The byte counts for the new and old records must be equal. Call five set the edit function off.

Hard error recovery for write operations is modified when Control Edit is on. Up to three retries are made in the event of a hard error; subsequently, an error status is returned.

Control Erase (1111)	This function performs a fixed length (filemark) or variable length erase. The erase mode bit is set to override a write operation. This function can be used with Control Edit to erase a record in place. Control Erase requires three calls to IO:. Call one sets Control Erase on. Call two performs a write or write file mark function. Call three sets Control Erase off.
All other function codes	No I/O.

6.6 STANDARD CHARACTER EDITING

In order to facilitate input from an operator, IOX supports character editing on input from all keyboard and paper tape devices. Three editing functions are supported by IOX.

1. Backsapce. Character backspace is implemented using the back arrow (←) character. One character is erased for each back arrow character input. Since it is impossible to physically backsapce on a teletype, the back arrows are echoed on the printer. Note that the character editing will take place over the length of the entire physical record, not just until the number of currently valid characters equals the requested count.

2. Ignore entire input. Occasionally the operator decides it would be easier to start over rather than backspace and correct all of the errors on the current input. IOX supports this by deleting the entire input and restarting whenever the back arrow is typed followed immediately by a carriage return.

3. Ignore this character. This is useful when the input is from a paper tape which was prepared off-line on a teletype. The punch on a teletype has a local backspace feature, and the most common means of correcting a tape such that it prints proprely when read off line is to backspace the punch over the offending character(s) and punch rubout(s) on top of them. IOX will read such tapes properly by ignoring all rubouts. In addition, IOX will read such tapes properly by ignoring all rubouts. In addition, IOX ignores all line feeds and all other characters whose ASCII code is less than :0D (e.g., bell, leader).

Since an end-of-file is defined as a Rubout, Null, Null on paper tape, and since it is difficult to enter Rubout, Null, Null on a keyboard, IOX recognizes two different end-of-file marks in the standard character editing mode for formatted ASCII input. These file marks are Rubout, Null, Null or /*. Either of these character sequences input at the beginning of a record will cause an end-of-file to be recognized.

SECTION 7

NON-STANDARD HANDLER DESCRIPTIONS

Some IOX handlers do not conform to the standard IOB, DIB, and CIB configurations described in sections 2 and 4. This section describes the software tables and device-dependent functions of these IOX handlers. (The A/D, D/A handler is described in Publication No. 93325-00.)

7.1 IEEE INTELLIGENT CABLE (IEC) HANDLER

The IEC Handler controls the operation of the IEEE Intelligent Cable. The IEC Handler and the IEEE Intelligent Cable together conform to the requirements for an IEEE (STD 488-1975) interface system controller. The IEEE Intelligent Cable provides the hardware to drive the IEEE interface bus and the firmware to conduct both the Source Handshake and the Acceptor Handshake. It also senses the state of the IEEE Interface Bus. The IEC Handler implements the remaining IEC functions. The interfaced devices must have no controller capabilities.

Refer to the Distributed I/O System User's Manual (revision B2 or higher) and IEEE document 488-1975, "IEEE Standard Digital Interface for Programmable Instrumentation" for detailed IEEE function descriptions.

Note that an arbitrary distinction is made between the terms "control" and "data" with respect to IEC handler message transfers. "Control" refers to bytes which are sent over the interface bus while ATN is true. "Data" refers to bytes which are sent or received over the interface bus while ATN is false.

.1.1 IEC IOB Configuration -- 9 to 12 words.

igure 7-1 illustrates the IOB configuration for the IEC Handler.

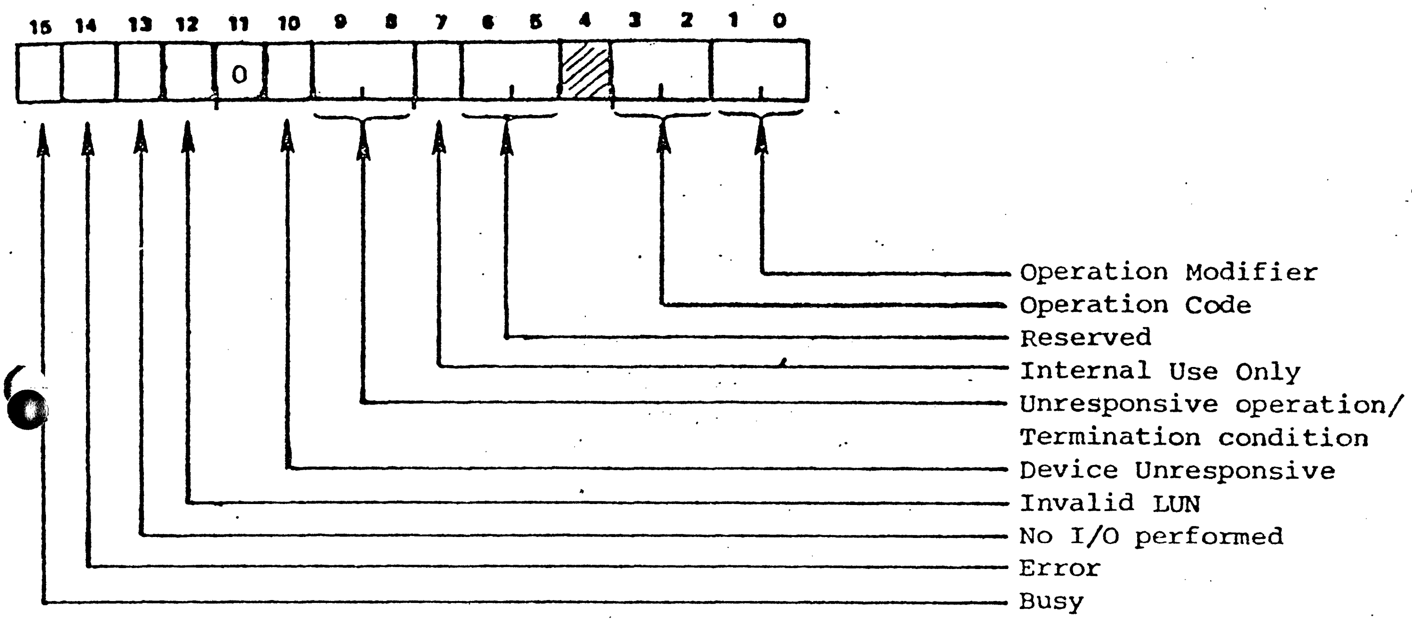
INPUT/OUTPUT BLOCK
FOR THE IEEE INTELLIGENT CABLE HANDLER

Standard Name	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	word
	STANDARD IOB CONFIGURATION																0
IDT																	1
I[illegible]N or [illegible]CB																	2
CN																	3
ILUN																	4
ISTA,IOP	BUSY	ERROR	NO I/O	BAD LUN	0	DEVICE	OP OR TERM COND.		INTERN	RES.			OP CODE		OP MOD.		5
IRCNT	USED FOR ALL REQUESTED FUNCTION CODES																6
IBUFF	USED FOR ALL REQUESTED FUNCTION CODES																7
[illegible]NT	USED FOR ALL REQUESTED FUNCTION CODES																8
IRCNTU	USED IF OP CODE IS 00 OR 01																9
IBUFFU	USED IF OP CODE IS 00 OR 01																10
ITIME	USED IF OP CODE IS 00 OR 01																11

Figure 7-1. IOB Configuration
IEC Handler

Words 0 through 4 are the same as the standard IOB configuration. Refer to Section 2 for detailed descriptions of these words.

Word 5 Status, Function Code. This word uses the following format:



All bit positions, with the exception of bits 9 and 8, are described in Section 2.

Bits 9 and 8. These bits can have two meanings, as follows:

1) Unresponsive operation. If an error has occurred (bit 14 set), bits 9 and 8 indicate what operation was being performed when the error occurred, as follows:

   01 while taking control of the IEEE interface
   10 while writing control
   11 while reading or writing data

2) Termination condition. For a read data operation, if bits 10 and 14 are zero, bits 9 and 8 indicate the reason for terminating the read data operation:

   00 END message detected
   10 Byte count reached zero (abnormal return)

   Bits 9 and 8 are zero when all other operations are terminated.

ne rmat of the IOB after the first six words is determined by bits 3-0 of word 5.

Format 1

Op Code (bits 3 and 2)	Op Modifier (bits 1 and 0)	Function
00	01	Write control and read data to END.
00	11	Same as 0001 with parity standardization
01	00	Write control and write data.
01	01	Write control and write data with END.
01	10	Write control only.
01	11	Write control and ignore data.

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
DATA REQUEST COUNT	6
DATA BUFFER ADDRESS	7
ACTUAL DATA TRANSFER COUNT	8
CONTROL REQUEST COUNT	9
CONTROL BUFFER ADDRESS	10
TIME LIMIT	11

ord   Data Request Count. This word is supplied by the user to specify the number of data bytes to be transferred. This word must not be zero.

ord 7   Data Buffer Address. This word is supplied by the user to specify the starting address of the data buffer. Note that this address is always a word address and that indirect addressing is not allowed.

ord 8   Actual Data Transfer Count. This word contains the number of data bytes transferred when the operation is completed. This word is returned by IOX at the completion of I/O.

Word 9 — Control Request Count. This word is supplied by the user to specify the number of control bytes to be transferred. No control bytes are transferred if this word is zero.

Word 10 — Control Buffer Address. This word is supplied by the user to specify the starting address of the control buffer. Note that this address is always a word address and that indirect addressing is not allowed.

Word 11 — Time Limit. This word is supplied by the user to specify the operation time limit. If negative, there is no time limit. If positive, a "device unresponsive" error will occur if the read or write operation has not completed within the number of clock ticks specified. If zero, the operation time limit will equal the number of data bytes (IOB Word 6) modified by the delay modification instruction stored into CIB word 20. (Refer to the SIO: description in Section 3).

Note that the specified number of clock ticks (word 11 positive) applies to data transfers only. The time limit for control transfers is always determined by the byte count and CIB word 20.

Format 2

Op Code (Bits 3 and 2)	Op Modifier (bits 1 and 0)	
10	00	Wait for SRQ

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
CLOCK TICKS	6
NOT USED	7
NOT USED	8

Word 6 — Clock Ticks. This word is supplied by the user to specify the number of clock ticks before SRQ is found. No time limit is applied if this word is negative. If positive, a "device unresponsive" error will occur if SRQ is not found within the number of clock ticks specified. This word may not be zero.

Words 7 and 8 are not used but must be provided.

Format 3

Op Code (bits 3 and 2)	Op Modifier (bits 1 and 0)	
11	00	Get IEC status
11	10	Get parallel poll response

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
NOT USED	6
NOT USED	7
BYTE REQUEST	8

rd 6 and 7 are not used but must be provided.

or 3 Byte Request. This word is returned to the user by IOX. It contains the requested byte (either status or parallel poll response). Figure 7-2 illustrates the IEC status byte configuration. The parallel poll response will be returned in the low order byte.

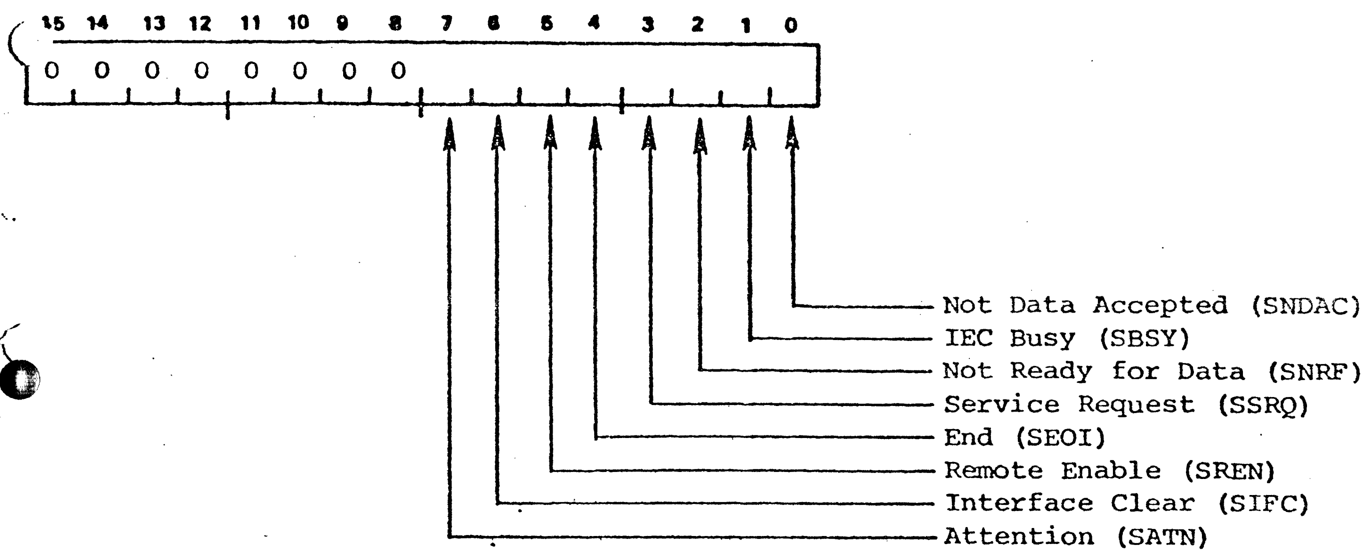


Figure 7-2. IEC Status Byte Configuration

Format 4

Op Code (bits 3 and 2)	Op Modifier (bits 1 and 0)	
11	01	Set IEC control lines

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
NEW CONTROL LINE VALUES	6
NOT USED	7
NOT USED	8

Word 6 New Control Line Values. This word is supplied by the user to specify the new value of the IEEE control lines. Only lines ATN, REN, IFC, EOI, and SRQ can be changed. A "Get IEC status" operation should be performed prior to a "Set IEC control lines" operation to ensure that the values of other lines are not changed inadvertently. Figure 7-3 illustrates the IEC Set Mode Command Word Format.

Words 7 and 8 are not used but must be provided.

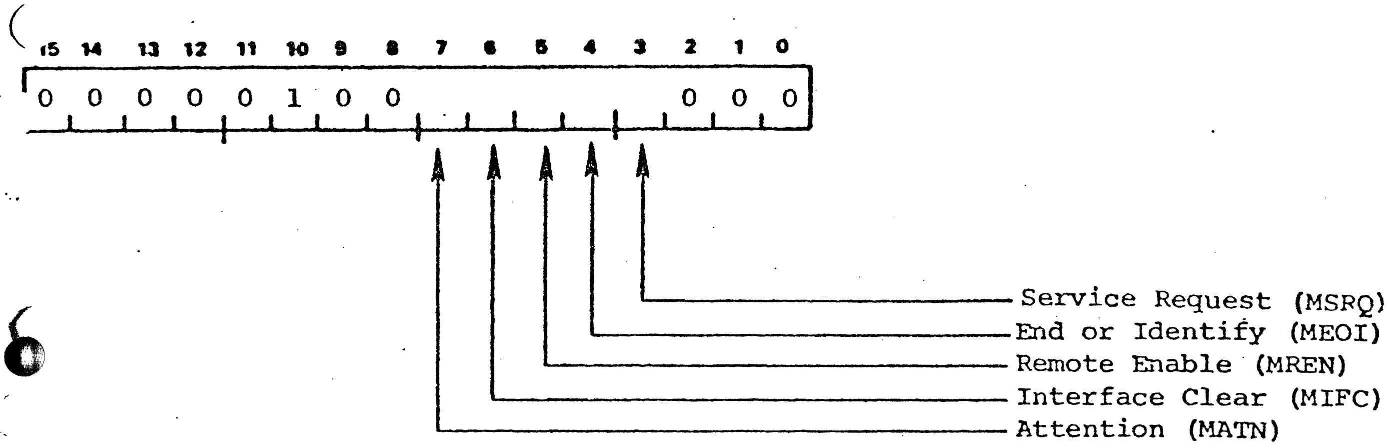


Figure 7-3. IEC Set Mode Command Word Format

The following function codes are undefined:

Op Code	Op Modifier
00	00
00	10
10	10
10	11
11	10

7.1.2 IEC DIB Configuration -- 11 words

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	word
REGULAR DIB CONFIGURATION	0 … 6
0	7
0	8
0	9
0	10

Words 0-6 correspond to the regular DIB configuration described in Section 4. Words 7-10 are zeros.

7.1.3 IEC CIB Configuration -- 34 words

Figure 7-4 illustrates the IEC Controller Information Block.

IEC CONTROLLER INFORMATION BLOCK

Name	15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	Word
CBOR	TC FOR IE:SIO--BEGINNING OF RECORD FLAG	0
CSEL7	TC FOR IE:SIO--SEL DA,7	1
	JST INTQ:	2
	DATA $ CALLING LOC	3
CTMP1	DATA 0 TEMP 1	4
CTMP2	DATA 0 TEMP 2	5
CTMP3	DATA 0 TEMP 3	6
CEBTSK	DATA INTP: TASK ADDRESS	7
	DATA 8180 PRIORITY	8
CNEWA	DATA 0	9
CNEWX	DATA $-10	10
	DATA $-11	11
CAIDL	CURRENT PICO IDLE STATE--INITIALIZE TO 0	12
CDOG	WATCHDOG FLAG FOR IE:SIO	13
REQCNT	TC	14
CJTBL	DATA IECR:	15
	DATA IECW:	16
	DATA 0	17
	DATA IECF:	18
CSPLOP	DATA 0	19
CDEL	TC FOR IE:SIO--WATCHDOG TIMER INSTR. (NOP)	20
CINTR	TC FOR IE:SIO--IEC WORD INTERRUPT ADDR.	21
CADDLY	TC FOR IOX--TIME DELAY FROM IOB	22
CSTPCH	TC FOR IOX--STOP CHARACTER	23
CIOB	TC FOR IOX--IOB ADDR.	24
COP	TC FOR IOX SCHED--OP CODE AND STATUS (IOB wd 5)	25
CRCNT	TC FOR IOX SCHED--REQUESTED DATA COUNT (IOB wd 6)	26
CBUFF	TC FOR IOX SCHED--DATA BUFFER ADDR (IOB wd 7)	27
CTCNT	TC FOR IOX--ACTUAL DATA BYTE COUNT (IOB wd 8)	28
CRCNTU	TC FOR IOX SCHED--REQUESTED CONTROL COUNT (IOB wd 9)	29
CDIB	TC FOR IOX SCHED--DIB ADDR AND BUSY FLAG	30
CBUFFU	TC FOR IOX SCHED--CONTROL BUFFER ADDR (IOB wd 10)	31
STATUS	TC FOR EOR:--STATUS	32
CRTN	TC FOR IE:SIO--RETURN ADDRESS	33

NOTE:
TC = Temp Cell

Figure 7-4. IEC CIB Configuration

7.1.4 IEC Device-Dependent Considerations

Write Control and Read Data to END (0001)	The contents of the control buffer (IOB word 10) are sent with the source handshake while ATN is true. The control buffer will usually contain interface commands which address a peripheral as the talker. The IEC then initiates the acceptor handshake. The peripheral will transmit data when ATN is false. The IEC receives data until an END message was received with a byte or the Auto I/O byte count reached zero. The handler will set bits 9 and 8 of IOB word 5 to the appropriate termination condition. The number of bytes transferred is returned to IOB word 6. A read data to END only operation is performed by issuing requested function code 0001 with the control request count (IOB word 9) equal to zero.
Write Control and Read Data to END with Parity Standardization (0011)	This function is the same as function code 0001; during input, however, the I/O Distributor performs parity standardization on all data bytes.
Write Control and Write Data (0100)	The control buffer is transmitted using the source handshake while ATN is true. The control bytes will generally address a peripheral to accept device programming. ATN is driven false following termination of the control sequence, and the data buffer is transmitted using the source handshake. A write data only operation is performed by issuing requested function code 0100 with the control request count (IOB word 9) equal to zero.
Write Control and Write Data with END (0101)	This operation is the same as function code 0100 except that the last byte of data is sent with the EOI control line true, indicating an END message. A write data with END only operation is performed by issuing function code 0101 with the control request count (IOB word 9) equal to zero.
Write Control Only (0110)	The control buffer is transmitted using the source handshake while ATN is true. The data request count (IOB word 6) must not be set to zero. The IEC will maintain control of the IEEE interface after the transfer by setting NRFD true.

Write Control and Ignore Data (0111)	The control buffer is transmitted using the source handshake while ATN is true. ATN is driven false and remains false following termination of the control sequence. Peripheral to peripheral data transfers may occur with the IEC in this state. Any read or write request following this function will be prefaced with a Take Control Synchronously operation so the IEC will regain control of the IEEE interface.
Wait for SRQ (1000)	The IEC is instructed to wait until the IEEE control line SRQ is found true. The handler will return immediately if SRQ is true when the request is made.
Get IEC Status (1100)	The IEC status is returned to IOB word 8.
Set IEC Control Lines (1101)	IEEE control lines ATN, REN, IFC, EOI, and SRQ assume the values contained in IOB word 6. This function allows the transmission of interface messages which involve these control lines, such as "interface clear" and "remote enable". Note that the handler changes the values of all these lines when performing other operations.
Get Parallel Poll Response (1110)	An IDY remote message is sent for parallel polling. When the IEC is ready, the handler returns the result of the parallel poll to IOB word 8.
All Other Function Codes	No I/O

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Original

VERTEILER	
Bpmann-Leer	
Duehr	
Emr...	
Kosch	
Martens	X
Sievers	
Uitz	
Ulbrich	X
Vorbeck	
...	X

SUBJECT: THE RTX SCHEDULER

In a typical application system based on LSI-Series computers, several independent external activities must be processed in the same time frame (for instance, a system may perform a test operation while the line printer is printing the results of the previous test, and the teletype is inputting parameters for the next test).

This implies that the system will be able to recognize events (probably via interrupts) and schedule appropriate service activities to process the events in a timely fashion. Generally, the most effective mechanism to accomplish this recognition and scheduling process is the Real-Time Executive (RTX). TAB/DB104 (TRN 93300-03-01-XX) discusses the recognition process and the insertion of new activities into the stream of ongoing activities (via INTQ:). This TAB discusses the actual scheduling mechanism,SCHED:.

The function of SCHED: can be described quite simply: If there are no activities to be performed, wait until there is one; if there are, merge the list of new activities (created by INTQ:) into the list of ongoing activities, according to priority,and cause the highest priority activity to be executed.

The term "activity" is nebulous, describing a whole class of "things to be processed," including interrupt service subroutines, Auto I/O, DMA, and tasks. The term "task" is much more definable, and in the context of RTX means precisely: "A program or set of programs which operates to perform a specific function within the Real-Time application."

A discussion of the difference between the two terms will clarify the operation of the system. When a user starts the execution of a task (by a call to BEGIN: or INTQ:), he is starting one or more activities, depending on the operation of the task.

For example:

1. A task is currently executing--this is one activity. Somewhere along the line an interrupt occurs, and the execution of the activities required to service the interrupt temporarily suspends the current task--and terminates the current activity. When the task is resumed, it will still be the same task, but of course, it is now a different activity.

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THE RTX SCHEDULER (continued)

2. A task--one activity--calls DELAY:, suspending the task, and terminating the activity. There is still an activity associated with the task though--the "active" delay.

Some activities such as an interrupt service subroutine, occur without intervention by RTX. Other activities, like those described above, must each be regarded by RTX as an entity, and kept track of in some manner.

The RTX work area contains a user-defined number of 5-word blocks (see section 2 of the RTX User's Manual). One of these blocks is used to record each activity known to the system. The table in the RTX manual shows the number of work area blocks allocated for each call for RTX service. This number is also the net gain or loss in number of activities in the system.

The user's initial call to RTX: causes his defined work area to be broken up into 5-word blocks. Each of these blocks contains, in the first word (word Ø), a pointer to the next block, thus forming a "linked list" of available blocks-- the FREE list. A pointer to the first of these available blocks is maintained at the location called FREE (at 7RF--see section 4 of the RTX User's Manual). One of these blocks is immediately allocated to contain information about the current activity-- the initialization task. (This block is placed at the top of the READY list, see below.)

Besides the FREE list, RTX maintains a number of other lists. This TAB is concerned with only two of them, the READY list and the FIFO list. The READY list (ØRF) contains blocks, linked in priority order, describing activities that are "ready" for service by the processor. The first of these (the "top" block) is the activity currently being processed, and is always the highest priority activity on the list. If there are no blocks on the READY list, this implies that--as far as RTX is concerned--the processor is idle (actually it is always doing something--note the "wait loop" in the attached flow chart).

Since these lists are linked, they must be maintained carefully. If an RTX service routine were in the process of changing the links in one of these lists, and an interrupt ocurred, the interrupt service activities could try to use the same list, which would be a disaster.

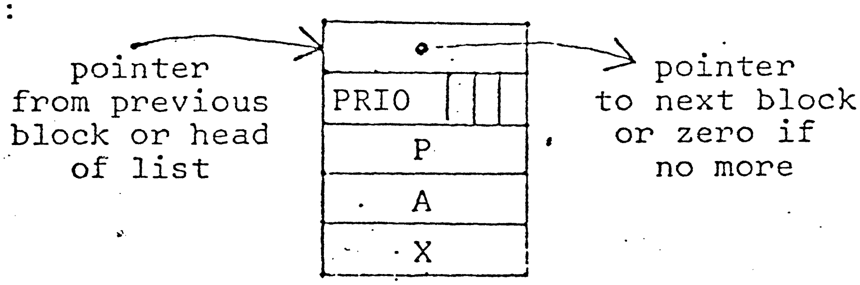
It is the responsibility of INTQ: to prevent this from happening. This imposes two requirements: if an RTX

THE RTX SCHEDULER (continued)

service routine is interrupted, it must be completed before any further service is performed; and INTQ: must not alter the linkage in any list that is also altered in a routine that may have been interrupted.

Therefore, a special list is used for the "handshake" between INTQ: and SCHED:-- the FIFO list (1RF, the name means nothing). This list is maintained very carefully. INTQ: puts any new activities to be queued at the top of this list, and SCHED: carefully removes these, one at a time, and places them in the READY list in priority order. Once all of these have been placed, the scheduler is ready to set up the highest priority activity to be processed. (Once it has done this, it must check the FIFO list once more to see if an interrupt ocurred during the scheduling process.)

Each of the blocks on the READY and FIFO lists has the following format:



Where:

PRIO	is the priority of the activity (exclusive or'd with :1000 and shifted left three bits). Bit 2 of this word contains EIN indicator from processor status--always enabled. Bit 1 contains the byte/word indicator. Bit Ø contains the OV indicator.
P	is the contents of the program counter for the activity (i.e., where it is to be entered).
A	is the A register contents for the activity.
X	is the X register contents for the activity.

Let's go through an example of the operation of the scheduler. The system is initialized by the following call:

```
WKAREA RES   25,Ø      Reserve 5 five-word blocks
MAIN   JST   RTX:      Initialize RTX
       DATA  5         ... using 5 blocks
       DATA  WKAREA    ... allocated here
       HLT             Return to here if
                         1)we run out of blocks, or
                         2)an RTX service other than INTQ:
                           is called when
```

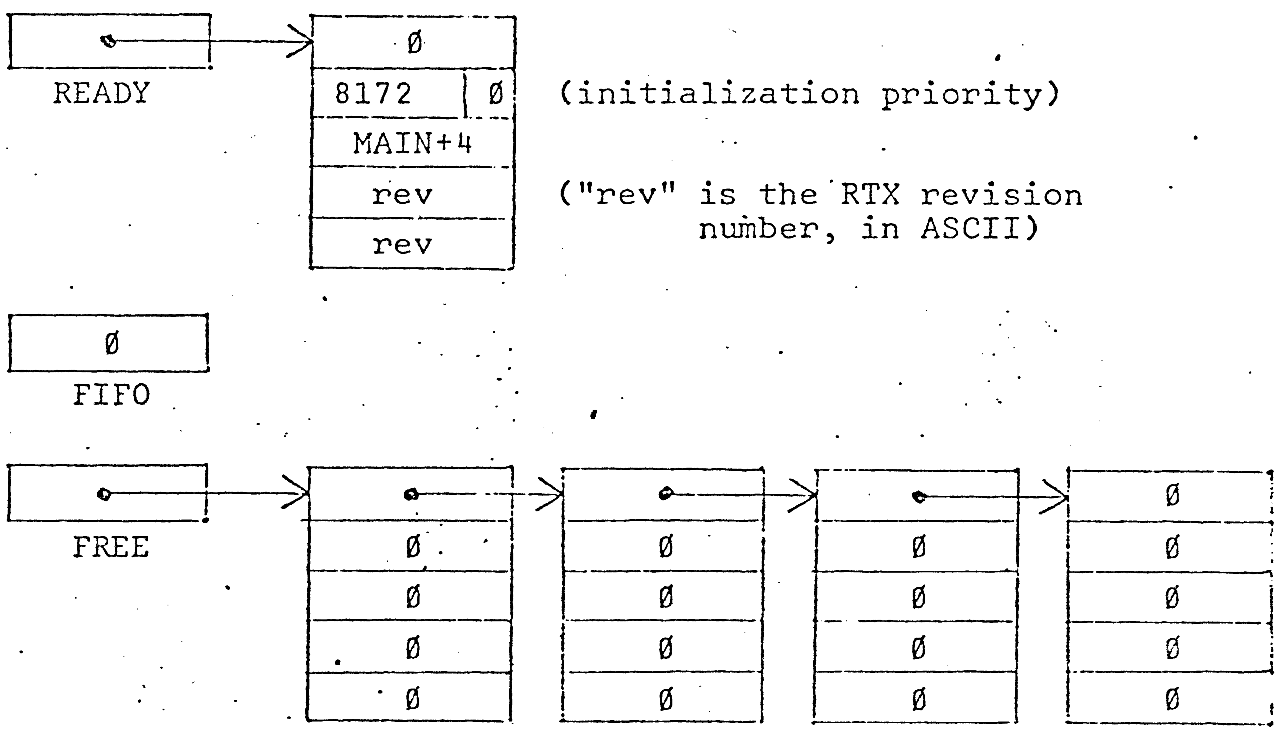
THE RTX SCHEDULER (continued)

there is no current activity
at the top of the READY
list.

⋮

Return to here to continue
initialization

After completion of this call, the work area has the following contents:

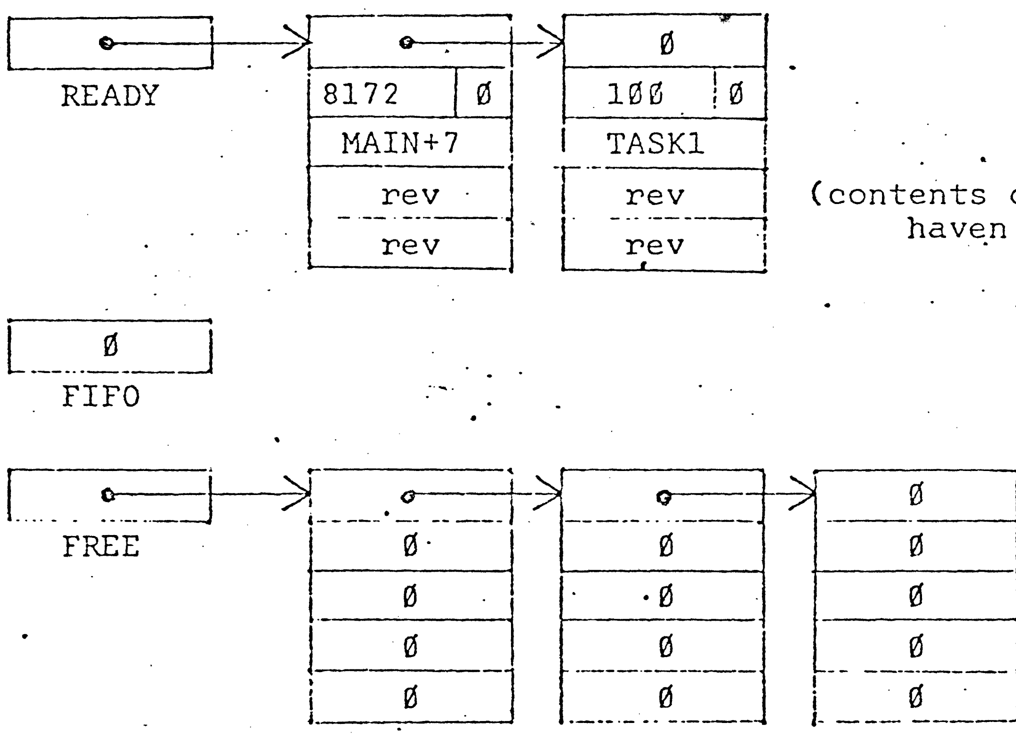


THE RTX SCHEDULER (continued)

Now suppose the next thing in the initialization task, (at MAIN +4) is the following call to BEGIN:

```
        :
        JST     BEGIN:   Queue a task
        DATA    TASK1    ... to be entered here
        DATA    1ØØ      ... at this priority
        :                ... and return to here
```

After completion of this call, the work area has the following contents:



(contents of A & X haven't changed)

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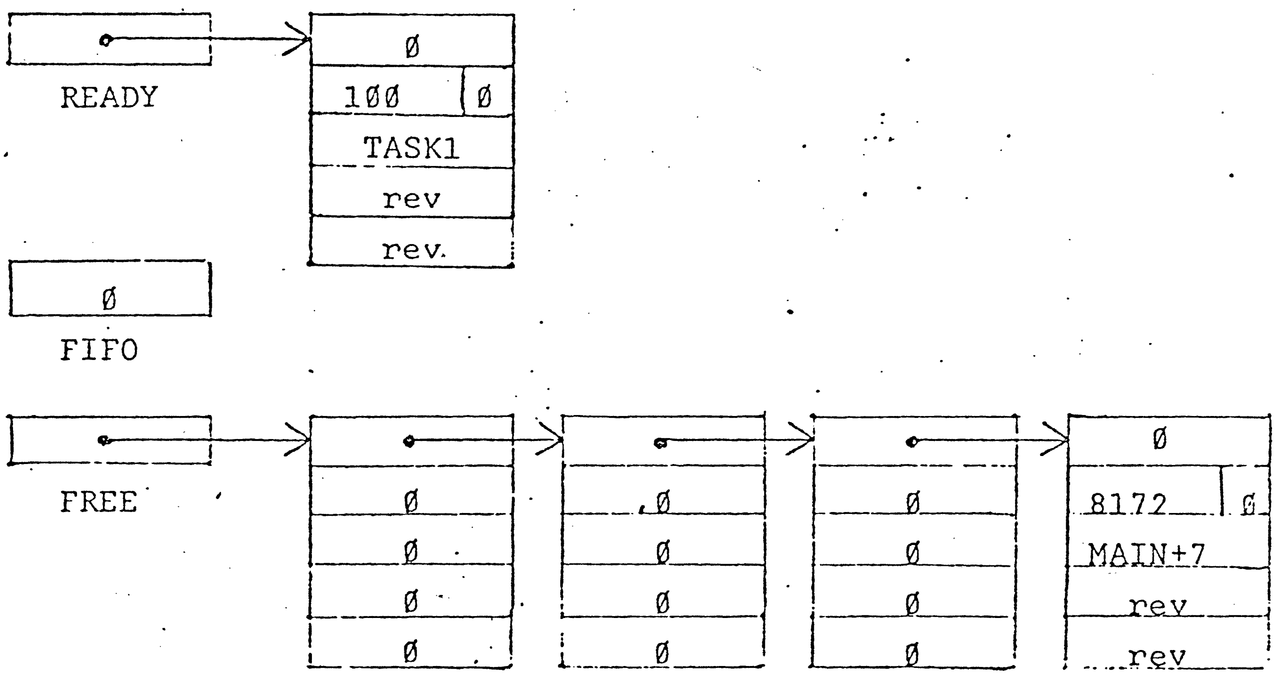
The highest priority activity on the READY list is still the initialization task. Next (at MAIN +7) it does:

```
        JST  END:    Terminate initialization
```

The work area now looks like this:



Note that TASK1 is now the highest priority activity, and will be executed next. Note also that blocks are returned to the <u>end</u> of the FREE list to allow the user to examine the history of the system if something goes wrong.

Therefore, we will begin executing at TASK1. Now suppose, for purposes of illustration, that the application program has a service subroutine for the console interrupt as follows:

```
        ABS  CONINT    interrupt location for console int
        JST  *$+1      call service subroutine
        DATA CONIS     at this location
        REL  Ø         relocatable portion
  CONIS ENT            save P here
        CID            turn off interrupt or switch bounces
        JST  INTQ:     call INTQ:
        DATA $,Ø,Ø,Ø   ...see TAB DB/104
        DATA CONTSK,200
                       queue this activity at prio 200
```

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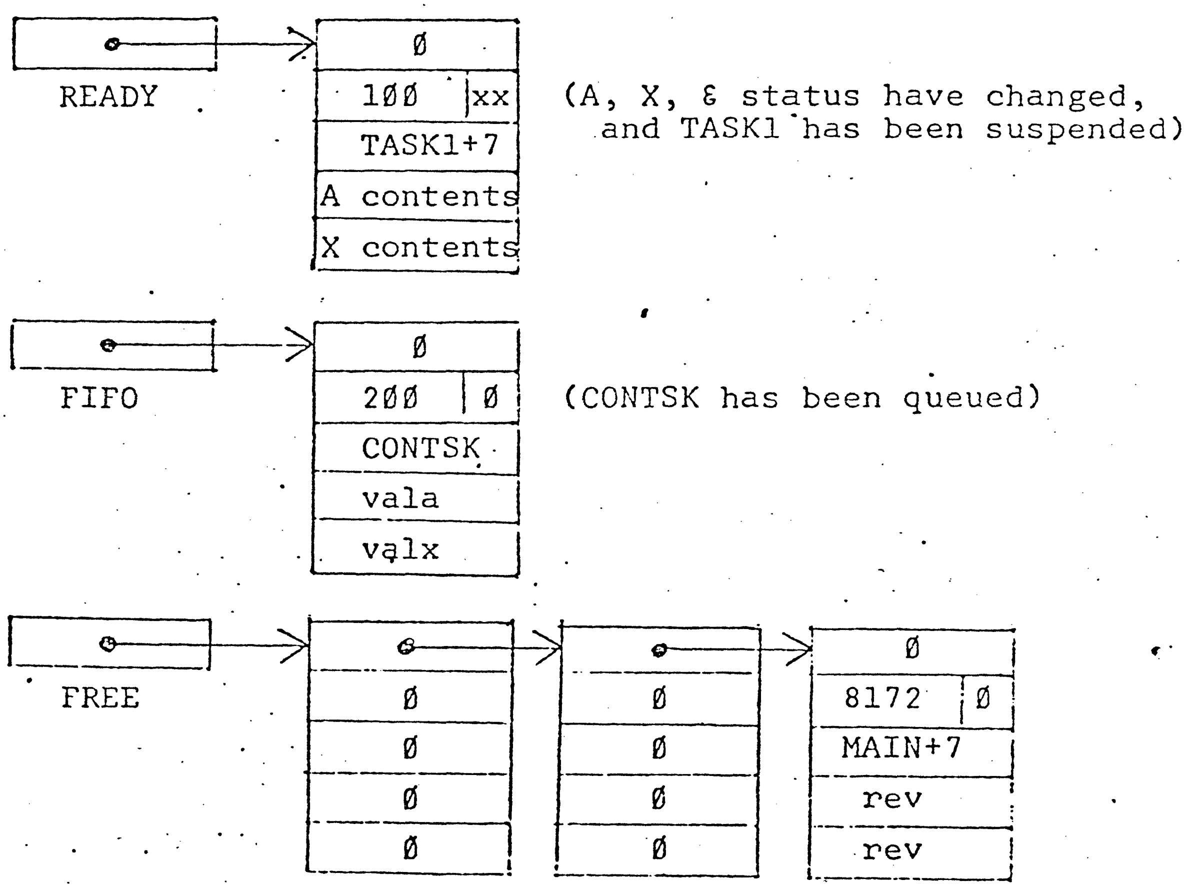
```
                DATA vala,valx  ...pass these values in A & X
                DATA CONIS      ...address of entry point
```

Now suppose that after seven instructions of TASK1, someone pushes the console interrupt switch. The interrupt service subroutine above will run, and call INTQ:, which will suspend the current activity (at TASK1 +7) and queue the console service task.

When INTQ: calls the scheduler, the work area looks like this:



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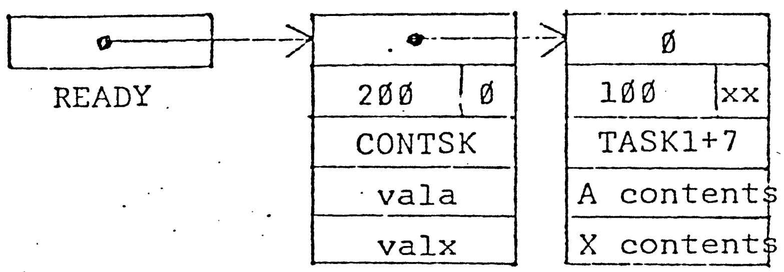
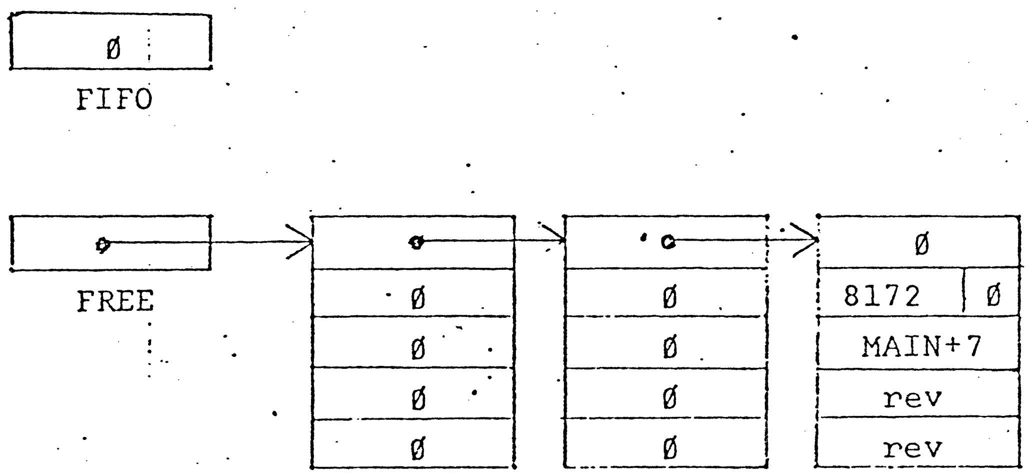
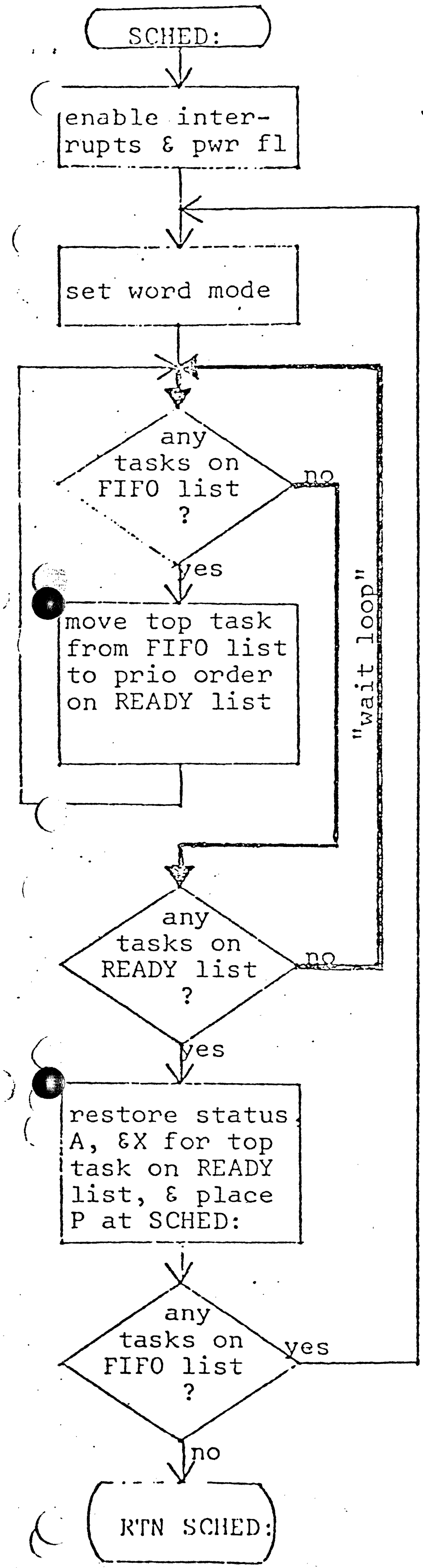
The scheduler will now merge the FIFO list into the ready list, leaving the work area as follows:



(the new task, CONTSK, is higher in priority than TASK1)



Now there are two activities on the READY list. The higher priority of the two, CONTSK, will be executed first. The other activity, TASK1 +7, will be executed when CONTSK suspends or terminates (unless something else of a higher priority comes in first).



flow of SCHED:
RTX task
scheduling
routine

KUNDENINFORMATION

CIB NO 1128 a   Real Time Executive (RTX) Version F2

Mit dieser Information erhalten Sie die neue Version F2 von RTX. Es enthält einen RTX Basis File Manager für die Handhabung von Files im Standard Computer Automation OS File Format (siehe Section 5) und ein RTX File Label Utility.

Der File Manager, eingegliedert im IOX, enthält eine Directory und File Verwaltung für sequentielle oder random disc storage devices, welche dem Anwenderprogramm erlauben, mit Hilfe von Namen mit Daten Files zu korrespondieren.

Zusätzlich enthält der File Manager ein automatisches Blocken und Nichtblocken von Datensätzen mit Zugriff in Speicherreihenfolge.

Das RTX Label Utility ist ein binäres "stand-alone" Programm zum Labeln von dateiorientierten Geräten. Das Labeln mit diesen Utility ist compartibel zum Computer Automation OS Datei Format.

Folgende Dokumentation und Lochstreifen sind beigefügt:

Dokumentation : RTX Users Manual Version F2

Lochstreifen : LSI 2 RTX/IOX Sequent 1 & 2
93300 - 30 F2 / 31 F2
LSI 2 RTX File Label Utility
93324 - 40 A1
LSI - 2 RTX Demo
93300 - 33 E1

Technischer Support
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