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IBM 1921 Magnetic Tape Control Unit, Model 5 Custom Feature for the IBM 1620

This publication provides operating and programming information for the use of magnetic tape units with the IBM 1620. The operation of the IBM 1921 Model 5 is explained with two magnetic tape unit models, the IBM 7330 and the IBM 729 II. Physical planning information is included for the 1921.

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The 1921 Magnetic Tape Control Unit brings the scope and speed of magnetic tape to the 1620 Data Processing System. A combination of faster data transfer speeds, increased programming flexibility, and new approaches to processing problems is added to the already powerful and versatile low-cost 1620 System.

The 1921 Model 5 Tape Control Unit (Figure 1) provides the electronic circuitry that enables the 1620 to utilize from one to six tape units. These tape units may be either the new, low-cost IBM 7330 Tape Unit, or the higher-speed IBM 729 II Low-Density Tape Unit; in either case, all units attached to a single system must be the same.

Figure 1. IBM 1620 Magnetic Tape System

With this expanded system, magnetic tape input and output speeds extend from 7,200 to 20,000 characters per second. This wide range of speeds provides a balanced 1620 System for research, engineering, and data processing problems requiring large amounts of input or output data.

NOTE: Availability of this feature can be determined by requesting a price quotation from IBM.

Although the features of the 7330 and 729 II provide versatility and a wide range of speeds, the operation of these two units is similar. This bulletin describes the features and operation of the 729 II Low-Density Tape Unit only. The significant operating characteristics of the 729 II are outlined in Figure 2.

Denisity, Characters per Inch	200	Character Rate, Characters per Second	15,000
Tape Speed, Inches per Second	75	High Speed Rewind, Minutes	1.2
Start/Stop Time, Read/Write Operations: Milliseconds	10.8	Regular Rewind, Inches per Second	75

Figure 2. Operating Characteristics of IBM 729 II Tape Unit

MAGNETIC TAPE OPERATING PRINCIPLES

Magnetic tape is a special plastic tape, coated on one side with a layer of magnetic material. Data is recorded on the tape in the form of magnetic spots or bits. Information written on tape remains there indefinitely, or until the tape is used in a new write operation. When the recorded information is no longer needed, the tape can be used to record new data. The write operation automatically erases old information. Tape is wound on plastic reels 10 1/2 inches in diameter. A full reel contains about 2,400 feet of usable tape, but lengths as short as 50 feet can be used.

Figure 3 shows the physical location of the tape when it is mounted on a tape unit. During reading or writing, tape is moved from the file reel on the left side of the unit, through the left vacuum column, across the read and write heads, through the right vacuum column, to the machine reel.

Reading or writing on a tape takes place while the tape moves across the read and write heads. The vacuum columns control separate drive motors and permit the read-write mechanism and each one of the two tape reels to move tape independently of the other two units. The read-write mechanism feeds tape according to instructions from the stored program. The file reel feeds tape when the tape reaches a minimum slack point in its vacuum column, and the machine reel winds tape when the slack tape reaches a point near the bottom of its vacuum column.

The read-write head assembly, which is located between the vacuum columns, is built in two sections. The lower section is stationary. The upper section can be moved up or down under control of the tape-unit keys: when it is up, the operator can thread tape. When it is down, it places the read and write heads in close contact with the tape for reading or writing. The tape reels and heads are accessible when the reel door is open.

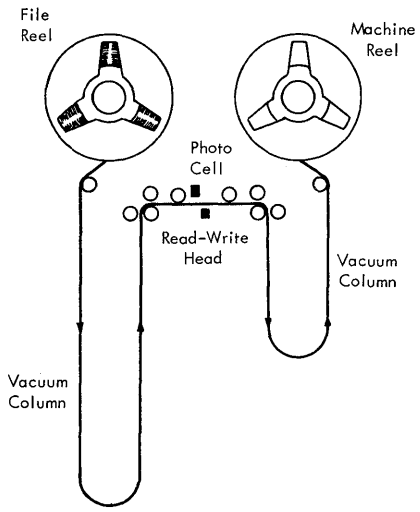


Figure 3. Tape Feed Diagram

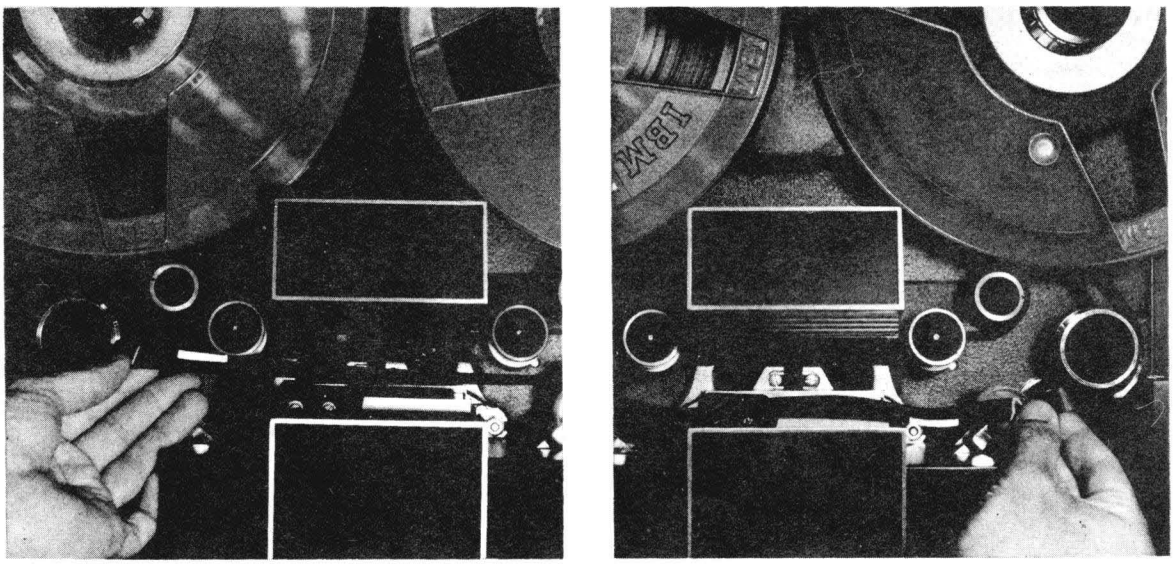
Reflective Spots

Reflective spots, also referred to as photosensing markers, are placed on the tape to enable the tape unit to sense where reading and writing are to begin and stop on the tape. The markers are small pieces of plastic, one inch by 3/16 inch, coated with vaporized aluminum on one side and with adhesive on the other. They are fastened to the "shiny" (uncoated) side of the tape. The photoelectric cells sense them either as the load-point marker where reading or writing is to begin on tape, or as the end-of-reel marker where reading or writing is to stop.

About 12 feet of tape must be left between the beginning of the reel and the load-point marker. This footage is used to thread the tape over the feed rolls and the read and write heads. Information must not be stored in this space. To indicate the load point, the one-inch dimension of the marker must be parallel to, but not more than 1/32 inch from, the channel 1 edge of the tape -- the edge that is near the operator when the reel is mounted (see Figure 4).

About 18 feet of tape should be reserved between the end-of-reel marker and the physical end of the tape attached to the hub of the file reel. To indicate end-of-reel, the marker must be placed parallel to, but not more than 1/32 inch from, the C-track edge of the tape (the edge near the tape unit when the reel is mounted).

Load-point and end-of-reel markers must be placed on tape with care. They should be properly aligned and pressed tightly onto the tape with the back of the fingernail. To reduce the collection of dust on the unrolled tape, markers should be affixed while the tape is loaded on a unit. If this



End-of-Reel Load Point

Figure 4. Reflective Spots on Tape

is done away from the unit, the unrolled end of tape should be kept off the floor and away from dusty areas. All new IBM magnetic tapes contain an end-of-reel marker that is placed on the tape when it is manufactured.

File Protection Ring

The back of the tape reel (machine side) has a circular groove that can hold a plastic ring (see Figure 5). This ring is called the file protection ring. The tape can be written on only when

Figure 5. File Protection Ring

the file protection ring is inserted into the back of the tape reel. A tape can be read whether or not the ring is inserted. After all the necessary records have been written on the tape, the file protection ring should be removed from the tape reel to prevent accidental writing and the resulting loss of valuable tape records. The file protection ring should not be removed while tape is loaded in the vacuum columns of the tape unit, because this can cause the tape to break or be damaged.

Tape Characteristics

Data is recorded in a 7-bit code, in seven parallel channels along the tape. Figure 6 shows magnetic tape characters and their corresponding codes.

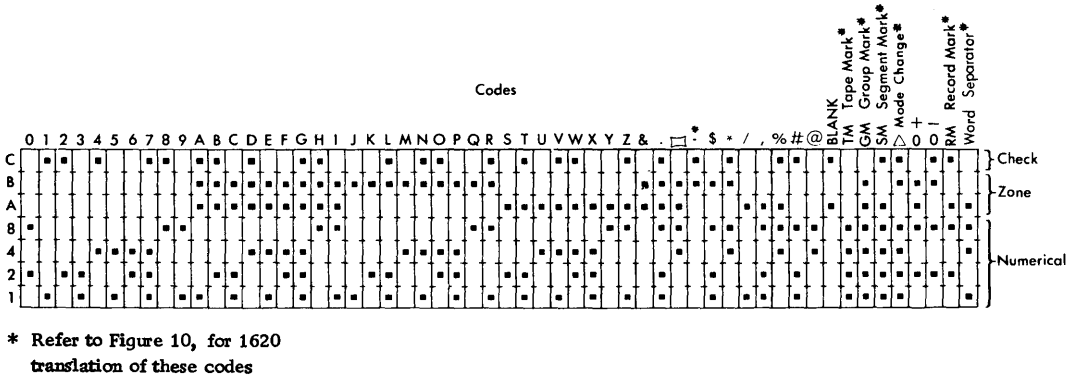


Figure 6. Magnetic Tape 7-Bit Coding

Records are separated from each other by approximately 3/4 of an inch of blank (unrecorded) tape, called an interrecord gap (IRG).

Each tape character is composed of an even number of magnetic bits. A check bit (labeled C in Figure 6) is written if the number of bits in the other six positions is an odd number. An even-parity check on each character ensures accuracy for tape-read and tape-write operations.

Besides this vertical parity check, a horizontal check (HC in Figure 7) is made on each record. The bits in each horizontal row are automatically counted when the record is written, and a bit (similar in function to the vertical check bit) is written at the end of each horizontal row that has an odd count. The vertical combination of these horizontal check bits makes up the horizontal check character. Thus, the coding of this character can change from record to record. When the tape is read, the same automatic count is made, but now each row in the complete record should have an even number of bits, or an error is indicated. The horizontal check character is used for checking only and is never read into core storage.

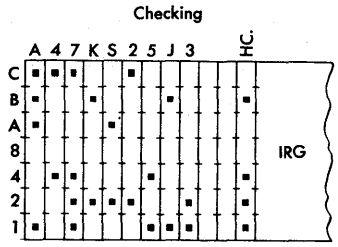


Figure 7. Vertical and Horizontal Check

Tape Checking

The IBM 729 Tape Unit has reading and writing reliability maintained through two features: the read-write head and dual-level sensing. The read-write head makes it possible to automatically verify the validity of recorded information at the time it is written. The relative positions of the read head and the write head (Figure 8) are such that a character written by the write head passes the corresponding read head almost simultaneously; and thus, after each character of a record is written, it is read, and a parity check is applied. If an error is detected, the stored program receives a signal, and corrective action can be taken. The ability of the read-write head assembly to read tape in both reading and writing operations makes it possible to check these operations by dual-level sensing. The read head reads the tape at two levels of pulse strength: high and low.

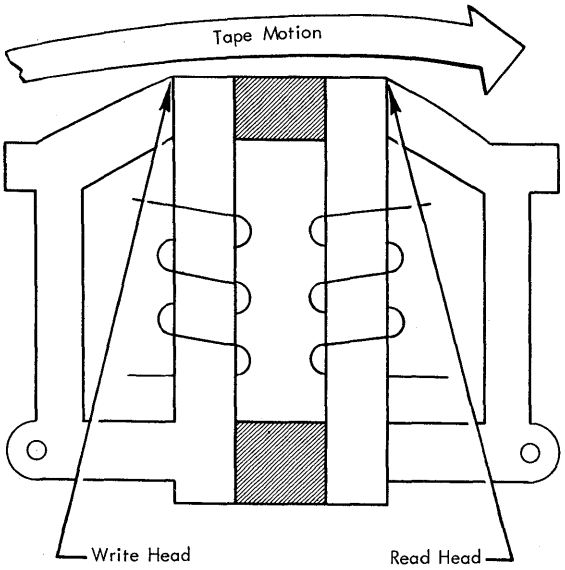


Figure 8. Read and Write Heads

There is a 7-position high register and a 7-position low register (one position for each tape channel). These registers accept the pulses from the tape at high-sensitivity and low-sensitivity levels, respectively, while each character is read. High sensitivity means that an impulse of comparatively low strength (voltage difference) is acceptable. Low sensitivity means that signals below a certain level or strength are not accepted. During a tape read, the registers function in a slightly different manner than during a tape write operation.

Figure 9 shows the sensitivity levels and the relative strength of pulses that are acceptable or not acceptable in read and in write conditions.

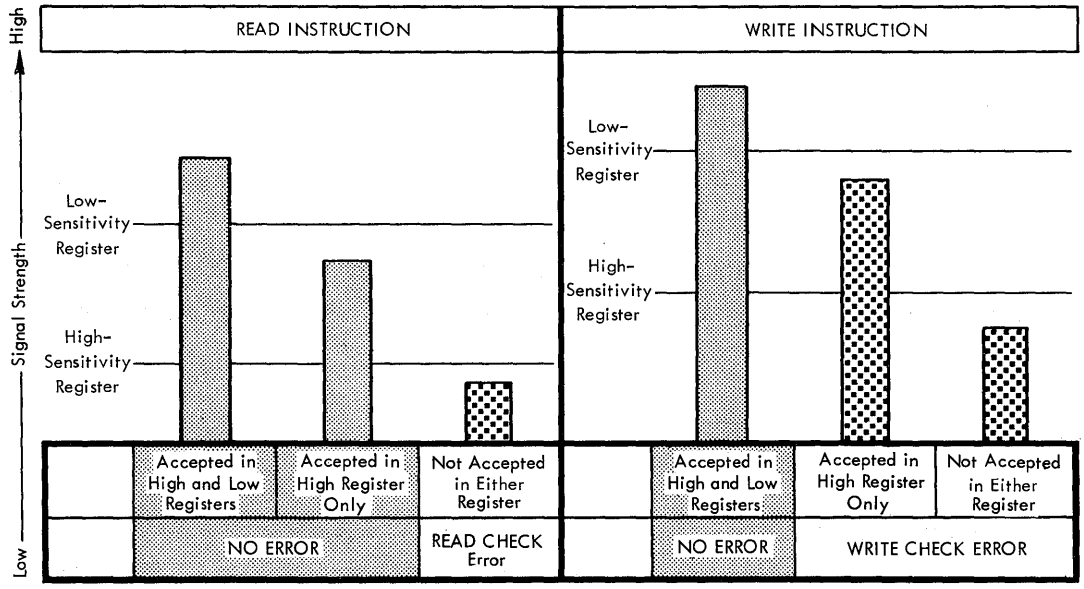


Figure 9. Dual-Level Sensing

Dual-Level Sensing When Reading

In a tape-read operation, the low-sensitivity level register is checked for an acceptable signal strength. If the signal strength is not acceptable, the contents of the high-sensitivity level register are sent to the read-write register.

A parity check is made in the read-write register. If a parity check is detected at the read-write register, the Read Check indicator is turned on. This indicator can be interrogated by a program instruction. Thus, a bit that results in a weak signal may still be read from the tape.

Dual-Level Sensing When Writing

In checking tape-write operations, the unit becomes harder to satisfy by automatically making the registers less sensitive than they were for tape read. Each tape character written is read back and must be accepted in both high and low registers. The contents of the high register are parity-checked and then are matched, bit for bit, with the contents of the low register.

If the parity check in the high register detects an odd number of bits, or if the bit-by-bit match between registers is unequal, the Write Check indicator is set.

If a tape error is detected, the tape unit can be backspaced by programming, and the record can be reread. If the error persists, the operator can intervene, or the program can branch to an error routine.

The errors most frequently detected during write operations result from dust or damage to the magnetic tape. In order to skip a dusty or damaged section during writing operations, the 1620 has a command that causes the tape to space forward approximately eight inches. During the space instruction, this eight inch area is erased so that extraneous data is not sensed during succeeding read operations.

Tape Codes

Figure 10 shows the magnetic tape codes that are used in the 1620 Magnetic Tape System. The corresponding paper tape code for each magnetic tape code is also shown. It is important to note that some of the special characters read from magnetic tape are represented as different characters when they are stored in the 1620 or punched on paper tape. When the characters are written back onto tape, they are written as shown in Figure 10.

CHARACTER TRANSLATION

1620 to Magnetic Tape

Magnetic Tape to 1620

Char.	Paper Tape Code 1 2 4 8 0 X C	Mag. Tape Code 1 2 4 8 A B C	Paper Tape Code 1 2 4 8 0 X C	
0	0	2 8	0	
1	1 C	1 C	1	
2	2 C	2 C	2	
3	1 2 C	1 2	1 2 C	
4	4 C	4 C	4	
5	1 4 C	1 4	1 4 C	
6	2 4 C	2 4	2 4 C	
7	1 2 4 C	1 2 4 C	1 2 4	
8	8 C	8 C	8	
9	1 8 C	1 8	1 8 C	
A	1 0 X	1 A B C	1 0 X	
B	2 0 X	2 A B C	2 0 X	
C	1 2 0 X C	1 2 A B	1 2 0 X C	
D	4 0 X	4 A B C	4 0 X	
E	1 4 0 X C	1 4 A B	1 4 0 X C	
F	2 4 0 X C	2 4 A B	2 4 0 X C	
G	1 2 4 0 X	1 2 4 A B C	1 2 4 0 X	
H	8 0 X	8 A B C	8 0 X	
I	1 8 0 X C	1 8 A B	1 8 0 X C	
J	1 X C	1 B	1 X C	
K	2 X C	2 B	2 X C	
L	1 2 X	1 2 B C	1 2 X	
M	4 X C	4 B	4 X C	
N	1 4 X	1 4 B C	1 4 X	
O	2 4 X	2 4 B C	2 4 X	
P	1 2 4 X C	1 2 4 B	1 2 4 X C	
Q	8 X C	8 B	8 X C	
R	1 8 X	1 8 B C	1 8 X	
S	2 0 C	2 A	2 0 C	
T	1 2 0	1 2 A C	1 2 0	
U	4 0 C	4 A	4 0 C	
V	1 4 0	1 4 A C	1 4 0	
W	2 4 0	2 4 A C	2 4 0	
X	1 2 4 0 C	1 2 4 A	1 2 4 0 C	
Y	8 0 C	8 A	8 0 C	
Z	1 8 0	1 8 A C	1 8 0	
+ }	0 X C	A B	0 X C	Plus on Paper Tape
& }				Ampersand on Mag. Tape
- }	X	2 8 B C	X	Hyphen on Paper Tape
ō }				Minus Zero on Mag. Tape
bl	C	A C	C	blank
.	1 2 8 0 X	1 2 8 A B C	1 2 8 0 X	Period
) }	4 8 0 X C	4 8 A B	4 8 0 X C	) on Paper Tape
¤ }				¤ on Mag. Tape
$	1 2 8 X C	1 2 8 B	1 2 8 X C	Dollar Sign
*	4 8 X	4 8 B C	4 8 X	Asterisk
/	1 0 C	1 A	1 0 C	Slash
,	1 2 8 0 C	1 2 8 A	1 2 8 0 C	Comma
(}	4 8 0	4 8 A C	4 8 0	(on Paper Tape
% }				% on Mag. Tape
= }	1 2 8	1 2 8 C	1 2 8	= on Paper Tape
# }				# on Mag. Tape
@	4 8 C	4 8	4 8 C	At
-	———	B C	X	Hyphen
ō	———	2 8 A B	0	Plus Zero
T.M.	———	1 2 4 8	C	Tape Mark
G.M.	———	1 2 4 8 A B	C	Group Mark
S.M.	———	1 2 4 8 A C	C	Sector Mark
M.C.	———	1 2 4 8 B C	C	Mode Change
W.S.	———	1 4 8 A	C	Word Separator
R.M.	2 8 0	2 8 A C	2 8 0	Record Mark written on Mag. Tape only on "Dump Numerical" instruction

Figure 10. Magnetic Tape Codes

Operating Keys and Lights

The operating keys and lights of the IBM 729 II Tape Unit are located at the top of the unit above the tape reels (Figure 11). All lights are on the upper row, and all keys are on the lower row. The Tape Address Selector switch is at the left.

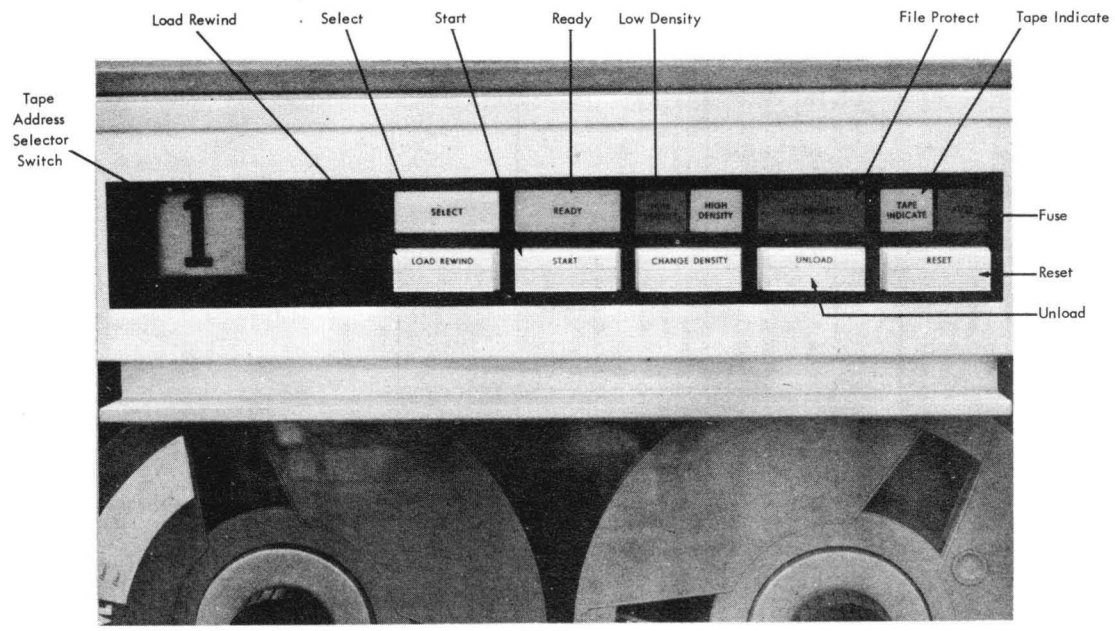


Figure 11. IBM 729 II Tape Unit Operating Keys and Lights

Tape Address Selector Switch. This switch assigns a number, from 0 to 9, to the tape unit to identify it to the stored program. The setting must not be changed when a tape operation is in progress. Only positions 0 to 5 are operative for this system.

Select. The Select light turns on automatically, when the Tape Address Selector switch is properly positioned and the unit is addressed by the computer.

Ready. This light indicates that the tape unit is ready for operation. See START KEY for method of turning this light on. The reel door should never be opened when the Ready light is on.

Low Density. This light indicates the tape unit is operating in the low-density mode (200 characters per inch of tape).

The next light is not used.

File Protection. This light automatically turns on if the unit is loaded with a reel that does not have the file protection ring inserted in the back of the reel. The tape cannot be written on as long as the File Protection light is on.

Tape Indicate On. This indicator is turned on either:

1. by sensing the end-of-reel mark (reflective spot) while writing, or
2. by sensing the tape mark while reading tape.

The indicator can be turned off either:

1. by pressing the Unload key on the tape unit, or
2. by executing a Turn Off Tape Indicate instruction in the stored program.

Fuse. This light turns on automatically whenever a fuse in the unit has blown.

Load Rewind. This key operates only when the reel door is closed and the Ready light is off. Operating this key, after tape has been properly mounted in the magnetic tape unit, lowers tape into the columns, lowers the head assembly, and moves tape in the rewind direction until the load-point reflective spot is sensed. If the reflective spot is to the left of the read-write head when this key is pressed, the tape will unwind from the machine reel.

Caution: Do not open the reel door during rewind or load-point searching.

Start. Operating this key places the tape unit in ready status and turns on the Ready light, provided that:

1. The reel door is closed.
2. Tape has been loaded into the columns.
3. The tape unit is not in the process of finding the load point (rewind or load-point operation).

Change Density. This key normally selects high-density or low-density operation. When connected to the 1921, the 729 is automatically set to LOW DENSITY.

Unload. This key is operative only when the Ready light is off, the tape is in the vacuum columns, and the reel door is closed. Operating this key raises the head assembly and removes the tape from the columns, regardless of the distribution of tape on the two reels. If the tape is not at load point when the operator wishes to change tape reels, a load-point search should be initiated first by pressing the Load-Rewind key. Pressing the Unload key also turns off the Tape-Indicate light.

Reset. Operating this key turns off the Ready light. If the Reset key is used during high-speed rewind, the operation stops and then continues as a slow-speed rewind. If the Reset key is used during a slow-speed rewind, the rewind stops.

Tape Unit Interlocks

Reel Door Interlock. When the door is open, the interlock contact prevents any normal operation of the tape unit. The reel door should never be opened when the Ready light is on or during any load-rewind operation.

Reel Release Key. When this key is pressed, both reels may be turned manually for threading tape or removing the file reel. To operate the Reel Release key, open the reel door.

Operating Pointers

Consider the following points whenever a tape unit is in operation:

1. Do not change the address of any tape unit in a system by operating the Address Selector switch during the execution of a program. This applies even if the tape unit is not being used, and regardless of whether the unit is in ready status or not.
2. Never set two tape units to the same address.
3. Do not open the door of a tape unit unless the tape is out of the vacuum columns and the read and write heads are raised.
4. In the event of a power failure, the ready status of a tape unit is lost. When the power is restored to the tape unit, the tape is automatically placed in a rewind operation.

1921 MAGNETIC TAPE CONTROL UNIT, Model 5

The 1921 Control Unit (Figure 12) contains the electronic circuitry required by the 1620 for controlling the operation of the 729 II Tape Units.

The 1921 is connected to the 1620 System by a data cable. The 1921 supplies power to each tape unit in the system.

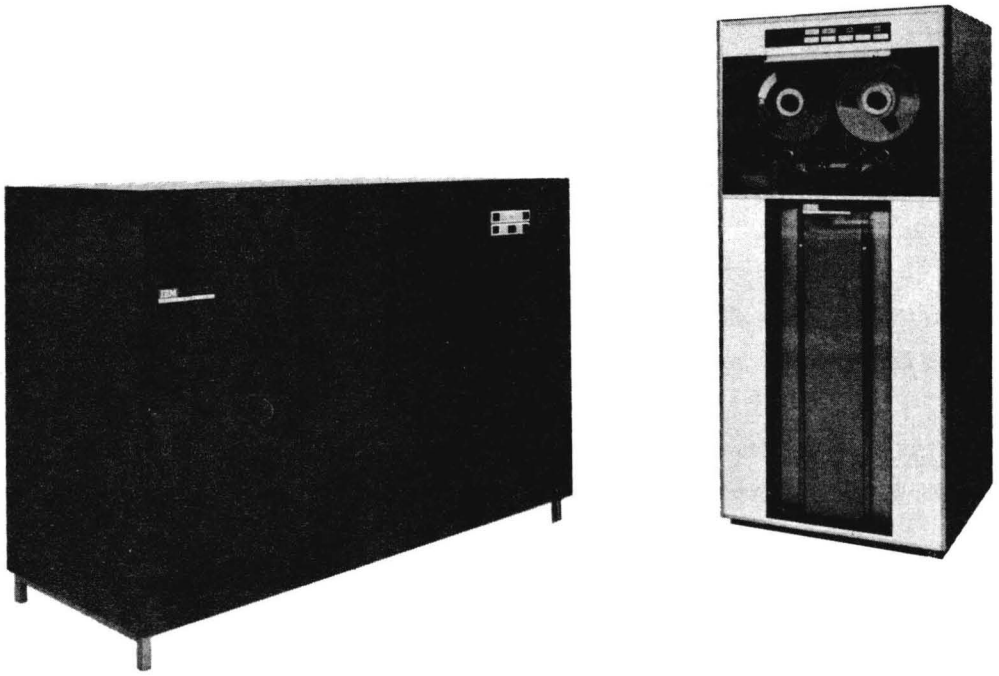


Figure 12. IBM 1921 Model 5 Magnetic Tape Control Unit

1921 Operating Keys and Lights

The 1921 keys and lights (Figure 13) are the only controls necessary for the operation of the 1921.

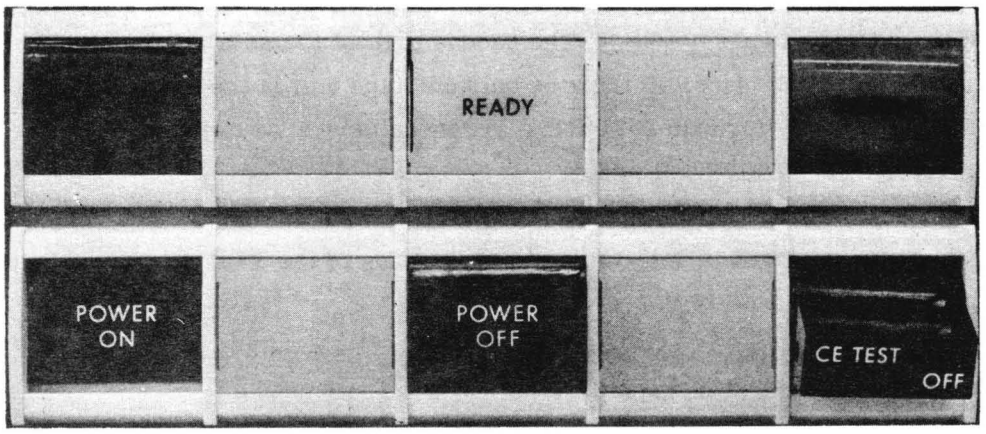


Figure 13. 1921 Operating Keys and Lights

Power On Key. Pressing the Power On key supplies AC and DC power to the 1921 and the tape units.

Power Off Key. Pressing the Power Off key removes AC and DC power from the 1921 and the tape units. Turning the 1620 Emergency Off switch to OFF also removes all power from the 1921 and the tape units.

CE Test Key. This key is used by the IBM Customer Engineer for off-line testing of the 1921 and 729. This key must be set to OFF for proper operation of the tape system.

Power On Light. This light indicates that AC power is available to the 1921 and the tape units. Pressing the Power On key turns on the Power On light.

Thermal Light. The Thermal light indicates that the temperature inside the 1921 has become too high.

Ready Light. The Ready light indicates that DC power is available to the 1921.

1620 MAGNETIC TAPE PROGRAM INSTRUCTIONS

Input/Output Device Address

Each 729 tape unit connected to the 1921 Tape Control Unit is selected by a two-digit I/O device address. This address code is placed in positions Q_8 and Q_9 of all tape instructions. The first digit of the address is always "2." The second digit of the address is determined by the particular tape unit being used. If there is only one tape unit in the system, the second digit is always "0" (zero). If, for example, there are three tape units in the system, the tape addresses may be "20," "21," and "22."

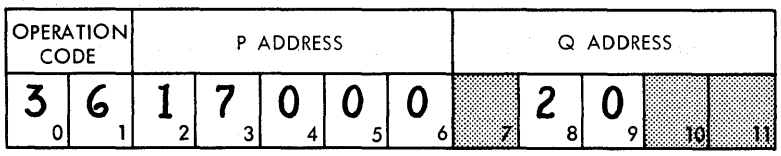
The address number of a tape unit is determined by the setting of the Tape Address Selector switch on each individual 729 Tape Unit.

Input/Output Instructions for the 1620 Tape System

The standard 1620 input/output instructions are used in the 1620 tape system. In addition, five control instructions are provided to control tape operations.

NOTE: Pressing the Single Cycle Execute key (SCE) results in an invalid operation for a 1620 tape instruction.

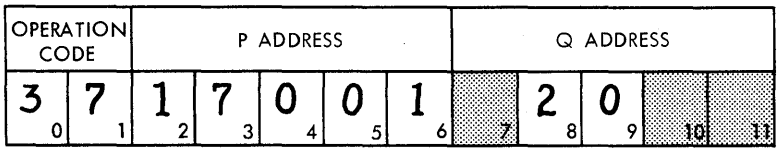
Read Numerically



Numerical data from the specified tape unit is transmitted serially to the P address and to successively higher core storage positions until an interrecord gap is sensed by the tape unit. The interrecord gap stops the reading operation and causes a record mark to be written in the next highest core storage position following the last character read from tape.

Each numerical character is stored in a single core storage location. If the end of 1620 core storage is reached before the end of the tape record is reached, the tape record continues to read into core storage positions 00000 and higher.

Read Alphamerically



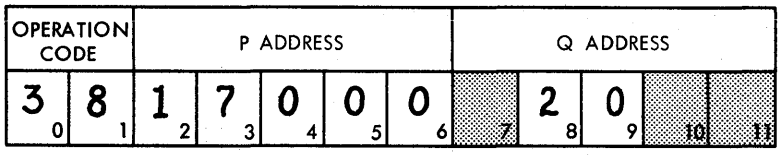
Alphameric data from the tape unit is transmitted serially to the P address and to successively higher core storage positions.

The units digit (P_6) of the P part of the instruction must be an odd number; otherwise, the input information is not placed in core storage correctly and parity errors may occur when it is read in. This is due to the two-character transfer operation of core storage. The odd-numbered location must contain the right-hand (numerical) digit of the two-digit alphameric code.

Sensing an interrecord gap by the tape unit terminates the read operation and places a record mark in the next highest core storage position.

Information from the input device may be a random mixture of numerical, alphabetic, and special characters (including the single record mark character). Each character is stored in core storage as two digits. A single record mark character read from tape is stored in core storage as a numerical zero digit (C bit) followed by a single record mark character (coded C-8-2).

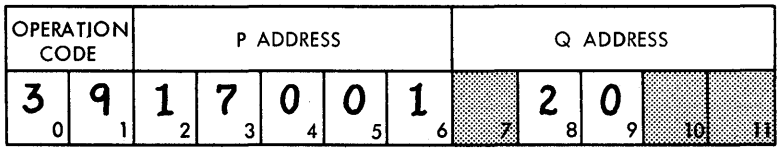
Write Numerically



Numerical data located at the P address and at successively higher core storage locations is transmitted serially to the tape unit. Sensing a record mark in core storage terminates the operation. The record mark is not written on the tape but it does create an interrecord gap. Data that is represented in core storage as two digits cannot be written as a single character by this instruction.

The P address must not be the location of a record mark.

Write Alphamerically

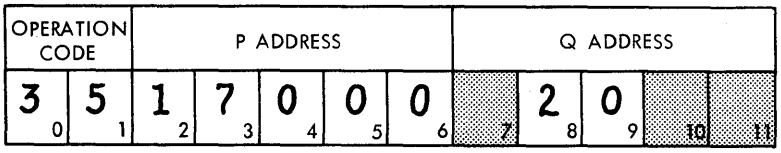


Alphameric data located at the P address and at successively higher core storage locations is transmitted serially to the tape unit. Sensing a record mark in core storage terminates the operation. The record mark is not written on the tape. The units digit (P_6) of the P part of the instruction must be an odd number.

Data that is represented in core storage as two digits is written as a single character.

The P address must not be the location of a record mark.

Dump Numerically

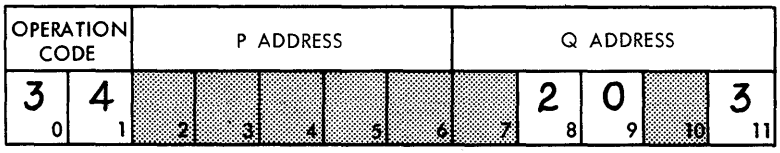


Numerical data is transmitted serially to the tape unit, beginning with the P address and continuing through higher core storage positions. Transmission terminates after the character from the highest numbered core storage address, 19999, 39999, or 59999, depending on which 20,000 module the P address specifies, has been written. Data that is represented in core storage as two digits cannot be written as a single character by this instruction. All numerical data and record marks are written on the tape.

Tape Control Instructions for the 1620 Tape System

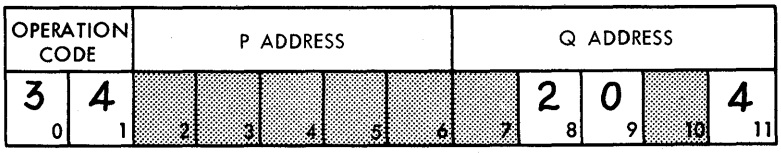
The standard 1620 Control instruction is used for tape operation. The address of the tape unit is placed in positions Q_8 and Q_9 of the instruction. The Q_{11} position of the instruction contains the code number of the control operation to be performed. The P portion of the instruction is not used.

Backspace



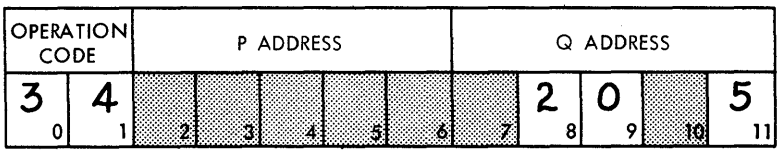
This instruction moves the tape backward to the beginning of a record. The first interrecord gap encountered stops the backspace. The 1620 is interlocked until the operation is completed. If the tape is at "Load Point," no operation takes place and the 1620 is immediately released for its next operation.

Rewind



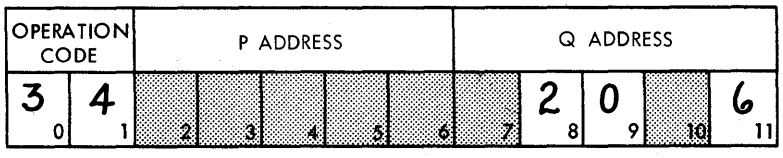
This instruction is usually given after an end-of-reel condition, and causes the tape to rewind onto the file reel. The tape rewinds until it reaches "Load Point." As soon as the rewind operation is initiated, the 1620 is released for its next operation.

Write Tape Mark



This instruction writes a one-character record on tape. The tape mark character consists of 8, 4, 2, and 1 bits. The tape mark is normally used to indicate an end-of-file or an end-of-reel condition. These two conditions are explained in more detail in the section entitled MAGNETIC TAPE PROGRAMMING PRINCIPLES. The 1620 is interlocked until the completion of this instruction.

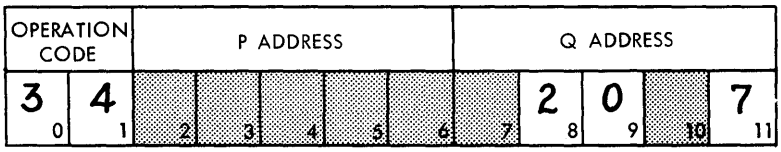
Erase Forward



This instruction moves tape forward approximately 8 1/2 inches. During this time the tape unit is in a "write" status, and because no data is received from the 1620, the result is that "nothing" is written on tape. This instruction makes it possible to bypass defective tape areas.

The data in the defective area is erased so that it will not be read during subsequent reading operations. The 1620 is interlocked until the completion of this instruction.

Turn Off Tape Indicate



This instruction turns off the Tape Indicate light on the 729. The purpose of this instruction is explained in the section called MAGNETIC TAPE PROGRAMMING PRINCIPLES.

Instruction Timing

The instruction cycle for all instructions addressing magnetic tape requires .160 milliseconds. The time for the execute cycle depends upon the particular instruction used.

Read and Write Instructions

The execute time for a read or write instruction is computed as follows:

Execute Time (ms) = .067 N + 12

N = number of characters in the record.

Backspace

If the tape unit is in read status:

Execute Time (ms) = .067 N + 57

If the tape unit is in write status:

Execute Time (ms) = .067 N + 64

Rewind

Execute time for a rewind instruction is approximately 50 milliseconds. This is the time required to start the operation of rewinding tape, and does not include the actual rewinding of tape. The 1620 is released for processing after rewind has been initiated.

Write Tape Mark

The execute time is the same as a write instruction for a single character record: .067 N + 12

Erase Forward

The execute time is approximately 115 milliseconds.

Turn Off Tape Indicate

The execute time is approximately .200 milliseconds.

ERROR CHECKING FEATURES

Extensive checking features are incorporated into the 1620 Processor, 1921 Control Unit, and the 729 Tape Unit. All data transferred to and from the 1620 is subjected to the normal 1620 Input/Output checking features. A summary of the additional error checking features for magnetic tape operation is presented in this section of the bulletin.

Error Checking During Write Operation

Any of the error conditions listed below turn on the 1620 Write Check (WR CHK) indicator. This indicator should be tested after each write operation.

Parity Check. All data written on tape passes through the read/write register. As each character is written, it is checked for even-bit parity.

Write Echo Check. There are seven write heads, one for each bit position of tape. Write impulses cause one or more of these heads to write on the tape. After a character is written on tape, each write head that received an impulse returns an impulse. These impulses are combined and one impulse is returned to the 1921. A write echo check results when the echo impulse is not returned.

Write Compare Check. During a write operation, all characters written on tape are read as they pass the read head. The characters are checked by dual-level sensing and must be accepted in both registers. As the characters are read for dual-level sensing, they are also checked for parity.

Skew Check. This checking feature determines whether the tape is moving correctly past the read/write heads.

Horizontal Check. During a write operation, a horizontal check bit is developed for each record and is written on the tape. After the record is written, it is read as it passes the read head, and the horizontal-check character is checked, like all other characters in the record, for an even-bit parity.

Invalid Character Check. Data received by the 1921 from the 1620 is checked for validity. Any combination of bits that does not represent a valid character is interpreted as an error condition.

Response Check. A check is made to ensure that proper synchronism between the 1921 and the 1620 is maintained.

Error Checking during Read Operations

The error conditions listed below turn on the 1620 Read Check (RD CHK) indicator. This indicator should be tested after each read operation.

Parity Check. All data read from tape passes through the read/write register. As characters are read they are checked for even-bit parity.

Read Compare Check. All characters read are checked by dual-level sensing. A valid character detected in either register can be read from tape. A character accepted by only the high register can also be read from tape. If a character cannot be read by either register, an error condition occurs.

Horizontal Check. All characters in a record and the horizontal check character (developed during a write operation) are checked for even-bit parity.

Response Check. A check is made to ensure that proper synchronism between the 1921 and the 1620 is maintained.

MAGNETIC TAPE PROGRAMMING PRINCIPLES

The complexity of a magnetic tape program depends upon the nature of the problem to be solved and the degree of experience of the programmer. But all magnetic tape programs, regardless

of how complex or simple they are, usually contain certain programming techniques that provide for efficient and orderly processing of data. This section of the bulletin presents an introduction to magnetic tape programming principles and is intended as a guide for programmers not familiar with magnetic tape processing.

Tape Records

A tape record is a group of characters that is physically separated from other groups of characters on the tape. Characters within a tape record are contiguous; there is no unused tape between them. (A "blank" character on tape is not void of bits. It is written as an A-bit and a C-bit.) Tape records are separated from each other by an interrecord gap -- a length of unrecorded tape about 3/4-inch long. During writing, the gap is automatically produced at the end of a tape record. During reading, the tape record begins with the first character sensed after an interrecord gap and continues without interruption until the next gap is reached. A single tape record is therefore recognized by the interrecord gaps occurring before and after the data (Figure 14).

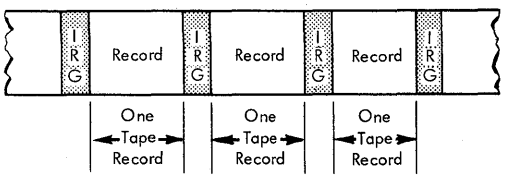


Figure 14. Single Records

The length of input records is an important factor in planning for a tape system. It is impractical to place input records of 80 or 100 characters on magnetic tape as individual tape records. An input record of even 100 character occupies only one-half inch of tape space, yet requires three-fourths inches of tape for an interrecord gap; thus most of the tape is used for interrecord gaps. Moreover, with short tape records the input and output time is disproportionate to the processing time of the record. Therefore, "blocking" of input records before they are written on an output tape is sometimes advisable.

Record Blocking

Blocking is the process of writing two or more input records on tape, without interrecord gaps. In this case, a tape record contains more than one input record. Figure 15 shows four input records that have been blocked on tape to form a single tape record, or block. The tape record shown in Figure 15 is sometimes defined as a "data record" or "block." For simplicity, a "tape record" is defined as two or more input records written on tape, not separated by

interrecord gaps. All input records that are blocked must be of the same length, so that the end of one input record and the beginning of the next input record can be determined during processing of the tape record.

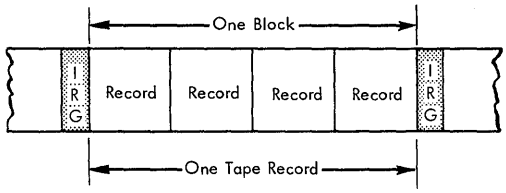


Figure 15. Block Records

Tape Mark

A tape mark is written on tape to indicate the end of a file of information. The tape mark is a single character with a bit configuration of 8, 4, 2, 1. The tape mark, although it is only a single character, is considered a tape record, because it is preceded and followed by an interrecord gap.

Tape File

A tape file consists of a series of related tape records written on tape. The last tape record of a file is always followed by a tape mark. A reel of tape can contain one or more tape files. Each tape file is separated from the next tape file by a tape mark. It is also possible, in a data processing problem requiring a large amount of input data, to have a file consist of more than one reel of tape. In this case, the last character on each reel is a tape mark that indicates an end-of-reel, and the last reel has two tape marks at the end of the tape to indicate the end of the job.

Header and Trailer Labels

Header and trailer labels are often used with magnetic tape so that the operator can identify the contents of a reel and learn other pertinent information about the tape. Header and trailer labels are not mandatory, but their use greatly facilitates magnetic tape handling.

Header Labels

The principal use of a header label is to assure that the correct tape is being used. There are two types of header labels: external labels and internal labels.

External Labels. A label is usually affixed to the outside of the reel container, and usually contains some or all of the following information:

1. A job number, and a reel number (if there is more than one reel).
2. The date the reel was created and how long the reel is to be retained.
3. The application, such as detail or master file.
4. The manufacturer's serial number, in case the reel is separated from its appropriate container.
5. The current length of the tape on the reel.

Internal Label. The internal label is written as the first record on the tape and contains some or all of the following information:

1. Job number and reel number.
2. The date created and the retention date, sometimes called obsolete date.
3. Cycle number. The cycle number is used, for example, when it is necessary to distinguish between job 24 reel 2, 1st quarter, and the same job and reel number for the 2nd quarter.

Trailer Label

A trailer label is an internal label used primarily to record the number of tape records contained in the file or on the reel. It may also be used to identify the end of a reel and to indicate whether the reel is the last reel in the file. A trailer label is customarily preceded by and followed by a tape mark.

Programming Header Routines

The method of programming for a header routine depends upon whether a read or a write operation is to be performed. Figure 16 illustrates a suggested program for reading and is explained in the following steps:

1. The correct header information is read into a storage work area.
2. The first record (the header label) is read from tape, and a check is made to determine that the record has been read correctly. Error routines are discussed later.
3. The job number and creation date from the tape label and header card are compared. If they are not equal, the program branches to rewind the tape, then halts so that the correct tape can be loaded, and then branches to the read instruction.
4. If the job number and creation date are correct, and the input data consists of more than one reel, the reel number is compared to a reel count. If the correct reel number has not been loaded, the program branches to the rewind instruction.

5. If the reel number is correct, the reel count is updated, and the program continues to the main routine.

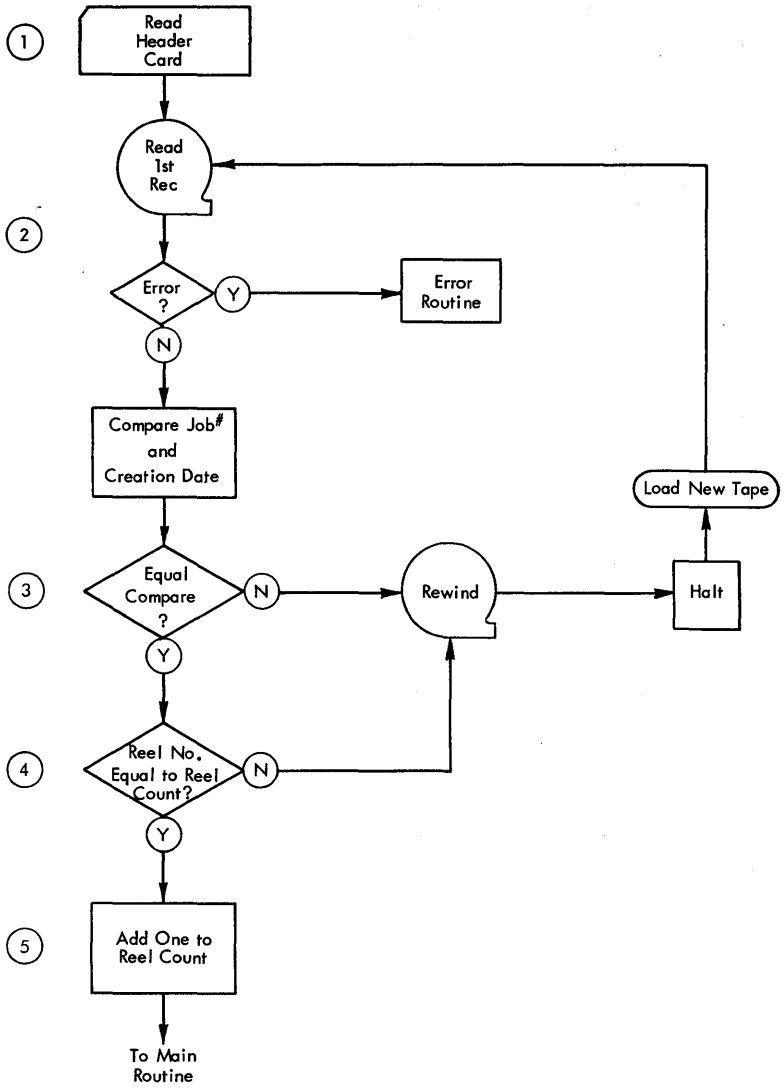


Figure 16. Header Routine — Reading

Figure 17 illustrates a program for a header routine for a writing operation. When developing a header routine for writing on tape, the problem is to determine if the tape to be written upon is obsolete, that is, if the information presently on the tape is no longer of any value.

1. The current date from a header card is read into a storage work area.
2. The header label is read from the tape, and the operation is checked for an error.
3. The current date from the header card is compared to the obsolete date in the tape label. If the current date is not as high as the obsolete date (for example, a current

date of 4/30/61 compared to an obsolete date of 8/30/61), the data on the tape is still required, and the program branches to rewind the tape, then halts so that another tape can be loaded, and then branches to the read instruction.

4. If the tape is obsolete, and therefore can be written upon, the tape is backspaced to the beginning of the first record (the tape label).
5. New header information is assembled from the header card.
6. The new header information is written on the tape in place of the obsolete header, and the program continues to the main routine.

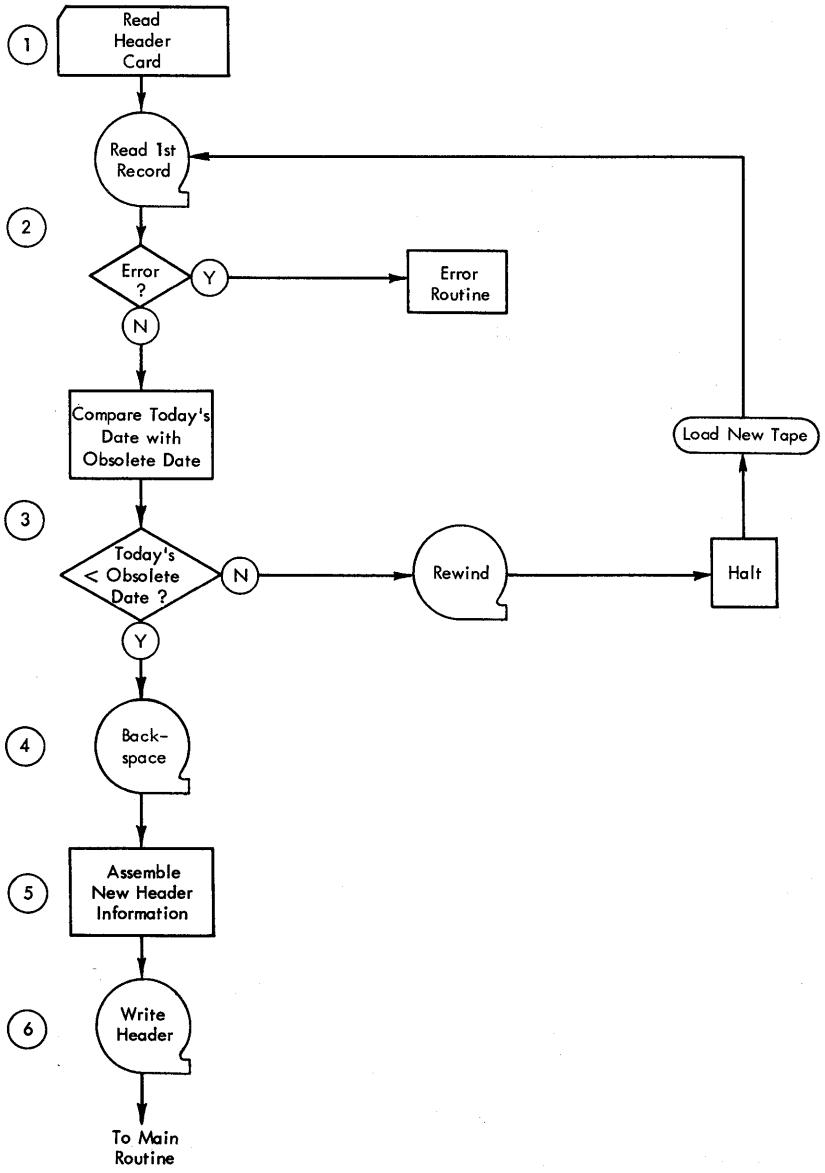


Figure 17. Header Routine – Writing

Error Routines

After every read or write instruction, an error test should be made immediately to determine if a transmission error has occurred. An error test is made by determining the status of the Read Check or Write Check indicators. These indicators are turned on by the various error conditions listed in an earlier section of this bulletin, and are turned off when their condition is tested.

Reading

Figure 18 illustrates an error routine following a read instruction.

1. A tape record is read and an error test is made.
2. If an error is detected, the tape is backspaced to the beginning of the record in which the error occurred, and another read instruction is given.
3. If the tape is read without detecting an error, the program returns to the main routine.
4. The number of times that the tape is backspaced is counted, and the count is compared to a predetermined limit, such as 10. The program continues in this loop until the limit is reached or until a correct transmission occurs.
5. If the limit is reached before a correct transmission has occurred, the record is typed out and is not processed.
6. The number of typeouts are counted and compared against a predetermined limit.
7. As long as the count of typeouts is less than the permanent count limit, the program branches back to the read instruction, to resume operations with the next tape record.
8. If the permanent count limit is reached, the program is halted to permit operator investigation.

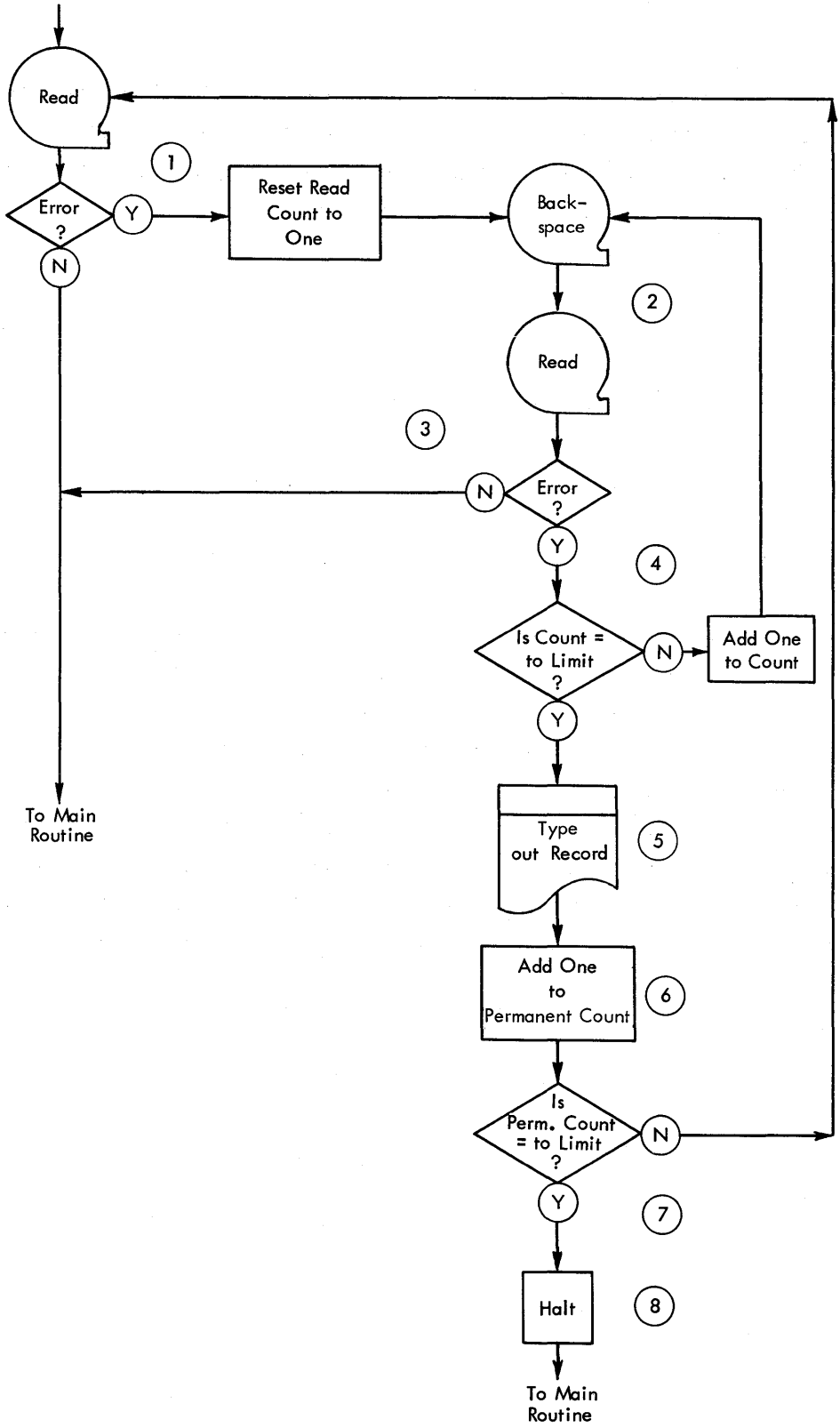


Figure 18. Error Routine — Reading

Writing

Figure 19 illustrates an error routine following a write instruction.

1. A record is written on tape and an error test is made.
2. If an error is detected, the tape is backspaced to the beginning of the record in which the error occurred, and another write instruction is given.
3. If the record is written on tape without detecting an error, the program returns to the main program.
4. The number of times that the tape is backspaced is counted, and the count of backspaces is compared to a predetermined limit, such as 3. The program continues in this loop until the limit is reached or until a correct transmission occurs.
5. When the limit is reached before a correct transmission occurs, an erase forward instruction is given. This instruction moves the tape forward about 8-1/2 inches and erases all data written on the skipped-over portion.
6. The number of erase forward instructions that are executed is counted and compared against a predetermined limit.
7. As long as the erase forward count is less than the limit, the program branches back to the write instruction to write the record on a new portion of tape.
8. If the erase forward count limit is reached, the tape is rewound and the program is halted so that the operator can load a new tape.

End-of-Reel, End-of-Job

An end-of-reel condition means that all of the usable portion of magnetic tape has been used. During a write operation, the reflective spot on the tape indicates the end-of-reel condition. During a read operation, a tape mark indicates an end-of-reel condition. When either the reflective spot or the tape mark is sensed, the Tape Indicate light on the 729 and the Overflow indicator on the 1620 are turned on. The Overflow indicator must be tested after each tape read or write instruction because the status of the Overflow indicator may be changed by subsequent tape instructions or by the processing of the data from the tape record. If a tape record is read or written and this indicator is not immediately tested, the indication of the end-of-file condition will be lost.

End-of-job and end-of-file both mean that the end of a processing problem has been reached. The term "end-of-job" is used when the input or output data requires more than one reel of tape. In a multireel file, the end of each reel is identified by a tape mark, and the last reel contains two tape marks to indicate end-of-job.

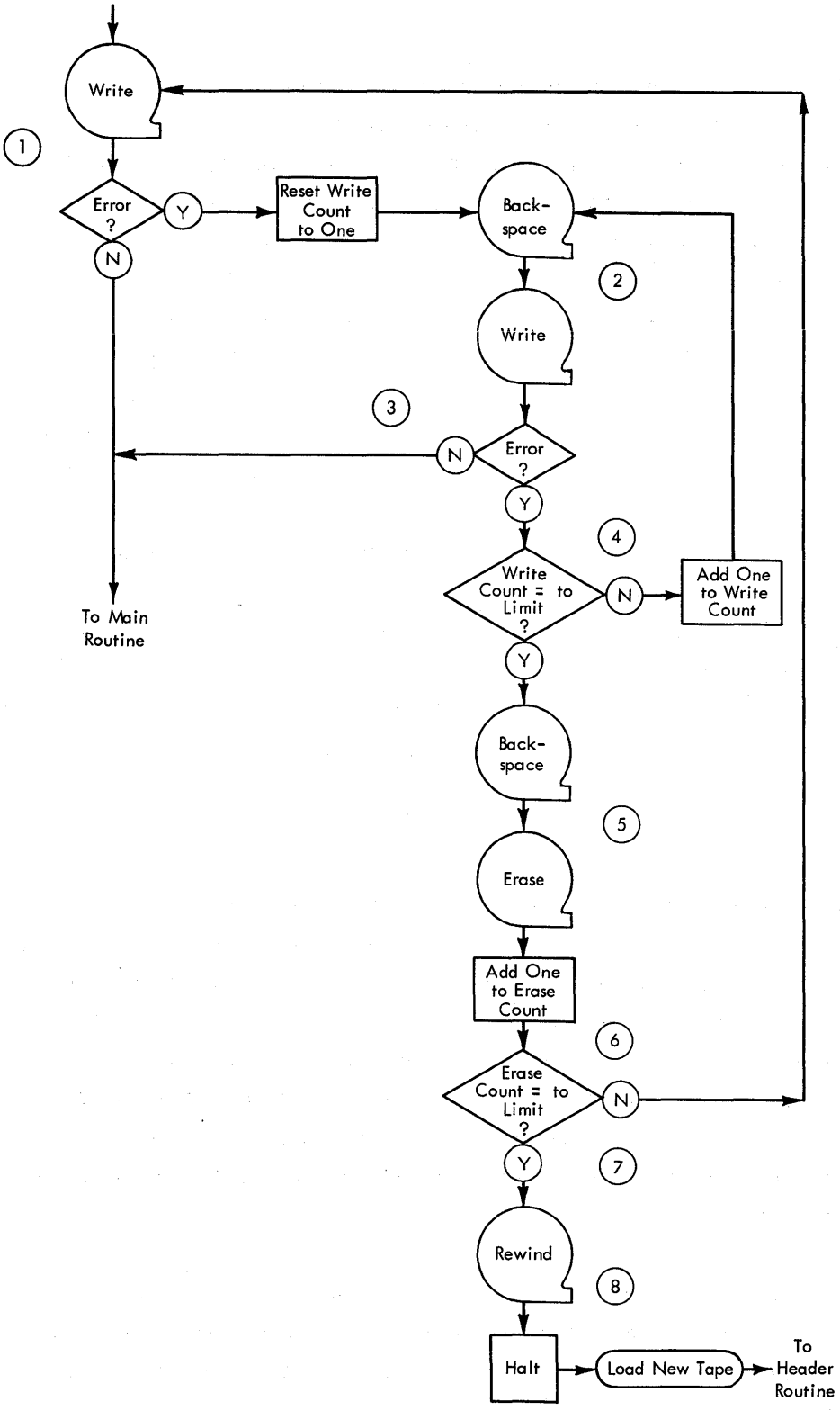


Figure 19. Error Routine — Writing

The term "end-of-file" is used when one reel contains one or more files. When this is the case, an interrecord gap, a tape mark, another interrecord gap, and the first tape record of the succeeding file follow the last tape record of a file. Therefore, the presence of a tape mark indicates an end-of-file condition. In addition to having an end-of-file identification, every tape reel must have its end-of-reel identified. There are several provisions for recognizing an end-of-reel:

1. Multiple tape marks — two or more tape marks in succession, after a tape record, indicate both an end-of-file and an end-of-reel, and cause the program to enter an end-of-reel routine.
2. Trailer label — a trailer label, usually preceded and followed by tape marks, indicates an end-of-reel. A trailer label is only recognized as such if its specifications are included in the program.
3. A single tape mark signifies an end-of-reel if:
   a. The exact number of files to be read by the program is known, or
   b. The number of files on the tape is unknown and the machine is instructed by the program to halt after each file is read; in this case, the operator must manually inspect the tape to determine if an end-of-reel has been reached.

End-of-Reel Routine - Writing

When writing on tape, the Tape Indicate light and Overflow indicator are turned on if the reflective spot is sensed. Figure 20 illustrates a program routine for end-of-reel. It includes the following:

1. A record is written on tape.
2. After the error test, the Overflow indicator is tested. If the Overflow indicator has not been turned on, the program continues on in the main routine.
3. If the Overflow indicator is turned on, a tape mark is written on the tape. The tape mark is then used for an end-of-reel indication when the tape is being read. The Overflow indicator is turned off by the test.
4. If desired, a trailer label can be written on the tape.
5. The tape is rewound and the Tape Indicate light is turned off.
6. The program halts to permit the operator to change tapes, and then it branches to the header routine.

Following the rewind instruction, the end-of-reel routine may take different forms, depending upon the number of tape units used for output. When only one tape unit is used, the program is normally written to stop as shown in Figure 20. If more than one tape unit is used for tape writing, the end-of-reel routine is normally written to alter the address of the output tape unit

in the program. This allows the program to continue processing data by writing the output on the second or alternate tape unit. The operator can then change the tape in the first unit in the conventional manner without stopping the 1620. This results in more efficient use of machine time.

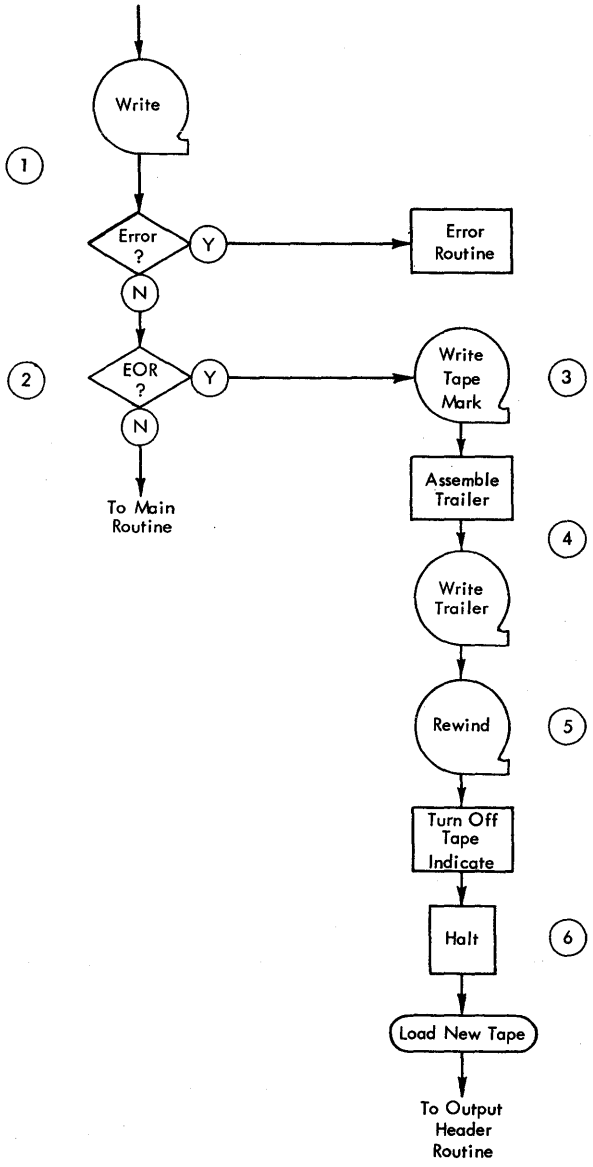


Figure 20. End-of-Reel — Writing

End-of-Reel or End-of-Job - Reading

When reading tapes, the Tape Indicate and Overflow indicator are turned on if a tape mark is read. The difference between reading and writing is the method used to turn on the Tape Indicate light and Overflow indicator. The reflective spot indicates the approximate physical end of the tape, but is not exact enough to indicate where the last record on tape has been written and therefore is not used during reading operations. That is why a tape mark is recorded after the last actual tape record during a write operation. Figure 21 shows a routine for end-of-reel and end-of-job for a multireel input file. This routine consists of the following:

1. A record is read from tape.
2. After the error test, the Overflow indicator is tested. If the Overflow indicator has not been turned on, the program continues on in the main routine. Testing the Overflow indicator always resets the indicator to its normal status, OFF.
3. If the Overflow indicator is turned on, another read instruction is given. If the record that is read is a tape mark, the Overflow indicator is turned on a second time.
4. The Overflow indicator is tested. If this indicator is off, only an end-of-reel condition exists.
5. On an end-of-reel condition, the reel is rewound, and the Tape Indicate light is turned off.
6. The program halts to permit the operator to change tape, and then it branches to a header routine. The end-of-reel routine for input tapes can be altered in the same way as is the routine for output tapes. With two tape units in use for input data, the program can be written to alter the tape unit addresses in the program to allow processing to continue to the second tape, while the operator changes the first tape.
7. If, in step 4 above, the Overflow indicator is on, then the tape unit has read two tape marks in succession, indicating an end-of-job.
8. The input tape is rewound.
9. Two tape marks are written on the output tape.
10. If desired, a trailer label can be written on the output tape.
11. The output tape is rewound, the Tape Indicate light is turned off, and the program is halted.

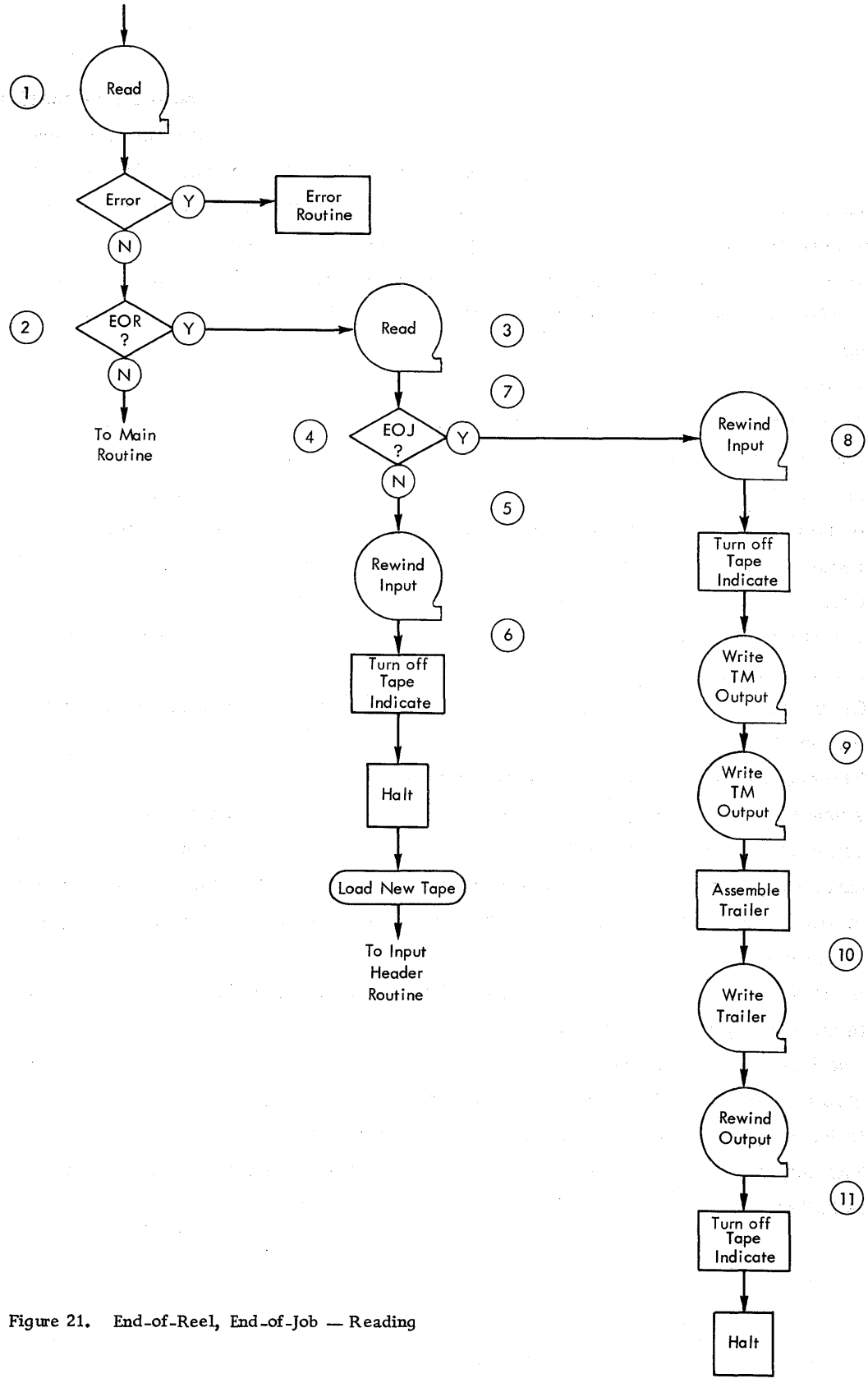


Figure 21. End-of-Reel, End-of-Job — Reading

OPERATOR INSTRUCTIONS FOR MAGNETIC TAPE HANDLING

Dust Prevention

Foreign particles on tape can reduce the intensity of reading and recording pulses by increasing the distance between the tape and read-write head. Be extremely careful to protect magnetic tape from dust and dirt.

Keep the tape in a dustproof container whenever it is not in use on a tape unit. When a reel of tape is removed from a tape unit, place it immediately in a container. Always place sponge rubber grommets or special clips on the reels when they are stored, to prevent the free end from unwinding in the container.

While the tape is on the machine, close the empty container and store it where it is not exposed to dust and dirt.

Store tapes in a cabinet elevated from the floor and away from sources of paper or card dust. This should minimize the transfer of dust from the outside of the container to the reel during loading or unloading operations.

Never use the top of a tape unit as a working area. Placing materials on top of the units exposes them to heat and dust from the blowers in the unit. It also interferes with the cooling of the tape unit.

Damage Prevention

Because information is recorded within .020 inch of the edge of the tape, the edge must be free from nicks and kinks.

Handle the reels near the hub, whenever possible. In picking up reels, grip the reel between the center hole and the outer edge. A grip that compresses the outer edges of the tape pinches a few turns of the tape near the outer edge of the reel. Personnel who handle tape reels inside and outside the machine room should be instructed to avoid pinching the reels or touching the exposed edges of the tape.

Dropping a reel of tape can easily damage both the reel and the tape. Never throw or mishandle reels even though they are in containers.

Cleaning Tape Units

Daily cleaning of all tape units is recommended, particularly the read-write heads and transport mechanism. Consult the Customer Engineer for the proper procedure.

Tape Break

If a tape break occurs, divide the reel into two smaller reels. A temporary splice may be necessary to recover information; however, splicing is not recommended as a permanent correction procedure. In making a temporary splice, be sure to use the special low cold-flowing splicing tape (a Customer Engineering supply item).

Dropped Tape Inspection

If a reel of tape has been dropped, the reel may be broken or bent (bending is less likely because a strain sufficient to bend a reel usually breaks it), the edge of the tape may be crimped, or the tape may be soiled. To test for and remedy these defects, proceed as described below:

1. Inspect the tape reel immediately. A broken or bent reel can usually be detected by visual inspection. Also check the reel by mounting it on the hub of a tape unit. If the reel has been bent or broken, it obviously should not be used again. The tape, however, may be serviceable.
2. Inspect the tape
   a. If there is no evidence of crimping or other tape damage and the reel is undamaged, thoroughly clean the exposed or unwound tape and the reel. The tape is then in good operating condition. If at all possible, test to verify that the tape is operating properly before using it on subsequent runs.
   b. If there is no evidence of tape damage, but the reel is damaged, thoroughly clean the exposed or unwound tape and rewind it on another reel. If possible, test the tape to verify that it is operating properly.
   c. If the edge of the tape is crimped, the action that should be taken will depend on whether the tape contains needed information. If the tape does not contain needed information, discard the crimped footage. If the tape contains essential information, thoroughly clean the tape and attempt to reconstruct this information either by printing out the data on another tape or by some other machine operation. If reconstruction fails, the records in question will have to be rewritten from cards or from another source.

Shipping Tapes

If a tape arrives from the manufacturer in unusable condition, ship it back to the factory according to these instructions to avoid additional defects before inspection.

1. Place the reel of tape securely in a dustproof container that supports the tape reel at the center.
2. Hermetically seal the container in a moisture-proof plastic bag.
3. Provide additional support by packing the container in an individual, stiff-cardboard shipping box.

Storing Tapes

1. Provide adequate protection and mechanical support for the reels of tape by using individual dust-proof containers.
2. For Mylar* tape, keep the atmosphere of the area used for long-term storage within the following limits:
   Temperature -- 40^{o} to 120^{o} F
   Relative humidity -- 40% to 80%
3. If the tape is removed from the stated conditions for more than four hours, it must be reconditioned before it is used. To recondition the tape, allow it to remain at the given condition for a length of time equal to the time it was away, up to 24 hours.

ORDERING A 1620 TAPE SYSTEM

All 1620 Magnetic Tape Systems must be factory installed. Orders for the system must specify RPQ 898005, in conjunction with an order for a 1620 Processor and a 729 II Magnetic Tape Unit.

Up to five additional tape units may be ordered by specifying RPQ F88983 in conjunction with an order for the number of tape units required.

* Registered trademark of E. I. du Pont de Nemours & Co., Inc.

PHYSICAL PLANNING CONSIDERATIONS

729 II Magnetic Tape Unit

Physical Characteristics

Width: 29 1/8"
Depth: 33 7/8"
Height: 69 1/4"
Weight: 1160 lb

Service Clearances

Right Side:	2"	Front:	30"
Left Side:	2"	Back:	30"

1921 Magnetic Tape Control Unit

Physical Characteristics

Width: 60"
Depth: 27"
Height: 44"
Weight: 810 lb
Color: Compatible with the 1620

Service Clearances

Right Side:	30"	Front:	30"
Left Side:	30"	Back:	44"

Electrical Requirements

Electrical requirements for this system are 30 amps, 208 v $\pm$ 10%, 3-phase 60-cycle $\pm$.5 cycles, 4-wire connector. Ground wire must be common to the 1620 208-v single-phase ground. A separate receptacle is required for the 1921. A Hubbell wall-type receptacle No. 20403, No. 20414, or equivalent must be supplied by the customer.

Heat Dissipation

1921	5000	Btu/hr
729 II	3520	Btu/hr

Environment

Temperature: 60^{o} to 90^{o} Fahrenheit
Humidity: 20% to 80%

During nonoperational periods, the temperature must be between 65^{o} and 100^{o} F, with a relative humidity of 20% to 80%.

Cables

Specifications for signal cables and power cables are shown below. These specifications contain two cable lengths: (1) a specified cable length that is supplied by IBM; (2) a maximum cable length that can be ordered. The cable length supplied by IBM does not include a machine allowance. The machine allowance is the length of cable required inside of a machine. The maximum cable lengths include the machine allowance. Figure 22 shows a cable layout.

1620 to 1921 I/O Signal Cable (or 19XX to 1921 I/O Signal Cable). An 18-ft cable (excluding machine allowance) will be supplied unless otherwise specified on the 1921 order. If other I/O devices are added to this line, the total I/O cable length must not exceed 35 feet. Machine allowance is 38"; 32" in the 1921,6" in the 1620.

1620 to 1921 Interlock. An 18-ft cable (excluding machine allowance) will be supplied unless otherwise specified on the 1921 order. A maximum cable length of 35 feet may be specified. Machine allowance is 104" 32" in the 1921, 72" in the 1620.

1921 to 729 II and to Second 729 II -- 729 II Signal Cable. Cables may be specified in combinations which do not exceed a total cable length of 60 feet. Machine allowance is 36" in the 1921, 15" in the 729 II.

1921 to 729 II and to Second 729 II -- 729 II Power Cable. Cables may be specified in combinations which do not exceed a total cable length of 60 feet. Machine allowance is 36" in the 1921, 15" in the 729 II.

NOTE: Machine allowances must be included as a part of the cable length. The cable length must not be exceeded.

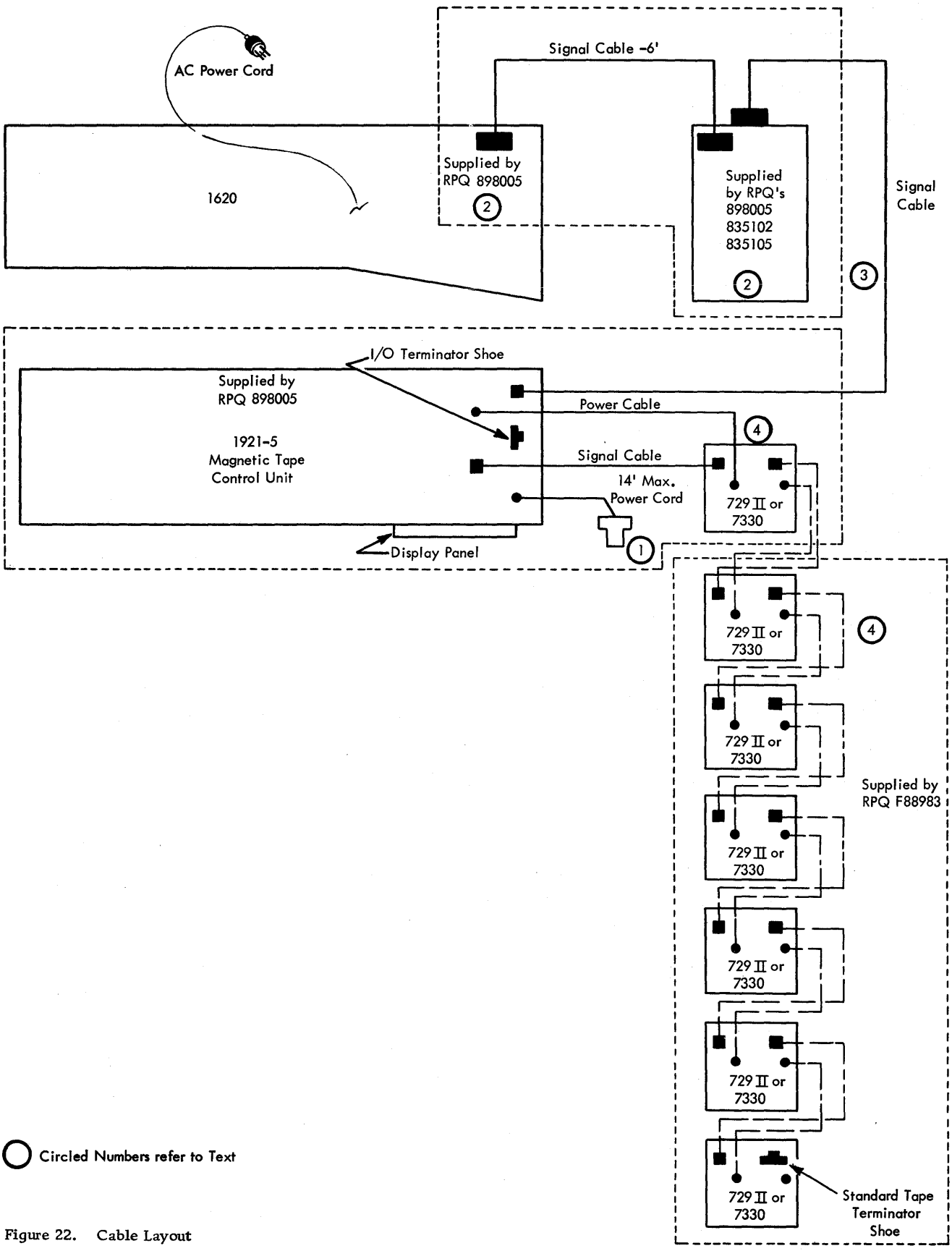


Figure 22. Cable Layout

The following notes are associated with the circled numbers in Figure 22.

1. Power: 208 or 230 volts AC, 3-phase, 60 cycles, 30 amperes. A Hubbell connector (P/N 21443) is supplied.

2. This Serial I/O unit (see description below) is used to attach the 1921-5 to the following 1620 units:
   1620-1 units with serial numbers greater than or equal to 10951 (RPQ 898005).
   All 1620-2 units irrespective of serial number (RPQ's 835102 and 835105).

Serial I/O Unit Description

Length:	15 inches
Height:	26 inches
Depth:	30 inches
Weight:	150 lb
Service Clearance:	minimum of 30 inches, all sides
Power requirements:	supplied by 1620

Note: For 1620-1 units with serial numbers less than 10951, the I/O circuitry is installed within the 1620--the Serial I/O unit is not used (RPQ 898005).

3. This cable is provided with any 1921-5 order; cable length is 20 feet unless specified differently at the time of order--maximum cable length is 35 feet.
   Up to five I/O units such as the 1921-5, 1011, etc., can be attached to this I/O channel. The maximum cable length for each unit other than the 1921-5 is 15 feet. The 1921-5 must be connected first, that is, the closest to the 1620. The I/O terminator shoe on the 1921-5 (see diagram) is then used to connect the second I/O unit. This I/O terminator shoe is capped if no other I/O unit is used.

4. The interconnecting cables between the 1921-5 and the tape drives are supplied with pluggable connectors. The type of tape unit terminator shoe and the required tape unit cable lengths must be specified with each tape unit cable order. The maximum distance from the 1921-5 to the last tape drive is 60 feet.

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