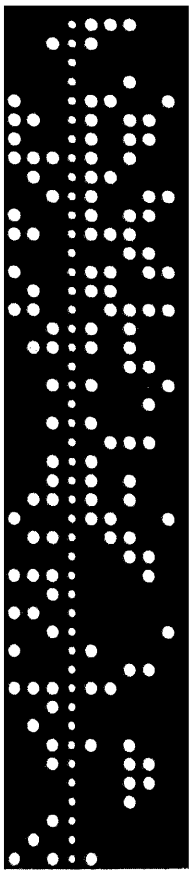
HEWLETT PACKARD

COMPUTER MAINTENANCE COURSE



VOLUME XVIII

HP 2000A TIME SHARE SYSTEM

HEWLETT-PACKARD

COMPUTER MAINTENANCE COURSE

VOLUME XVIII

STUDENTS MANUAL

HP 2000A TIME SHARE SYSTEM

(HP STOCK NO. 5951-1346)

-NOTICE-

The information contained in this manual is for training purposes only. Consult the Hewlett-Packard documentation supplied with the computer for current information concerning the specific computer system furnished.

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FORWARD

This manual has been prepared by the Cupertino Division Maintenance Training Group. It is intended to serve as an introduction to the HP 2000A Time Share System. It is hoped that the manual will serve the needs of system operators and Service Technicians.

This manual was written to help introduce the student to the Time Share Listing, and the Internal Software Reference Specifications. All specific references to the listing are to the 2000A Version "F". Other versions can also be used, although slight differences in page numbers and memory addresses will be experienced. These previous versions have been corrected and improved. Version F represents the up-to-date system and it should be in use by all installations. This manual is written from the standpoint of the functional system, with hardware emphasis. It does not go into detail on the interpreter or software technique.

It is hoped that this manual will take the hardware strengths of the service technician, and build upon that to provide the technician with an appreciation of the Time Share operating environment. The material is written under the assumption that the computer technician has completed the Basic Maintenance and the Advanced Options Maintenance Training courses. In order to effectively use the listings, it is essential that the reader be familiar with the machine language as well as the Assembler.

A system operator without adequate training on the hardware and programming may find some chapters difficult.

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CHAPTER 1
COMPUTER TIME SHARE

1-1 INTRODUCTION

The computer has become an integral part of our lives. To the uninitiated, it has almost magical qualities. To a child, the computer seems to have an answer to any question. Often to a service technician with no prior computer experience the computer may be an awesome beast. Actually it can do a certain limited repertoire of instructions rapidly and reliably. Let's look at some of the capabilities to gain an appreciation of the computer environment.

The computer is the center of an operating system with two primary interfaces. One interface is to the physical world. This includes transducer inputs measuring voltage, temperature, strain, and other physical quantities. It can then control certain aspects of the environment. It does this by controlling voltage, switch closures, motor velocity, mechanical positions and other physical quantities. Some of these applications include data acquisition and process control. Figure 1 shows a representation of this generalized computer system.

The other primary interface is with man. Man has vast capabilities for memory, intelligent and rational thought, and decision making. Our communications channels with the computer are somewhat limited however. Visual display and printer output are the primary links used in computer to man output. The man to computer input is chiefly a manual operation via the keyboard or punched cards. What is the nature of common computer applications? These are discussed in following paragraphs. As we review these it will help in understanding the time share environment.

Throughout the book, we use the word system. It refers to an operating module requiring both hardware and software. Thus the Time Share system is not so much the equipment which must be purchased, or the paper tapes and listing as it is the personality of the operating environment. To the user, it is the program solution and error messages and response time. To the operator it may be the sleep tapes, the Log on–Log off messages, and status reports. To the service technician it may be the symptoms used to troubleshoot a fault.

1-2 SMALL SCIENTIFIC SYSTEMS

The small scientific systems are used chiefly to solve mathematical or engineering type problems. The programmer or engineer may set up mathematical models which can represent the physical or theoretical system under study. A language such as Fortran can be used to describe the problem and provide solutions. The computer is used to provide the manipulation, iteration, and data output. As such, it can be considered an extension of the human capability because of its speed, program, and data storage capabilities.

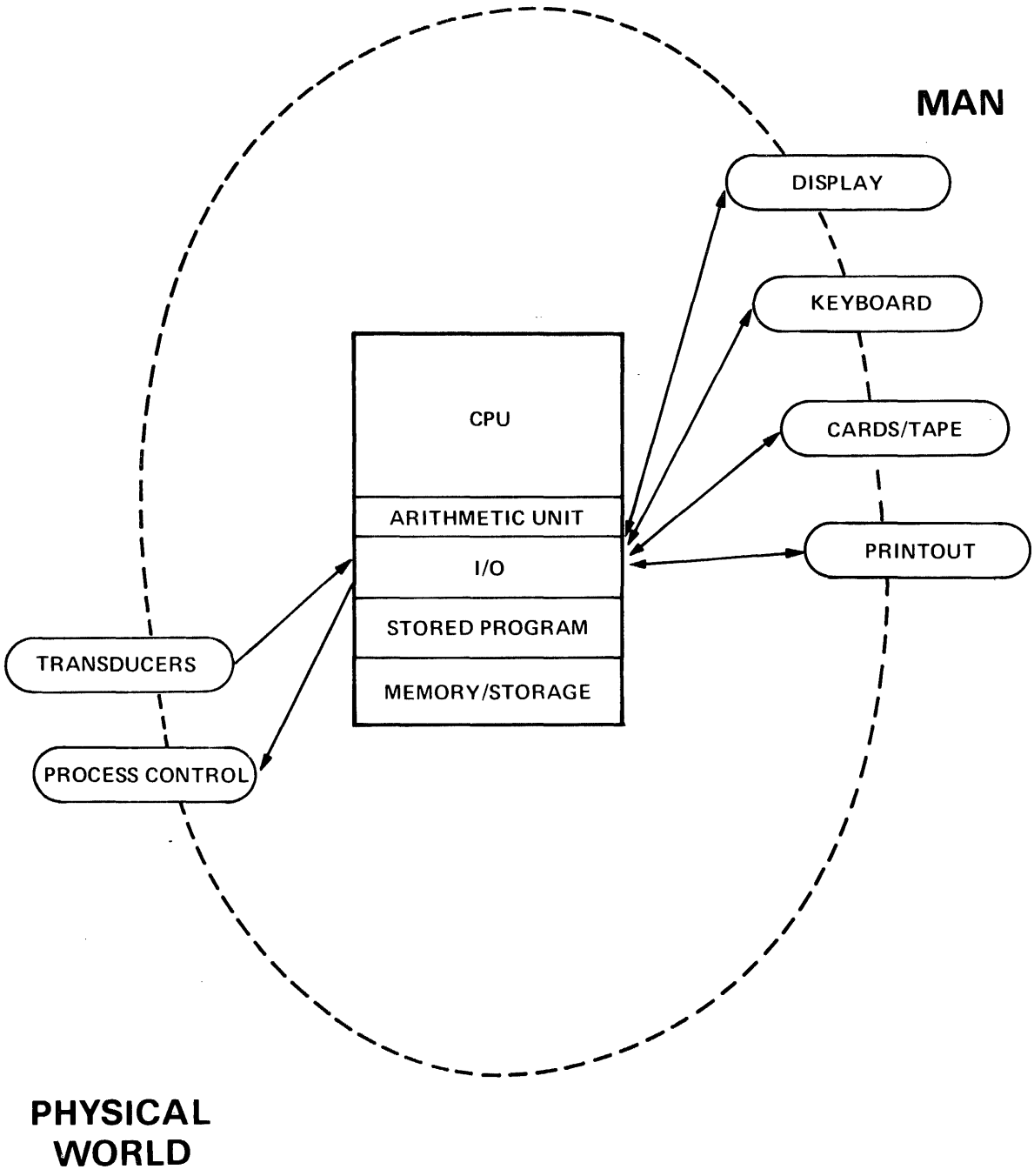


FIGURE 1. GENERALIZED COMPUTER SYSTEM

Inputs for this type of service include manual input on a keyboard, punched cards or tape. These can be on-line or off-line depending on the speed or convenience desired, and the operating system available. If tables or data are required, they may be provided on mag tape, disc or other suitable means.

Since the computer is a binary device with a very limited vocabulary - and is difficult to interface with directly, an operating system is usually provided. This is an optimized software-hardware system. The stored program modifies the apparent interface, making it easier for man to input or interpret information. Many operating systems and/or languages have been developed to facilitate the interaction with man.

Certain problems occur frequently. Operating systems have been designed specifically with these requirements in mind. They include: Disc Operating Systems, Mag Tape Operating Systems, "Batch Mode" systems, and Time Share Systems.

1-3 OTHER MINI-COMPUTER APPLICATIONS

To complete the discussion, we should also consider other applications utilizing mini-computers. Some are used as data concentrators. These computers interface with a data channel by performing some preliminary processing which improve the effectiveness and decrease the cost of the data line. Sometimes the computer is dedicated to a specific task, such as the controller of a test stand. A Fourier Analyser is another example of a dedicated computer. It receives physical input in the form of time and magnitude while performing mathematical operations and provides a frequency and magnitude output. Other applications include Fire Control applications, traffic control, high speed transportation controllers, ticket booking services, etc. The reader can undoubtedly add many other applications from his own experience.

1-4 TIME SHARING

A certain class of computer applications has arisen enough to warrant designing a special operating system and a special language. The language is BASIC. The operating system varies with the manufacturer and his hardware capability. The requirements are characterized by small data base requirements and straight forward computational requirements. In the generalized computer system diagram, figure 1, the interface is typically a keyboard for both input and output.

Under these circumstances, the computer (Central Processor Unit) has a great deal of spare time when servicing a single user. The operating system allows multiple users access to the system in a quasi-simultaneous manner; hence, the name Time Share.

Time Sharing systems run the gamut from the small dedicated single language systems like the HP 2000 family right up to the largest multilanguage-multiprocessor systems. The system cost ranges from under $100,000 to well above $10 million.

1-5 INTERPRETER

Perhaps we should say a word about the Interpreter. A compiler translates symbols meaningful to the programmer into machine language code. Fortran or Cobal are examples of common compiler languages. In both cases, machine language code is generated in absolute or relocatable code, and the program is run. An Interpreter takes the symbolic statements one at a time, executing them in the proper order – but without generating any machine language program code.

The BASIC on-line interpreter checks for syntactical errors, wrong data type, missing delimiters and other common type errors. It provides error messages immediately. This allows the user to correct the program statements and try again. The on-line error messages and immediate correction feature provides a real benefit for the writing and debugging of a program.

The interpreter converts the program statements to a compiled format. This is a more efficient coding or symbolic representation for the program statements. The system makes use of this as well as syntax stacks, pointers and linkages. But this is not machine code, and the computer does not execute these statements in the normal machine language sense.

1-6 BASIC LANGUAGE

The HP 2000 family makes use of the "BASIC" language. This is a powerful conversational language using English words and common mathematical symbols. Basic stands for Beginners All-purpose Symbolic Instruction Code. It was developed at Dartmouth University in 1964 under the direction of Professors J. G. Kemeny and T. E. Kurtz.

Its simplicity along with the use of common English words and its free form input makes it easy to learn and use. Yet the strings, files, and matrix capability makes it powerful and effective.

The on-line feature provides error diagnostic messages both at program writing time and at Run time. This certainly assists the beginning programmer in learning and using the BASIC language. Although the language is easy to use, it does provide a powerful programming capability. The manual "A Guide to Time Shared Basic", HP Stock Number 02000-90002, is useful both as a reference and for self instruction.

An extensive library of programs is available for the HP 2000 Time Share Systems. These include applications in business and finance, engineering and scientific, mathematics, statistical analysis, educational, utility, and demonstrations and games.

An example of the usefulness and flexibility of the language is the Computer Aided Instruction (CAI) programs. One is the HP mathematics drill and practice program. It provides a six year program for grades one to six. In addition to the actual students drill material, it provides various teachers reports. These include students progress, new concepts in the next lesson block, and unusual circumstances such as low grades, skipping or review lessons. Another significant application is the Accounting package for small businesses.

1-7 RESPONSE TIME

One of the primary limitations of many computer systems is the speed of the I/O devices. In Time Share applications, the most common terminal used is the teleprinter. Its maximum speed is 10 characters per second. This data speed is compatible with a voice quality telephone line. It is not much of a challenge to the CPU, however. The system accepts input data from all teleprinters. At the end of each input line, an individual user is given high priority. The system determines the nature of the input and services it rapidly. This enables the user to continue with his next line and the system appears quite responsive.

In output operation, the system fills an output buffer for the user. It continues to process all outputs through the multiplexor routine. If the system fills an output buffer and cannot continue the user goes into output suspend. The multiplexor routine requires very little additional processor time and keeps a steady output to all users. When the buffer gets low the system again schedules the user and resumes his program. With this technique, the user receives a fairly steady output rate, and still the processor can service other users too.

The system achieves this responsive nature by establishing the priority for tasks. The maximum time slice allowed for any user when others are queued up awaiting service is 1.0 second. A user who had used up his maximum time period and had not completed his program would then be placed at the bottom of the queue.

Every 0.1 second, the system scans all inputs to determine whether some one had completed a line and was awaiting service. Priority is established to optimize reaction time. Highest priority is given to syntax lines, user requeued after I/O suspend, and then continuing programs during the time allowed. Next the core resident programs called by the system (SCRatch, TAPe and KEY) and called by BASIC (RUN, LISt and PUNch). The Disc resident programs including those called by a user and those called by the system operator are assigned the third priority. The lowest priority is assigned for the users who have expended their time allocation without completing their program.

The result of assigning priorities in this manner is a system that responds to a user very rapidly. In most situations, a user will not notice the delays. Typical delays for syntax lines are in the order of one second or less.

The largest delays are experienced when all terminals are being used for CAI exercises. In this case, everyone is executing a program. A significant number of input suspensions occur. These tend to speed up the system since each user does not require his full time allocation at one second. The nature of the exercise has a lot to do with the delays experienced. Delays of two to four seconds are common. Occasionally substantially longer delays may be encountered.

The remainder of this book will deal with the HP 2000A Time Share system. We are particularly interested in the hardware and in those aspects of the software system that affect system operation and maintenance.

equipment

CHAPTER 2
EQUIPMENT

The 2000A Time Share system requires a wide range of equipment and options. Some are required, others are optional. Even in the required list, certain substitutions can be made.

2-1 MINIMUM CONFIGURATION

The minimum hardware configuration for the HP 2000A system is shown in Table 1. The slot for all CPU options is fixed. The I/O slot for these minimum configuration peripherals is also fixed. The slot designators for Table 1 correspond to the 2116B computer. Figure 3 shows the specific locations in the 2116C computer.

This minimum configuration shows the 2773A Drum. Actually any Disc or Drum from TAble 3 would be satisfactory.

It is expected that the reader is familiar with the equipment used in the HP 2000A. And further, that he has available the instrument manuals. We need not describe their general function and purpose. There is more detailed information on the multiplexor hardware in Chapter 4.

The next three sections deal with the positions of the switches in the HP 2000A. Their positions are important. The instrument manuals describe the individual function but do not indicate the required position for a particular operating system.

2-2 SWITCH, POWER FAIL

The Power Fail board has a switch which defeats the automatic restart feature. This switch must be up to allow restart. If the switch is down and the computer experiences a momentary power failure, a halt $\emptyset$ at P=31141 will be experienced. When power is restored, the computer may come up at some random address. If the switch is raised to the up position, it will restart.

When the switch is up and a momentary power failure is experienced, the interrupt to the power fail routine stores away the necessary information and halts the computer. When power is restored, the switch in up position allows an interrupt to take place. This time the flag indicates power is coming up and the "restart" portion of the routine is called. This restores the registers, initializes the Time Base Generator, restores the condition of the interrupt, synchronizes the multiplexors, and then returns to the P register location at the time of the initial power fail interrupt.

2-3 SWITCH, PARITY

The Parity check board has a switch that forces an immediate halt when up, or allows an interrupt to the trap cell if down whenever a parity error occurs. The immediate halt is caused by PEH signal clearing the RUN 1 flip flop. The Parity Error light on the front panel will be illuminated indicating the parity error condition. An interrupt mode exists with the switch down. A parity error occurring during a DMA transfer (core to disc) will be ignored. Because of this limitation it is essential that the switch on the Parity board be up in halt mode.

2-4 SWITCH, DISC

The Disc interface has a track protect switch. This allows read only operation from the protected tracks. The switch is located on the Data board. This switch must be down in unprotected position for the Time Share system allowing read/write capability on all tracks.

The protected tracks always include track zero (additional tracks are protected by removing additional diodes). The Time Share system must have access to track zero so the switch must be down.

TABLE 1
2000A MINIMUM HARDWARE CONFIGURATION

HARDWARE GROUP	MODEL NUMBER	NAME	BOARD STK.NO.	COMMENTS	2116B LOCATION
CPU	2116B-05	16K MEMORY			
	12588A	PWR FAIL	12588-6001	(SWITCH UP)	A1
	12591A	PARITY ERROR	12591-6001	(SWITCH UP)	A3
	12579A	EAU	02116-6196	TIMING	A109
			02116-6202	LOGIC	A110
	12578A	DMA	02116-6206	DMA REG.	A116,117
			02116-6205	ADDR ENCODER	A118
			02116-6204	DMA CONTROL	A119
			02116-6203	CHAR. PACKER	A120
PERIPHERALS	12584A-01	MULTIPLEXOR	12584-6001		A203 SC10
	2754B	TELEPRINTER	12531-6001		A204 SC11
	12539A	TIME B.GEN.	02116-6119		A205 SC12
	2748A	READER	12597-6001		A206 SC13
	2773A	DRUM	12610-6001	DATA (SWITCH DOWN)	A207 SC14
			12610-6002	COMMAND	A208 SC15
OTHER	2776A	DRUM POWER SUPPLY			
	2160A	POWER SUPPLY EXTENDER			
	2992Z	2 BAY CABINET			

TABLE 2

2000A OPTIONAL HARDWARE

DESCRIPTION	MODEL	INTERFACE	
Mag Tape	HP 3030G	12559A	(60K Char/Sec)
	HP 7970A-200	13181A-001	(20K Char/Sec)
	HP 7970A-202	13181A	(30K Char/Sec)
Telephone-Auto Disconnect	12584B-001		
Keyboard-Display Terminal	2600A	None required	
DISC/DRUM			
Drum (393,216 words)	2773A*	12610B	48 tracks/128 sectors
(786,432 words)	2774A		96 tracks/128 sectors
(1,572,864 words)	2775A		192 tracks/128 sectors
Disc (1,048,576 words)	2776A-004**	12610B	128 tracks/128 sectors
(786,432 words)	2776A-003		96 tracks/128 sectors
(524,288 words)	2776A-002		64 tracks/128 sectors

*HP 2776A Power Supply

**HP 2772A Power Supply

2-5 OPTIONAL HARDWARE

Table 2 shows the optional hardware available for the 2000A System. Three different mag tape units are available. The interface requires two adjacent I/O slots. These can be located in any slots starting at SC16 (A209). The Mag Tape command tells the system which unit is being used (i.e. MAG TAPE-22* indicates the 13181A Controller for 7970 because of the asterisk following the Select Code. Mag Tape-22 indicates the 12559A controller for the 3030.)

The Telephone Auto Disconnect option is required whenever the system contains a telephone Data Set like the 103E series. In the 2000A the board can be plugged into any available I/O slot. The PHOnes command gives the select code information and the number of seconds allowed for log on (i.e., PHONES-26,240).

A Keyboard Display unit (HP 2600A) is available. It can be used in place of the 2749A Teleprinter. It is usuable either hardwired, or connected through an acoustic coupler. In both cases, it can operate at a higher transmission data rate than the teleprinter.

Various Drum and Disc units are available. These are shown in Table 2. These can be substituted in place of the Drum on the minimum configuration list for larger capacity. Or they can be added as additional Disc or Drum units to increase storage capacity. The Discs and Drums are considered as logical units. Each 64 tracks (or a portion thereof) constitute a logical disc. The system will handle four logical discs. The first physical unit must utilize the I/O slots 14 and 15 for the interface. Succeeding physical units can use any two adjacent I/O slots. The various disc commands are used to modify the equipment status.

TABLE 3

DISC/DRUM
REFERENCE TABLE

DEVICE	TYPE	SECTORS/ TRACK	NO. TRACKS*	STORAGE	POWER SUPPLY	INTERFACE
2770A-01	Disc	90	64	368,640	2772A	12606B
2771A	Disc	90	64	(Expandable)	2772A	12606B
2771A-01	Disc	90	128	737,280	2772A	12606B
2773A	Drum	128	48	393,216	2776A	12610A
2774A	Drum	128	96	786,432	2776A	12610A
2774A-003	Drum	128	128	1,048,576	2776A	12610A
2766A	Disc	128	32	262,144	2772A	12610B
2766A-002	Disc	128	64	524,288	2772A	12610B
2766A-003	Disc	128	96	786,432	2772A	12610B
2766A-004	Disc	128	128	1,048,576	2772A	12610B

*These are logical tracks and sectors. Refer to the instrument manual for data on physical tracks and sectors.

FIGURE 2.
2000A BOARD LOCATIONS
(2116B COMPUTER)

	SPARE		A22	CROW BAR ASSSEMBLY			A222
	MEMORY PROTECT	*	A21			Mem Ext	A221
	DML		A20	DMA CHAR PACKER	A120		A220
	SPARE		A19	DMA CONTROL	A119	I/O Extender	A219
	INHIBIT DRIVER	XØ	A18	DMA ADDRESS ENC	A118	I/O BUSS LOADER	SC27 A218
	SPARE		A17	DMA WORD COUNT	A117		SC26 A217
	INHIBIT DRIVER	X1	A16	DMA WORD COUNT	A116		SC25 A216
	DRIVER SWITCH	X0-1	A15	SPARE			SC24 A215
	DRIVER SWITCH	Y0-1	A14				SC23 A214
	SENSE AMPLIFIER	XØ	A13				SC22 A213
	SENSE AMPLIFIER	X1	A12				SC21 A212
	SENSE AMPLIFIER	X2	A11				SC20 A211
	SENSE AMPLIFIER	X3	A12	FAN LOGIC	A110		SC17 A210
	DRIVER SWITCH	X2-3	A9	EAU TIMING	A109		SC16 A209
	DRIVER SWITCH	Y2-3	A8	SHIFT LOGIC	A108	DRUM COMMAND	SC15 A208
	SPARE		A7	INSTRUCTION DEC.	A107	DRUM DATA	SC14 A207
	INHIBIT DRIVER	X2	A6	SYS. TIMING GEN.	A106	+8 BIT DUP REG	SC13 A206
	SPARE		A5	Arithmetic Logic Cards	A105	TIME BASE GEN	SC12 A205
	INHIBIT DRIVER	X3	A4		A104	BUF'R'D TTY REG	SC11 A204
	PARITY ERROR		A3		A103	I/O MULTIPLEXOR	SC10 A203
	MMD		A2		A102	CENTRAL INTERRUPT	A202
	POWER FAIL		A1	FRONT PANEL COUP	A101	I/O CONTROL	A201

*Optional, not required.

FIGURE 3.
2000A BOARD LOCATIONS
(2116C COMPUTER)

	INHIBIT DRIVER	A22	CROW BAR ASSEMBLY			SPARE	
	X-Y DRIVER	A21				SPARE	
	SSA	A20				I/O Extender	A220
	SSA	A19					A219
	X-Y DRIVER	A18					SC27 A218
	INHIBIT DRIVER	A17					SC26 A217
	MEMORY PROTECT*	A16					SC25 A216
	PARITY ERROR	A15					SC24 A215
	MAD	A14					SC23 A214
	MDB	A13					SC22 A213
	INHIBIT DRIVER	A12					SC21 A212
	X-Y DRIVER	A11					SC20 A211
	SSA	A10		EAU LOGIC	A110		SC17 A210
	SSA	A9		EAU TIMING	A109		SC16 A209
	X-Y DRIVER	A8		SHIFT LOGIC	A108	DRUM COMMAND	SC15 A208
	INHIBIT DRIVER	A7		INSTRUCTION DEC.	A107	DRUM DATA	SC14 A207
	POWER FAIL	A6		SYS TIMING GEN	A106	+8 BIT DUP REG	SC13 A206
	DMA CHAR PACKER	A5		Arithmetic Logic Cards	A105	TIME BASE GEN	SC12 A205
	DMA CONTROL	A4			A104	BUF'R'D TTY REG	SC11 A204
	DMA ADDRESS ENC	A3			A103	I/O MULTIPLEXOR	SC10 A203
	DMA WORD COUNT	A2			A102	CENTRAL INTERRUPT	A202
	DMA WORD COUNT	A1		FRONT PANEL COUP.	A101	I/O CONTROL	A201

*Optional, not required.

software system

CHAPTER 3
2000A SOFTWARE SYSTEM

The 2000A Time Share System consists of six modules. The modules are in absolute format (not relocatable). They have limited ability to communicate with each other. The scheduler might be considered the master control program. We shall look briefly at each of these modules. Refer to Figure 4 for a representation of these modules. Those six modules consist of the multiplexor, system console, disc driver, library, Basic interpreter, and scheduler.

The understanding of the relationship between these Time Share System modules is essential. We might consider the primary purpose of the HP 2000A to execute the user program or user command (like RENumber). Incidental to this is the process of inputting program statements, providing syntax checking, error messages and these other services. In either case the executing program is a portion of the Basic Interpreter or the Library program. We might consider these as foreground activities.

It is first necessary to swap the users swap track to the user swap area in core. The actual swap is made on a cycle stealing basis with DMA. There may also be required communications through the multiplexor. The scheduler does the checking and scheduling for all pending activities. These activities might be considered background or overhead.

We do not wish to make these definitions more rigorous, and would prefer not to examine them too closely. What we are trying to do is first provide an intuitive feel for the different modules, their purpose, and the manner in which they share the available CPU time.

3-1 MULTIPLEXOR

The teleprinters are input-output devices. The data format is the 8-bit ASCII code embedded within three other start and stop bits. Communications between the teleprinters and the system is handled in bit serial manner.

The multiplexor panel has a sheet metal deck with 16 connectors, one for each possible teleprinter or telephone data channel. The multiplexor data interface board has the flag and interrupt circuitry, an 880 hertz oscillator to generate the interrupts and allow synchronism with the teleprinter data, sixteen data input circuits and sixteen data output circuits. Refer to Figure 5 for the multiplexor Data and Phone hardware diagram.

3-2 MULTIPLEXOR SOFTWARE MODULE

The multiplexor software module makes use of the TTY Tables and buffer areas. Each port has an associated teletype table containing temporary storage for pointers, time counters, status, priority, etc. The buffer areas provide temporary storage for input and output communications with each teleprinter.

The multiplexor system handles the character input bit-by-bit, stacking the characters into the proper buffer area. It processes the special characters as it goes, such as backspace and alt-mode. When the carriage return indicates the end of the line, the multiplexor sets a bit in the status word used by the scheduler. The next time through the scheduler the proper action will be determined and the user will be placed on the queue.

Up until the final character in the line, all of the necessary processing has taken place within the multiplexor module. It operates under interrupt mode using only the necessary time required for the bit-by-bit and character-by-character processing.

Similarly, in output mode, a Library module or the basic module will provide output rapidly filling the buffer area. The multiplexor system then processes the output character-by-character and bit-by-bit. This may be likened to a background-foreground mode of operation. All communications are handled essentially in parallel in the background. This requires a certain amount of time and appears as system overhead. In the foreground the Time Share system is working with one individual user at a time.

The multiplexor operates on a statistical basis. There are 8 interrupts per bit, and 11 bits per character. Thus, with 88 interrupts per character, it is highly unlikely that all teleprinters would start a character at the same instant.

Normally, the processing load of the multiplexor is distributed fairly evenly between the various interrupts. The overhead due to processing the multiplexor interrupts (when no user is being serviced) is about 90 microseconds. This represents about 8% of the available CPU time. The module requires about 160 microseconds to service a new character, 80 microseconds to process each bit, 245 microseconds for end of character. Additional time is required for special character (i.e., alt mode, carriage return, backspace, etc.)

The multiplexor board has a flag storage flip flop. This allows the multiplexor system up to two interrupt time periods without losing an interrupt. An occasional loss of an interrupt would not be accumulative. End of line processing places the users on the queue, thus reducing the duty cycle of the multiplexor.

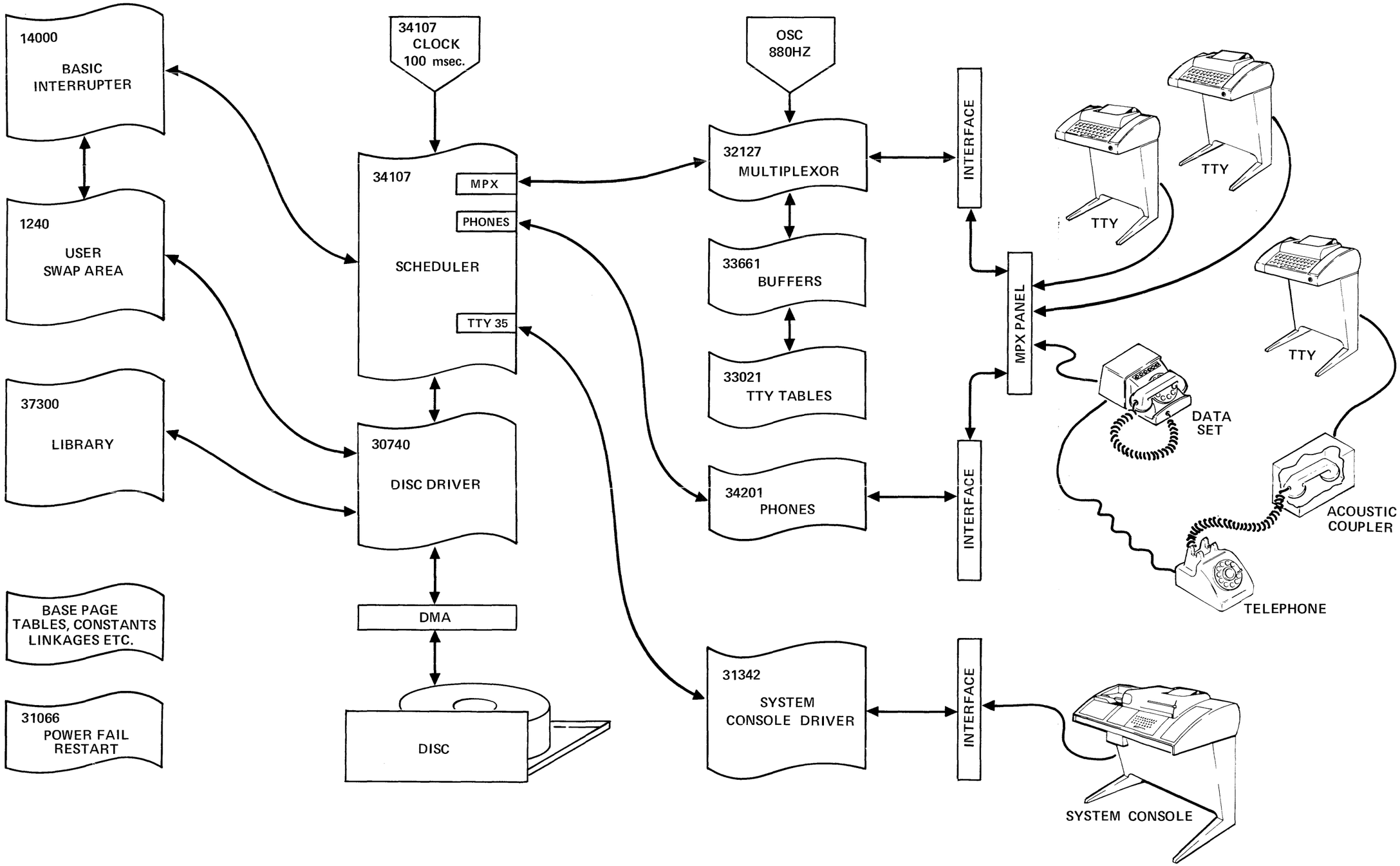


FIGURE 4. 2000A TIME SHARE SYSTEM

3-3 PHONES

The phones routine handles the control signals for the Bell Telephone Model 103 data set. It provides the proper time for initial log on. It also handles inadvertant disconnect. Although it is shown as a separate module, it is just a small portion of the scheduler.

3-4 SYSTEM CONSOLE

The system console provides a means of controlling the hardware system. The 2754B Teleprinter is interfaced with an HP 12531B Interface Card. The system console is used for four functions. First it allows control over user ID. This is done by adding new ID's, killing ID's, changing passwords, resetting time clocks, and controlling the allocation of disc space and allowable time. Second it is used for hardware control. This includes the DISc, MAG tape, PHOnes, LOCk and UNLock commands and the ROSter and STAtus requests.

The third function deals with program control. These commands include the DIRectory listing and the REPort listing all ID's with time and disc usage. PURge command allows cleaning up old programs which have not been used recently. SLEep command is used to save a tape copy of the system and all library and directory programs. It also provides a compaction of available disc spaces.

The fourth use of the system console provides log-on log-off messages to support the accounting and billing procedures. Since the logging is such an important function, the teleprinter punches a paper tape back up for all log-on log-off messages. The logging functions are of high priority, because they directly affect the system response time to the user, so these messages interrupt routine functions such as a DIRectory print, STAtus, or REPort.

The system console software module is operated under the interrupt mode. It uses two flags T35F1 and T35F2 to keep track of its current operating mode. T35F2 must be zero to allow input. The 36 word buffer is used for both input and output buffering.

Library routines can use the buffer by setting T35F2 thus inhibiting any input. In addition to the separate console driver significant coding exists within the scheduler. This portion deals primarily with setting up the log buffer, and in setting up the queue entry for the system console.

The function of the system console can be defeated by setting bit 0 of the computer switch register. This allows the 2000A cabinet door to be locked, thus preventing unauthorized tampering with the console. The console will continue to print log on and log off messages.

3-5 DISC DRIVER

The fourth software module is the Disc Driver. The Time Share system makes full use of the fixed head disc or drum. All disc transfers are made under DMA control. The computer memory size limits the system to only one user at a time. Each user (port) has one dedicated swap track on the disc. As a user reaches the top of the queue, the scheduler initiates the disc to core transfer. This brings in 85 sectors replacing the previous contents of the core swap area. The disc driver also writes the user core swap area to the disc swap track, or brings in the 4 sectors associated with each library program to the library core area starting at address 37300.

The disc driver is entered with the A and B registers containing the disc and core address. The location WORD contains the number of words to be transferred. A status location ENDSK is set at the beginning of the transfer, and is cleared at the completion of the transfer. Its condition indicates whether a transfer is underway.

3-6 LIBRARY

A 256 word segment of core is used by the various library programs. The origin address is 37300. There are more than 30 of these programs. They are disc resident, and are brought in whenever needed to this 256 word library area. In certain cases, the program exceeds the 256 word limit. This is handled by breaking the program into segments and executing the program and overlay sequentially. These programs are absolute. They can call other programs as necessary. For example: Save can call Supersave, and Hello program will search the library for $Hello executing it upon process completion.

It should be apparent that the use of a disc and the availability of these library programs has added a significant amount of power and sophistication to the system capability compared to Single Terminal Basic capabilities.

3-7 BASIC INTERPRETER

The Basic Interpreter is the heart of the software system. It is comprised of many functional subsections. These include syntax checking, compile and decompile, error routines, generation of symbol tables, formula evaluation, arithmetical routines, utility routines, and the program execution loop. This entire program uses only slightly more than 6600 words of memory.

One of the most significant problems to be overcome was the multi-entry nature of the compiler. This allows a users program to terminate at any point in the compiler. When he works up through the queue, the compiler can continue the execution again at the proper place. To accomplish this certain pointers and stacks had to be included in the user swap area.

The actual user program is maintained in the core user swap area. This area consists of 5440 words of memory. The swap area has various sub-routine pointers, value tables, symbol tables, syntax stacks, etc. All of these are of syntactical nature. They are not computer programs. The computer P register should never be executing in the user swap area. Some of the swap area is on the base page to facilitate access from anywhere in the interpreter.

The program may be in the uncompiled mode. This is the regular English language form as the program is initially entered. When the user types RUN, the program must be complied. This is a translation to a symbolic form required by the interpreter.

3-8 POWER FAIL/AUTO RESTART

The Time Share system requires a software module to service the power fail conditions. It is not considered one of the system software modules because of its specialized nature.

3-9 SCHEDULER

The sixth system module is the scheduler. This is the executive module. It handles the service requests from the other modules. It is responsible for making good use of CPU time.

The scheduler is entered every 100 milliseconds by an interrupt from the Time Base Generator. It is also entered whenever the interpreter module completes its task. Let's look at the various functions performed by the scheduler.

The Time Base Generator interrupt is serviced. The time of day counters are updated and serviced in case of roll over. The timer for a user is updated. The swap out is initiated if the users time slice is exhausted.

The queue is an ordered list of users awaiting service. It is maintained on a priority basis. The scheduler inserts new entries, and removes those who are done. It removes those who have exhausted their time slice and re-inserts them at the proper priority.

As the scheduler works through, it checks the status of the multiplexor through the MPCOM word, the phones input for changes or time outs, the system console through its flag words, and the logger request.

3-10 SYSTEM FUNCTIONS

Let's consider the relationship between these system functions. The multiplexor handled the bit by bit and character by character transfer until the carriage return was detected. Then the user's flag was set in the MPCOM word indicating service required. The input line was placed in the appropriate buffer, and the pointers are available in the TTY tables. There are various reasons for a service request. These include a command or syntax statement, output buffer down to 10 characters on an output wait, input provided following an input wait, or a user abort. The response may require initializing a library program or entering the interpreter, or it may be to continue a program suspended for I/O wait. In any case, it will require placing the user on the queue.

The phones processing is simple. It looks at the ringing and carrier lines from the data set. A change in the status (or voltage level) of these lines requires service. The action required is normally to provide the Data Terminal Ready signal, or to remove it. In the event of unintentional disconnect, the log off procedure is initiated.

The system console has an associated buffer for input and output. A logger buffer also exists for log on and log off messages. A log on/off message will be placed in the logger buffer. If the console is quiet, the log message prints. If the console was actively outputting a print (as in DIRectory or STAtus), the logger message waits until the completion of the current line before gaining control.

The scheduler also provides swapping. The time required to effect a disc transfer is significant. The swapper thus initiates the disc transfer at the earliest possible moment. The scheduler continues to process routine matters while awaiting the transfer completion.

multiplexor system

IV

CHAPTER 4
MULTIPLEXOR SYSTEM

The multiplexor system provides a means to link the computer to the teleprinters. The input to the Time Share system may be syntax statements, commands, or data input. The output will be program messages, error messages, command completion, etc. The multiplexor is the communications link. We will consider the characteristic of the elements within this system.

4-1 TELEPRINTER

The teleprinter is an electro-mechanical device. The main shaft is driven by a synchronous motor. This establishes the data rate, and all data to and from the teleprinter must be synchronized at this rate.

The teleprinter uses an eight level ASCII code. ASCII stands for an industry adopted standard code called the American Standard Code for Information Interchange. The code requires 7 bits for data and the eighth is an optional parity bit. These eight ASCII bits are preceeded by a start bit (logic zero level) and followed by two stop bits (logic one level). The data rate is 10 characters per second. The time period for a full character is 100 milliseconds. Each bit requires about 9.09 milliseconds.

4-2 SIGNAL QUALITY

The signal output will seldom be an ideal pulse train. Noise bursts and pulse deterioration due to long transmission lines or telephone circuits will reduce this quality. Time synchronism will not be exact. The best time to sample a bit will be somewhere near the middle of the bit.

4-3 TTY CHARACTER PRINT

In LINE mode pushing a key will initiate the generation of the pulse train and will result in a complete rotation of the main shaft. The character will not print automatically however. An electrical signal must be sent back to the teleprinter from the computer in order to print a character. This is referred to as an echo.

Let us digress a moment and see how this works. In LOCAL mode depressing a key moves the code bars under the keyboard setting up switch conditions for the 8 data bits. It also initiates one rotation of the shaft. The switches place voltages on the individual segments of the distributor which are then scanned sequentially during the shaft revolution by the distributor. The start and stop bits are also added. This is the data signal which is available for the computer while in LINE mode. In LOCAL mode the signal actuates the selector solonoid. This in turn allows the cams sequentially to set up code bars for print selection. In the time share application, each bit is sampled in the middle of the bit period. The returned signal is delayed 4 or 5 milliseconds compared with LOCAL mode. There are adjustments to help optimize the unit for this time shift. These adjustments include the mechanical "Range

Finder" adjustment, and the armature spring tension and setting. These adjustments should be attempted only by qualified technicians. If misadjusted occasionally a character may misprint even though the proper data has been received by the computer.

4-4 MULTIPLEXOR DATA

How does the hardwired teletype work from a data flow concept? See figure 5 for the multiplexor data and phones information. The interrupt circuit on the multiplexor assembly generates computer interrupts. These interrupts allow synchronization with the teleprinter data train. We need to locate the center of the bit, thus requiring more than one interrupt per bit. It would be desirable to spread the teleprinter servicing over various interrupts so all 16 units would not likely require simultaneous servicing, An interrupt rate of 880 cycles per second was selected thus giving 8 interrupts per bit.

Figure 5 shows one teleprinter. Its cable can be attached to any one of the 16 connectors (JØ to J15). In the event a data phone is used, the teleprinter would plug into an acoustic coupler. It would make an acoustic coupling with the telephone hand set to the telephone network. The telephone network would terminate in a 103 type data set which would then plug into the multiplexor connector (instead of the teleprinter cable).

The physical wiring on the multiplexor should be described. The Data lines are wired on the connector chassis from each port connector to J17. A Data cable (12584-6005) then takes all of these connections from J17 to the multiplexor Data board in I/O slot 10.

The Ringing and Carrier signals are routed from each of the 16 connectors to the Ring Carrier assembly which is mounted directly behind the connector chassis. The ring or carrier connections are then routed to J16. The cable (12584-6008) then takes these signals to the multiplexor phones board which can be located in any available I/O slot SC16 or above. The Data Terminal Ready signal then returns through the cable and J16 to the individual port.

The incoming data from the teleprinter is routed through the multiplexor panel to the multiplexor data board. The input circuits monitor the voltage levels of each of the 16 lines. The computer uses the LIA/B instruction to input the data levels. Each Port is associated with one of the 16 bits of the computer word. It should be noted that the input circuit inverts the logic level. The start bit for character is a logic zero at the teleprinter. After being inverted on the multiplexor data card, it is a logic one at the I/O slot.

It is up to the multiplexor software to recognize the initial change of state from a zero to a one as the start of a new character. It counts 4 interrupts to the middle of the bit. It then begins to send the output data back to the teleprinter to allow printing. After 8 more interrupts, it determines the logic level of the first data bit and sends it back, etc. This results in a 4.5 millisecond phase difference between the generated and returned data. Mechanical phasing adjustments allow for this mode of operation.

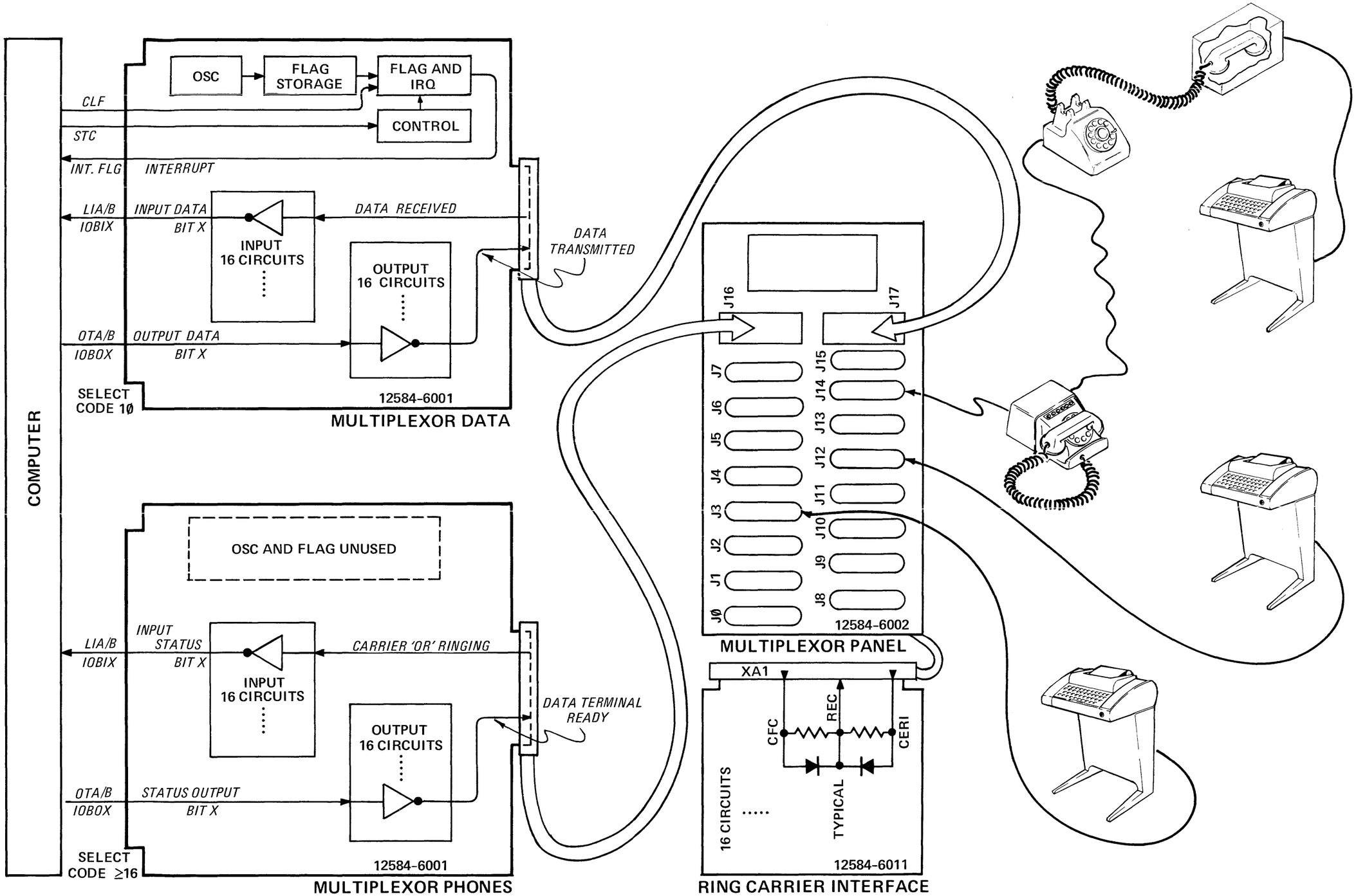


FIGURE 5. MULTIPLEXOR DATA AND PHONES

3-3 PHONES

The phones routine handles the control signals for the Bell Telephone Model 103 data set. It provides the proper time for initial log on. It also handles inadvertant disconnect. Although it is shown as a separate module, it is just a small portion of the scheduler.

3-4 SYSTEM CONSOLE

The system console provides a means of controlling the hardware system. The 2754B Teleprinter is interfaced with an HP 12531B Interface Card. The system console is used for four functions. First it allows control over user ID. This is done by adding new ID's, killing ID's, changing passwords, resetting time clocks, and controlling the allocation of disc space and allowable time. Second it is used for hardware control. This includes the DISc, MAG tape, PHOnes, LOCk and UNLock commands and the ROSter and STAtus requests.

The third function deals with program control. These commands include the DIRectory listing and the REPort listing all ID's with time and disc usage. PURge command allows cleaning up old programs which have not been used recently. SLEep command is used to save a tape copy of the system and all library and directory programs. It also provides a compaction of available disc spaces.

The fourth use of the system console provides log-on log-off messages to support the accounting and billing procedures. Since the logging is such an important function, the teleprinter punches a paper tape back up for all log-on log-off messages. The logging functions are of high priority, because they directly affect the system response time to the user, so these messages interrupt routine functions such as a DIRectory print, STAtus, or REPort.

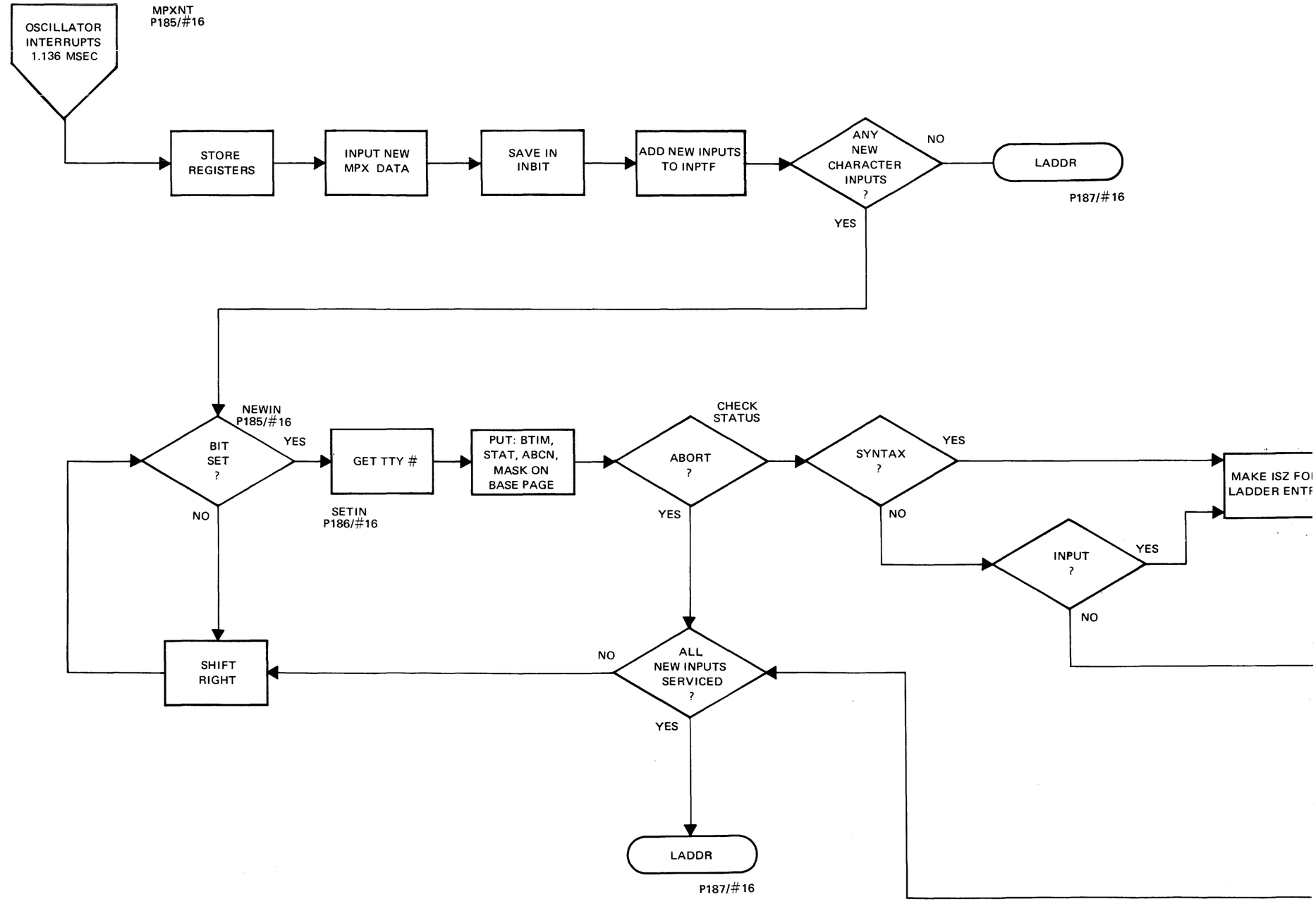
The system console software module is operated under the interrupt mode. It uses two flags T35F1 and T35F2 to keep track of its current operating mode. T35F2 must be zero to allow input. The 36 word buffer is used for both input and output buffering.

Library routines can use the buffer by setting T35F2 thus inhibiting any input. In addition to the separate console driver significant coding exists within the scheduler. This portion deals primarily with setting up the log buffer, and in setting up the queue entry for the system console.

The function of the system console can be defeated by setting bit 0 of the computer switch register. This allows the 2000A cabinet door to be locked, thus preventing unauthorized tampering with the console. The console will continue to print log on and log off messages.

During output when the bit timer rolls over the new bit must be sent out. When character roll over occurs, the buffer pointers are incremented and the new character is prepared, While in output wait the number of characters are checked. If 10 characters remain the MPCOM bit is set to reschedule the user.

The flow chart is roughly proportional to the time required by the multiplexor driver. The oscillator frequency of 880 hertz was selected to distribute possible end of character processing over the various interrupts. Decreasing the oscillator frequency would slightly reduce multiplexor overhead. But the number of users (per interrupt) requiring service would increase. The multiplexor board has a special flag and interrupt circuit. It has a storage flip flop which retains an interrupt occurring before the completion of the multiplexor routine. It virtually doubles the amount of time available for any one interrupt before resulting in erroneous data.


OSCILLATOR INTERRUPTS 1.136 MSEC
MPXNT P185/#16
STORE REGISTERS
INPUT NEW MPX DATA
SAVE IN INBIT
ADD NEW INPUTS TO INPTF
ANY NEW CHARACTER INPUTS ?
NO
LADDR
P187/#16
YES
NEWIN P185/#16
BIT SET ?
YES
NO
GET TTY #
SETIN P186/#16
PUT: BTIM, STAT, ABCN, MASK ON BASE PAGE
CHECK STATUS
ABORT ?
YES
SYNTAX ?
YES
NO
MAKE ISZ FOR LADDER ENTR
INPUT ?
YES
NO
SHIFT RIGHT
NO
ALL NEW INPUTS SERVICED ?
YES
LADDR
P187/#16

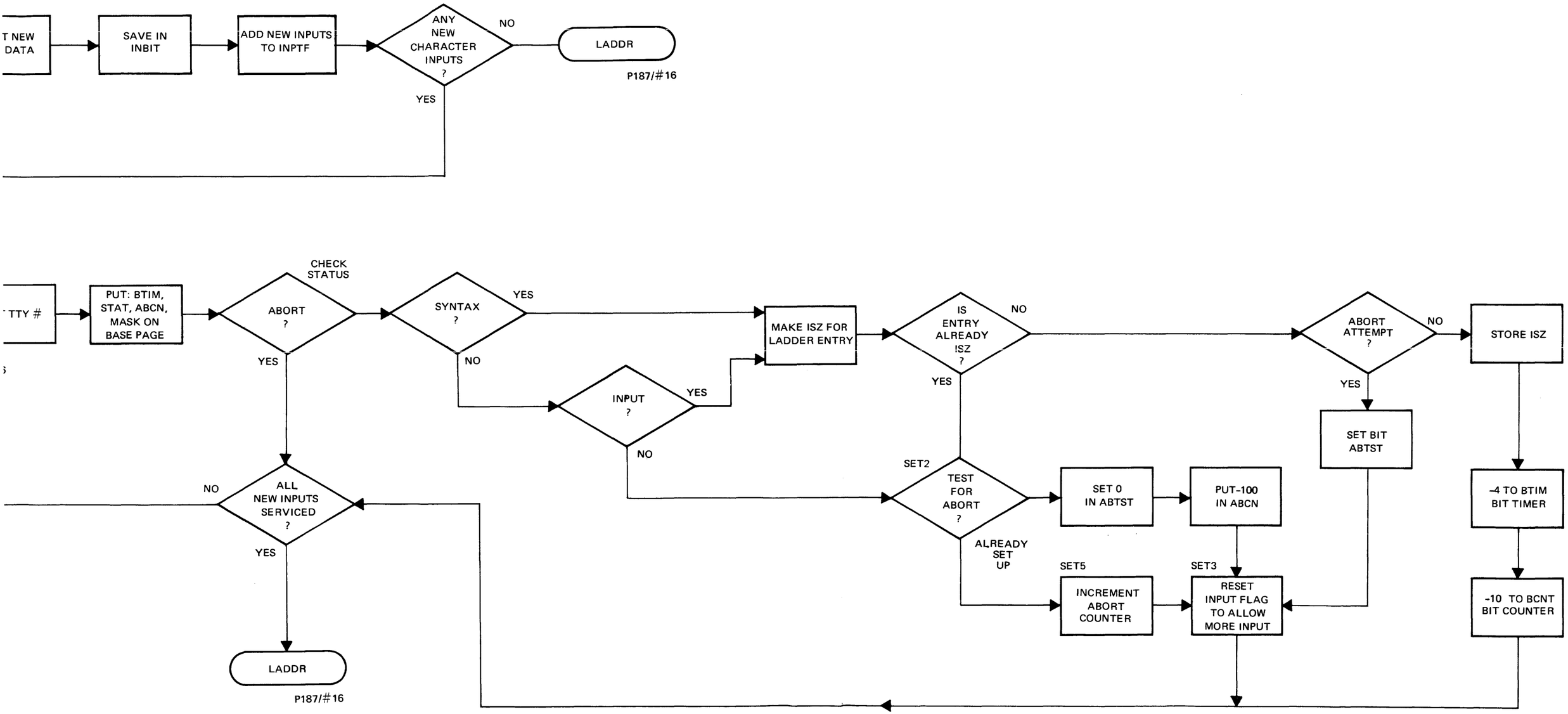


FIGURE 6. MULTIPLEXOR FLOW CHART
SHEET 1 OF 3

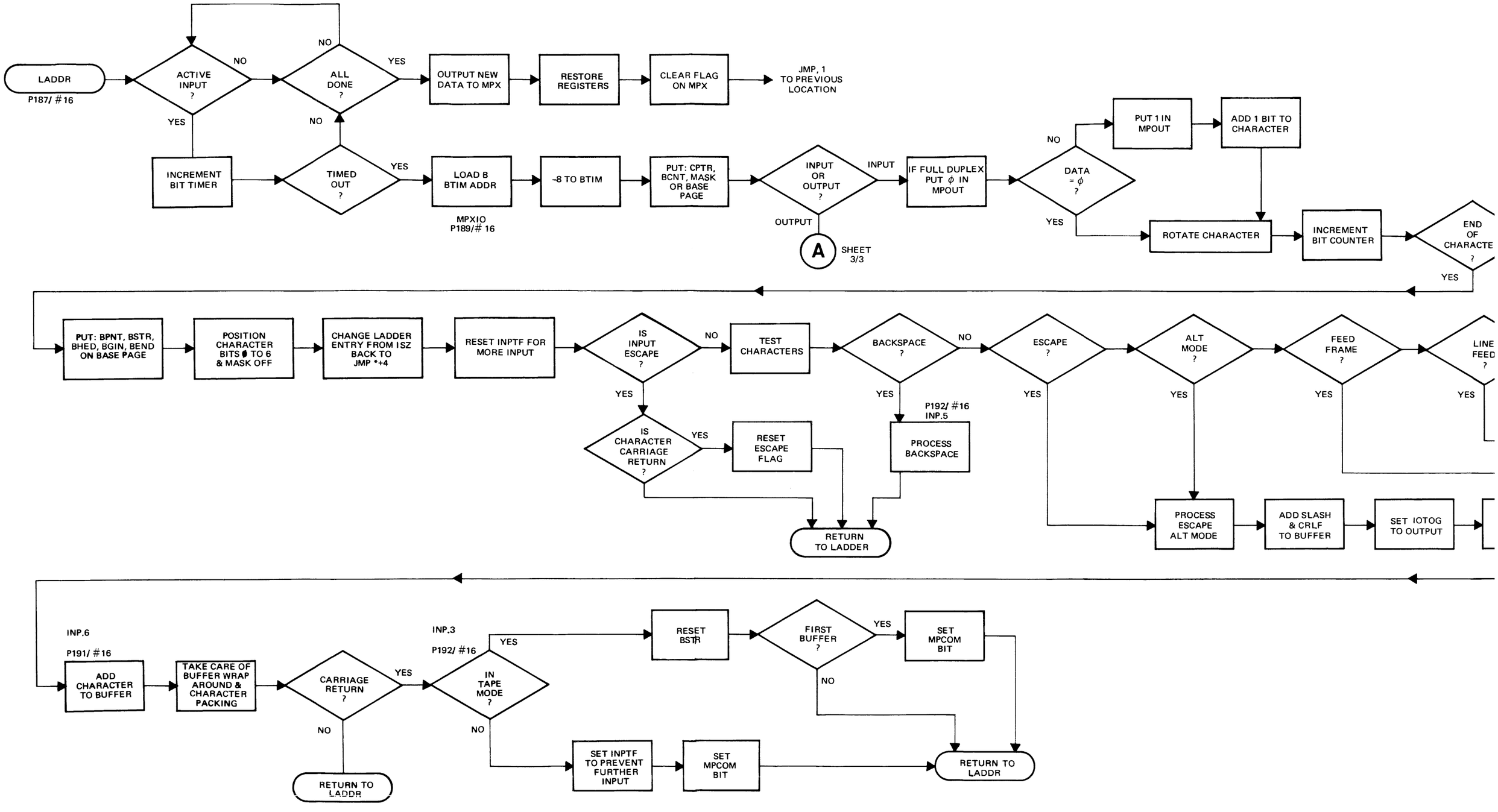


FIGURE 6. MULTIPLEXOR FLOW CHART
SHEET 2 OF 3

LAG
'X

JMP, 1
TO PREVIOUS
LOCATION

'TR,
ASK
SE
E

INPUT
OR
OUTPUT
?

INPUT

OUTPUT

A

SHEET
3/3

IF FULL DUPLEX
PUT ϕ IN
MPOUT

DATA
= ϕ
?

NO

YES

PUT 1 IN
MPOUT

ADD 1 BIT TO
CHARACTER

ROTATE CHARACTER

INCREMENT
BIT COUNTER

END
OF
CHARACTER
?

NO

RETURN TO
LADDR

YES

NO

TEST
CHARACTERS

BACKSPACE
?

NO

YES

ESCAPE
?

YES

ALT
MODE
?

YES

FEED
FRAME
?

YES

LINE
FEED
?

YES

X
OFF
?

YES

P192/ #16
INP.5

ES

RESET
ESCAPE
FLAG

PROCESS
BACKSPACE

RETURN
TO LADDER

PROCESS
ESCAPE
ALT MODE

ADD SLASH
& CRLF
TO BUFFER

SET IOTOG
TO OUTPUT

-4 TO CCNT

ISZ → LADDR

RETURN TO
LADDR

T
R

FIRST
BUFFER
?

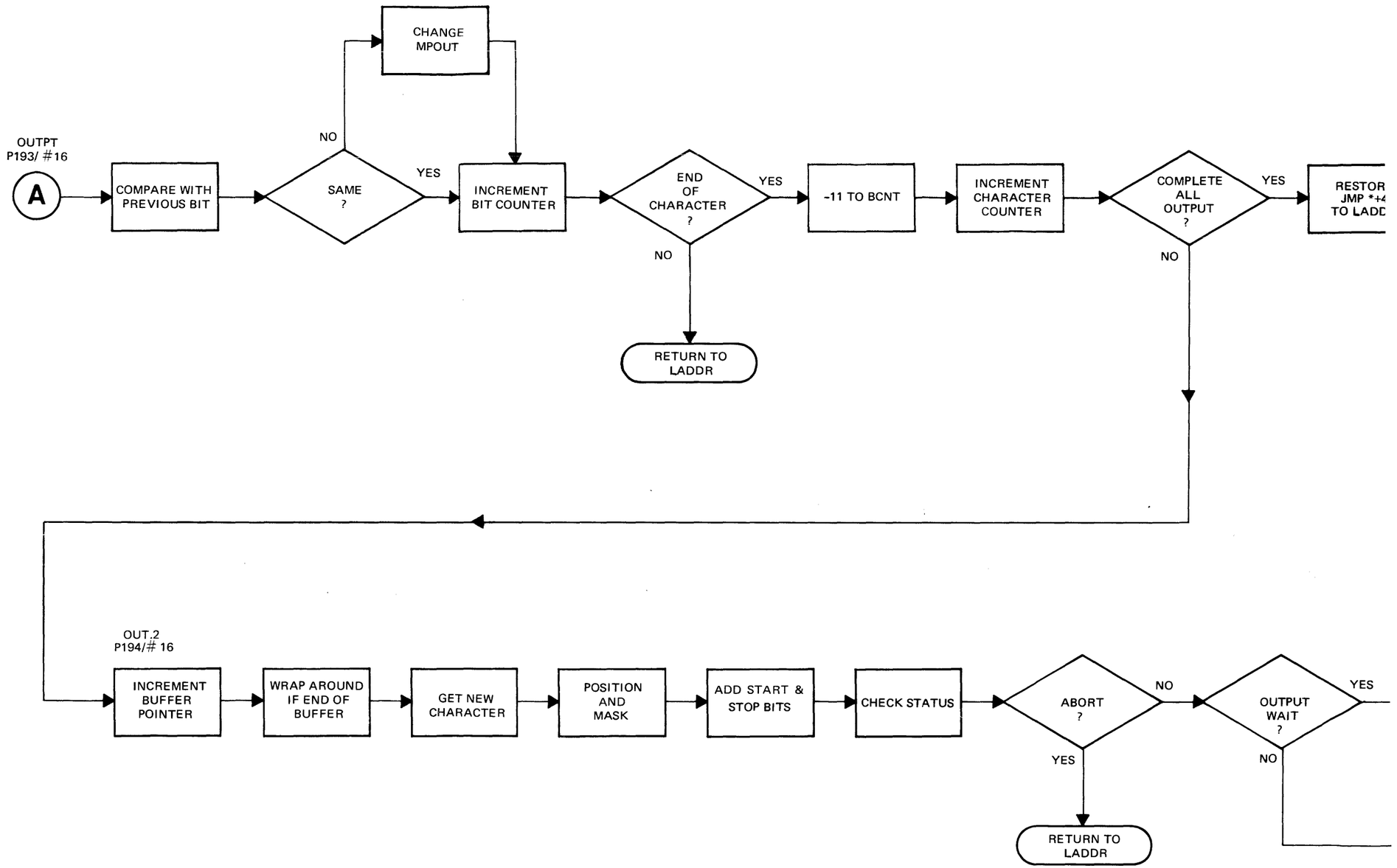
YES

NO

SET
MPCOM
BIT

SET
MPCOM
BIT

RETURN TO
LADDR


OUTPT
P193/ #16
A
COMPARE WITH
PREVIOUS BIT
SAME
?
NO
YES
CHANGE
MPOUT
INCREMENT
BIT COUNTER
END
OF
CHARACTER
?
YES
NO
RETURN TO
LADDR
-11 TO BCNT
INCREMENT
CHARACTER
COUNTER
COMPLETE
ALL
OUTPUT
?
YES
NO
RESTOR
JMP *+4
TO LADD
OUT.2
P194/# 16
INCREMENT
BUFFER
POINTER
WRAP AROUND
IF END OF
BUFFER
GET NEW
CHARACTER
POSITION
AND
MASK
ADD START &
STOP BITS
CHECK STATUS
ABORT
?
NO
YES
RETURN TO
LADDR
OUTPUT
WAIT
?
YES
NO

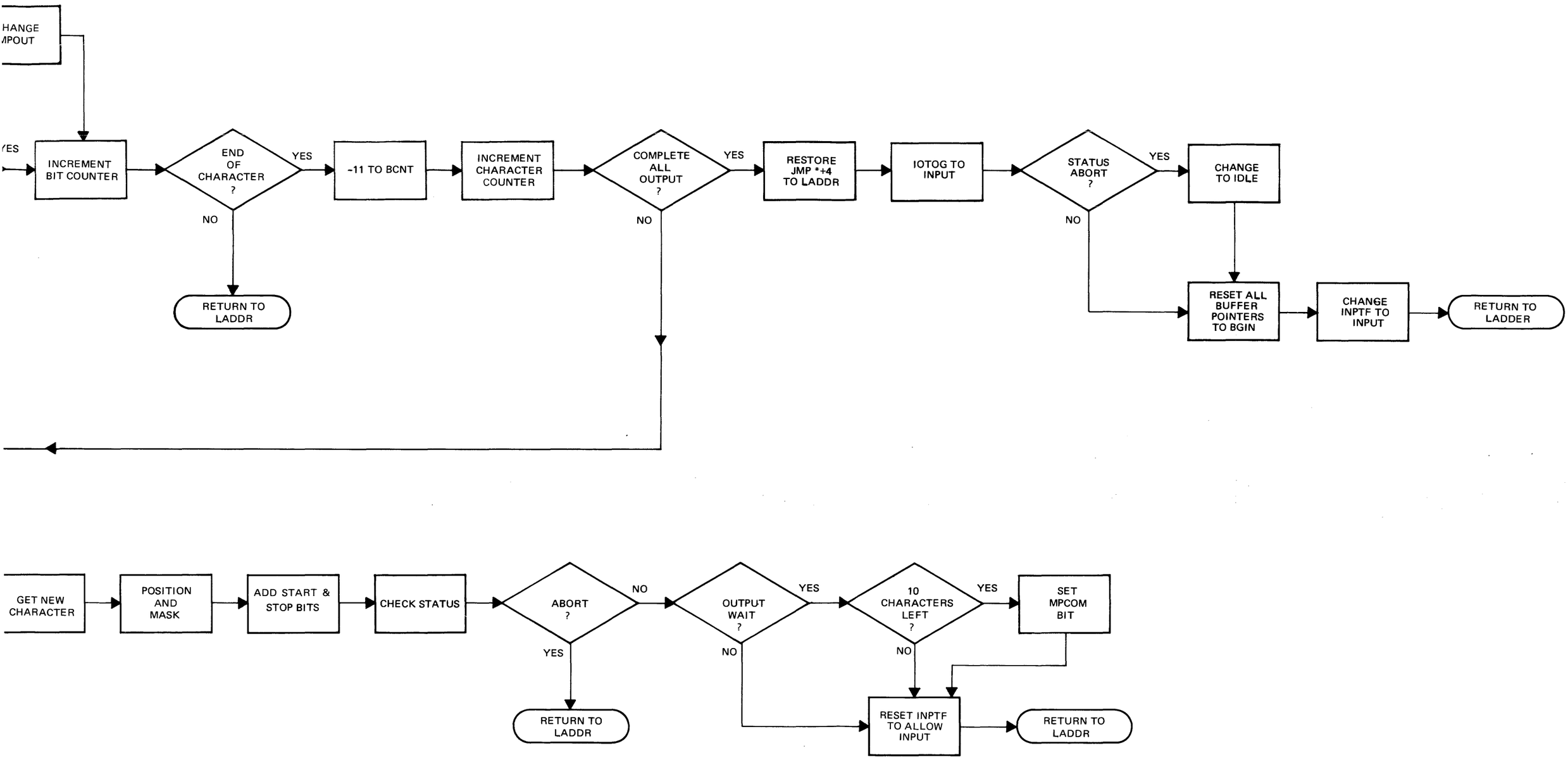


FIGURE 6. MULTIPLEXOR FLOW CHART
SHEET 3 OF 3

scheduler

V

CHAPTER 5
SCHEDULER

The Scheduler is the Time Share Executive. A review of figure 4 shows the significant relationship between the scheduler and the other modules. The Queue is an ordered listing of all users desiring to be serviced. It is the servicing of the queue, including the status and priority, which constitutes the primary function of the scheduler.

The scheduler calls the Disc to effect a swap from the disc to core or from core to the disc. It controls the transfer to either the Basic intrepreter or to the library. The multiplexor is a self contained driver. It is entered by the interrupt from its oscillator. It handles communication from the teleprinter to the buffer or from the buffer to the teleprinter. The scheduler checks the MPCOM status word to determine when a user requires servicing.

The interaction of these modules depends in great measure on the queue. Before continuing with the operation of the scheduler, it is important to understand the queue.

5-1 QUEUE

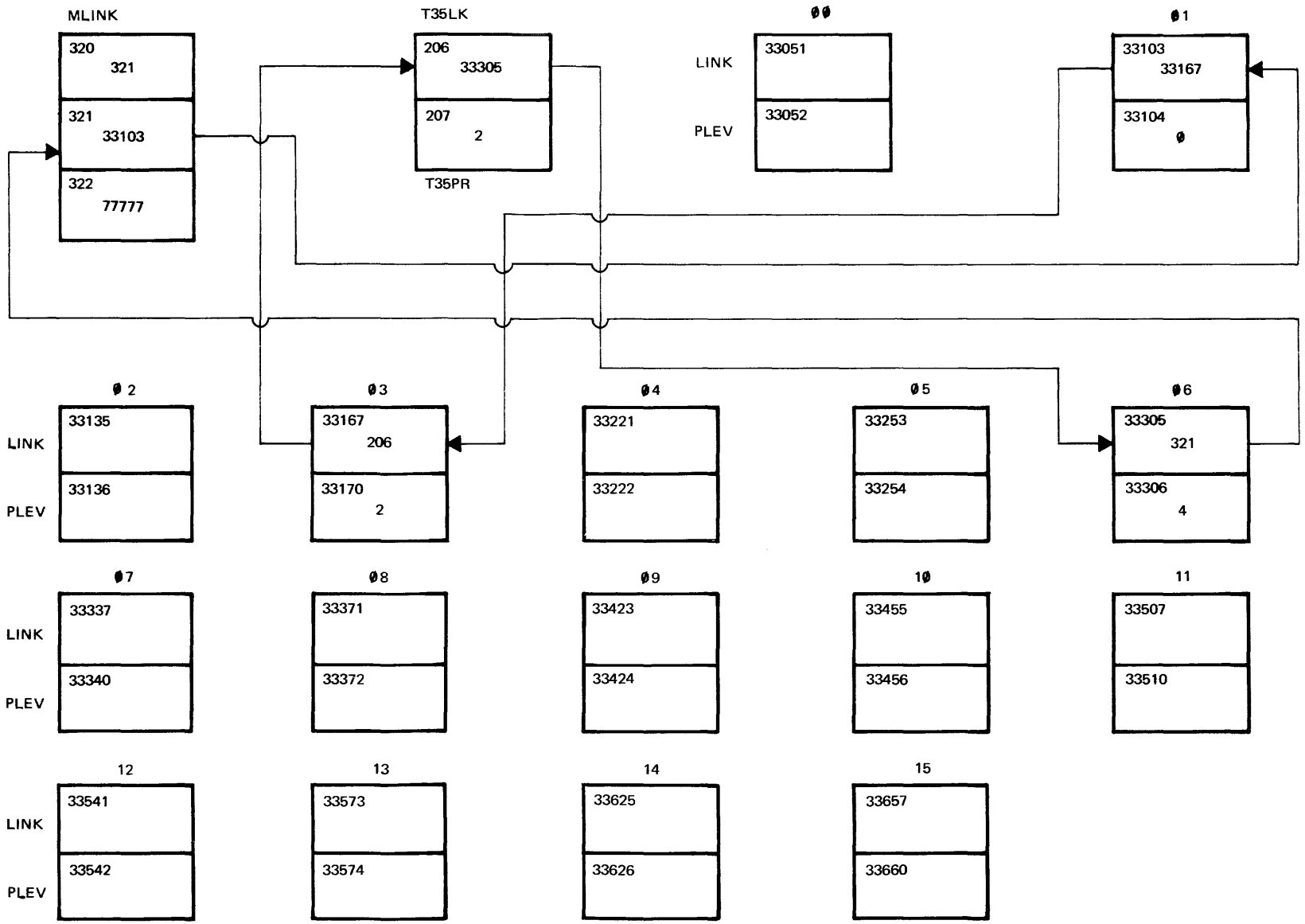
The queue is an ordered list of users desiring service. The list is ordered by priority. Within each priority, the queue follows the first-in, first-out concept. The fundamental concept in the queue philosophy is to accomplish the short interactive tasks rapidly at the expense of compute (or run) bound programs. This gives the system a responsiveness and speed which is very desirable.

Priority is assigned in this manner. The highest priority is 0 and it is assigned for users returning following an I/O syspend, and for syntax lines. Priority 1 is assigned to those commands handled by the Basic interpreter - RUN, LISt and PUNch. All other commands are disc resident and are assigned a priority level of 2. Whenever a command of priority 2 reaches the top of the queue, its priority is reassigned 0. If the job is not completed within its one second time slice, it is reassigned a priority of 4 and requeued. The commands KEY and TAPe are executed immediately and do not require being placed on the queue.

5-2 QUEUE EXAMPLE

Figure 7 shows an example of a queue. The queue is comprised of one to eighteen entries. Each entry consists of a link address to the next entry and the priority level of the user. The queue consists of the pseudo entry at MLINK +1. It points to itself, (or to the top of the queue), with a priority of 77777B.This priority insures that this entry will always be the last entry on the queue. The words LINK and PLEV are entries from the users teletype table. They have significance only if the user is on the queue.

FIGURE 7. QUEUE EXAMPLE
SHEET 1 OF 2



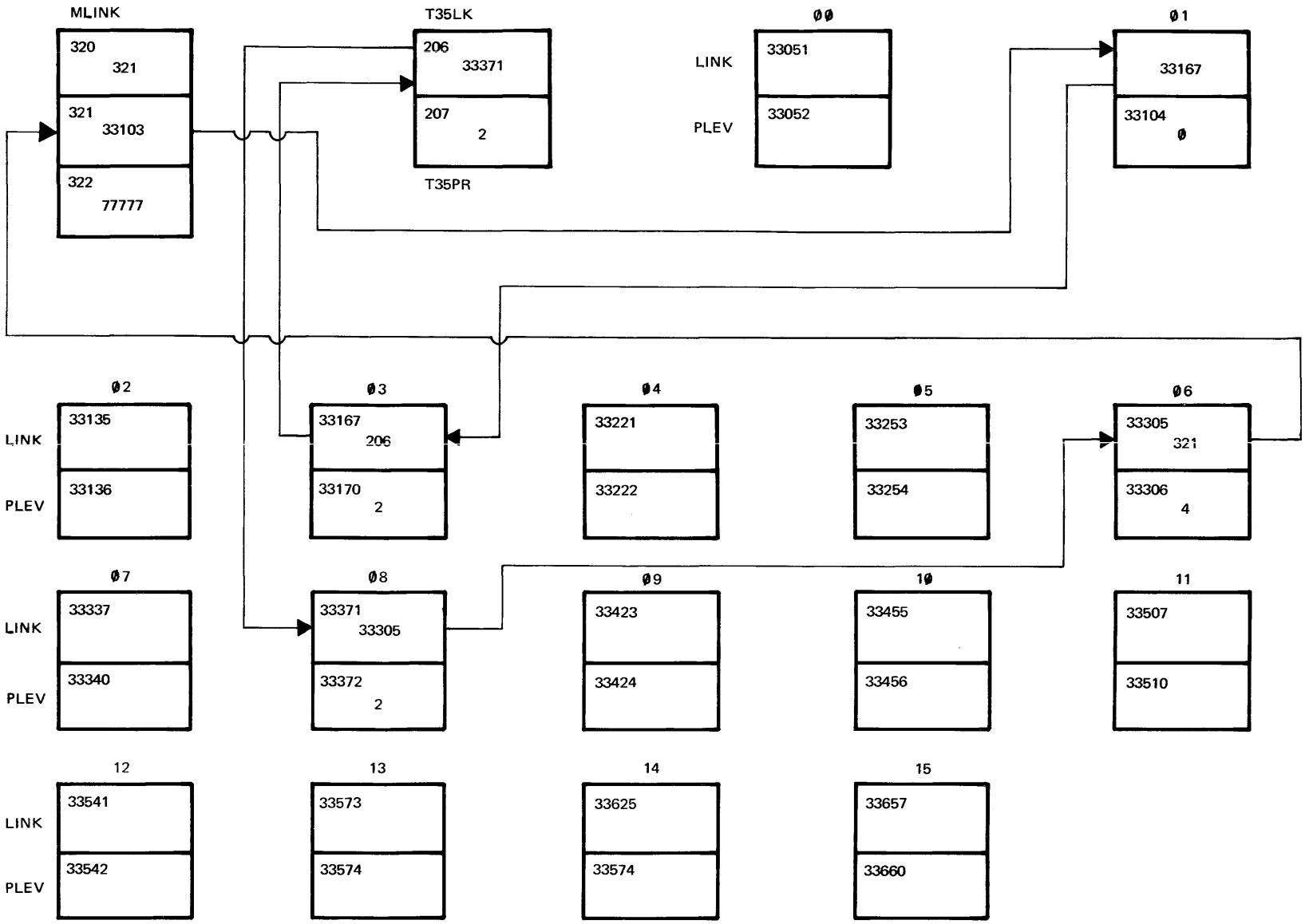


FIGURE 7. QUEUE EXAMPLE
SHEET 2 OF 2

MLINK +1 always points to the top of the queue. In this case (figure 7) it is the LINK address of port 1, with a priority of 0. Port 1 LINK points to the second entry, Port 3 with a priority of 2. The other entries are the console with priority 2, and Port 6 with priority 4. Port 6 is the last user entry. It points to the pseudo entry MLINK +1.

To remove an entry from the queue requires merely changing the preceding LINK. For example, if port 1 had completed its task changing MLINK +1 to 33167 would dequeue port 1. The addition of another user to the queue is similar.

Suppose that port 8 typed GET-SAM. It would be assigned a priority 2. The scheduler would then search the queue to determine its proper location, The scheduler compares the priority to be inserted with each queue entry until the new priority is less than the next queue entry. MLINK +1 points to the top of the queue.

In this case, the priority is not less than port 1. It is not less than Port 3. It is not less than the console. But it is less than Port 6. Therefore it must be inserted between the console and Port 6. This is done by placing the priority 2 in location 33372. The link value in the console T35LK (33305) is placed in location 33371, and 33371 is placed in 206. The queue is now expanded to include the new user. See figure 7 sheet 2/2 for the queue after inserting Port 8.

5-3 SCHEDULER LOOP

We are now ready to look at the overall scheduler loop. Whenever the system has nothing to do the queue is empty, and the scheduler stays in the idle loop. See figure 8. The loop starts at SCH1. It checks to determine whether any phone servicing is necessary, whether the multiplexor has any user teleprinter business ready to handle, whether the system console needs servicing and finally if some one is on the queue and is in core ready to run.

The scheduler remains in this loop. It is interrupted by the multiplexor oscillator but returns on completion. It is also interrupted by the Time Base Generator. When the time clock is updated, the return to the scheduler is through the jump at the CLKIN NOP location.

The loop will finally be broken when a user logs on. At the end of the log on line multiplexor processing will be indicated by the MPCOM bit. The user will be queued up, and the HELlo command will be brought in by the SWAPR. When it is in and ready the Time Share System will exit the loop to initiate the command execution.

5-4 CLOCK INTERRUPT

Each 100 milliseconds the scheduler will be entered again to check for phones, multiplexor, and console servicing requirements. The scheduler will exit to continue the command execution. The library commands are not timed, but continue to completion. The user will be dequeued when a library command is completed. The entry point for this is SCHEQ. The scheduler will stay in the loop until another user is placed on the queue.

When a user is in run mode, he is allowed a one second time slice. Each time the clock interrupt takes place, his timer CLOC is checked against time of day. When his time slice is used up and someone else is on the queue, he is swapped out and requeued at the lower priority.

Input-output operations also provide entry points to the scheduler. In the case of required input, the user is immediately dequeued and placed in input suspend. This is required because the input wait is always extremely long. This entry point is SCHIQ. Another point is provided for output request. The routine #OUTC is called whenever a character is outputted to the teleprinter. This is accomplished by adding the character to the output buffer which is then serviced by the multiplexor. In the case in which the buffer is completely filled, the user is then removed from the queue. The scheduler services the next user on the queue, or remains in the scheduler loop. When the output buffer decreases to exactly 10 characters remaining the user is requeued by the multiplexor with a priority of 0, thus ensuring early service.

In general, there are only the four entry points to the scheduler. The only exit is to initiate execution. The TSB entry is the initial entry point called when the system is entered from the loader.

5-5 DETAILED SCHEDULER FUNCTIONS

We can now consider more detailed blocks of the scheduler. Figure 9 shows the action required by a clock interrupt. The software merely updates the 0.1 second counter, and then the hour counter in case of roll over. Then it returns to the scheduler if it was there at interrupt. Otherwise it enters the scheduler at SCHED.

The lisitng at SCHED determines whether the operation is untimed, or timed but not used up, and then goes to the SCHI main part of the scheduler. If the user is timed and the time slice is used up, he is requeued at the lower priority. The program jumps to SWAPR to start early swapping. The scheduler then remains in the loop until the new user is in and ready. Figure 11 shows the processing required by the SCHED coding.

Figure 10 shows the main part of the scheduler. The phones coding is bypassed unless the phones command is used to indicate the hardware exists. The function is rather simple. It must connect the user on call up. It must time for log on within the allowable time. It must detect and process a disconnect. When this is completed, it goes on to the multiplexor communications.

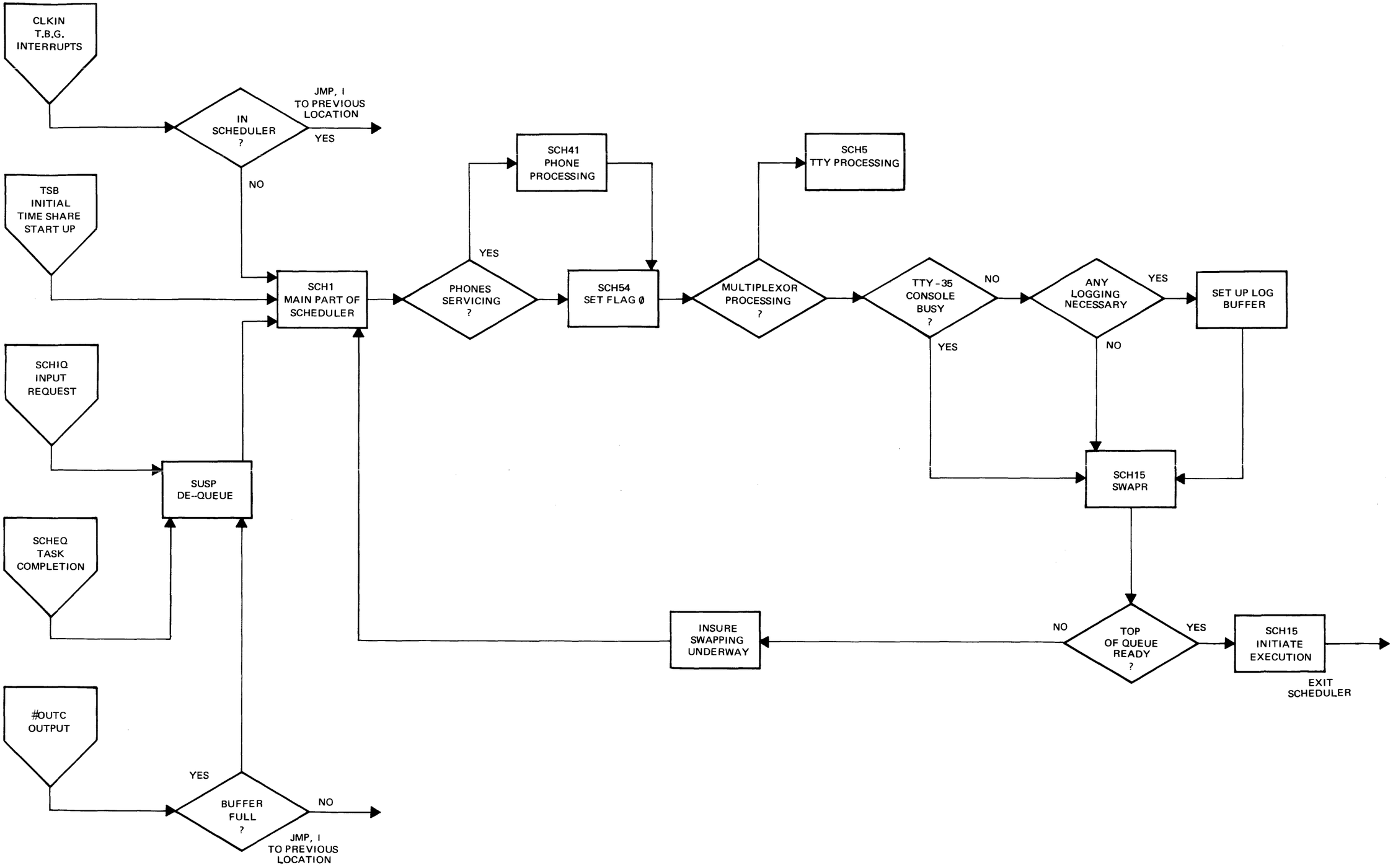


FIGURE 8. SCHEDULER LOOP

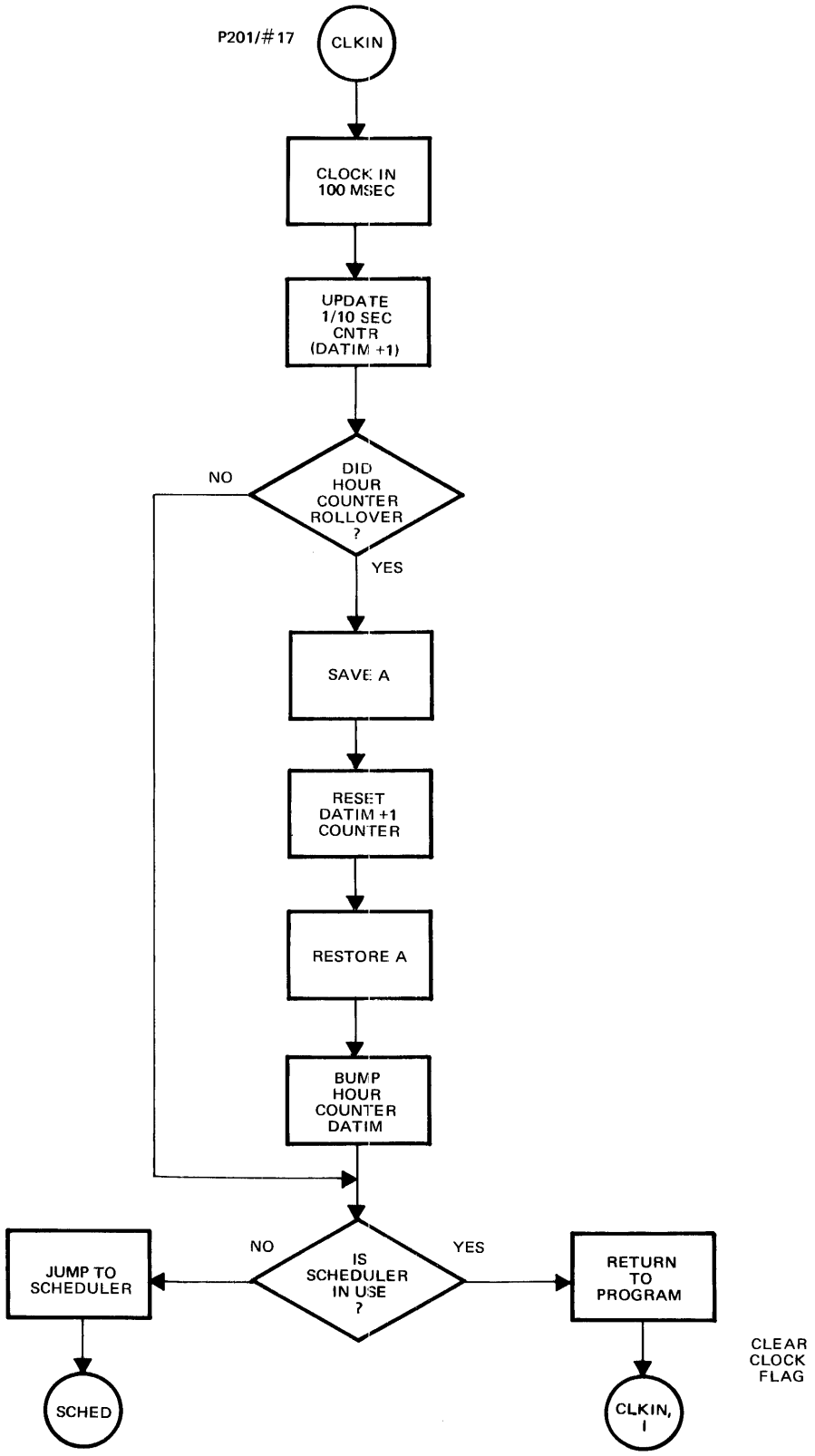


FIGURE 9. CLOCK INTERRUPT

The multiplexor communications is indicated by the word MPCOM. The corresponding user bit is set whenever servicing is required. The scheduler uses the user status to help determine what is required. A status of 2 or 3 is a return from I/O suspend. This establishes a new priority of 0 and the user is placed on the queue. A status of 4 or more indicates that a command is being processed. RUN = 5, LISt = 6, PUNch = 7, etc. Refer to the command table P222/#18 for the sequence.

A status of -1 is given when the multiplexor determines the user desires an abort. When the scheduler begins to process the abort it gives a status of 1. A status of 1 thus indicates an abort is underway and no further processing is required.

A status of zero indicates the user is in idle condition. This is the normal condition for receiving a new line of syntax or a command. The status of -2 indicates a special disconnect from the phones coding.

Once all of the multiplexor processing is completed, the scheduler then checks the console. When the console is finished, the scheduler continues with the SWAPR routine.

The SWAPR routine has two exit points. One is to initiate execution. This occurs when the user is in the swap area, or a library program is in 37300. If these are not ready, then the SWAPR exits to SCH1 again and continues in the scheduler loop. Refer to figure 12 for the swapper clock diagram.

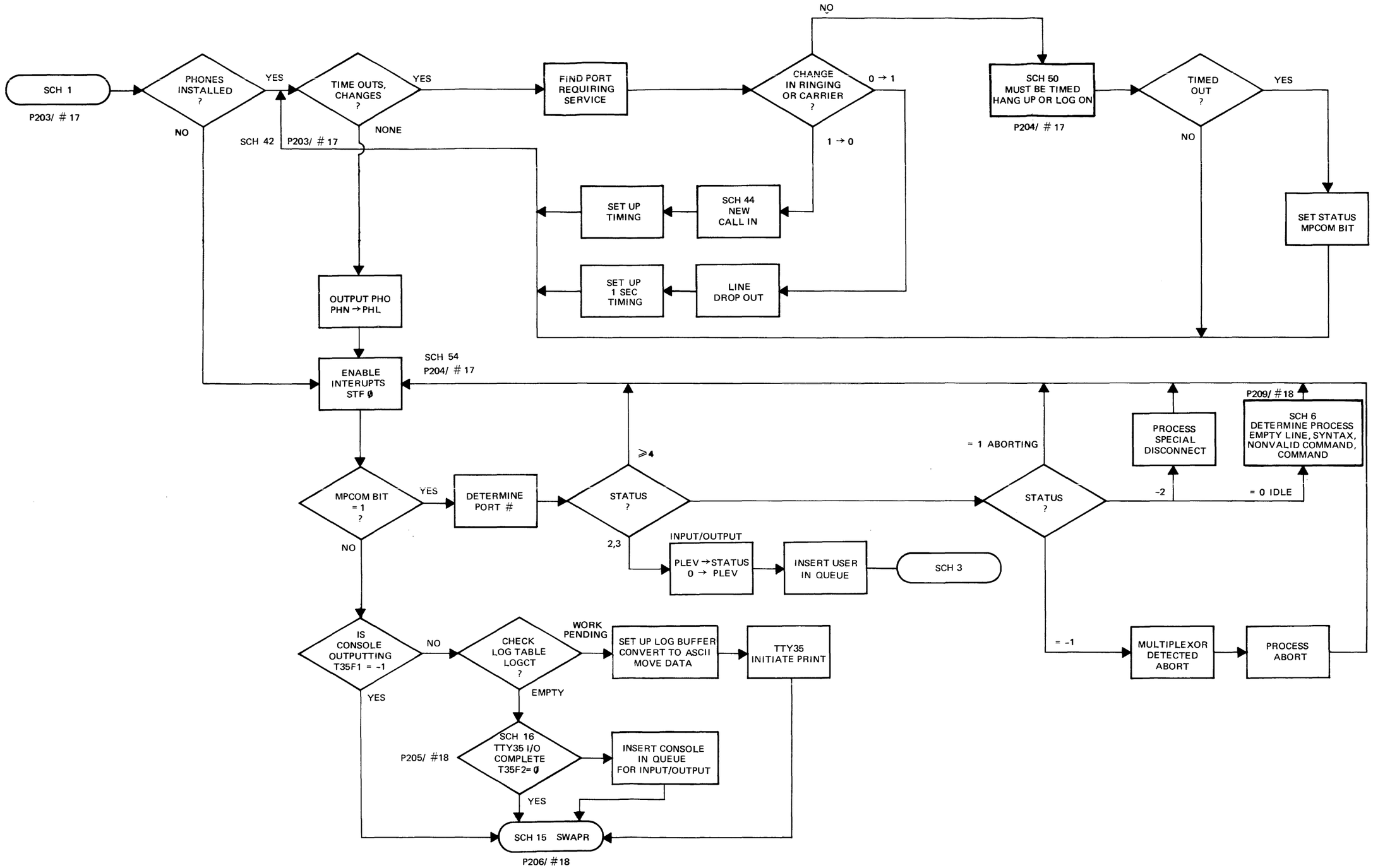


FIGURE 10. SCHEDULER (MAIN PART)

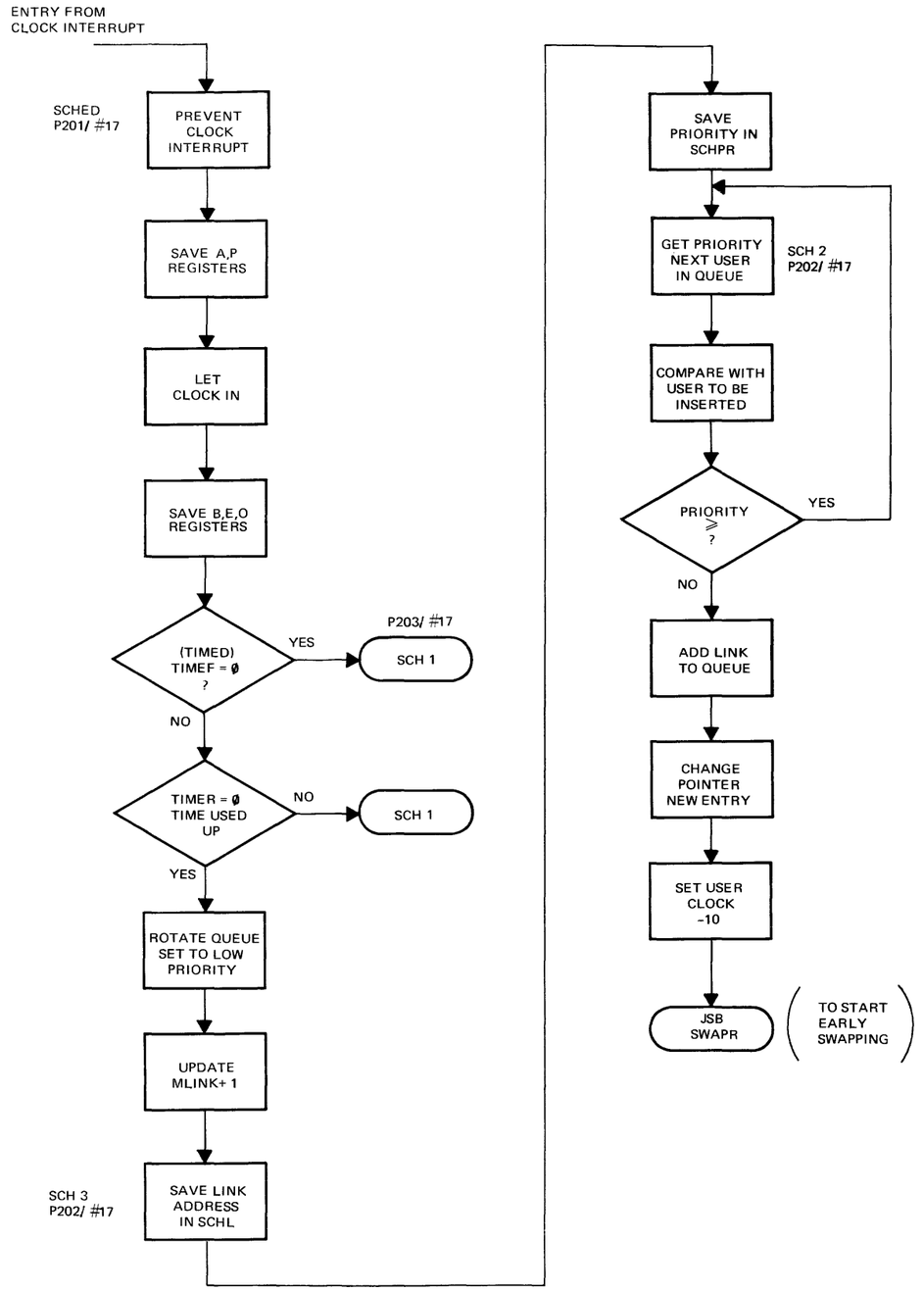
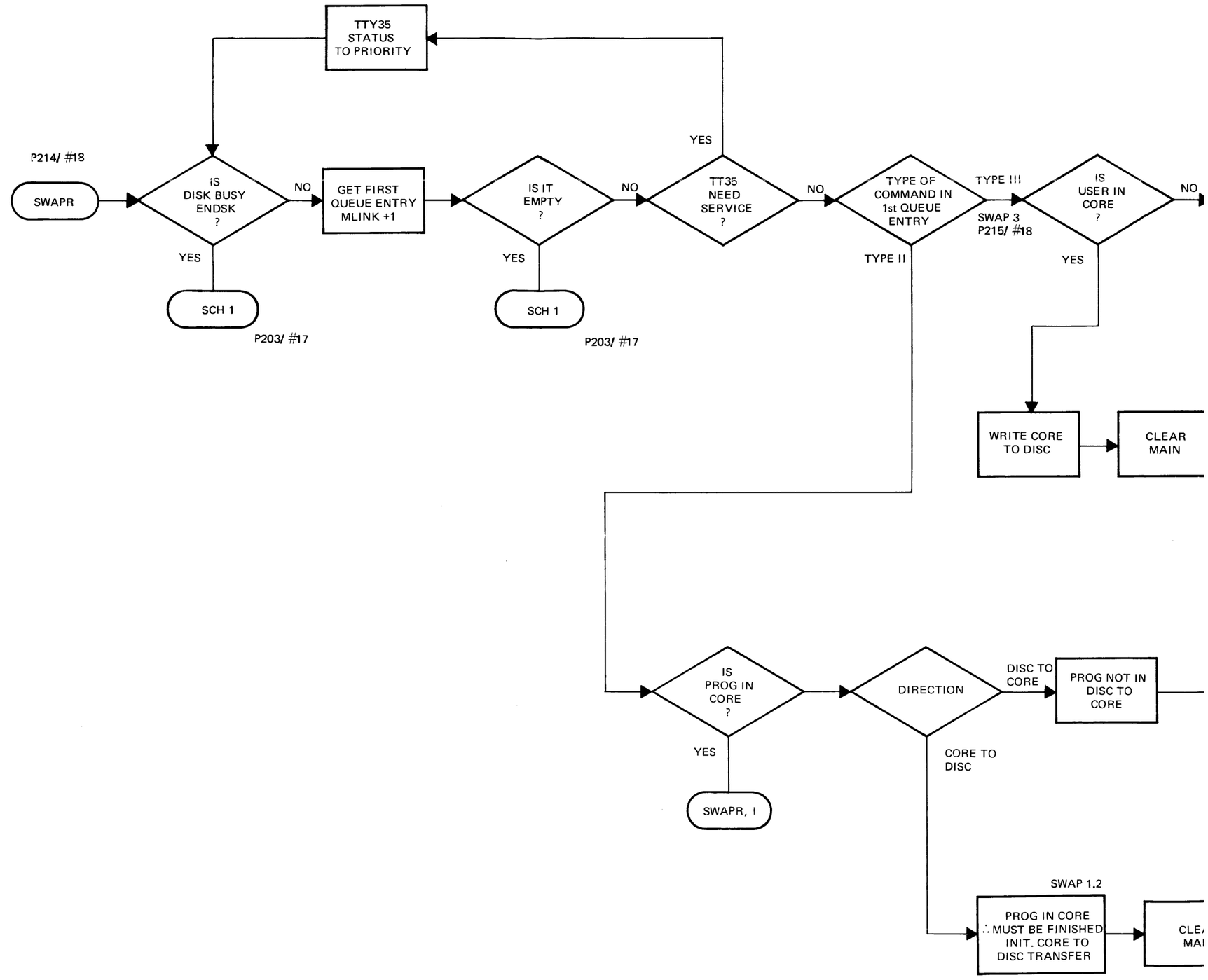


FIGURE 11. SCHEDULER (SCHED)


TTY35
STATUS
TO PRIORITY
P214/ #18
SWAPR
IS
DISK BUSY
ENDSK
?
NO
YES
SCH 1
P203/ #17
GET FIRST
QUEUE ENTRY
MLINK +1
IS IT
EMPTY
?
NO
YES
SCH 1
P203/ #17
YES
TT35
NEED
SERVICE
?
NO
TYPE OF
COMMAND IN
1st QUEUE
ENTRY
TYPE III
SWAP 3
P215/ #18
TYPE II
IS
USER IN
CORE
?
NO
YES
WRITE CORE
TO DISC
CLEAR
MAIN
IS
PROG IN
CORE
?
YES
SWAPR, I
DIRECTION
DISC TO
CORE
PROG NOT IN
DISC TO
CORE
CORE TO
DISC
SWAP 1,2
PROG IN CORE
∴ MUST BE FINISHED
INIT. CORE TO
DISC TRANSFER
CLEA
MAI

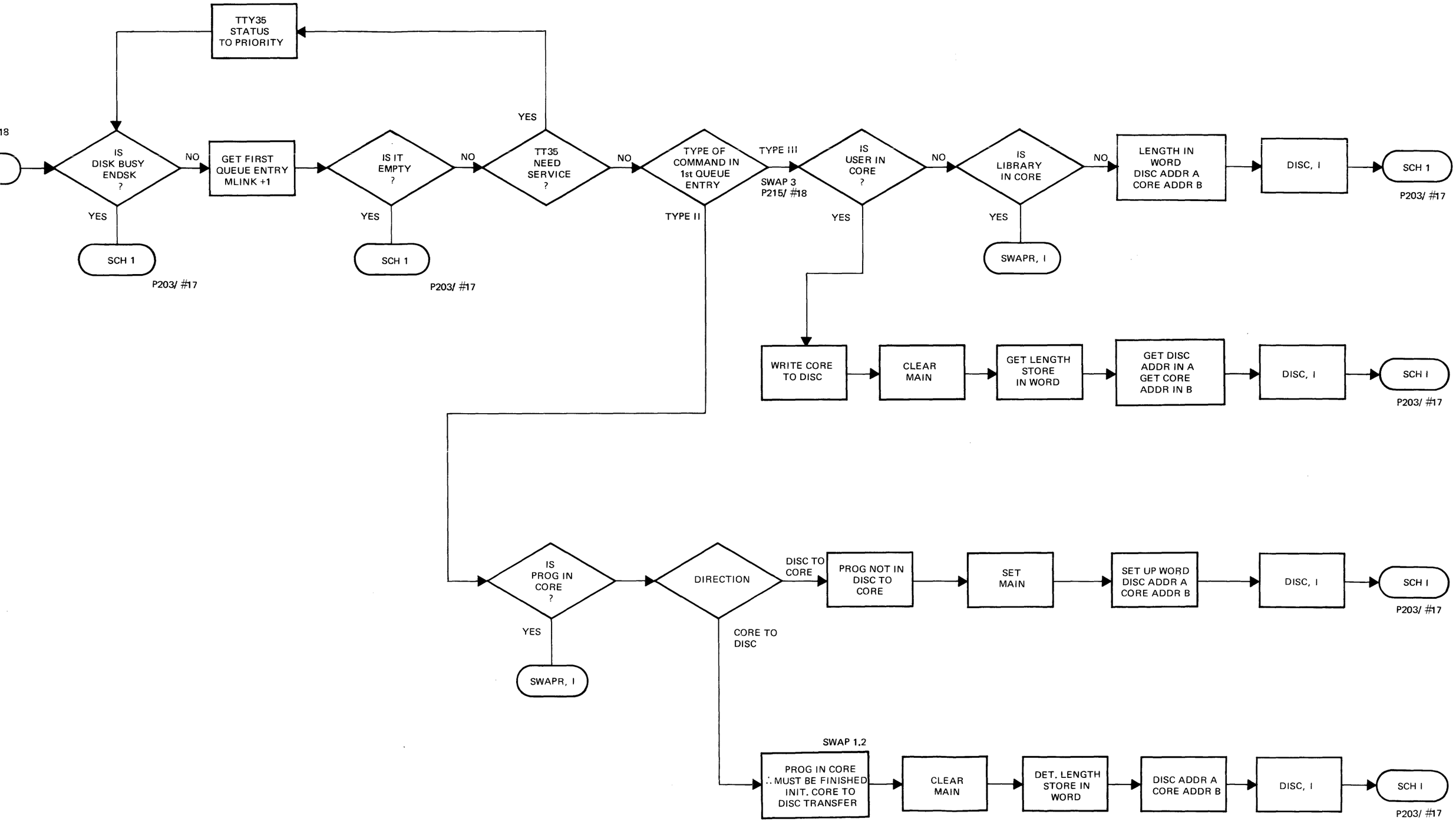


FIGURE 12. SCHEDULER (SWAPPER)

time share tables

VI

CHAPTER 6
TIME SHARE TABLES

The Time Share system uses a number of tables. An understanding of these tables is helpful when working with the HP 2000A system. Some are core resident and some are disc resident.

6-1 TELETYPE TABLES

The teletype tables consist of sixteen tables, one per user. Each table consists of twenty-six words (twenty-three entries). Table 7 gives a listing of the teletype table with the core address for each entry. During certain operations, some of the data from the respective teletype table is transferred to the base page, giving easier access to the data.

Some entries are fixed by the operating system. These include:

MASK — A "one" in the bit corresponding to the port number and allows AND and EOR type instructions to update pointers.

BGIN — Associated with each port is a 50 word buffer. BGIN is the address of the first word.

BEND — BEND is the address of the next word following the end of the physical buffer.

LADR — The multiplexor contains a ladder sub program. LADR is the address of an instruction corresponding to the user port. This allows this instruction to be changed from an ISZ to a JMP from time to time.

Certain entries are of general interest. These include:

ID — Whenever a user successfully logs on his ID code is placed in this location.

NAME — The name of the current program is contained in these three words. When the name is less than six characters, blanks are used to fill out the three words.

TIME — This two word entry contains the time of day at log on. It is used to update the accounting information at log off.

DISC — This contains the disc address of the first sector of the swap area. To facilitate swapping, it is not required that the first sector of the program coincide with the track origin.

PROG — This entry monitors the amount of required core by pointing to the last word used in the swap area.

Associated with the Scheduler are five of the teletype table entries.

LINK	This entry contains the address of the next user on the Queue. The contents has significance only if the user is on the queue.
PLEV	This word is used in conjunction with LINK and contains the priority of the user when he is entered on the queue.
STAT	This contains the status of the user.
RSTR	Contains the starting address of the program when initially placed on the queue, or the restart address when suspended.
CLOC	This entry has the time of day value when his time slice will run out.

Two entries are used for general timing.

PHON	Is used for timing required by the Phones Logic, including log on and disconnect timing.
ABCN	This is a counter used by the multiplexor to handle possible abort timing.

A number of the entries are used by the multiplexor for the input/output communications and for buffering.

BTIM	Is a counter location to count the multiplexor interrupts corresponding to the individual bits.
CHAR	Is a location which contains the current character being processed. The character is input or output a bit at a time and the packing or unpacking is done in this location.
BCNT	Counts the number of bits within a character for both input and output mode.

Four entries remain. They are associated with the character buffer for input and output.

CCNT	Contains the number of characters to be output including the current one. The number is in minus form.
BPNT	Points to the location in which the next input character will be placed. In output it points to the character currently being transmitted.
BSTR	Points to the first character of the current line.
BHED	Points to the head of the input or output character sequence.

For keyboard input, BSTR=BHED. In tape mode, however, multiple input lines may exist. BSTR points to the start of the current input line. At the end of a line, it points just beyond the line. BHED points to the beginning of the next line requiring service by Basic. When Basic completes the processing of a line, BHED is

advanced to the next line. In this mode of operation the buffer must act as a wrap around buffer. When a character would exceed the physical buffer (i.e., equals BEND) it is placed at the beginning BGIN.

During output the buffer acts as a wrap around buffer. BPND points to the character being transmitted. BSTR points to the location into which the next character will be deposited.

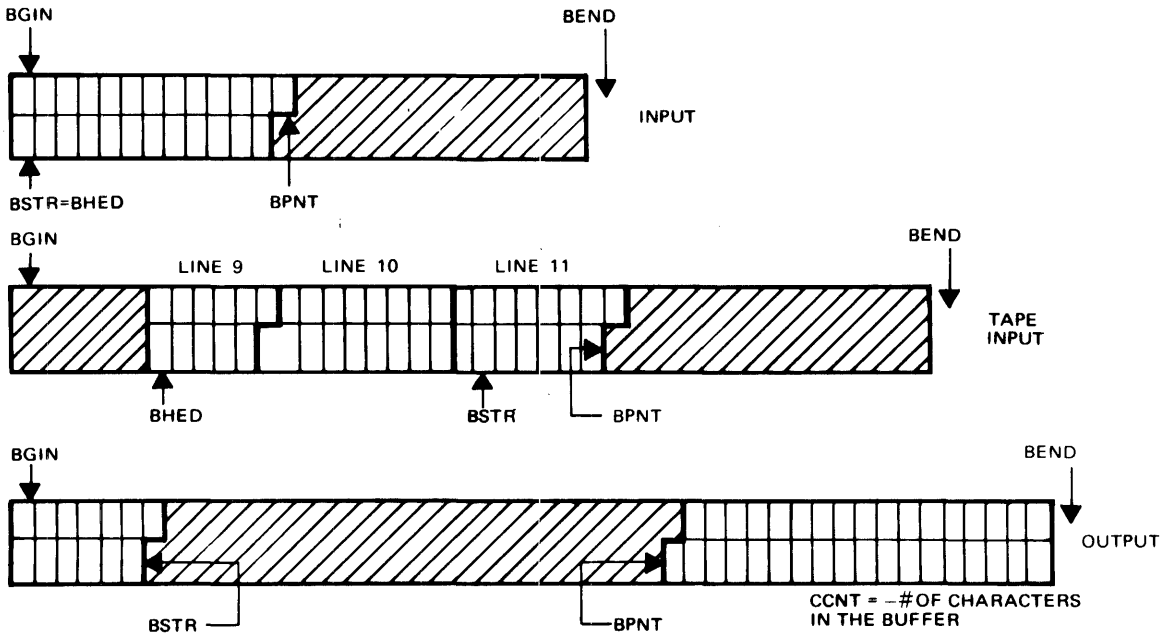


FIGURE 13. INPUT/OUTPUT BUFFERING

Figure 13 shows a diagrammatic representation of the buffer pointers. The Input example shows BSTR=BHED. The input line originates at the start of physical buffer. BPNT points to the location to be used by the next character. After processing by the system or basic BPNT will be reset to BSTR for the next input line.

The Tape input example shows three lines of input data. BHED points to the beginning of the next line remaining to be processed by basic. BPNT indicates the position of the next character input by the multiplexor. In this example, the buffer has wrapped around one or more times.

In the output example, output lines have no significance. BPNT is the position into which the next character will be appended by the system. BSTR points to the current character being output. CCNT maintains a count of the number of characters remaining to be output. In this case, the buffer has wrapped around one or more times.

6-2 DIRECTORY

The Directory is a disc resident table containing information on every program and file. It includes the public library and individual users. The directory contains one disc track for each logical disc (up to 4). When a disc is removed, the directory track is not deleted. Thus, the number of directory tracks represents the maximum number of discs which have been on the system.

Each directory entry contains eight words. Figure 14 shows the format for the directory entry. These entries are sorted by words 0 to 3. Word 0 allows sort by ID codes. Then within each ID code, words 1 to 3 allow sort by program or file name. Bit 15 of words 1 and 2 are ignored for the sort.

The first and last entries in the directory table are pseudo entries. The date insures these entries will not be lost due to the PURge command. The values of words 0 to 3 insure these will be the first and last entries respectively in the Directory. Figure 14 also shows a specific example of a directory entry.

The maximum number of Directory entries is 680 per track. Routines exist which distribute the entries over all directory tracks whenever a track is filled up. This tends to minimize the time required for adding, deleting and searching for an entry.

The equipment table contains entries with information about the directory. DIREC contains seven words for each of the four possible directory tracks. It is located from address 100 to 133. The first location is the length of that directory track. The next four words repeat the first four words of the first entry on the track, and provide sort information about the contents of the track. The sixth word is unused. The last word contains the disc address for that track. These entries are repeated for the other three directory tracks if required. A disc address of 0 indicates the directory track is not set up.

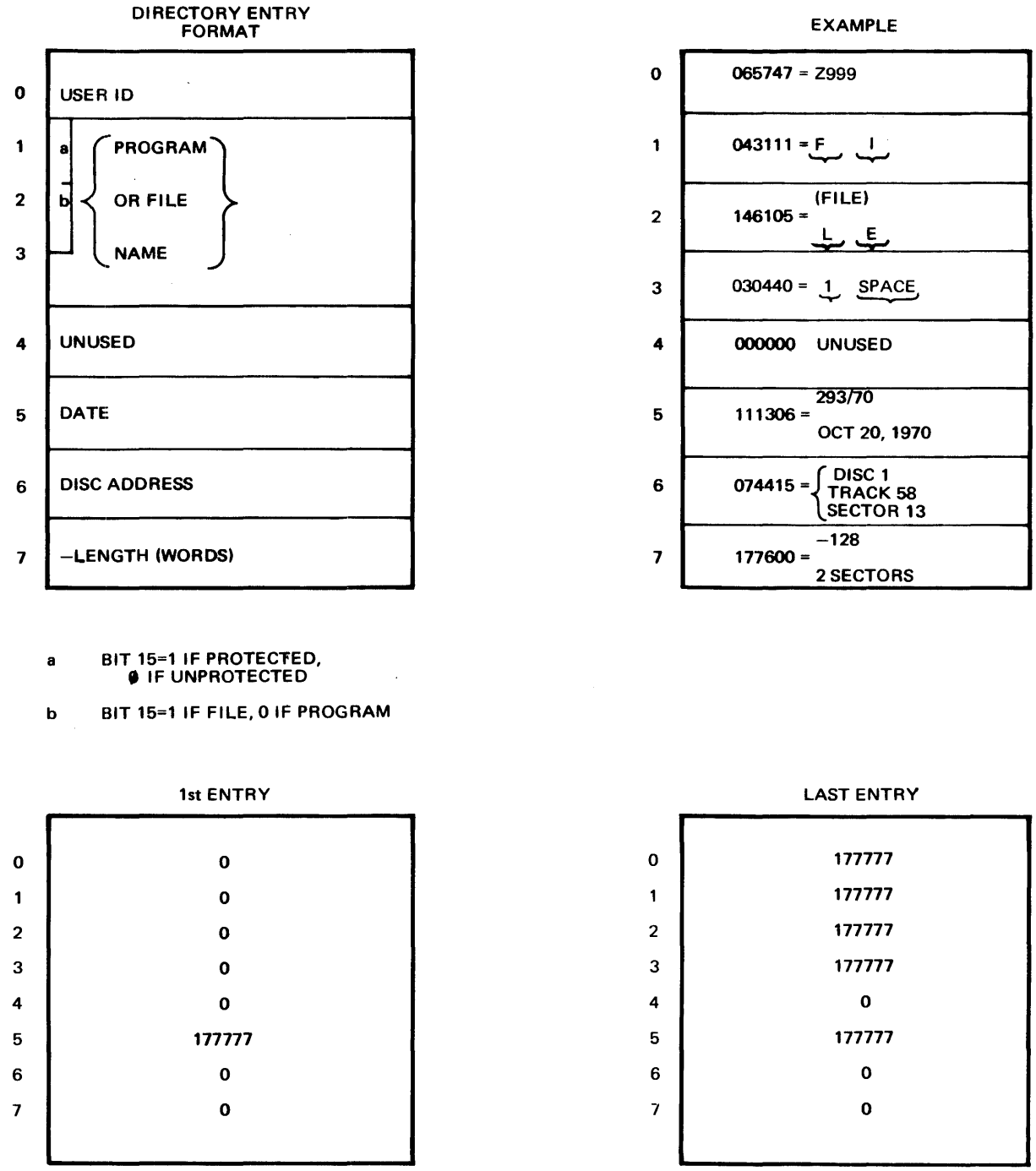


FIGURE 14. DIRECTORY ENTRIES

6-3 EQUIPMENT TABLE

Core locations 100 to 166 contain the Equipment Table. Locations 100 to 137 deal with the Directory, AD and ID tables.

Locations 140 to 157 are used to indicate which disc tracks are available for the system. Each logical disc requires four words. Each track is represented by a bit. A one in the bit indicates the track is locked off. A zero indicates the track is available. For example, address 140=000020 indicates that track of the first logical disc is locked off. The same contents at 142 would indicate track 37.

The information concerning the disc addresses are contained in address 160 to 163. Figure 15 shows the format for this data.

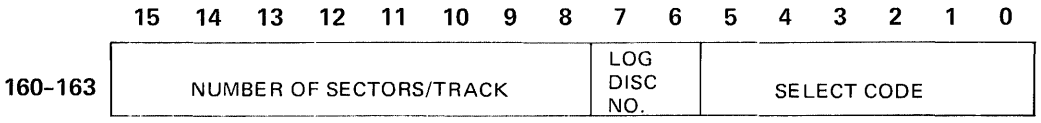


FIGURE 15. LOGICAL DISC INFORMATION

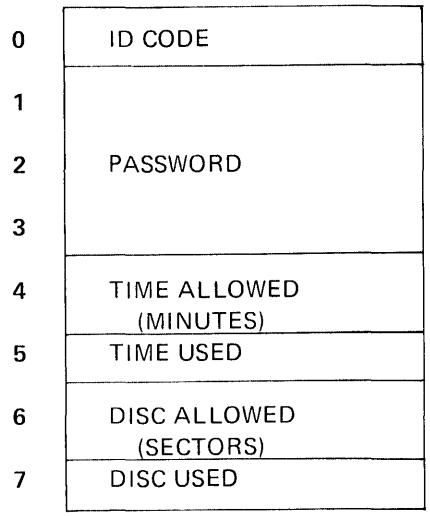


FIGURE 16. ID TABLE ENTRY FORMAT

The Select Code for the Mag Tape interface is contained in address 164. 165 contains the Select Code of the phones board. 166 has the log on time constant associated with the phones option. It is the number of seconds allowed times ten.

6-4 ID TABLE

The AD and ID tables are disc resident. They share the same track.

The ID table is a list of information associated with each assigned ID code. Figure 16 shows the format for each ID table entry. Words 4 to 7 use the full 16 bits for magnitude allowing values from 0 to 65535.

IDLOC is a word in the equipment table giving the disc address of the ID table. IDLEN provides the current length in words.

The ID table starts at the track origin, using as many sectors as necessary.

6-5 AD TABLE

The AD table is a list of all available space on the disc. The format is a two word entry. The first is the disc address of the first sector available. The second is the length of the area in sectors. This table begins at the first available sector following the ID table.

An entry exists for each of the system and swap tracks, but the length is zero. The last entry is a pseudo entry of the form: address 177777, length 0. Since track zero is required by the T.S. system, this insures that every entry is bounded by two AD entries.

Initially each track has an entry equal to the length of the track. As programs are saved and killed, the AD entry for that track expands or contracts keeping the available number of sectors updated.

Whenever a space is exactly used up, the AD entry is deleted. When an interior program is killed, a new AD entry is generated. This eventually leads to a situation where holes exist through out the disc. The sleep command repacks all programs and files on each track so that all available space is at the end of each track. Thus, after sleep, not more than one entry exists per track. Bringing up the system from mag tape sleep is even more efficient in packing. Programs are moved up filling the empty spaces on earlier tracks. Thus the available space occurs on the upper disc tracks.

6-6 FILE TABLE

The 128 word table FUSS resides on the disc. An eight word subtable exists for each of the 16 users. These words contain the disc address of each of the files currently being used by the user. Bit 7 of the word is set for read only access to the file. The first user declaring a file obtains the write capability. All subsequent users get read only access.

TABLE 4

EQUIPMENT TABLE

		FIRST DIRECTORY TRACK	
DIREC	00100	_____	LENGTH OF THIS TRACK
	00101	_____	First 5 words of this Directory Track (Pseudo Entry)
	00102	_____	
	00103	_____	
	00104	_____	
	00105	_____	
	00106	_____	DISC ADDRESS
		SECOND DIRECTORY TRACK	
	00107	_____	LENGTH OF THIS TRACK
	00110	_____	First 5 words of this Directory Track
	00111	_____	
	00112	_____	
	00113	_____	
	00114	_____	
	00115	_____	DISC ADDRESS
		THIRD DIRECTORY TRACK	
	00116	_____	LENGTH OF THIS TRACK
	00117	_____	First 5 words of this Directory Track
	00120	_____	
	00121	_____	
	00122	_____	
	00123	_____	
	00124	_____	DISC ADDRESS
		FOURTH DIRECTORY TRACK	
	00125	_____	LENGTH OF THIS TRACK
	00126	_____	First 5 words of this Directory Track
	00127	_____	
	00130	_____	
	00131	_____	
	00132	_____	
	00133	_____	DISC ADDRESS
IDLOC	00134	_____	DISC ADDRESS OF IDT
IDLEN	00135	_____	NEGATIVE LENGTH OF ID TABLE
ADLOC	00136	_____	DISC ADDRESS OF ADT
ADLEN	00137	_____	NEGATIVE LENGTH OF AD TABLE
		LOGICAL DISC ZERO	
TRAX	00140	_____	0-15 Track Lock/Unlock Bits
	00141	_____	16-31 0 = Unlocked
	00142	_____	32-47 1 = Locked
	00143	_____	48-63

TABLE 4 (CONTINUED)

EQUIPMENT TABLE

		LOGICAL DISC ONE	
TRAX (Con't)	00144	_____	0-15
	00145	_____	16-31
	00146	_____	32-47
	00147	_____	48-63
		LOGICAL DISC TWO	
	00150	_____	0-15
	00151	_____	16-31
	00152	_____	32-47
	00153	_____	48-63
		LOGICAL DISC THREE	
	00154	_____	0-15
	00155	_____	16-31
	00156	_____	32-47
	00157	_____	48-63
?TBL	00160	_____	Logical Disc Zero [0-5 = SC, 6-7 = Disc #, 8-15 = #Sect per Track]
	00161	_____	Logical Disc One
	00162	_____	Logical Disc Two
	00163	_____	Logical Disc Three
MAGSC	00164	_____	SC for Magtape, 0 if None
PHSC	00165	_____	SC for Phones Board
PHR	00166	_____	Log On Time Constant

TABLE 5

IMPORTANT CORE LOCATIONS

MPCOM	00234: _____	Bits indicate terminals attempting to communicate with scheduler
MAIN	00242: _____	Address of TTY table for terminal whose swap track is now in core (Ø indicates no swap track in core)
LIB	00243: _____	Address of a word containing the disc address of the program or overlay currently loaded in core at address 37300
ENDSK	00247: _____	If = 0 then disc transfer not in prog-
INPTF	00250: _____	ress. Bits indicate ports whose input is being deliberately ignored by the system. These bits are set to a 1 when a start bit is sensed and remain set until the system is ready to receive another character from the corresponding terminal.
WORD	00303: _____	Word count (-words) of last disc transfer
MLINK	00320: _____	First link of queue – contains address of link word in a TTY table which in turn contains address of next link word – ultimately one link points back to address 320 (could be as many as 18 words in Queue)
MLINK+1	00321: _____	
	_____	
	_____	
	_____	
AREG	02140: _____	A-Register at last program suspend
BREG	01241: _____	B-Register at last program suspend
EREG	01242: _____	E and OV registers at last prog. suspend
PREG	01243: _____	P-Register at last program suspend Check for swap track in correct position
DISC	30740: _____	Return address for last call to disc driver
DINT	30773: _____	Interrupt return address for disc driver
DFAIL	31062: _____	Disc retry counter (-10 to Ø)
DADDR	31057: _____	Disc address of last disc transfer
POW	31066: _____	Power fail interrupt return address
TT35	31342: _____	Return address for last call to ASR-35 driver
TT2	31361: _____	Interrupt return address for ASR-35 TTY

TABLE 5 (CONTINUED)

IMPORTANT CORE LOCATIONS

MPXNT	32127:	_____	Interrupt return address for TTY Multiplexor
CLKIN	34107:	_____	Clock Interrupt return address
LTEMP	00013:	_____	Temporary Locations
	00014:	_____	
	00015:	_____	
	00016:	_____	
	00017:	_____	
	00020:	_____	
	00021:	_____	Used by system library routines
	00022:	_____	
	00023:	_____	Important if crash occurred during execution of a system command
	00024:	_____	
	00025:	_____	
	00026:	_____	
	00027:	_____	
	00030:	_____	
	00031:	_____	
	00032:	_____	
OUTMI	00033:	_____	
MOVES	00040:	_____	Move routine source ADDR
MOVED	00041:	_____	Move routine destination ADDR

TABLE 6

CONTENTS OF LIB (243)

CONTENTS OF LIB.	ROUTINE LOADED AT ADDR. 37300	PAGE IN LISTING	CONTENTS OF LIB.	ROUTINE LOADED AT ADDR. 37300	PAGE IN LISTING
35662	LIBR. SIZES	232	35706	ECHO	298
35663	FUSS TABLE	233	35707	REPORT	299
35664	FILES	234	35710	RESET	302
35665	SAVE	240	35711	CHANGE ID	304
35666	SUPER SAVE	245	35712	DIRECTORY	307
35667	GET	251	35713	STATUS	311
35670	APPEND	254	35714	SLEEP	317
35671	HELLO	257	35715	SLEEP OVERLAY	322
35672	BYE	263	35716	NEW ID	328
35673	KILL	267	35717	KILL ID	332
35674	RENUMBER	272	35720	KILL ID OVERLAY	336
35675	NAME	278	35721	UNLOCK	342
35676	CATALOG	280	35722	LOCK	346
35677	LIBRARY	284	35723	LOCK OVERLAY	352
35700	DELETE	285	35724	PURGE	356
35701	TIME	287	35725	PURGE OVERLAY	362
35702	PROTECT	289	35726	ROSTER	366
35703	UNPROTECT	291	35727	DISC	368
35704	OPEN	292	35730	MAG TAPE	374
35705	LENGTH	297	35731	PHONES	375

NOTES

* Note a system command

** Not loaded at 37300

TABLE 7. TELETYPE TABLE

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
BTIM	33021	33053	33105	33137	33171	33223	33255	33307	33341	33373	33425	33457	33511	33543	33575	33627
CHAR	33022	33054	33106	33140	33172	33224	33256	33310	33342	33374	33426	33460	33512	33544	33576	33630
BCNT	33023	33055	33107	33141	33173	33225	33257	33311	33343	33375	33427	33461	33513	33545	33577	33631
MASK	33024 (1)	33056 (2)	33110 (4)	33142 (10)	33174 (20)	33226 (40)	33260 (100)	33312 (200)	33344 (400)	33376 (1000)	33430 (2000)	33462 (4000)	33514 (10000)	33546 (20000)	33600 (40000)	33632 (100000)
CCNT	33025	33057	33111	33143	33175	33227	33261	33313	33345	33377	33431	33463	33515	33547	33601	33633
BPNT	33026	33060	33112	33144	33176	33230	33262	33314	33346	33400	33432	33464	33516	33550	33602	33634
BSTR	33027	33061	33113	33145	33177	33231	33263	33315	33347	33401	33433	33466	33520	33552	33604	33636
BHED	33030	33062	33114	33146	33200	33232	33264	33316	33350	33402	33434	33466	33520	33552	33604	33636
BGIN	33031 (67542)	33063 (67706)	33115 (70052)	33147 (74134)	33201 (74300)	33233 (74444)	33265 (74610)	33317 (74754)	33351 (63272)	33403 (63436)	33435 (57756)	33467 (47752)	33521 (53752)	33553 (63602)	33605 (63746)	33637 (64112)
BEND	33032 (67706)	33064 (70052)	33116 (70216)	33150 (74300)	33202 (74444)	33234 (74610)	33261 (74754)	33320 (75120)	33352 (63436)	33404 (63602)	33436 (60122)	33467 (50116)	33521 (54116)	33553 (63746)	33605 (64112)	33637 (64256)
LADR	33033 (32337)	33065 (32343)	33117 (32347)	33151 (32353)	33203 (32357)	33235 (32363)	33267 (32367)	33321 (32373)	33353 (32377)	33405 (32403)	33437 (32407)	33471 (32413)	33523 (32417)	33555 (32423)	33607 (32427)	33641 (32433)
DISC	33034	33066	33120	33152	33204	33236	33270	33322	33354	33406	33440	33472	33524	33556	33610	33642
PROG	33035	33067	33121	33153	33205	33237	33271	33323	33355	33407	33441	33473	33525	33557	33611	33643
ID	33036	33070	33122	33154	33206	33240	33272	33324	33356	33410	33442	33474	33526	33560	33612	33644
NAME (3)	33037-41	33071-73	33123-25	33155-57	33207-11	33241-43	33273-75	3325-27	33357-61	33411-13	33443-45	33475-77	33527-31	33561-63	33613-15	33645-46
PHON	33042	33074	33126	33160	33212	33244	33276	33330	33362	33414	33446	33500	33532	33564	33616	33650
TIME (2)	33043-44	33075-76	33127-30	33161-62	33213-14	33245-46	33277-60	33331-32	33363-64	33415-16	33447-50	33501-02	33533-34	33565-66	33617-20	33651-52
ABCN	33045	33077	33131	33163	33215	33247	33301	33333	33365	33417	33451	33503	33535	33567	33621	33653
CLOC	33046	33100	33132	33164	33216	33250	33302	33334	33366	33420	33452	33504	33536	33570	33622	33654
RSTR	33047	33101	33133	33165	33217	33251	33303	33335	33367	33421	33453	33505	33537	33571	33623	33655
STAT	33050	33102	33134	33166	33220	33252	33304	33336	33370	33422	33454	33506	33540	33572	33624	33656
LINK	33051	33103	33135	33167	33221	33253	33305	33337	33371	33423	33455	33507	33541	33573	33625	33657
PLEV	33052	33104	33136	33170	33222	33254	33306	33340	33372	33424	33456	33510	33542	33574	33626	33660

time share loader

VII

CHAPTER 7
TIME SHARE LOADER

7-1 LOADER

The Time Share Loader has the following primary operation modes:

1. A paper tape load of a completely new system. This implies no ID codes, no library, etc.
2. A load from disc following a disc sleep.
3. A load from mag tape following a mag tape sleep.
4. An update to the system which retains the ID's, public and user library but updates or replaces the operating system. This would include updating from 2000A Version E to Version F, or an update from the 2000A to 2000B.
5. The final mode is an attempt to resuscitate following operator error or hardware or software failure.

7-2 PAPER TAPE LOAD

This is the initial load of a Time Share system. We can follow the sequential steps by following the loader block diagram. Refer to figure 17. The loading is initiated by first loading the HP 2000A Time Share Loader Tape HP 20872F. This is loaded using the protected binary loader at address 37700. The Loader starting address is 2000.

The first question is "LIBRARY?" The answer is 'NO cr ' This initiates the system generation and sets system generation flag, creates the equipment table, sets number of sectors for disc 0, and locks discs 1,2,&3. The question "SECTORS/TRACK ON DISC-Ø?" is answered '90 cr' for 2770, 2771 discs or '128 cr' for 2773,2774 and 2775 drums or 2766 disc.

The system must now set up the disc tables. It asks "DISC MODIFICATIONS?" This allows adding logical discs 1 to 3 if available. The system gets the disc number, select code, and number of sectors. It then updates the equipment table entries ?TBL. This is terminated by the carriage return instead of another disc command. The system now builds the available Disc table for all sixty-four tracks of each logical disc.

The system then asks "GIVE LOCK, UNLOCK OR LOAD COMMAND." The system uses the LOCk and UNLock commands to update the equipment table TRAX entries. The sequence is terminated by the LOAD command. At this point the T.S. system tape (part 1 of 2) must be in the photoreader.

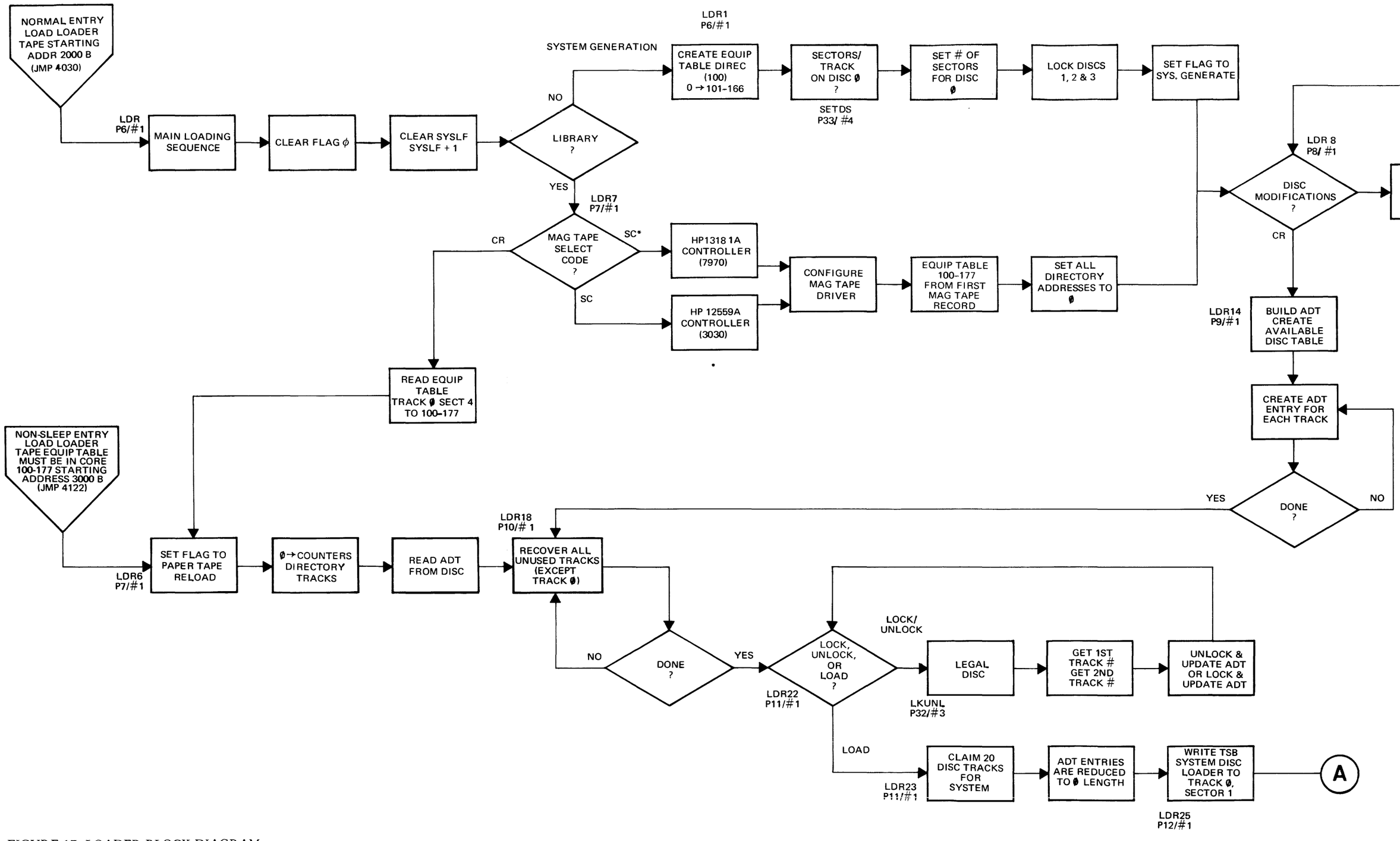
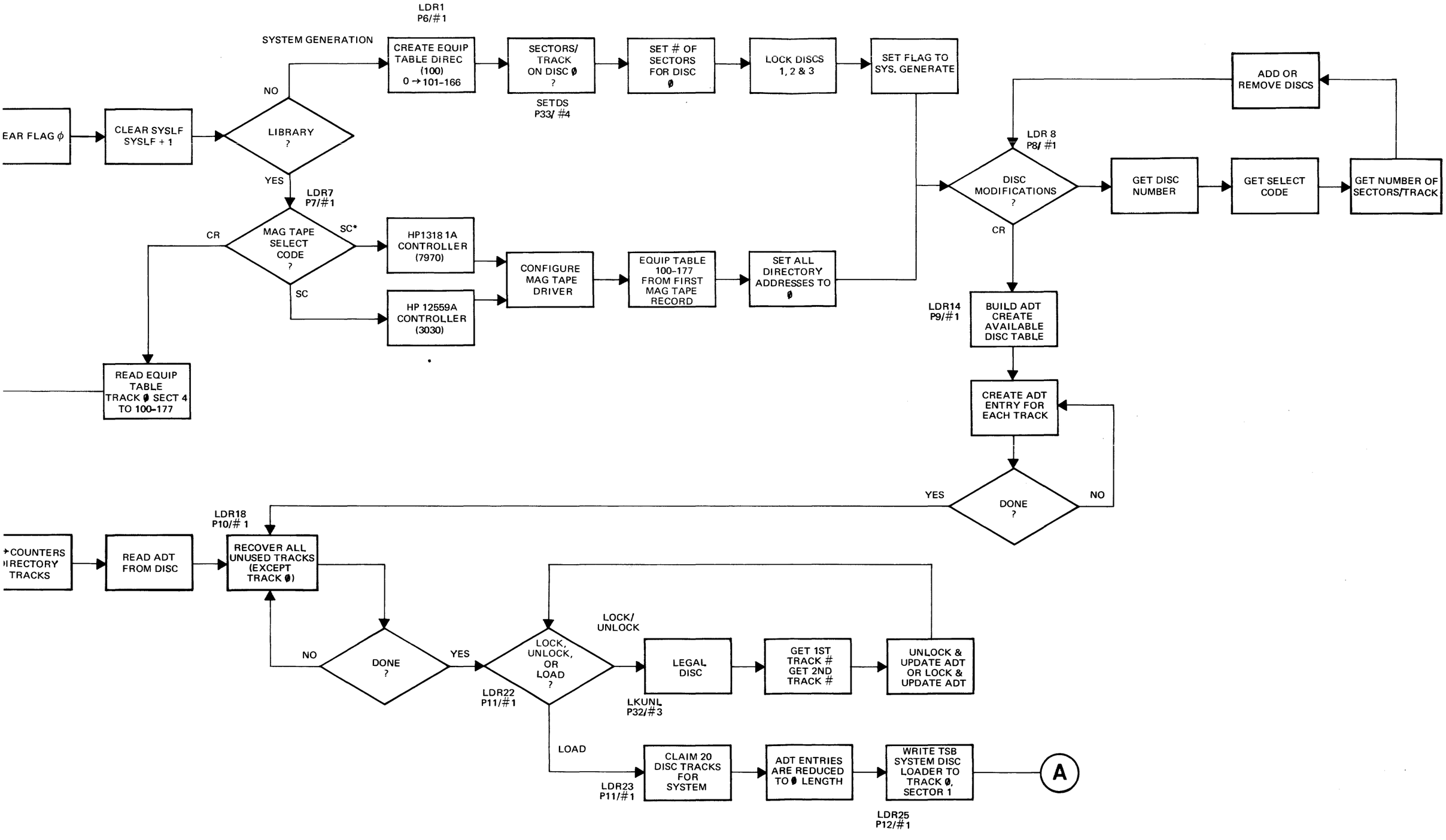
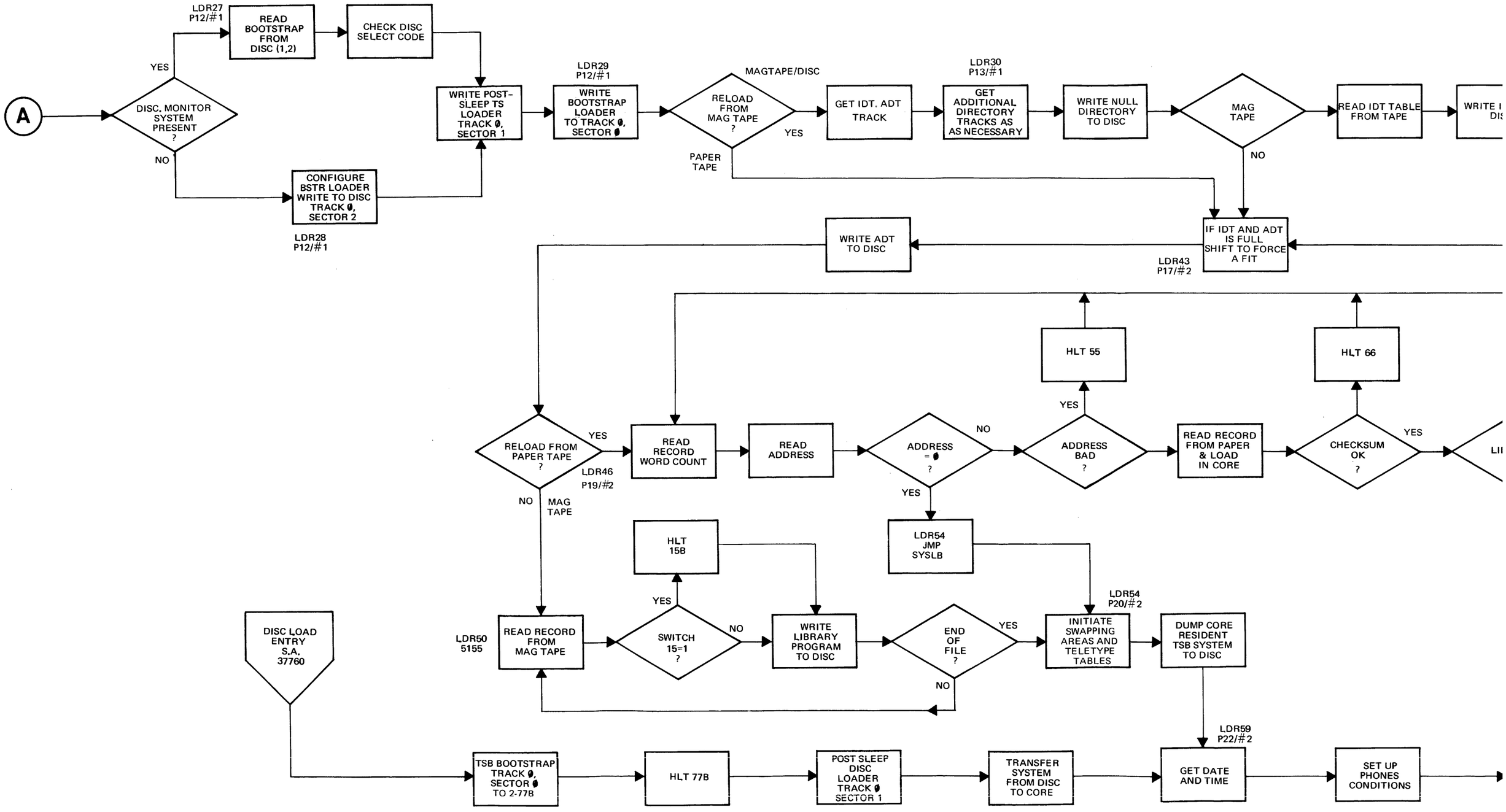


FIGURE 17. LOADER BLOCK DIAGRAM
SHEET 1 OF 2


LDR1
P6/#1
SYSTEM GENERATION
CREATE EQUIP TABLE DIREC (100) 0→101-166
SECTORS/ TRACK ON DISC ∅ ?
SETDS
P33/ #4
SET # OF SECTORS FOR DISC ∅
LOCK DISCS 1, 2 & 3
SET FLAG TO SYS. GENERATE
NO
LIBRARY ?
YES
LDR7
P7/#1
MAG TAPE SELECT CODE ?
CR
SC*
SC
HP1318 1A CONTROLLER (7970)
HP 12559A CONTROLLER (3030)
CONFIGURE MAG TAPE DRIVER
EQUIP TABLE 100-177 FROM FIRST MAG TAPE RECORD
SET ALL DIRECTORY ADDRESSES TO ∅
READ EQUIP TABLE TRACK ∅ SECT 4 TO 100-177
LDR8
P8/ #1
DISC MODIFICATIONS ?
ADD OR REMOVE DISCS
GET DISC NUMBER
GET SELECT CODE
GET NUMBER OF SECTORS/TRACK
LDR14
P9/#1
BUILD ADT CREATE AVAILABLE DISC TABLE
CREATE ADT ENTRY FOR EACH TRACK
DONE ?
YES
NO
LDR18
P10/# 1
READ ADT FROM DISC
RECOVER ALL UNUSED TRACKS (EXCEPT TRACK ∅)
DONE ?
NO
YES
LOCK, UNLOCK, OR LOAD ?
LDR22
P11/#1
LOCK/ UNLOCK
LEGAL DISC
LKUNL
P32/#3
GET 1ST TRACK # GET 2ND TRACK #
UNLOCK & UPDATE ADT OR LOCK & UPDATE ADT
LOAD
CLAIM 20 DISC TRACKS FOR SYSTEM
LDR23
P11/#1
ADT ENTRIES ARE REDUCED TO ∅ LENGTH
WRITE TSB SYSTEM DISC LOADER TO TRACK ∅, SECTOR 1
LDR25
P12/#1
A


A
DISC. MONITOR SYSTEM PRESENT ?
YES
NO
LDR27 P12/#1
READ BOOTSTRAP FROM DISC (1,2)
CHECK DISC SELECT CODE
CONFIGURE BSTR LOADER WRITE TO DISC TRACK 0, SECTOR 2
LDR28 P12/#1
WRITE POST-SLEEP TS LOADER TRACK 0, SECTOR 1
LDR29 P12/#1
WRITE BOOTSTRAP LOADER TO TRACK 0, SECTOR 0
RELOAD FROM MAG TAPE ?
MAGTAPE/DISC
YES
PAPER TAPE
GET IDT, ADT TRACK
LDR30 P13/#1
GET ADDITIONAL DIRECTORY TRACKS AS AS NECESSARY
WRITE NULL DIRECTORY TO DISC
MAG TAPE
NO
READ IDT TABLE FROM TAPE
WRITE I DIS
IF IDT AND ADT IS FULL SHIFT TO FORCE A FIT
LDR43 P17/#2
WRITE ADT TO DISC
HLT 55
HLT 66
YES
RELOAD FROM PAPER TAPE ?
YES
LDR46 P19/#2
NO
MAG TAPE
READ RECORD WORD COUNT
READ ADDRESS
ADDRESS = 0 ?
NO
YES
ADDRESS BAD ?
READ RECORD FROM PAPER & LOAD IN CORE
CHECKSUM OK ?
YES
LI
LDR54 JMP SYSLB
HLT 15B
YES
LDR54 P20/#2
DISC LOAD ENTRY S.A. 37760
LDR50 5155
READ RECORD FROM MAG TAPE
SWITCH 15=1 ?
NO
WRITE LIBRARY PROGRAM TO DISC
END OF FILE ?
YES
NO
INITIATE SWAPPING AREAS AND TELETYPE TABLES
DUMP CORE RESIDENT TSB SYSTEM TO DISC
LDR59 P22/#2
TSB BOOTSTRAP TRACK 0, SECTOR 0 TO 2-77B
HLT 77B
POST SLEEP DISC LOADER TRACK 0 SECTOR 1
TRANSFER SYSTEM FROM DISC TO CORE
GET DATE AND TIME
SET UP PHONES CONDITIONS

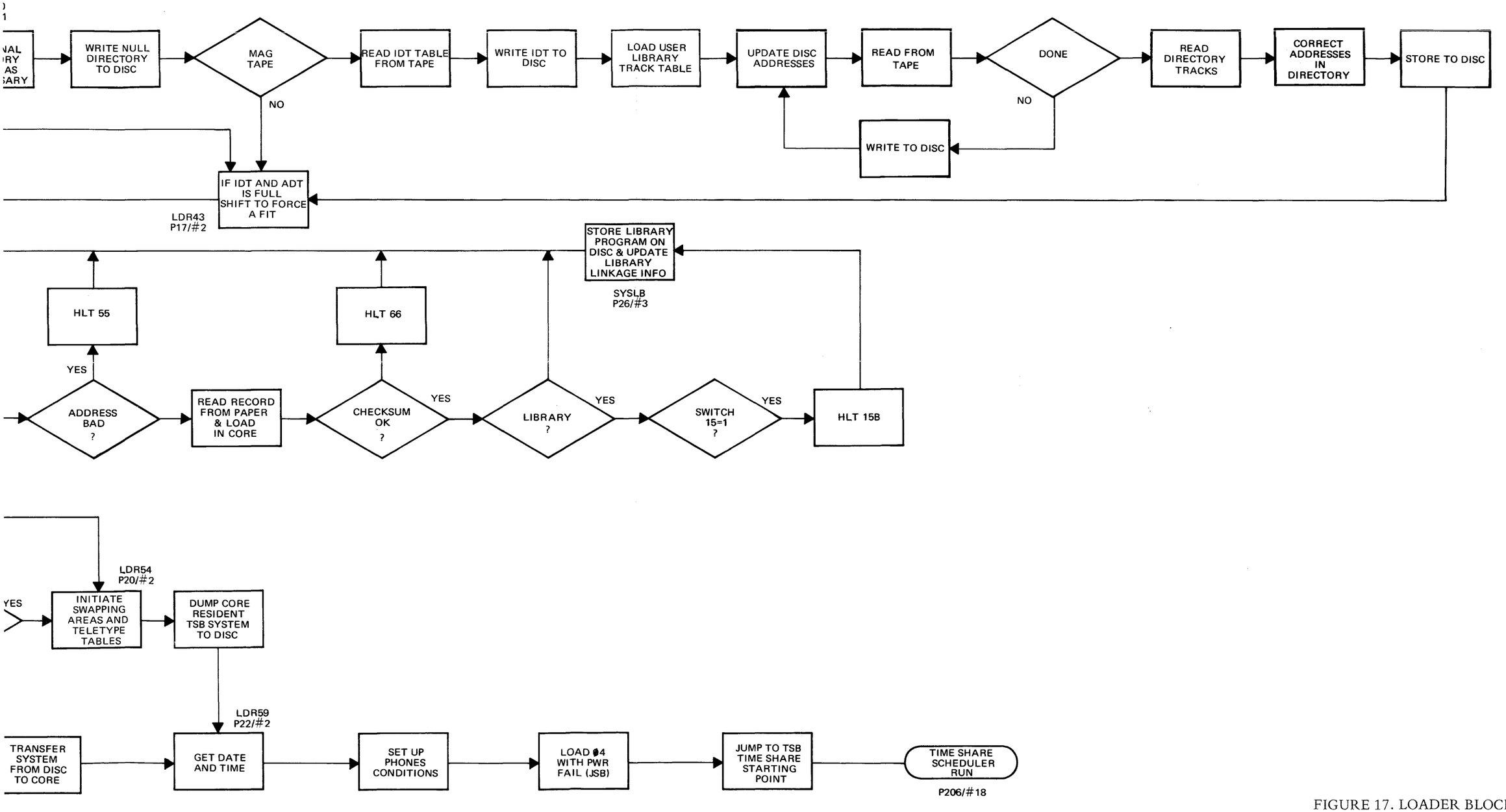


FIGURE 17. LOADER BLOCK DIAGRAM
SHEET 2 OF 2

The 20 system tracks are claimed and the ADT entries for those tracks are set to zero. The T.S. disc loader is written to track 0, sector 1. The question "DISC MONITOR PRESENT?" allows the DOS system to be resident on the DISC. The DOS bootstrap is on track 0, sector 2. The bootstrap loader is written to track 0, sector 0.

The loader now reads the paper tape records and begins to fill core. These records are in regular absolute assembly format. The first byte is the number of words in the record. The second byte is 0. The second word is the core address for the first data entry. Following the last data word in the record is the check sum word. As these records are entered, the system checks for valid address and checksum. The first system tape is read in. The break between the two tapes is completely arbitrary. A group of 10 feed holes between records is evaluated as the end of the first tape. The Part 2 of 2 is then placed in the reader and loading continues.

When the first library program is encountered, and for each succeeding one, the status of bit 15 switch is checked. A "1" results in a HLT 15B allowing patching to take place. Pushing RUN results in writing to the disc the preceeding program. More about this switch 15 option later.

When all library programs are completed, a record at address 0 signifies the end of the paper tape read. The library programs require 2 disc tracks.

The system now initializes the user swap area and the teletype tables for all 16 users. Certain information must be generated, i.e., mask bit, buffer beginning and end, logical buffer head and pointer. This information is placed both in the teletype core table and written to the user swap track for the language processor.

The core resident system is written to disc. Core addresses 0 to 12000 are placed in track 0 starting at Sector 3. Core locations 14000 to 26500 are written to the second system track. Core locations 26500 to 37300 are written to the third system track.

The system now requests the "DATE" and "TIME." With this information, it sets up the two time of day counters, one in tenths of seconds, the other in hours of the year. The power fail halt is replaced with the jump to power fail subroutine. The system then jumps to the TSB entry in the scheduler.

At TSB, the time base generator is set for 100 msec interrupts and the multiplexor is started. The system console prints "READY". The system enters the Scheduler loop at SCH1. This completes the Paper tape load.

The system is up and running, but is clean. There are no entries in the ID table. The AD table contains an entry for each disc track. The entries for all system tracks show an available length of 0 sectors, thus preventing subsequent allocation. All other tracks show a length equal to the number of sectors per track for the disc or drum. The final pseudo entry completes the ADT. The Directory has just the 2 pseudo entries.

To make a useful system, the system operator must log on new ID's for himself and other users. He may want to add public library. He may desire to use equipment commands to add mag tape and phones.

7-3 AWAKEN FROM DISC

Mose of the Loader steps are bypassed when bringing up a time share system from the Disc. The assumption is that an operating system existed and was satisfactorily slept.

The procedure uses the protected disc loader option at address 37760. This reads the time share bootstrap from track Ø, sector Ø into Location 2 to 77. This program halts at P=10 so the Loader Protect switch can be set to protected. It also allows the switch option bit 0="1" for a DOS.

The protected loader at 37760 sets up a DMA transfer from disc address track 0, sector 0 to core address 0, with transfer length 100B words. It then puts a jump self in address 77 and jumps to 77. The program stays there until the DMA transfer is completed. The final word is a JMP 35 which is placed in location 77. This allows a jmp to the 2-77 program when the transfer is done. The disc parity is checked. If satisfactory a halt 77 is executed. This allows protecting the binary loader before proceding.

Pushing RUN again initiates the transfer of the Post-Sleep Disc Loader from disc track 0, sector 1 to core address 2436. This loader reads in the entire core resident system from the three system tracks. It then jumps to the Date/Time routine of the loader and continues to the Time Share Scheduler.

A few comments can be made at this time about the limitations of this process. The contents of the disc must be intact. The system can not operate if a disc failure occurs on a system track. A failure on a library track will result in the loss of all program and files resident on that track. If the time share system was not terminated with a sleep command, this awaken from the disc may not be successful.

7-4 AWAKEN FROM MAG TAPE

The process of bring up the system from a mag tape sleep requires that the Time Share Loader paper tape be loaded first. The starting address is 2000. The 'YES' answer to the question"LIBRARY?" indicates that the reload is from mag tape or disc, and is not a new system generation.

The "mag tape select code?" is answered with the select code information if a mag tape is present. The select code followed by an "*" indicates the mag tape controller is an HP 13181A Interface (7970A). The absence of the "*" indicates an HP12559A Interface (3030). An answer of select code Ø indicates this is a system update and will be covered under that section. If a satisfactory select code is given, the mag tape driver is configured. The EQT table is read from the first tape record to core starting at address 100. The directory addresses are then set to zero in the equipment table to allow reassigning the system tracks.

The "DISC Modifications?" question allows changes to be made. If no changes are required, the hardware system will be the same as when slept. The ADT table is built up as in the paper tape load example.

The "LOCK, UNLOCK, OR LOAD?" allows changes to be made otherwise the tracks will be the same as at last sleep.

The necessary tracks for the system are allocated. The "Disc Monitor Present?" proceeds as before, and the configured bootstrap is written to the disc.

The IDT, ADT track is read from mag tape and a track is claimed. The proper number of directory tracks are claimed.

The track length table corresponding to the track images for all library is read. One by one the tracks are read in from tape and written to the disc. The old and new address are put in a table so the directory table can be updated. The ADT is updated as the records are written.

The Directory track(s) are read in, updated and written to the disc.

The System Segment table is read from mag tape. This allows the core resident system to be read from mag tape to the correct core location. When the last segment is finished, the Disc resident Library is read from mag tape and written to the disc. This is terminated at the EOT mark.

The user teletype tables and swap area are intitalized and loading continues as in the paper tape load to TSB and the scheduler loop.

7-5 SYSTEM UPDATE

The system update procedure provides a great deal of usefulness and power. It allows retaining the user and public library. In order to do this, it requires the Directory Tracks, IDT/ADT tracks, and Equipment table. The procedure replaces the system with a new system loaded from paper tape.

The normal entry is used. Load the Loader tape and start at address 2000. The "LIBRARY?" is answered 'YES cr' and "MAG TAPE SELECT CODE?" by cr. The lack of a valid select code tells the system it is a paper tape reload and not a mag tape restart. Thus, we will use the Equipment table on the disc. Read the Equipment table from disc track 0, sector 4 to core address 100. Proceed now to the non-sleep entry point.

Read the ADT for Disc to core. Recover 2 of 3 system tracks for core system (track 0 is necessary and cannot be recovered), 2 for library, and 16 user tracks.

Configure and write Bootstrap loader and TS loader to disc. Read core system from paper. Read from paper tape and write to disc all library programs. Initiate swap tracks and teletype tables, dump core system to disc. Get Date/Time. Jump to TSB and to scheduler loop.

This procedure will not work if track 0, or a directory track, or the IDT/ADT track is defective. Disc problems on any other system track will be okay if an unused track exists on the Disc. If disc problems occur on a user or public library track the lock command will cause a loss in the contents of the track.

7-6 CONVERSION VS UPDATE

The preceding discussion involves updating a system. An update utilizes the existing equipment table, Directory Tracks, and IDT/ADT. It provides a vehicle to replace the core resident program and library programs while retaining the user and public library programs and files.

It may be necessary to convert as well as update. Conversion was required in converting from Version I of the 2000A to Version II. This involved substantial changes in ADT due to the disc/drum capability of more sectors per track and disc organization. It is also necessary to convert the 2000A to 2000B. This involves changes in the Directory and equipment table.

In situations where both update and conversion is required it is necessary first to sleep the system. The conversion program is loaded and executed. This makes all necessary changes in the tables. Then the update procedure is followed with the load of the new system from paper tape.

7-7 LOADER SWITCH 15 OPTION

The use of switch 15 in the "1" position during load allows changes to be made to the system or library programs prior to writing to the disc.

The first halt 15 occurs when the core system is fully loaded. The correction can be made by toggling through the switch register, or by using the protected binary loader. In either case, the P register contents must be noted prior to the change. The P register must be reset before pushing RUN again. It is important not to push PRESET during these changes. The halt 15 occurs in the SYSLB routine in the loader.

Corrections to Library programs may also involve changes to the Library Sizes program. Library Sizes is the first Library segment loaded and stored. It contains the negative length of all library programs. A change to a library program which involves a length change must also be reflected in this library Size table. Library Sizes and all other Library programs are loaded into Location 37300.

The procedure for a correction would be first to determine the coding change, and then the new length. The first halt is the core resident system. Push RUN. The second halt is the Library Size table. At this time, the length correction can be made. It is helpful to DISPLAY MEMORY at 37300 and a few additional locations to insure the correct program is in core.

After making the length correction and restoring the P register, push RUN. Each halt corresponds to another library program loaded in core. The list in Library Sizes helps keep track of the sequence. It is helpful to DISPLAY MEMORY prior to the actual program requiring correction to insure you haven't passed it by miss counting. After all corrections are made, switch 15 can be lowered to facilitate the rest of the load process.

The contents of the A and B register do not have to be reloaded. It is important that PRESET not be pushed at any time.

7-8 NON-SLEEP RESTART

The non-sleep entry point uses the Equipment table in core. It also requires the contents of the Directory tracks and the IDT/ADT track to be complete and correct. The primary difference between the system update and the non-sleep restart is that in the update the Equipment table is read from the disc whereas in the non-sleep restart the Equipment table must be in core.

Note that this non-sleep restart requires loading the loader paper tape. It is not an attempt to restart the core resident program.

7-9 RESUSCITATION

Resuscitation is the art (not science) of recovering from system difficulties. These difficulties may be hardware failure, or operator error. It is difficult to anticipate the specific action required in resuscitation because of the large number of possible conditions and the subtle nature of the detective work. There are certain types of difficulties that can be covered generally. It is helpful to use the non-sleep entry in the loader. The following halts are possible failures requiring resuscitation. The non-sleep entry point for the Loader is at Location 3000.

7-10 DISC HALT

We shall consider some of the possible crash conditions. Halt 4 is a halt associated with a failure in the disc driver. Refer DISER in the interrupt section. This failure indicates either parity error or abort flag from the Disc Controller. Before halt 4 the read or write is attempted 10 times. The B register contains the core address. Bit 15 of the B register indicates read if "zero", write if "one". The A register contains the disc address (bits 14-15=logical disc, bits 8-13=track, bits 0-6=sector, bit 7 is unused). WORD contains the minus number of words to be transferred. The options available include locking the track if it is a user or public library. This will result in a loss of all contents of that track.

A failure of a system track is usually fatal. It may be worth while to try a non-sleep recovery. If this works immediately attempt a sleep. Then use a system update to lock the offending track. In any case, a mag tape rewake is the final solution, but this results in a loss of all activity since the time of the mag tape sleep.

Since track zero is always required, there is no way to get the system up until this track is repaired. It should be obvious that the contents of all remaining tracks should not be disturbed during repair procedures in order to salvage the contents of the system. It is necessary to recover the equipment table in order to salvage the system.

7-11 PARITY HALT

Another general class of failure is a parity halt. This would be caused by equipment malfunction. The halt 5 occurs by execution of the trap cell. A careful analysis of the failure is necessary. A parity error in the core resident system can be corrected by referring to the listings. An error, however, in tables or users swap areas may cause a fatal system crash.

It is important to have the switch on the parity board up in halt mode. This results in an immediate halt. The Parity Error Lamp will be illuminated. This is the indication that a parity error has occurred. In the down position, the board works in the interrupt mode. Phase 5, however, prevents the interrupt and parity errors due to DMA would be ignored.

In the case of a DMA parity error with the switch up, the P register will be the location at the time of the DMA parity error, but of course this will not be related to the actual DMA address causing the error because the DMA transfer continues to completion even though the CPU had halted due to the parity error. With the switch up the Halt 5 will not be executed but the Parity Error Light will be illuminated.

7-12 WRAP AROUND

It is possible, due to hardware difficulties, for the computer to wrap around memory. It may halt at address 2 on the base page. This is probably the most difficult single malfunction to diagnose. It is not apparent how much damage may have been done to the core system prior to the actual halt. It is desirable to shorten any possible loop before starting the resuscitation. Do this by removing the multiplexor cables and time base generator before starting the 3000 non-sleep restart. If successful immediately sleep. Then ascertain the hardware condition by running equipment diagnostics. Restart the system with a system update to insure the core resident system is correct.

7-13 SOFTWARE LOOP

In some cases a software loop may be produced. This might be a queue loop in the scheduler, or a skip if flag set wait for the mage tape, or some such loop. The program can be halted and single cycled to determine the nature of the loop. The Preset button must not be pushed. It should be pointed out that the SINGLE CYCLE will not allow an Interrupt phase 4 to take place. By holding the HALT button and pushing RUN, it accomplished the single cycle function but allows interrupts.

In diagnosing such a loop, it may be desirable to shorten the loop. This can sometimes be done by removing the multiplexor cables or disabling the Data Set phone answering, removing the Time Base Generator board, etc.

Certain data is extremely helpful in troubleshooting a crashed system. This includes the equipment table, base page temporaries, teletype tables, and other selected locations such as: MPCOM, MAIN, LIB, ENDSK, WORD, etc.

In general, it is much better to call for immediate help from the Service Technician or System Analyst before playing with a crashed system. Careless technique may obliterate any troubleshooting symptoms, and make a recoverable halt a non-recoverable crash.

7-14 OPERATING HALTS

The halts which can occur in the normal operating system follow (for 2000A Version F).

ADDR	HLT	PURPOSE
00002	102002	System protection against wrap around
00004	103004	Power Fail during Loading
00005	102005	Parity Error
31055	103004	Disc Error
31140	102000	Power Fail
10273	10277	Completed sleep (in loader-Mag Tape dump)

7-15 LOADER HALTS

There are various halts in the loader. During initial system load a halt during loading is not a problem. Since there is no user or public library, the system can be checked with diagnostics, repaired, and then reloaded.

When the system contains user and public library then halts are much more important. The following list of halts help locate the location in the listing. These halts are listed sequentially as they appear in the listing.

HLT, CODE	P REG	LISTING	PURPOSE
103004	00005	P2/#1	Power Fail
102077	05102	P17/#2	End of First System Tape
102066	05145	P20/#2	Checksum Error
102001	05433	P25/#2	Mag Tape Error (timing or parity)
102015	05443	P26/#3	Halt before writing to disc–allows changes
102055	07144	P41/#4	Address Outside of Expected Area
102022	04001	P52/#5	Halt to Insure Loader Tape is Loaded Ref P=10263
102077	10274	P52/#5	Sleep tape done–can repeat
102011	10317	P52/#5	Tape Bad or too Short
102033	10772	P63/#6	3030 Mag Tape write ring
102044	11005	P63/#6	3030 Mag Tape to Auto
102033	11413	P69/#6	7970 Mag Tape Write Ring
102044	11442	P69/#6	7970 Mag Tape to Auto
102002	02462	P80/#7	Disc Error during transfer
103004	00005	P81/#7	Power Fail
102000	00044	P81/#7	Disc Error during Bootstrap
102001	00044	P81/#7	Disc Error Following the Bootstrap check
102077	00010	P81/#7	Completion Loading of Bootstrap

7–16 KEY CORE LOCATIONS

Certain core locations are helpful for non–sleep restart, troubleshooting and resuscitation. Refer tables 4 to 7. The equipment table contains information in core which is not updated onto track 0 sector 4. The most obvious changes are in ADLEN and ADLOC, and directory length DIREC. Less frequent changes occur to the IDLEN and IDLOC, TRAX and changes in the directory reference locations. When a system is not slept, there is no record of the up–to–date equipment table except in core itself.

Certain core locations are of tremendous importance; such as, MPCOM, MAIN, LIB, ENDSK. Some of the locations shown are entry points for subroutines.

The LIB location 243 indicates which library program is in core. In the Teletype tables, certain locations are fixed including MASK, BGIN, BEND, and LADR. It should be obvious that if the port to the multiplexor is not in use, the corresponding teletype entry will not have significance. And further, if the ID entry is zero, then no user is currently logged on that port and the corresponding table is of no importance.

time share example

VIII

CHAPTER 8
TIME SHARE EXAMPLE

8-1 INTRODUCTION

The Time Share Listings may be quite formidable the first time a person starts to work with them. An example through the multiplexor and scheduler provides a mechanism to follow the activities of the system. It also provides an opportunity to tie together the functional flow charts.

The examples are complete. It is highly recommended that the reader try to forge ahead of the example by using the listings. Try to determine the course the system will take. Use the example to verify your conclusions.

The purpose of following the system action through this example is threefold. First, it acquaints the reader with many clever programming techniques. These include the use of pointers for access to tables, and the methods for moving the pointer through the table.

A second purpose is to familiarize the reader with some of the commonly used labels. It is helpful to see how the teletype tables are used, and how the base page helps for extensive use of certain teletype table entries. The third purpose if to give a feel for the activity in the multiplexor and scheduler. The skill developed in the example may be helpful in analysing a crashed system.

These examples are based on the current 2000A listings - Version F. It is possible to use previous listings C, D, or E. There will be slight differences. The page references may be off by one or two, and specific core locations may be off in come cases. Specifically, a shift in 2 memory addresses for certain program segments occurred in Version F. With these differences in mind, the example will still be useful.

8-2 MULTIPLEXOR EXAMPLE

The example we will use is a log on command. The user has a teletype hardwired to port 5. He turns the TTY to line and types: HELLO-HØØØ, SALES cr. To simplify the example, we will assume no other user activity. This will allow one new set up, one loader entry, one character to process, etc. We can focus in on all the relevant servicing for this one user without getting mired down with other users.

The first letter typed is the "H" in Hello. This is an eleven bit character requiring 100 milliseconds. Keep in mind this is a very long time period for the computer. For a normal typist, the time interval between the "H" and the "E" will also be quite long. Figure 18 shows a representation of the serial data from the teleprinter.

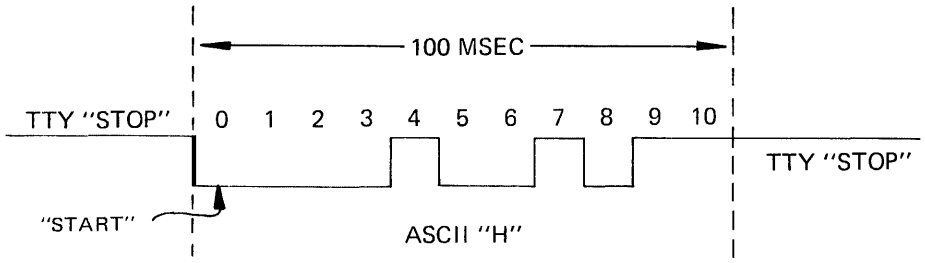


FIGURE 18. TELETYPE SERIAL DATA

The data requires 11 bits. The first is a start bit in position zero. The next eight are the ASCII representation. For letters they range in octal value from 101 for A to 132 for Z. Bit eight may be used for parity. Depending on the equipment used, it may be even or odd parity, or always zero or always set. In the HP 2749A Teleprinter this bit generates even parity.

In the 2000A, this bit is masked off. So it has no significance. Then two stop bits are sent, completing the character.

It may be hard at first to get a concept of relative time for the servicing of these TTY bits. There are 88 multiplexor interrupts during the time required for the letter "H". Of these interrupts, only 10 require specific servicing except to increment the bit counter each interrupt.

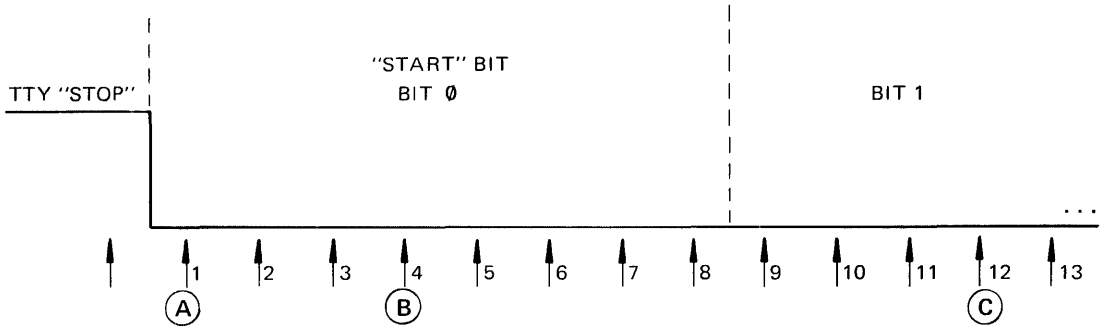


FIGURE 19. MULTIPLEXOR INTERRUPTS

The Interrupt designated A is the first "interrupt" occurring since the TTY data transition from the stop to start mode. We must start the new character processing. This requires about 160 microseconds.

The routine interrupts without specific tasks to perform require about 90 microseconds. Interrupt B is the next interrupt doing special servicing for our port. This interrupt represents the middle of bit. At this time, the output signal is sent to the teleprinter. Note that this produces a phase shift between the incoming and outgoing

data of about 4.5 milliseconds. Interrupt B and the other middle of bit interrupts require an additional 80 microseconds to process each new bit.

The interrupt occurring in the middle of bit number 9 is the end of character bit. This corresponds to interrupt number 76 as numbered in Figure 19. It is not necessary to process bit 10 because it must also be a stop bit. This end of character processing requires about 245 microseconds. There will be no further processing until the "A" interrupt for the Letter E at some subsequent time.

Now each 0.1 second the time base generator interrupts. This will occur once during the long elapsed time required for the letter H to come in. The scheduler requires about 150 microseconds for a routine service interrupt. Note, the system will normally be servicing the current user at the top of the queue, or it will be in the scheduler loop if there is no user on the queue.

Let's review the action that will be required by referring to the multiplexor flow chart Figure 6.

The initial multiplexor interrupt will occur at time A. The MPXNT entry point stores the registers, and inputs the new multiplexor data. It is determined that a new character is present. NEWIN routine determines the port number. SETIN puts necessary TTY table entries on the base page. It checks for abort, syntax or command entry. It prepares an ISZ instruction to count the multiplexor bits to determine the time for servicing the bits. It places a -4 in the BTIM. This is the number of interrupts required to get to the middle of the bit. A-10 is placed in the bit counter to determine when the full character is finished. We then continue with the ladder. The initial processing is finished. The program continues at the ladder.

During the fourth interrupt, we ISZ the BTIM and it rolls over. We then must service the character. We place the -8 in the bit timer. We put certain TTY tables entries on the base page. We add the current bit to the MPOUT data word. We add the current bit to the partial character being built up. We rotate the character and increment the bit counter. This completes the bit processing.

During the 76th interrupt, we service the 9th bit. This causes a roll over in the bit counter and we must service the end of character. We place TTY table entries on the base page, position and mask the character, replace the JMP *+4 to the ladder, and reset the input flag to allow more input. We now test it for certain special characters, and process it if necessary. If it is an acceptable character, we add it to the buffer, taking care of packing and buffer wrap around. We then return to the ladder.

The final character in the line is usually a carriage return. When this is typed, we set the input flag to prevent further input until the line is processed. We set the MPCOM flag which tells the scheduler there is a user requiring service.

With this review of the block diagram, it should be possible to follow the step by step example through the multiplexor. Refer to figure 20.

8-3 SCHEDULER EXAMPLE

We will continue the same example through the Scheduler. The HELLO-H000, SALES cr command is in the users buffer. His TTY entries point to the actual location of the packed characters. His status is idle, no priority has been established.

Assume that no activity is currently going on, but that we will enter through the Time Base Generator entry point and continue through the Scheduler. This assumption gives us a clean entry point, but also let us queue the new user and go directly to the swapper to start the disc transfer. Refer to the Scheduler Loop simplified block figure 10. We enter CLKIN and update the clock and go to the main part of the shceduler SCHI. There are no phones to answer since we are hard wired. Multiplexor processing is required, however, since the MPCOM bit is set. We go to SCH5 for this processing.

The main work takes place in SCH5, SCH6, SCOM, SCHAR, and SCH11. The activities include locating the port numbers and clearing the MPCOM bit, checking for syntax or commands, and other special conditions like abort.

In this case, it is a command. The first three valid characters are then checked against the command table to determine which command is requested. The priority of 2 is assigned.

In SCH3 the user is placed on the queue. His entry is established according to his priority. SWAPR is called to effect the queue rotation. The user at the top of the queue is brought in. This is actually accomplished by using the Disc driver with DMA to bring in the HELLO library program to 37300.

Once the swap is initiated, the scheduler remains in the loop until ENDSK indicates the transfer is completed. This completes the example. Refer to figure 21 for the scheduler example.

Certain processing follows the example before the action requested by the Hello command is completed and the terminal is ready to use.

The HELLO program checks for a current ID. If one exists, then it must be logged off, with appropriate accounting update. It checks the new ID and ID code against the IDT to insure that both are valid, and the allowable time is not expended. It initiates a log on message to the system console. It updates the ID information in the TTY table. It then uses DLOOK to search for the $HELLO program in the public library. If one exists, it is read in to the users swap area. Status is put to RUN with a jump to the Basic Interpreter executive. When the program is completed, the user is dequeued. The terminal is now ready for business.

```
PAGE 0185 #16  MULTIPLEXOR INTERRUPT DRIVER.
                ENTRY POINT    880 Times Per Second

0002  32127 000000  MPXNT  NOP  <-- P REG     (RETURN ADDRESS)
0003  32130 074052         STA MPXA       SAVE REGISTERS A,
0004  32131 074053         STB MPXB        B,
0005  32132 006500         ERB            AND
0006  32133 074054         STB MPXE        E.
0007  32134 102510         LIA MPX        GET NEW INPUT.   A=177737
0008  32135 070051         STA INBIT      SAVE IN INBIT.
0009  32136 064250         LDB INPTF      GET OLD INPTF IN B. A=000000
0010  32137 003000         CMA            COMPLEMENT NEW BITS. A=000040
0011  32140 030001         IOR 1          SET INPTF=1 FOR EACH NEW 0 BIT.
0012  32141 070250         STA INPTF       000040
0013  32142 060051         LDA INBIT      GET INBIT AGAIN, GET 0'S FOR EAC
0014  32143 010246         AND ABTST      NEW INPUT OR OLD ABORT TRY. 177777
0015  32144 030001         IOR 1          INHIBIT IF INPTF=1.         177737
0016  32145 003003         CMA,SZA,RSS    SET 1 FOR EACH BIT FOR WHICH
0017  32146 026354         JMP LADDR      WE WILL CALL SETIN.
0018  32147 070001         STA 1         B=000040

0020* NOW CALL SETIN FOR EACH NEW INPUT

0022  32150 004075  NEWIN  CLE,SLB,ERB   TTY00  Bit 0=0          B=000020
0023  32151 016210         JSB SETIN
0024  32152 004075         CLE,SLB,ERB   TTY01  Bit 0=0          B=000010
0025  32153 016210         JSB SETIN
0026  32154 004075         CLE,SLB,ERB   TTY02  Bit 0=0          B=000004
0027  32155 016210         JSB SETIN
0028  32156 004075         CLE,SLB,ERB   TTY03  Bit 0=0          B=000002
0029  32157 016210         JSB SETIN
0030  32160 004075         CLE,SLB,ERB   TTY04  Bit 0=0          B=000001
0031  32161 016210         JSB SETIN
0032  32162 004075         CLE,SLB,ERB   TTY05  Bit 0=1
0033  32163 016210         JSB SETIN ------------------------> P 186/#16
0034  32164 004075         CLE,SLB,ERB   TTY06
0035  32165 016210         JSB SETIN
0036  32166 004075         CLE,SLB,ERB   TTY07
0037  32167 016210         JSB SETIN
0038  32170 004075         CLE,SLB,ERB   TTY08
0039  32171 016210         JSB SETIN
0040  32172 004075         CLE,SLB,ERB   TTY09
0041  32173 016210         JSB SETIN
0042  32174 004075         CLE,SLB,ERB   TTY10
0043  32175 016210         JSB SETIN
0044  32176 004075         CLE,SLB,ERB   TTY11
0045  32177 016210         JSB SETIN
0046  32200 004075         CLE,SLB,ERB   TTY12
0047  32201 016210         JSB SETIN
0048  32202 004075         CLE,SLB,ERB   TTY13
0049  32203 016210         JSB SETIN
0050  32204 004075         CLE,SLB,ERB   TTY14
0051  32205 016210         JSB SETIN
0052  32206 004075         CLE,SLB,ERB   TTY15
0053  32207 016210         JSB SETIN
0054*
0055* CONTROL SHOULD NEVER RETURN TO THIS POINT.
0056*
```

FIGURE 20. MULTIPLEXOR EXAMPLE
SHEET 1 OF 10

```
PAGE 0186 #16  MULTIPLEXOR INTERRUPT DRIVER.

0058* SETIN SETS UP CONTROL FOR A NEW INPUT CHARACTER. IT FIRST DETER-
0059* MINES WHETHER INPUT IS LEGAL FROM THE SPECIFIED TELETYPE.

0061  32210 000000 SETIN NOP  <- P REG   RETURN ADDRESS (32164)
0062  32211 074055       STB MPXT0      SAVE BIT INDICATORS.  B=000000
0063  32212 060210       LDB SETIN      B=NEWIN+2*(TTY#+1)    B=32164
0064  32213 044410       ADB MNEWN      B=2*TTY#              B=000012
0065  32214 005000       BLS            B=4*TTY#              B=000024
0066  32215 044331       ADB DLADR      B=DLADR+4*TTY#+3      B=032363
0067  32216 160061       LDA 1,I        A=TTY TABLE ADDRESS   A=33223
0068  32217 040520       ADA .+?STAT    A=STATUS ADDRESS      A=33252
0069  32220 070056       STA MPXT1      SAVE STATUS ADDRESS.
0070  32221 040466       ADA .+?ABCN-?STAT A=ABORT COUNTER ADDRESS  A=33247
0071  32222 070062       STA CPNT       SAVE ABORT COUNTER ADDRESS.
0072  32223 040450       ADA .+?MASK-?ABCN A=MASK ADDRESS.          A=33226
0073  32224 070061       STA MASK       SAVE MASK ADDRESS.
0074  32225 160056       LDA MPXT1,I    A=STATUS.          A=0   Initially
0075  32226 002021       SSA,RSS        IGNORE IF STATUS IS ABORTING.
0076  32227 050472       CPA %ABOR
0077  32230 026331       JMP SET1
0078  32231 002002       SZA            IF OTHER THAN IDLE
0079  32232 050475       CPA %SYNT        SYNTAX
0080  32233 026237       JMP *+4
0081  32234 050473       CPA %INPT      OR INPUT, WE ABORTHIM.
0082  32235 002001       RSS
0083  32236 026272       JMP SET2+1

0085* SET UP LADDER CODE AND INITIALIZE VARIABLES.

0087  32237 160001       LDA 1,I        A=>TELETYPE ENTRY  A=33223
0088  32240 010325       AND B1777                         A=001223
0089  32241 040403       ADA ISZ1P      CREATE ISZ INSTRUCTION.  A=037223
0090  32242 044466       ADB .-3        B=DLADR+4*TTY#     B=32360
0091  32243 150001       CPA 1,I        IF ISZ ALREADY THERE THIS IS
0092  32244 026271       JMP SET2       ABORTING.
0093  32245 070057       STA CPTR       SAVE ISZ.
0094  32246 060246       LDA ABTST      IS ABTST SET TO INDICATE AN  A=177777
0095  32247 130061       IOR MASK,I     ABORT ATTEMPT?     A=000040
0096  32250 050246       CPA ABTST
0097  32251 026254       JMP *+3        NO--START SETTING UP INPUT.
0098  32252 070246       STA ABTST      YES--FORGET ABORT ATTEMPT AND
0099  32253 026307       JMP SET3       GO REINSTATE INPTF.
0100  32254 060057       LDA CPTR       GET ISZ AGAIN.     A=037223
0101  32255 170001       STA 1,I        SET UP ISZ.
0102  32256 044474       ADB .+3        B=>TTY TABLE ADDRESS  B=32363
0103  32257 164001       LDB 1,I        B=>TTY TABLE          B=33223
0104  32260 060465       LDA .-4        SET TIME COUNTER
0105  32261 170001       STA 1,I          TO -4.  4 interrupts to middle of bit
0106  32262 000004       INB            B=>CHARACTER.
0107  32263 002400       CLA            INITIALIZE CHARACTER
0108  32264 170001       STA 1,I          TO ZERO.
0109  32265 000004       INB            B=>BIT COUNTER.
0110  32266 060457       LDA .-10       SET BIT COUNTER  10 bits to complete
0111  32267 170001       STA 1,I          TO -10.              character
0112  32270 026331       JMP SET1       GO CHECK FOR ANY MORE TTYS.

0114* ABORT CODE

                                  -> P 187/#16
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 2 OF 10

```
PAGE 0187 #16  MULTIPLEXOR INTERRUPT DRIVER.


0115  32271 044474  SET2  ADB .+3
0117  32272 060246        LDA ABTST      TEST FOR ATTEMPTED ABORT.
0118  32273 110061        AND MASK,I
0119  32274 002002        SZA
0120  32275 020314        JMP SET4       NO--GO START ATTEMPTED ABORT.
0121  32276 060051        LDA INBIT      IF ABORT ATTEMPTED, TEST FOR
0122  32277 110061        AND MASK,I     INPUT BIT STILL 0.
0123  32300 002003        SZA,RSS
0124  32301 020320        JMP SET5       IT IS--GO BUMP COUNTER.
0125  32302 030246        IOR ABTST      INPUT=1. DISCONTINUE ABORT.
0126  32303 070246        STA ABTST
0127  32304 160062        LDA BPNT,I     IF COUNTER REACHED 0, SET UP
0128  32305 002003        SZA,RSS         ABORT CONDITION.
0129  32306 020324        JMP SET6
0130  32307 160061  SET3  LDA MASK,I     RESET INPTF TO 0 TO ALLOW MORE
0131  32310 004000        CMA               INPUT.
0132  32311 010250        AND INPTF
0133  32312 070250        STA INPTF
0134  32313 020331        JMP SET1       GO DO NEXT ENTRY.
0135  32314 020246  SET4  XOR ABTST      SET ABTST=0 TO INDICATE ABORT
0136  32315 070246        STA ABTST      ATTEMPT.
0137  32316 060421        LDA M100       SET ABCN TO -100 TO COUNT
0138  32317 020322        JMP *+3          LENGTH OF BREAK.
0139  32320 160062  SET5  LDA BPNT,I     IF COUNTER NOT ALREADY ZERO,
0140  32321 002024        SSA,INA           BUMP IT BY 1.
0141  32322 170062        STA BPNT,I
0142  32323 020307        JMP SET3
0143  32324 003400  SET6  CCA             SET ABORT REQUEST MODE.
0144  32325 170056        STA MPX11,I
0145  32326 060234        LDA MPCOM      SET COM.BIT TO
0146  32327 130061        IOR MASK,I      TELL SCHEDULER.
0147  32330 070234        STA MPCOM

0149  32331 064055  SET1  LDB MPXT0      GET BIT INDICATORS AGAIN.B=000000
0150  32332 006002        SZB            IF ALL 0, GO DIRECTLY TO LADDR.
0151  32333 126210        JMP SETIN,I    OTHERWISE,RETURN.


0153* THE INPUT-OUTPUT LADDR CONSISTS OF A SEQUENCE OF FOUR INSTRUCTIONS
0154* FOR EACH TELETYPE. THESE INSTRUCTIONS ARE AS FOLLOWS:
0155*      1.ISZ TIME COUNTER     OR    JMP *+4
0156*      2.JMP *+3
0157*      3. JSB MPXIC
0158*      4.DEF TIME COUNTER

0160* THE FOLLOWING INSTRUCTION EXISTS ONLY TO GET AN ERROR MESSAGE
0161* FROM THE ASSEMBLER IF A PAGE BOUNDARY OVERFLOW CAN BE PRO-
0162* DUCED AT RUN TIME.

0164  32334 037627        ISZ TTY15
0165  32334               ORG *-1



0168  32334 020340  LADDR JMP *+4
0169  32335 020340        JMP *+3
0170  32336 016444        JSB MPXIC
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 3 OF 10

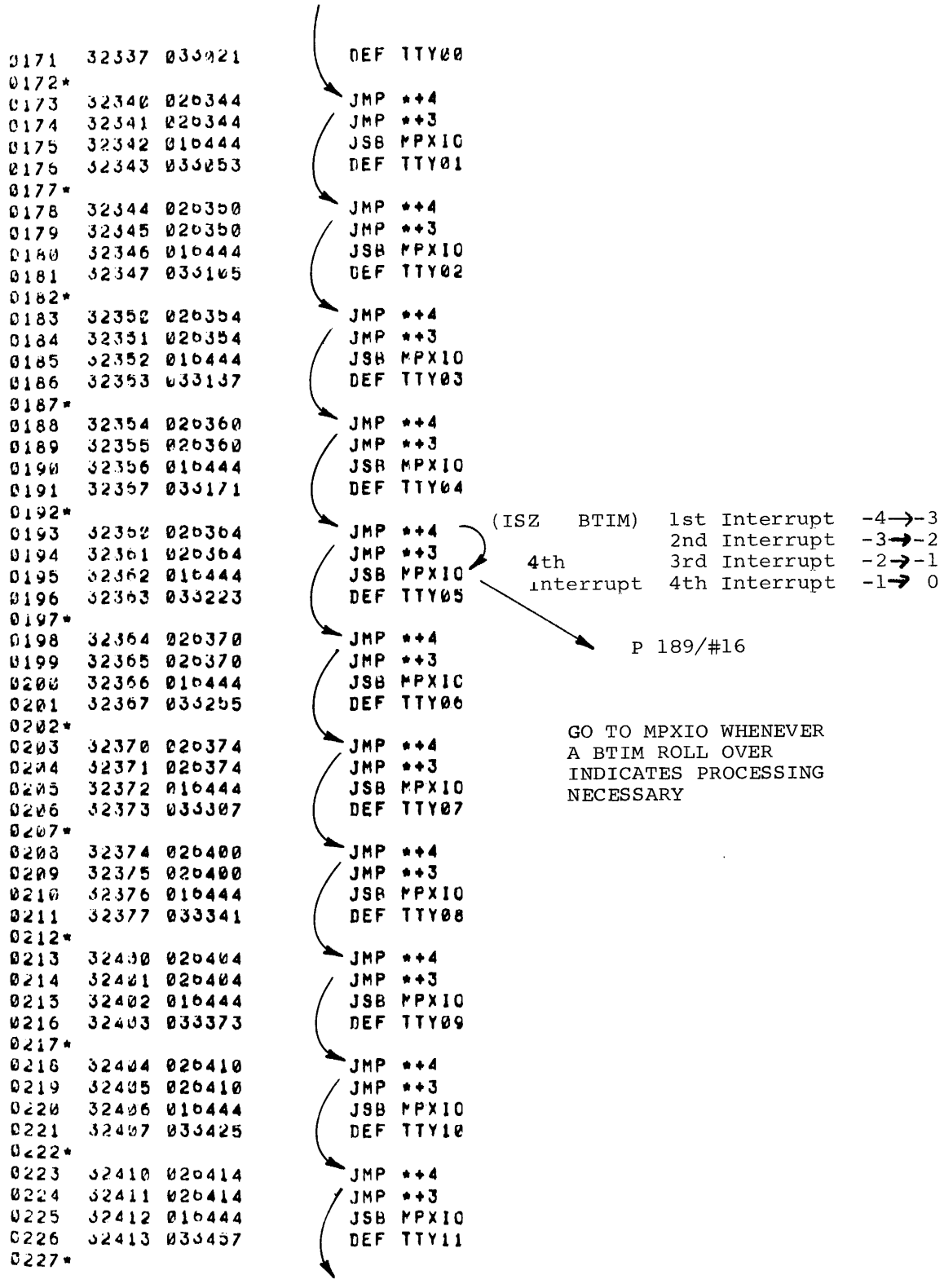


FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 4 OF 10

```
PAGE 0189 #16  MULTIPLEXOR INTERRUPT DRIVER.


0228  32414 020420          JMP *+4
0229  32415 020420          JMP *+3
0230  32416 016444          JSB MPXIO
0231  32417 033511          DEF TTY12
0232*
0233  32420 020424          JMP *+4
0234  32421 020424          JMP *+3
0235  32422 016444          JSB MPXIO
0236  32423 033543          DEF TTY13
0237*
0238  32424 020430          JMP *+4
0239  32425 020430          JMP *+3
0240  32426 016444          JSB MPXIO
0241  32427 033575          DEF TTY14
0242*
0243  32430 020434          JMP *+4
0244  32431 020434          JMP *+3
0245  32432 016444          JSB MPXIO
0246  32433 033627          DEF TTY15



0248  32434 060252          LDA MPOUT     OUTPUT A NEW WORD TO A=177777
0249  32435 102610          OTA MPX        THE MULTIPLEXOR. Data Output
0250  32436 060054          LDA MPXE      RESTORE
0251  32437 001600          ELA            E,
0252  32440 060052          LDA MPXA       A,
0253  32441 064053          LDB MPXB       AND B.
0254  32442 103110          CLF MPX       ENABLE INTERRUPTS AGAIN.
0255  32443 120127          JMP MPXNT,I   Return to prior activity.
                            Multiplexor processing done
                            for this interrupt.

0257* THE MPXIO ROUTINE IS CALLED FOR IO    SERVICE OF A SINGLE TELE-
0258* TYPE. IT IS CALLED WHENEVER A NEW BIT FOR A TELETYPE HAS COME IN
0259* TO THE TELETYPE I/O REGISTER, OR WHEN IT IS NECESSARY TO
0260* SEND A BIT OUT. THIS IS INDICATED BY THE TIME COUNTER
0261* FOR THAT TELETYPE ROLLING OVER TO ZERO.
0262*
0263* CALLING SEQUENCE:              At fourth interrupt we
0264*     ISZ TIME COUNTER           must service the
0265*     JMP *+3                    first bit.
0266*     JSB MPXIO
0267*     DEF TIME COUNTER


                                   PREG  = 32363     RETURN TO LADDER
0269  32444 000000  MPXIO NOP      ENTRY POINT
0270  32445 166444          LDB MPXIO,I   B=>TIME COUNTERB=33223
0271  32446 036444          ISZ MPXIO     ADJUST RETURN ADDRESS.MPXIO=32364
0272  32447 060461          LDA .-8       RESET TIME COUNTER TO -8.
0273  32450 170001          STA 1,I      Count interrupts to middle next bit
0274  32451 000004          INB           B=>CHARACTER
0275  32452 074057          STB CPTR      CPTR=>CHARACTERon base page
0276  32453 000004          INB           B=>BIT COUNTER.
0277  32454 074060          STB BCNT      BCNT=>BIT COUNTER on base page
0278  32455 000004          INB           B=>MASK.
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 5 OF 10

```
0279  32456 160001        LDA 1,I         A=MASK.          B=33226
0280  32457 070061        STA MASK        SAVE IN MASK.              ON BASE PAGE
0281  32460 010251        AND IOTOG       TEST FOR INPUT OR OUTPUT.  IOTOG=177777
0282  32461 002003        SZA,RSS         INPUT IF BIT = 1
0283  32462 026700        JMP OUTPT        OUTPUT IF 0.
0284  32463 010244        AND PLEX        IF FULL DUPLEX,            PLEX=177777
0285  32464 003000        CMA             FORCE A ZERO INTO          A=000000 000040
0286  32465 010252        AND MPOUT        THE APPROPRIATE BIT IN    A=177737
0287  32466 070252        STA MPOUT        MPOUT.      DATA OUTPUT
0288  32467 060051        LDA INBIT       GET THE INPUT AND ISOLATE  A=177737
0289  32470 010061        AND MASK         THE BIT FOR THIS TELETYPE. A=000000
0290  32471 002003        SZA,RSS         IF 0 SKIP NEXT PART
0291  32472 026476        JMP *+4
0292  32473 030252        IOR MPOUT       SET A ONE INTO THE
0293  32474 070252        STA MPOUT         OUTPUT WORD.
0294  32475 002404        CLA,INA         SET FLAG TO ONE.
0295  32476 140057        ADA CPTR,I      ADD TO CHARACTER,          First bit is zero
0296  32477 001300        RAR  Bit to 15   ROTATE,                   and doesn't hurt
                           position
0297  32500 170057        STA CPTR,I       AND REPLACE
0298  32501 134060        ISZ BCNT,I      TEST BIT COUNTER AND       BCNT=-9
0299  32502 126444        JMP MPXIO,I      RETURN IF NOT END OF CHARACTER.
                                             CONTINUE LADDER

0301* END-OF-CHARACTER PROCESSING.   CONSIDER 10th BIT.    CHARACTER NOW COMPLETE

0303  32503 044473        ADB .+2         B=>RUNNING BUFFER POINTER  B=33230
0304  32504 074062        STB BPNT                                    on base page
0305  32505 006004        INB             B=>START OF BUFFER         on base page
0306  32506 074063        STB BSTR
0307  32507 006004        INB             B=>START OF FIRST BUFFER.
0308  32510 074064        STB BHED                                    on base page
0309  32511 006004        INB             B=>START OF PHYSICAL BUFFER.
0310  32512 074065        STB BGIN                                    on base page
0311  32513 006004        INB             B=>END OF PHYSICAL BUFFER.
0312  32514 074066        STB BEND                                    on base page
0313  32515 001200        RAL    Remove stop  POSITION DATA BITS TO   Character was
                               bit          14-7      7 to 0
0314  32516 001727        ALF,ALF          BITS 6-0 OF A.   MASK   8th Bit
0315  32517 010570        AND B177        MASK DATA BITS.
0316  32520 170057        STA CPTR,I      PUT INPUT CHAR IN CPTR POSITION.
0317  32521 062444        LDA MPXIO       A=>  <JSB INPUT> +2        A=32364  ASCII H=000110
0318  32522 040466        ADA .-3         A=>  <JMP *+3>   A=32361
0319  32523 164000        LDB 0,I         B= <JMP *+3>     B=026364
0320  32524 040470        ADA .-1         CHANGE ISZ TO    A=232360
0321  32525 174000        STB 0,I           JMP *+4        RESTORE  JMP  *+4 TO LADDER
0322  32526 060250        LDA INPTF       RESET INPTF TO 0 SO ANOTHER
0323  32527 020061        XOR MASK         CHARACTER CAN START.
0324  32530 070250        STA INPTF
0325  32531 164057        LDB CPTR,I      GET CHARACTER IN B.        B=000110 ASCIIM
0326  32532 060245        LDA ESCF        HAS THIS TELETYPE BEEN RUBBED?
0327  32533 010061        AND MASK
0328  32534 002003        SZA,RSS
0329  32535 026542        JMP INP.1       NOT RUBBED OUT.
                                             P 191/#16

0331* THE INPUT LINE HAS BEEN RUBBED OUT AND NOTHING HAS
0332* BEEN DONE SINCE THE USER IS IN TAPE MODE.

0334  32536 020245        XOR ESCF        PREPARE NEW VALUE OF ESCF.
0335  32537 054506        CPB .+158       IF CHARACTER IS A CARRIAGE
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 6 OF 10

```
PAGE 0191 #16  MULTIPLEXOR INTERRUPT DRIVER.

0336  32540 070245          STA ESCF        RETURN, CLEAR ESCF.
0337  32541 126444          JMP MPXIO,I

0339* NOW TEST CHARACTER *                  B=000110 ASCII H

0341  32542 054326  INP.1   CPB BKSPC      TEST FOR BACKSPACE.
0342  32543 020670          JMP INP.5
0343  32544 054524          CPB .+338       TEST FOR ESCAPE.
0344  32545 020606          JMP INP.2
0345  32546 054324          CPB ALTMD       TEST FOR ALTMODE
0346  32547 020606          JMP INP.2
0347  32550 054572          CPB .176        OLD ALTMODE?
0348  32551 020606          JMP INP.2
0349  32552 006002          SZB             IGNORE FEED FRAMES AND
0350  32553 054570          CPB B177        RUBOUTS.
0351  32554 126444          JMP MPXIO,I
0352  32555 054503          CPB .+128       IGNORE LINE FEEDS ALSO
0353  32556 126444          JMP MPXIO,I
0354  32557 054514          CPB .+238       IGNORE XOFF ALSO.
0355  32560 126444          JMP MPXIO,I


0357*  APPEND CHARACTER TO BUFFER *
                             VALID CHARACTER

0359  32561 160062  INP.6   LDA BPNT,I      A=>POSITION FOR THIS CHARACTER.
0360  32562 002004          INA             A=>POSITION FOR NEXT CHARACTER.
0361  32563 150066          CPA BEND,I      IF A=> BEYOND END OF BUFFER,
0362  32564 040405          ADA MBLEN        MAKE IT POINT TO THE START
0363  32565 150064          CPA BHED,I      IF BUFFER FULL,
0364  32566 020606          JMP INP.2        TRANSFER FOR SPECIAL HANDLING.
0365  32567 164062          LDB BPNT,I      B=>CURRENT CHARACTER ADDRESS.
0366  32570 170062          STA BPNT,I      SAVE NEXT CHARACTER ADDRESS.
0367  32571 004065          CLE,ERB         B=WORD ADDRESS
0368  32572 160001          LDA 1,I         A=DESTINATION WORD
0369  32573 002041          SEZ,RSS         IF HIGH CHAR, ROTATE
0370  32574 001727          ALF,ALF          TO BOTTOM.
0371  32575 010416          AND HIMSK       CLEAR BOTTOM PART
0372  32576 140057          ADA CPTR,I      MERGE IN NEW CHARACTER.
0373  32577 002041          SEZ,RSS         IF HIGH CHARACTER,
0374  32600 001727          ALF,ALF          ROTATE BACK.
0375  32601 170001          STA 1,I         STORE BACK IN MEMORY.
0376  32602 160057          LDA CPTR,I       IF CHARACTER WAS A
0377  32603 050506          CPA .+158         CARRIAGE RETURN,
0378  32604 020647          JMP INP.3       GO TO PROCESS IT.
0379  32605 126444          JMP MPXIO,I

P192/#16 WHEN CARRIAGE RETURN
          IS FOUND
0381* PROCESS ESCAPE/ALT-MODE

0383  32606 160063  INP.2  LDA BSTR,I      RESET BUFFER POINTER
0384  32607 170062          STA BPNT,I       TO BEGINNING.
0385  32610 060253          LDA TAPEF       IS USER IN TAPE MODE?
0386  32611 010061          AND MASK
0387  32612 002002          SZA
0388  32613 020644          JMP INP21       YES.
0389  32614 164063          LDB BSTR,I      MOVE REVERSE
```

PACK CHAR IN BUFFER

DONE WITH CHARACTER RETURN TO LADDER

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 7 OF 10

```
0390  32615 004065          CLE,ERB        SLASH
0391  32616 060411          LDA RVRSL       AND
0392  32617 170001          STA 1,I         CRLF TO
0393  32620 000004          INB            USER'S
0394  32621 060233          LDA CRLF         BUFFER.
0395  32622 170001          STA 1,I
0396  32623 060061          LDA MASK        SET IOTOG TO
0397  32624 020251          XOR IOTOG      OUTPUT.
0398  32625 070251          STA IOTOG
0399  32626 007400          CCB
0400  32627 174060          STB BCNT,I     FORCE OUT FIRST CHARACTER.
0401  32630 174057          STB CPTR,I     SET OUTPUT CHARACTER TO ALL ONES
0402  32631 044062          ADB BPNT       SET CHARACTER
0403  32632 060465          LDA .-4        COUNT TO SAY
0404  32633 170001          STA 1,I        FOUR CHARACTERS.
0405  32634 007400          CCB            SET AN
0406  32635 040444          ADB MPXIO       ISZ
0407  32636 160001          LDA 1,I        INSTRUCTION
0408  32637 010325          AND B1777        INTO THE
0409  32640 030403          IOR ISZIP      FIRST WORD OF
0410  32641 044466          ADB .-3        THE USER'S RUNG
0411  32642 170001          STA 1,I          IN THE LADDER.
0412  32643 120444          JMP MPXIO,I
0413  32644 030245  INP21    IOR ESCF       IF TAPE MODE, SET
0414  32645 070245          STA ESCF        ESCF BIT AND RESET BUFFER
0415  32646 120444          JMP MPXIO,I

0417*  ENTER USER IN TTO WHEN A CARRIAGE RETURN COMES IN
                        FINAL CHARACTER IN LINE
0419  32647 060253  INP.3   LDA TAPEF      IS USER IN    =1 IF IN TAPE
0420  32650 010061          AND MASK        TAPE MODE?
0421  32651 002002          SZA
0422  32652 020662          JMP INP31      YES
0423  32653 060250          LDA INPTF      IF NOT TAPE MODE, SET
0424  32654 030061          IOR MASK        INPTF TO PREVENT FURTHER
0425  32655 070250          STA INPTF        INPUT.
0426  32656 060234  INP32   LDA MPCOM      SET COM.BIT.      TELL SCHEDULER WE
0427  32657 030061          IOR MASK                          REQUIRE SERVICING
0428  32660 070234          STA MPCOM
0429  32661 120444          JMP MPXIO,I    --> BACK TO LADDER.  THIS COMPLETES
0430  32662 160063  INP31   LDA BSTR,I     GET POINTER TO BEGINNING OF    MULTIPLEX-
0431  32663 164062          LDB BPNT,I      CURRENT BUFFER AND RESET TO   OR SERVIC-
0432  32664 174063          STB BSTR,I       CURRENT CHARACTER.           ING FOR
0433  32665 150064          CPA BMED,I     IF BUFFER JUST COMPLETED WAS   ENTIRE
0434  32666 020656          JMP INP32       FIRST, GO MAKE TTO ENTRY.     LINE.  IT
0435  32667 120444          JMP MPXIO,I    OTHERWISE JUST RETURN.         IS NOW UP TO
                                                                        THE SCHEDULER.

0437* PROCESS BACKSPACE

0439  32670 160062  INP.5   LDA BPNT,I     GET BUFFER POINTER.
0440  32671 150063          CPA BSTR,I     IF NO CHARACTERS,
0441  32672 120444          JMP MPXIO,I     RETURN IMMEDIATELY.
0442  32673 150065          CPA BGIN,I     IF AT BEGINNING OF PHYSICAL
0443  32674 040327          ADA BLEN        BUFFER, MOVE TO END.
0444  32675 040470          ADA .-1        BACK UP ONE.
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 8 OF 10

```
 PAGE 0193 #16  MULTIPLEXOR INTERRUPT DRIVER.        NOT USED FOR
                                                     THIS EXAMPLE

0445  32676 170062          STA BPNT,I
0446  32677 120444          JMP MPXIO,I



0449* THE OUTPT SECTION IS CALLED FOR OUTPUT SERVICE FOR A SINGLE TELE-
0450* TYPE. IT IS CALLED WHENEVER A NEW BIT MUST BE SENT TO THE TELE-
0451* TYPE. THIS HAPPENS WHENEVER THE TIME COUNTER FOR THE TELETYPE BE-
0452* COMES ZERO.


0454  32700 160057  OUTPT LDA CPTR,I     A=OUTPUT CHARACTER.
0455  32701 001300          RAR           SHIFT NEXT BIT TO A0.
0456  32702 170057          STA CPTR,I    STORE BACK IN MEMORY.
0457  32703 002030          SSA,SLA       NOW TEST THE OUTGOING BIT. IF
0458  32704 020712          JMP OUT.1      IT DIFFERS FROM THE PREVIOUS
0459  32705 003030          CMA,SSA,SLA     BIT WE HAVE TO CHANGE THE BIT
0460  32706 020712          JMP OUT.1        IN THE OUTPUT WORD.
0461  32707 060252          LDA MPOUT
0462  32710 020061          XOR MASK
0463  32711 070252          STA MPOUT
0464*
0465  32712 134060  OUT.1 ISZ BCNT,I     RETURN UNLESS THIS IS THE LAST
0466  32713 120444          JMP MPXIO,I    BIT OF THE CHARACTER.
0467  32714 060456          LDA .-11      RESET BIT COUNTER TO -11 FOR
0468  32715 170060          STA BCNT,I     THE NEXT CHARACTER.
0469  32716 000004          INB           B=>CHAR COUNTER.
0470  32717 134001          ISZ 1,I       TEST TO SEE IF ANY CHARACTERS
0471  32720 020754          JMP OUT.2      ARE LEFT.
0472*
0473*  END OF OUTPUT
0474*
0475  32721 060444          LDB MPXIO     B=>  <JSB MPXIO>+2
0476  32722 044466          ADB .-3       B=>  <JMP *+3>
0477  32723 160001          LDA 1,I       A=   <JMP *+3>
0478  32724 044470          ADB .-1       B=>  <JMP *+4>
0479  32725 170001          STA 1,I       SET  <JMP *+4>
0480  32726 060251          LDA IOTOG     SET IOTOG TO
0481  32727 020061          XOR MASK        SAY
0482  32730 070251          STA IOTOG     INPUT.
0483  32731 064057          LDB CPTR      SET
0484  32732 044517          ADB .+?STAT-1  B=>STATUS.
0485  32733 160001          LDA 1,I       A=STATUS
0486  32734 050472          CPA XABOR     IF STATUS IS ABORT, CHANGE TO
0487  32735 002400          CLA             IDLE.
0488  32736 170001          STA 1,I
0489  32737 044452          ADB .+?BGIN-?STAT  RESET ALL
0490  32740 160001          LDA 1,I          BUFFER
0491  32741 044466          ADB .-3          POINTERS
0492  32742 170001          STA 1,I         TO
0493  32743 000004          INB                THE
0494  32744 170001          STA 1,I         BEGINNING
0495  32745 000004          INB              OF THE USER'S
0496  32746 170001          STA 1,I          BUFFER.
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 9 OF 10

```
 PAGE 0194 #16  MULTIPLEXOR INTERRUPT DRIVER.                    NOT USED
                                                                 FOR THIS
                                                                 EXAMPLE
0497  32747 060061  CLT.3 LDA MASK
0498  32750 003000        CMA              COMPLEMENT TO
0499  32751 010250        AND INPTF         TURN OFF
0500  32752 070250        STA INPTF          INPTF BIT.
0501  32753 120444        JMP MPXIO,I


0503*  END OF CHARACTER -- AT LEAST ONE LEFT

0505  32754 006004  CLT.2 INB              B=>BUFFER POINTER.
0506  32755 160001        LDA 1,I          A=BUFFER POINTER.
0507  32756 002004        INA              A=>NEXT CHARACTER.
0508  32757 044475        ADB .+?BEND-?BPNT  B=>BUFFER END.
0509  32760 150001        CPA 1,I          IF END OF BUFFER, CHANGE TO
0510  32761 040465        ADA MBLEN         BEGINNING.
0511  32762 044465        ADB .+?BPNT-?BEND  B=>BUFFER POINTER.
0512  32763 170001        STA 1,I          RESET BUFFER POINTER.
0513  32764 064000        LDB 0            MOVE POINTER TO B.
0514  32765 004065        CLE,ERB          POSITION AS WORD POINTER.
0515  32766 160001        LDA 1,I          A=WORD CONTAINING CHARACTER.
0516  32767 002041        SEZ,RSS          POSITION SO THAT CHARACTER IS
0517  32770 001727        ALF,ALF           IN BITS 7-0
0518  32771 010570        AND B177         MASK OUT CHARACTER.
0519  32772 001222        RAL,RAL          POSITION IN ORDER TO SET UP
0520  32773 030404        IOR MBITS         FOR OUTPUTTING AND MERGE IN
0521  32774 050404        CPA MBITS
0522  32775 020735        XOR B1000
0523  32776 170057        STA CPTR,I         STOP AND PARITY BITS.
0524*
0525  32777 064057        LDB CPTR         SET B=> STATUS.
0526  33000 044517        ADB .+?STAT-1
0527  33001 160001        LDA 1,I          A=STATUS
0528  33002 050472        CPA %ABOR        IF ABORT STATUS, RETURN
0529  33003 120444        JMP MPXIO,I      IMMEDIATELY.
0530  33004 050474        CPA %OUTW        IF OUTPUT WAIT, CHECK FOR
0531  33005 002001        RSS               ALMOST DONE.
0532  33006 020747        JMP OUT.3        OTHERWISE GO CLEAR INPTF.
0533*
0534  33007 044446        ADB .+?CCNT-?STAT  IF OUTPUT WAIT, TEST FOR
0535  33010 160001        LDA 1,I              10 CHARACTERS LEFT.
0536  33011 044514        ADB .+?STAT-?CCNT
0537  33012 050457        CPA .-10
0538  33013 002001        RSS
0539  33014 020747        JMP OUT.3        NOT EXACTLY 10 LEFT.
0540  33015 060234        LDA MPCOM
0541  33016 030061        IOR MASK
0542  33017 070234        STA MPCOM
0543  33020 020747  MPXED JMP OUT.3
```

FIGURE 20. MULTIPLEXOR EXAMPLE (Con't)
SHEET 10 OF 10

```
0264*  THE CLOCK DRIVER IS THE CENTRAL POINT THROUGH WHICH CONTROL IS
0265*  PASSED TO THE SCHEDULER. ENTRY COMES TO THE DRIVER WHENEVER THE
0266*  CLOCK (REAL TIME SCALAR) INTERRUPTS.  THIS EVENT OCCURS EVERY
0267*  100 MS.  BESIDES GIVING CONTROL TO THE SCHEDULER, THE CLOCK
0268*  DRIVER ALSO HAS THE TASK OF UPDATING THE TIME OF DAY CLOCK.
0269* THIS CLOCK IS A TWO WORD ENTRY WHOSE VALUE IS AS FOLLOWS:
0270*      DATIM=24*DAY+HOUR
0271*      DATIM+1=6000*MIN+100*SEC-36000
       ENTER EVERY 0.1 SECOND T.B.G. INTERRUPT

                                          PREG  RETURN ADDRESS
0273  34107 000000  CLKIN NOP                   ENTRY POINT.
0274  34110 034037        ISZ DATIM+1          BUMP 100MS COUNTER   ROLL OVER EACH HOUR
0275  34111 026120        JMP CLC1             NO PROBLEM IF NO SKIP
0276  34112 070077        STA CTEMP            SAVE A.
0277  34113 060401        LDA M36K             RESET 100MS COUNTER.
0278  34114 070037        STA DATIM+1
0279  34115 060077        LDA CTEMP            RESET A.
0280  34116 034036        ISZ DATIM            BUMP HR COUNTER.
0281  34117 000000        NOP                  JUST IN CASE.

0283* THE NEXT INSTRUCTION IS NORMALLY A JMP. WHEN THE
0284* SCHEDULER IS RUNNING, HOWEVER, IT PREVENTS ITSELF
0285* FROM BEING REENTERED BY INSERTING A NOP.

0287  34120 000000  CLC1  NOP  / JMP SCHED

0289  34121 103112        CLF CLOCK            ALLOW ANOTHER CLOCK INTERRUPT.
0290  34122 126107        JMP CLKIN,I          RETURN.
0291  34123 026124  CLC2  JMP SCHED           USED TO INSERT IN CLC1.



0293*  THE SCHEDULER SECTION OF TSB DETERMINES WHICH
0294*  PROGRAM IS TO RUN NEXT. FIRST IT CLEARS CLC1,
0295*  ALLOWING THE CLOCK TO CONTINUE INTERRUPTING.

0297  34124 071240  SCHED STA AREG            SAVE A-REGISTER.
0298  34125 002400        CLA                  INSERT NOP IN CLC1 TO PREVENT
0299  34126 072120        STA CLC1              REENTERING SCHED.
0300  34127 062107        LDA CLKIN            SAVE THE PROGRAM COUNTER
0301  34130 071243        STA PREG              ALSO.
0302  34131 103112  CLKED CLF CLOCK            NOW LET THE CLOCK IN AGAIN.
0303  34132 075241        STB BREG             SAVE B REGISTER,
0304  34133 001520        ERA,ALS              E-REGISTER,
0305  34134 102201        SOC                  AND OVERFLOW REGISTER.
0306  34135 002004        INA
0307  34136 071242        STA EREG

0309  34137 060254        LDA TIMEF            GET TIMER FLAG.
0310  34140 002002        SZA                  IF 0, THIS IS NOT A TIMED PROG.
0311  34141 134067        ISZ TIMER,I          IF NOT 0, BUMP TIMER.
0312  34142 026177        JMP SCH1             IF NOT OUT OF TIME, SKIP ROTAT-
0313*                                         ING RUN QUEUE.
0314*                                  P 203/#17
0315*      AT THIS POINT WE HAVE DISCOVERED THAT THE PROGRAM THAT HAS
0316*      BEEN RUNNING HAS EXHAUSTED ITS TIME LIMIT. THE NEXT STEP IS
```

INITIAL ENTRY

FIGURE 21. SCHEDULER EXAMPLE
SHEET 1 OF 18

```
0317*     TO ADJUST THE QUEUE SO THAT THIS PROGRAM IS MOVED TO THE
0318*     BOTTOM.  THIS IS ACCOMPLISHED BY DELETING THE PROGRAM
0319*     FROM THE QUEUE AND THEN REINSERTING IT WITH ITS NEW PRIORITY.
0320*
0321  34143 064321          LDB MLINK+1    GET THE ADDRESS OF PRIORITY
0322  34144 000004          INB             FOR THE CURRENT PROGRAM.
0323  34145 060475          LDA .+4        SET IT TO LOW PRIORITY.
0324  34146 170001          STA 1,I
0325  34147 044470          ADB .-1
0326  34150 160001          LDA 1,I        GET THE LINK FROM THE CURRENT
0327  34151 070321          STA MLINK+1     PROGRAM AND STORE IT IN MLINK+1
0328*
0329*  THE NEXT SECTION INSERTS A USER INTO THE QUEUE IN ORDER OF HIS
0330*  PRIORITY. WHEN WE ARRIVE HERE, THE B REGISTER POINTS TO THE LINK
0331*  WORD FOR THE USER.
0332*                                          SCHL=33253
0333  34152 074071 SCH3     STB SCHL       SAVE LINK ADDRESS IN SCHL.
0334  34153 000004          INB            B=>USERS PRIORITY
0335  34154 160001          LDA 1,I        A=PRIORITY      A=2
0336  34155 003000          CMA            STORE -1-PRIORITY  A=177775
0337  34156 070076          STA SCHPR       IN SCHPR.
0338  34157 064320          LDB MLINK      B=>PHONY USER.  B=321
0339  34160 074074 SCH2     STB SCHP       SAVE IN SCHP.
0340  34161 164001          LDB 1,I        B POINTS TO NEXT USER.   B => LINK
0341  34162 060001 HIS      LDA 1          GET PRIORITY OF          A => LINK
0342  34163 002004 PRIORITY INA             THAT USER IN             A => PLEV
0343  34164 160000 <OURS    LDA 0,I         A.    A=PRIORITY
0344  34165 040076          ADA SCHPR      COMPARE WITH PRIORITY
0345  34166 002020          SSA                    <HIS  OF USER BEING INSERTED.
0346  34167 020160          JMP SCH2       IF >= GO TO LINK TO NEXT ENTRY.
0347  34170 174071          STB SCHL,I     SET NEW ENTRY TO POINT TO HIM.
0348  34171 060071          LDA SCHL
0349  34172 170074          STA SCHP,I     SET PREVIOUS ENTRY => NEW ENTRY.
0350  34173 040466          ADA .+?CLOC-?LINK  SET NEW USERS CLOCK TO -10.
0351  34174 064457          LDB .-10        SET UP TIME SLICE
0352  34175 174000          STB 0,I
0353  34176 017240          JSB SWAPR      START EARLY SWAPPING.
0354*                                                 P214/#18
0355*     THIS SECTION IS THE BEGINNING OF THE MAIN PART OF THE SCHEDU-
0356*     LER. CONTROL ALWAYS COMES HERE TO EXAMINE THE TTQ UNTIL IT'S
0357*     EXHAUSTED, OR WHEN THERE IS NOTHING TO DO. SWAPR ALWAYS COMES
0358*     TO THIS POINT WHEN THE QUEUE IS EMPTY OR THE FIRST PROGRAM ON
0359*     THE QUEUE IS ABSENT.
0360*
0361* THE FOLLOWING SECTION OF CODE TAKES CARE OF THE TELEPHONE LOGIC.
0362* IT IS RESPONSIBLE FOR MAKING 3 DECISIONS:
0363*     1) A USER HAS CALLED UP;
0364*     2) A USER HAS HUNG UP;
0365*     3) A USER HAS BEEN ON TOO LONG WITHOUT SUCCESSFULLY LOGGING IN
0366* THE FOLLOWING BIT FLAGS ARE USED:
0367*     PHL=MOST RECENT INPUT FROM DISCONNECT BOARD
0368*     PHN=CURRENT INPUT FROM DISCONNECT BOARD
0369*     PHO=OUTPUT TO DISCONNECT BOARD
0370*     PHT=1 IF USER IS BEING TIMED FOR SOMETHING
0371* WHEN A USER IS BEING TIMED, LOCATION ?PHON IN HIS TTY TABLE CON-
0372* TAINS THE VALUE OF DATIM+1 NECESSARY FOR TIMEOUT TO BE ACHIEVED.
```

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FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 2 OF 18

```
0374  34177 000000 SCH1  NOP (CHANGED TO RSS BY PHONES COMMAND)
0375  34200 020324        JMP SCH54 ---> IF NO PHONES          P204/#17
0376  34201 102500 SCH41  LIA 2          GET NEW INPUT FROM DISCONNECTOR.
0377  34202 070236        STA PHN        SAVE.
0378  34203 020235        XOR PHL        TEST FOR ANY CHANGES
0379  34204 030240        IOR PHT         OR TIMEOUTS.
0380  34205 064276        LDB DMAS0      => TTY00+?MASK-(TTY01-TTY00)
0381  34206 002003 SCH42  SZA,RSS        TEST FOR ANYTHING TO DO.
0382  34207 026320        JMP SCH52      NO.
0383  34210 044523        ADB .+TTY01-TTY00  SET NEW MASK ADDRESS.
0384  34211 000075        CLE,SLA,ERA    BIT TEST.
0385  34212 002001        RSS            FOUND ONE.
0386  34213 026210        JMP *-3        TEST NEXT.
0387*
0388  34214 070074        STA SCHP       SAVE BIT TEST WORD.
0389  34215 074071        STB SCHL       SAVE MASK ADDRESS
0390  34216 060236        LDA PHN        TEST FOR CHANGE IN
0391  34217 020235        XOR PHL         DISCONNECT INPUT.
0392  34220 110001        AND 1,I
0393  34221 002003        SZA,RSS
0394  34222 026271        JMP SCH50      NO  CHANGE--MUST BE TIMEOUT.
0395  34223 010236        AND PHN        WHICH WAY DID TI CHANGE?
0396  34224 002002        SZA
0397  34225 026245        JMP SCH43      CHANGE FROM 0 TO 1.
0398*
0399  34226 060240        LDA PHT        TEST IF TIMED.
0400  34227 110001        AND 1,I
0401  34230 002002        SZA
0402  34231 026237        JMP SCH48      GO HANDLE LINE DROPOUT.
0403  34232 160001        LDA 1,I        ANSWER
0404  34233 003000        CMA             THE
0405  34234 010237        AND PHO          PHONE.
0406  34235 070237        STA PHO
0407  34236 026243        JMP SCH44      NO--USER JUST CAME ON.
0408  34237 044503 SCH48  ADB .+?ID-?MASK     LINE DROPOUT--IGNORE IF
0409  34240 160001        LDA 1,I              VALID ID.
0410  34241 002002        SZA
0411  34242 026266        JMP SCH49
0412*
0413* USER HAS JUST CALLED IN. SET UP TIMING FOR LOGON.
0414*
0415  34243 060166 SCH44  LDA PHR        GET REQUIRED RESPONSE TIME.
0416  34244 026251        JMP SCH45      GO SET UP ENTRY.
0417  34245 010240 SCH43  AND PHT        IGNORE DROPOUT IF ALREADY
0418  34246 002002        SZA             TIMING.
0419  34247 026263        JMP SCH47
0420  34250 060515        LDA .+20       OTHERWISE SET UP 2 SEC TIMER.(F)
0421  34251 064071 SCH45  LDB SCHL       COMPUTE ADDRESS OF PHONE LOC.
0422  34252 044507        ADB .+?PHON-?MASK
0423  34253 000040        CLE            COMPUTE REQUIRED TIME FOR RUNOUT
0424  34254 040037        ADA DATIM+1
0425  34255 002040        SEZ
0426  34256 040401        ADA M36K
0427  34257 170001        STA 1,I
0428  34260 060240        LDA PHT        SET TIMING BIT.
0429  34261 130071        IOR SCHL,I
0430  34262 070240 SCH46  STA PHT
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 3 OF 18

```
0431  34263 060074  SCH47 LDA SCHP       GET BIT TEST AND COUNTER
0432  34264 064071        LDB SCHL        WORDS AGAIN.
0433  34265 026206        JMP SCH42       LOOP.
0434*
0435  34266 160071  SCH49 LDA SCHL,I     CLEAR PHT.
0436  34267 020240        XOR PHT
0437  34270 026262        JMP SCH46
0438*
0439* CODE TO TEST FOR HANGUP OR UNSUCCESSFUL LOGON.
0440*
0441  34271 044507  SCH50 ADB .+?PHON-?MASK  TEST FOR KICKOFF.
0442  34272 160001        LDA 1,I         GET REQUIRED TIME.
0443  34273 003004        CMA,INA         SUBTRACT FROM
0444  34274 040037        ADA DATIM+1     CURRENT TIME.
0445  34275 002020        SSA
0446  34276 026263        JMP SCH47       NOT TIMED OUT.
0447*
0448  34277 044477        ADB .+?STAT-?PHON
0449  34300 160001        LDA 1,I         GET USER'S STATUS.
0450  34301 050467        CPA .-2         ALREADY HANDLED.
0451  34302 026263        JMP SCH47
0452  34303 040460        ADA .+.-%SYNT-1-COM3+COM2
0453  34304 002021        SSA,RSS         TEST FOR LIBRARY TYPE PROGRAM.
0454  34305 026263        JMP SCH47       IGNORE FOR NOW IF IT IS.
0455  34306 060467        LDA .-2         SET STATUS TO -2.
0456  34307 170001        STA 1,I
0457  34310 103100        CLF 0
0458  34311 160071        LDA SCHL,I      SET MPCOM BIT.
0459  34312 030234        IOR MPCOM
0460  34313 070234        STA MPCOM
0461  34314 102100        STF 0
0462  34315 044472        ADB .+?LINK-?STAT
0463  34316 017461        JSB DEQUE       REMOVE USER FROM QUEUE.
0464  34317 026263        JMP SCH47
0465*
0466* END OF PROCESSING
0467*
0468  34320 060237  SCH52 LDA PHO         OUTPUT TO PHONES.
0469  34321 102600  SCH53 OTA 0
0470  34322 060236        LDA PHN         COPY N INTO L.
0471  34323 070235        STA PHL
0472*
0001  34324 102100 SCH54  STF 0             ENABLES INTERRUPTS
0002  34325 060234        LDA MPCOM       TEST FOR ANY COMMUNICATION MPCOM=00040
0003  34326 002002        SZA              FROM MULTIPLEXOR.
0004  34327 026546        JMP SCH5
0005*                                     P208/#18      TO SERVICE MULTIPLEXOR
0006* TEST FOR ANY TTY35 BUSINESS
0007*
0008  34330 003400        CCA             TEST FOR DRIVER BUSY.
0009  34331 050356        CPA T35F1
0010  34332 026507        JMP SCH15       DRIVER IS BUSY.
0011*
0012* WHEN T35F1=0, THE CONSOLE IS QUIET SO WE CAN DO LOGGING.
0013*
0014  34333 040332        ADA LOGCT       TEST FOR ANY ENTRIES IN LOGTABLE
0015  34334 050470        CPA .-1
```

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FIGURE 21. SCHEDULER EXAMPLE (Con't)
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```
0016  34335 020430         JMP SCH16      LOG TABLE IS EMPTY.
0017*
0018* SET UP LOG BUFFER
0019*
0020  34336 070332         STA LOGCT      DECREMENT LOG COUNTER.
0021  34337 060333         LDA LOGP1      BUMP LOG POINTER
0022  34340 002004         INA
0023  34341 050336         CPA LOGND      IF AT END,
0024  34342 060335         LDA LOGBG        WRAP AROUND.
0025  34343 070333         STA LOGP1
0026  34344 160333         LDA LOGP1,I    TEST FOR LOGON
0027  34345 064337         LDB ASCIN        OR LOGOUT.
0028  34346 002020         SSA
0029  34347 064340         LDB ASCFF
0030  34350 076417         STB LOGBF+3
0031  34351 101052         LSR 10         SHIFT LOG CHAR TO LEAST 5 BITS.
0032  34352 010530         AND .+378      MASK OFF OTHER STUFF.
0033  34353 040341         ADA ASCBA      CONVERT TO ASCII.
0034  34354 072420         STA LOGBF+4
0035  34355 160333         LDA LOGP1,I    GET ACCOUNT NUMBER AGAIN.
0036  34356 010325         AND B1777      KEEP ONLY # PART.
0037  34357 006400         CLB
0038  34360 100400         DIV .+10       GET 1ST 2 DIGITS IN A, LAST IN B
0039  34362 005727         BLF,BLF        SET UP LAST DIGIT AS
0040  34363 044342         ADB ASC0B       ASCII LEFT HALF.
0041  34364 076422         STB LOGBF+6
0042  34365 017134         JSB #LTEN      CONVERT FIRST 2 TO ASCCII ALSO.
0043  34366 072421         STA LOGBF+5
0044  34367 034333         ISZ LOGP1
0045  34370 160333         LDA LOGP1,I    NOW GET THE TIME.
0046  34371 010510         AND .+17B      GET TERMINAL NUMBER.
0047  34372 017134         JSB #LTEN      CONVERT AND STORE IN BUFFER.
0048  34373 072426         STA LOGBF+10
0049  34374 160333         LDA LOGP1,I
0050  34375 006400         CLB
0051  34376 101024         ASR 4
0052  34377 100400         DIV D60
0053  34401 174333         STB LOGP1,I    SAVE SECOND HALF
0054  34402 017134         JSB #LTEN      CONVERT FIRST HALF TO ASCII.
0055  34403 072423         STA LOGBF+7
0056  34404 160333         LDA LOGP1,I
0057  34405 017134         JSB #LTEN      CONVERT 2ND HALF TO ASCII.
0058  34406 072424         STA LOGBF+8
0059  34407 060520         LDA .+23
0060  34410 060413         LDB LOGR2       TO PPRINT THE
0061  34411 114270  SCH21 JSB TTY35,I     STUFF.
0062  34412 020507         JMP SCH15
0063  34413 134414  LOGR2 DEF **+1,I     BUFFER ADDRESS (I=>PUNCH)
0064  34414 025052  LOGBF ASC 11,**LOGOFF A123 0930 #01
0065  34427 011400         OCT 11400       XOFF
0066*
0067*  TTY35 IU COMPLETE
0068*
0069  34430 050357  SCH16 CPA T35F2      TEST DRIVER COMMUNICATE FLAG.
0070  34431 002001         RSS
0071  34432 020507         JMP SCH15
0072  34433 060347         LDA T35ST      GET CONSOLE STATUS.
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
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NOT USED FOR THIS EXAMPLE

```
0073  34434 064351          LDB T35PR
0074  34435 050474          CPA %OUTW      IF OUTPUT WAIT,
0075  34436 026462          JMP SCH23      GO SET HIM UP.
0076  34437 002002          SZA            IF NOT IDLE WE'VE ALREADY
0077  34440 026507          JMP SCH15        QUEUED HIM.
0078* TTY35 INPUT COMMAND
0079*
0080  34441 060353          LDA T35B2      POINTER TO FIRST CHARACTER
0081  34442 070070          STA SBHED       OF CONSOLE BUFFER.
0082  34443 060354          LDA T35ND      POINTER TO END OF
0083  34444 070071          STA SCHL        CONSOLE BUFFER.
0084  34445 060531          LDA .+408      INITIALIZE COMMAND
0085  34446 070074          STA SCHP        HOLDER.
0086  34447 017162          JSB SCOM       GET COMMAND.
0087  34450 026470          JMP SCH17      BLANK LINE
0088  34451 026472          JMP SCH18      ERROR
0089  34452 026472          JMP SCH18      ERROR
0090*
0091* SET UP QUEUE ENTRY FOR CONSOLE.
0092*
0093  34453 060070          LDA SBHED      SET POINTER FOR
0094  34454 070044          STA T35CP       T35CR.
0095  34455 060531          LDA .+408      SET UP LA2T CHAR
0096  34456 070045          STA T35LC       AS BLANK
0097*
0098  34457 060263          LDA #LIB#      SET RESTART ADDRESS.
0099  34460 070346          STA T35RS
0100  34461 046467          ADB SCH19      SET PROGRAM STATUS
0101  34462 074347  SCH23 STB T35ST        TYPE.
0102  34463 060473          LDA .+2        SET PRIORITY.
0103  34464 070351          STA T35PR
0104  34465 064352          LDB T35LN      GO INSERT IN QUEUE
0105  34466 026152          JMP SCH3
0106  34467 142127  SCH19 ABS -COM2+%SYNT-.+1
0107  34470 060374  SCH17 LDA ONEI        OUTPUT LINE FEED
0108  34471 002001          RSS
0109  34472 060475  SCH18 LDA .+4         OUTPUT ERROR MESSAGE
0110  34473 006400          CLB
0111  34474 074357          STB T35F2
0112  34475 064375          LDB LEM
0113  34476 026411          JMP SCH21
0114*  START OF SYSTEM  *
0115  34477 060474  TSB   LDA .+3         START CLOCK COUNTING IN
0116  34500 102612          OTA CLOCK      100 MS UNITS.
0117  34501 103712          STC CLOCK,C    START CLOCK AND
0118  34502 103710          STC MPX,C      MPX.
0119  34503 060477          LDA .+6        START SYSTEM
0120  34504 064311          LDB READY      TELETYPE BY OUTPUTTING
0121  34505 114270          JSB TTY35,I      READY MESSAGE.
0122  34506 026177          JMP SCH1


0124*
0125*
0126  34507 01/240  SCH15 JSB SWAPR       CHECK FOR ANYTHING TO DO. IF NOT
0127*                                     SWAPR WILL GO TO SCH1 AGAIN.
0128*                                     IT WILL RETURN HERE IF THERE IS
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 6 OF 18

```
0129*                                   AN EXECUTABLE PROGRAM IN CORE.


0131*      THE PROGRAM TO RUN IS AT THE HEAD OF THE QUEUE, AND SWAPR HAS
0132*      GUARANTEED THAT IT IS IN CORE. THE FOLLOWING SECTION OF CODE
0133*      SETS IT UP TO RUN, AND ALSO SETS UP THE CLOCK DRIVER SO THAT
0134*      FUTURE INTERRUPTS WILL GO BACK INTO THE SCHEDULER.

0136  34510 103100          CLF 0           INHIBIT INTERRUPT.
0137  34511 062123          LDA CLC2        RESTORE A <JMP SCHED> IN THE
0138  34512 072120          STA CLC1          CLOCK INTERRUPT ROUTINE.
0139  34513 060321          LDA MLINK+1
0140  34514 002004          INA             GET PRIORITY OF PROGRAM.
0141  34515 164000          LDB 0,I
0142  34516 054473          CPB .+2         IF PRIORITY IS 2, CHANGE IT TO
0143  34517 006400          CLB             ZERO SO IT DOESNT GET INTERRUPTE
0144  34520 174000          STB 0,I
0145  34521 040466          ADA .+?RSTR-?PLEV   GET RESTART ADDRESS
0146  34522 164000          LDB 0,I           IF NOT 0, PUT IT IN PREG
0147  34523 006002          SZB              TO START UP PROPERLY.
0148  34524 075243          STB PREG
0149  34525 006400          CLB             PUT 0 INTO TABLE IN ANY CASE
0150  34526 174000          STB 0,I
0151  34527 074254          STB TIMEF       SET TO SAY NO TIMING.
0152  34530 002004          INA             GET PROGRAM STATUS.
0153  34531 164000          LDB 0,I
0154  34532 040467          ADA .+?CLOC-?STAT   SET TIMER POINTER.
0155  34533 070067          STA TIMER
0156  34534 054476          CPB %SYNT+1     IF STATUS IS RUN, SET
0157  34535 034254          ISZ TIMEF        TIMEFLAG FOR CLOCKING.
0158  34536 061242          LDA EREG        RESTORE E
0159  34537 103101          CLO              AND OVERFLOW
0160  34540 000036          SLA,ELA           REGISTERS.
0161  34541 102101          STO
0162  34542 061240          LDA AREG        RESTORE A AND
0163  34543 065241          LDB BREG          B REG.
0164  34544 102100          STF 0           ENABLE INTERRUPT AND
0165  34545 125243          JMP PREG,I       TRANSFER TO PROGRAM.
0166*
0167*  THIS SECTION ACTUALLY PROCESSES A TTQ ENTRY. THERE ARE SEVERAL
0168*  KINDS OF ENTRIES WHICH MAY BE CLASSIFIED AS FOLLOWS:
0169*
0170*     1) ABORT - THIS IS INDICATED BY THE TELETYPE STATUS BEING
0171*        -1. THE ACTION TAKEN IS TO STOP THE PROGRAM (IF IT IS
0172*        IN THE QUEUE), AND TO INITIATE THE ABORT MESSAGE.
0173*
0174*     2) OUTPUT TERMINATE - THIS IS INDICATED BY THE STATUS BEING
0175*        %UUTW.  THE TTQ ENTRY REALLY MEANS THAT THE OUTPUT BUFFER
0176*        IS ALMOST EMPTY. THE PROGRAM IS PLACED BACK ON THE QUEUE
0177*        ACCORDING TO ITS PRIORITY.
0178*
0179*     3) INPUT - THIS IS INDICATED BY STATUS BEING %INPT. IT INDI-
0180*        CATES THAT A USER PROGRAM OR SYSTEM PROGRAM THAT HAS
0181*        REQUESTED INPUT HAS GOTTEN IT. THE PROGRAM IS PLACED IN
0182*        THE QUEUE.
0183*
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 7 OF 18

```
0184*      4) COMMAND - WHEN STATUS IS XIDLE, EITHER A COMMAND OR
0185*         A SYNTAX STATEMENT HAS BEEN ENTERED. THESE CAN BE DISTIN-
0186*         GUISHED BY THE FIRST NON BLANK INPUT CHARACTER, WHICH IS
0187*         A DIGIT ONLY IF SYNTAX HAS BEEN ENTERED.
0188*
0189  34546 064300  SCH5   LDB DTTY0      COMPUTE ADDRESS OF TABLE
0190  34547 000033         SLA,RAR       ENTRY FOR SIGNALLING TELETYPE.
0191  34550 026553         JMP *+3       FOUND.   FIND BIT IN MPCOM WHICH
0192  34551 044523         ADB .+TTY01-TTY00   INDICATES SERVICE REQUIRED
0193  34552 026547         JMP *-3       PORT 5
0194  34553 074072         STB TTQ       SAVE ADDRESS IN TTQ   B=33223 BASE PAGE
0195  34554 044506         ADB .+?ID     STORE ID ADDRESS IN
0196  34555 074073         STB SCHID      SCHID.                ID ADDR TO BASE PAGE
0197  34556 103100         CLF 0         INHIBIT MULTIPLEXOR.
0198  34557 044457         ADB .+?MASK-?ID                B=33226
0199  34560 160001         LDA 1,I       CLEAR MPCOM BIT.
0200  34561 020234         XOR MPCOM
0201  34562 070234         STA MPCOM                          MPCOM=000000
0202  34563 044515         ADB .+?STAT-?MASK  B=>STATUS.
0203  34564 160001         LDA 1,I       GET STATUS IN A.  A=Ø  IDLE
0204  34565 040465         ADA .-4       MAKE SURE STATUS  A=-4
0205  34566 002021         SSA,RSS         IS < 4.
0206  34567 026324         JMP SCH54     IGNORE OTHERWISE.
0207  34570 042572         ADA *+2       BRANCH TO SECTION TO HANDLE REQU A=34575
0208  34571 124000         JMP 0,I
0209  34572 034601         DEF *+7
0210  34573 026636         JMP SCH8      SPECIAL DISCONNECT.
0211  34574 026612         JMP SCH7      ABORT
0212  34575 026651         JMP SCH6      COMMAND
0213  34576 026324         JMP SCH54     ABORTING.
0214  34577 000000         NOP           INPUT
0215*                                                P 209/#18  CHECK FOR COMMAND
0216*  CODE TO HANDLE INPUT OR OUTPUT.
0217*
0218  34600 044473         ADB .+2       B=>PLEV
0219  34601 160001         LDA 1,I       GET ACTUAL STATUS
0220  34602 044467         ADB .-2       B=>STATUS.
0221  34603 170001         STA 1,I       SET ACTUAL STATUS
0222  34604 102100         STF 0
0223  34605 044473         ADB .+2       B=>PLEV
0224  34606 002400         CLA           SET PRIORITY TO 0
0225  34607 170001         STA 1,I
0226  34610 044470         ADB .-1       GO INSERT USER IN
0227  34611 026152         JMP SCH3       QUEUE.
0228*
0229*  CODE TO HANDLE ABORT
0230*
0231  34612 102100  SCH7   STF 0
0232  34613 006004         INB           B=>LINK
0233  34614 017461         JSB DEQUE     REMOVE USER FROM QUEUE.
0234  34615 064072         LDB TTQ       CHANGE STATUS
0235  34616 044520         ADB .+?STAT
0236  34617 060472         LDA XABOR     TO ABORTING
0237  34620 170001         STA 1,I
0238  34621 003400         CCA           SET CHARACTER COUNT TO -1 TO
0239  34622 044446         ADB .+?CCNT-?STAT
0240  34623 170001         STA 1,I       TERMINATE ANY CURRENT OUTPUT.
```

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FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 8 OF 18

```
0241  34624 054072          LDB TTQ        PRINT ABORT
0242  34625 060461          LDA .-8         MESSAGE.
0243  34626 01/144          JSB TYPE
0244  34627 000412          OCT 6412      CRLF
0245  34630 051524          ASC 2,STOP
0246  34632 000412          OCT 6412      CRLF
0247  34633 064072          LDB TTQ        SCRATCH IF SHELLO IS RUNNING.
0248  34634 017640          JSB HTEST
0249  34635 026324          JMP SCH54
0250*
0251* CODE TO SET UP FORCED DISCONNECT.
0252*
0253  34636 044454  SCH8    ADB .+?LADR-?STAT                              [F]
0254  34637 160001          LDA 1,I        GET POINTER TO USER'S LADDR.    [F]
0255  34640 040466          ADA .-3        POINTS TO MODIFIED WORD.        [F]
0256  34641 070071          STA SCHL       SAVE IN SCHL.                   [F]
0257  34642 002004          INA            A POINTS TO JMP *+3.            [F]
0258  34643 160000          LDA 0,I        LOAD "JMP *+3" AND STORE IN     [F]
0259  34644 170071          STA SCHL,I     LADDR. THIS SHUTS OUT MPX.      [F]
0260  34645 060001          LDA 1          SET A TO POINT AT RESTART       [F]
0261  34646 040505          ADA .+?RSTR-?LADR  ADDRESS.                    [F]
0262  34647 102100          STF 0                                          [F]
0263  34650 027072          JMP SCH61      GO SET UP STARTING INFO.
0264*
0265*
0266*  CODE TO HANDLE COMMANDS.        B => STAT
0267*                                  ALLOW MULTIPLEXOR INTERRUPTS AGAIN
0268  34651 102100  SCH6    STF 0
0269  34652 044451          ADB .+?BHED-?STAT  B=>BUFFER HEAD.  B=33232
0270  34653 160001          LDA 1,I        GET BUFFER HEAD.
0271  34654 070070          STA SBHED      INITIALIZE BUFFER POINTER.BASE PAGE
0272  34655 044473          ADB .+2        B=>BUFFER END
0273  34656 074071          STB SCHL                          ON BASE PAGE
0274  34657 002400  SCH24   CLA            INITIALIZE SCHP TO HOLD
0275  34660 070074          STA SCHP        CHARACTERS.            ON BASE PAGE
0276  34661 017162          JSB SCOM       INTERPRET COMMAND
0277  34662 026704          JMP SCH30      EMPTY LINE.
0278  34663 026666          JMP SCH9       FIRST CARACTER A DIGIT
0279  34664 026734          JMP EHERR      INVALID COMMAND.
0280  34665 026742          JMP SCH11      COMMAND IS OK.
0281*       RETURN HELLO                    P213/#18 GET CHARACTER
0282* THE FIRST CHARACTER IS A DIGIT. THIS MEANS THE LINE IS SYNTAX AND
0283* WE HAVE TO QUEUE IT AS SUCH.          P 210/#18
0284*
0285  34666 064071  SCH9    LDB SCHL       GET TABLE POINTER AGAIN.
0286  34667 044511          ADB .+?PLEV-?BEND  B=>PRIORITY
0287  34670 002400          CLA            SET PRIORITY TO 0
0288  34671 150073          CPA SCHID,I    IF NO ID, GO LOG IN.
0289  34672 026746          JMP SCH25
0290  34673 170001          STA 1,I
0291  34674 044466          ADB .+?RSTR-?PLEV  SET UP STARTING ADDRESS
0292  34675 060601          LDA SYNTA          FOR SYNTAX
0293  34676 170001          STA 1,I
0294  34677 044472          ADB .+?STAT-?RSTR
0295  34700 060475          LDA %SYNT      SET STATUS TO
0296  34701 170001          STA 1,I         SYNTAX.
0297  34702 000004          INB            GO INSERT IN QUEUE.
```

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VARIABLE RETURN

FIGURE 21. SCHEDULER EXAMPLE (Con't)
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```
0298  34703 026152          JMP SCH3
0299*
0300  34704 064072  SCH30   LDB TTG        TEST FOR TAPE MODE IF NULL LINE.
0301  34705 044474          ADB .+?MASK
0302  34706 060253          LDA TAPEF
0303  34707 110001          AND 1,I
0304  34710 002003          SZA,RSS
0305  34711 026730          JMP SCH20     NO TAPE--GO EMIT LINE FEED.
0306  34712 103100          CLF 0          INHIBIT INTERRUPT.
0307  34713 064070          LDR SBHED      SET SBHED TO POINT AT 1ST CHAR
0308  34714 000004          INB             OF NEXT BUFFER.
0309  34715 154071          CPB SCHL,I
0310  34716 044405          ADB MBLEN
0311  34717 074070          STB SBHED
0312  34720 060071          LDA SCHL      SET BHED ALSO.
0313  34721 040467          ADA .-2
0314  34722 174000          STB 0,I
0315  34723 040470          ADA .-1        TEST FOR CONTINUATION.
0316  34724 164000          CPB 0,I
0317  34725 026324          JMP SCH54      NO CONTINUATION.
0318  34726 102100          STF 0          INTERRUPT BACK ON.
0319  34727 026657          JMP SCH24      GO SCAN NEXT BUFFER.
0320*
0321  34730 060503  SCH20   LDA .+128      OUTPUT A LINE FEED.
0322  34731 064072          LDB TTG
0323  34732 114323          JSB OUTCH,I
0324  34733 026324          JMP SCH54
0325*
0326* COME HERE WHEN ANY ILLEGAL INPUT IS FOUND.
0327*
0328  34734 060463  EHERR   LDA .-6
0329  34735 017144          JSB TYPE
0330  34736 005077  EH      OCT 5077,37477,6412   (???)
0331  34741 026324          JMP SCH54
0332*
0333* COME HERE WHEN A LEGITIMATE COMMAND IS FOUND
0334*                              B=35671
0335  34742 160073  SCH11   LDA SCHID,I   PROCESS COMMAND ONLY IF ID=Ø FROM TTY
0336  34743 002003          SZA,RSS         ID#Ø OR                      TABLE
0337  34744 056761          CPB HI           HELLO COMMAND.
0338  34745 026763          JMP SCH22
0339  34746 060451  SCH25   LDA .-16       PRINT LOG IN MESSAGE
0340  34747 017144          JSB TYPE
0341  34750 000120          OCT 5120       LF-P
0342  34751 040105          ASC 6,LEASE LOG IN
0343  34757 006412          OCT 6412
0344  34760 026324          JMP SCH54
0345  34761 035671  HI      DEF HELLO
0346  34762 035661  LTAPE   DEF CTAPE
0347  34763 064072  SCH22   LDB TTG        IF COMMAND, CLEAR TAPE FLAG.B=33223
0348  34764 044474          ADB .+?MASK      B=33226
0349  34765 103100          CLF 0           HOLD OFF INTERRUPTS
0350  34766 160001          LDA 1,I        IF TAPEF AND    A=000040
0351  34767 010253          AND TAPEF       INPTF ARE
0352  34770 010250          AND INPTF       BOTH SET,
0353  34771 002002          SZA
0354  34772 026734          JMP EHERR       KILL HIM.
```

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FIGURE 21. SCHEDULER EXAMPLE (Con't)
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```
PAGE 0211 #18  SCHEDULER
                                          B =>MASK
0355  34773 160001          LDA 1,I         A=000040
0356  34774 030250          IOR INPTF       BLOCK FURTHER
0357  34775 070250          STA INPTF        INPT.     INPTF=000040
0358  34776 102100          STF 0         ALLOW INTERRUPTS
0359  34777 160001          LDA 1,I        A=000040
0360  35000 003000          CMA           A=177737
0361  35001 010253          AND TAPEF             WOULD HAVE REMOVED FROM
0362  35002 070253          STA TAPEF             TAPE MODE
0363  35003 160074          LDA SCHP,I    TEST FOR HELLO,BYE,OR SCRATCH.
0364  35004 053671          CPA HELLO     OK TO PROCEDE IF ANY
0365  35005 027021          JMP SCH27     OF THESE.
0366  35006 053653          CPA SCR
0367  35007 027021          JMP SCH27
0368  35010 053672          CPA BYE
0369  35011 027021          JMP SCH27
0370  35012 160001          LDA 1,I       TEST FOR ANY TAPE ERRORS.
0371  35013 010047          AND TERR
0372  35014 002003          SZA,RSS
0373  35015 027025          JMP SCH26     NO TAPE ERRORS--CONTINUE.
0374*
0375  35016 062762          LDA ITAPR     OTHERWISE, SET UP FOR EXECU-
0376  35017 070074          STA SCHP       TION OF TAPE ERROR
0377  35020 027025          JMP SCH26      PRINTOUT ROUTINE.
0378*
0379  35021 160001 SCH27    LDA 1,I       IF HELLO, BYE OR SCRATCH, A=000040
0380  35022 003000          CMA            CLEAR TAPE ERROR BIT.  A=177737
0381  35023 010047          AND TERR
0382  35024 070047          STA TERR         AND PROCEDE.
0383  35025 044504 SCH26    ADB .+?NAME-?MASK    B=33241
0384  35026 160001          LDA 1,I       TEST FOR        A=000000
0385  35027 002021          SSA,RSS       RUN-ONLY PROGRAM.
0386  35030 027040          JMP SCH28     NOT RUN-ONLY.
0387  35031 160074          LDA SCHP,I    IF RUN-ONLY, DON'T
0388  35032 053665          CPA SAVE       ALLOW THESE
0389  35033 027052          JMP SCH29      COMMANDS.
0390  35034 053657          CPA LIS
0391  35035 027052          JMP SCH29
0392  35036 053660          CPA PUN
0393  35037 027052          JMP SCH29
0394*
0395  35040 044462 SCH28    ADB .+?BHED-?NAME   B=33232
0396  35041 060070          LDA SBHED     SET BUFFER POINTER.
0397  35042 170001          STA 1,I        WRITE INTO TTY TAPE
0398  35043 064074          LDB SCHP                    A=35671
0399  35044 044407          ADB MCOM2     TEST FOR TYPE I COMMAND.  B=000013
0400  35045 006021          SSB,RSS
0401  35046 027062          JMP SCH12     NOT TYPE I.
0402  35047 047051          ADB *+2       GET STARTING ADDRESS FOR COMMAND
0403  35050 124001          JMP 1,I        PROCESSOR AND GO THERE.
0404  35051 135735          DEF COM5-COM1+COM2,I
0405  35052 060457 SCH29    LDA .-10
0406  35053 017144          JSB TYPE
0407  35054 005122          OCT 5122      LF-R
0408  35055 052516          ASC 3,UN ONL
0409  35060 054415          OCT 54415     Y-CR
0410  35061 026730          JMP SCH20
0411*                       NEXT PAGE
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
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```
PAGE 0212 #18  SCHEDULER


0412* TYPE II AND III COMMANDS
0413*
0414  35062 044476  SCH12 ADB %SYNT+1    DETERMINE PROGRAM STATUS.  B=000020
0415  35063 060072        LDA TTQ          A=33223
0416  35064 040520        ADA .+?STAT      A=33252
0417  35065 174000        STB 0,I          STATUS=20
0418  35066 040470        ADA .+?RSTR-?STAT  A=>RESTART ADDRESS A=33251
0419  35067 044460        ADB .+.-%SYNT+COM2-COM3-1    TYPE II OR III ??
0420  35070 000020        SSB                                    B=000007
0421  35071 027103        JMP SCH13      TYPE II COMMAND
0422  35072 064263  SCH61 LDB #LIB#      TYPE III COMMANDS HAVE A STAN-
0423  35073 174000        STB 0,I         DARD STARTING ADDRESS AND  B=37300
0424  35074 064473        LDB .+2         PRIORITY 2.
0425  35075 040474  SCH14 ADA .+?PLEV-?RSTR            A=33254
0426  35076 174000        STB 0,I          PLEV=2
0427  35077 007400        CCB             GET LINK POINTER IN B AND GO
0428  35100 044000        ADB 0            TO INSERT INTO QUEUE.  B=33253
0429  35101 026152        JMP SCH3  ------------------>  P202/#17
0430  35102 035741        DEF COM3+COM5-COM1
0431  35103 047102  SCH13 ADB *-1        GET STARTING ADDRESS FOR TYPE
0432  35104 164001        LDB 1,I          II COMMANDS.
0433  35105 174000        STB 0,I
0434  35106 006404        CLB,INB         GO SET PRIORITY TO 1
0435  35107 027075        JMP SCH14
0436*
0437* "SCRATCH" COMMAND
0438*
0439  35110 064072  #SCR  LDB TTQ         B=>TTY TABLE.
0440  35111 017113        JSB SCRAT       PERFORM SCRATCH FUNCTION.
0441  35112 026730        JMP SCH20       TERMINATE.
0442*
0443  35113 000000  SCRAT NOP             SCRATCH A PROGRAM (B=>USERS TTY)
0444  35114 060400        LDA PBUFF       IF MAIN=B, SET PBPTR.
0445  35115 054242        CPB MAIN
0446  35116 070046        STA PBPTR
0447  35117 044505        ADB .+?PROG     B=>PROGEND
0448  35120 170001        STA 1,I         RESET TABLE(PROG)
0449  35121 044473        ADB .+?NAME-?PROG   CLEAR
0450  35122 160001        LDA 1,I          READ-ONLY BIT.
0451  35123 001665        ELA,CLE,ERA      BIT.
0452  35124 170001        STA 1,I
0453  35125 127113        JMP SCRAT,I
0454*
0455* "TAPE" COMMAND
0456*
0457  35126 064072  #TAP  LDB TTQ         B=>TTY TABLE.
0458  35127 044474        ADB .+?MASK     B=>MASK
0459  35130 060253        LDA TAPEF       SET TAPE BIT.
0460  35131 130001        IOR 1,I
0461  35132 070253  #TAP1 STA TAPEF
0462  35133 026730        JMP SCH20       TERMINATE.
0463*
0464*
0465  35134 000000  #LTEN NOP             CONVERT A # FROM 0-99 TO ASCII.
0466  35135 006400        CLB             GET FIRST DIGIT IN A,
0467  35136 100400        DIV .+10         SECOND IN B.
0468  35140 001727        ALF,ALF         POSITION FIRST ON LEFT,
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
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```
0469  35141 040001          ADA 1          ADD IN SECOND,
0470  35142 040315          ADA ASC00        ADD IN ASCII BITS.
0471  35143 127134          JMP #LTEN,I      RETURN.
0472*
0473* TYPE SENDS AN ENTIRE STRING TO A TELETYPE. IT IS CALLED AS FOLLOWS
0474*     A=-#OF CHARS--MUST END ON RIGHT HALF OF WORD
0475*     JSB TYPE
0476*     <CHAR STRING>
0477*     RETURN


0479  35144 000000  TYPE  NOP
0480  35145 073161        STA TYPET      SAVE COUNTER
0481  35146 163144  TYPEL  LDA TYPE,I    GET WORD CONTAINING CHAR.
0482  35147 067161        LDB TYPET      GET COUNT IN B.
0483  35150 006011        SLB,RSS        IF COUNT IS EVEN, TAKE HIGH
0484  35151 001727        ALF,ALF         CHAR;
0485  35152 004010        SLB            IF COUNT IS ODD,
0486  35153 037144        ISZ TYPE        BUMP TYPE.
0487  35154 064072        LDB TTO        OUTPUT CHAR TO TELETYPE.
0488  35155 114323        JSB OUTCH,I
0489  35156 037161        ISZ TYPET      ANY MORE?
0490  35157 027146        JMP TYPEL      YES.
0491  35160 127144        JMP TYPE,I     NO.
0492  35161 000000  TYPET NOP
0493* SCOM SCANS A COMMAND INPUT BUFFER TO DETERMINE WHAT
0494* THE COMMAND IS. THE CALLING SEQUENCE TO SCOM IS:
0495*
0496*     JSB SCOM
0497*     <RETURN IF BLANK LINE>
0498*     <RETURN IF FIRST CHARACTER A DIGIT>
0499*     <RETURN IF NO LEGAL COMMAND>
0500*     <RETURN IF COMMAND FOUND--B=COMMAND ADDRESS>
0501*
0502* SCOM ASSUMES THAT BEFORE IT IS CALLED, SBUFD AND
0503* SCHL ARE INITIALIZED AS REQUIRED BY SCHAR,, AND
0504* SCHP=0 FOR NORMAL USERS AND OCT40 FOR CONSOLE.
                                          PREG=34662
0506  35162 000000  SCOM  NOP            ENTRY POINT.
0507  35163 064466        LDB .-3        INITIALIZE CHAR. COUNT TO -3
0508  35164 074075        STB SCNT        P217/#18          ON BASE PAGE
0509  35165 017437        JSB SCHAR      GET A CHARACTER.
0510  35166 127162  RETURN JMP SCOM,I    NOT THERE-BLANK LINE.
0511  35167 037162        ISZ SCOM34663  BUMP SCOM TO POINT AT DIGIT REI.
0512  35170 040434  A=110"H" ADA M60BA=030 TEST FOR FIRST CHAR A DIGIT.
0513  35171 002020        SSA            AUTOMATIC FAILURE IF
0514  35172 037162        ISZ SCOM        < ASC0
0515  35173 040457        ADA .-10  A=000018
0516  35174 002020        SSA            IF <=ASC9,RETURN TO P+2 IF A
0517  35175 127162        JMP SCOM,I      DIGIT, P+3 IF NOT.
0518  35176 037162        ISZ SCOM       SCOM=34664
0519  35177 040436        ADA M41B       TEST FOR LETTER. A=177757
0520  35200 002021  SCOMB SSA,RSS
0521  35201 127162        JMP SCOM,I     NOT ALETTER.
0522  35202 040523        ADA .+32B        A=000007        "H"
0523  35203 002020        SSA
0524  35204 127162        JMP SCOM,I     NOT A LETTER.
```

P209 — 2nd CHAR — P214

FIGURE 21. SCHEDULER EXAMPLE (Con't)
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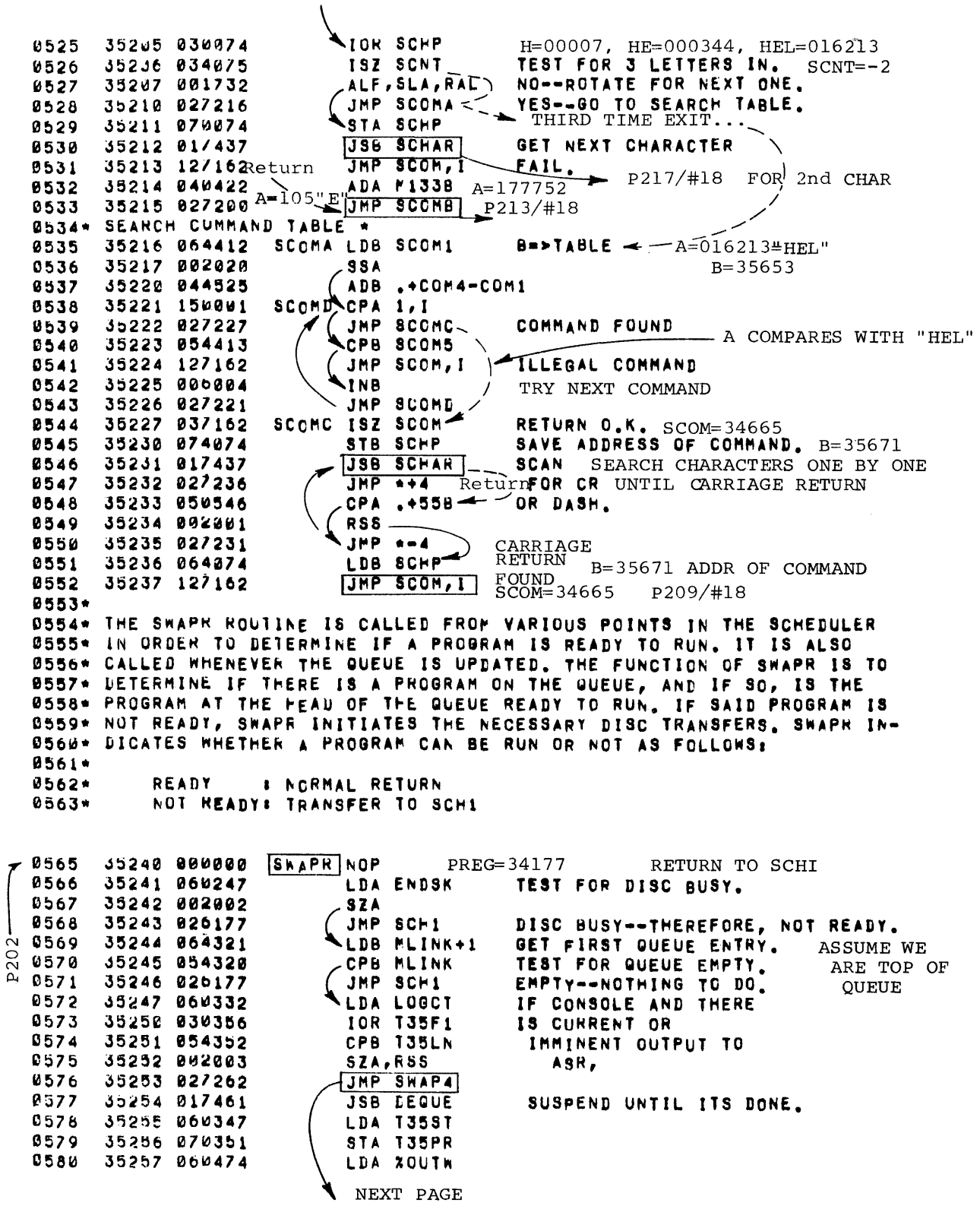

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 14 OF 18

```
PAGE 0215 #18  SCHEDULER

0581  35260 070347          STA T35ST
0582  35261 027241          JMP SWAPR+1
0583  35262          SWAP4  EQU *                    B=33253
0584  35262 044470          ADB .-1          B=>STATUS OF FIRST ENTRY.
0585  35263 160001          LDA 1,I          A=STATUS    A=2
0586  35264 050467          CPA .-2          TEST FOR SPECIAL DISCONNECT.
0587  35265 000512          LDA XSYNT+1+BYE-COM2
0588  35266 040460          ADA .-5+COM2-COM3  TEST FOR TYPE II OR III.
0589  35267 002021          SSA,RSS                 A=-7
0590  35270 027364          JMP SWAP3        PROGRAM IS OF TYPE III.
0591  35271 044442          ADB .-?STAT      TEST FOR PROGRAM IN CORE.
0592  35272 054242          CPB MAIN
0593  35273 127240          JMP SWAPR,I      PROGRAM PRESENT.
0594  35274 060242          LDA MAIN         FIND OUT WHAT PROGRAM IS.
0595  35275 002002          SZA              IS ANY PROGRAM PRESENT?
0596  35276 027313          JMP SWAP1        YES.
0597  35277 074242          STB MAIN         SET MAIN TO NEW PROGRAM.
0598*
0599* INITIATE DISC TO CORE TRANSFER
0600*
0601  35300 044505          ADB .+?PROG      B=>PROGRAM END LOCATION.
0602  35301 160001          LDA 1,I          COMPUTE NUMBER OF
0603  35302 070046          STA PBPTR
0604  35303 003000          CMA               WORDS IN PROGRAM.
0605  35304 041236          ADA LSE
0606  35305 070303          STA WORD         STORE -LENGTH INTO WORD.
0607  35306 044470          ADB .+?DISC-?PROG
0608  35307 160001          LDA 1,I          A=DISC ADDRESS
0609  35310 065237          LDB LSEI         B=CORE ADDRESS
0610  35311 114317          JSB DISC,I       INITIATE DISC TRANSFER.
0611  35312 026177          JMP SCH1         RETURN BUSY.

0613*                                  P174/#15        INITIATE TRANSFER.
0614* INITIATE CORE TO DISC TRANSFER                   THEN RETURN TO
0615*                                                SCHEDULER LOOP UNTIL
                                                     TRANSFER COMPLETED.
0617  35313 070001  SWAP1 STA 1            B=>TABLE OF USER TO BE WRITTEN.
0618  35314 002400  SWAP2 CLA              SET MAIN TO SAY NO USER IN
0619  35315 070242          STA MAIN         CORE.
0620  35316 044505          ADB .+?PROG      B=>PROG.END LOCATION.
0621  35317 060046          LDA PBPTR
0622  35320 170001          STA 1,I
0623  35321 003000          CMA
0624  35322 041236          ADA LSE
0625  35323 070303          STA WORD         STORE -LENGTH INTO WORD.
0626  35324 044470          ADB .+?DISC-?PROG  B=>DISC ADDRESS.
0627  35325 160001          LDA 1,I          GET USER DISC ADDRESS.
0628  35326 010416          AND MSK          DELETE SECTOR PART.
0629  35327 170001          STA 1,I
0630  35330 001222          RAL,RAL          GET DISC TABLE
0631  35331 010474          AND .+3           ADDRESS
0632  35332 040377          ADA ?ATBL
0633  35333 160000          LDA 0,I          A=SELECT CODE FOR DISC.
0634  35334 077161          STB TYPET        SAVE DISC ADR. LOCN.
0635  35335 000400          CLB
0636  35336 100050          LSL 8            SHIFT TRACK LENGTH INTO B.
0637  35337 001727          ALF,ALF          GET SELECT CODE.
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 15 OF 18

```
PAGE 0215 #18  SCHEDLLER
                                                    NOT USED FOR
                                                    THIS EXAMPLE
0638   35340 010557          AND B77
0639   35341 040304          ADA LIA1        SET UP LIA.
0640   35342 073343          STA **1         READ DISC STATUS.
0641   35343 102500          LIA 0
0642   35344 001727          ALF,ALF         GET CURRENT SECTOR.
0643   35345 010570          AND B177
0644   35346 040473          ADA .+2         GET POTENTIAL DEST. SECTOR.
0645   35347 007000          CMB             GET # OF SECTORS LEFT
0646   35350 044000          ADB 0            ON TRACK.
0647   35351 007000          CMB
0648   35352 005700          BLF             GET # OF WDS LEFT ON
0649   35353 005222          RBL,RBL          TRACK.
0650   35354 044303          ADB WORD        TEST TO SEE IF THERE'S ENOUGH.
0651   35355 143161          ADA TYPET,I     COMPUTE NEW DISC ADDRESS.
0652   35356 006020          SSB             IF END OF TRACK NOT LONG ENOUGH,
0653   35357 163161          LDA TYPET,I      WRITE TO BEGINNING.
0654   35360 173161          STA TYPET,I     STORE NEW DISC ADR IN TABLE.
0655   35361 065236          LDB USE         B=CORE ADDRESS.
0656   35362 114317          JSB DISC,I      INITIATE DISC TRANSFER
0657   35363 026177          JMP SCH1         AND RETURN BUSY.

0659*
0660*  TYPE III PROGRAMS
0661*

0663   35364 064242  SWAP3 LDB MAIN         TEST FOR MAIN PROGRAM IN CORE
0664   35365 006002          SZB
0665   35366 027314          JMP SWAP2       GO TO WRITE OUT MAIN PROGRAM.
0666   35367 040330          ADA LCOM6       A=>DISC ADDRESS FOR LIB.PROG.
0667   35370 050243          CPA LIB         IS IT IN CORE?
0668   35371 127240          JMP SWAPR,I     YES--RETURN PRESENT.
0669   35372 070243          STA LIB         IF NOT, INITIATE READ IN.
0670   35373 064416          LDB M256        LENGTH OF PROGRAM =256
0671   35374 074303          STB WORD
0672   35375 064262          LDB #LIBI
0673   35376 160000          LDA 0,I
0674   35377 114317          JSB DISC,I
0675   35400 026177          JMP SCH1
0676*
0677* ENTRY POINT FOR INPUT REQUEST
0678*
0679   35401 000000  SCHIO NOP
0680   35402 103100          CLF 0           INTERRUPT INHIBIT.
0681   35403 064321          LDB PLINK+1     SET RESTART ADDRESS
0682   35404 044467          ADB .+?RSTR-?LINK  INTO TABLE.
0683   35405 063401          LDA SCHIO
0684   35406 170001          STA 1,I
0685   35407 006004          INB             GET PROGRAM TYPE
0686   35410 160001          LDA 1,I
0687   35411 002020          SSA             QUIT IF ABORT REQUEST.
0688   35412 027623          JMP SUSP
0689   35413 044473          ADB .+?PLEV-?STAT
0690   35414 170001          STA 1,I         SET INTO PLEV.
0691   35415 044467          ADB .+?STAT-?PLEV
0692   35416 060473          LDA %INPT       CHANGE STATUS TO
0693   35417 170001          STA 1,I          INPUT WAIT.
0694   35420 027623          JMP SUSP         GO REMOVE FROM QUEUE.
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 16 OF 18

```
0695*
0696* ENTRY POINT FOR TERMINATION
0697*
0698  35421 103100  SCHED CLF 0
0699  35422 054321        LDB MLINK+1    SCRATCH IF
0700  35423 054352        CPB T35LN
0701  35424 027430        JMP *+4
0702  35425 044441        ADB .-?LINK     THIS IS
0703  35426 017640        JSB HTEST        $HELLO.
0704  35427 054321        LDB MLINK+1         CHANGE
0705  35430 044470        ADB .+?STAT-?LINK  STATUS
0706  35431 160001        LDA 1,I
0707  35432 050470        CPA .-1         QUIT IF ABORT REQUEST.
0708  35433 027623        JMP SUSP
0709  35434 002400        CLA                  TO IDLE
0710  35435 170001        STA 1,I
0711  35436 027623        JMP SUSP
0712* SCHAR FETCHES THE NEXT CHARACTER FROM A BUFFER. BUFFER
0713* POINTERS FOR SCHAR ARE INITIALIZED AS FOLLOWS:
0714*     SBHED=>FIRST CHARACTER IN BUFFER
0715*     SCHL,I=>BUFFER END
0716*
0717* SCHAR CALLING SEQUENCE:
0718*
0719*     JSB SCHAR
0720*     RETURN HERE IF CR
0721*     RETURN HERE IF ANY OTHER CHARACTER

0723  35437 000000  SCHAR NOP          <- PREG=35166
0724  35440 064070        LDB SBHED      GET POINTER.
0725  35441 004065        CLE,ERB1       right POSITION AS WORD POINTER.
0726  35442 160001        LDA 1,IØ       left GET WORD CONTAINING CHARACTER.
0727  35443 005610        ELB,SLB        REPOSITION POINTER AND TEST
0728  35444 002001        RSS                 FOR UPPER OR LOWER.
0729  35445 001727  LEFT  ALF,ALF       right
0730  35446 010573        AND 8377       MASK OUT CHARACTER.
0731  35447 050506        CPA .+15B      RETURN IMMEDIATELY IF CR
0732  35450 127437        JMP SCHAR,I
0733  35451 006004        INB            BUMP CHARACTER POINTER.
0734  35452 154071        CPB SCHL,I     TEST FOR END OF BUFFER.
0735  35453 044405        ADB MBLEN      IF END, CHANGE TO BEGINNING.
0736  35454 074070        STB SBHED
0737  35455 050531        CPA .+40B      SKIP BLANKS
0738  35456 027441        JMP SCHAR+2
0739  35457 037437        ISZ SCHAR
0740  35460 127437        JMP SCHAR,I    SCHAR=35167
0741*                                    -> P213/#18
0742* DEQUE REMOVES A USER FROM THE QUEUE. IT IS CALLED WITH THE USER'S
0743* LINK ADDRESS IN B.
0744*
0745  35461 000000  DEQUE NOP
0746  35462 060320        LDA MLINK      GET POINTER TO FIRST ENTRY.
0747  35463 154000  DEQ1  CPB 0,I        TEST FOR ENTRY FOUND.
0748  35464 027471        JMP DEQ2
0749  35465 160000        LDA 0,I        LINK TO NEXT ENTRY.
0750  35466 050320        CPA MLINK      TEST FOR END OF QUEUE.
0751  35467 127461        JMP DEQUE,I    NOT ON QUEUE--RETURN.
```

P123

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 17 OF 18

NOT USED FOR THIS EXAMPLE

```
0752  35470 02/463        JMP DEQ1       LOOP.
0753  35471 164001 LEQ2   LDB 1,I        LINK AROUND THIS USER.
0754  35472 174000        STB 0,I
0755  35473 127461        JMP DEQUE,I
```

FIGURE 21. SCHEDULER EXAMPLE (Con't)
SHEET 18 OF 18

glossary

A

APPENDIX
GLOSSARY OF TERMS

absolute - Pertaining to an address fully defined by an address word. In the Time Share system listing, an address corresponding to a label once the assembler has assigned a particular location to that label.

accumulator - A register in which data is totaled or manipulated, or temporarily stored for transfers to and from memory or external devices. Specifically the A and the B registers.

acoustic coupler - An acoustic coupler is a device which interfaces between the electrical signals of the teleprinter or CRT terminal and the audio soundwaves required by the telephone network. The telephone handset fits into a suitable receptacle and the signals are coupled acoustically. It allows connecting the terminal to the computer with a regular telephone.

address - An identification label or number that specifies a memory location or a disc sector and track.

address modification - a programming technique of changing an address referred to by a Memory Reference instruction so that each time that particular instruction is executed it will affect a different memory location.

ADT - Available Disc Table. A disc resident table that lists each portion of the disc(s) that is not currently being used and is thus available to the system.

ASCII - A standard 8 level code for the symbols, letters, numericals, etc. used in communications. The letters stand for American Standard Code for Information Interchange.

Assembler - A program which converts the symbolic source statements (i.e., using defined symbols, mnemonics, labels, and comments) into binary machine language and generates the program listing.

Autorestart - The hardware-software system that allows the Time Share operating system to save the necessary information on power failure, and then to restore the system and continue its previous activities when power is restored.

background processing - The reversion of a data-processing system to the execution of lower priority programs during intervals in which higher priority programs have relinquished system resources. In the Time Share system, it includes the routine multiplexor, scheduler, and console interrupts and system overhead.

base - The quantity of different digits used in a particular numbering system. The base in the binary numbering system is two; thus there are two digits (0 and 1). In the octal system (base 8), there are 7 digits (0-6). In the decimal system (base 10), there are ten digits (0-9).

base page - The lowest 2000 octal memory locations corresponding to bits 10 to 14 cleared. It can be directly addressed from any other memory page.

Basic - A language designed for time sharing applications. It characterized by simple syntax using English words and common mathematical relations. The letters stand for Beginners All-purpose Symbolic Instruction Code.

bit - A single digit in a binary number, or in the recorded representation of such a number (by hole punches, magnetic states, etc.). The digit can have one of two values 0 or 1. Bit can also refer to a specific location in a computer word (i.e., bit 5).

buffer - A register, memory location, or multiple memory locations used for intermediate storage of information used in the Time Share system. Specifically, temporary storage for input output buffering required by the data rate limitations of the terminals.

bus - A major electrical bus connecting one or more electrical circuits. In the CPU the R-bus S-bus, and T-bus are used for data paths within the main frame.

carry - A digit, or equivalent signal, resulting from an arithmetic operation which causes a positional digit to equal or exceed the base of the effective numbering system.

character - the general term to include all symbols such as alphabetic letters, numerials, punctuation marks, mathematical operators, etc. Also, the ASCII coded representation of such symbols.

code - The binary representation of the machine language instructions appearing in core or in the listing.

command - A control word requesting the Time Share system to perform a task. Commands execution is not part of the Basic Interpreter. Some commands are available to users, others are available only to the system console.

communication system - A computer system having facilities for long-distant transfers of information between remote and central stations. Specifically, the multiplexor and telephone networks used for the Time Share system.

compiler - A language translation program, used to transform symbols meaningful to a human operator to codes meaningful to a computer. More restrictively, a program which translates a machine-independent source language into the machine language of a specific computer.

compiled form - The program statements in ASCII form are converted to a symbolic representation more meaningful to the Time Share system. This new symbolic form is referred to as the compiled form.

computation - The processing of information within the computer.

compute bound - A Basic program in run mode which does not suspend due to input/output communications is considered to be compute bound. All compute bound users share the available CPU on a one second time slice basis.

computer (digital) - An electronic instrument capable of accepting, storing, and arithmetically manipulating information, which includes both data and the controlling program. The information is handled in the form of coded binary digits (0 and 1) represented by dual voltage levels, magnetic states, punched holes, etc.

configuration - The arrangement of either hardware instruments or software routines when combined to operate as a system. Specifically, the hardware arrangement necessary for the HP 2000A Time Share system.

console - The system console provides an input/output capability which is used to control the system. It allows the system operator to monitor and change the hardware configuration, print out library and user information, and punch the Log On-Log Off messages.

control flip-flop - The control flip-flop is used on the input/output interface to initiate action by the device, and in conjunction with the flag flip-flop to control the interrupt.

core - The smallest element of a core storage memory module. It is a ring of ferrite material which can be magnetized in clockwise or counter-clockwise directions to represent the two binary digits, 0 and 1. More generally, core refers to the installed memory of the computer system.

CPU - Central Processor Unit. The CPU is that part of the computer system containing the buses, registers, and circuits for implementing the machine language instructions. Main frame is a synonym.

device flag - A signal from an input/output device flag is used to set the flag flip-flops on the interface card.

disc - A device using a rotating circular plate on which digital data can be stored by selective magnetization of the surface material. The reading and writing of data is performed by

precision heads. The device may use fixed heads with one head per track or use variable position heads in which a single head can be moved to service more than one track.

DMA – Direct Memory Access. A computer option which provides an efficient input to core or core to output transfer on a cycle stealing basis without requiring machine language code for each individual transfer.

double-length word – A word, due to its length, which requires two computer words to represent it. Double-length words are normally stored in two adjacent memory locations. Used particularly in multiplication and division of integers and in floating point.

driver – An input/output routine to provide automatic operation of a specific device with the computer. Particularly the multiplex driver, disc driver, and console driver.

dump – To record memory contents on an external medium, especially the mag tape dump during sleep.

executive – The Scheduler routine which controls the primary relationship between the individual program modules. It organizes and controls the transfers between the discs and core, services the queue, and generally maintains the primary control of the operating system.

exit sequence – A series of instructions to conclude operation in one area of a program and to move to another area. This would not include leaving the scheduler loop to service a multiplexor interrupt, but would include leaving the scheduler loop when the user is in core and is ready to execute.

fixed point – A numerical notation in which the fractional point (whether decimal, octal, or binary) appears at a constant, predetermined position. Especially used in single word representation for positive and negative integers, or in double precision representation for integers with larger values.

Flag bit – A signal indicating completion of an I/O operation. This flag bit is used in conjunction with I/O interface cards.

flag word – Computer words are used for flag purposes in which a particular bit corresponds to the user number. For example, MPCOM is a flag word corresponding to those users requiring multiplexor servicing.

flip-flop – an electronic circuit having two stable states, and thus capable of storing a binary digit. Used in the CPU registers, and on I/O interface boards.

floating point – A numerical notation using two computer words in which the variable is expressed in terms of a mantissa and an exponent. In normalized form the decimal point is to the left of the mantissa and the first digit in the mantissa is a 1, with the exponent varied as necessary. In the Time Share system the range of variable values ranges from 10^{-38} up to 10^{+38} with significant accuracies of 6 or 7 digits.

flowchart – A diagrammatic representation of the operation of a computer program.

foreground processing – The execution of programs which have been assigned the highest priorities for the use of the system. In the Time Share system, those activities which have been scheduled on the queue.

format – A predetermined arrangement of bits or characters.

hardware – Electronic or electro mechanical components, instruments, or systems. Specifically the computer, computer options, and peripherals used in the Time Share system. Refer also to software.

IDT – I.D. TABLE. A Disc Resident Table containing all ID codes, passwords, as well as time authorized and used and disc storage authorized and used.

initialize – The procedure of setting various parts of a stored program to starting values, so that the program will behave the same way each time it is repeated. The procedures are included as part of the program itself.

input – information transferred from a peripheral device into the Computer. Also can apply to the transfer process itself.

input/output – Relating to the equipment or method used for transmitting information into or out of the computer. Including terminals, system console, disc unit, etc.

integer – A whole number thus without a fractional part; (i.e., . . .-2, -1, 0, 1, 2 . .).

interface – The connecting circuitry which links the central processor of a computer system to its peripheral devices. Specifically those boards which plug into the computer I/O area.

interpreter – A computer program that translates and executes each program statement before proceding to the next and does so without generating machine language code.

interrupt – The process, initiated by an external device, which causes the computer to interrupt a program in progress, generally for the purpose of transferring information between that device and the computer.

interrupt location – A memory location whose contents (always an instruction) are executed upon interrupt by a specific device. Commonly referred to as the trap cell.

label – one or more characters associated with or attached to an item of data for purposes of identification. Used symbolically by the Assembler for addressing.

language – The set of symbols, rules, and conventions used to convey information, either at the human level or at the computer level. Particularly the Basic language implemented on the Time Share system.

library – An organized collection of Basic programs. Some are provided by the system operator and are available to all users. Other programs belong to an individual user and are available only to the user who saved the program. Library also refers to the absolute machine language programs loaded at 37300 for command execution.

library routine – A program designed to accomplish some commonly used function and kept permanently available on the Time Share system. This includes system library programs, as well as user library programs.

linkage – A sequence of Code that serves to connect a pair of independently coded routines.

loader – A software program to facilitate loading programs into the computer. Specifically a loader program on paper tape to initially load a Time Share system or awaken from mag tape sleep. Also, a bootstrap loader on disc track Ø, sector Ø; and a post sleep loader on disc track Ø, sector 2.

loader, basic binary disc – A 64 word program residing in the top 64 locations of core, and capable of being hardware protected. The Disc loader can load track 0, sector 0 into core locations 0 to 100B (S.A. 37760). The loader also loads paper tape from the input device (S.A. 37700). The records on the paper tape must conform to a certain absolute format.

loader, protected – A 64 word program residing in the top 64 locations of core, and capable of being hardware protected.

loop – a repeating sequence of instructions. Intentional as in the case of the scheduler loop, or unintentional because of hardware or software difficulties.

machine language – The binary coded instructions and data used directly by the computer. Appearing either in core or in the assembler listing.

machine timing – The regular cycle of events in the operation of internal computer circuitry. Specifically a machine cycle of 1.6 microseconds broken into 8 equal time periods of 200 nanoseconds each.

magnitude – That portion of a computer data word which indicates the absolute value of a number, thus excluding the sign bit.

mag tape – A digital tape recorder utilizing a mylar based tape with an iron oxide coating. This tape is used by selectively magnetizing portions of the oxide coating to store digital data. The Time Share system uses a 9 track tape recorder to sleep the system and save the core resident system and the public and users library.

memory – That portion of the CPU consisting of ferrite cores and driver circuits into which information, data, and instructions can be stored and from which it can later be retrieved.

memory module – A complete segment of core storage consisting of 4,096 computer words. Bits 12, 13, and 14 of the M register determine the module addressed.

memory protect – A means of preventing inadvertent alteration of a selectable segment of memory. This option is not required for Time Share.

mnemonic – An abbreviation or arrangement of symbols used to assist human memory. Used particularly in machine language instructions.

module – A program unit that is separate and distinctly indentifiable.

multiple-precision – Referring to data in which the computer, for greater accuracy, uses two or more words to represent one number.

multiplexor – A system allowing simultaneous input and output communications with the Time Share system. Specifically a hardware-software system providing input and output buffering, and conversion from characters into bit serial data for transmission to and from the Time Share terminals.

normalized form – A floating point value is considered in normalized form when the first digit of the mantissa is a "1".

octal code – A six digit notation for representing a machine language instruction or data with the use of octal numbers instead of binary numbers.

off-line – Pertaining to the operation of peripheral equipment not under control of the computer.

on-line – Pertaining to the operation of peripheral equipment under computer control.

output – Information transferred from the computer to a peripheral device. Also can apply to the transfer process itself.

Overflow – A one-bit register in the Computer, which indicates that the result of an addition in the A or B Register has exceeded the maximum possible signed value (+32767 or -32768, decimal). The addition result will therefore be missing one or more significant bits.

overhead – The time required by the system for supervision and swapping. It includes the routine activities of the scheduler and multiplexor. Although it is essential to the system it does reduce the time available for actual program execution.

packed word – A computer word containing two or more independent units of information. This is done to conserve storage when information requires relatively few bits of the computer word. Pertains particularly to the packing of two characters within each computer word.

page – An artificial division of memory consisting of 2000 octal locations. The size is dictated by the direct addressing range of memory reference instructions. Each page is represented by a unique combination of M Register bits 10 through 14.

page zero – The memory page which includes the lowest numbered memory addresses, corresponding to M register bits 10 through 14 equals 0.

parity bit – A supplementary bit added to an information word to make the total of the bits in the "1" state odd. This permits checking the accuracy of information transfers. This feature

is used in the computer memory, in the disc, and in the mag tape unit.

peripheral device – An instrument or machine electrically connected to the computer, but which is not part of the computer itself.

phase – One of the specific states of the CPU processor to help implement instructions (Phase 1 fetch, Phase 2 indirect, Phase 3 execute, Phase 4 interrupt, and Phase 5 a special DMA phase).

phones – The Time Share system can operate with the terminals connected to the computer through telephone data networks. Phones may refer to the equipment which provides this capability such as the data terminals and acoustic couplers, or to the software module which services the data terminal control signals.

port – The multiplexor connector and the internal associated hardware for a user; and further, the associated flag words and bits used in the system in servicing that user.

power failure control – A means of sensing primary power failure so that the special routine maybe executed in the finite period of time available before the regulated DC supplies discharge to unusable levels. Upon power resumption, this routine reinitializes the Time Share system and commences execution again.

precision – Numerical quantities represented in computer data format have a maximum number of digits of significant accuracy. The Time Share system uses double precision format. This results in at least 6 digits and sometimes 7 digits of significant accuracy depending on the actual value.

priority – The automatic regulation of events so that chosen actions will take precedence over others in cases of timing conflict. Priority pertains both to hardware relationships of I/O devices, and users sequence on the queue.

processor – The central unit of the computer system consisting of the bus structure arithmetic unit and memory. It also includes the DMA, EAU, power fail, and parity error options.

program – The plan of steps necessary to solve a problem. In this environment it refers to a sequence of statements prepared in Basic Language suitable for solution on the Time Share system.

pseudo-instruction – A symbolic statement, similar to assembly language instructions in general form, but meaningful only to the program containing it rather than to the computer as a machine instruction. Used in the assemblier for generating the Time Share software.

punched tape – A strip of paper tape consisting of feedholes and 8 data levels. Usually containing ASCII or binary information, and used with the photoreader or teleprinter.

queue – An ordered list of users (including the system console) who are awaiting service by the Time Share system. Users are serviced on a first in-first out basis within each priority. Servicing the queue is accomplished by the scheduler.

register – An array of hardware circuits, flip-flops, switches and so on, for temporary storage of data instructions and information. Specifically the A, B, P, M, T, I, E, O, and Switch registers.

rotate – A positional shift of all bits in an accumulator or in two linked accumulators. Those bits lost off one end of the accumulator are "rotated" around to enter vacant positions at the other end.

routine – A program or program segment designed to accomplish a single function.

run – The execution of a basic program is accomplished by the Basic Interpreter. This process is initiated by the command RUN. Thus, the time during which a program is being executed is referred to as 'run time', or 'running'.

Scheduler – The Scheduler is the primary program routine of the Time Share system. It is referred to as the Executive. It supervises the relationship between various software modules, especially servicing the queue, and initiating disc to core swaps.

Sector – The minimum storage space on the disc is referred to as a sector. It provides storage for 64 words of 16 data bits and a parity bit each. The sectors are grouped into tracks, and have individual addresses.

Sector Logical – An address used by the system in communications with the controller to specify the location of a program or data. Refer Sector Physical.

Sector Physical – The physical location of a disc sector is the narrow arc on the magnetic surface of the disc. The circular track is divided into as many sectors of 64 words each as the instrument design allows. The number of sectors may be too small a size for convenient handling by the system. These physical tracks and sectors are grouped together by the system. A Physical sector thus refers to a particular sector on the disc as it is internally wired and addressed, as opposed to the apparent system address referred to between the computer and controller.

Select Code – A number assigned to input/output channels for purposes of identification in information transfers between the computer and external devices.

shift – A positional shift of bits within a computer word to help implement the multiply or divide instruction or to reposition bits in a flag word.

sign – The algebraic plus or minus indicator for a variable, or the bit position in a computer word corresponding to the sign.

significant digit – A digit so positioned in a numeral as to contribute a definable degree of precision to the numeral. Generally the most significant digit in a numeral is the left most digit, and the least significant digit is the right most digit.

skip – A condition causing the computer to omit the next sequential instruction. A skip is usually arranged to occur only if certain specified conditions are true, thus allowing various decisions to be made.

software – computer programs. Specifically the Time Share system program, or program segments.

starting address – The memory location corresponding to the first instruction of a given program routine.

statement – An instruction in any computer-related language other than machine language. Specifically a line in a basic program.

symbolic address – A label assigned in place of absolute numeric addresses to ease changes in the Time Share system. The symbolic address is converted to an absolute address by the Assembler. Refer to symbol table.

symbol table – Program reference points and data locations are used by the programmer to simplify writing the Time Share software. The list becomes a map to specific memory locations. The list of all such symbols are tabulated, including the initial location as well as all references to this symbol. This composite list comprises the symbol table. It is useful when using the Listing.

syntax – The structure of expressions and the rules governing the structure. These are formal rules describing the allowable statements in the Basic language.

syntax stack – A collection of data required by the Basic Interpreter and associated with an individual user. Incorporation in the user area allows the Interpreter to be re-enterable.

system – An assembly of units both hardware devices and software routines combined to work as an integrated unit. For example, the multiplexor system.

table – A collection of data used by the system. Some are core resident, some are disc resident. Examples include the Equipment table and Teletype table.

Time Base Generator – A computer option providing interrupts at specified time intervals. Counting these interrupts provides time of day information for the Time Share system, as well as a mechanism for allocating computer resources on a timed basis.

time out – Certain Time Share functions are timed. This includes a maximum time for achieving Log on, minimum time before acknowledging an abort, and expending a users time slice. Time out is achieved when the time allocated for the task is completely used up.

Time Share – A system performing several independent activities almost simultaneously by interleaving the tasks on the processor(s). The time available is divided into short non-overlapping segments. The speed of the processor makes it appear that all operations are done simultaneously.

time slice – Each user is allocated a maximum time period of one second when others are on the queue. If the task is not completed when the one second interval is expended, he is requeued at the bottom and given another one second period. These one second intervals are referred to as a users time slice.

track – A physical disc track is a narrow annular ring on the disc surface on which the digital data is magnetically stored. The track is divided into a minimum storage unit called a sector. Each track has a unique track address within the disc unit. In the Time Share system, the storage of a single track is too small so 4 physical tracks are organized into a single logical track. Within the Time Share system, this Logical track has a unique address.

user – A user is an actual or potential terminal with access to the Time Share system. From the system standpoint, it refers to the terminal, communications line, port on the multiplexor, bit in the multiplexor data and flag words, and the corresponding teletype tables and buffers. With respect to the Library, it refers to the programs associated with a specific ID code.

utility routine – A standard routine to assist in the operation of the computer. Usually coded in a convenient location for easy accessability. An example is rounding a number to integer form.

variable – A variable is a numerical value used by the computer. Its instantaneous value may change. It is designated by a label consisting of a single letter, or a letter and one or two subscripts.

waiting loop – A sequence of instructions which are repeated indefinitely until a desired external event occurs, such as the receipt of a Flag signal. These loops are usually transparent to the operator except in cases of operator difficulties or hardware failures.

write – The process of transferring data from the CPU to the memory, or outputting a data record to an external device like the disc or mag tape.

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