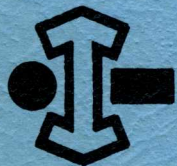


CHARACTERISTICS  
OF THE  
**1607 MAGNETIC  
TAPE SYSTEM**

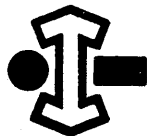


**CONTROL DATA CORPORATION**  
MINNEAPOLIS, MINNESOTA



CHARACTERISTICS  
OF THE  
**1607 MAGNETIC  
TAPE SYSTEM**

PUBLICATION 041a



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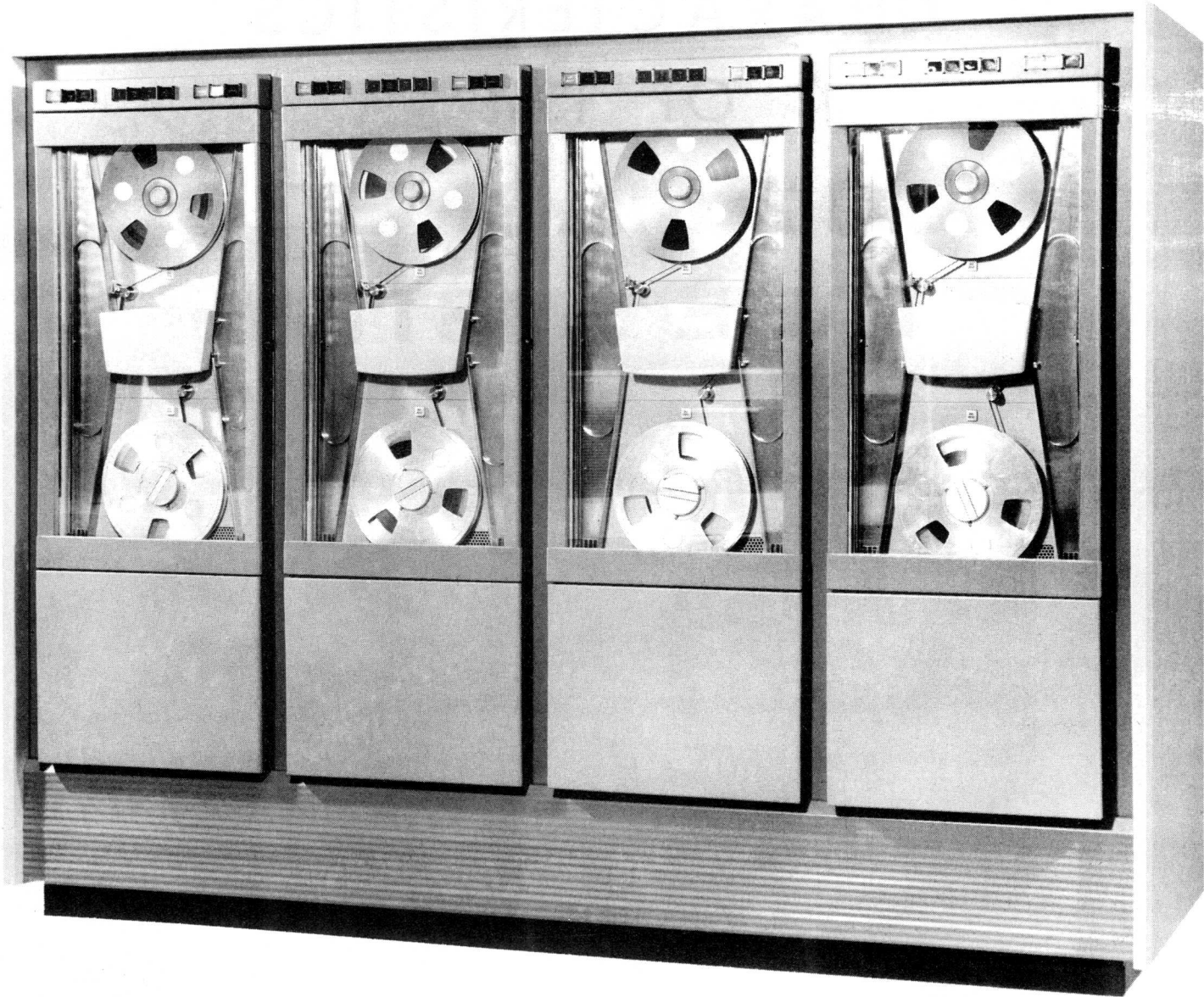


Figure 1-1. Magnetic Tape System.

## CHAPTER 1. GENERAL DESCRIPTION

### INTRODUCTION

The Control Data Corporation model 1607 Magnetic Tape System (MTS) (figure 1-1) is an optional input-output and auxiliary memory storage device for the Control Data Model 1604 Computer. A MTS is comprised of four Ampex FR307 digital tape handlers and a synchronizer control unit, all housed in a single cabinet. Each tape unit handles and processes plastic base tape on which data are stored as magnetized spots. The synchronizer buffers and controls the flow of data between the computer and the individual tape units. Transfer of data from the computer memory to the magnetic tapes, and vice versa, and exchange of control information is accomplished through coded programmed External Function (74) instructions.

Chapter 1, 2, and 3 describe the 1607 MTS as designed for use with the 1604 Computer only. Additional design features now provide for the use of the 1607 MTS with either the 1604 Computer or the 160 Computer. These features are described in Chapter 4, "The Satellite Computer System".

Information contained in this instruction book is subject to correction and change.

### PHYSICAL DESCRIPTION

The MTS cabinet is 88 1/2 inches long, 67 3/4 inches in over-all height, and 27 1/2 inches wide. The approximate weight of the cabinet is 2500 pounds. Components within the cabinet are air cooled by blowers at the bottom of the cabinet which circulate air-conditioned room air. The equipment operates from a 208-vac, 3-phase, 400-cps supply at 5 amps and a 208-vac 3-phase 60-cps supply at 25 amps.

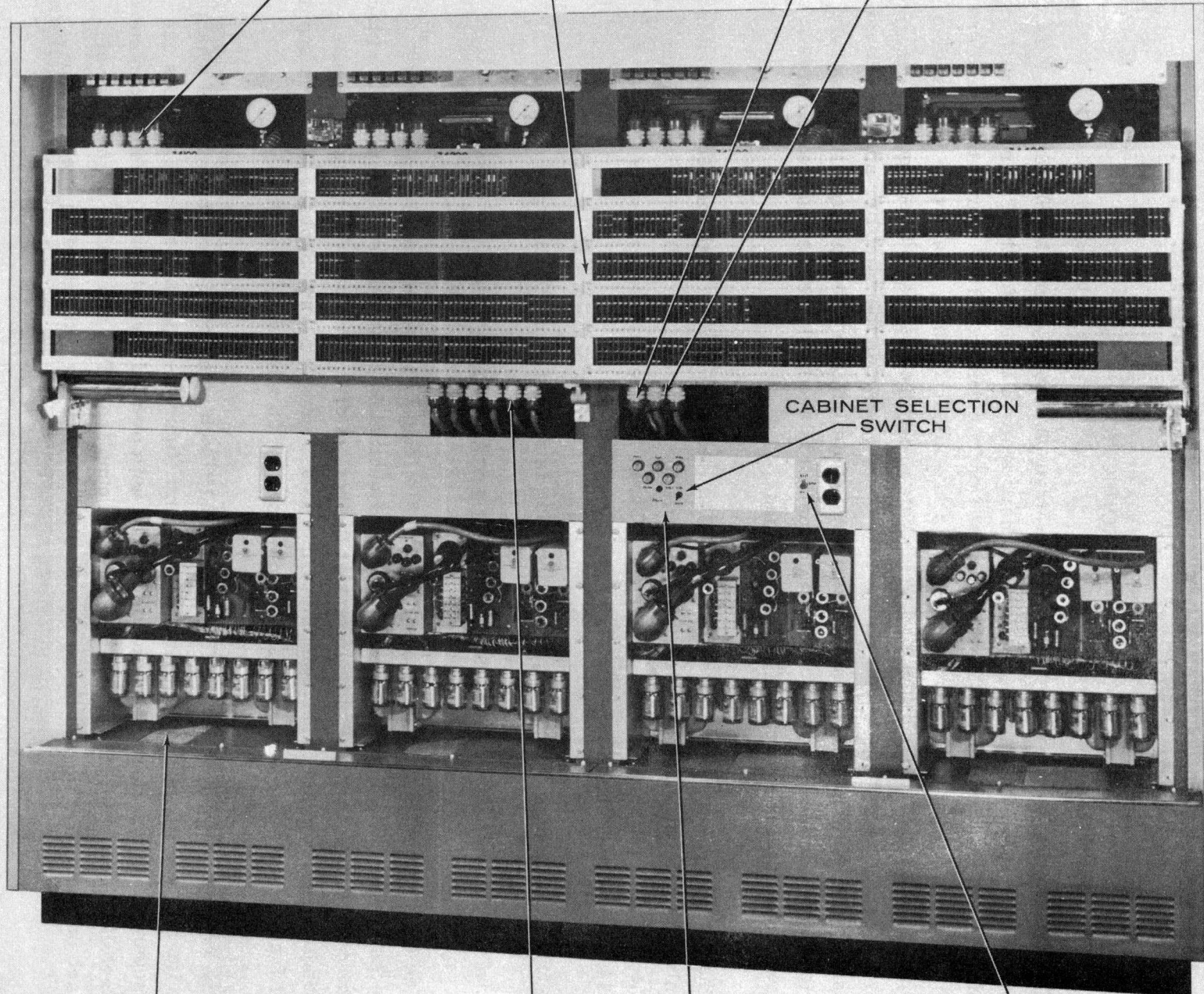
The cabinet is subdivided into four standard 19-inch relay rack sections, each of which holds the chassis associated with one tape unit (figure 1-2). The tape unit circuits use vacuum tubes and transistors in conjunction with printed circuit board wiring techniques. Each tape unit has self-contained d-c power supplies. The glass door at the front of each unit provides access to the tape handler for loading and unloading reels of tape.

TAPE UNIT COMMUNICATION CABLES

SYNCHRONIZER CHASSIS

SYNCHRONIZER 400 ~ POWER CABLE

160 COMPUTER COMMUNICATION CABLES



CABINET SELECTION SWITCH

BLOWER VENT

1604 COMPUTER COMMUNICATION CABLES

AC POWER DISTRIBUTION PANEL

COMPUTER SELECTION SWITCH

Figure 1-2. Rear View Magnetic Tape System.

The switches and indicators above the front door allow the operator to monitor and manually control tape unit conditions.

The synchronizer chassis is mounted at the rear of the cabinet (figure 1-2). Spring-loaded hinges in the lower corners of the chassis and release catches and handles at the top allow horizontal positioning of the chassis (with the sliding doors removed) for maintenance purposes. The circuits of the synchronizer are composed of printed circuit cards identical in construction to those used in the computer. The majority of the cards contain the standard building-block circuit properly interconnected to form the logical networks necessary to communicate with the tape units and computer.

Data is transferred between the MTS and the computer via six cables which connect to the bottom of the synchronizer chassis (figure 1-2). Jumper wires from these six cable connectors to another set of six cable connectors allow other equipment to communicate with the computer on the same communication paths. Data is transferred between each tape unit and the synchronizer via separate cable groups of four cables each which connect at the top of the synchronizer chassis.

Separate cables carry 400-cps and 60-cps, 208-vac primary power to the MTS a-c power distribution panel (figure 1-2). From this panel 400-cps power is cabled to the bottom of the synchronizer chassis and distributed from this point to the d-c power supply circuits located in the four corners of the chassis. The 60-cps power is routed to the blowers and to the convenience outlet panels in each cabinet section. Power cables carry 110-vac, 60-cps power from the outlets to each tape unit.

### MAGNETIC TAPE CHARACTERISTICS

The MTS provides the computer with a high-speed non-volatile data storage system. Computer output data is recorded on the tape in a format compatible in all respects with the IBM 727 magnetic tape system. This facility enables communication with IBM 700 series computers as well as with a variety of IBM peripheral equipment.

A seven track non-return to zero (change-on-ones) recording scheme is used. Six tracks are assigned to the data (termed a character) and one track contains a parity check bit for the character. A character and its parity bit comprise a line of tape data.

Data is recorded in two formats: binary and binary-coded-decimal (coded). The parity bit is chosen to make the total number of "1" bits in a line odd in binary format, even in coded format. The format is chosen by the EF instruction, and the synchronizer generates the appropriate parity bit for each character. Figure 1-3 shows the bit assignments on the tape for the two formats. Table 1-1 gives the IBM character code used when generating tapes for reproduction by IBM peripheral equipment. The parity bit is recorded in tracks 6 and C for binary and coded format, respectively; the least-significant bit position is in tracks 0 and 1, respectively.

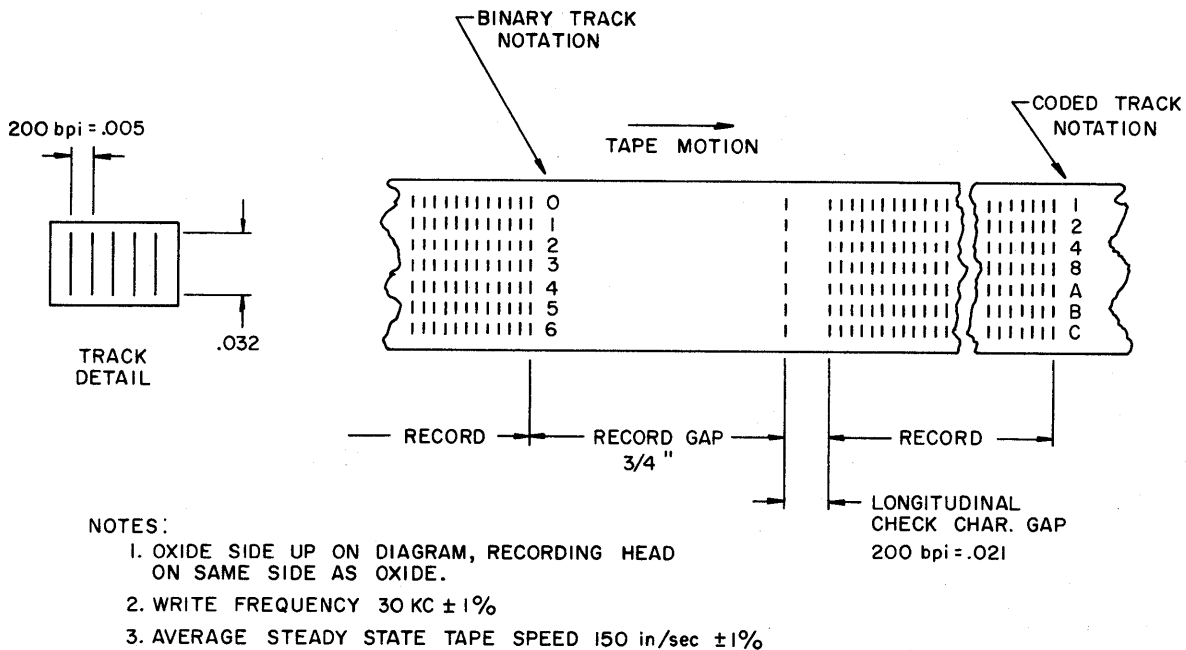


Figure 1-3. Magnetic Tape Specifications

Data is recorded on the tape at a density of 200 lines per inch and in records of varying length. A 3/4-inch unrecorded area or blank space separates adjacent records. A number of records may be grouped into a file of information on the tape by recording of a special character (octal 17 code) spaced 6 inches from the last record in the file.

Tape speed during reading and writing operations is 150 inches per second; the character transfer rate is 30 KC. Standard tape is 1/2 inch wide and up to 3600 feet long. Small reflective spots attached to the tape mark the beginning and end of the useable portion of tape. These markers are referred to as load-point and end-of-tape and are detected by photo-sensing means.

## BASIC PRINCIPLES OF OPERATION

The MTS communicates through the synchronizer with the computer on a 12-bit function channel, a 48-bit input buffer channel, a 48-bit output buffer channel, and associated control signal lines (figure 1-4). The channels and control signals are activated by the External Function (EF 74) instruction.

Depending on the installation, a MTS can communicate with the computer on buffer channel pairs 1 and 2, 3 and 4, or 5 and 6 (even numbers denote computer output channels, odd numbers input channels). This instruction manual assumes a MTS connected to channels 3 and 4.

Each tape unit communicates with the synchronizer on a 7-bit read bus, a 7-bit write bus and associated control lines. The appropriate unit and its cable lines are activated in response to the EF instruction.

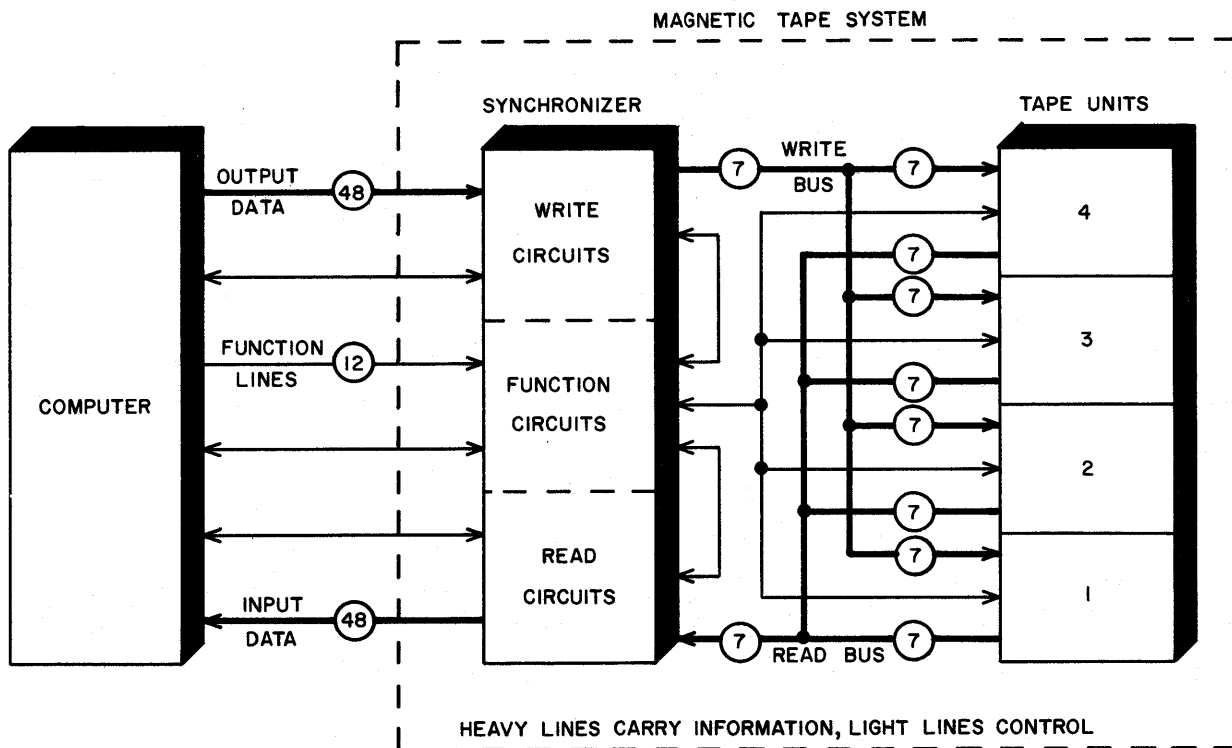


Figure 1-4. Magnetic Tape System, Information Flow.



The circuits of the synchronizer portion of the MTS are organized into function, write, and read circuits. The function circuits store control information regarding the tape units that is received from the computer or the units themselves. The write and read circuits provide independent write and read channels (to accommodate simultaneous read and write operations) and use information stored in the function circuits to direct writing and reading. The write and read circuits each have access to the four tape units; a tape unit must be assigned to operate with the read or write channel. This unit assignment and other functions are accomplished by the EF instruction.

#### EXTERNAL FUNCTION INSTRUCTION

The various subinstructions of the EF instruction are used to initiate and control all MTS operations. Briefly, their function are as follows:

(EF Select) 74.0X ----	requests specific tape operations and assigns a tape unit to a read or write channel (X).
(EF Sense) 74.7X ----	enables computer to determine status or condition of particular tape unit. For example, determines if unit is ready to be operated, if error was detected in previous operation, and so forth.
(EF Output Buffer) 74.4 ----	initiates and controls buffering of 48-bit words <u>from</u> computer to MTS for recording on tape.
(EF Input Buffer) 74.3 ----	initiates and controls buffering of MTS data <u>to</u> computer.

#### Select Operations

During select (74.0X----) instructions the lower-order 12 bits of the instruction are sent out on the function channel with a function ready signal to all equipment connected to channel X. The upper 3 bits of the code specify the equipment, the lower-order 9 bits the operation requested. The synchronizer function circuits interpret the EF code and store the information in control flip-flops. In general, input channel codes are stored in control FFs which communicate with the read circuits; output channel codes are stored in control FFs which communicate with the write circuits. Table 1-2 lists all MTS select codes.

As noted earlier the write and read circuits each have access to the four tape units and it is necessary to assign a unit (n=1, 2, 3, 4) to one channel or the other. In table 1-2 the first two instructions in the two select code groups assign a tape unit to a read or write

channel. All other selections and sense operations (see below) in the same group are accomplished on the previously selected unit. By means of manual controls on each tape unit, any of the four tape units can be operated as the unit designated by the program.

Write. A write select (20n1, 2) instruction assigns unit n to the output channel specified and prepares the synchronizer for an impending output buffer operation (a 2001, 2 select instruction is used if unit was selected previously). Execution of a subsequent 74.4 output buffer instruction establishes the output buffer initial address and causes the computer to issue an output buffer active signal (buffer terminal address is generally established prior to write select).

The computer signal starts the selected tape moving and after a short delay the write circuits accept the initial 48-bit word indicated by an output data ready signal. The word is transferred to a disassembly register and an output data resume signal is returned to the computer after which the word is recorded. Each word is disassembled into 6-bit characters, a parity bit generated for each, and the 7 bits transmitted over the write bus to the tape unit for recording on the tape. One character is recorded every 33  $\mu$ secs.

The sequence continues with exchange of ready and resume signals until the end of the buffer is reached as indicated by turn-off of the active signal. This causes a record check character to be recorded .02 inch from the last character of the record. The check character provides for a longitudinal parity check for IBM compatibility.

During the sequence each recorded line (exclusive of the check character) is sensed by a read head (spaced .390 inch from the write head), returned to the write reply circuits for a parity check and any error condition stored for subsequent sensing by the computer. An additional check determines if the number of lines read was an integral multiple of eight; if not a write reply length error is stored for later sensing by the computer.

After the last character is read the tape is stopped with the heads positioned in the inter-record space ready to write the next record. If the end-of-tape reflective spot marker is sensed during the operation, the fact is stored for later sensing by the computer.

Read. A read select (20n1, 2) instruction assigns unit n to the input channel specified and prepares the synchronizer for an impending input buffer operation. As in the write select case, establishment of the buffer initial address causes an input buffer active signal to be generated by the computer.

The computer signal starts the tape moving and, after a suitable delay to position the read head over the data, reading begins. The lower-order 6 bits of each line are assembled into 48-bit words in an assembly register and then transferred to an input register for transmission to the computer. An input data ready signal from the synchronizer initiates computer storage action for the assembled word. A computer input data resume signal acknowledges the word and clears the input register in preparation for the next word.

A parity check is performed on each line read (exclusive of the check character) and an error condition stored for later sensing by the computer.

A lack of tape information for a predetermined period indicates the end of the record and the tape is stopped with the read head positioned in the inter-record gap ready to read the next record.

The computer may call for more or less words than are available in a record. Under these conditions a read length error is detected and stored for later sensing by the computer. If the computer buffer is equal to or less than the tape record length the buffer active signal is terminated automatically; if the buffer length is greater than the tape record length the computer executes additional instructions to artificially terminate the buffer and turn off the active signal.

Reading of an end-of-file mark ( $17_8$ ) is also stored for sensing by the computer.

Write End-Of-File Mark. An end-of-file mark is used to group a number of records into a file of information. An output channel select write end-of-file mark (2003) instruction causes the  $17_8$  code to be recorded on the tape 6 inches after the last record in the file. The mark is treated as a 1-character record and a longitudinal check character (also an octal 17) is also written. No computer buffer is established for this operation.



Backspace. An input or output channel select backspace (2006) instruction moves the tape backwards past one record to the preceding inter-record gap. None of the information passed over is available to the computer and therefore no computer buffer is established.

Rewind. An input or output channel select rewind (2005) instruction rewinds the tape from its current position to the load point.

Rewind Interlock. An input or output channel select rewind interlock (2007) instruction rewinds the tape from its current position to the load point and provides an interlock at that point so that the tape is not again available to the computer. Tape speed is 225 inches per second in this operation.

Interrupt. An input or output channel interrupt select (2004) instruction may be executed after any of the select instructions (except rewind interlock) to automatically interrupt the main computer program upon completion of the previously selected tape operation. For read or write select instructions, the interrupt select is executed after the read or write operation is selected and after the buffer initial address has been established.

#### Sense Operations

During sense (74.7X----) instructions the lower-order 12 bits of the instruction are sent out on the function channel with an appropriate sense ready signal to all equipment connected to channel X. As in select instructions the upper 3 bits specify the equipment the lower-order 9 bits, however, request an indication of the status or condition of a tape unit (unit selected previously). If the condition being sensed is present, the synchronizer returns (immediately) a positive sense response to the computer; if the condition is not present a negative response is generated. The computer interprets the response internally. Table 1-2 lists the sense codes for determining MTS conditions. A brief description of the conditions follows.

Ready to Read. A tape unit must be ready to accept new input channel (or output channel; see below) select instructions. This sense instruction (2000,1) enables the computer to determine a unit's readiness. A unit is ready if:

- 1) Unit has power on and all protective interlocks are closed (front door closed, etc).
- 2) No current input channel select operation is in process.

- 3) Unit is not rewound with interlock.

Read Parity Error. This input channel sense instruction (2002,3) enables the computer to determine a parity error (vertical). A positive response indicates:

- 1) A previous read binary operation detected one or more lines with an even number of "1" bits.
- 2) A previous read coded operation detected one or more lines with an odd number of "1" bits.

Read Length Error. This input channel sense instruction (2004,5) enables the computer to determine if, in a previous read operation, the word length of the tape record was in agreement with the computer buffer length. A negative response indicates non-agreement and it is necessary for the computer to insure that its input buffer is terminated. Tape motion will be prevented if a previous input buffer was not completed and the input buffer active signal turned off.

End-of-File Mark. This input channel sense instruction (2006,7) enables the computer to determine if an end-of-file mark (octal 17) was read in a previous read operation.

Ready to Write. This output channel sense instruction (2000,1) enables the computer to determine a unit's readiness to perform an output channel select operation. Ready conditions are the same as described for the Ready to Read sense instruction.

Write Reply Parity Error. This output channel sense instruction (2002,3) enables the computer to determine if a parity error (vertical) was detected in the write reply sequence of a previous write operation. Error conditions are as described for the Read Parity Error sense instruction.

Write Reply Length Error. This output channel sense instruction (2004,5) enables the computer to determine, for a previous write operation, if the number of lines read in the write reply sequence was an integral multiple of eight.

End-of-Tape Marker. This output channel sense instruction (2006,7) enables the computer to determine when no more tape is available for writing. The end of the useable portion of the tape is indicated by a reflective marker on the tape. Enough useable tape is available between the marker and the physical end of the tape to store approximately 20,000 characters.

**TABLES CHAPTER ONE**



TABLE 1-1. IBM CHARACTER CODE

Character	Code (Octal)	Character	Code (Octal)
A	61	2	02
B	62	3	03
C	63	4	04
D	64	5	05
E	65	6	06
F	66	7	07
G	67	8	10
H	70	9	11
I	71	&	60
J	41	-	40
K	42	(blank)	20
L	43	/	21
M	44	. (period)	73
N	45	\$	53
O	46	*	54
P	47	, (comma)	33
Q	50	%	34
R	51	#	13
S	22	@	14
T	23	⌘	74
U	24	0 (numerical zero)	12
V	25	record mark	32
W	26	0 (minus zero)	52
X	27	0 (plus zero)	72
Y	30	group mark	77
Z	31	tape mark	17
0	00		
1	01		

TABLE 1-2. EXTERNAL FUNCTION CODES

Channel		Select Codes
Input Channel	20n1	Select read tape n, binary
	20n2	Select read tape n, coded
74.03----	2001	Read selected tape, binary
	2002	Read selected tape, coded
	2004	Interrupt when selected tape ready
	2005	Rewind selected tape
	2006	Backspace selected tape
	2007	Rewind selected tape with interlock
	Output Channel	20n1
	20n2	Select write tape n, coded
74.04----	2001	Write selected tape, binary
	2002	Write selected tape, coded
	2003	Write end-of-file mark on selected tape
	2004	Interrupt when selected tape ready
	2005	Rewind selected tape
	2006	Backspace selected tape
	2007	Rewind selected tape with interlock
		Sense Codes
Input Channel	2000	exit on ready to read
	2001	exit on not ready to read
74.73----	2002	exit on read parity error
	2003	exit on no read parity error
	2004	exit on read length error
	2005	exit on no read length error
	2006	exit on end-of-file mark
	2007	exit on no end-of-file mark
	Output Channel	2000
	2001	exit on not ready to write
74.74----	2002	exit on write reply parity error
	2003	exit on no write reply parity error
	2004	exit on write reply length error
	2005	exit on no write reply length error
	2006	exit on end-of-tape marker
	2007	exit on no end-of-tape marker

Notes: Code for alternate MTS: 3---  
n=1, 2, 3, or 4 for tape units

## SUMMARY OF EQUIPMENT CHARACTERISTICS

A summary of MTS equipment characteristics is listed in table 1-3.

TABLE 1-3. SUMMARY OF EQUIPMENT CHARACTERISTICS

Equipment	Four Ampex FR307 digital tape handlers and a synchronizer control unit all contained in a single cabinet
Tape speed	a) 150 inches per second during read, write, backspace, and rewind operations b) 225 inches per second during rewind interlock
Recording density	200 lines per inch
Character transfer rate	30,000 six-bit characters per second
Seven track recording	six bits contain data, seventh bit is parity bit
Data format	a) binary: provides odd parity b) binary-coded-decimal: provides even parity
Tape length	up to 3,600 feet
Tape width	1/2 inch
Tape thickness & material	1 mil Mylar base
Reel diameter	10 1/2 inches
Inter-record gap	3/4 inch
Character spacing	.005 inches (33 $\mu$ sec)
Read or record time per 48-bit word	264 $\mu$ sec
Record check character	recorded .02 inch after last character in record
End-of-file mark	Octal 17 code recorded 6 inches from last record in file. Check character written for file mark.
Tape markers	Small reflective spots are placed on tape to denote usable portion of tape.
Record length	Varies from 1 computer word to capacity of magnetic core storage.
Spacing of read & write heads	.390 inch
Recording method	non-return to zero (change-on-ones)



TABLE 1-3. (CONT'D.)

Recording current	75 ma
Read head signal	13 to 17 mv peak-to-peak
Spacing of erase head	7/8 inch (approx.) from write head
Erase head current	110 ma
Cabinet size	length, 7 feet 4 1/2 inches height, 5 feet 7 3/4 inches width, 2 feet 3 1/2 inches
Cabinet weight	2,500 pounds
Power requirements	208 vac, 3-phase, 400 cps, 3-wire, 5 amps 208 vac, 3-phase, 60 cps, 4-wire, 25 amps
Cooling requirements	21,000 BTU/hr. (minimum)

SUMMARY OF DATA AND CONTROL LINE CHARACTERISTICS

Summary descriptions and electrical characteristics of all signal lines between the MTS and the computer are presented in table 1-4. Table 1-5 provides cable and pin number designations for the various signals. Figure 1-5 shows the relation of the signals to the over-all MTS.

TABLE 1-4. DATA AND CONTROL LINE CHARACTERISTICS

Number of cables	6
Number of wires/cable	24 twisted pair (one wire each pair connected to pin b (ground) each end of cable).
Signal information on cables (static)	represented as binary "1" (-0.5v) or binary "0" (-16v).
Signal rise & fall times	2 $\mu$ sec (minimum) to 4 $\mu$ sec (maximum).
Signal current required	10 ma (maximum).
Line capacity	variable, 0 -.002 $\mu$ f (maximum)
Cable ground return d-c resistance	1/2 ohm (maximum).
Signal stabilization time required	2 $\mu$ sec (minimum) is required from the instant data signals appear on the lines until an accompanying ready signal is generated.
Data lines	48 output data lines carry computer information to the MTS; 48 input data lines carry MTS information to the computer.
Output data ready	accompanies each word of computer output information; turned off by output data resume signal from MTS.
Output data resume	indicates that MTS has accepted the computer word; turns off computer output data ready signal.
Input data ready	indicates information is present in the input register of MTS in a state which computer may sample; signal is dropped by reception of input data resume from computer.
Input data resume	indicates the computer has accepted a MTS input word. The signal turns off the MTS input data ready. The end of the input data ready turns off the input data resume at the computer.
Output buffer active	indicates the computer output buffer channel is active; remains on until the final word of the record is buffered to MTS and the last output data resume is returned to the computer.
Input buffer active	indicates that computer input buffer channel is active; remains on until computer buffer is terminated.
Function lines (12)	These lines are continuously monitored by MTS. Only the presence of the proper input or output function ready signal or input or output sense ready signal enables the sampling of the content of these lines by MTS as an external function code.

TABLE 1-4. (CONT'D.)

Output function ready	indicates an output channel external function select code is present on function lines for translation by MTS; selects output channel operations within MTS. Signal is automatically dropped after 8 $\mu$ secs.
Input function ready	indicates an input channel external function select code is present on function lines for translation by the MTS; selects input channel operations within MTS. Signal is automatically dropped after 8 $\mu$ secs.
Output sense ready	indicates an output channel external function sense code is present on the function lines to sense existence of an output channel condition within MTS. Signal is automatically dropped after 8 $\mu$ secs.
Input sense ready	indicates an input channel external function sense code is present on the function lines to sense existence of an input channel condition within MTS. Signal is automatically dropped after 8 $\mu$ secs.
Sense response	indicates to computer the presence of the condition specified by the upper 11 bits of the 12-bit sense code sent to MTS via the function lines. The line is sampled by computer at end of sense ready (input or output) signal.
Interrupt	indicates the MTS has reached the end of an operation for which interrupt has been selected. Interrupt is possible after all MTS select operations except rewind interlock. MTS signal causes computer to interrupt the main program and enter a special subroutine which determines cause of the interruption, takes appropriate action and then returns to main program. The signal remains on until computer senses for ready condition on interrupting tape unit.
External master clear	establishes initial conditions in MTS and is produced whenever Clear switch at computer console is placed in the up position.

TABLE 1-5. CONNECTOR PIN NUMBER ASSIGNMENTS

Pin No.	Input Buffer Channel			Output Buffer Channel			
	Cable 1	Cable 2	Cable 3	Cable 1	Cable 2	Cable 3	
A	Bit 47	Bit 24	Bit 01	Bit 00	Bit 23	Bit 46	
B	46	23	00	01	24	47	
C	45	22	Input Data Ready	02	25	Output Data Ready	
D	44	21	Input Data Resume	03	26	Output Data Resume	
E	43	20	Input Buffer Active	04	27	Interrupt	
F	42	19	External Master Clear	05	28	Input Function Ready	
H	41	18	Not used	06	29	Input Sense Ready	
J	40	17	↓	07	30	Output Function Ready	
K	39	16		08	31	Output Sense Ready	
L	38	15		09	32	Sense Response	
M	37	14		10	33	Output Buffer Active	
N	36	13		11	34	Function Bit 00	
P	35	12		12	35	01	
R	34	11		13	36	02	
S	33	10		14	37	03	
T	32	09		15	38	04	
U	31	08		16	39	05	
V	30	07		17	40	06	
W	29	06		18	41	07	
X	28	05		19	42	08	
Y	27	04		20	43	09	
Z	26	03		21	44	10	
a	25	02		Not used	22	45	Function Bit 11
b	ground	ground		ground	ground	ground	ground

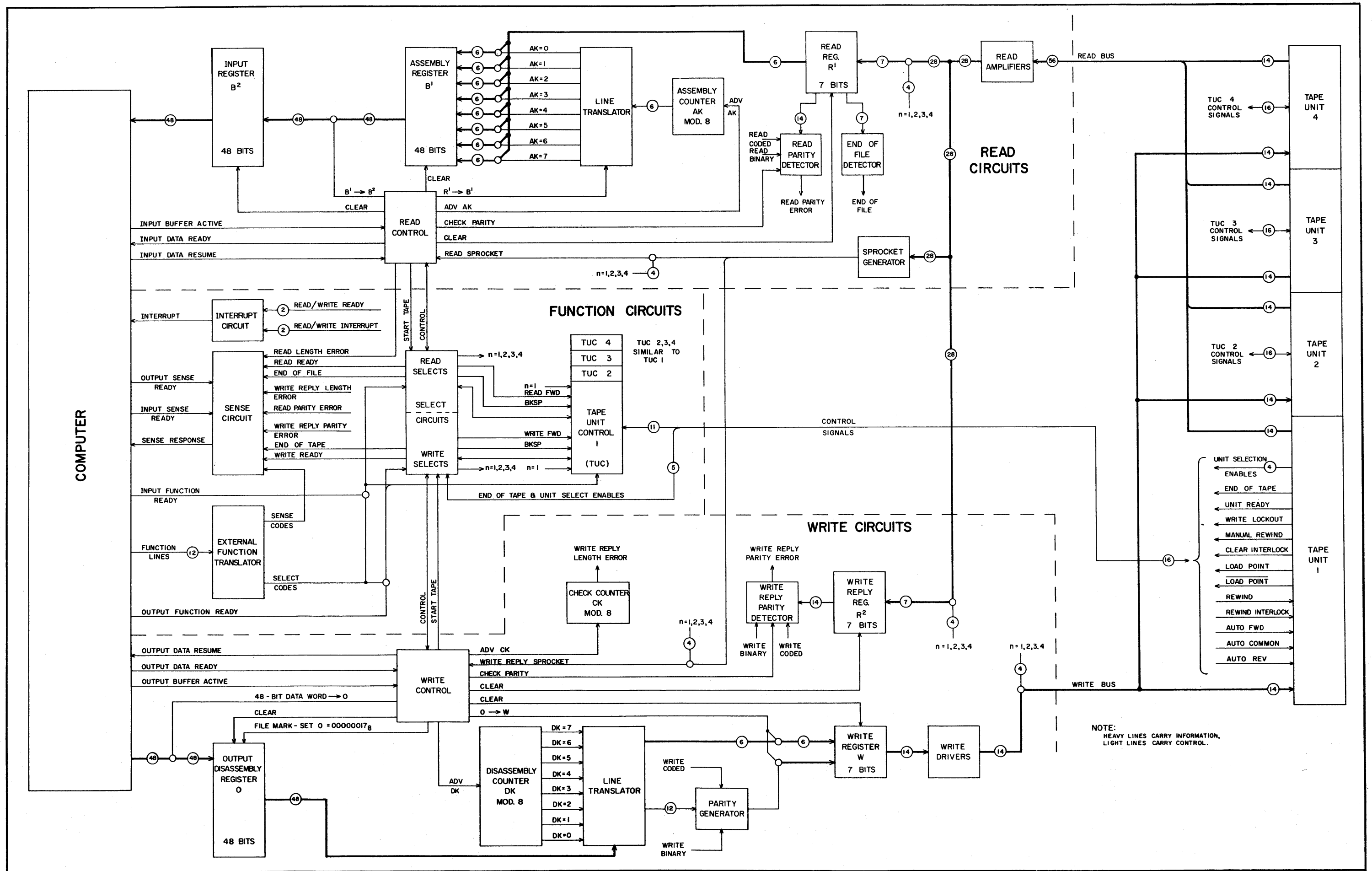
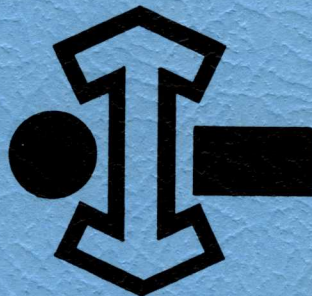


Figure 1-5. Over-all Magnetic Tape System.





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