UNIVAC SCIENTIFIC

MAGNETIC TAPE SYSTEM

PRELIMINARY INFORMATION

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GENERAL DESCRIPTION

a. INTRODUCTION - The Magnetic Tape System of the Univac Scientific Computer System comprises a number of Uniservo tape handling mechanisms, which are located externally to the computer, and an electronic control section which is located in the computer structure. The number of uniservos used is optional up to a maximum of ten functional units. By means of manual selections the unit designations may be assigned in any manner to the functional units. Use of the uniservo units makes possible off-line processing of information by a variety of Univac peripheral equipments.

For input to the Univac Scientific, information may be recorded on tape in three forms:

Fixed Block Length Recording
Variable Block Length Recording
Continuous Data Input Recording

Output information from the Univac Scientific may be recorded on tape in the Fixed Block Length Recording form and the Variable Block Length Recording form.

The Fixed Block Length mode is standard with the Magnetic Tape System. Optional control circuitry may be added to provide both the Variable Block Length mode and the Continuous Data Input mode.

The Variable Block Length mode reads and records information on tape in blocks of variable length. A block of information is recognized by a one inch space preceding it and following it in which no information is recorded. The length of the block is limited in that the data input from it must not exceed the capacity of high speed storage.

The Continuous Data Input mode reads information recorded continuously on the tape with the only limitation on the length of a "block" of information being the length of the tape. This form of recording is useful for real time observations which will not permit interruptions to format the information in fixed or variable block lengths. Data input from tape recorded in this manner would need be interrupted when the capacity of high speed storage is reached.

The Fixed Block Length mode reads and records information on the tape in blocks of fixed length. The remainder of the remarks in this paper apply in particular to this mode of operating.

b. TAPE CHARACTERISTICS.- Unitape is the metallic tape used by the tape handling equipment in recording and reading information. Information is recorded as magnetized areas in eight channels across the width of the tape. Data bits are recorded in six of these channels; one channel contains parity check bits on the six data channels; and one channel contains sprocket, or timing, signals.

A uniservo is a unit of tape handling equipment. A uniservo comprises a read/write head, an erase head, a bad spot (in the tape) detector, and tape handling mechanism such as the tape reel mount, reel drives, etc. In a reading operation the read/write head detects "1's" recorded on the forward or backward moving tape; in a writing operation the read/write head records both "0's" and "1's" on the forward moving tape. During a writing operation the erase head is also activated such that the tape in its passage through the erase head has "0's" written on it. The bad spot detector enables the uniservo to interrupt reading, moving, or writing operations until the undesirable tape area passes the read/write head.

A tape speed of 100 inches per second is standard. The approximate length of a reel of tape is 1500 feet.

A column of eight binary digits across the width of a tape is termed a line; the six data binary digits, a hexabit character. Lines are recorded on the tape at a density of 128 lines per inch (standard) or 50 lines per inch.

A block consists of 720 consecutive lines; a blockette consists of 120 consecutive lines. A "dead space" (in which no information is recorded) of 1.0 inch (standard) or 2.4 inches exists between blocks; a dead space of zero, 0.1, or 1.0 inches exists between the six blockettes of a block. The optional recording formats are selected by program control in accordance with the intended future use of the recorded tape, possibly with Univac auxiliary equipment. Recording format specifications for Univac auxiliary equipment are shown in Table 1.

When a stop of tape movement occurs, the tape is halted in the dead space between blocks. Blockettes and blocks are recognized by the tape control section by counting the timing signals recorded on the tape. A timing device, actuated in the last blockette, signifies the end of a block if the interval between timing signals exceeds a certain length of time. The detection of the end of a block in combination with a stop signal causes a halt of tape movement.

In terms of a 36-bit computer word, six lines are necessary for recording one word: a block comprises 120 computer words; a blockette, 20 computer words. Thus, approximately 326,000 computer words may be stored on a 1500 foot reel of tape. The maximum transfer rate of information between the computer and the tapes is approximately 1810 words per second. This is assuming a free-running tape, one inch block spacing, and zero blockette spacing. Average magnetic tape times for other block and blockette spacings are shown in Table 2.

c. PROGRAMMING TAPE OPERATIONS. - A programmed External Function instruction (17-V) initiates the various reading, writing, and positioning operations of the uniservos. Coded information provided by the External Function instruction includes the following:

(1) specification of optional recording mode if available
(2) designation of the selected uniservo
(3) type of tape operation to be performed
(4) type of recording format for writing, i.e., block and blockette spacing and recording pulse density.
(5) number of blocks to be moved without reading or writing.

The External Function instruction transfers the content of its v-address to the Input/Output Register, IOB. The 36-bit word thus introduced into IOB designates the magnetic tape operation to be performed. The "Select Magnetic Tape" bit in IOB causes a transmission of the content of IOB to registers in the tape control system. The tape control system then interprets this word and initiates tape operation accordingly. A list of IOB Select bits which govern the tape operations is given in Table 3.

If a reading or writing operation is initiated, the External Function instruction which initiates the operation must be followed by an appropriate number of External Read (76jv) or External Write (77jv) instructions to transfer the information between the IOB register and the computer memory. One hundred twenty of these External Reads or External Writes are needed for each block of tape. The reading or writing operation is terminated by an External Function instruction specifying a "Stop" code. This is executed after the last word in the final block has been read or written. When a single block is to be read or written, the "Stop" code may be included in the External Function instruction which initiates the read or write.

A list follows of tape operations initiated by an External Function instruction.

(1) READ FORWARD. - Read data from tape on the specified uniservo, assemble into 36-bit computer words, and transfer the words to the Computer Input/Output Register, IOB.

The initiation of this operation causes the designated uniservo to read a number of blocks from the tape. The reading operation must be terminated by an External Function Stop instruction which is programmed immediately following the External Read instruction used to read the last word in the final block. If it is desired to read one block only, the "Stop" code may be included in the External Function Read Forward instruction which precedes the 120 External Read instructions.

(2) WRITE FORWARD. - Transfer words from the computer Input/Output register, IOB, and record on tape on the specified uniservo. Each word is recorded in six segments of six bits each in accordance with the specified density and spacing.

The initiation of this operation causes the uniservo to write a number of blocks on the tape. The writing must be terminated by an External Function Stop instruction which must be programmed immediately following the External Write instruction used to write the last word in the final block. If it is desired to write one block only, the "Stop" code may be included in the External Function Write Forward instruction which precedes the 120 External Write instructions.

(3) READ BACKWARD. - Identical to Read Forward except that the tape is moved in the reverse direction. The bits of each computer word are assembled in the same order as in a Read Forward operation.

(4) MOVE FORWARD (n BLOCKS). - Move tape forward n blocks on the specified uniservo, without a read or write operation ($0 \leq n \leq 2^{12}-1$).

(5) MOVE BACKWARD (n BLOCKS). - Move tape backward n blocks on the specified uniservo, without a read or write operation ($0 \leq n \leq 2^{12}-1$).

(6) STOP. - Stop tape movement and tape reading or writing after the desired number of blocks have been read or written.

An External Function Stop instruction must be programmed immediately following the terminal External Read or External Write instruction used to read or write the last word in the final block of a group of blocks. This External Function instruction need not, and in fact should not, specify a particular uniservo.

(7) REWIND. - Rewind tape on the specified uniservo to the leader position.

(8) REWIND INTERLOCK. - Rewind tape on the specified uniservo to the leader position; and provide an interlock which prevents further effective references to that tape unit until appropriate steps are taken to remove the interlock.

No more than one uniservo can be in operation at any one time unless the operations are Rewind and Rewind Interlock. After either of the rewind operations is initiated, the uniservo proceeds under its own control until the operation is completed; therefore, an operation on another unit may be performed before rewinding is completed. Any number of functional units may be rewinding concurrently.

(9) CHANGE BIAS. - Change the read bias level to higher or lower than normal; or return bias level to normal if high or low bias level was chosen by a previous External Function. No uniservo specification necessary or possible in the same instruction.

(d) MAGNETIC TAPE CONTROL. - The transfer of information between the computer and the magnetic tapes is controlled by the Magnetic Tape Control System situated within the computer. The link between IOB and the tape is a 36-bit Tape Register (TR) in the tape control section. A writing operation involves the transmission of a word from IOB to TR, the break down in TR of the 36-bit word into six hexabit characters, the generation of a parity check bit for each character, and the transfer of each character, its parity check bit, and a timing signal to a line of tape. A reading operation involves the assembly of data from the tape in the Tape Register, a parity check on each line of tape as it is received in TR, and the transmission of a 36-bit word from TR to IOB.

The parity check bit generated during a writing operation is a "0" if the number of "1's" in the character is odd, and the parity check bit is a "1" if the number of "1's" in the character is even: this will always result in an odd sum if the character and parity bits are added together. When the parity check is made during the reading operation, a parity error is indicated by a "0" sum. When a parity error is detected, a "1" is placed in stage IOA_0 of the IOA register, and the tape movement is halted automatically at the end of the block. Thus, the content of IOA must be examined by the program immediately following the execution of the External Read instruction used to read the last word in each block. If no error indication is detected, the program proceeds normally. If an error is detected, a standard subroutine stored in the computer can be used under control of the main program to initiate and perform re-reading operations in an attempt to read the block correctly. The automatic stop of a tape unit on a parity error indication is effectively completed before the initiation of a re-read operation is allowed by the tape control system.

The features which provide a read backward operation and a change in the bias level may permit proper reading of marginal signals which have caused a parity check failure. Since both of these operations are available under program control, a correct reading of the block in question may be accomplished without a computer stop. A change in the read bias level to either higher or lower than normal may permit the correct reading of the block by virtue of ignoring any "noise" factor on the tape or picking up any marginally recorded bits.

When a block of information is read from magnetic tape, a check is also made to determine if the proper number of lines are recorded in the block. A properly recorded block consists of 720 lines. A count is kept of the number of lines in a block by a series of counters which are advanced by the reception of the sprocket pulses (timing signals) recorded on the tape. If a 720 count has been tallied and another sprocket pulse is detected within a certain period of time, an inter-block space is not passing beneath the read/write head and a 720 check failure is indicated; also, if less than a 720 but more than a 600 count has been tallied and no sprocket pulse is detected within a certain period of time, an inter-block space may be passing under the read head and a 720 check failure is indicated. A 720 check failure incurred in a reading operation stops the tape unit and causes a sprocket error fault indication.

A 720 check failure incurred in a moving operation stops the tape unit and causes a sprocket error indication if a >720 count is detected; if a <720 count is detected, the 720 check failure is ignored in that no tape stopping action or error indication is effected.

The timing signals are recorded on the tape at the same time as the lines of information. During a writing operation, previously recorded signals are removed from the tape by the erase head which "erases" the entire width of the tape during the tape passage under it. The position of the erase head is several inches in advance of the read/write head. This insures the removal of signals from inter-block spaces during continuous writing from the beginning of the tape. However, it is not possible to guarantee a safe rewrite of a previously recorded block(B) when the writing operation is initiated with the read/write head positioned in the inter-block space immediately preceding that block. Also, a block in the middle of a tape cannot be rewritten without erasing at least part of the following block. The last block that has been recorded(A) may be rewritten but the entire block will not be subjected to the erase head when the read/write head is positioned before that block. At any point writing can be stopped, the tape moved backward for reading purposes, and writing later resumed safely at the point at which it was stopped. In particular, a block can be written and then read backward to check for accuracy in writing. If no errors are detected, writing can be continued by repositioning the tape after the block.

Thus, any writing operation should be started either at the beginning of the tape or at the point at which previous writing was stopped.

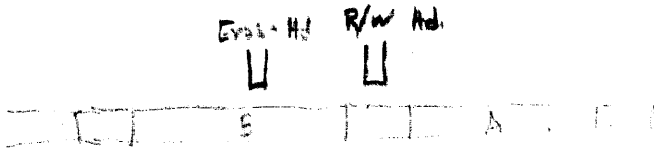


TABLE 1

UNITAPE STANDARDS

The standards listed for tape preparation equipment are those (approximate) densities and spacings at which the equipment records; the standards listed for tape transcription equipment are those (approximate) densities and spacings acceptable to the transcribing equipment for conversion. Equipment specified as using 1500 foot reels also accepts 200 foot reels.

Equipment	Tape Length (feet)	Density (Characters/ inch)	Inter-Blockette Space (inches)	Inter-Block Space (inches)
Unityper II	200	50	2.4	2.4
Card-to-Tape Converter	1500	128	1.8	2.4
PTM Converter* (Paper Tape-to-Magnetic Tape)	200	128	1.0	1.0, 2.4
Uniprinter II*	1500	50	0 min	2.4
High Speed Printer	1500	128	1.0 min	2.4
	1500	50	2.4	2.4
Tape-to-Card Converter	1500	128	.1	2.4
MTP Converter* (Magnetic Tape to Paper tape)	1500	128	1.0	1.0
Transrecorder* (Unitape Transmission)	1500	128	1.0	1.0
Univac Scientific-internal	1500	128	0 min	1.0 min
Univac I-internal	1500	128	.1 min	2.4
Univac II*-internal	1500	50, 128	.1 min	1.0, 2.4

* under development

TABLE 2

AVERAGE MAGNETIC TAPE TIMES

To estimate running times of programs using magnetic tapes

Recording Density (lines per inch)	Block Space (inches)	Blockette Space (inches)	Block Length (including block space, in inches)	Block Period* (milliseconds)	Rate (36-bit words per second)
128	1	none	6.625	66.25	1811
128	1	0.1	7.125	71.25	1684
128	1	1.0	11.625	116.25	1032
128	2.4	none	8.025	80.25	1495
128	2.4	0.1	8.525	85.25	1408
128	2.4	1.0	13.025	130.25	921
50	1	none	15.4	154.0	779
50	1	0.1	15.9	159.0	755
50	1	1.0	20.4	204.0	588
50	2.4	none	16.8	168.0	714
50	2.4	0.1	17.3	173.0	694
50	2.4	1.0	21.8	218.0	550

Tape speed: 100 inches per second
Time to reverse direction of tape: 600 milliseconds

* These block periods are for either free run or for a single block. The block period does not include the starting or stopping times.

TABLE 3

EXTERNAL FUNCTION BIT ASSIGNMENT FOR UNISERVO CONTROL

The bits in IOB_{23} ... IOB_{12} are placed in the Tape Control Register (TCR_{11} ... TCR_0); the bits in IOB_{11} ... IOB_0 are placed in the Block Counter (BK_{11} ... BK_0) where they are used to govern the number of blocks moved in a Move Forward or Move Backward operation.

IOB_{31}	= 1 - Select Magnetic Tape
IOB_{23}-IOB_{22}	Select Rewind or Stop Tape = 01 - Rewind = 10 - Rewind Interlock = 11 - Stop
IOB_{21}	Select Block Spacing = 0 - 1" interblock spacing = 1 - 2.4" interblock spacing
IOB_{20}-IOB_{19}	Select Blockette Spacing = 00 - zero spacing = 01 - 0.1" spacing = 10 - 1.0" spacing
IOB_{20}-IOB_{19}	= 11 - Select operation in Variable Block Length mode or Continuous Data Input mode*
IOB_{18}-IOB_{16}	= 100 - Select option of operating in Continuous Data Input mode or change to option of operating in Variable Block Length mode.**
IOB_{18}-IOB_{16}	Select Tape Operation = 001-Read Forward = 010-Move Forward = 011-Write Forward (128 lines/inch) = 101-Read Backward = 110-Move Backward = 111-Write Forward (50 lines/inch)
IOB_{15}-IOB_{12}	Select uniservo unit or Read Bias Level = 0001-Uniservo 1 = 0010-Uniservo 2 ⋮ = 1010-Uniservo 10 = 1101-Normal read bias = 1110-Low read bias = 1111-High read bias
IOB_{11}-IOB_0	Select the number of blocks to be moved in a Move Forward or Move Backward operation.

see next page for footnotes

* If the Variable Block Length and Continuous Data Input modes are available, these bits included in an EF for an allowable tape operation cause the mode of operation to be either (1) Variable Block Length instead of Fixed Block Length, or (2) Continuous Data Input instead of Fixed Block Length. A computer Master Clear automatically establishes the conditions necessary for the choice described in (1).

** An EF with these bits and the Select Magnetic Tape bit establishes the conditions necessary for the choice described in (2) above if the conditions for (1) were established previously; and vice versa.

OPERATION THEORY

a. GENERAL. - The presence of an IOB_{31} Select "1" bit, as placed in IOB by an External Function instruction, informs the tape control system that a tape operation is desired and the contents of IOB are to be transferred to the Tape Control Register (TCR). The presence of the proper tape operation codes in TCR provides the control system with the information needed to carry out the particular tape operation designated. These tape operations are Write Forward, Read Forward, Read Backward, Stop Tape, Move Forward, Move Backward, Rewind, Rewind with Interlock, and Change Bias. A brief description of these follows.

A properly recorded block consists of 720 lines (each line containing six data bits) or 120 computer words. Thus, 120 External Writes or External Reads need to be executed to record a block or read a block. The flow of information in a writing operation is from IOB to the Tape Register (TR) to the tape. Each line of tape written consists of six data bits from TR, a parity bit, and a sprocket pulse. After six lines of tape are written, the next word to be written is transmitted to TR. Since the tape operations proceed under their own timing control, a word must be ready in IOB for transfer to TR each time tape control signifies it is ready to write a word. If an External Write instruction has not been executed to fill IOB, a No Information fault is generated which causes a B Fault computer stop and a tape stop at the end of the current block. Thus, a No Information fault indicates that insufficient EW's are programmed, or an External Write is programmed to be executed too late.

The flow of information in a reading operation is from tape to the Align Input Register (AIR) to the Tape Register to IOB. The transmission from AIR to TR is caused by the sprocket pulse (delayed) which was recorded with the bits now in AIR. Information is assembled in TR six data bits at a time. When six lines have been read, TR contains a complete word and tape control performs the transmission TR to IOB. Again, the assembly of words in TR proceeds timewise under tape operation control. The nature of the IOB lockout system provides the wait for IOB to be filled if an External Read instruction is begun before IOB receives information from external equipment; after this occurs the External Read is completed and the content of IOB is sent to computer storage. If tape control performs a second transmission TR to IOB before IOB has been cleared by an ER, an IO computer fault is incurred, a B Fault computer stop occurs, and tape movement is stopped at the end of the current block. This again could mean a lack of sufficient ER's programmed or the tardy execution of an External Read.

The detection of a sprocket error during reading initiates a tape stop immediately and causes a B Fault computer stop. The occurrence of a parity check error is detected at the end of the block in which it occurred. At this time a tape stop is initiated and a parity error is indicated by setting a "1" in stage IOA_0 of the IOA register. Thus IOA must be checked at the completion of reading every block before any continuance of tape operation.

The halt of a correctly executed read or write operation occurs when a stop code in the Tape Control Register (TCR) and an "end of block" count both exist. Hence, if only one block is to be read or written, the stop code may be placed in TCR by the External Function instruction which initiated the read or write

operation; if more than one block is to be read or written, the stop code is placed in TCR by an EF instruction following the last EW or ER instruction. In this case, the EF instruction needs only to contain the stop code in its v-address. A programmed stop tape operation is necessary only to conclude reading and writing operations.

A programmed External Function instruction for a move operation must include the Move Forward or Move Backward code and a specification of the number of blocks to be moved. The number of blocks n to be moved are coded in IOB_{11} ... IOB_0. During a moving operation no information transfer occurs past the Align Input Register. The delayed sprocket pulse from each line of tape does not cause the transmission AIR to TR but is used only to form a count of the lines moved. Each time a block count is reached, the Block Counter is reduced by one. When BK has been reduced to zero, a tape stop is initiated. In moving, the detection of a block with less than 720 recorded lines does not effect a tape stop and a computer fault; the detection of a block with more than 720 recorded lines causes an immediate tape stop and a computer B Fault stop.

A change in the bias level needs to be programmed only when an incorrect reading operation has occurred. Reading forward and backward at the high and low bias levels may accomplish a correct reading of the block. It is not permissible to program any other tape operation in the instruction which specifies a change in bias. The return to the normal reading bias level must also be programmed unless a computer Master Clear occurs which also accomplishes this.

Both the Rewind and Rewind with Interlock operations cause the tape on the uniservo specified to be positioned to its leader position. A uniservo whose tape has been rewound with interlock cannot be referenced effectively until the uniservo door interlock switch has been opened and closed. This occurs when the uniservo is provided with another tape.

After the Rewind and Rewind with Interlock operations are through their initiation phase, another tape operation on a different uniservo may be started. Thus, any number of uniservos may be rewinding concurrently. If a tape operation is desired on a uniservo which is rewinding when this tape operation is initiated, the tape operation is held up until the rewinding is completed. Then, if the tape has not been rewound with interlock the tape operation is resumed and completed.

It is not possible to execute correctly a second tape operation on any uniservo while a previous one is still in progress unless the tape operation in progress is a rewind operation .

b. GLOSSARY. - The following glossary lists terms pertaining to the magnetic tape system. A brief description is given of the primary function of the principal registers and counters involved in tape control. Also described are the basic divisions in which tape control components are grouped to handle the various tape operations.

The simplified diagrams shown in Figures 1 - 4 , although they are by no means complete in detail, show adequately for purposes here the interrelationship between the control components as they are involved in starting a tape operation and tape reading, moving, and writing operation.

Read/Write head - Binary digits are represented in channels across the width of the tape as areas magnetized in opposite directions. In a writing operation areas in the channels on the forward moving tape are magnetized in the "0" direction except when pulses are received by the read/write head from tape control in which case areas are magnetized in the "1" direction.

In a reading operation the read/write head, as it detects in the channels the areas magnetized in the "1" direction, directs pulses to be sent to tape control. Accurate detection occurs when the backward or forward moving tape has reached its free-running rate (100 inches per second).

Erase head - during a writing operation, the erase head magnetizes in the "0" direction the entire width of the tape in its passage under the erase head. The position of the erase head several inches from the read/write head is such that the traversal of the tape in a forward direction is first under the erase head and then under the read/write head. This guarantees a "clean" portion of the tape on which to write.

Tape Leader - the plastic length of the tape which precedes the metallic length of the tape on which information can be recorded.

Ringed tape - A tape reel fitted with a ring which prevents writing on this tape and in so doing provides indication of this condition. This feature is to be made available in the near future.

Writing Oscillator - emits pulses at the rate of one every $\approx 80\ \mu s$ (for writing 128 lines/inch) or one every $200\ \mu s$ (for writing 50 lines/inch). The rate depends upon the selection made for density of lines in a writing operation. An oscillator pulse (in conjunction with other conditions) initiates the writing of a line.

Sprocket Pulse - formed by sensing the sprocket channel as a line of tape moves past the read/write head in a reading or moving operation. After a short delay the sprocket pulse is instrumental in a reading operation in routing the information read from that line of tape to the computer. In a moving operation each sprocket pulse is used to form a count of lines moved.

Parity bit - recorded on each line of tape during a writing operation and used as a check on the accuracy of reading each line of tape. The parity bit generated during writing a character (six data bits) is a "1" if the number of "1's" in the character is even and a "0" if the number of "1's" is odd. The sum of the data bits and the parity bit should be odd.

Bad Spot Control

Bad Spot on tape - Areas on the tape on which no recording should be attempted are marked as "bad spots". Holes punched in the tape preceding, following, and in the bad spot area are sensed by photoelectric tape readers during tape movement. During a reading operation, Bad Spot Control interprets the position of these holes and temporarily stops any transmissions from tape until the bad spot is

passed; during a moving operation Bad Spot Control stops temporarily the counting procedure of the lines moved; during a writing operation, Bad Spot Control temporarily stops oscillator pulses from initiating the writing of a line.

Reading Bias - the voltage applied to the read/write head when reading from the tape. By changing the bias level to higher or lower than normal, the read/write head responds to weaker than normal signals on the tape or ignores objectional "noise" factors on the tape.

Tape Control Register (TCR) - a 12 bit register in the tape control system which receives the bits in $IOB_{23}...IOB_{12}$ when the bit in IOB_{31} is "1" (Select Magnetic Tape bit). The actual transmission IOB→TCR is held up (i.e., TCR is "locked out") until the tape control system signals that it is ready to receive another operation code. The presence of operation bits in TCR enables the various tape operations.

Block Counter (BK) - a 12 bit register in the tape control system which receives the bits in $IOB_{11}...IOB_0$ on an IOB→TCR transmission as described above. The content of BK is used to regulate the number of blocks (n) moved in a More Forward or More Backward operation.

Tape Register (TR) - a 36 bit register in the tape control system through which words are routed in their transmission between tape and IOB. In a writing operation six-bit segments of a word in TR (placed there by an External Write instruction) are positioned in $TR_{5...0}$ and consequently written on tape. In a reading operation, a word is assembled in TR until six lines have been received; the transmission TR→IOB then occurs.

Align Input Register (AIR) - a seven bit register which receives six data bits and the parity bit from a line of tape passing under the read/write head in a read or move operation. In a reading operation the delayed sprocket pulse formed by sensing the sprocket channel in the same line of tape causes the transmission $AIR_{5...0}→TR_{35...30}$; AIR is then cleared.

Tape Shift Counter (TSK) - a counter which regulates the shifting in TR of the six data bits of a line. On the completion of the shift of six bits (one line), a TSK "end carry" is propagated which is interpreted as an "advance LK" signal by the Line Counter; TSK is then cleared".

Line Counter (LK) - a counter which controls during reading and writing the shifting in TR of the six lines of a word. In a reading operation, when six lines have been assembled in TR, LK propagates a signal to effect TR→IOB; an "advance WK" signal is sent to the Word Counter, and TR and LK are "cleared". In a writing operation when six lines have been written on tape from $TR_{5...0}$, LK propagates a signal which clears TR and enables the transmission IOB→TR (if IOB has been filled by an EW instruction); an "advance WK" signal is sent to the Word Counter, and LK is "cleared".

In a moving operation LK is advanced by the receipt of a delayed sprocket pulse. When six lines have been "moved", an "advance WK" signal is sent to the Word Counter and LK is cleared.

Word Counter (WK) - counts the number of words read, written, or moved until a blockette count is reached; i.e., when a 20 word count is reached, an "advance BTK" is sent to the Blockette Counter and WK is "cleared".

Blockette Counter (BTK) - counts the number of blockettes read, written, or moved until a block count is reached; i.e., when a six blockette count is reached, a "BTK end carry" is sent to various portions of tape control, and BTK is "cleared". A BTK end carry is used during a moving operation to subtract "1" from the Block Counter.

Tape Control Register Sync (TCRS) - controls the transmission IOB→TCR and informs the Tape Start Control of this transmission when it occurs.

Tape Start Control (TSC) - decides if tape movement is to be initiated after the IOB→TCR transmission; if so, TCRS is directed to "lock out" any IOB→TCR transmissions until further notice.

Tape Direction Control (TDC)
Tape Direction Delay Control (TDDC) - decides if tape movement is to be in an opposite direction from the previous movement. A delay is incurred, the length of which depends upon whether a reversal is required, which provides the time necessary for the adjustment of the tape handling mechanisms. Tape movement is started after the proper delay.

Tape Leader Delay Control (TLDC) - determines whether the tape being moved is on its leader. If so, a delay is incurred, allowing the tape to be moved off its leader, before further tape operations are initiated. If a read, write, or move operation is to occur, the appropriate control sections are informed of this after the delay.

Tape Shift Counter Control - controls the shifting of the Tape Register during reading and writing operations and propagates an "end carry" when shifting is completed.

MT Write Control - decides if and when the current oscillator pulse received during a writing operation should effect the initiation of the writing of a line and informs other portions of control (Tape Shift Counter Control, Write Fault Control, parity control) of its decision. Delays prevent the oscillator pulse from being effective while block spacing, blockette spacing, or a bad spot is being moved past the read/write head.

Tape Write and Resume Control - signals the read/write head to write a line of tape when six bits have been shifted into position in TR; advances the Line Counter when a line is written.

Tape Register Control (TRC) - interprets a Line Counter end carry during a writing operation to mean that a word has been written on tape and TR should now receive the next word to be written; hence, it directs the clearing of TR and enables the transmission IOB→TR if IOB has been filled by an EW instruction. During a reading operation, directs the transmission TR→IOB and clears TR when it receives a LK end carry.

Tape Parity Translator

Tape Parity Translator Control - during a writing operation, determines the parity bit to be written; during a reading operation, determines if each line was read correctly by checking its parity bit. Indicates a parity error at the end of reading a block.

Write Fault Control - checks with Tape Register Control when the six-bit shift in TR is initiated during writing to see if a word is present in TR. If TRC indicates that a word should be but is not in the Tape Register because an EW instruction has not yet been executed, a No Information fault is indicated.

Read and Move Control - during a reading operation, controls the transmission of the data bits from AIR to TR, and notifies other portions of control of this transmission each time it occurs. During a moving operation, notifies the Line Counter of the movement of each line of tape past the read/write head.

Sprocket Error Control - during reading and moving operations, indicates a greater or less than 720 line count when a recorded block such as this is detected.

Block End Stop Control - during reading and writing operations, directs Stop Control to effect a tape stop any time a stop enable is in TCR and a BTK end carry is sensed. Also, if the BTK end carry is the result of the reading or writing of the last block of a number of blocks, the "stop tape" signal is generated when the stop code is placed in TCR. During a moving operation, the BTK end carry which reduces the Block Counter to a zero count directs Stop Control to effect a tape stop.

c. OPERATION SEQUENCES. - On the following pages the theory of operation of the magnetic tape system is described in terms of a Start Sequence, Read, Write and Move Sequences, and a Stop Sequence. The conditions necessary for initiating and continuing the steps of each sequence to its conclusion are listed.

The presentation of each sequence is as follows: the portion of control being described is bracketed and its title noted in caps to the right of the description of its function. The functional signals and conditions effective in this portion of control are listed to the left of the page; the signals or conditions resulting from these are indented below them. The source and destination of functional signals are noted directly to their right. A condition listed as an "enable", such as a write or stop enable, is effected by the presence of the operation code in the Tape Control Register (described previously in the glossary).

"Flow diagrams" precede the Write, Read, and Move Sequences.

START SEQUENCE

(assuming the occurrence of the transmission X to IOB during the execution of a previous External Function tape instruction).

IOB_{31} Select "1"
AND
No IOB to TCR transmission within previous 10 ms
No moving operation in progress (no move enable from TCR)
No Initiate Stop signal received within previous 10 ms
No "TCR lockout"*
i.e., (1) No reading or writing of a block in progress, reading or writing not occurring while tape is moving through inter-block spaces; and (2) No Rewind initiation in progress; a rewind operation completes the initiation phase after the Start Tape signal is emitted.

after all of conditions above met:
- $IOB_{23} \ldots 12 \rightarrow$TCR
- $IOB_{11} \ldots 0 \rightarrow$BK
- Clear IOB
- Initiate Start to Tape Start Control

TAPE CONTROL REGISTER SYNC (TCRS)

Initiate Start from TCRS or Manual Start
AND
Not (BK=0 and Move Enable) **
AND
Uniservo j Select Enable ***
provided uniservo j is available ****
Set TCR lockout to TCRS
Initiate Tape Movement to TDC
IOB Resume to IOB Control if there is a Read, Write, Move, Rewind, or Rewind Interlock enable from TCR.

TAPE START CONTROL (TSC)

---

* The condition of the TCR lockout is effected by the following signals:

TSK end carry from Tape Shift Counter during reading and writing–
Initiate Start from Tape Start Control (if the conditions noted exist)–
Set TCR lockout

BTK end carry from Blockette Counter during reading, writing, and moving–
Following a Start Tape signal for a Rewind or Rewind Interlock operation–
"Master Clear" tape control system from Stop Control–
Clear TCR lockout

, *, ****, (see the following page)

** Not (BK=0 and Move Enable) can be any of the following combinations:

No Move Enable and BK=0
No Move Enable and BK≠0
Move Enable and BK≠0

A Move Enable and BK=0 (with a valid uniservo selection) clears TCR, effects an IOB Resume but no TCR lockout. Thus, the next tape operation may be initiated immediately.

*** A uniservo selection is not necessary for a Bias Change operation. No TCR lockout is effected but also no IOB Resume is given at this point. A Bias Change Acknowledge Signal occurring approximately 20 ms later effects the Clear TCR and IOB Resume signals. Any EF instruction attempted during this time will set up an IOB lockout condition.

**** uniservo j is not available when

(1) no uniservo designation has been made.

(2) uniservo j doesn't exist; i.e. the j designation exceeds the number of installed uniservos and hence is not allowable, or none of the physical units have been designated as j. (This would include the case where the unit assigned the number j is out of use for maintenance purposes). When a correct designation is made, the uniservo j becomes available. (Two uniservos cannot be given the same designation - this will cause a computer B-Fault.)

(3) uniservo j is rewound with interlock. An attempt to remove a tape from a uniservo rewound with interlock while referencing that uniservo results in a "not ready" condition and a Uniservo Interlock fault as explained below.

If uniservo j is rewinding when referenced, it is available when rewinding is completed, if it is not interlocked at completion.

If uniservo j is not available for any of the above reasons, tape movement is not started, no TCR lockout is effected, and no IOB Resume is given. Any External Function or External Write (or External Read) instruction attempted under these conditions will set up an IOB lockout condition.

Uniservo j is "not ready", when the uniservo interlock circuit is open, i.e., voltage is dropped in the unit. This is evidenced by the extinguishment of the green "Ready" indicator on the uniservo. If this condition exists, a Uniservo Interlock fault results from referencing this uniservo. This causes a B-Fault computer stop. The Set TCR Lockout, and Initiate Tape Movement signals occur, but tape movement is not started.

Initiate Tape Movement from TSC
Initiate Initial Delay to TDDC
Initiate Direction Change Delay to TDDC if tape movement is to be in opposite direction from previous tape movement

TAPE DIRECTION CONTROL (TDC)

Initiate Initial Delay from TDC
after 2.5 ms delay
Leader Delay Probe to TLDC
Set Leader Delay to TLDC
Start Tape to Tape Drive Control

simultaneously-

Initiate Direction Change Delay
after 600 ms (for direction change)
Leader Delay Probe to TLDC
Set Leader Delay to TLDC
Start Tape to Tape Drive Control

TAPE DIRECTION DELAY CONTROL (TDDC)

Set Leader Delay from TDDC and Write Enable
Start Write to Tape Register Control
Start Write to Write Control

OR

Set Leader Delay, Leader Delay Probe finds uniservo j on leader, and Write Enable
after 1500 ms
Start Write to Tape Register Control
Start Write to Write Control

OR

Set Leader Delay from TDDC and Read Enable or Move Enable
Start Read/Move to Read/Move Control

OR

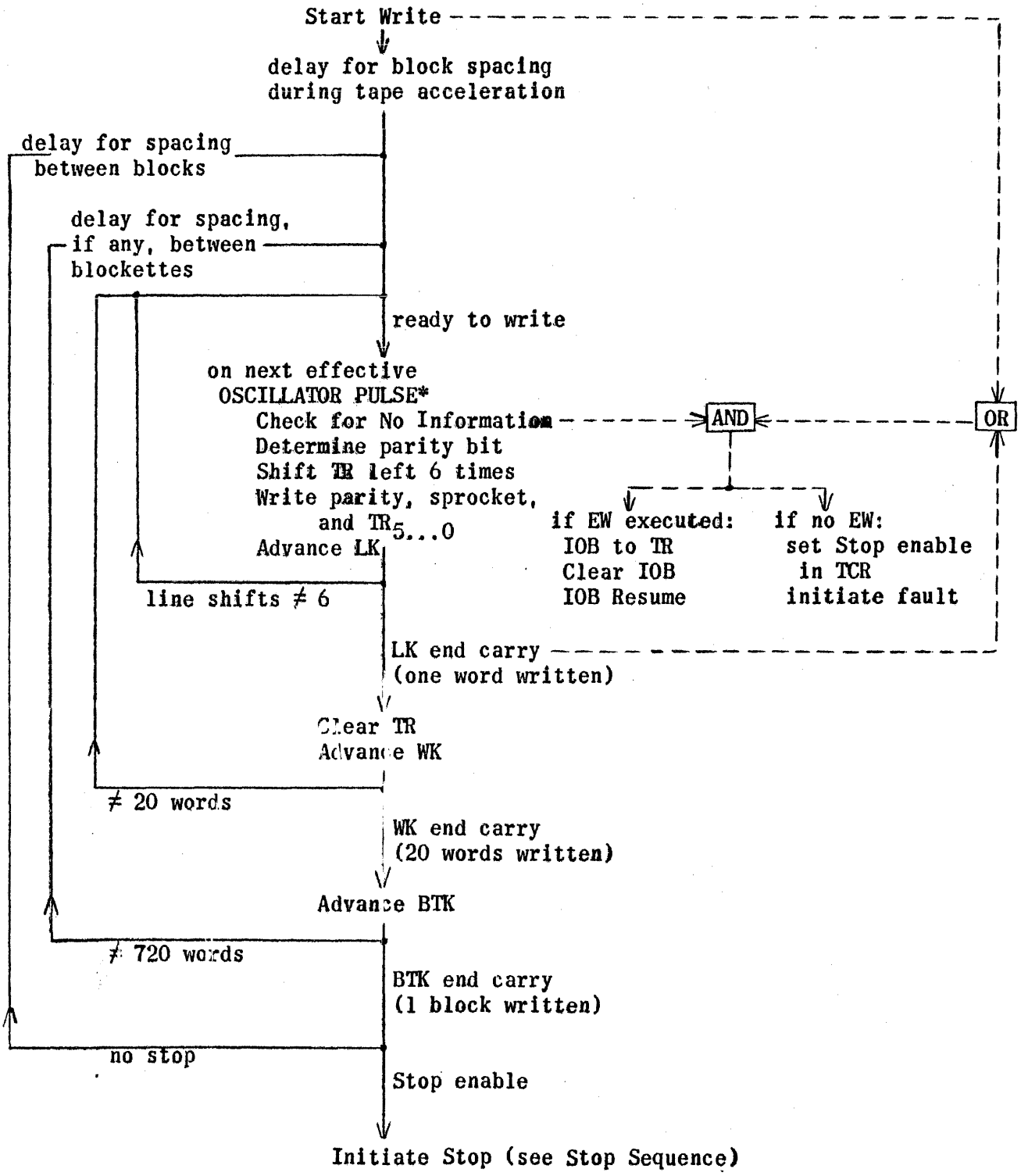
Set Leader Delay, Leader Delay Probe finds uniservo j on Leader, and Read or Move Enable
after 1000 ms
Start Read/Move to Read/Move Control

OR

Set Leader Delay, Rewind or Rewind with Interlock enable
Clear TCR
Clear TCR lockout to TCRS

TAPE LEADER DELAY CONTROL (TLDC)

WRITE SEQUENCE



* Oscillator pulses do not effect any writing initiation during any of the delays quoted and during the time the tape is moving through a bad spot. During a stop initiation, oscillator pulses are made temporarily ineffectual by virtue of the delay (for the inter-block space) caused by a BTK end carry. During this delay, a Master Clear from Stop Control renders them ineffectual until the next Write Sequence.

WRITE SEQUENCE

from Tape Leader Delay Control (from Start Sequence)
Start Write to Tape Register Control
Start Write to MT Write Control

WRITING PULSES FROM OSCILLATOR

AND (any of following groups)

Start Write from TLDC, 1.0 block spacing enable
after 7.5 ms delay
(see below)

OR

Start Write from TLDC, 2.4 block spacing enable
after 14.5 ms delay
(see below)

} initiate start writing

OR

MT Write Control I set to "1" (set by Start Write from TLDC; cleared by Stop Write from Bad Spot Control; cleared by BTK end carry and reset 1.8 microseconds later if no Stop Select; cleared by "Master Clear" - see stop sequence.
(see below)

} initiate write one line on each osc pulse

OR

Start Write from Bad Spot Control
(see below)

OR

} initiate continue writing after bad spot has passed

BTK end carry, 1.0 block spacing enable, write enable, no stop enable
after 10 ms delay.
(see below)

OR

BTK end carry, 2.4 block space enable, no stop enable, write enable
after 24 ms delay
(see below)

OR

} initiate continue writing after block space has passed

} MT WRITE CONTROL

WK end carry, write enable, 1.0 blockette space enable after 10 ms delay (see below)

OR

WK end carry, write enable, 0.1 blockette space enable after 1 ms delay

initiate continue writing after blockette space has passed

MT WRITE CONTROL (continued)

Check Write Fault to Write Fault Control
Set Parity to Parity Translator and Control
Initiate Shift to Tape Shift Control

Initiate Shift from MT Write Control
TR shifted left six times
TSK end carry on last shift-
Write signal to Write and Resume Control
Set TCR lockout to TCRS (Start Sequence)
Clear Block End Indicator to Block End Stop Control

TAPE SHIFT (COUNTER AND) CONTROL (TSK)

Write Signal from Tape Shift Control
Write one line (parity bit, sprocket, $TR_{5...0}$
Write Resume (Advance LK)

TAPE WRITE AND RESUME CONTROL

Advance Line Counter
(LK advanced six times, on sixth advance-)
LK end carry to Word Counter
LK end carry (Clear TR) to Tape Register Control

LINE COUNTER (LK)

Advance Word Counter
(WK advanced 20 times, on last advance)-
WK end carry to Blockette Counter
WK end carry to MT Write Control

WORD COUNTER (WK)

Advance Blockette Counter
(BTK advanced 6 times, on last advance-)
BTK end carry (set Block End Indicator) to Block End Stop Control
BTK end carry to MT Write Control
BTK end carry (clear TCR lockout) to TSC (Start Sequence)

BLOCKETTE COUNTER (BTK)

Block End Indicator set and Stop Select enable available before next, if any, TSK end carry received
Initiate Stop (Write) to Stop Control
Initiate Stop to TCRS (Start Sequence)

BLOCK END STOP CONTROL

Start Write from TLDC
OR
Write Enable and LK end carry (clears TR)

AND

X → IOB (From EW instruction)
IOB → TR
Clear IOB
IOB Resume

TAPE REGISTER CONTROL

if { Start Write
OR
Write Enable and LK end carry

AND

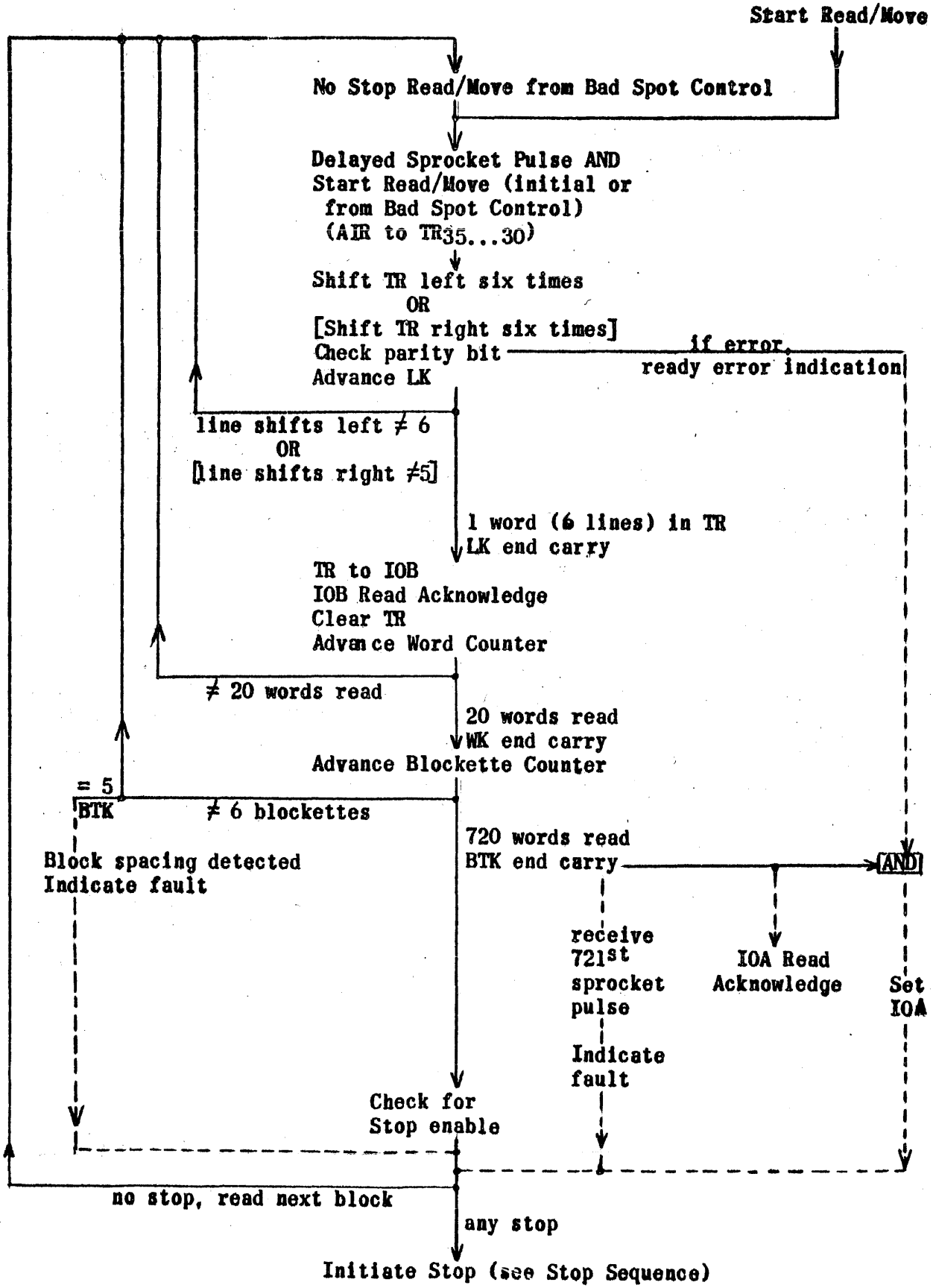
Check Write Fault from MT Write Control before EW instruction executed
Indicate fault
Set TCR_{10} and TCR_{11} (stop code)

WRITE FAULT CONTROL

Set Parity
Write Parity Enable to Write and Resume Control
(if no. of "1's" even)

TAPE PARITY TRANSLATOR AND CONTROL

READ FORWARD [BACKWARD] SEQUENCE
(Delayed sprocket pulse ≈40 μs after tape line to AIR)



READ FORWARD SEQUENCE

when tape has reached free-running speed, line of tape → AIR. Delayed sprocket pulse emitted approximately 40 us later.

from Tape Leader Delay Control (from Start Sequence)
Start Read/Move to Read Control

Start Read/Move (from TLDC)
OR
Start Read/Move from Bad Spot Control
Set Read/Move Control I to "1" (cleared by Stop Read/Move from Bad Spot Control, giving Hold Clear AIR)

Read/Move Control I "1" (and Read Enable)
AND
DELAYED SPROCKET PULSE
AIR to $TR_{35 \ldots 30}$ and Tape Parity Translator
Clear AIR
Read "pulse"

Read Pulse from Read/Move Control
Initiate Shift to Tape Shift Control
Test Parity (check odd count) to Parity Translator

READ AND MOVE CONTROL

1. DELAYED SPROCKET PULSE
2. possible "1" from parity track
3. possible odd count from check of bits

Check Parity from Tape Shift Control AND 1 only or 1, 2, and 3.
Set Parity Error Indicator to "1"

BTK end carry
IOA Read Acknowledge

BTK end carry and Parity Error Indicator "1"
Set parity error indication in IOA
Initiate parity error stop to Stop Control
Initiate parity error stop to TCRS (Start Sequence)

TAPE PARITY TRANSLATOR AND CONTROL

Initiate Shift from MT Read Control
TR shifted left six times
TSK end carry on last shift-
Clear Block End Indicator to Block End Stop Control
Check Parity to Parity Control
Advance LK
Set TCR lockout to TCRS (Start Sequence)

TAPE SHIFT (COUNTER AND) CONTROL (TSK)

Advance Line Counter
(LK advanced six times, on sixth -)
LK end carry to Word Counter (Advance WK)
LK end carry to Tape Register Control

LINE COUNTER (LK)

Advance Word Counter
(WK advanced 20 times, on last advance) -
WK end carry to Blockette Counter

WORD COUNTER (WK)

Advance Blockette Counter
(BTK advanced 6 times, on last advance) -
BTK end carry to Block End Stop Control
BTK end carry to Sprocket Error Control
BTK end carry to TSC (Clear TCR lockout, Start Sequence)

BLOCKETTE COUNTER (BTK)

Block End Indicator set and Stop Select Enable available before next, if any, TSK end carry received
Initiate Stop (Read) to Stop Control
Initiate Stop to TCRS (Start Sequence)

BLOCK END STOP CONTROL

LK end carry
TR → IOB
IOB Read Acknowledge to IOB Control
Clear TR

TAPE REGISTER CONTROL (TRC)

>720 error caused by
Delayed Sprocket no. 721 received within 250 micros after BTK end carry -
Initiate sprocket error stop to Stop Control
Initiate sprocket error stop to TCRS (Start Sequence).

SPROCKET ERROR CONTROL

<720 error caused by
BTK = 5, BSK = 0
and during 225 micros wait after last delayed sprocket pulse (no additional sprocket pulse during this time) -
No WK end carry (i.e., no advance BTK)
No advance BSK

After 225 micros wait, all conditions above, and Read Enable
Initiate sprocket error stop to Stop Control
Initiate sprocket error stop to TCRS (Start Sequence)

---
pulse rates -
50 lines/in: every≈200 us

128 lines/in: every≈80 us

READ BACKWARD SEQUENCE

when tape has reached free-running speed, line of tape → AIR. Delayed sprocket pulse ≈40 us later.

from Tape Leader Delay Control (from Start Sequence)
Start Read/Move to Read Control

Same as Read Forward until LK = 5

LK ≠ 5 line shifts
Initiate Shift to Tape Shift Control
Set parity (test odd count) to Parity Translator and Control

LK = 5 line shifts
Inhibit Shift to Tape Shift Control
Set Parity to Parity Translator and Control

READ AND MOVE CONTROL

Same as Read Forward

TAPE PARITY TRANS. AND CONTROL

Same as Read Forward (except TR shifted right six times) -

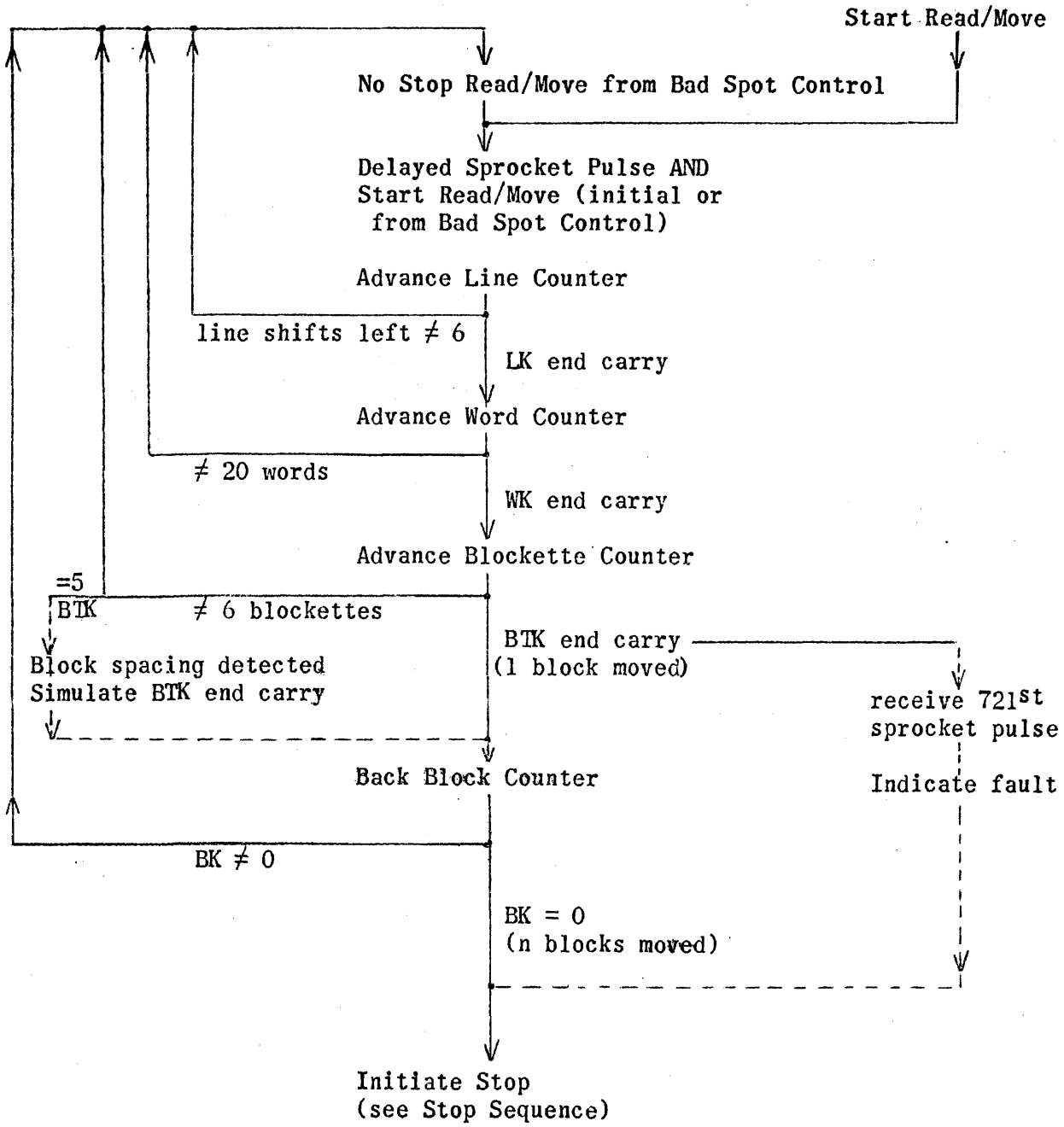
Until

Inhibit Shift from Read Control (LK = 5)
AND
Initiate Shift on sixth line
No TR shift
Simulate TSK end carry giving -
Clear Block End Indicator to Block End Stop Control
Check arity to Parity Control
Advance LK
Clear TCR lockout to TCRS (Start Sequence)

TAPE SHIFT COUNTER AND CONTROL (TSK)

REMAINDER OF SEQUENCE same as Read Forward

MOVE FORWARD OR BACKWARD SEQUENCE
(Delayed sprocket pulse ≈40 us after tape line to AIR)



MOVE FORWARD OR BACKWARD SEQUENCE

when tape has reached free-running speed, line of tape —→AIR. Delayed sprocket pulse emitted approximately 40 us later.

from Tape Leader Delay Control (from Start Sequence)
Start Read/Move to Read and Move Control

Start Read/Move (from TLDC)
OR
Start Read/Move from Bad Spot Control
Set Read/Move Control I to "1" (cleared by Stop Read/Move from Bad Spot Control)

Read/Move Control I "1" (and Move Enable)
AND
Delayed Sprocket Pulse
Delayed sprocket pulse to Line Counter (Advance LK)

READ AND MOVE CONTROL

Advance Line Counter (Delayed Sprocket Pulse)
LK advanced six times, on sixth -
LK end carry to Word Counter (Advance WK)

LINE COUNTER (LK)

Advance Word Counter
WK advanced 20 times, on last advance -
WK end carry to blockette counter (Advance BTK)

WORD COUNTER (WK)

Advance Blockette Counter
BTK advanced six times, on sixth -
BTK end carry to Block End Stop Control
BTK end carry to Sprocket Error Control
BTK end carry to Block Counter (Back BK)

BLOCKETTE COUNTER (BTK)

Blockette end carry
Back BK (=n) until zero, then BK = 0 enable to Block End Stop Control

BLOCK COUNTER (BK)

BKT end carry, BK = 0, and Move enable
Initiate Stop (Move) to Stop Control
Initiate Stop to TCRS (Start Sequence)

BLOCK END STOP CONTROL

>720 error caused by
Delayed sprocket pulse no. 721 received within 250 us after BTK end carry -
Initiate sprocket error stop to Stop Control
Initiate sprocket error stop to TCRS (Start Sequence)

<720 error caused by
BTK = 5, BSK = 0
and during 225 us wait after last delayed sprocket pulse (no additional sprocket pulse during this time)
No WK end carry (i.e., No Advance BTK)
No Advance BSK

After 225 us. wait, conditions above, and Move enable
Simulate BTK end carry to Block Counter
Simulate BTK end carry to Block End Stop Control
No fault indication

SPROCKET ERROR CONTROL

STOP SEQUENCES

(Signals from Read, Write, and Move Sequences)

Initiate Stop (Write) from Block End Stop Control
If 2.4 inch block space enable, after ≈ 9.5 ms delay -
If 1.0 inch block space enable, after ≈ 2.5 ms delay -
Stop Uniservo to Tape Drive Control
Clear TCR, BK, TR, AIR
"Master Clear" tape control system

Initiate Stop (Read or Move) from Block End Stop Control
after ≈ 2.5 ms delay
Stop Uniservo to Tape Drive Control
Clear TCR, BK, TR, AIR
"Master Clear" tape control system

Initiate Parity Error Stop from Tape Parity Translator and Control

OR

Initiate Sprocket Error Stop from Sprocket Error Control

OR

Initiate No Information Fault Stop from Block End Stop Control

after ≈ 2.5 ms delay
Stop Uniservo to Tape Drive Control
Clear TCR, BK, TR, AIR
"Master Clear" tape control system.

STOP CONTROL

d. TAPE OPERATION TIMING.

(1) GENERAL.- Before a study is undertaken of the available computation times during tape operations, it is helpful to review the conditions which are necessary during tape operations before

(a) An External Function, External Write, or External Read instruction can be executed following an EF tape instruction and

(b) the transmission IOB→TCR can occur after an EF tape instruction is executed. (IOB is automatically cleared immediately after this transmission.)

The transmission X→IOB during the execution of an EF or EW instruction is not possible after the execution of a previous EF instruction until an IOB Resume is received by IOB Control. (A lockout condition is established by IOB when a second X→IOB transmission is attempted before an IOB Resume is received from external equipment. This prevents the use of IOB for a second output operation before the first is completed.) No wait for an IOB Resume is necessary when an ER instruction follows an EF instruction since the attempted execution of an ER instruction sets up an IOB lockout until information is received from external equipment (and this transmission is not received until a tape operation is underway). An IOB Resume generated by tape control after an EF instruction indicates that tape control has accepted the current content of TCR as a tape operation. Since this IOB Resume allows the loading of IOB by a second EF instruction or an EW instruction, TCR must be protected against receiving another IOB→TCR transmission until the first tape operation is completed. This protection is provided by setting the "TCR lockout" before giving the IOB Resume. Then, since these transmissions are blocked, IOB may be loaded safely by another EF or an EW (or an ER). Since a Bias Change operation does not effect a TCR lockout, it does not generate an IOB Resume until the change of bias is completed.)

After an EF tape instruction has been executed, the TCR lockout set up by the previous tape operation must be removed before the operation code currently in IOB can be transmitted to TCR. (In some cases, as pointed out previously in the description of the Start Sequence, the removal of the TCR lockout is not sufficient to allow the IOB→TCR transmission.)

It should be noted that if TCR has not been cleared previous to an IOB→TCR transmission, the logical sum of IOB and the current content of TCR is formed in TCR. This is not allowable except when an EF stop instruction is programmed to terminate a Read or Write operation.

The occurrence of these signals, IOB Resume, set TCR lockout, clear TCR lockout, and clear TCR, during each of the legitimate tape operations is pointed out below.

Read or Write Uniservo j (and stop)

1 When and if j is available (see Start Sequence), the TCR

lockout is set and the IOB Resume is given.

2 A BTK end carry clears the TCR lockout. (A TSK end carry, if reading or writing is continued, resets it).

3 A BTK end carry and a Stop enable initiates a tape stop during which TCR is cleared.

4 A stop initiation prevents another IOB to TCR transmission for approximately 10 ms. (See Start Sequence)

[Note that an IOB to TCR transmission can occur immediately after the last BTK end carry (unless a Read or Write One Block and Stop operation was programmed). Since TCR is not yet cleared, no operation except a Stop should be programmed immediately after reading or writing n (>1) blocks.]

Move Uniservo j n blocks, n >0

1 When and if j is available (see Start Sequence) the TCR lockout is set and the IOB Resume is given.

2 BTK end carry clears the TCR lockout (TSK end carry resets it) but IOB to TCR transmission is not allowed until TCR is cleared, removing the Move enable.

3 A BTK end carry from the nth block and a Move enable from TCR initiates a tape stop during which TCR is cleared.

Stop Reading or Writing of n (>1) blocks

(Uniservo designation and read or write enable remain in TCR from the read or write operation to be terminated.)

1 Since j is available, the TCR lockout is set and the IOB Resume given.

2 The Stop enable now in TCR with the previous BTK end carry initiates a tape stop during which TCR is cleared and TCR lockout cleared. However, the stop initiation prevents another IOB to TCR transmission for approximately 10 ms. (See Start Sequence)

Rewind j or Rewind j with interlock

1 When and if j is available, TCR lockout is set and IOB Resume is given.

2 When Rewind initiation is completed (see Start Sequence), TCR lockout is cleared and TCR is cleared.

Bias Change

1 TCR lockout is not set

2 Bias Change completion after approximately 20 ms effects IOB Resume and Clear TCR.

(2) AVAILABLE COMPUTION TIMES.

(a) A tape operation becomes effective when the operation specification, as placed in IOB by an External Function instruction, is transmitted to TCR. This transmission may not occur immediately after the execution of an EF instruction. The initiation of a tape stop on any uniservo causes a Stop Initiation delay which prevents for 10 ms the following: IOB to TCR transmission, IOB to BK transmission, and Clear IOB signal. Consequently, the emission of the IOB Resume signal is also detained until this time, and longer if a Change Bias operation is being initiated. During this 10 ms, an External Function instruction may be executed but the tape operation is not initiated. The attempt to execute an External Read or External Write instruction, if a read or write operation is to be initiated, or a second EF instruction, establishes an IOB lockout condition until the IOB Resume is emitted.

(b) Between an External Function instruction for a read or write operation on uniservo j and the first External Read or External Write. It is assumed that uniservo j is immediately available.

	Writing operation	Reading operation
Possible Stop Initiation delay*	10 ms (maximum)	10 ms (maximum)

The following delays are incurred after a read or write operation is initiated, but before a word is transmitted to IOB (in reading) or (in writing) before tape control assumes a word has been received from IOB.

Tape Direction delays		
normal	2.5 ms	2.5 ms
if movement is to be in opposite direction from previous movement	600 ms	600 ms
Leader delays		
if tape is on leader	1500 ms	1000 ms

* If the EF Read or Write instruction immediately follows an EF Stop Instruction or the last ER or EW of a previous Read or Write One Block and Stop operation. See paragraph (a).

Block Spacing delays		
for one inch block spacing	7.5 ms	5.0 ms *
for 2.4 inch block spacing	14.5 ms	5.0 ms *

The delays listed are "progressive", i.e., they are not initiated simultaneously. The delays listed detain signals internal to the tape control system with the exception of the block spacing delays listed for a reading operation.

(c) Between successive External Read instructions or successive External Write instructions:

at a recording density of 128 lines per inch	436 microseconds
at a recording density of 50 lines per inch	1168 microseconds

Tape moves at a rate of 100 inches per second. Therefore, for a recording density of 128 lines per inch, 36-bit words are transferred to IOB (or sensed from IOB) at the rate of one word every 468 microseconds ($10^4 \cdot 6/128$ microseconds). When the execution time for the External Read (or External Write) instruction is subtracted from this time, 436 microseconds remain for computation. The available computation times for other recording densities are similarly computed.

(d) During the time a block or blockette spacing is moving past the read/write head:

	Writing operation**	Reading operation***
One inch inter-block or inter-blockette space	9.968 ms	7.468 ms
2.4 inch inter-block space	23.968 ms	17.968 ms
0.1 inch inter-blockette space	.968 ms	.718 ms

---

*Actual reading of the tape does not begin until the tape is moving through the read/write head at its free-running speed. The times quoted above are acceleration time for the tape to reach this rate. These delays assume no variation from a tape speed of 100 inches per second and are minimum times for this speed. The times of 7.5 or 14.5 are allowable assuming that block spacing is exactly 1.0 or 2.4 inches and that tape movement is stopped exactly in the middle of the block spacing. Only when the block spacing is known to be consistently 2.4 inches can the 14.5 ms time be used.

**During a writing operation the writing pulses are cut off for 10, 24, or 1 ms. These times minus the .032 ms execution time of the External Write instruction yield the times quoted above.

***Again the reading rate is dependent on the tape speed and the length of the inter-block and inter-blockette spaces. It is ample to allow for a 25% deviation in the length of spaces between blockettes and between blocks. Thus, the minimum available computation time, assuming tape motion at the rate of 100 inches per second and a space of 0.75 inches in length, is computed to be (7500 - 32) microseconds while a "one inch" block space is moving by the read/write head.

(e) A maximum computation time of 250 microseconds can be used for other than tape operations between the External Read or Write instruction which reads the last word in the last block and the External Function instruction which initiates a tape stop.

(f) Computation time available after a Move Forward or Move Backward operation becomes effective (on IOB to TCR, IOB to BK). Another EF tape instruction may be executed immediately but it will not become effective until after times listed below.

Tape Direction delays	minimum 2.5 ms or maximum 600 ms if tape movement is to be in opposite direction from last movement.
Leader delay or Acceleration time*	1000 ms if tape positioned on leader 5 ms if tape not positioned on leader

Free-running time* for n blocks:

Block rate	
recording density 128 lines/inch	n x 56.25 ms
recording density 50 lines /inch	n x 144.00 ms
Inter-block space rate	
one inch inter-block space	(n-1) x 7.468 ms
2.4 inch inter-block space	(n-1) x 17.968 ms

Stop Initiation delay 10 ms

(g) Computation time available after a Rewind or Rewind with Interlock operation becomes effective (on IOB to TCR). Another EF tape instruction may be executed immediately but the IOB to TCR transmission for this operation is not allowed until after the times listed below:

Minimum 10 ms or

Maximum 600 ms if tape movement is to be in opposite direction from last movement

In addition to the times quoted above, if the tape instruction following a Rewind instruction references the same uniservo, this next instruction will not become effective until the rewinding is completed. Maximum rewinding time is approximately three minutes. In this case, this time also could be used advantageously for other computations not referencing IOB.

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* Assuming no variation from a tape speed of 100 inches per second.

(h) Computation time available after a Change Bias operation becomes effective. The attempt to execute immediately another External Function instruction establishes an IOB lockout condition. There is a 20 ms delay after the initiation of a bias change before another EF instruction can be executed to its completion.

START DIAGRAM

CONTROL LINES
CONTROL SIGNALS ORIGINATING IN OTHER PORTIONS OF CONTROL
INFORMATION FLOW

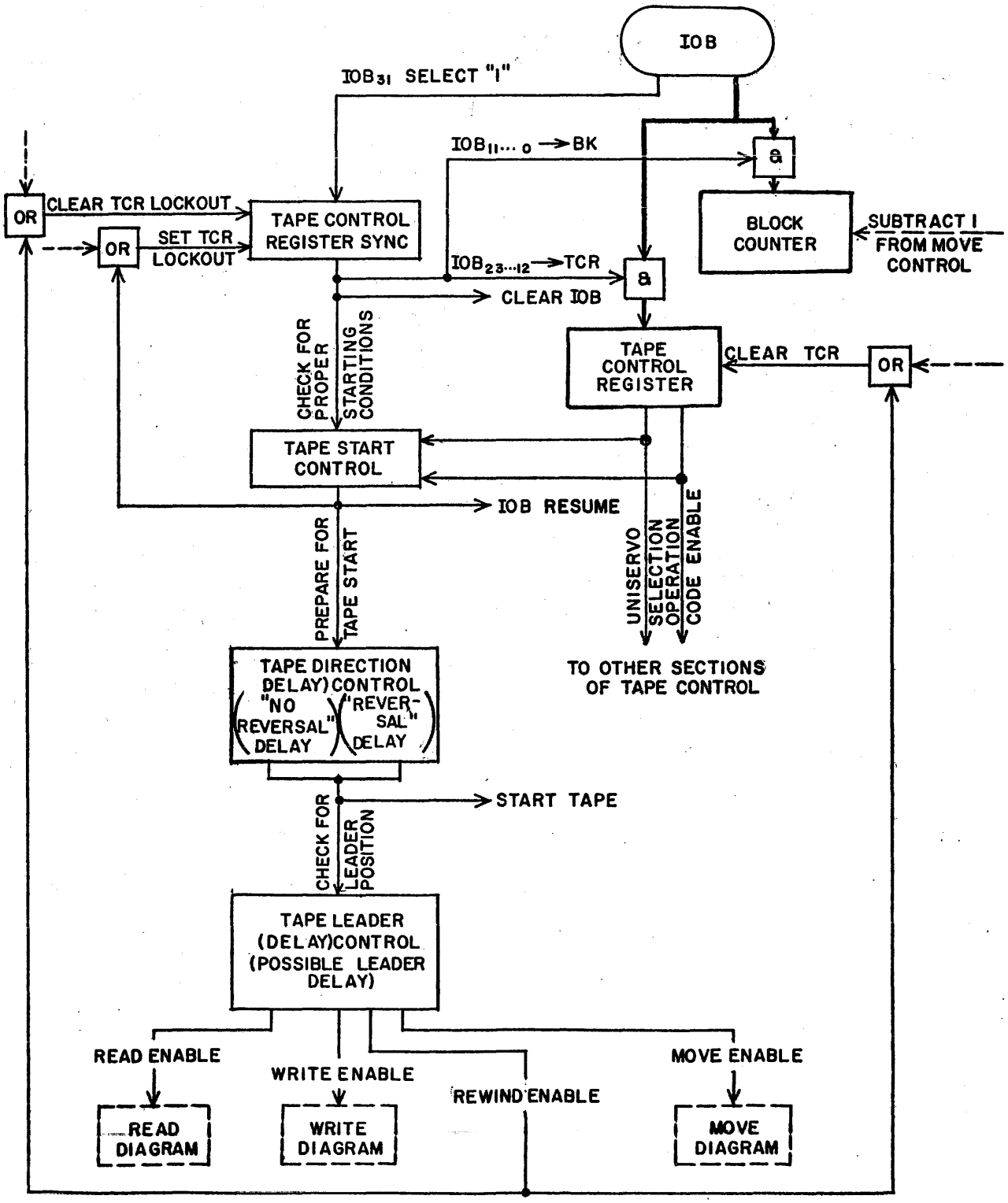

Figure 1

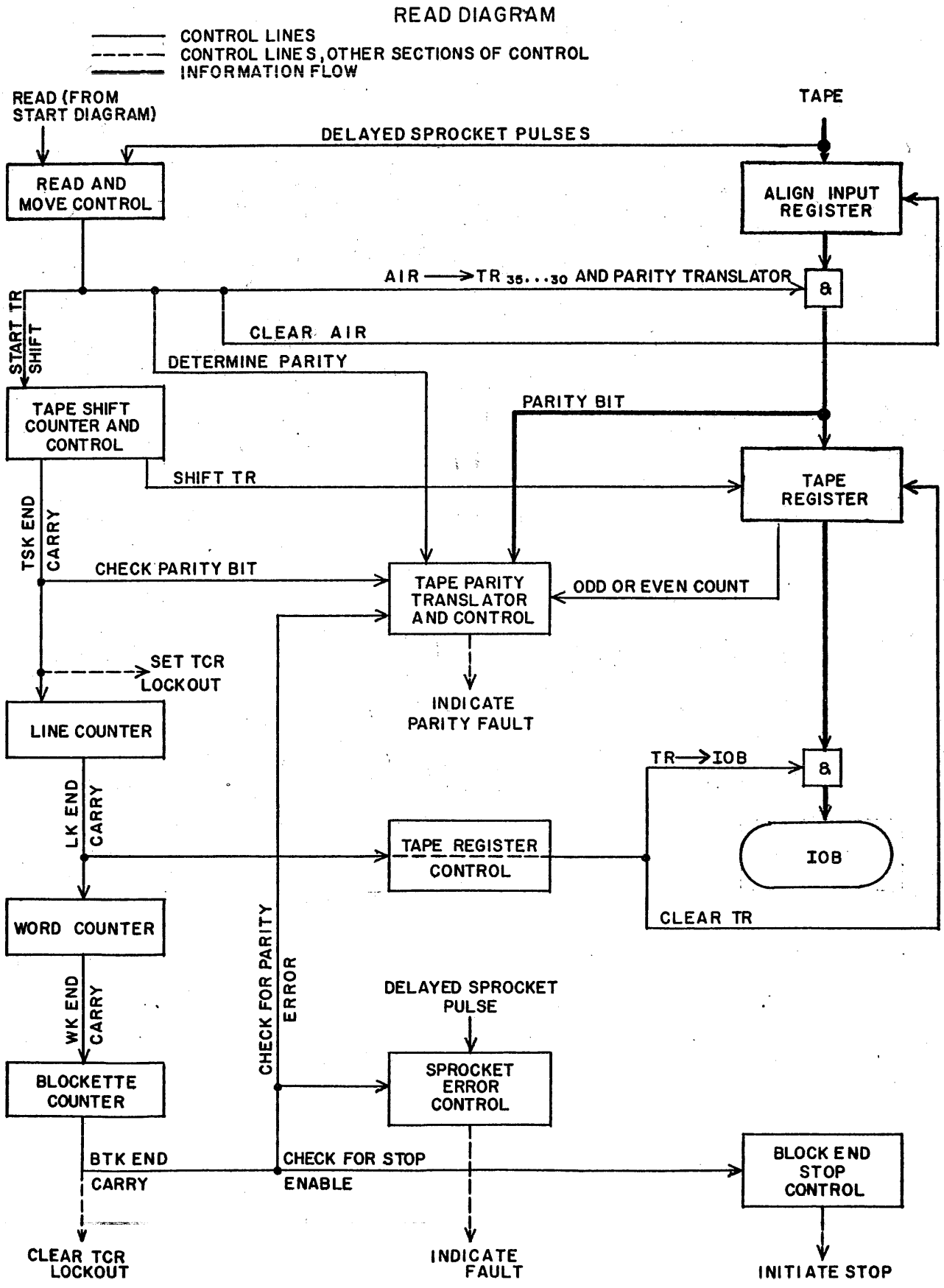
READ DIAGRAM
CONTROL LINES
CONTROL LINES, OTHER SECTIONS OF CONTROL
INFORMATION FLOW
READ (FROM START DIAGRAM)
TAPE
DELAYED SPROCKET PULSES
READ AND MOVE CONTROL
ALIGN INPUT REGISTER
AIR → TR 35...30 AND PARITY TRANSLATOR
&
START TR SHIFT
CLEAR AIR
DETERMINE PARITY
PARITY BIT
TAPE SHIFT COUNTER AND CONTROL
SHIFT TR
TAPE REGISTER
TSK END CARRY
CHECK PARITY BIT
TAPE PARITY TRANSLATOR AND CONTROL
ODD OR EVEN COUNT
SET TCR LOCKOUT
INDICATE PARITY FAULT
LINE COUNTER
TR → IOB
&
LK END CARRY
TAPE REGISTER CONTROL
IOB
CLEAR TR
WORD COUNTER
CHECK FOR PARITY ERROR
DELAYED SPROCKET PULSE
WK END CARRY
SPROCKET ERROR CONTROL
BLOCKETTE COUNTER
BTK END CARRY
CHECK FOR STOP ENABLE
BLOCK END STOP CONTROL
CLEAR TCR LOCKOUT
INDICATE FAULT
INITIATE STOP

Figure 2

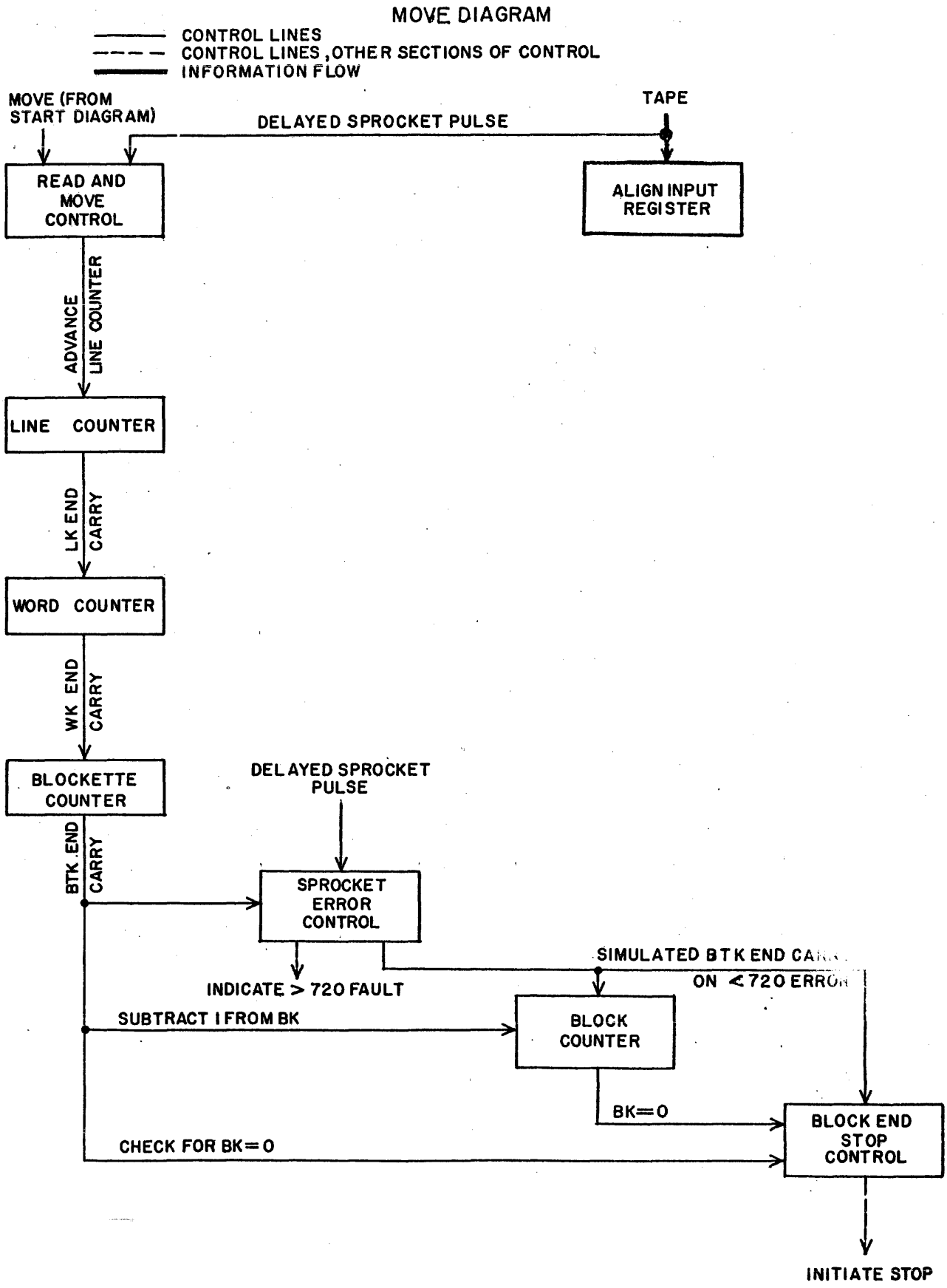
MOVE DIAGRAM
CONTROL LINES
CONTROL LINES, OTHER SECTIONS OF CONTROL
INFORMATION FLOW
MOVE (FROM START DIAGRAM)
DELAYED SPROCKET PULSE
TAPE
READ AND MOVE CONTROL
ALIGN INPUT REGISTER
ADVANCE LINE COUNTER
LINE COUNTER
LK END CARRY
WORD COUNTER
WK END CARRY
BLOCKETTE COUNTER
DELAYED SPROCKET PULSE
BTK END CARRY
SPROCKET ERROR CONTROL
SIMULATED BTK END CARRY ON <720 ERROR
INDICATE > 720 FAULT
SUBTRACT 1 FROM BK
BLOCK COUNTER
BK=0
CHECK FOR BK=0
BLOCK END STOP CONTROL
INITIATE STOP

Figure 3

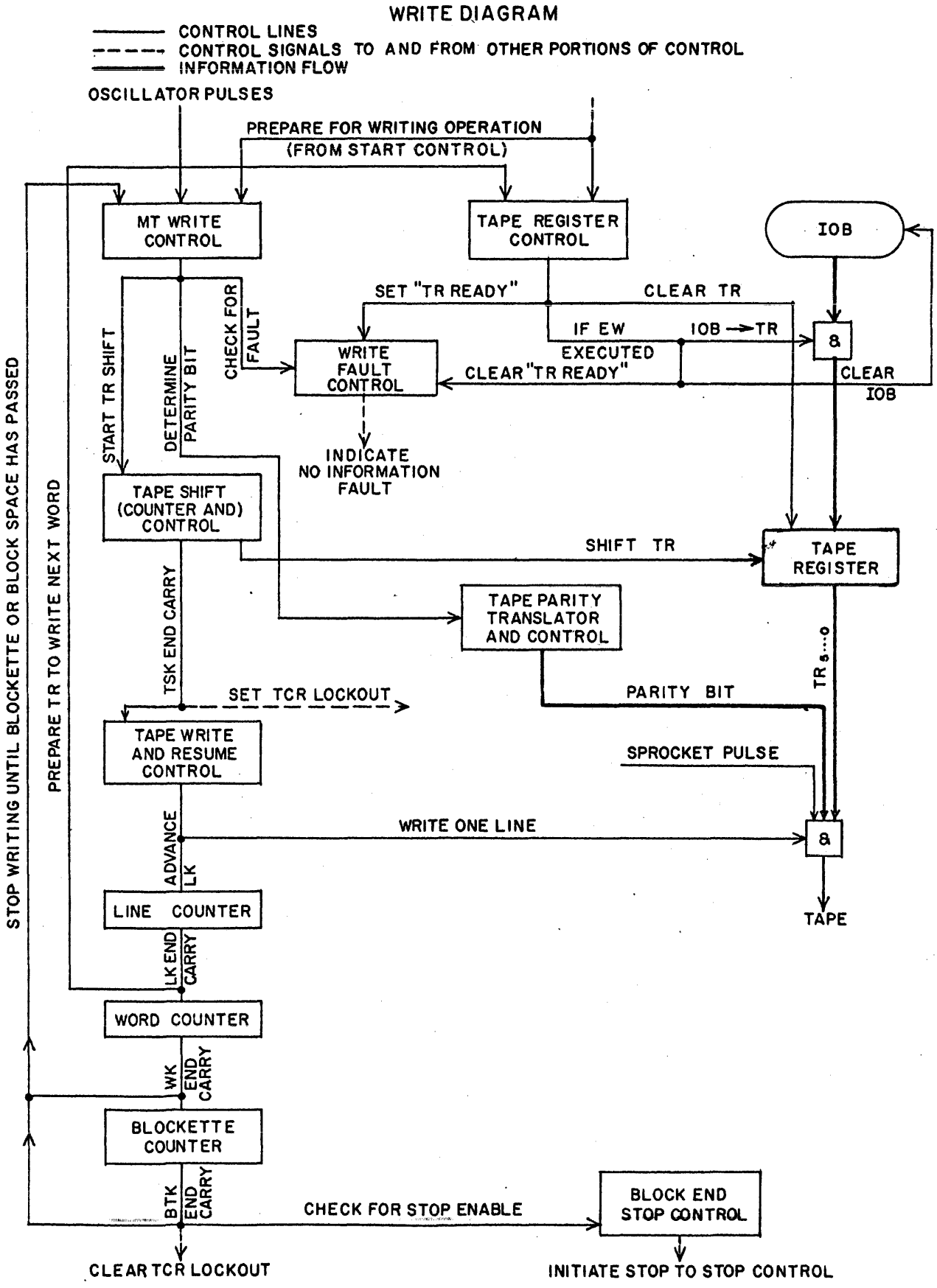
WRITE DIAGRAM
CONTROL LINES
CONTROL SIGNALS TO AND FROM OTHER PORTIONS OF CONTROL
INFORMATION FLOW
OSCILLATOR PULSES
PREPARE FOR WRITING OPERATION
(FROM START CONTROL)
MT WRITE CONTROL
TAPE REGISTER CONTROL
IOB
SET "TR READY"
CLEAR TR
IF EW EXECUTED
IOB → TR
&
CLEAR IOB
CLEAR "TR READY"
CHECK FOR FAULT
START TR SHIFT
DETERMINE PARITY BIT
WRITE FAULT CONTROL
INDICATE NO INFORMATION FAULT
TAPE SHIFT (COUNTER AND) CONTROL
SHIFT TR
TAPE REGISTER
TAPE PARITY TRANSLATOR AND CONTROL
TR 5...0
TSK END CARRY
SET TCR LOCKOUT
PARITY BIT
TAPE WRITE AND RESUME CONTROL
SPROCKET PULSE
WRITE ONE LINE
&
ADVANCE LK
LINE COUNTER
TAPE
LK END CARRY
WORD COUNTER
WK END CARRY
BLOCKETTE COUNTER
BTK END CARRY
CHECK FOR STOP ENABLE
BLOCK END STOP CONTROL
STOP WRITING UNTIL BLOCKETTE OR BLOCK SPACE HAS PASSED
PREPARE TR TO WRITE NEXT WORD
CLEAR TCR LOCKOUT
INITIATE STOP TO STOP CONTROL

Figure 4

a. OPERATION INDICATORS. - Tape operation is reflected by the condition of indicators on the uniservos, the tape control cabinet, and the left section of the computer control panel. These indicators and their reactions to tape operation and tape operation faults are discussed in the following paragraphs.

(1) UNISERVO. - The "Ready" indicator (green) is between the tape reel panel doors, upper center section of the uniservo. This indicator is illuminated when the uniservo interlock circuit is energized; i.e., when power has been applied to the uniservo, when the tape reel panel door switch is set to its ON position, and when the Forward Limit, Mylar Detector, Left Tape Loop, and Right Tape Loop switches are in their normally closed position. If this indicator is not illuminated, the uniservo is not ready for operation.

A failure to have the interlock circuit not energized because power has not been applied to the uniservos would not usually occur. Power is normally applied to the uniservos (and the tape control system) at the same time power is turned on for the computer. Normally, if it is noted that the "Ready" indicator is not illuminated, the interlock circuit is not energized because one of the switches in the circuit is open. The condition which caused the switch to be opened must be corrected before any operation on the unit can be undertaken. If operation is attempted on a unit in which the interlock circuit is not energized, a computer B-Fault condition is incurred. The interlock switches and the conditions which cause them to open are discussed in the following paragraphs.

The tape reel panel door switch is located immediately below the "Ready" indicator. This interlock switch must be set to OFF to open the left tape reel panel door and cannot be returned to its ON position until the door is closed. Effectively, then, opening the uniservo door causes the "Ready" indicator to be dropped. The door must be closed and the door switch reset to ON before the interlock circuit is energized.

A Mylar shim, or buffer tape, is inserted between the read-write head and the metallic recording tape. This plastic tape serves to reduce both tape wear and friction. When this tape is broken or the supply is exhausted, the Mylar detector interlock switch is opened, dropping the "Ready" indicator. The replacement of the Mylar tape by maintenance procedures closes this interlock switch.

The Forward Limit interlock switch is opened when the magnetic tape moves into its "leader" area on its far end, i.e., the left-hand tape reel is depleted and the right-hand tape reel contains all of the tape. (The Forward Limit switch is opened when the "rubber bumpers" on the "leader" on the far end of the tape are detected). To close this switch and energize the uniservo interlock circuit, the tape must be rewound past its "leader" position. This is accomplished by opening the panel door and manually turning the reel in the counter-clockwise direction several times (until the switch no longer makes contact with the rubber bumpers). The complete rewinding of the tape onto the left-hand reel can then be accomplished by the normal rewind operation

which can be instigated manually from the computer control panel or under program control.

The Right and Left Tape Loop switches are opened when the tape loops are out of normal position. This could be caused by tape breakage or possibly could result from faulty operation of control circuits in the uniservo. Maintenance procedures are necessary to correct these conditions.

De-energizing the uniservo interlock circuit could also be caused by blowing a fuse. A blown fuse in the uniservo cabinet is shown by the illumination of the Fuse indicator.

Inside the right-hand tape reel door, above the tape reel mounting, are indicators labeled Rewind Interlock and Fault, Fuse and Temp.

The Fuse indicator is illuminated by a blown fuse. This indicates that some part of the uniservo is inoperative and the uniservo interlock circuit may be de-energized. Detection and replacement of the blown fuse is a maintenance procedure.

The Temp. indicator is illuminated when a temperature rise above 120° F. is detected in the uniservo. This condition causes a computer A Fault and illuminates the Temp indicator in the A Fault Group on the computer control panel. Computer operation is halted by an A Fault condition. Operation is resumed after corrective maintenance by depressing the Clear A Fault button (unless a B-Fault has resulted from tape reading or writing occurring at the time of the computer stop. If this is the case, either (1), the MT fault indicator in the B-Fault group on the computer control panel and the No Information fault indicator in tape control cabinet are illuminated, or (2), the IO fault indicator in the B-Fault group on the computer control panel is illuminated).

The Rewind Interlock indicator is illuminated when the magnetic tape has been rewound with interlock on the left-hand tape reel. This condition indicates that the tape on this uniservo should be replaced before this unit is used again. Opening the door to replace this tape drops the "Ready" condition of this unit (because the door switch must be set to OFF) and drops the rewound with interlock condition.

Inside the right-hand tape reel door, above the tape reel mounting, are indicators labeled Clutch, Stop (red) and Go (green). The Go indicator is illuminated by the signal which is sent to the tape drive mechanism to pull in the clutch and start tape movement. This indicator remains illuminated until a stop tape signal is received by the tape drive mechanism to operate the brake, thus releasing the clutch. At this time the Stop indicator is illuminated and remains illuminated until the tape is re-started or until power is dropped from the unit.

(2) TAPE CONTROL CABINET. - This cabinet is located immediately to the left of the Power Supply Cabinet. Located inside the right-hand door are tape fault indicators and the Logical Number Selection switches. Each uniservo is physically defined by one of the numbers 1,2,...10, depending upon the number of uniservos installed. For instance, if an installation has eight uniservos,

it would be expected that the numbers 1 ... 8 would define the eight units. The Logical Number Selection switches are labeled Uniservo 1, Uniservo 2, etc. Encircling the switches are the numbers 1 through 10. A uniservo is assigned a logical designation by turning the appropriate selection switch so that the white line on the switch is in line with the number desired. The numbers available for logical assignment depends upon the number of uniservos installed, i.e., if eight uniservos are installed, any of these units may be logically assigned any of the numbers one through eight. Thus, if the eight uniservos at an installation are physically defined as uniservos 1...8, the switches labeled Uniservo 9 and Uniservo 10 should be set to the logical designations of 9 and 10. It is not allowable for two switches to be set to the same logical designation even though some of the switches define a non-existent uniservo.

The tape fault indicators (red) above the Logical Number Selection switches are labeled No Information, Sprocket Error, Selection Error, and Uniservo Interlock. These indicators are illuminated by the detection of one of these tape faults. These faults also cause the illumination of the MT indicator in the B-Fault group on the computer control panel and cause a computer B-Fault stop.

The logical number Selection Error is caused at any time the computer is in operation by setting two Logical Number Selection switches to the same number, i.e., giving two "uniservos" the same logical designation. The fault occurs regardless of whether or not the "uniservo" is non-existent or out of service for maintenance reasons. This fault must be corrected before computer operation can be resumed. Correcting the selection causes the Selection Error fault light to be extinguished. Operation is resumed by depressing the Master Clear Button (which drops the B-Fault light), making the desired selections on the computer control panel, and depressing the computer Start button.

In order to prevent a Selection Error fault from occurring at the time of making a logical number designation change, the computer operation must be stopped. Depressing the Force Stop button on the computer control panel will allow a setting to be made safely. Computation is re-started by depressing the Start button.

The Uniservo Interlock Fault is caused by referencing for a tape operation a unit in which the interlock circuit is de-energized. This condition is shown on the unit referenced by the extinguishment of the "Ready" indicator. The causes of this condition have already been discussed in the paragraphs discussing the "Ready" indicator and uniservo interlock circuit. Computer operation can be resumed by depressing the Master Clear button, which extinguishes both the MT and Uniservo Interlock indicators, making the desired selections on the control panel, and depressing the Start button; but, if the cause of the uniservo interlock fault was not corrected and the same unit is again referenced, the B-Fault will re-occur. Correcting the Uniservo Interlock fault during a B-Fault Stop extinguishes both the Uniservo Interlock indicator and the MT fault indicator. Operation is resumed by depressing the Master Clear button (which drops the B-Fault indicator), making the desired selections on the control panel, and depressing the Start button.

The No Information and Sprocket Error faults are discussed later in the fault section. These faults can be cleared, and their indicators, the MT Fault indicator, and the B-Fault indicator are extinguished, by depressing the Master Clear button on the computer.

When the occurrence of an MT B-Fault is noted, observing the condition of the tape fault indicators in the tape control cabinet is an aid to diagnosing the cause of the fault. Before the cabinet door is opened, the Bypass Cabinet Interlock key in the Test Switch group, right section of the computer control panel, must be turned to its Abnormal position. The failure to do this before opening a cabinet door causes an emergency power drop to the computer system, and maintenance procedures are necessary to resume operation.

(3) SUPERVISORY CONTROL PANEL. - Represented on the left section of the Supervisory Control Panel are components of the tape control system. The banks of lights which assist the operator in manual operation of the uniservos and aid in diagnosing certain of the fault conditions and computer operation "delays" are those labeled TCR, Tape Control Register, TR, Tape Register, and BK, Block Counter. The button labeled MT Test Start Step in the MT Test Writing Rate group is depressed to manually initiate a tape operation. The illumination of one of the indicators labeled MT Read Bias, high or low, shows the selection of a read bias other than normal.

The bank of lights labelled Center Drive Control, Start and Stop, indicate tape movement on the uniservos. An indicator in the top row is illuminated by an "operate clutch" signal to a particular unit; this indicator is extinguished by an "operate brake" signal which illuminates the indicator in the bottom row. The numbers below the ten pairs of indicators, between the "set" buttons (black) and "clear" buttons (white) are the physical definitions of the uniservos. If the need for an immediate stop of tape movement should arise, this can be effected, <u>if</u> the computer is not in operation at the time or if operation is in the Test mode, by depressing the "clear" button for the appropriate uniservo. (Depressing the computer Force Stop button stops operation.)

b. PREPARATION FOR OPERATION. - The procedure for preparing for tape operation under program control or manual control is as follows (assuming that the uniservos have been properly fitted with tape reels):

(1) Determine whether those Logical Number Selection switches in the tape control cabinet which physically define installed uniservos have been set to the logical number designations used in the program.

NOTE

(The numbers which can be used for logical designations cannot exceed the number of installed uniservos.) If any logical designations are to be changed and the computer is in operation, the Force Stop button must be depressed before <u>making</u> the switch changes to prevent the occurrence of a Selection Error.

(2) Check for the illumination of the green "Ready" indicators on the uniservos to be used. If this indicator is not illuminated, the "not ready" condition must be corrected before this unit can be used. Assuming that power has been applied to the uniservos, the attempt to use any unit not ready causes a Uniservo Interlock B-Fault.

(3) Check for the illumination of the Rewound Interlock indicators on the uniservos to be used. This condition should be eliminated before attempting any operation on the uniservo. A tape reference to a uniservo which has a Rewound Interlock condition causes a computer stall, and until this tape reference is removed from tape control the attempt to eliminate the Rewound Interlock condition causes a Uniservo Interlock B-Fault.

The procedure to replace any rewound tape is as follows:

(1) Turn the door switch to its OFF position and open the left tape reel panel door.

(2) The small spring clip connecting the magnetic tape and the leader should be positioned immediately below the tape reel. This connection is broken by spreading the sides of the spring clip, thereby releasing its prongs from the small cylindrical ending of the leader.

(3) Pull forward the holding latch on the tape reel mounting. This releases a locking pin directly under the knob from its position in one of the slots in the inner circumference of the tape reel. Remove the tape reel from the tape reel mounting.

(4) Place another rewound tape on the tape reel mounting so that the tape winding is in the clockwise direction. Return the holding latch to its closed position, first positioning the tape reel so that the locking pin is inserted into any of the slots in the inner circumference of the tape reel.

(5) Connect the magnetic tape to its leader by inserting the prongs of the spring clip in the cylindrical ending of the leader.

(6) Turn the tape reel counterclockwise until any tape slack is taken up.

(7) Close the panel door and set the door switch to its ON position.

c. MANUAL OPERATION. - To initiate tape operations from the computer control panel, the computer must be set to operate in the Test mode. The operations which can be successfully completed after a manual initiation are Rewind, Rewind Interlock, Move Forward and Backward, and Change Bias. To initiate one of these operations, set the desired operation code and uniservo selection (except for a Change Bias operation) in TCR by depressing the appropriate "set" (black) buttons. (The white button is depressed to clear the

register). Manual settings may be made any time the computer is not in operation and when operation is in the Test mode. If a Move operation is desired, the number n of blocks to be moved is inserted in BK. Depressing the MT Test Start Step button then causes the specified tape operation.

At the completion of the Move Forward, Move Backward, and Change Bias operations, the Tape Control Register and the Block Counter are automatically cleared. If the bias is changed to high or low, one of the bias indicators (red) in the MT Test Writing Rate group is illuminated. If a manual rewind operation is performed, TCR is cleared when the rewind operation is initiated.

The failure of the registers to be cleared as expected after attempting a manual operation could be due to one of the following reasons: (1) The Test mode of operation was not selected; (2) for a rewind or move operation, no uniservo selection was made in TCR or the uniservo specified is not available; (3) for a move operation, the block count set in TCR was greater than the number of blocks available for moving on the tape. This is evidenced by a reduced block count $\neq 0$ in BK and a Uniservo Interlock B-Fault if the move was in a forward direction.

If a manual Move Forward or Move Backward operation is attempted without inserting a block count in BK, TCR is cleared but no tape movement is initiated.

IMPROPER PROGRAMMING OR OPERATION

a. GENERAL - Consideration must be given to the effects of improper programming and operation errors on both tape operation and computer operation. In general, a program should run correctly if the equipment has been prepared properly, the uniservo designated is available, a legitimate tape operation has been specified, the correct number of External Reads and External Writes have been coded, a Stop has been coded to terminate a Read or Write operation, and the timing restrictions have been noted in coding, in particular, the External Read instructions, External Write instructions, and an EF Stop instruction. A disregard for these requirements may result in an operation "delay" (a temporary halt of operation) which (1) may not be immediately noticed or (2) may cause indirectly a computer fault; or a disregard for these requirements may cause directly a computer fault. Any time computer operation is stopped, tape operation should be stopped to prevent the possibility of a "runaway" tape, i.e., a tape which moves free of control to its "leader" position on the far end.

If erroneous operation is detected by the tape control system after tape movement has been initiated, the tape control system effects the tape stop and initiates a B-Fault computer stop. The tape stop occurs at the end of the block (i.e., midway of the next interblock space) which was being read, written, or moved at the time of the fault detection. At the time the "stop tape" signal is sent to the uniservo, the Tape Register, Tape Control Register and tape counters are cleared. In some cases, the execution of computer instructions may continue until the time of the actual computer stop, approximately 80 ms after the detection of the tape fault. If this is the case, and an External Function instruction for a tape operation is executed during this time, the possibility exists of starting another tape movement. If this next EF instruction executed is an EF Stop (Read or Write) instruction, the lack of a uniservo designation in TCR prevents the initiation of tape movement and effects an IOB lockout condition. For this reason, it is important that an EF Stop instruction does not specify any particular uniservo. If tape movement is started erroneously, depressing the computer Master Clear button stops the tape movement. To stop tape movement without clearing any of the registers on the computer control panel, a button in the Center Drive Control can be depressed as described in the section OPERATION.

When computer operation is stopped by a computer A-Fault, a B-Fault, a Force Stop, or a Manually Selective programmed stop, any tape movement in progress at the time of the actual operation stop is halted (1) during a rewind operation, at the completion of the rewind; (2) during a move operation, at the completion of the move; (3) during a read or write operation at the end of the current block being read or written. This block is not read completely or written correctly to completion since the appropriate number of External Reads and External Writes are not executed.

In diagnosing the cause of an operation delay or computer fault, noting the condition of the following indicators is helpful.

(1) On the Supervisory Control Panel:

The registers in Magnetic Tape Control, in particular, TR, TCR, BK.

The IOB register, located above TR.

The Program Control Register (PCR) and Program Address Counter (PAK) both located in the center section of the control panel. At any time PCR holds the instruction being executed and PAK holds the address of the next instruction to be executed.

The IO and MT fault indicators in the B Fault group, lower center section of the control panel. The illumination of the IO fault indicator indicates the occurrence of one of the IOB (or IOA) external faults shown in the External Fault group, lower left section of the control panel. The illumination of the MT fault indicator shows the occurrence of some other fault originating in the tape system.

The Temp fault indicator in the A-Fault group.

An IOB lockout condition is shown by (1) the illumination of the top-most light in the column labeled Wait External in the Pulse Distribution Control group, center section of the control panel, and (2) the presence of an ER, EW, or EF instruction in PCR.

(2) The indicators on the uniservos: Ready, Rewind Interlock, Fuse, and Temp.

(3) The Fault indicators in the tape control cabinet: No Information, Sprocket Error, Selection Error, and Uniservo Interlock.

Note: The door of the Tape Control Cabinet must not be opened without first turning the Bypass Cabinet Door Interlock key (in the Test Disconnect switches, right section of the computer control panel) to its Abnormal position.

b. OPERATION DELAYS - Operation is "delayed" when an IOB lockout condition is caused by the failure to receive an IOB Resume from the tape control system. In most cases this is caused by the refusal of tape control to accept the current content of TCR as the proper specification for a tape operation or by the refusal of tape control to allow an IOB to TCR transmission. Erroneous conditions which cause operation delays are listed below:

(1) Uniservo j not available.
No uniservo designation made.

Indications: Computer ceases operation with the next External Function, External Write, or External Read instruction in PCR. TCR contains the current tape operation select bits. IOB is cleared.

Diagnosis: Operation delay is caused when j designates a "uniservo" for which there is no physical unit, when uniservo j is rewinding, when uniservo j is rewound with interlock, when the j designation is not allowable (i.e., it exceeds the number of uniservos installed), or when no j designation was made. Note the j selection in TCR, the assignment in the tape control

cabinet of this j to a uniservo, and the condition of the Rewind Interlock indicator on this uniservo.

Correction: For the first condition, assigning j (as shown in TCR) to one of the physical units releases the IOB lockout condition and operation is resumed. In order to avoid causing a Selection Error B-Fault by changing any logical designations at this time, the computer Force Stop button must first be depressed. After re-assigning the logical designations, the computer is re-started by depressing the Start button. If j is currently rewinding, operation is automatically resumed in no more than approximately three minutes if j is not rewound with interlock when rewinding is completed. If the stall is caused by referencing a uniservo rewound with interlock, this uniservo selection must be dropped from tape control to eliminate the stall condition and allow the tape on the unit to be changed. This is accomplished by depressing the Master Clear button, first noting the address in PAK and the operation code in TCR. After eliminating the Rewind Interlock condition, computation can be resumed with the tape operation which caused the stall. This is accomplished by starting with the instruction which specified the operation noted in TCR. The address of this instruction should be the address of the first tape instruction preceding the instruction whose address was noted in PAK.

(2) Move Backward programmed for rewound tape (not with interlock).

Indications: TCR contains the operation select bits for the Move Backward operation. The next EF instruction is executed with IOB reflecting the contents of its v-address. Computer operation is delayed on the following External Function, External Write, or External Read instruction with one of these instructions in PCR. The rewound condition of the tape can be noted by observation of the uniservo referenced.

(3) Read Backward programmed for rewound tape (not with interlock).

Indications: Computer operation is delayed on the first External Read attempted. PCR contains this instruction. TCR contains the Read Backward operation codes. IOB is cleared. The rewound condition of the tape can be noted by observation of the uniservo referenced.

A Rewind programmed for a rewound tape, not with interlock, is allowable and needs no special treatment.

(4) Read Backward n blocks when m (< n) blocks are recorded.

Indications: An IOB lockout occurs during the execution of the first ER for the block m+1. PCR contains this instruction. TCR contains the Read Backward operation code. IOB is cleared. Tape is rewound and stopped on the leader.

(5) Move Backward n blocks were m (< n) blocks are recorded.

Indications: TCR holds the Move Backward operation codes and BK has a count of n-m. The next EF instruction is executed with IOB reflecting the contents of its v-address. Computer operation is delayed on the next EF, EW, or ER instruction with PCR reflecting one of these instructions. Tape is

rewound and stopped on the leader. (A Move Forward n >m blocks leaves the same conditions in the registers, but it also causes a Uniservo Interlock B-fault since tape movement is not stopped until the far end of the tape is reached.)

c. TAPE OPERATION FAULTS - The operation errors which may occur during tape operation are listed below and discussed in detail subsequently.

Parity Check Error: effects a stop of tape movement; caused by a reading or recording error.

Temperature Fault: effects a computer A-Fault; equipment fault.

Uniservo Interlock: effects a computer B-Fault; operators error or equipment fault.

No Information: effects a computer B-Fault; programming error.

IO Read Fault: computer B-Fault; programming error.

Selection Error: effects computer B-Fault; operators error.

Sprocket Error: effects computer B-Fault; recording error.

The detection of a parity check error does not effect a computer fault but does effect a stop of tape movement. At the completion of reading every block, a check is made to determine if a parity error occurred in reading any of the 720 lines in the block. If one or more errors occurred, a "1" is set into stage 0 of IOA and a tape stop is initiated. If no error was detected, only the IOA Read Acknowledge signal is sent to IOA. Thus, IOA must be "read" and its content tested after reading every block. Computation continues depending upon the result of the test. If a parity check error is indicated, the block can be re-read in the opposite direction, and read and re-read at the different bias levels. If none of these passes effect a correct reading, a computer stop can be programmed to indicate the unsuccessful attempt to read the block correctly.

(1) UNISERVO TEMPERATURE FAULT.

Indications: Illumination of the Temp A Fault indicator on the computer control panel. Illumination of the Temp Fault indicator on a uniservo.

Diagnosis: The temperature fault results from a temperature rise above 120 F in any uniservo. The occurrence of a Temp Fault during tape operation does not interfere with the tape operation unless reading or writing is occurring at the time of the computer stop. If this is the case, a computer B Fault is also incurred. This is evidenced by the illumination of the MT fault indicator on the computer control panel and the No Information fault indicator in the Tape Control Cabinet, or the illumination of the IO B Fault indicator on the computer control panel.

Resumption of Operation: If a B Fault has not occurred, turning the Bypass Temperature Interlock key to its Abnormal position after the computer stop has occurred allows resumption of the program in the Test mode after the Clear A Fault button is depressed. However, this procedure should be undertaken with caution. To resume computation in the Normal mode, the Temp fault must be corrected. The correction of the fault extinguishes the Temp Fault indicator on the uniservo. Operation is then resumed by depressing the Clear A Fault button which extinguishes the Temp Fault indicator on the computer control panel.

If a B Fault condition exists, the A Fault is cleared by one of the procedures above; clearing the B Fault condition requires the depression of the Master Clear button. Operation is resumed according to the type of read or write fault incurred. These faults are discussed subsequently.

(2) UNISERVO INTERLOCK FAULT

Indications: Illumination of MT fault indicator and B Fault indicator in B Fault group, computer control panel. Illumination of Uniservo Interlock fault indicator in tape control cabinet. The "Ready" light on the uniservo in use at the time is extinguished.

Diagnosis: This fault is caused when a uniservo interlock circuit is de-energized and this particular uniservo is referenced for tape operation. The conditions which cause the uniservo interlock circuit to be de-energized and the correction of these conditions are discussed in the Operation section in the paragraphs describing the "Ready" indicator on uniservo and the uniservo interlock circuit. If the not ready condition is detected by the attempt to initiate a tape operation, tape movement is not started. The execution of computer instructions may continue until the time of the computer fault stop. During this time, if External Write instructions are executed, "writing" is performed on the stationary tape; if External Read instructions are programmed to be executed, an IOB lockout condition is established.

If the uniservo interlock circuit is de-energized after a tape operation and tape movement have been initiated, the execution of instructions continues until the time of the computer fault stop. Tape movement is stopped by virtue of the drop of power on the circuit.

Resumption of Operation: Depressing the computer Master Clear button extinguishes the fault indicators and allows the resumption of operation. Correction of the fault condition is not necessary to resume operation, but if the same uniservo is referenced again, the fault will re-occur.

(3) NO INFORMATION FAULT: Caused at the initiation of writing a word from TR on tape by the failure to have transferred a word from the computer to TR.

Indications: On the computer control panel MT B fault indicator is illuminated. In the tape control cabinet, No Information fault indicator is illuminated. TCR is cleared by the fault stop but may be filled by the execution of another EF tape instruction before the computer is stopped. Tape movement is stopped at the end of the block being written when the error occurs.

Computer is stopped approximately 80 ms after the completion of writing the block in which the fault was detected.

Diagnosis: This fault is caused by the failure to provide 120 External Writes to write a block or by the failure to execute in time a External Write. When this fault is detected by tape control, the stop code bits are set in TCR and a B fault is initiated.

If the fault is caused by programming too few External Write instructions, the bits of the missing words are written as zeros.

If the No Information fault is caused by the failure to execute an External Write in time, the data bits of the lines written on tape at that particular time will be zeros until the EW is executed; then, the transmission IOB to TR occurs and the remainder of the lines written are taken from the current content of TR.

If the block being written when the fault is incurred is not the last block programmed to be written, the attempt to execute the next group of External Writes will cause an IOB lockout condition. If this block was the last block to be written in this particular writing operation, the execution of computer instructions, including any External Function instruction, may continue until the time of the computer fault stop.

Resumption of Operation: All fault indicators are extinguished by depressing the Master Clear button. After remaking selections, operation can be resumed by depressing the Start button.

(4) IO READ (IOB I) FAULT, i.e., Failure to execute a sufficient number of External Reads: where 120 n-j (j=1...), ER's programmed and an EF stop programmed to terminate presumably the reading of the nth block; failure to execute an External Read in time.

Indications: Illumination of the IO B fault indicator and the IOB I fault indicator. Tape movement is stopped at the end of the block being read when the error occurred. TCR is cleared by the fault stop but may be filled by the execution of another EF tape instruction before the computer is stopped. The computer is stopped approximately 80 ms after the fault is detected.

Diagnosis: Each word received by IOB from the Tape Register should be removed from IOB by an External Read instruction before the next transmission from TR occurs. If a second transmission occurs before IOB is cleared by an ER, an IOB I computer B fault is incurred. In a tape reading operation this fault is caused by the failure to execute the sufficient number of ER's, or it could occur when an ER is programmed to be executed too late.

If two or more External Reads are not programmed for reading a single block or reading the last of a series of blocks, the tape is stopped at the end of this block but computer instructions continue to be executed. The execution of an External Function instruction during this time will transmit tape operation codes to IOB which has not been cleared. Thus, IOB will contain the logical sum of its previous contents and the tape operation code, and these

bits are transmitted to TCR. No prediction can be made as to whether or not a tape operation will be initiated since both the operation code and the uniservo selection may have been changed.

If two or more External Reads are not programmed for reading any but the last of a series of blocks, tape movement is stopped at the end of the block and the execution of the second ER for the next block sets up an IOB lockout condition which stops the execution of further instructions until the time of the computer stop. (The execution of the first ER for the next block transmits to storage from IOB the logical sum of the last two words of the last block.)

The lack (in the program) of one External Read in reading a single block or the last of a series of blocks does not cause directly a computer fault; but since IOB is not cleared before another EF instruction is executed at any future time, the bits transferred from IOB to TCR at that time may not specify the desired tape operation. Again, a tape operation may or may not be initiated. If an EF Stop Read instruction is executed, the logical sum of IOB and the specification of the read operation (currently in TCR) is formed in TCR. If the uniservo selection is changed, tape movement on this uniservo is <u>not</u> stopped and tape movement on another uniservo may be started.

The lack (in the program) of an External Read in reading any particular block but the last could cause an IOB I fault at the beginning of the next block or could be interpreted as a missing ER for the last block of the series.

If an External Read is not executed in time during the reading of any block, tape movement is stopped at the end of this block and an IOB lockout condition is caused by the execution of the "extra" ER at the end of this block. This stops the execution of any further computer instructions until the computer fault stop.

Resumption of Operation: All fault indicators are extinguished by depressing the Master Clear button. Operation is resumed after remaking basic selections by depressing the Start button.

(5) SELECTION ERROR FAULT.

Indications: Illumination of the MT and B fault indicators on the computer control panel and the Selection Error indicator in the tape control cabinet.

Diagnosis: This fault is caused by setting two of the Logical Number Selection switches to the same number at any time the computer is in actual operation. Any changes in logical designations should be made during a computer stop.

Resumption of Operation: Operation cannot be resumed until the logical designations are corrected. When this is done, the Selection Error indicator is extinguished. Depressing the Master Clear button extinguishes the B fault indicator and allows resumption of operation.

(6) SPROCKET ERROR FAULT: In reading, >720 or < 720 line count; in moving, > 720 line count.

Indications: MT B fault indicator illuminated. Sprocket Error indicator in tape control cabinet illuminated.

Tape movement is stopped at the end of the block recorded with the improper number of lines. A computer fault stop occurs approximately 80 ms after the detection of the fault.

Diagnosis: A sprocket error results from (1) the detection of a block spacing before a count of 720 lines has been accumulated in reading or moving, and (2) the reception of a sprocket signal from the tape after a 720 line count has been accumulated in reading or moving and before the block spacing is detected. The detection of a < 720 line count during moving is ignored: this condition propagates a "false" 720 line count to the tape control system.

During a reading operation, a < 720 line count means that an "extra" External Read is executed at the end of the block. The execution of this ER establishes an IOB lockout condition which prevents the execution of further instructions until the computer is stopped. This lockout condition is indicated by an ER instruction in PCR.

During a reading operation, if a >720 line count occurs in a block which is not the last of a group of blocks being read, the execution of an External Read after tape movement is stopped establishes an IOB lockout condition and prevents the execution of further instructions until the computer stop. If a >720 line count occurs in the last block being read, another External Function instruction may be executed before the computer stop occurs, and another tape movement could be initiated. An additional word is sent to IOB for each extra six lines recorded on tape, if such should be the case. Then, since IOB is not cleared before the computer fault stop, if an EF instruction is executed, the logical sum of IOB and the tape operation specification is sent to TCR.

When a >720 line count is detected during moving, computer instructions may continue to be executed until the time of the computer stop.

Resumption of Operation: Depression of the Master Clear button extinguishes all fault indicators. Operation may be resumed after remaking basic selections by depressing the Start button.

d. OTHER PROGRAMMING ERRORS - Listed subsequently are programming errors which may lead indirectly to the fault conditions discussed previously:

(1) Read Forward m blocks when only n (< m) blocks are recorded on the tape: (If there are m blocks recorded and 120 n+j (j=1...119). External Read instructions programmed before an EF Stop instruction, the fault is diagnosed as a "Failure to execute a sufficient number of ER's".)

Indications: External Read in PCR. IOB lockout condition shown by illumination of Wait External Indicator. Uniservo Interlock fault indicator illuminated.

Diagnosis: If more than 120n External Reads are programmed for reading n recorded blocks, the attempt to execute the first additional ER is

made after the last recorded block has been read. This ER establishes an IOB lockout condition which prevents further computer instructions from being executed. If m Read (one block) and Stop operations are specified, tape movement is not stopped at the end of the block n+1; if the read operation was to be terminated by the execution of an EF Stop instruction, tape movement is not stopped until the tape reaches its far end, resulting in a Uniservo Interlock fault.

Resumption of Operation: Depression of the Master Clear button clears both the lockout and fault conditions. Operation may be resumed after remaking basic selections by depressing the Start button.

(2) "Too Many" External Writes Programmed:

Indications: IOB lockout condition with an External Write in PCR; or No Information fault. Tape movement is stopped in both cases.

Diagnosis: If more than 120 External Write instructions are programmed for a Write (one block) and Stop operation, tape movement is stopped at the end of the block, but the 121st EW executed initiates an IOB lockout condition which is established when the next EW or EF instruction is attempted.

If more than 120n External Writes are programmed for a Write n Blocks operation, the first extra EW is executed at the end of writing the nth block. After the block spacing has passed, this word is written on tape (in the "n+1" block) since tape movement was not stopped by an EF stop instruction. Writing continues with the execution of the extra EW's until an EF Stop instruction is executed. Then, because the transmission of operation codes from IOB to TCR is not possible except between blocks, tape movement continues to the end of the n+1 block and the "too many EW's" is interpreted as "too few EW's". This results in a No Information Fault, a tape stop at the end of the n+1 block, and a computer B fault stop. The execution of computer instructions may continue until the time of the computer stop, and other tape operations might be undertaken.

Resumption of Operation: If a No Information fault has occurred, operation is resumed by following the procedure given in the No Information fault discussion. Depression of the Master Clear button clears the fault and lockout conditions

(3) Failure to execute an EF Stop instruction to terminate reading or writing.

Indications: IO or MT B fault indicator illuminated. Possible illumination of Uniservo Interlock indicator and the No Information fault indicator in the tape control cabinet.

Diagnosis: If the last block read is not the last block recorded on the tape, an IOB I fault occurs because of the lack of External Reads to read the information IOB is receiving from the tape. The results of this fault are those discussed in the paragraphs describing the results of programming an insufficient number of External Reads. If the last block read is the last block recorded on the tape, the tape movement is not stopped until the end of

the tape is reached at which time a Uniservo Interlock fault is incurred initiating a B fault computer stop. Until the time of the actual computer stop, the execution of instructions may continue with the possibility of initiating other tape operations. Since TCR is not cleared, the specification of an operation by an EF instruction is added logically to the read operation codes still in TCR. This may change both the uniservo selection and the operation code specified by the EF, and it is impossible to predict whether a tape operation will be initiated.

If a writing operation is not terminated, again, until the time of the actual computer stop, instructions continue to be executed, TCR is not cleared, and the execution of an External Function instruction will result in a logical sum in TCR. If an EF instruction is not executed during the time normally allowed for a block spacing to be passing the read/write head, a No Information fault occurs at the beginning of the "next" block. This will cause a tape stop and a computer B fault. If an EF is executed, the continuance of the execution of computer instructions depends upon the operation code and uniservo selection introduced into TCR.

Resumption of Operation: All fault indicators are cleared by the depression of the Master Clear button. Computer operation may be resumed after remaking basic selections by depressing the Start button.

(4) Programming a Change Bias and any other tape operation in the same External Function instruction:

Indications: No tape movement, possible illumination of Read Bias indicators on computer control panel. Possible IOB lockout condition with an External Read or External Write in PCR.

Diagnosis: The presence of Bias code select bits makes a uniservo selection impossible. Probably the bits intended to specify a uniservo were erroneously altered to become a bias change configuration. Any tape operation specified with a Change Bias operation is stalled, because of the absence of a uniservo selection, while the bias change is carried out. After the bias change is completed, TCR is cleared and an IOB Resume signal is sent to the computer. No tape movement is initiated. After the IOB Resume, another EF instruction or an EW instruction may be executed. The execution of an External Read or a second External Write causes an IOB lockout condition. If a block count was not specified with a Change Bias/Move combination, no bias change is effected since TCR is cleared immediately. The execution of the next EF instruction establishes an IOB lockout condition.