IBM Customer Engineering

Manual of Instruction

IBM 7330 Magnetic Tape Unit

7330 Magnetic Tape Unit

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Customer Engineering Manual of Instruction

7330 Magnetic Tape Unit

Preface

This manual covers the physical layout of the IBM 7330 Magnetic Tape Unit theory of writing on magnetic tape, mechanical operation principles, and circuit logic.

Names of electronic lines are distinguished by quotation marks. Note that engineering changes may alter logic and machine functions, causing a tape unit to differ from the descriptions presented here.

Certain illustrations referred to in this manual are in the *IBM 7330 Magnetic Tape Unit Customer Engineering Reference Manual,* Form 223-6967. An alphabetical figure list is given in front of the reference manual. By the title given, the CE can attain the figure and/or page number.

MINOR REVISION (May, 1965)

This manual, Form 223-6943-3, obsoletes Form 223-6943-2. Minor changes have occurred on the machine since the last revision. These changes have been incorporated into this revision. Items with asterisks in the contents indicate revised or added material.

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*Revised or added since previous printing.

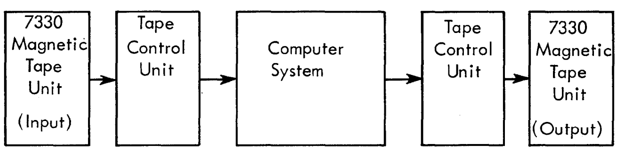
IBM 7330 Magnetic Tape Unit

Magnetic tape is used extensively in data processing systems to provide a compact, economical data storage medium. Because data processing systems range from relatively simple low-speed systems to complex high-speed systems, IBM provides a variety of magnetic tape units. Each type has certain functions and speed to meet a particular area of demand.

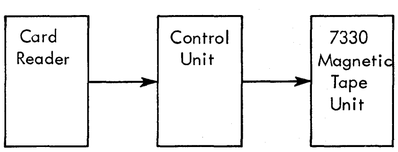
The IBM 7330 Magnetic Tape Unit is designed to operate with a suitable control unit as an on-line and off-line device (Figure 1). On-line refers to an operation in which the tape unit is under control of a computer system. Off-line refers to an operation in which the tape unit operates with another input or output device completely independently of a computer system.

The IBM 7330 moves tape at 36 inches per second while reading or writing, and data can be written on tape at a density of either 200 or 556 characters per inch. The complete tape unit is contained within a standard modular system double cube. The upper half of the cube contains the tape transport, relay gate, DC power supplies, and transistor logic circuits. The lower half of the cube contains the cable receptacles.

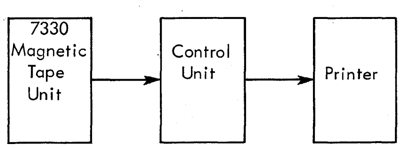
Magnetic tape is ½ inch wide and 2400 feet long. It is supplied on 10½-inch reels. Magnetic tape consists of a plastic base, coated on one side with a ferromagnetic material. During a write operation, tape is passed over a recording head that is capable of magnetically saturating the ferromagnetic material in one direction (polarity) or the other.



On-Line Operation of Tape Unit



Off-Line Card-to-Tape Operation



Off-Line Tape-to-Printer Operation

Figure 1. Uses of IBM 7330 Magnetic Tape Unit

Coding System

Writing is accomplished by changing the direction of the magnetizing force at the point where data are to be recorded. Thus, data on tape appear as changes in magnetic flux direction. Data are written in code form using the IBM seven-bit code.

A bit may be thought of as a binary one; the absence of a bit is a binary zero. For our purposes, a bit will refer simply to a reversal of flux on tape.

The IBM seven-bit code requires the use of seven recording channels or tracks on tape. The seven recording tracks are designated as C, B, A, 8, 4, 2, and 1. A character is written across the width of tape by writing combinations of bits in appropriate tracks. Each character has its own bit configuration and is different from the bit configuration of all other characters. Actually, only six tracks are required for writing data; the seventh track is used for checking.

An interesting comparison can be made between the seven-bit tape code and the IBM card code. A numeric character is represented on an IBM card by a single punch in one of nine rows (rows 1 through 9). An alphabetic character is represented by a numeric punch and a punch in one of the three zone rows (row 12, 11, or 0). Note that twelve rows are required to represent all characters in card code. On magnetic tape, we have only six tracks in which to represent the code for all characters; obviously, a different code must be employed.

Consider the number three. In card code, this character is represented by a punch in row 3. We do not have a 3 track on magnetic tape; therefore, the number three is represented by bits written in tracks 1 and 2. Likewise, a seven on tape consists of bits in tracks 1, 2, and 4.

Next consider the alphabetic character A. In card code, this character is represented by punches in rows 12 and 1. On magnetic tape, the character A consists of bits written in tracks 1, A and B.

From the examples, we may conclude that tracks 1, 2, 4, and 8 on magnetic tape compare to rows 1 through 9 in an IBM card; tracks A and B compare to zone rows 12, 11, and 0. Because only two tracks are available for zone information, track A on tape compares to zone row 0 in a card; track B compares to zone row 11; bits in both tracks A and B represent zone row 12.

Figure 2 shows the data format on magnetic tape. Note the seven tracks and the bit combinations used to form the characters.

The C bit track is used for error checking. One checking method requires that all characters consist of an even number of bits. Because some characters contain an odd number of information bits, a C bit is added to make an even bit count for these characters.

Another error checking method requires that all characters have an odd bit count. In this case, the C bit is added to any character that normally has an even number of bits.

To further understand the use of the C bit, consider the checking system using an even bit count.

From Figure 2, we find that the character M consists of a 4 bit and B bit. Because this is an even bit count, the C bit is not needed. The character T consists of bits in tracks 1, 2, and A. This represents an odd bit count; therefore, the C bit is added to make an even count. All characters on tape, therefore, have an even bit configuration and, during a reading operation, each character is checked for this condition. If the tape unit fails to read a bit or if it indicates a bit that does not exist, an odd count results, causing an error indication.

Reading information from tape is closely related to the write operation. Reading is accomplished by sensing the bits as tape passes over a read head containing seven separate sections, one for each of the recording tracks on tape. Output of the individual read head sections is low and must be amplified to a useful level.

The seven read head sections are assembled with the seven write head sections to form a single read-write head assembly.

Tape Movement

An important function of any tape unit is the movement of tape during reading or writing. Motion is obtained in the 7330 tape unit by squeezing the tape against a continuously rotating roller called the drive capstan. The tape is pulled over the read-write head at 36 inches per second. Tape is stopped by squeezing it against a stationary stop capstan.

Quick starting is an important requirement in a magnetic tape unit. To pull tape directly from a reel is impractical, because of the mass involved. The mass of a reel of tape would place excessive tension on the tape and further complicate the problem of quick acceleration. Excessive tension also would break or otherwise damage tape.

To overcome the problem encountered in pulling tape directly from a reel, a buffer area is provided. The buffer area consists of two columns in which loops of tape are maintained (Figure 3).

Each column is constructed of metal and has a glass front. One end of the column is open and the distance between the glass front and metal back is just sufficient to allow the passage of ½ inch wide tape. The other end of the column is connected to a vacuum source

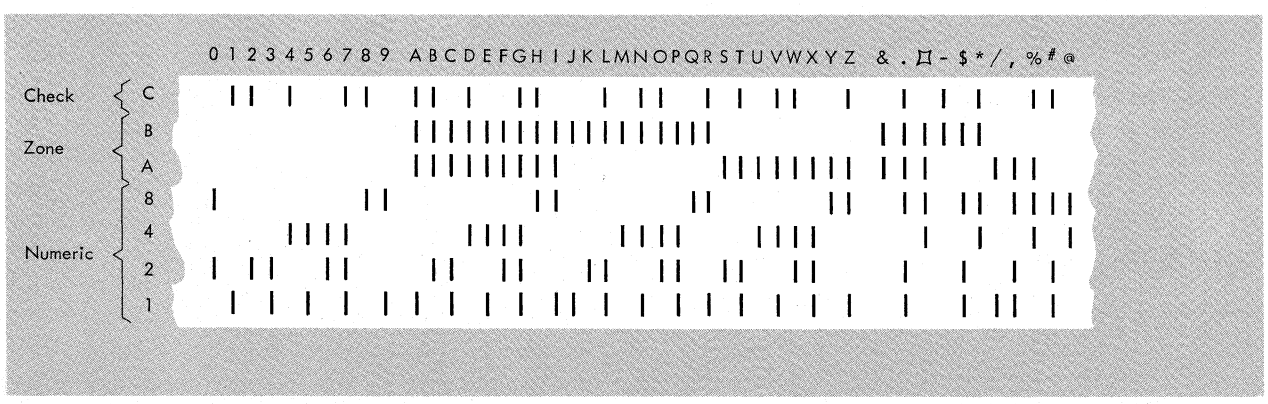
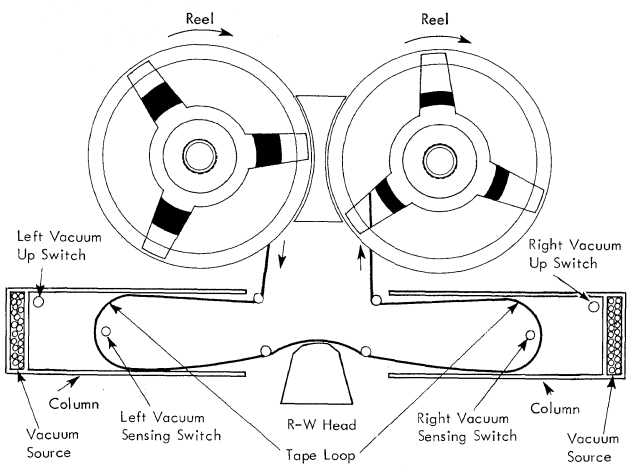


Figure 2. Characters on Magnetic Tape



(Figure 3) so that air entering the open end, keeps a slight tension on the tape loop. Tension is sufficient to hold the tape in contact with the read-write head but does not interfere with its movement. As tape is pulled from one column, it passes over the head and is drawn into the other column.

As tape is pulled from the left column, it must be replenished from the supply reel. Likewise tape must be pulled from the right column and wound on the take-up reel. To accomplish this, the tape reels are rotated by motors controlled by sensing switches. Each sensing switch contains an element capable of detecting a change in air pressure.

The sensing switch is attached through a hole in the back of the vacuum column (Figure 3) about halfway between the ends. When the tape loop is between the hole and the open end of the column, the switch sensing element is under partial vacuum. When the tape loop moves more than halfway into the column, the sensing switch is exposed to atmospheric pressure. Thus, the sensing switch is able to detect which half of the column the loop occupies. The action of the sensing switches in controlling tape reel motion is illustrated in Figures 4A and 4B.

When tape is pulled more than halfway out of the left column (Figure 4A), the sensing switch causes the left reel to rotate clockwise and put more tape into the column. When the tape loop goes further than halfway into the right column (Figure 4B), the sensing switch causes the right reel to rotate clockwise, removing tape from the column.

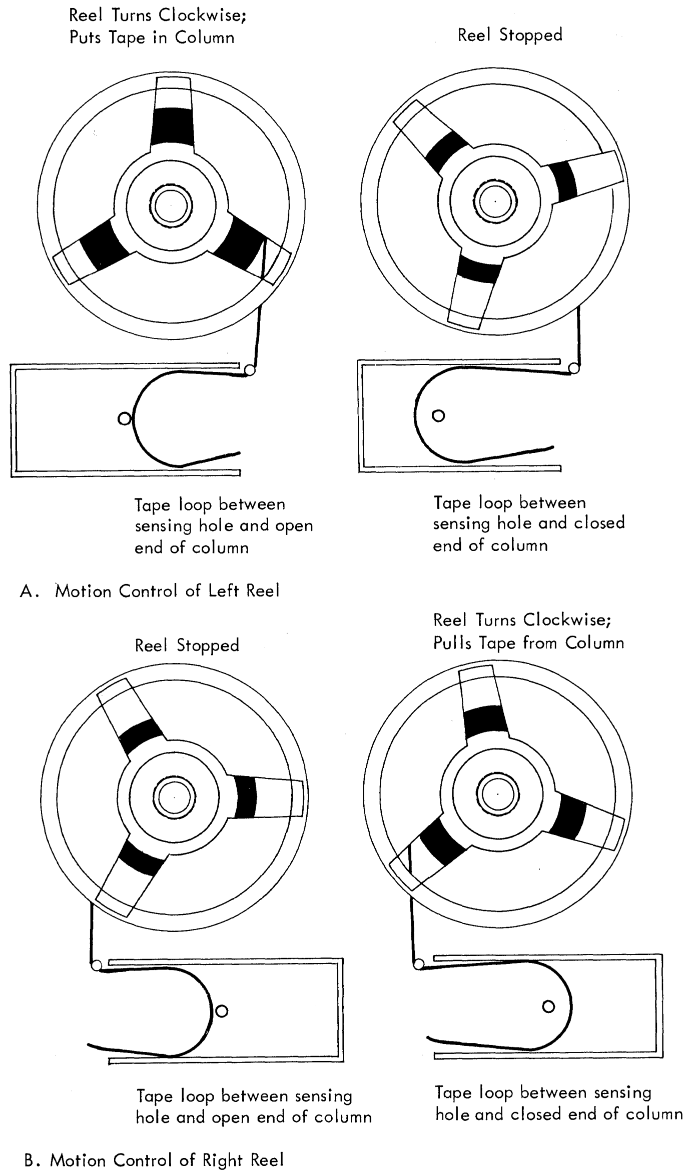


Figure 4. Motion Control of Reels

Markers on Tape

During a write operation, some means must be provided to sense the approaching end of tape before the end is stripped from the supply reel. Tape indicate (end-of-tape) sensing is accomplished by a small reflective spot placed on tape about 18 feet from the actual end of tape. The reflective spot is detected by a photocell and, during a write operation, provides adequate warning to the external system.

During a read operation, the end of a file of records is sensed by reading a tape mark (special character).

When the bulk of tape is on the take-up reel it must be rewound onto the supplying reel. A high-speed rewind operation can be initiated by the operator or by the computer through a program instruction. During high-speed rewind, the file reel turns counterclockwise and rewinds tape directly from the take-up reel. Tape motion starts slowly, to prevent placing excessive strain on the tape, and gradually increases until an average rewind speed of 220 inches per second is reached.

During high-speed rewind, the tape unit must be able to determine when the starting end of tape is being reached. For this purpose another reflective spot, the load point, is used to stop the rewind operation. Figure 5 shows the location of the reflective spots. Note that the load point spot is near the front edge of tape, while the end-of-tape spot is near the rear edge.

Besides stopping a rewind operation, the load point reflective spot is used during a tape loading operation to position tape for the start of reading or writing the first record.

After a reel of tape is placed on the IBM 7330, tape is threaded over the read-write head and the end is wound on the take-up reel until the load point spot is to the right of the head assembly. The operator lowers the rewind arm and, aided by vacuum, places a loop of tape in each column. He then closes the door and depresses the low-speed rewind key. Tape moves backward until it is stopped by the load point spot.

Tape Compatibility

Compatibility refers to the ability of a tape written on an IBM 7330 Magnetic Tape Unit to be read on the same tape unit, other tape units of the same type, and on certain high-speed tape units, such as the IBM 729 II and 729 IV.

For tape to be compatible, the first record must be a prescribed distance from the load point spot, characters must be properly spaced, and records must be separated by accurately controlled inter-record gaps of blank tape. See Figure 6. (A record on magnetic tape is defined as a group of data separated from other groups of data.)

Consider the position of the first record in respect to the load point spot. It might seem feasible to start writing from the point where tape stops after a load operation. Writing from this point is not practical, however, because tape does not stop at the same point after each load-rewind operation. This condition is due mainly to the variation in characteristics between photocells and relays used in the load point circuit. To examine the effect of the stopping point on the first record, consider Figure 7. Part A shows the position of the load point reflective spot in reference to the write head gap after a load-rewind operation. If writing is started from this point and tape is moved from left to right, the first record will be positioned as shown by the shaded area.

Assume now that this tape is again loaded on a tape unit and, after low-speed rewind, stops with the reflective spot in the position shown in Figure 7B. Note that this position is different from the position in Figure 7A and that part of the first record previously written is positioned to the right of the recording head.

Now, we are going to write new records on this tape. As new data are written, old data are erased. Writing from the position indicated in Figure 7B erases only part of the old data (Figure 7C). If the old data remained preceding the new record, the first record would be inaccurate and useless. To eliminate the possibility of a useless record, tape is moved

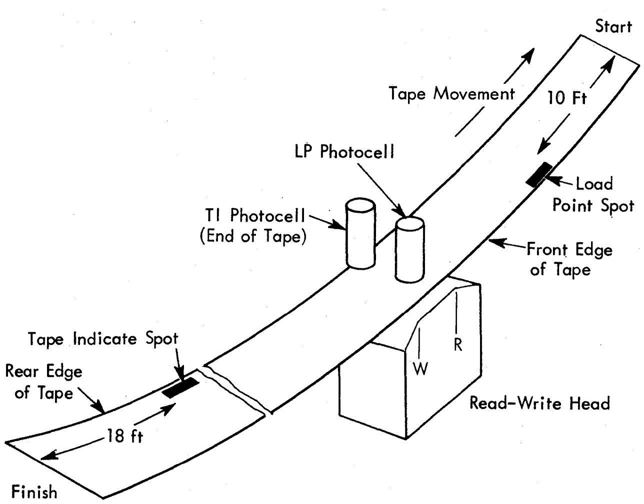


Figure 5. Reflective Spots on Tape

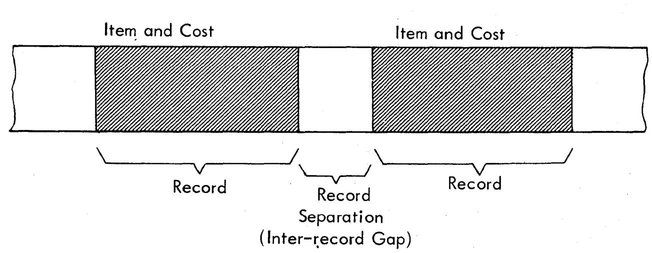


Figure 6. Records on Magnetic Tape

forward from load point, erasing about 3¾ inches of tape before starting to write the first record.

The length of the load point skip is accurately controlled by timing circuits in the control unit used with the 7330 tape unit. Figure 8 shows how the load point skip affects the first record on tape. In section A, assume that tape has stopped in the position shown after a low-speed rewind. Tape then moves from left to right over the write head, erasing all noise for a distance of 3¾ inches.

Following the load point skip, the first record is written. Assume that this same tape is again loaded on a tape unit and has stopped in the position shown in Figure 8B. Note relative positions of the load point spot and write head in Figures 8A and 8B. Now, we are again going to write records on tape. With the conditions shown in Figure 8B, the load point skip will erase the remainder of the old record. By employing the load point skip, all noise is removed preceding the first record, regardless of the normal variations in load point stopping.

Records on tape are separated by a ¾ inch erased section called an inter-record gap. This gap is the result of stopping tape at the end of one record and starting it again for the next record. Stopping tape motion may be compared with stopping a car. When the brakes are applied, a car does not stop immediately but travels some distance. This distance is greatly determined by the speed of the car and the speed with which the brakes are applied. The same is true with the distance that tape moves after it is instructed to stop. The mechanical operation necessary to stop tape takes time and, with tape speed, determines the stopping point beyond a record.

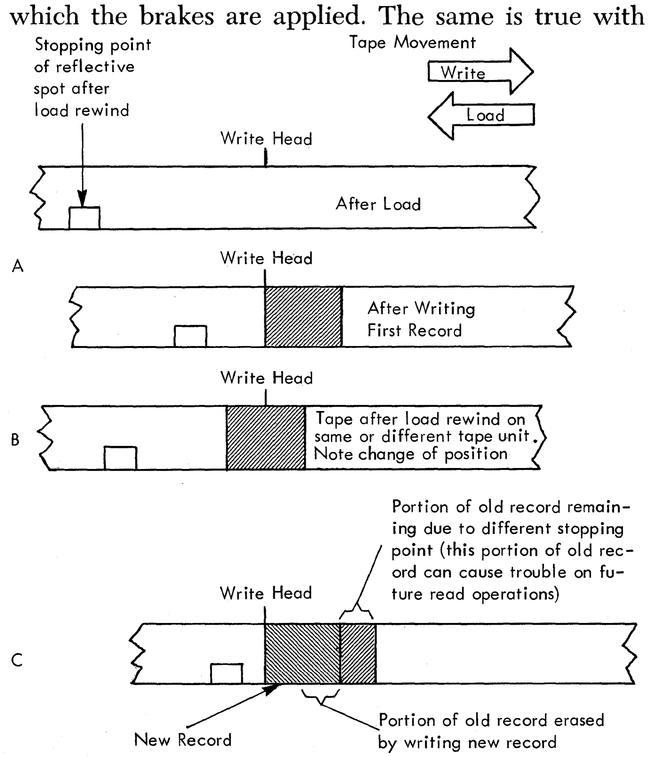


Figure 7. Effect of Load Point Stop on First Record (Without Load Point Delay)

Tape motion must be started again to write the next record and, because it takes time to get up to the operating speed, writing of the first character must be delayed. During the delay, tape is moving over the write head and erasing old information. The total length of the inter-record gap is, therefore, the sum of the stopping and starting distance. A ¾ inch inter-record gap is employed between records written on the 7330 tape unit so that these tapes may be read on other IBM tape systems operating at higher speeds.

Spacing of characters on tape is also an important factor in compatibility because of the time required to read a character from tape, check it for accuracy and deliver it to an external system. If characters are too closely spaced, a character may pass over the read head before the previous character is sent to the external system. In this case, records read from tape will be inaccurate. Likewise, too great a space between characters can cause improper operation because each character of a record must be read within a certain time limit.

If the time limit between characters is exceeded, the tape system recognizes the condition as the end of the record, even though there are more characters to be read. Character spacing on tape is determined by two factors:

1. Intervals at which characters are written
2. Velocity of tape past the write head

The intervals at which characters are written are accurately maintained by the tape control unit. The velocity of tape across the write head is maintained by an accurately machined and constructed capstan drive assembly.

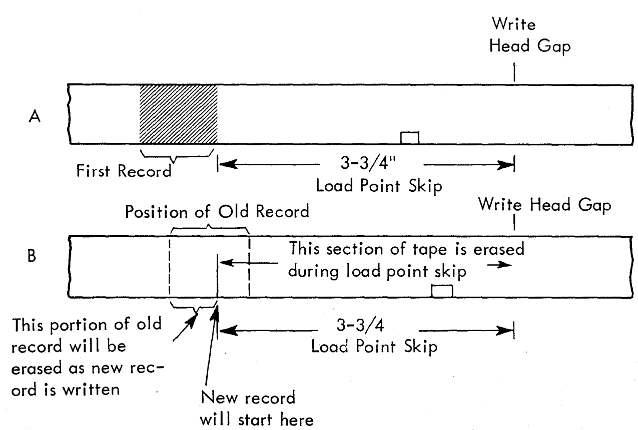


Figure 8. Effect of Load Point Skip on First Record

Inter-Record Gap

The generation of the inter-record gap while writing is shown in Figure 8a. Since tape moves at the speed of 36 inches per second, 0.036 inch per millisecond, and we know the various delays for starting and stopping, we can compute the distance of the inter-record gap generated in each instance.

$$\begin{array}{ll} & \text{speed} - \text{inches/ms} \\ \text{x} & \text{time} \ \ - \text{ms} \\ \hline = & \text{distance} - \text{inches} \end{array}$$

The theoretical inter-record gap should be .75 inch with a tolerance of +0.125 and −0.0625 inch.

Referring to Figure 8a, the control unit initiates the first delay while writing. This delay is 8.3 ms and is the time between the last character written and the time it is read for checking. The tape is moving at full speed and the distance generated is .2988 inch. After checking the character, the control unit initiates a 6.6 ms "Forward Stop Delay." The distance generated here is .2376 inch, since tape is still moving at full speed. At the end of this delay, the control unit causes GO to fall which results in a forward stop time of 4 ms. This distance generated for 3 ms is .1080 inch and the distance generated for 1 ms is .0182 inch. The total distance is .1262 inch. At this point the tape is stopped. The rest of the gap is not generated until the next record is to be written. There is a 5 ms delay before GO rises. The purpose of this delay is to wait until tape gets up to full speed before writing the first character. The instant GO rises there is no tape motion at all for 2 ms. In the next 1 ms, tape increases its speed from 0 to .036 inch/ms and results in a distance generated of .0182 inch. For the remaining 2 ms the distance generated is .0720 inch. The total write delay distance is .0902 inch and the total write gap distance is .7528 inch, which is within the specifications.

Figure 8b shows the distances generated when the tape unit is reading a record. After the last character is read in a record, the control unit initiates a 12.5 ms delay. This delay results in a distance of .45 inch. The control unit then allows the GO signal to fall. This results in a forward stop delay of 4 ms which generates a distance of .1262 inch. At this point the next record to be read is in the position shown in Figure 8b. The control unit now initiates a read delay of 7.6 ms so that tape can get up to speed and the first character is over the read head. GO rises at the beginning of this delay and there is no tape motion for 2 ms. This leaves 5.6 ms before the first character is to be read. It takes 1 ms for the tape to get up to full speed. The distance this generates is .0182 inch. In the remaining 4.6 ms the distance generated is .1656 inch. At this point the first character of the new record to be read is over the read head and the total distance generated is .7600 inch.

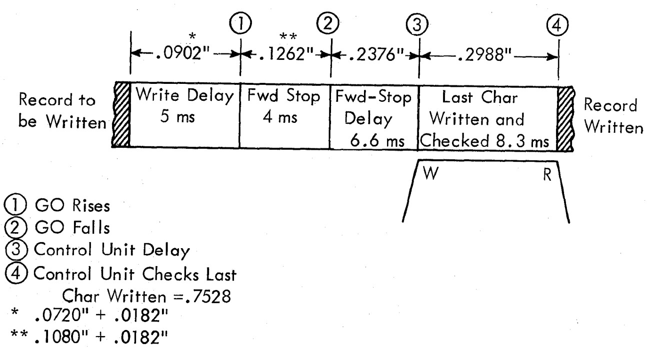


Figure 8a. Inter-Record Gap — Write

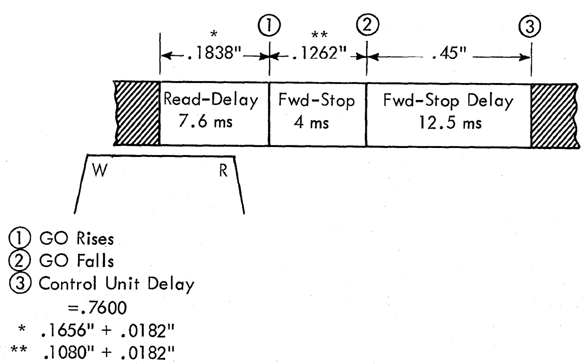


Figure 8b. Inter-Record Gap — Read

The IBM 7330 Magnetic Tape Unit is assembled on a swinging gate that occupies the upper front half of a standard double modular cube (Figure 9). The operator's panel is located above the tape transport mechanism and contains the manual controls and indicator lights. The front of the tape transport is covered by a glass door for safety and to prevent dust from contaminating the magnetic tape.

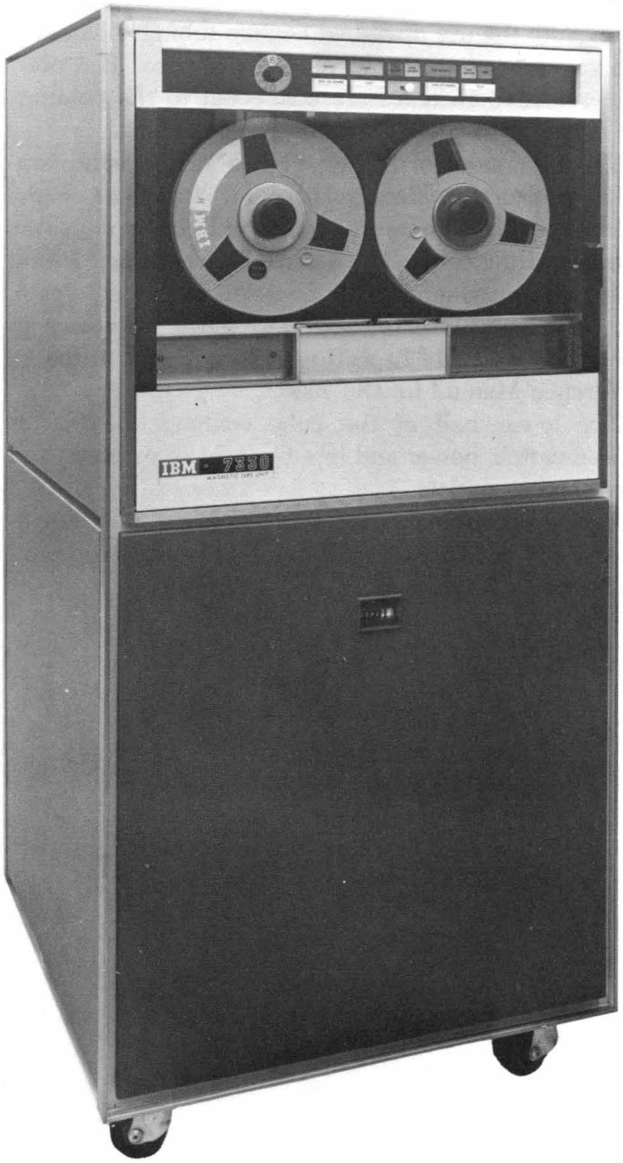


Figure 9. IBM 7330 Tape Unit

The operator's panel layout is shown in Figure 10. The purpose of the keys and indicator lights is:

Select Indicator: Lights when the address selector is switched to a select line at a +S level; indicates that tape unit is selected.

Ready Indicator: Lights when the tape unit is mechanically and electrically ready; means that tape has been properly loaded and the start key has been depressed.

Tape Indicator: Lights when the end-of-tape reflective spot is sensed during a write operation to warn of the approaching end of tape; may also be turned on by program instruction from a computer.

Fuse Indicator: Turns on when a fuse blows; turns off when defective fuse is removed.

File Protect Indicator: Lights when a file protected reel is placed on the file reel hub (a file protected reel is one that does not contain a plastic ring in the groove in its rear side); also lights when the tape unit is not in ready status. When the file protect indicator is on, reading may be performed on the tape unit but writing is suppressed.

Low-Density Indicator: Lights when the high-low density switch is in low-density position; indicates that records will be written with a density of 200 characters per inch.

High-Density Indicator: Lights when the high-low density switch is in high-density position; indicates that records will be written with a density of 556 characters per inch.

Address Selector Switch: Used to switch the tape unit to any one of ten select lines (lines 0 through 9). The tape unit is in a selected status only when the select line to which it is switched is active.

Reset Key: When pressed, removes the tape unit from computer control; will also stop a low-speed or a high-speed rewind; takes tape unit out of ready status and turns off ready indicator.

Start Key: When pressed while the tape unit is mechanically ready, places the unit under computer control; also disables high-speed and low-speed rewind keys and turns on ready light.

Low-Speed Rewind Key: Operative if tape unit is not in ready status; depressing this key when the tape unit is loaded causes tape to move backward to load point at 36 inches per second.

High-Speed Rewind Key: Operative only when tape is not in ready status; causes rewind arm to rise; tape

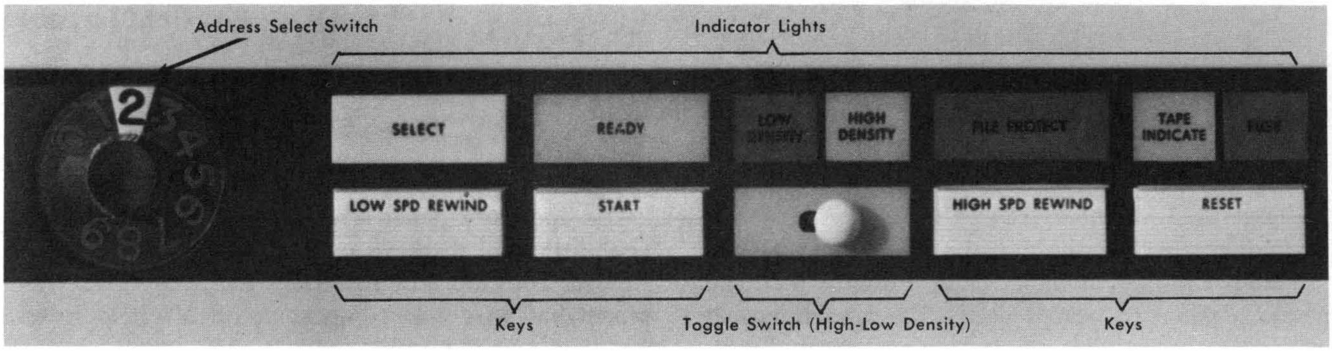


Figure 10. Operator's Panel

is slowly pulled from columns and then rewound at high speed.

Density Switch: Position of switch determines whether tape is written at high density (556 characters per inch) or low density (200 characters per inch).

General Description

In the "Physical Locations" section of the *IBM 7330 Magnetic Tape Unit Customer Engineering Reference Manual,* Form 223-6967, is a detailed front view of the tape transport with decorative covers and head area shield removed. The read-write head is in the center, just below the reels. At the right and left of the head are glass-covered horizontal vacuum columns that function as buffer storage so that tape can be moved independently of the tape reels.

The gate containing the entire tape transport is hinged so that it swings open for easy access to the tape mechanism.

The Figure, "Tape Transport Rear View," in the CE Reference Manual for the IBM 7330 shows the location of the main components on the rear of the tape unit gate. Note the use of ribbed flexible tubing to connect the vacuum pump to the vacuum columns. The pressure sensitive switches are connected to the columns by means of smaller diameter plastic tubing.

The remainder of the upper half of the cube contains power supplies, relays and transistor logic. Transistor logic circuits are assembled on pluggable printed wiring cards. These cards are contained within a single SMS swinging gate. Location of the logic gate, the power supply gates and relay gates are shown in the figure entitled "Tape Unit – Rear View" in the CE Reference Manual for the 7330.

The lower half of the cube contains the master power switch, power and input-output connectors, and convenience outlets.

Power requirements for the 7330 tape unit are 3-phase, 208 or 230 VAC ±10 per cent at the tape unit, 60 cycles ±.5 cycle.

This section describes the mechanical and electrical operation of the tape transport mechanism and associated logic circuits.

Theory of Writing on Magnetic Tape

A magnetic material can be polarized or partially polarized by a magnetic field. For every magnetic material, a B-H curve (Figure 11) can be plotted, showing the resultant flux densities (B) when the material is placed under the influence of a varying magnetizing force (H). If a magnetizing force of ampere-turns (H) is slowly increased in the positive direction, the resultant flux density in a magnetic material increases rapidly at first, then slowly attains a steady value of flux. The phenomenon of attaining a steady value of flux density is called saturation of the magnetic material.

When the ampere-turns are slowly reduced, flux density also decreases, but at a different rate. This is the hysteresis effect. When the magnetizing force is again zero, the flux density is not equal to zero but is equal to some positive value (point A). The amount of magnetic flux remaining (distance A-O) when H is equal to zero is the residual magnetism in the material.

If: (1) the ampere-turns are reversed, (2) current magnitude is increased until saturation is reached again, and (3) current magnitude is returned to zero, a negative resultant flux remains (point B). Using suitable circuit techniques, a flux pattern of either positive or negative polarity can be impressed on a magnetic material.

Figure 12 shows how information is written on magnetic tape. The magnetic circuit consists of a laminated core, an air gap, a Mylar* shim, and magnetic oxide on the tape. The core is MuMetal†, which has a high permeability and low retentivity.

Permeability is the ability of a magnetic material to conduct lines of flux; it is designated by the Greek letter Mu (μ) and is numerically equal to the ratio of the flux density to the magnetizing force ($\mu = B \div H$; the mu of air = 1).

Retentivity is the capacity of a magnetic material to retain magnetism after the magnetizing force is removed.

The oxide has a low permeability of about 7-9 and a high retentivity. The air gap causes the magnetic lines of flux to diverge away from the head and into the magnetic oxide on the tape. The plastic shim prevents loose oxide from filling the gap.

*Trademark of E.I. duPont de Nemours & Co. (Inc.)
†Trademark of Allegheny Ludlum Steel Corporation

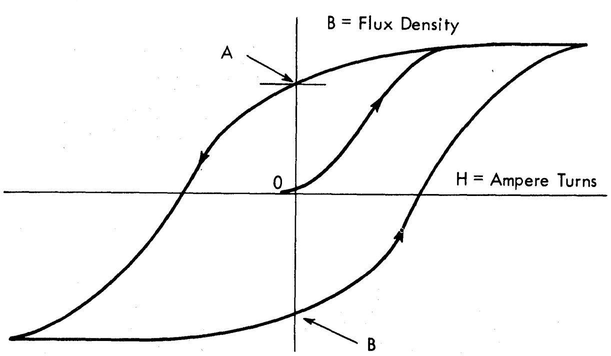


Figure 11. B-H Curve

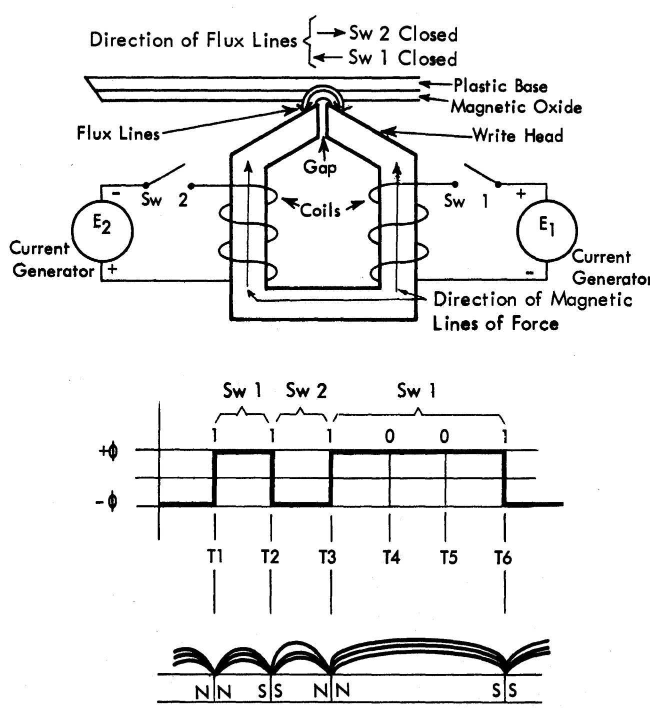


Figure 12. Method of Writing on Magnetic Tape (NRZI System)

NRZI System

The NRZI (non-return to zero IBM) system of recording information is one in which tape is continuously saturated in either the positive or negative direction. Within a given period of time, a change in saturation polarity is called a one, and no change is called a zero. The process of storing information on magnetic tape is called writing and the process of detecting stored information is called reading.

When switch 1 is closed at time T1 (Figure 12), current generator E1 causes current to flow through the coil; a flux path is set up as shown by the arrows. Because this flux path extends into the magnetic oxide on the tape, the oxide particles are magnetized in the direction of the flux path. If the tape is moving, all of the area passing over the write head is magnetized in the same direction.

If, at time T2, switch 2 is closed and switch 1 is opened, current generator E2 causes current to flow through the opposite write coil. This causes the flux path to be reversed and the oxide particles to magnetize accordingly. Because switching time in a tape system is very short, the tape moves only a minute distance during the reversal. This process constitutes writing a one bit on the tape. If, at time T3, the flux in the head is again reversed, another binary one is written. If, at time T4, no reversal is made, a binary zero is written. Thus, if a reversal in flux is made at any time, a binary one is written; if no reversal is made, a binary zero is written. The magnetic material on tape can be considered as being a series of tiny bar magnets placed end to end. Where the change in flux occurs, there are like poles; where no change occurs, there appears to be a long magnet (Figure 12).

The advantages of the NRZI system compared to other methods of recording are:

High Inherent Density. Binary ones can be written closer together than in a pulse system.

High Output When Reading. Maximum change of flux occurs from one saturation level to the other.

Simplified Erasing Technique. Erasing to saturation is simpler than erasing to zero flux. (Writing a new record erases the old record.)

Instead of the two write coils shown in Figure 12, the write head used on the 7330 tape unit uses a center tapped coil for each of seven write tracks.

As tape passes over the write head, the writing of characters (made up of bits) is controlled by write pulses generated in a tape control unit. The 7330 tape unit can write information at either high density (556 characters per inch) or low density (200 characters per inch). Density of writing is a function of tape speed across the write head and write pulse frequency. For the 7330 tape unit to write records at the densities stated, the external control unit must furnish data at a 20 KC rate for high-density writing and at a 7.2 KC rate for low-density writing.

Reading

Reading bits from tape makes use of the principle that a voltage is induced in a coil when a changing magnetic field cuts the turns of wire in the coil. This principle can be stated in the equation:

$$e = N \frac{d\Phi}{dt} \quad \text{where:}$$

e = Induced voltage
N = Number of turns in each read coil
$d\Phi$ = Small change in magnetic flux
dt = Small change in time
$\frac{d\Phi}{dt}$ = Ratio of small change in flux with respect to small change in time

Applying this principle to the reading of information from tape we find that a reversal of magnetic flux lines on tape (bit) causes a changing magnetic field to cut the windings on a read coil as the tape moves over the read head. This changing field produces an output pulse.

There are seven read coils, one for each of the seven bit tracks on tape. These seven sections are combined to form the read head.

TWO-GAP READ-WRITE HEAD

The two-gap head used in the IBM 7330 Magnetic Tape Unit contains seven write heads in laminated form, one adjacent to the other. The assembly also contains seven read heads. The two groups of heads (Figure 13) are positioned so that the gap in the write heads is three tenths of an inch to the left of the gap in the

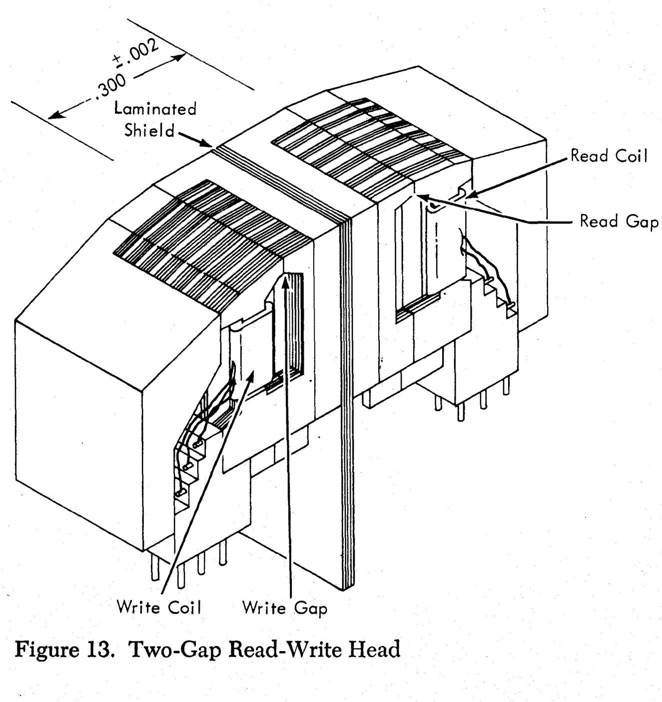


Figure 13. Two-Gap Read-Write Head

read heads. Tape passes over the head assembly, oxide side down, to complete the flux path of the write and read heads. By using separate heads for writing and reading, it is possible to read a record, for checking purposes, while it is being written.

As mentioned, the NRZI system of writing on tape erases old information as new records are written. The 7330 tape unit, in addition, employs a separate erase head to insure that tape is completely erased before writing new records.

Tape Motion

When tape is moving forward (left to right), it is pulled across the read-write head by squeezing it between a rotating drive capstan and a pinch roller, GO idler (Figure 14).

Some operations require that tape move backward (right to left) across the read-write head. Backward motion is obtained by reversing the direction of capstan rotation. Tape is then pushed toward the read-write head and the vacuum in the left column draws the tape across the head in the backward direction. The action of the left vacuum column also keeps sufficient tension on the tape to hold it in contact with the head.

The drive capstan rotation in either direction is provided by a single motor. The motor is reversible and can rotate in a direction to drive tape forward or can rotate in a direction to drive tape backward. Figure 14 shows the drive capstan assembly. Figure 15 shows the capstan motor direction control.

The capstan drive motor operates on three-phase 208-230 VAC. The motor has three field coils. Each one

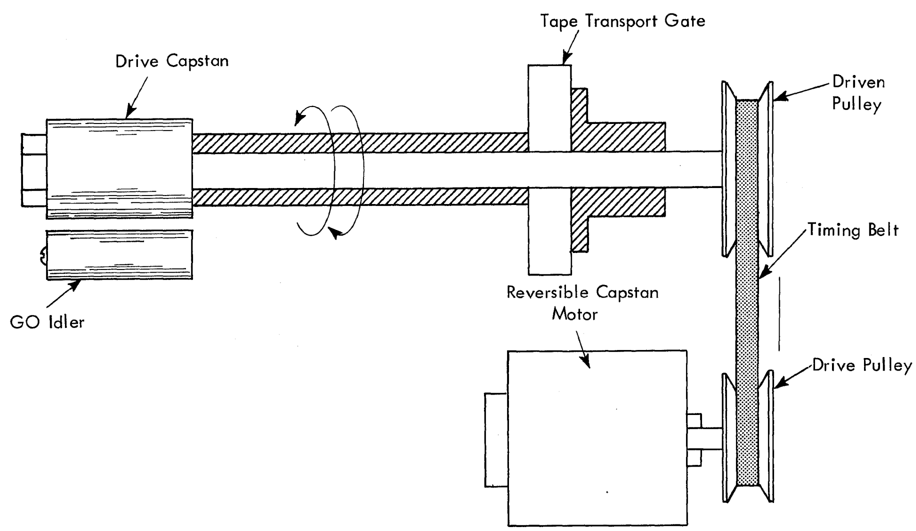


Figure 14. Capstan Drive Assembly

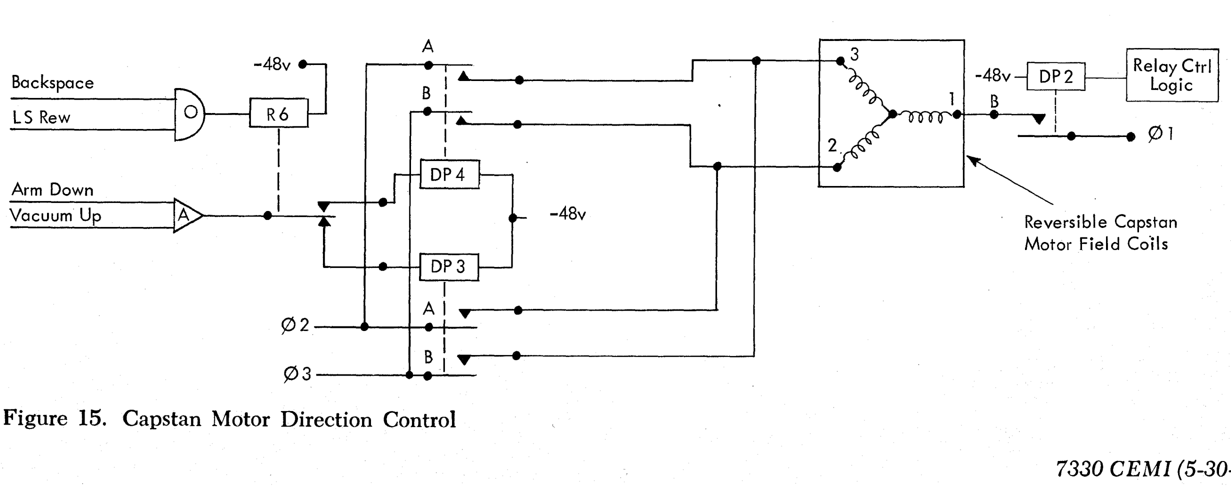


Figure 15. Capstan Motor Direction Control

is connected to one of the AC input lines. To reverse the rotation of the motor, two of the field coils must be reversed with two of the AC input lines.

Relays DP3 and DP4 are used for controlling the line reversal, thus the direction of rotation of the motor. If the motor is to rotate in a direction in which tape is to move forward, then relay DP3 is energized and relay DP4 is de-energized. For tape to move in a backward direction, relay DP4 is energized and relay DP3 is de-energized. If DP3 is energized, its contacts connect AC input lines 2 and 3 to field coils 2 and 3 respectively. The motor can now rotate in a direction for tape forward. If relay DP4 is energized, its contacts connect AC input lines 2 and 3 to field coils 3 and 2, respectively. The motor can now rotate in a direction for tape backward. Figure 15 shows this control logic.

The state of relays DP3 and DP4 is controlled by relay 6. Relay 6 is energized on a low-speed rewind or a backspace operation and, if energized, DP4 can be energized. Relay 6 is de-energized on a high-speed rewind or read-write operation. The conditions that actually determine whether DP3 or DP4 are energized are the two conditions that are gated to the make-brake contacts of relay 6, "arm down" and "vacuum up." The only time both conditions are not present at the same time is during a high-speed rewind.

GO-STOP

Tape is moved by squeezing it against the drive capstan. Tape motion is stopped by releasing pressure against the drive capstan and by quickly squeezing the tape against a stop capstan. This operation is performed by two pinch rollers and a rocker arm assembly operated by a moving coil actuator.

The actuator consists of a lightweight coil suspended in a powerful permanent magnetic field (Figure 16).

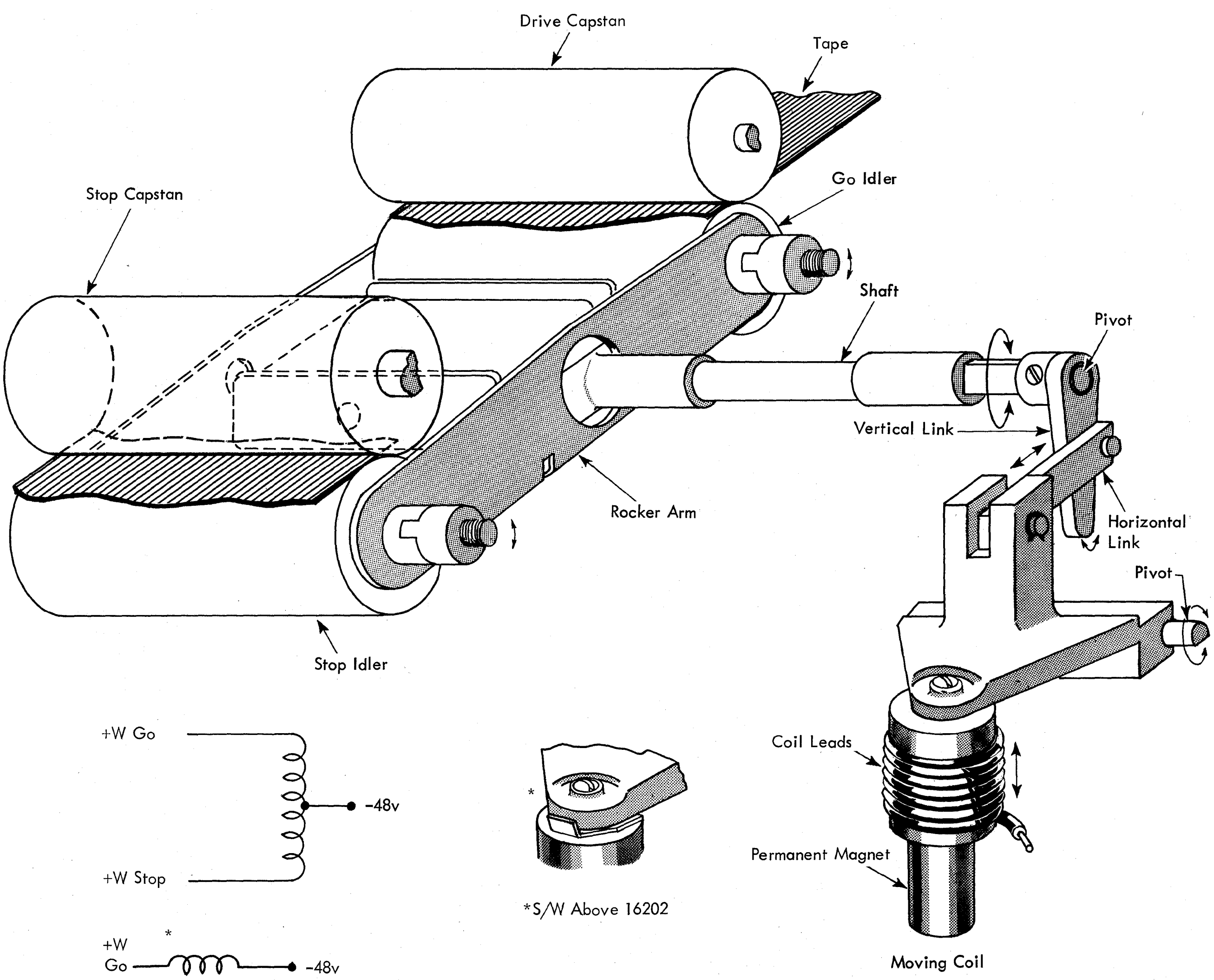


Figure 16. Tape Motion Control

To produce tape movement (GO), an upward movement of the moving coil is required. The upward movement of the coil causes the horizontal link to move to the right. This causes the vertical link to move to the right. The movement of the vertical link is actually in a counterclockwise rotation. The pivot point of the vertical link causes the rocker arm shaft to rotate in a counterclockwise direction. This rotation causes the rocker arm assembly to rotate in a counterclockwise direction which results in pinching tape between the GO idler and the rotating drive capstan. The direction of rotation of the drive capstan determines the direction of tape movement.

To stop tape (STOP), a downward movement of the moving coil is required. This downward movement causes the horizontal link to move toward the left which results in the vertical link moving toward the left. The actual movement of the vertical link is in a clockwise direction. The pivot point of the vertical link causes the rocker arm shaft to rotate in a clockwise rotaton which causes the rocker arm assembly to move clockwise. This movement causes the tape to be pinched between the stop capstan and the stop idler, thus stopping tape movement.

There are two different type coils used in the 7330 tape unit. The tape units with S/N below 16203 use the centertapped type as shown in Figure 16. The non-centertapped type coil, also shown in Figure 16, is used on machines with S/N above 16202. The two types of coil use the principle of electrically generated magnetic fields to produce the GO and STOP positions of the moving coil.

S/N BELOW 16202

To produce the upward movement of the moving coil (GO), a + W level is applied to one end of the centertapped coil. This allows current to flow in such a direction that a magnetic field electrically generated opposes the magnetic field resulting from the permanent magnet. The opposition allows the moving coil to move up, thus causing tape movement.

To cause the moving coil to move downward, +W is applied to the other end of the centertapped coil. A current flows in such a direction that a magnetic field is produced. This field is attracted to the field of the permanent magnet, which allows the moving coil to move downward to stop tape.

S/N ABOVE 16202

The second type of coil used on machines above S/N 16202 has current flow in only one direction. This current flow generates the magnetic field to move the coil upward for tape movement. Note that there is no +W stop signal as in the centertapped type coil, to allow the coil to move downward for stopping tape. To allow the moving coil to move downward, a stop slug is used. This stop slug is a permanent magnet. To produce the downward motion of the coil, the magnetic field of the stop slug is attracted to the field of the permanent magnet.

Since the two fields are always present because of the stop slug and the permanent magnet, the moving coil tends to be pulled down at all times. If it is desired to move tape, the coil is energized and the magnetic field produced is stronger than the field caused by the stop slug; hence the coil moves upward. If it is desired to stop tape, the +W GO signal becomes inactive and the electrically produced magnetic field collapses. The magnetic stop slug allows the moving coil to be moved downward to stop tape.

Reel Drive and Vacuum Column Control

The tape reels are mounted on hubs protruding from the upper front of the tape unit. Each hub contains a rubber rim that expands and grips the reel securely when the knob in the center of the hub is tightened.

The reels are driven by individual DC motors through timing belts. Each reel shaft is equipped with a magnetic brake that is energized during the intervals when the reel drive motor is not operating.

Associated with each reel is a vacuum column and a pressure sensitive switch that controls start and stop of the reel drive motor. Vacuum in the columns also provides tension to hold the tape in contact with the read-write head and to prevent buckling during the starting and stopping of tape motion. Location of the reel drive motors is shown in the figure entitled "Tape Transport—Rear View" in the 7330 CE Reference Manual.

VACUUM COLUMNS AND PRESSURE SENSITIVE SWITCHES

The vacuum columns are provided with hinged glass doors that open for easy cleaning. The inside dimension between the hinged door and the back of the column is just sufficient to permit the passage of ½ inch wide magnetic tape. One end of the column is attached to a vacuum pump; the other end is open to permit a tape loop to enter the column.

A pressure sensitive switch assembly is attached by plastic tubing to an opening near the midpoint of the vacuum column. This pressure sensitive vacuum column switch consists of a resilient diaphragm and two sets of contacts. When atmospheric pressure is present on both sides of the diaphragm, the diaphragm is in the position shown in the figure entitled "Vacuum Column Switch" in the 7330 CE Reference Manual, and the contacts are in their normal position.

When the tape loop is positioned between the center and the mouth of the column, pressure is reduced on one side of the diaphragm causing it to move in a direction to transfer the switch contacts. Two sets of contacts are used in parallel for added reliability. The switch contacts are used in logic circuits to control starting and stopping of the tape reels.

The vacuum column and switch operate as follows: The vacuum pump causes air to rush into the mouth of the column and pass out the opposite end. When a loop of tape enters the column, the flow of air is restricted causing a partial vacuum within the column. The reduced pressure causes the diaphragm to move and transfer the switch contacts. If the tape loop moves farther into the column until it passes the hole located near the midpoint of the column, the diaphragm is again exposed to atmospheric pressure and the switch contacts return to normal. This action takes place because the vacuum exists only between the tape loop and the exhaust end of the column.

Note that the pressure sensitive switch assembly detects which half of the column the tape loop is in and thus can be used to control the reel drive motor.

When tape moves forward, it is pulled from the left column and is drawn into the right column. The left column switch causes the left reel (file reel) to turn clockwise whenever tape is drawn more than halfway out of the column. This action replenishes the tape in the left column.

When sufficient tape enters the right vacuum column so that the loop is between the center of the column and the exhaust end, the right column switch contacts return to normal, causing the right reel (machine reel) to rotate clockwise. This action removes tape from the right column until the diaphragm is again moved by vacuum, transferring the contacts and stopping the reel. Note that during the operation just described, the tape reels are under complete control of the vacuum column switches.

VACUUM SYSTEM AND VACUUM-UP SWITCHES

Vacuum is provided by a pump consisting of a motor and fan arrangement similar to the type found in commercial vacuum cleaners. Each vacuum column is connected to the vacuum pump by an arrangement of flexible plastic hoses and a tee connection as shown in the figure entitled "Tape Transport—Rear View" in the 7330 CE Reference Manual.

Two pressure sensitive switches, identical to the vacuum column switches, are employed to sense the presence of tape in each column. These switches are called the left and right vacuum-up switches. The function of these switches is not the same as the vacuum column switches. The vacuum-up switches (Figure 3) signal the presence of tape in the columns and pick a relay to control logic functions in the tape unit. The vacuum column switches actually sense the position of tape within the columns and control the reel drive motors.

TAPE REEL BRAKING

The tape reel brakes are shown in the figure entitled "Tape Reel Brakes" in the 7330 CE Reference Manual. The magnetic coil and armature are used to stop the rotation of the tape reel. The armature has a left and right movement on the hub due to the flexible leaf spring and rubber retainer. When the coil is energized, it creates a magnetic field which attracts the armature. The armature moves to the left and touches the brake housing. Friction between the surfaces of the housing and the armature is used to stop the tape reel rotation.

Part of the figure entitled "Tape Reel Motor and Brake Circuit" shows the reel brake circuits. The −48 VDC on one end of the brake coil completes the brake circuit. Whenever DP1 is energized (rewind arm is down), the −48 VDC is applied directly to the coils. When DP2 is de-energized (when the tape unit is not loaded), the operator can release the tape reel brakes by use of the reel release key when he wants to manually wind tape on the reels. Note that the figure shows how the brake signals are generated and how they are applied to the brake coil.

TAPE REEL MOTORS

Part of the figure entitled "Tape Reel Motor and Brake Circuit" in the 7330 CE Reference Manual shows a simplified diagram of the motor circuits. A chart accompanies the diagram to show what relays are energized to allow the reels to rotate in the direction required for a particular operation. Both reels turn clockwise for a normal read-write operation; counterclockwise, for a high-speed or low-speed rewind or a backspace operation. For a backspace or low-speed rewind, R5 is energized, allowing the control signals for the tape reel motors to be returned to −48 VDC through the commutator for a counterclockwise direction. For a normal read-write operation, R5 is de-energized. This allows the control signals to be returned to −48 VDC through the commutator for a clockwise direction. These directions are denoted by arrows on both reels.

For a high-speed rewind, R2 and R1 are energized as denoted by the table in the figure. This allows only the left tape reel to rotate in a counterclockwise direction. Note that both field coils are energized because DP2 is energized. At the beginning of a high-speed rewind, the halfwave DC waveform is utilized to pull tape slowly from the columns for 6 seconds, delay contacts 2 (AL) close, and tape is rewound at an intermediate speed. Three seconds later delay contacts 1 (AU) close, and the left reel rewinds tape at full speed.

Photosensing

LOAD POINT

The load point is a small reflective spot (3/16 inch x 1 inch), placed on the plastic side of the tape (Figure 17). The reflective spot is placed 1/32 inch from the front edge and 10 feet from the physical beginning of the tape and locates the beginning of the usable portion of the tape. The ten feet of tape preceding the spot is for threading the machine reel.

During a rewind operation, the load point reflective spot is sensed as it passes under the photocell and light source (Figure 17).

Light from the front lamp is reflected from the load point to the photocell directly to the left of it. This action causes the photocell to conduct and, through suitable logic circuits, picks relay 107, stopping tape motion.

END-OF-TAPE

The end of the usable portion of a reel of tape is indicated by a reflective spot about 18 feet from the physical end of the tape. This spot is identical to the one used for load point, but is placed 1/32 inch from the rear edge of tape.

The rear lamp and photocell are used to sense the end-of-tape reflective spot (Figure 17).

TAPE BREAK

To detect a tape break, the 7330 depends on light reflected off the read-write head. The load point photocell is used in this case. The lamp projects light to the read-write head and the load point photocell detects the reflected light. The load point logic circuits pick R107, thus stopping the tape reels.

File Protection

A file protection device is provided in the tape unit to prevent accidental writing on master tapes. The file protection system operates as follows: A groove is molded in the rear side of each tape reel. A plastic ring may be placed in this groove. If the ring is not in the groove of the file reel, writing is suppressed but reading is allowed. If the ring is in the groove of the file reel, writing is permitted.

The presence of the ring is sensed by a pin that protrudes from the front of the tape unit above the file reel hub. The pin is connected to the armature of a duo relay mounted behind the panel. See the figure entitled "Tape Transport—Rear View" in the 7330 CE Reference Manual. If a ring is in the groove

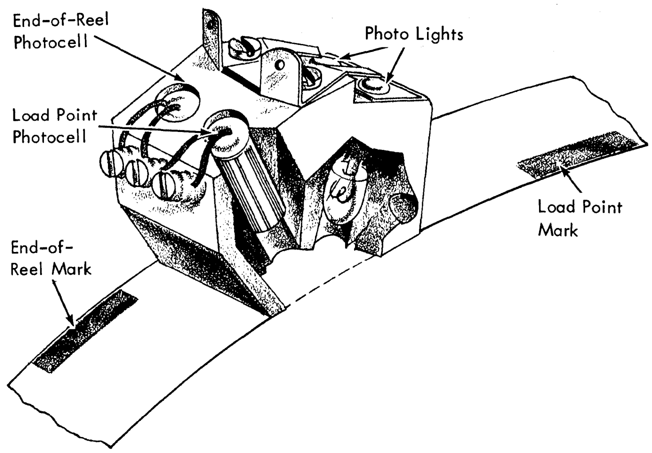


Figure 17. Photocell Sensing

of the file reel, the pin is pushed to the rear, moving the relay armature. This action closes the relay contacts, energizing the relay through its own contacts. When the relay is energized, the sensing pin is pulled clear of the plastic ring so that it does not drag as the reel turns. If the groove in the reel is empty, the pin is not actuated, the relay is not energized, and writing is prevented.

The pick circuit for the file protect relay contains additional relay points that de-energize the relay and allow the sensing pin to protrude whenever the tape unit is in the unload status.

Linkage Assembly

The following explanation applies to the figure entitled "Moving Coil and Rewind Arm Linkages" in the 7330 CE Reference Manual. The figure displays the rear of the tape transport and shows all linkages. Since the figure is a rear view, the right and left rewind arms are shown in dotted lines. The left rewind arm can be raised in one of two ways; manually or electrically with the arm raising solenoid. The upper and lower travel of the arm is limited by two stop screws as shown. These screws are adjustable.

When the left rewind arm is raised, the right rewind arm is raised also through a spur gear arrangement as shown. The top spur gear is connected to the right rewind arm. As the left rewind arm is raised, the top spur gear rotates counterclockwise, causing the lower spur gear to rotate in a clockwise direction thus raising the right rewind arm.

As the arms are raised, the vertical link connected to the pawl is pushed down. This causes the pawl to rotate in a clockwise rotation because of its center pivot and to engage the trip lever stud which is shown as a dotted circle. The purpose of the pawl engaged in the trip lever stud is to keep the rocker arm assembly idlers away from both capstans. This is necessary on a high-speed rewind in which tape should not be held against either capstan. The rocker arm centering device is adjusted to attain the even gap between the idlers and their respective capstans when rewind arm is up.

When the rewind arms are lowered, the vertical link connected to the pawl is pulled up which in turn rotates the pawl in a counterclockwise direction. This causes the pawl to disengage the trip lever stud and the moving coil can now travel its full limit for starting and stopping tape.

With the arms lowered, the dashpot becomes effective to ease the lowering of the arms so as not to hit the read-write head. With both arms down, the tape is now held snugly against the read-write head since both arm idlers are below the right and left tape guides as shown in Figure 18.

Tape Cleaner Blade

Loose oxide and particles of dirt eventually cling to the recording surface of magnetic tape. This tends to decrease the reliability of reading and writing on tape. To overcome this effectively, a tape cleaner blade is mounted in the left vacuum column.

The blade is a finely polished piece of metal with holes punched in it. The holes are used to catch the oxide and dirt. The tape rides across the surface of the blade so that it can clean the recording surface of the tape. The blade is mounted in the left vacuum column so that the recording surface can be cleaned before it reaches the read-write head. The figure entitled "Tape Cleaner Blade" in the 7330 CE Reference Manual shows the top and side views of the blade.

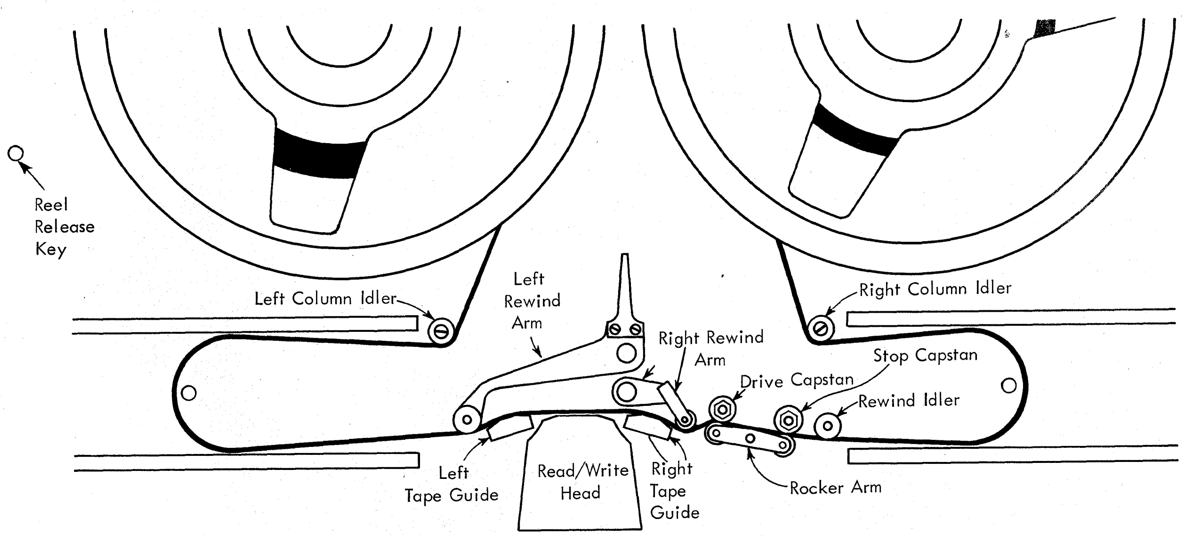


Figure 18. Tape Path for 7330

This section describes the manual operations associated with loading, unloading and rewinding tape. All page numbers refer to the 7330 tape unit Systems. Note that Systems 73.50.01 through 73.50.20 are divided into sections labeled horizontally by alphabetic characters and vertically by numbers. A letter-number combination is used to locate a particular relay or contact on a Systems page.

Low-Speed Rewind

This section covers the manual operations of threading tape and the electrical operations required to rewind tape to the load point reflective spot. Figure 18 shows the tape path of the 7330.

To load the tape unit, place a reel of tape on the file reel hub (left hub) and securely tighten the knob. If a write operation is to be performed, a plastic ring must be inserted in the reel before mounting. Hold the reel release key depressed, thread tape over the head assembly, and wind tape on the machine reel (right reel) until the load point reflective spot appears well to the right of the head assembly.

Lower the rewind arm by moving the rewind lever to the left. The reel release key must be held depressed to de-energize the reel brakes, otherwise tape may be damaged by excessive tension when the rewind arm is lowered.

Release the reel release key and allow vacuum to come up. Press the reel release key again and turn reels manually, allowing vacuum to pull the tape loops into the vacuum columns. Release the reel release key. This method of loading tape and keeping excess slack out of the tape minimizes the possibility of contaminating tape with foreign particles.

Reseat the rewind arm, check that the load point reflective spot is positioned to the right of the head assembly. Close the glass door and depress the low-speed rewind key. Tape will rewind at a speed of 36 inches per second until the load point relay is picked. The start key must then be pressed to put the tape unit in ready status.

A low-speed rewind operation can also be initiated by a program instruction from a computer.

POWER ON AND LOW-SPEED REWIND SEQUENCE

Table 1 is a sequential listing of a low-speed rewind operation. The same information is provided in the figure entitled "Power On and Low-Speed Rewind" in the 7330 CE Reference Manual.

The figure entitled "Power On and Low-Speed Rewind" in the CE Reference Manual shows the sequence of events, from initial turn on of power to the instant the tape unit is ready for operation. When system power is turned on, the 240v contactor is energized if the master power switch is on and the ±6 ±12 VDC circuit breakers are on. The contactor, when energized, closes the three legs of the AC power input. This in turn brings up the AC and DC power. The AC power turns on the blower motors and the DC power picks R3 if the TI and LP lamps are good. R106 is picked because the rewind arm is up. R111 is energized because there is no vacuum at this point in time; therefore, we must return to the load point. The tape reel brakes are energized immediately through DP2 contacts. When the reel release key is pressed, the tape reel brakes are de-energized so that the tape reels can be rotated manually while loading tape.

When the rewind arm is lowered, R106 de-energizes, energizing DP1. DP1 only allows the vacuum motor to rotate. When vacuum is up, R114 is energized through the vacuum pressure switches. Since R114 is energized and R106 is de-energized, DP3 and DP2 are energized. DP3 allows the reversible capstan motor to rotate in the forward direction and DP2 supplies power to the tape reel motor field coils.

The tape unit door is closed and the low-speed rewind key is pressed. R102 is energized which de-energizes R111. R102 activates "−W machine rewind" and results in "−S backward status" and "+W backward pick." The "+W backward pick" will energize R5 and R6. "−W machine rewind" activates the 45 ms ss to energize the tape reel brakes while R5 is energizing. With R6 energized in the backward status, DP4 can be energized for the backward direction of tape. R5 is used to control the direction of the tape reel motors.

When the load point is sensed on machines with S/N below 16203, the 64 ms single-shot is turned on. When the single-shot times out, the 90 ms turns on, which energizes and holds R107. When the load point is sensed on machines with S/N above 16202, the 64 ms single-shot is turned on which turns on the load point latch. R107 is energized when the 64 ms single-shot times out and the latch holds the relay energized. When R102 de-energizes as a result of R107 energizing, "−W machine rewind" is de-activated, allowing the reel brakes to energize for 45 ms, as "−S backward status" and "+W backward pick" fall off. The de-activation of "+W backward pick" allows R5, R6, and DP4 to de-energize.

When R6 de-energizes, the DP3 is energized allowing the capstan motor to rotate for tape forward. The machine now waits until the GO signal from the outside system is active. The GO signal de-energizes R107 by tripping the latch type relay on machines below S/N 16203 and turning off the load point latch on machines above S/N 16202.

High-Speed Rewind

After a reel of tape is read or written, the bulk of the tape is on the machine reel and must be rewound onto the file reel. The purpose of high-speed rewind is to accomplish this objective with minimum lost time. The operation can be initiated manually from the operator's panel or electronically by a program instruction in the computer system with which the tape unit is operating.

In either case, the rewind arm rises, the file reel turns slowly to remove tape from the vacuum columns. Shortly after the slack is removed from tape, the file reel speeds up to begin rewinding tape. After a further time delay, the file reel speed is again increased to allow rewinding at full speed. Rewind speed is increased in steps to prevent excessive stress on the tape while it is accelerating. High-speed rewind ends when the load point reflective spot is sensed. At this time, power is removed from the file reel drive motor and both reel brakes are energized. If the reel of tape is to be removed, the operator can now press the reel release key and manually wind the remaining tape onto the file reel. If the tape is to be re-run, the machine reel must be rotated to position the load point spot to the right of the head assembly. A load operation must then be performed as outlined in the previous operation.

HIGH-SPEED REWIND SEQUENCE

Assume that the tape unit is loaded and in ready status and that a high-speed rewind is to be initiated by the operator. See Table 2. The operator must first press the reset key to take the tape unit out of ready status. Next, the high-speed rewind key is pressed (Systems 73.50.01). A sequence chart for high-speed rewind is shown in the figure entitled "High-Speed Rewind" in the 7330 CE Reference Manual.

The figure entitled "High-Speed Rewind" in the 7330 CE Reference Manual shows the sequence of events for a high-speed rewind operation. The status of the machine normally preceding the operation would be that it is ready (R101 is picked); the arm is down (R106 is de-energized) and tape is loaded (DP2 is picked); vacuum is up (R114 is picked); the photocell lamps are lit (R3 is picked).

When the high-speed rewind key is pressed, R110 picks. R110 then holds through R110-1 points. Through R110-5 points, R4 is picked to energize the arm solenoid and raise the arm. When the arm is raised, the arm switch transfers. The n/c points of the arm switch opens and breaks the circuit to the arm solenoid. The n/o points of the arm switch close and pick R106. R106 remains energized as long as the arm is raised. Until R106 picks, DP3 remains energized to supply current to the capstan motor. When R106 picks, R106-3 n/c points open to de-energize DP3 and stop the capstan motor. At the same time, R106-4 n/o points activate the −W arm up signal, and R106-6 n/o points close to complete a circuit through R110-4 n/o points and pick R104. Then, R1 and R2 are picked through the R104-1 n/o points. When R1 AL n/o points close, the left reel motor, at reduced torque, starts to remove tape from the vacuum columns. R2 points condition the right reel motor to provide dynamic braking during HS rewind. Current is supplied to the field coils of the right reel motor while a load resistor is placed across the armature; the right reel motor acts as a generator and maintains slight tension on the tape as it winds from the right reel to the left reel. In addition, the R2 AU n/o points activate the −W HS rewind signal line to TAU.

The left reel motor rotates slowly as tape is removed from the right vacuum column, and the right vacuum switch opens (left vacuum column switch is bypassed by R110-2 n/o points). When the right vacuum column switch opens, R114 drops; R114-3 n/o points open and drop R4. R4 AU n/o points then open to de-energize DP1 and stop the vacuum motor. When R114-2 n/c points close, R111 is picked to prevent ready status from activating until a manual load rewind is performed. When DP 1B n/c points close, the timer motor(s) start. About 6 seconds after the timer motors(s) start, time-delay 2 switch closes and establishes circuits to accelerate the left reel motor to intermediate speed. About 3 seconds later (9 seconds after the timer motor(s) start), time-delay 1 switch closes and provides full power to the left reel motor. The left reel accelerates and runs at high-speed until the load-point spot passes the photo-sensing area.

When the load point spot is detected on machines below S/N 16203, the +W LP signal becomes active and turns on the 90 ms single-shot. This immediately energizes R107 and is held energized for 90 ms. When the load point spot is detected on machines above S/N 16202, the load point signal turns on the 64 ms single-shot which immediately turns on the load point latch, energizing R107 immediately.

When R107 energizes, R110 is de-energized which in turn de-energizes R104, thus allowing R1 to de-energize, and finally de-energizing R2. When R110 is de-energized, R107 is de-energized and DP2 falls off. DP2 allows the tape reel brakes to be energized, thus ending a high-speed rewind.

Systems Page and Location	Sequence of Operations	Conditions	Remarks
73.50.01 (2B)	Rewind arm switch opens	Rewind arm lever moved to left	Arm down
73.50.01 (2B)	Drop R106	Rewind arm switch open	
73.50.05 (3B)	Pick DP1	R106 de-energized	Turn on vacuum motor
73.50.20 (9B)	Vacuum motor operate	DP1 energized	Vacuum comes up
73.50.05 (4B)	Pick R114	Left and right machine vacuum up switches close when vacuum is up and tape is in both columns.	Vacuum is up
73.50.05 (35)	Pick DP2	R114 picked	Tape loaded
73.50.05 (3B)	Pick DP3	R106 de-energized; R114 picked	Capstan motor rotates for tape forward
73.50.10 (5B)	"−W arm up" becomes inactive	R106 de-energized	Conditions reel drive logic circuits.
73.50.01 (1B)	Depress low-speed rewind key.	Tape unit must not be in ready status.	
73.50.01 (1B)	Pick R102	R114 energized and low-speed rewind key depressed.	
73.50.10 (5B)	"−W machine rewind" active	R102 picked	Conditions logic circuits for rewind operation.
73.20.15	"+W bkwd pick"	"−W machine rewind" active	
73.20.15	Trigger 45 ms single-shot	"−W machine rewind" active	Applies brake to both reels for 45 ms.
73.50.05 (4B)	Pick R5, R6	"+W backward pick"	Conditions reel motors to turn reels counterclockwise.
73.50.01	Pick DP4, drop DP3	R6 energized	Capstan motor rotates for tape backward.
**73.20.05	Trigger 200 ms single-shot	"−W machine rewind" active	Prevents "go" from coming up until tape has had time to adjust in columns.
*73.50.10	Activate R-C network	R102 picked	Replaces 200 ms single-shot.
73.20.05	Activate "go"	When 200 ms single-shot turns off or R-C network discharges	Tape moves backward toward load point.
73.20.10	Trigger 64 ms single-shot	Load point reflective spot passes under photocell	Permits load point spot to move to left of head before dropping "go."
*73.20.10	Turn on load point latch	64 ms single-shot turns on	Latch holds R107.
**73.20.10	Trigger 90 ms single-shot	When 64 ms single-shot turns off	90 ms single-shot duration allows time to latch pick load point relay.
73.20.10	Activate "+W load point pick"	When 90 ms single-shot turns on	
73.50.01	Pick R107 load point relay	"+W load point" active.	
73.20.05	"Go" becomes inactive	R107 picked	Tape motion stops.
73.50.01	Drop R102	When R107 picks	
73.50.10	"−W mach rewind" becomes inactive	R102 de-energized	
73.20.15	"+W bkwd pick" becomes inactive	Machine rewind inactive	
73.50.05	Drop R5, R6	"+W bkwd pick" inactive	Reels return to forward status.
73.50.01	Pick DP3	R6 de-energized	Capstan motor rotates for tape forward.
†73.20.10	3.5 ms single-shot triggered	When "go" becomes inactive	Delays activating stop line for 3.5 ms to prevent mechanical resonance.
†73.20.10	"−S stop" becomes active	When 3.5 ms single-shot turns off	Moving coil actuator energized in stop position.

Note: Instead of depressing the low-speed rewind key to initiate the rewind operation, "Rewind Call" (Systems 73.20.01) from an external source can be used. "Rewind Call" is AND'ed with "select and ready" and "not at load point" to activate "rewind pick." When active, this line picks relay 102 (Systems 73.50.01) to start a rewind.

*Only on machines above S/N 16202
**Only on machines below S/N 16203
†Not used on machines above SN 16203. Magnetic stop slug used to stop tape.

Table 1. Low-Speed Rewind Operation

SYSTEMS PAGE AND LOCATION	SEQUENCE OF OPERATIONS	CONDITIONS	REMARKS
73.50.01 (1B)	Drop R101	Reset key Depressed	Machine must not be ready and not at load point to perform HS Rewind.
73.50.01 (1B)	Pick R110	High speed rewind key depressed; tape unit not in ready status	R110 holds through its own R110-1 points.
73.50.05 (4B)	Pick R4	R110 picked and machine vacuum up	To energize arm solenoid.
73.50.15 (8B)	Arm solenoid energized	R4 picked and arm down	Arm solenoid raises rewind arm.
73.50.01 (2B)	Pick R106	Arm switch closed (n/o points)	Arm switch n/o points close when rewind arm is raised.
73.50.15 (8B)	Arm solenoid de-energized	Arm switch opens n/c points	Arm switch n/c points open when rewind arm is raised.
73.50.01 (2B)	Drop DP3	R106 energized	Prevents capstan motor from turning.
73.50.10 (5A)	Activate −W arm up	R106-4 n/o closed	
73.50.01 (1B)	Pick R104	R110 and R106 picked	
73.50.05 (4B)	Pick R1	R104-1 n/o points closed	Left reel motor operates with reduced power; reel moves slowly — removing tape from columns.
73.50.05 (4B)	Pick R2	R104-1 n/o points closed	R2 contacts condition right reel motor to provide dynamic braking.
73.50.10 (5A)	Activate −W HS rewind	R2 AU n/o points closed	
73.50.05 (4B)	Drop R114	Right machine vacuum switch opens	Tape has been removed from both columns.
73.50.05 (4B)	Drop R4	R114-3 n/o points open	
73.50.05 (3B)	Drop DP1	R4 AU n/o points open	Vacuum motor stops and timer motor(s) start.
73.50.05 (3B)	Pick R111	R114-2 n/c points close	When picked, R111 prevents machine ready from activating until a load rewind is performed.
73.50.20 (11B)	Energize timer motor(s)	DP 1B n/c points close	
73.50.15 (7B)	Time delay 2 (AL)* closes	Switch closes about 6 sec after motor starts	Left reel speed increased to intermediate high speed.
73.50.15 (7B)	Time delay 1 (AU)* closes	Switch closes about 9 sec after motor starts	Full power applied to left reel motor; tape moves at high speed (220 ips avg).
73.50.01 (2B)	Pick R107	+W Load point pick becomes active when load point marker is sensed	To end rewind.
73.50.01 (1B)	Drop R110	R107-2 n/c points open	
73.50.01 (1B)	Drop R104	R110-4 n/o points open	
73.50.05 (3B)	Drop DP2	R110-3 n/o points open	DP 2A points remove power from left reel motor field coil and applies brake to both reels.
73.50.01 (2B)	Latch trip R107	R110-4 n/c points close	Machines below SN 16203.
73.50.01 (2B)	Drop R107	Load point latch is turned off when R110 drops	Machines above SN 16202.

NOTE: The purpose of picking R111 at the beginning of a high speed rewind is to force the operator to perform a load rewind operation before "mechanical ready" can be activated. This action assures that the load point reflective spot is properly positioned before the start of a read or write operation.

*Machines above SN 16202 use a single timer motor with two sets of contacts. The AL points correspond to the 6 sec. timer #2, and the AU points to the 9 sec. timer #1.

Table 2. High-Speed Rewind Operation

Lines

"Select" (73.20.20): A select switch on the operator's panel allows the tape unit to be connected to any one of ten select lines from the tape control unit. The tape unit can be given any one of ten addresses (0 through 9) as determined by the setting of the select switch. "+S Select" is active only when the line to which the select switch is set is at an up level. "+S Select" is AND'ed with other logic lines within the tape unit to assure that only the selected tape unit responds to instructions from the control unit.

"Machine Ready" (73.50.10): When active, the "machine ready" line indicates that the tape unit is mechanically and electrically ready for operation. This line is active under the following conditions:

1. Vacuum is up and tape is in the columns, (R114 picked).
2. Rewind arm is down (rewind arm switch open, R106 de-energized).
3. Door interlock contact closed.
4. R111 latch tripped (a low-speed rewind operation must have been performed previously).
5. Start key has been pressed (R101 picked).

"Select and Ready" (73.20.01): This line is the result of AND'ing "Select" and "Machine Ready." The line is used to condition logic circuits in the tape unit and is sent to the external control unit as a response.

"Machine Rewind" (73.20.01): This line is active whenever the tape unit is in rewind status (R102 picked).

"Hi Density" (73.20.01): This line is under control of the density change switch (Systems 73.30.10) and is active when the switch is set to the high-density position. The line is used as a response to the control unit to indicate that data are to be written at high density.

"+W *Load Point" (73.20.01):* Active whenever the load point relay is latch picked, this line is used to prevent rewinding tape if it is already at load point. The line also causes the control unit to provide the proper load point skip when starting from load point.

"Rewind Call" (73.20.01): When activated, this line causes the tape unit to go into backward status, which affects control of the tape reels and direction of the drive capstan.

"Set Read" (73.20.05): When activated from the control unit, this line causes the read-write status latch to turn on, putting the tape unit in condition for a read operation.

"Set Write" (73.20.05): Activating this line from the control unit turns off the read-write status latch and puts the tape unit in condition to perform a write operation.

"−*W File Protect" (73.20.05):* This line is active whenever the file reel does not contain a plastic file protect ring. Without the plastic ring, writing is suppressed. "−W File Protect" is also active during rewind (R102 picked) or when the tape unit is not in ready status (R102 de-energized).

"+*S Go" (73.20.05):* This line is activated by the control unit to cause tape motion. The "go" line becoming active actually produces three "go" lines "go A," "go B" and "go C." These lines are required to provide smooth starting of tape. The associated logic circuits are discussed later in this section.

"Stop" (73.20.05): "Stop" is activated 3.5 ms after "go" becomes inactive. When the stop line is active, tape is held against the stop capstan to prevent tape movement.

"Rewind Unload Call" (73.20.05): This line is activated from the external control unit to cause the tape unit to unload tape from the vacuum columns and rewind to load point at high speed. This instruction performs the same function as the high-speed rewind key. Note that the tape unit must be "selected" in order to respond to the "rewind unload" command.

Writing on Tape (One Bit Position)

Review the method of writing on tape. Recall that tape is magnetically saturated by passing current through the write coil in either direction. Direction of current flow in the write coil is determined by the status of the write trigger. Current always flows through the write coil in one direction or the other when the tape unit is in write status and the "not file protect" line is at a +12 volt level.

Figure 19 is a simplified diagram of the write circuit for one bit position. The on-side and off-side outputs of the write trigger are fed to the two inputs of a head driver. The loads for this driver are the two halves of the write coil. One side of the head driver is cut off while current flows in the other side. The side of the head driver that conducts is determined by the status of the write trigger (on or off). Current flow in the

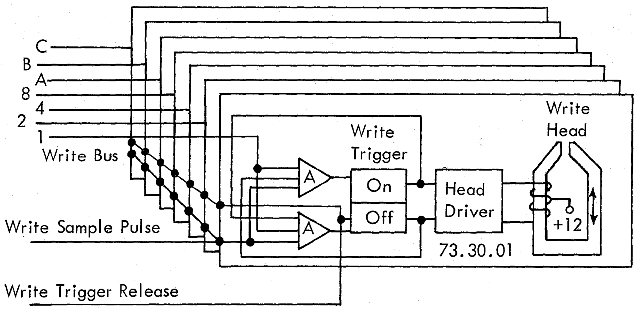


Figure 19. Write Circuit – One of Seven Positions

write coil, therefore, is through the conducting side of the head driver to the center tap of the coil (+12v).

Writing a bit on tape consists of flipping the write trigger, which switches conduction to the other side of the head driver and its associated half of the write coil. This action reverses the direction of the magnetic flux cutting the tape. The bit is written on tape at the point where the reversal of flux occurs.

The remainder of the write operation is concerned with the action of flipping the write trigger to write a bit.

A character is placed on the write bus (seven lines), by raising the proper combination of lines to +S level. Each line of the write bus connects to the gate input of its associated write trigger.

When a particular line is at +S level, the associated write trigger is conditioned so that it can be flipped by a sample pulse applied to its binary input. Thus, the trigger will be turned on if it was off or it will be turned off if it was on. The sample pulse is generated in the external control unit and one pulse is sent for each character to be written. If a bit is not to be written in a particular track, the write bus line for that track will be at −S level. The associated write trigger will not have its input gated and, even though a sample pulse is applied to its binary input, the trigger will not flip.

Delay Line (73.30.01.3)

When a character is written on tape, the bits must be in a straight line across the tape. Any deviation from this pattern is called skew and must be held to a minimum.

There are two methods of obtaining minimum skew. One is by mechanical adjustment to position the head assembly parallel to the tape. The remaining skew is due to slight misalignment of the individual write coils that make up the write head assembly and to slight delays in the flip time of the write triggers and their associated circuits. The remaining skew is adjusted to a minimum by inserting small increments of delay in the sample pulse circuit for those tracks that require it. By this means the write triggers are flipped at slightly different intervals that compensate for the delays and misalignment previously mentioned. The result is that characters are written with their bits in straight line.

Increments of delay are obtained from a four-section delay line. A sample pulse driver is used between each section of the delay line to maintain the shape of the write sample pulse. Outputs are available directly from the sample pulse line or from any of the four delay sections.

Write Echo Pulse (*73.30.01.2*):A pulse is provided at the output of the head driver each time conduction is switched from one side to the other. The echo output lines from the seven head drivers are OR'ed together. The output of this OR circuit feeds the input to a 9 μs single-shot. Thus, a bit written in any track will trigger the single-shot and produce a 9 μs echo pulse. This pulse is sent back to the control unit as an indication that a character was written. The 9 μs single-shot is eliminated on new production machines with serial number 14883 and above.

Writing a Check Character (LRCC) (73.30.01): Because the write trigger for each track is turned alternately on and off to write 1 bits, the state of the trigger at the end of a block of information indicates whether an odd or even number of 1's have been written. If an even number of 1's have been written, the write trigger is off; if an odd number have been written, the write trigger is on. After a block of information is written, all of the write triggers receive a reset pulse. Only the triggers that were on are turned off, thereby writing bits on the tape. The character written, as a result of resetting the write triggers, is called longitudinal redundancy check character (LRCC). The LRCC is used during reading of this block of information from tape to detect the dropping or picking up of bits in any track.

A "write trigger release" line is routed to the tape unit from the external control. This line is normally at +S level. When it drops to a −6v level, the write triggers are reset.

Tape Reel Control Logic

The complete control logic to start and stop the tape reels is given in Systems 73.29.15. Part of the figure entitled "Tape Reel Brake and Motor Circuit" in the CE Reference Manual shows a simplified logic diagram that will be used to explain the function of the vacuum column switches in controlling the start and stop action of the tape reels.

When a tape reel motor is signaled to start turning, the direction of rotation is determined by the status of relay 5 (Systems 73.50.15) whose points control the direction of current through the reel motor armature. Relay 5 is de-energized when the tape unit is in forward status and is picked when the tape unit is in backward status.

With the tape unit in forward status, motion is from left to right across the head assembly. The backward line is negative; therefore, the output of the inverter (block 4) is positive. As tape is pulled from the left vacuum column by the action of the drive capstan, a point is reached where the left column switch is under vacuum and its contacts transfer, putting a positive level on the upper leg of +AND circuit block 5. The lower leg of this AND circuit is the output of block 4 and is also positive.

The negative output of block 5 feeds the lower input of −OR circuit block 3, producing a positive output that causes the left reel to turn. Because R5 is de-energized at this time, the direction of rotation of the left reel motor is such as to cause more tape to be put into the column until the column switch contacts return to normal. The reel then stops and the magnetic brake is energized.

At the same time, tape is being drawn into the right vacuum column and must be wound on the right reel. When sufficient tape enters the right column, the column switch returns to normal, putting a negative level on the input of the inverter (block 7). The positive output of block 7 feeds the lower input of +AND circuit (block 9). The upper input to block 9 is also positive at this time. The resulting negative output of block 9 feeds the lower input to the −OR circuit (block 10), producing a positive output that causes the right reel to turn. Because R5 is de-energized at this time, the right reel turns in the direction that will remove tape from the column. When enough tape is removed from the right column to permit the column switch to transfer, the reel stops turning, and the right reel magnetic brake is energized.

The operation of the reels is reversed when tape moves backward. In this case, the backward line is positive, and relay 5 is energized. The action of the column switches causes the right reel to put tape into the right vacuum column and the left column.

When changing from forward to backward status or from backward to forward status, both reel brakes are energized and the reel drive logic circuits are deconditioned for 45 ms (Systems 73.20.15). The reel drive logic circuits are deconditioned to prevent contact arcing while relay 5 is picking or dropping. The 45 ms period is obtained from one single-shot.

Forward-Backward Status Change Delay

When the tape unit status is changed from forward to backward at the start of a rewind operation, or from backward to forward at the end of a rewind operation, tape position in the vacuum columns is adjusted by the reel control logic circuits. If "go" is allowed to become active before tape assumes its new position, there is a possibility of pulling tape completely out of one of the columns. To prevent this, tape motion is suppressed for 200 ms after a change of status. When "−W machine rewind" (Systems 73.20.01) becomes active, a 200 ms single-shot is turned on through its hold-over input and remains on as long as the input is active. At this same time, "+S machine rewind" also becomes active and triggers another 200 ms single-shot (Systems 73.20.05). This single-shot prevents "go" from becoming active until 200 ms after the tape unit goes into backward status.

On machines with S/N above 16202, the forward to backward 200 ms single-shot is replaced with an R-C network (Systems 73.50.10.0). Before the low-speed rewind key is pressed, the capacitor C12 is charged up as a result of the N/C contacts of R102. When the N/C contacts open, C12 discharges through R20. When C12 is fully discharged "+S dly rew" becomes active after a delay. The purpose of the R-C network is the same as the 200 ms single-shot – to delay GO from becoming active immediately.

Upon completion of the rewind operation, "−W machine rewind" (Systems 73.20.01) becomes inactive and releases the holdover single-shot. The single-shot stays on for an additional 200 ms and holds "select and ready" inactive until 200 ms after the tape unit changes into forward status. This action assures that the tape unit will not respond to a command from the control unit until tape has become adjusted in the vacuum columns.

Load Point Photocell Logic

S/N BELOW 16203

The load point photocell is shown in the Systems (73.50.10). One terminal of the cell is connected to a +12v source; the other terminal connects to the input of a transistor amplifier (Systems 73.20.10). When the load point spot is sensed during a low-speed rewind, the photocell conducts and a +S level is produced at the output of the amplifier. This level is AND'ed with "backward status." The output of the AND block is inverted and used to trigger a 64 ms single-shot. When the single-shot times out, its output goes positive and triggers a 90 ms single-shot. The output of the 90 ms single-shot latch picks the load point relay R107.

The purpose of the 64 ms single-shot is to allow the load point reflective spot to move to the left of the head assembly before dropping "go." This action assures that the 7330 tape unit stops tape with the load point spot in the same position with respect to the head as do other IBM Magnetic Tape Units to assure compatibility between tapes written and read on the 7330 tape unit and certain other IBM tape units. When the load point spot is sensed during high-speed rewind, the 90 ms single-shot is triggered immediately so that tape is stopped without regard to the position of the load point reflective spot.

S/N ABOVE 16202

On machines with S/N above 16202, the 90 ms single-shot is replaced with a latch. The load point latch relay, R107, has been replaced with a regular pick and hold type relay. The purpose of the latch is to energize and hold R107. On a low-speed rewind, the relay is energized after a 64 ms delay. On high-speed rewind, R107 is energized immediately.

When the load point is detected on any operation, the 64 ms single-shot is turned on (Systems 73.20.10.1, EC 252698), thus the load point latch is immediately turned on. For a low-speed rewind, gate 3A inhibits R107 to be energized until the single-shot times out. For a high-speed rewind, gate 3B is enabled by "−S HS rewind" and as soon as the latch is turned on, the gate becomes active and energizes R107 immediately.

To de-energize R107 after a backspace on a low-speed rewind, "−S backward status" becomes inactive, enabling gate 5C. When GO becomes active again, the latch is turned off, thus R107 is de-energized. To de-energize R107 on a high-speed rewind, the latch must be turned off. Gate 4F is enabled by the "−S arm up" signal. When R107 is energized, R110 is de-energized allowing "−S HS rewind" to become inactive which makes gate 4F become active. Thus, the latch is turned off.

Tape Indicate Logic Circuit (73.20.10)

The method of sensing the end-of-tape reflective spot is similar to the method used for load point sensing. The reflective spot is sensed by the tape indicate (TI) photocell (Systems 73.50.10). A + S level at the output of the TI amplifier (Systems 73.20.10) is AND'ed with "write" to turn on the TI latch. The output of the TI latch is AND'ed with "select and ready" to produce "select, ready and TI on." This line is sent back to the external control unit as an indication that the physical end of tape is being approached. The TI light on the tape unit operator's panel is also turned on. Note that the end-of-tape reflective spot can turn on the TI latch only during a write operation. The circuit is inactive during a read operation. The manner in which the "TI on" condition is used is determined by the external system to which the tape unit is connected.

The TI latch may also be turned on from an external system by means of a program instruction. When this is done "+S TI on" is made active. This line is AND'ed with "select and ready" to turn on the TI latch. When turned on by a program instruction, the TI latch is used simply as a memory device.

The TI latch may be turned off either by raising the read-write head cover or by program instruction. Raising the head cover activates "−S arm up" to reset the latch. "+S TI off" activated by a program instruction is AND'ed with "select and ready" to reset the latch.

File Protect Logic

When a reel of tape containing a plastic ring is mounted on the tape unit, the "not file protect" (NFP) relay armature is operated. This action closes the NFP A contacts (Systems 73.50.05) and picks the NFP1 relay to draw the sensing pin away from the plastic ring. With the NFP1BL N/O contacts closed, relay 109 picks, if the tape unit is in ready status and the rewind relay R102 is de-energized. When R109 picks, the file protect light turns off and "W file protect" becomes inactive due to the R109-3 N/C contacts opening (Systems 73.50.10).

Without the plastic ring in the file reel, the file protect relay will be de-energized; therefore, R109 will not be picked. With the R109-1 and R109-2 N/O contacts open (Systems 73.50.10), there will be no voltage supplied to the centertap of the write head coils and, therefore, writing cannot take place.

Go-Stop Control Logic

GO

Tape motion is obtained by squeezing the tape against a rotating drive capstan through the action of a moving coil actuator. To avoid the effects of mechanical resonance in the moving coil and rocker arm assembly, voltage is applied to the moving coil in three steps. Three "go" lines are employed, "go A," "go B" and "go C" (Systems 73.20.05). When tape is to be put into motion, "+W go A" is activated and this voltage is fed to the moving coil through a capacitor. Full voltage is applied to the moving coil when "go A" first becomes active but diminishes rapidly as the capacitor charges. The purpose of the "go A" line is to put the moving coil into motion.

A variable single-shot is also triggered when "go A" becomes active. This single-shot is adjusted for about 2.5 ms duration. The output of the variable single-shot feeds a 6 ms single-shot and, when the variable single-shot turns off, the 6 ms single-shot turns on. This action activates "go B" which applies full voltage to the moving coil for 6 ms. During this time, the rocker arm completes its travel and the tape is squeezed firmly against the drive capstan.

When the rocker arm has completed its travel and tape is in motion, a reduced voltage is sufficient to maintain tape motion. Therefore, "go B" becomes inactive when the 6 ms single-shot turns off and "go C" is applied to the moving coil through a resistor (Systems 73.50.15). The "go C" line remains up for the remainder of time that tape motion is required.

Figure 20 shows the voltage applied to the moving coil during "go" status. The command to start tape motion can be initiated in either of two ways: "+S go" can be activated from the external control unit or "+S machine rew" can be activated by the tape unit during rewind.

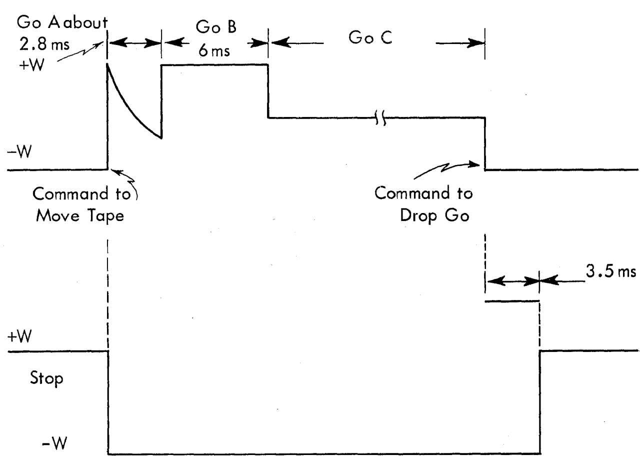


Figure 20. Go-Stop Voltage Applied to Moving Coil

STOP—S/N BELOW 16203

Tape motion is stopped by squeezing tape against a fixed stop capstan. Stop status is obtained by passing current through the moving coil in a direction that causes the rocker arm to perform the action. Here again, the effects of mechanical resonance must be dealt with. Construction of the moving coil and rocker arm mechanism is such that gravity causes the rocker arm to move its pinch roller toward the stop capstan when "go" becomes inactive. If "stop" were activated immediately, the pinch roller would slam the tape against the stop capstan producing a bouncing motion. To prevent this, a 3.5 ms delay is allowed from the time that "go" becomes inactive until "stop" is activated. The delay allows the rocker arm to move completely into stop status before voltage is applied to the moving coil. The moving coil is energized by the "stop" line simply to hold the tape against the stop capstan after motion has stopped. The 3.5 ms stop delay is provided by a single-shot (Systems 73.20.10) that turns on when "go C" becomes inactive. "Stop" is prevented from becoming active until the 3.5 ms single-shot times out. The "stop" voltage applied to the moving coil is illustrated in Figure 20. Note its relationship to the "go" waveform.

STOP—S/N ABOVE 16202

On machines above S/N 16202, the stop control logic is eliminated. To stop tape, a mechanical stop slug is utilized. For operation, refer to "Go-Stop" section under tape motion.

COMMENT SHEET

IBM 7330 MAGNETIC TAPE UNIT

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