THE IBM HYPERTAPE SYSTEM

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GENERAL DESCRIPTION

The IBM Hypertape system was designed as a high-speed I/O device for the IBM 7074–7080–7090–7094 computers.* It is composed of a two-channel control unit, the IBM 7640 (Figure 1), and IBM 7340 tape drives (Figure 2). Ten 7340s can be attached to each 7640 channel.

The 7640 is attached to a computer through a simplex interface consisting of 33 lines. Four commands can be issued from the computer to the 7640 across this interface—a Read, a Write, a Control, and a Sense. The Control command instructs the 7640 to perform such operations as Space, Backspace, Rewind, etc. The Sense command interrogates the status of the 7640 and 7340. It allows the computer to determine, for example, if the tape drive is loaded or busy, or what type of errors occurred in the control unit on the last operation. The two channels of the 7640 time-share a Read and a Write section. This allows one channel to write while the other channel is reading. Instead of the NRZI method of recording, the system uses IBM's phase-encoding technique, ** which records a signal for both a one and a zero. This system is very reliable, since the possibility of either losing a weak signal or picking up noise is greatly reduced.

The tape used is 0.1-mil oxide on a 1-mil polyester base. It is one inch wide, with 1800 feet on a reel. Written across the tape are ten bits; eight are information bits, and two are check bits used for error correction during reading. These two check bits, in conjunction with a signal-strength monitor, provide detection of all errors and correction of all single- and 33 of 45 possible double-bit errors. In alphanumeric mode, six of the information tracks are utilized per character. In packed-numeric mode, two four-bit characters are written side by side across the tape, as shown in Figure 3. The character density is 1511/inch, and tape speed is 112.5 inches/sec. This results in an alphanumeric data rate of 170,000 characters/sec, or a packed-numerica data rate of 340,000

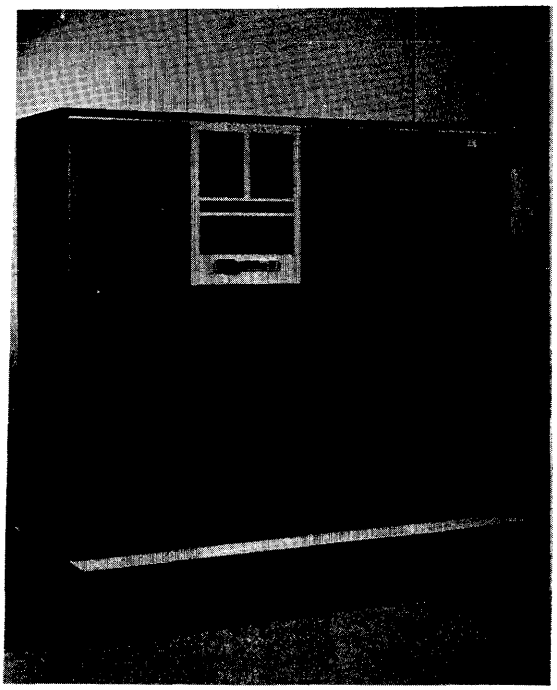

Figure 1. IBM 7640 Hypertape Control Unit.

* A modified version is also offered for the IBM System/360 (see page).

** Williams Patent #2734186

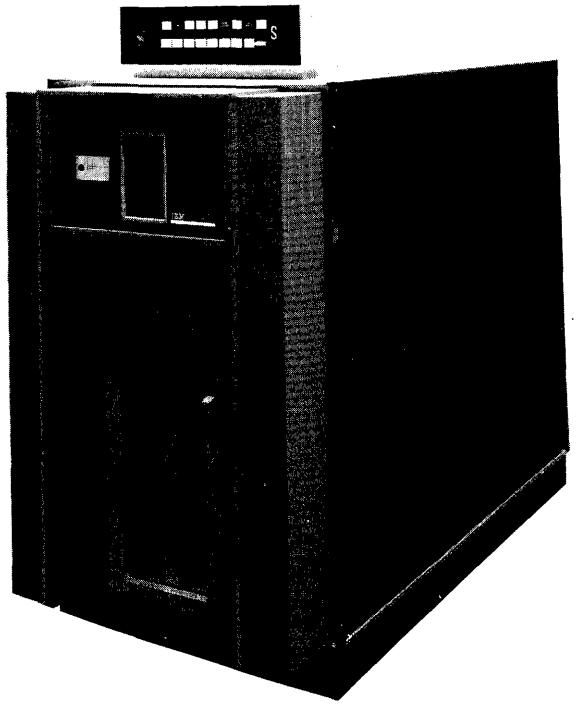

Figure 2. IBM 7340 Hypertape Drive.

characters/sec. Figure 4 shows a comparison of the reel capacity of Hyper and IBM 729 reels.

The tape has been completely enclosed in a dust-resistant cartridge to eliminate as much contamination as possible, and to provide a means of automatic loading and unloading without physically handling the tape. Another advantage of the cartridge is a programmable file-protect device. A tape can be file-protected under program control, but it can be "un-file-protected" only manually.

An Automatic Cartridge Loader (ACL) is available as an optional feature (Figure 5). A

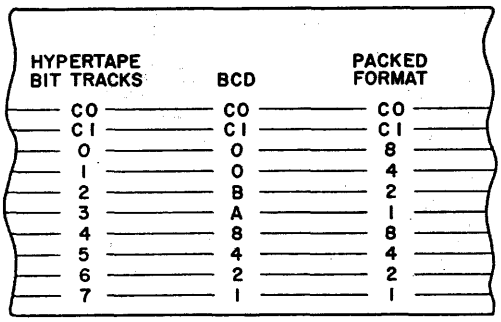

Figure 3. Hypertape Character Formats.

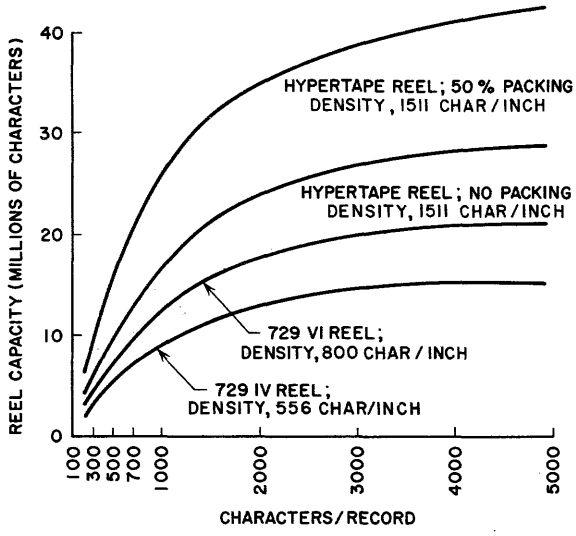

Figure 4. Comparison of Character Capacities—Hyper and IBM 729 Reels.

cartridge for the next job can be inserted in the ACL while the current cartridge is being processed. Then, under program control, the processed cartridge can be unloaded, and the cartridge which was stored in the ACL can be loaded automatically, all within approximately 40 seconds.

The average read-write access time is 4.2 milliseconds, and the average gap is 0.45 inches. The fast processing time of the Hypertape system is accomplished by the high data rate, narrow gaps, short access times, ability to read backward, and a very low rerun time due to extremely reliable operation.

THE IBM 7340 TAPE DRIVE

A major requirement of the 7340 was high reliability. To help achieve this, the tape is designed so that there is no physical contact with the oxide side of the tape during motion (Figure 6). The vacuum columns hold the tape taut over the single, rubber-surfaced capstan. The capstán can accelerate the tape to nominal velocity or decelerate it to a halt in 3.0 milliseconds. Note that the wear of such motion occurs on the *Mylar* side of the tape. When the tape passes by the read-write head, the oxide side of the tape rides on an air bearing and hence undergoes no wear.

Once a tape is initially loaded into the dust-resistant catridge, it is normally opened only in

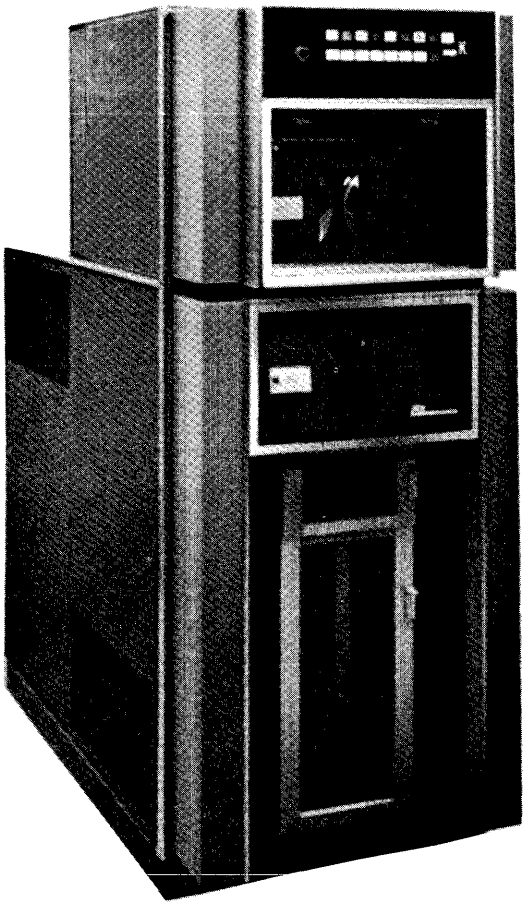

Figure 5. The 7340 Hypertape Drive with Automatic Cartridge Loader Option.

the pressurized chamber of the 7340. However if the tape in a cartridge must be changed, the front of the cartridge can be removed easily by means of a small Allen wrench. To load a cartridge into the 7340, the operator must raise the top cover of the 7340, and lower the cartridge into the cartridge receiver (Figure 7). When the top cover is closed, the tape reels in the cartridge are moved backward to engage the reel hubs, the servo motors on the hubs release the tape from both reels, the vacuum in each column draws the tape into the columns, and the head moves into place. The load operation takes less than 15 seconds. After tape is loaded into the columns, it is backspaced a short distance; thus the overall effect of the unloading and later reloading is to position the head slightly closer to the Beginning Of Tape (BOT) than it was before unloading.

Note that tape can be loaded and unloaded without the operator's hands touching the tape. Also, since a cartridge contains two reels, a tape no longer need be rewound before it is unloaded. This allows off-line rewinds, or a very short search on-line for the last record processed before the tape was unloaded. Rewinding can occur either under program control by means of a Control command, or by pushing the Rewind button. Rewind occurs at 112.5 inches/sec (normal processing speed) for 10 seconds; if the BOT mark is not encountered, the head moves ¼ inch away from the tape and a 225 inches/sec rewind "in the columns" is initiated. Rewind continues at full speed until the BOT is sensed; this is made possible through the continuous tape control provided by the capacitative sensing of the tape location in the vacuum column.

As previously mentioned, each cartridge can be "file-protected" either under program control or manually. The control instruction "Set File Protect" will cause a mechanism in the 7340 to depress a plunger on the back of a

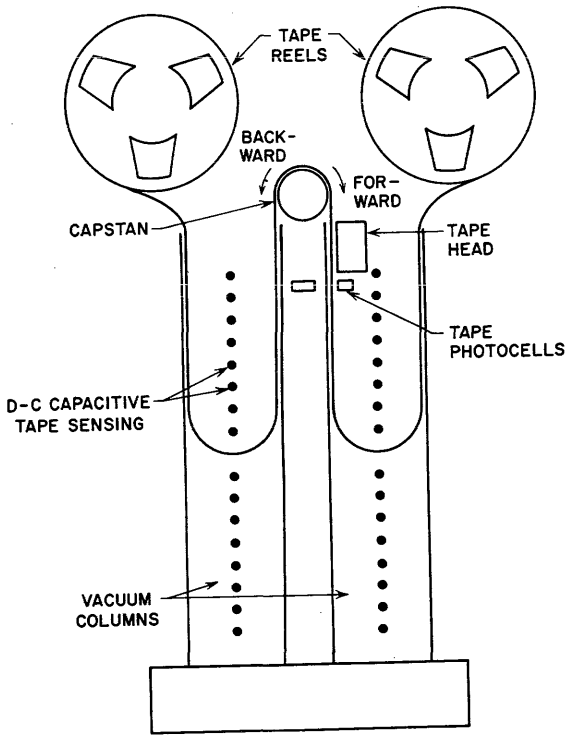

Figure 6. Tape Path in the 7340.

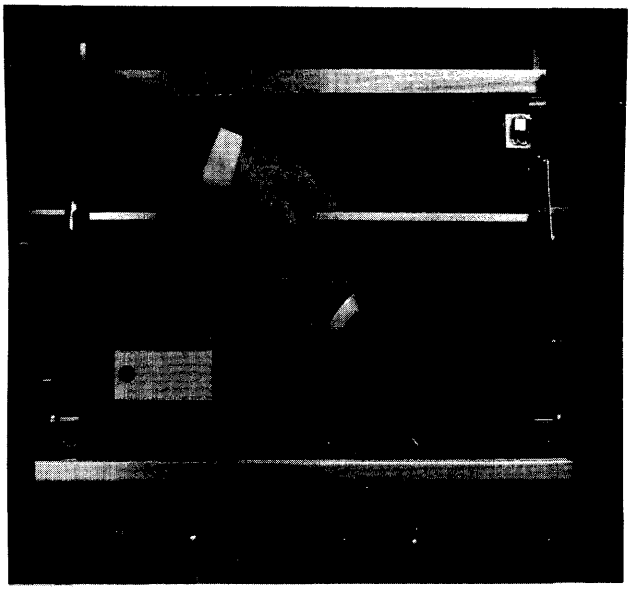

Figure 7. Inserting a Tape Cartridge.

loaded cartridge; this plunger can also be depressed manually. When the cartridge is file-protected, an indicator on the back of the cartridge displays the letters "FP." The cartridge can be "un-file-protected" only by manually releasing the plunger by means of a slide-release mechanism (Figure 8).

The Beginning Of Tape (BOT), End Of Tape (EOT), and End Warning Mark (EWM) are detected by three photosensed markers. Backward tape motion is halted when the BOT marker is sensed. The marker is about 15 feet from the physical beginning of tape on the take-up reel; it consists of 12 holes occupying about 1.5 inches along the edge of tape nearest the drive. Forward motion of tape is halted when the EOT marker is sensed, and hence tape cannot run off the end of the reel. This marker is about 15 feet from the physical end of tape on the supply reel; it also consists of 12 holes, but they are located midway between the edges of the tape. The EWM is about 40 feet from the EOT marker. It consists of 23 holes occupying about 1.5 x 0.07 inches along the edge of tape nearest the operator; the holes do not interfere with recording of data on tape. When EWM is sensed on a selected drive, the end-warning-area status indication in the IBM 7640 is available to the program.

The Automatic Cartridge Loader (ACL) can be used very effectively if a number of tapes must be loaded at the same time for a new job. During the processing of the previous job, the operator can insert the next cartridge to be processed in the "load storage position" (back of the ACL). Then, under program control, all the processed cartridges can be unloaded at the same time and deposited in the "discharge storage position" at the front of the ACL, and the next cartridges to be processed will be loaded in. The entire load operation of all the drives will take approximately 40 seconds, and is accomplished without operator intervention.

A cartridge may also be loaded into the ACL-equipped drive by direct operator control. The operator merely places the new cartridge in the load-storage position of the ACL, and when the door is closed the cartridge automatically is loaded into the 7340, if no other cartridge was in the loaded position. If a cartridge was in the loaded position, the operator would have to push the Unload button. The loaded cartridge would then be placed automatically on the discharge

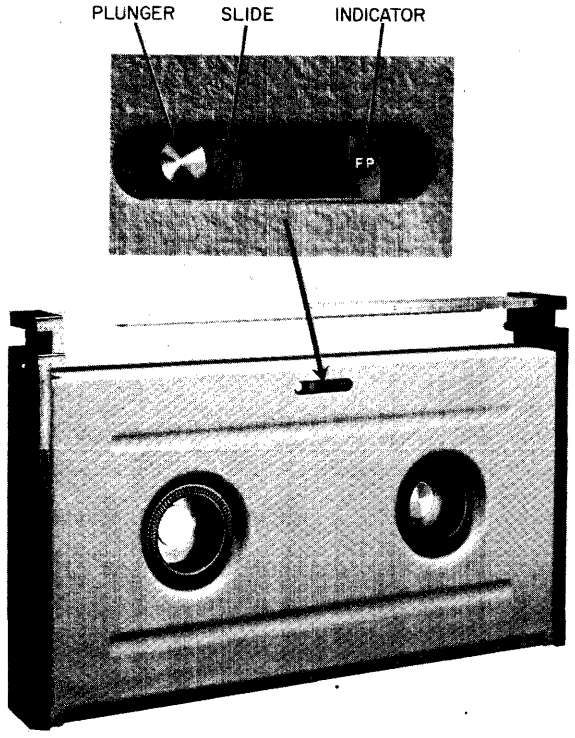

Figure 8. Cartridge File-Protect Device.

shelf at the front of the ACL, and the other cartridge would be loaded.

SIMPLEX INTERFACE

The simplex I/O interface is a set of lines which connect the 7640 to the computer. There are a total of 33 lines, 18 from the computer to the 7640, and 15 from the 7640 to the computer. (See Fig. 9.) Generally speaking, any signal must be maintained until its response is provided by the receiving unit.

The 7640 can be operated in one of three modes: CE, Ready, or Diagnostic. Normally the 7640 is operated on-line in Ready mode, but for testing and repair it can be operated off-line in CE (Customer Engineering) mode. Diagnostic mode is identical to Ready mode except that three switches on the CE panel are operable. These will be discussed later.

Initially, the computer and 7640 are interlocked by the Operational Out line and the Operational In line respectively. The Operational In line is conditioned by the 7640 if it receives the Operational Out line from the computer and it is not in CE mode.

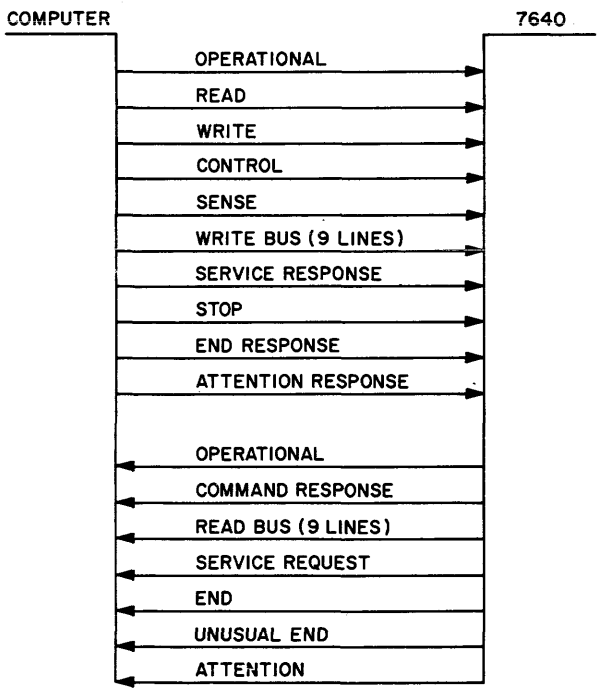

Figure 9. Interface Lines.

An operation is initiated on one of the four command lines: Read, Write, Control, or Sense. Upon receipt of the command, the 7640 will answer with a signal on the Command Response line.

During both a Write and a Control operation, information is transferred from the computer to the 7640 via the Write Bus (9 lines). The 7640 asks for the information by means of a signal on the Service Request line, and when the information is available on the Write Bus, the computer answers with a Service Response. The Write command is terminated by a STOP, and the Control command is terminated by either a STOP or a special instruction called an End of Sequence (EOS). The 7640 indicates successful completion of the command by sending an End to the computer, or an unsuccessful completion by means of an Unusual End. In either case, the computer responds with End Response. The cause of an Unusual End may be determined by analysis of the status information obtained by a subsequent Sense command.

During both a Read and a Sense command, information is sent to the computer from the 7640 over the Read Bus (9 lines). When the information is available on the Read Bus, the 7640 sends a Service Request to the computer. When the information has been accepted, a Service Response is returned. During a Read operation, the transfer of information occurs until a STOP is received from the computer or the end of the record is reached. At this point the 7640 indicates a successful completion of the Read by sending an End to the computer or an unsuccessful completion by means of an Unusual End. The computer responds with End Response to either case. Since the Sense operation is simply a request for the status information of the 7640, only an End can occur at its completion. The 7640 will indicate there is status information on the Read Bus by means of a Service Request, and the computer will answer with a Service Response when this information has been accepted. The operation will be terminated when STOP occurs or when 14 "bytes" of information have been sent to the computer. End response will answer the End signal.

WRITE OPERATION

As previously defined, the Write section of the 7640 is time-shared between both channels. If a Write command occurs in Channel A, and then later a Write command occurs in Channel B, the command in Channel B will be stacked in the 7640 until Channel A releases the Write section.

Upon receiving a Write Command, the 7640 tests for the following two error conditions:

1. Operator Required—indicated if the selected drive is not ready;
2. Program Check—indicated if the selected drive is not loaded, or if it is file-protected, busy, or at EOT.

If either of these conditions exists, an Unusual End will be signaled immediately. If neither exists, a write Delay must be taken before actual writing can commence. If the Write Command occurs while the tape is stationary and the 7340 is in Write status, a 3.1-msec delay is taken before writing is started. The Start specification of the 7340 is 3.0 msec. To test if the proper speed has been achieved, a burst of zeros is written in *one* track for a certain period of time; this is called the "velocity burst." The 7340 has a two-gap head; hence, information written on a tape passes under the read head approximately 1.3 msec later. At this time the duration of the velocity burst is checked. If the tape was not up to speed when the velocity burst was written, the burst's duration will be less than expected.* A variation of approximately minus 10% is allowed before an Unusual End is signaled. The error is identified as a Track Start in the Sense Data, and the programmer has the option of rewriting the record.

As previously stated, the stop time of the 7340 is 3.0 msec. After the Move Tape line from the 7640 to the 7340 is deconditioned, there is a period of 300 μsec during which the line could be conditioned again. This is allowed because of the mechanical delays in actuating the stop mechanism. If the Move Tape line does not rise again during this time interval, the tape must be allowed to stop completely before it can be told to move again. However, the 7640 provides to the computer a 1.0-msec time interval, during which the computer can reinstruct with another Write command and the tape will not stop between Writes. This is accomplished, in conjunction with the above-described 300 μsec, by holding up the Move line for 700 μsec after the completion of a Write. Upon completion of any Write operation, another Write operation is *anticipated,* and a short write delay of 2.6 msec is started. If the Write command does not materialize in the allotted 1 msec, the tape is stopped. From the time the Move line is deconditioned, a 3-msec interlock prevents the Move line from being conditioned again except during the initial 300 μsec. Reinstruct within the 1.0 msec results in minimum gaps and fast access times. This is called a Continuous Write, for which there is no velocity burst since tape continued to move at nominal velocity. Figure 10 illustrates the 1.0-msec Reinstruct.*

The 7340 is in Write status if the last operation it performed was a Write operation. If a Write command is sent from the computer to the 7640, and the 7340 is not in Write status, a "backhitch" (reorienting of the head in relation to the previous record) must occur. This is because the previous operation could have been a Backspace or a Read, etc., and the exact position of the read-write head in the gap would be unknown. A Write without reorienting the head could result in a partially erased record in the gap. Thus, in order to erase a proper gap, a Write command, with the 7340 not in Write status, will cause the tape to backspace until the previous record is encountered. The tape will stop, and then move forward out of the record. Just as the read head leaves the record, Write status will be set, and a 2.6-msec Write delay will be taken at full velocity. In addition to eliminating the partially erased record in the gap, the "backhitch" results in a minimum interrecord gap.

As previously mentioned, the Hypertape system uses a phase-encoding type of recording rather than NRZI. With phase-encoding recording a signal exists for both ones and zeros, with their differentiation depending on the phase (or direction) rather than on the magnetic strength of the recorded signal. Thus, phase encoding is less sensitive to noise than NRZI, and hence is inherently more reliable.

* Patent applied for.

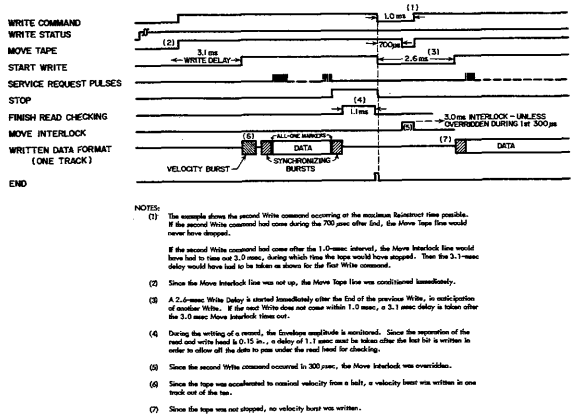

Figure 10. 1.0-msec Reinstruct (Write Operation).

Figure 11 illustrates the phase relationship of a one and zero. As mentioned, the data rate of the 7640 is 170 kc. If the data is all-ones or all-zeros, this results in 340,000 flux changes/sec to produce the 170,000 characters/sec. When data switches from a one to a zero or from a zero to a one, a long wavelength results. Hence, data consisting of alternating ones and zeros results in 170,000 flux changes/sec. Figure 12 shows a series of bits for one of the ten tracks. Note that a long wavelength marks a change from a one to a zero or vice versa, rather than the presence or absence of a signal.

After the velocity burst is written, or after a 2.6-ms Continuous Write delay is taken, a synchronizing burst of 40 zeros is written on all tracks, followed by a one in all tracks, followed by the data. (See the data format in Figure 10.) After a STOP is received from the computer by the 7640, another all-one marker is written, followed by another synchronizing burst of 40 zeros. Hence, the record is symmetrical and can be read backward or forward. The synchronizing bursts are used during reading to synchronize the read clocks and phase the data properly. The all-one marker indicates that data will follow. As previously described, the transfer of information from the computer to the 7640 over the 9-line Write Bus occurs on a Service Request, Service Response basis. Eight of the lines are for data, and the ninth is a parity check. The 7640 checks the parity of every character received on the Write Bus, and will call an Unusual End at the completion of the Write operation if incorrect parity is received. If the computer does not answer a Service Request with a Service Response before the next Service Request occurs, an Overrun Error is called resulting in an Unusual End.

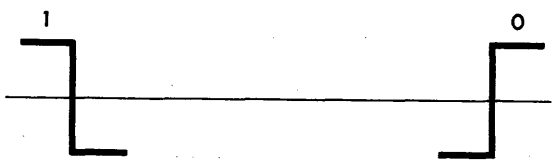

Figure 11. IBM Phase-Encoding "1" and "0" Waveforms.

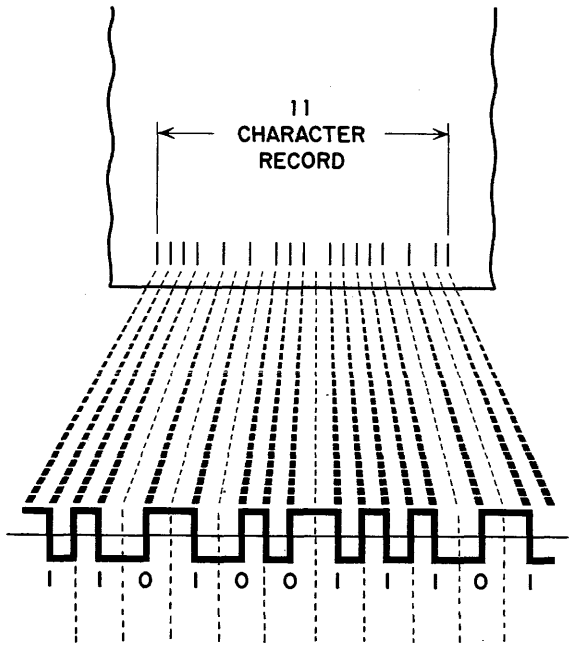

Figure 12. Waveforms for a Series of Bits.

In alphanumeric mode, only six of the eight lines contain data for each Service Response. In packed-numeric mode, two 4-bit characters are sent to the 7640 with each Service Response. Actually, no packing or unpacking is done in the 7640. It simply writes the information on the Write Bus on tape, along with two check bits. The check bits are generated during the Write operation according to the following two equations.*

$$C_0 \vee I_0 \vee I_1 \vee I_3 \vee I_4 \vee I_6 \vee I_7 = 1$$

$$C_1 \vee I_0 \vee I_2 \vee I_3 \vee I_5 \vee I_6 = 1$$

where $\vee$ means Exclusive Or,

C is a check bit, and

I is an information bit.

* Patent applied for.

The generated check bits are rechecked again during writing, and if they are wrong, a Code Check indication is stored for later sensing, and an Unusual End will occur at the termination of the Write operation. The check bits are regenerated during a Read operation and are used in conjunction with the amplitude of the Read signal to correct all single errors and most double errors.

During a Write operation, as the written data passes under the read head it is monitored by a Motion Integrator. If the signal amplitude of the envelope in any one track drops below a specified level, an Envelope Check is stored in the 7640 to be later sensed. This error will result in an Unusual End at the termination of the Write operation. At this point it is recommended that the programmr perform a Backspace and an Erase over the faulty section of tape. The Erase is called an Erase Long Gap (ERG), and is a Control instruction. It will result in the erasure of eight inches of tape. Then the error record should be rewritten.

When the EWM is sensed by the 7340 during a Write operation, an Exceptional condition is stored for sensing and an Unusual End will terminate the operation. Hence the programmer is informed he is near the end of tape.

READ OPERATION

Channel A and B time-share the Read section in the same manner they share the Write section. A Read command will be stacked in one channel if the other channel is utilizing the Read section. When the Read section is available the 7640 checks for Operator Required and Program Check, as described for a Write operation. If no errors exist, the Move Tape line is activated to the 7340, and a 2-msec Read delay is taken. After this delay, the Motion Integrators start to look for a record. The ten tracks are divided into three different groups, and a signal in one track of each of the three groups will identify a record. The group approach was used to eliminate noise from being recognized as a record. As in writing, 1 msec is allowed by the 7640 for a Read Reinstruct without stopping tape. Again the Move Tape line is held up for 700 μsec after recognizing the end of data in a record. The additional 300 μsec is the time during which the Move Tape line can be deactivated and activated again without affecting the stop mechanism of the 7340.

Clearly the optimum use is made of the Hypertape system if the tape does not stop between records.

Once a record is recognized, a variable-frequency clock (VFC) in each track must be given time to synchronize with data. Since there is a signal for both a one and a zero, the problem of a clock dropping out of sync during a long string of zeros does not exist. After approximately 25 zeros of the start burst have been read, the VFCs should be synchronized, and the phase of the signal in the detection circuitry must be corrected if necessary. The detection circuitry will be interpreting the start burst as either zeros or ones, since it will either be in or out of phase respectively. At this point, the data is sampled. If the data is not recognized as zeros, the phase is incorrect and has to be inverted. After this has been done, a search is started for the all-one marker which will indicate that data will follow immediately.

One problem in reading a wide, high-density tape is skew in the characters across tape. This is handled in the 7640 by means of a six-position skew buffer and a Read-In Counter (RIC), for each track, which counts the bits 1 through 6 which have been read from tape. Pulses generated from the VFCs step the RICs midway between the data bits and hence act as gates into the skew buffer. A single Read-Out Counter (ROC) controls the reading of deskewed characters. When all the RICs have stepped ahead of the ROC, a character has been deskewed and can be read from the skew buffer into the Error Correction Register. Between four and five bits of skew can be handled in the skew buffer. Under normal operation the skew is less than two bits. If the skew is so great that the RIC overlaps the ROC, an "excessive skew error" is stored for sensing and an Unusual End is signaled at the termination of the Read operation.

Once the characters have been deskewed and gated into the Error Correction Register, the check bits C_0 and C_1 are regenerated and compared with C_0 and C_1 read from tape.

The bits can be divided into three zones from the two check-bit equations:

Zone 1 contains the bits only in the C_0 equation

Zone 2 contains the bits only in the C_1 equation

Zone 3 contains the bits only in both the C_0 and C_1 equations

Hence,

Zone 1 contains bits C_0, I_1, I_4, I_7

Zone 2 contains bits C_1, I_2, I_5

Zone 3 contains bits I_0, I_3, I_6

An Envelope Detector in each track monitors the read-detector amplitude. If the signal from the read detector drops below a certain level in one track, the track is "dead tracked." This essentially resets that track for the rest of the record, since it is assumed that the VFC could have lost synchronization. If a parity error is found to occur in the zone containing the "dead track," the track which has been "dead tracked" is assumed to be in error, and the output of that particular track's Error Correction Register is inverted. Hence a zero is made a one or vice versa, and single-error correction is accomplished.

If two tracks in the same zone are dead tracked, or more than two tracks are dead tracked, an uncorrectable error called an Envelope Check is stored for sensing. This will result in an Unusual End at the termination of the Read operation. Two tracks in the same zone are obviously uncorrectable since the parity error would be negated. However, the C_0, C_1 equations were generated such that no adjacent tracks would be in the same zone. Hence, all adjacent double errors are correctable along with some nonadjacent double errors. Any double error that does occur is more likely to be an adjacent double error due to the character of tape defects.

There are 45 possible combinations of double errors, of which 33 are correctable. When a correctable double error occurs, a dead track exists in two different zones, with the parity error appearing to be in the third zone. For example, consider the case of a dead track in both I_0 and I_1. If both bits were incorrect they would negate each other in equation C_0, but equation C_1 would appear incorrect. Hence, the parity error would appear to be in zone 2.

If a parity error occurs without a corresponding dead track, an uncorrectable error called a Code Check is stored for sensing and an Unusual End is signaled at the end of the Read operation. For both a Code Check and an Envelope Check, the 7640 sends the first uncorrectable character to the computer with incorrect parity. No further characters are sent to the computer for the duration of the record. This is to prevent uncorrected characters from appearing like packed characters and hence overflowing allotted memory when unpacked. If the complete record is desired, HECF (Error Correction Off) may be programmed prior to the Read command. This Control instruction will allow uncorrectable characters to be transmitted.

Another error that can occur on a Read is an Overrun Error. During reading the 7640 sends a Service Request to the computer when data is available on the Read Bus. A Service Response from the computer indicates the information was received. If the Service Response does not come back from the computer before the next Service Request is issued, an Overrun condition exists, and the computer could miss a character. The Overrun Error is stored for sensing later and an Unusual End is initiated at the termination of the Read operation.

CONTROL OPERATIONS

The Control command transmits instructions such as Backspace, Backspace File, Space, Rewind, Write Tape Mark, etc., to the 7640 from computer core storage. Each instruction is defined by an 8-bit code. The instruction is assimilated in the 7640 Instruction Register by means of two 4-bit bytes. The computer sends a Control command to the 7640, which responds with a Command Response. The 7640 then obtains two 4-bit bytes of information from the computer through a Service Request, Service Response exchange. The instruction is decoded and the 7640 checks to see if the operation can be done. If the instruction is a Select, a third 4-bit byte is requested to identify the drive to be selected. If there is an error condition, an Unusual End is signaled immediately to the

computer. If there is no error condition, the operation is started. Upon successful completion of the operation, the 7640 will request two more bytes of information, assemble them and decode the instruction, etc. This processing of a so-called "chained sequence of instructions" will continue until either a STOP is received from the computer or an End of Sequence (EOS) instruction is received. Either will cause the 7640 to terminate the Control command with an End signal. At all times any error condition will break the chain and an Unusual End will be sent to the computer. There are five "free-running' control operations, HCHC (Change Cartridge), HCCR (Change Cartridge and Rewind), HRUNL (Rewind and Unload), HFPN (file Protect ON), and HRWD (Rewind). These operations are *initiated* in the 7340 by a Control command, and then the 7640 continues on to the next instruction as if the free-running instruction had been completed. A drive performing a free-running operation is in Busy status, but the 7640 channel which initiated the operation is free to perform other instructions, internally, or on other drives. Additional instructions to a busy drive must be delayed until the drive indicates the completion of the free-running operation with an Attention signal.

Upon receipt of an Attention pulse, the computer responds with an Attention Response. All Attention pulses are stored in the 7640 relative to a specific drive address, such that the program can sense to see which drive completed the free-running operation. The next operation (other than a Sense) done on that selected drive resets the stored Attention.

A group of control instructions exists for diagnostic purposes only. They allow diagnostic functions to be performed on-line under program control. These functions can also be performed off-line by means of toggle switches on the Customer Engineering panel (as described in the following section on "Customer Engineering Facilities").

SENSE OPERATION

A Sense operation enables the computer to learn the cause of an Unusual End, the status of the 7340 and 7640, and which 7340 signalled Attention.

A Sense command from the computer causes a Command Response from the 7640. Then the 7640 gates the status condition of the 7340 and 7640 to the computer by means of 14 four-bit bytes of information over the Read Bus. Again the transfer of information occurs on a Service Request, Service Response basis. The sense bytes contain information such as Operator Required; the selected drive address; reasons for a Program Check or Data Check—e. g., Selected drive Busy, or a Code Check, respectively; Attention pulses from drives which completed free-running operations; Diagnostic conditions; etc.

The Sense operation is terminated either by a STOP signal from the computer or by the 7640 after the 14-byte transfer is complete. Since the Sense operation is merely a status transfer, it can be terminated only by an End, rather than an Unusual End.

CUSTOMER ENGINEERING (CE) FACILITIES

In order to use the entire CE section of the 7640 for off-line debugging, the Mode switch must be set to CE Test. However the 7640 can also be operated in a Diagnostic mode which makes some of the CE switches functional during computer usage.

The CE panel (Figure 13) attempts to simulate a computer. A three-step program loop is available with all four commands, Read, Write, Control, and Sense, and also with HNOP (No Operation), HBSR (Backspace), and Read Backward. Switch controls govern the tape selected, the number of characters/record during a Write, and the loop interval (the time between the termination of one command and the issuance of the next). The loop interval can vary from eight microseconds to two seconds.

A Write command causes the information in the bit switches of bytes 1 through 4 to be written on tape until the record length is satisfied, determined by the Characters per Record switch. A Read operation can then be performed to check the record written. If the Read Compare toggle is on, the characters read from tape are compared bit for bit with the characters set up in the byte switches. The Stop On Check toggle switch will cause the loop to stop

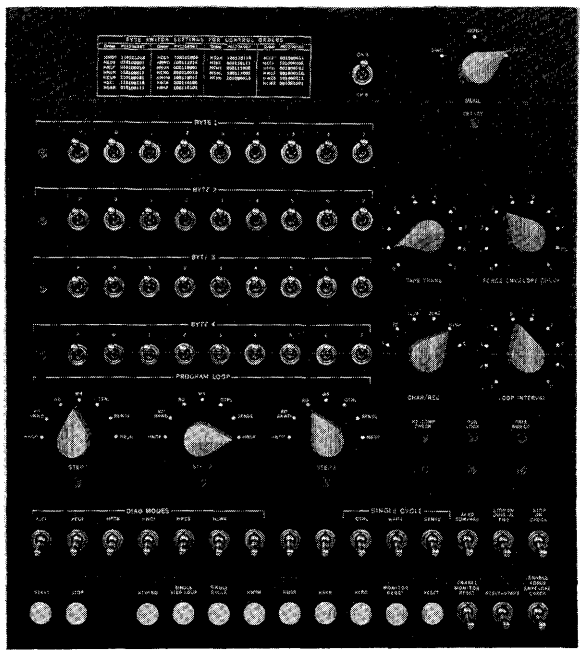

Figure 13. CE Panel on the 7640.

immediately on any error, including any compare error that might occur. It is also possible to stop at the *end* of an operation on all errors, except compare errors, by using the Stop on Unusual End toggle.

For debugging purposes, a Single Cycle button and a Single Step Loop button are provided. The Single Cycle button is used in conjunction with the appropriate Single Cycle toggle switch to single-step through a Write, Control, or Sense; while the Single Step Loop button merely steps the program loop one step at a time, as opposed to running continuously if the Start button is pushed.

A number of indicators in the 7340 are not reset at the start of a new operation if a switch called Enable Monitor Reset is on. This toggle prevents all normal resets from resetting these holdover indicators until a Monitor Reset button is pushed. This allows selected indicators to be monitored over a period of time.

The error-correction circuitry can be tested through manipulation of a Force Envelope Check switch. During a Write operation this switch will cause groups of 16 information bits to be degated from tracks selected by a rotary switch. Hence, during a Read operation, the Envelope Detectors should sense the absence of signal in these tracks and indicate the appropriate "dead track," causing the error correction and detection circuitry to be exercised.

The Reset Start toggle switch is used to help debug a failing operation. Operations which are functioning properly are set up in steps 1 and 2 of the program loop, and the failing operation is set up in the third step. Pushing the Start button will cause the first two steps to be performed, and the failing third step will be attempted. After a certain time has elapsed, depending on the loop interval selected, a Reset will be initiated and the loop will step back to program step 1. Hence, an oscilloscope can be conveniently used on the failing operation, since it is repetitive.

Another very powerful CE tool is the Loop Write to Read (LWR). It essentially gates the information, which is normally written on tape, directly from the Write section into the read-detection circuitry. Thus the tape path is eliminated. Two modes associated with LWR are Write Clock Fast (HWCF) and Write Clock Slow (HWCS). These modes are selected by toggle switches and cause either a 10%-fast oscillator or a 10%-slow oscillator to be gated into the write clock. The functions performed by these toggle switches are also programmable.

If the 7640 mode switch is in the previously mentioned Diagnostic position, the relation between the computer and the 7640 is exactly the same as in Ready mode, except that the following three toggle switches on the CE panel are operable:

1. Enable Monitor Reset
2. Stop On Check
3. Enable Force Envelope Check

Hence, these three switches may be used while running programs on the computer.

OFF-LINE EQUIPMENT

A low-speed, single-channel control unit, the 7641, is available to connect into an IBM 1401, an IBM 1410, or an IBM 1460 computer. The 7641 controls a drive, the 7340 Model 2, which

has a data rate of 34kc. There is complete compatibility of tapes between the 7340 Model 1 and the 7340 Model 2. Therefore, for example, a job can be processed on an IBM 7094 computer using 7340s, and the off-line printing can be handled on a 1401 or 1410 using a 7340 Model 2.

HYPERTAPE MODIFIED FOR IBM SYSTEM/360

A version of the Hypertape system is now offered as I/O for the new IBM System/360. A slightly modified 7340, designated as the 7340 Model 3 Tape Drive, is controlled by a single-channel control unit, the IBM 2802, attached to a CPU channel through a new interface. The 7340 Model 3 tape speed is 112.5 inches/sec, but the bit density has been increased to 1511 or 3022 bits/inch. Hence the data rate is either 170,000 or 340,000 alphanumeric characters/sec, or 340,000 or 680,000 packed-numeric characters/sec. The desired data rate is program-selected. The lower data rate allows interchangeability with the 7340 Model 1 or 2. The nominal gap has been reduced to 0.38 inches and the average access time is 3.5 msec.

The 2802 consists of five major sections—Read, Write, Control, Sense, and Customer Engineering Facilities—all of which function in a manner similar to those described in the 7640. The major differences are:

1. Employment of miniature c i r c u i t r y (IBM's Solid Logic Technology);
2. A modified control section due to the System/360 interface;
3. Reduction of the Sense information to four bytes;
4. No overlap of operations because of the single-channel design;
5. Increased data rate under program control.

The 2802 Hypertape control unit can control up to eight drives. However, an optional sixteen-address feature enables the 2802 to address as many as sixteen drives when used with the IBM 2816 Switching Unit Model 2, which is available for switching 4, 8, 12, or 16 drives to any one of up to four 2802 units (under program control).

The 2802 controlling 7340 Model 3 Tape Drives maintains the high reliability previously described for the Hypertape System, while increasing the data rates by a factor of two, and decreasing the interrecord gap and access time appreciably.