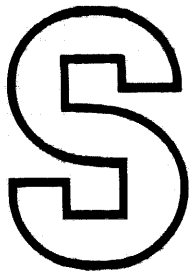

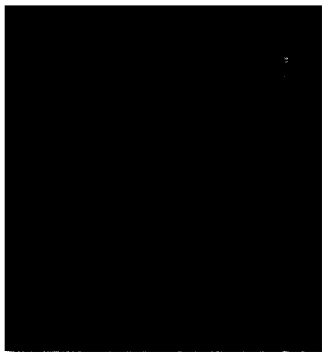

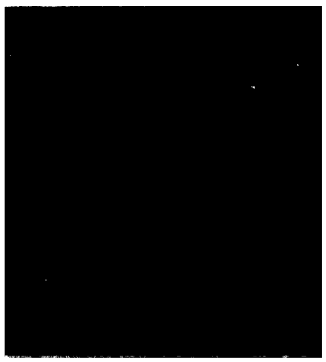

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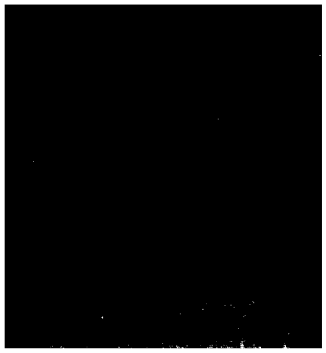

Reference Manual

IBM Magnetic Tape Units

IBM

Reference Manual

IBM Magnetic Tape Units

Preface

This manual contains reference material for operators of IBM Magnetic Tape Units, and general information for other persons interested in the uses of these units. Although the sections on organizing tape records and reels, sorting, and tape error recovery procedures are general and have been simplified for the purposes of this manual, some background in data processing concepts is assumed.

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IBM *Technical Newsletter, Intermixed* IBM *729II, 729IV, 729V, 729VI, and 7330 Magnetic Tape Units,* Form N22-0003
IBM *Technical Newsletter,* IBM *7330 Magnetic Tape Unit, Operating Precautions and Tape Loading Procedure,* Form N22-0020

Address comments regarding this publication to:
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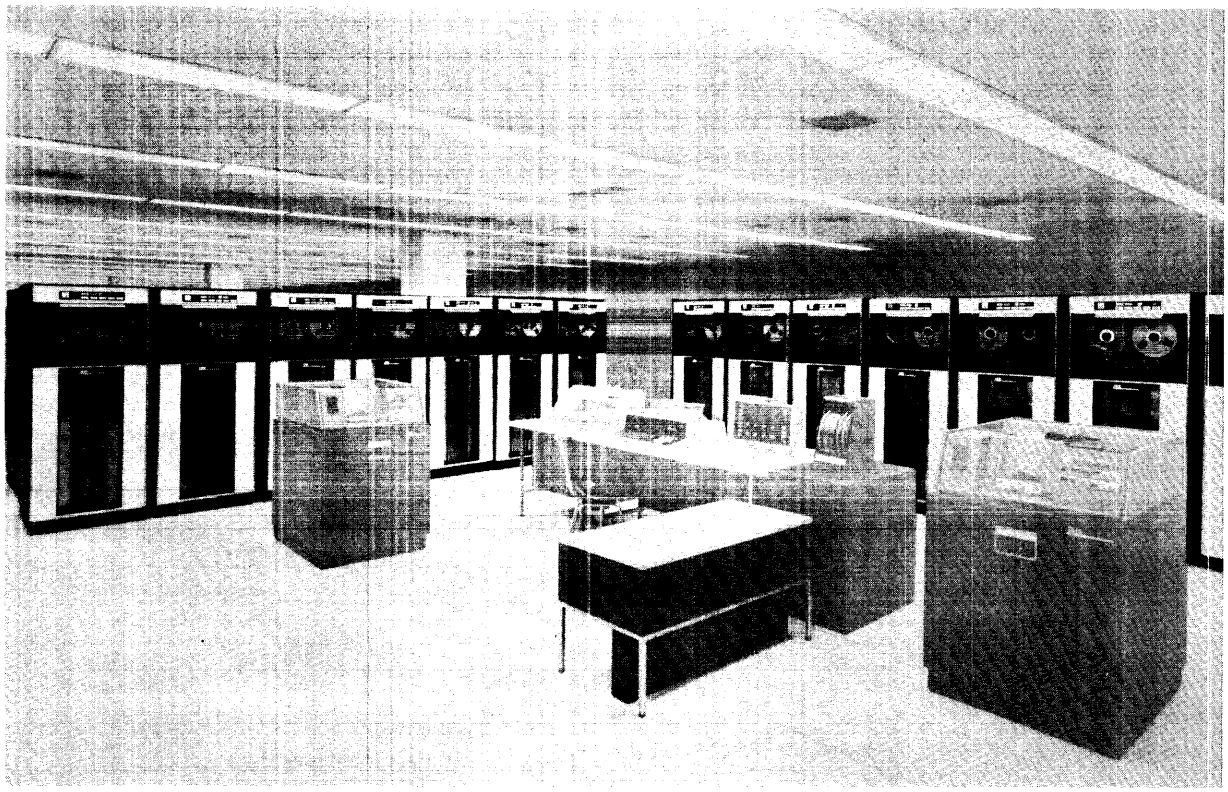


IBM 729 Magnetic Tape Units with IBM 7070 Data Processing System

Magnetic tape is the principal input-output medium for data processing systems. The tape is also used for storing intermediate results of computations and for permanent storage of large files of data.

IBM magnetic tape units function in the system as both input and output devices. They transport the magnetic tape and accomplish the actual reading and writing of information, as directed by outside control, for use in the data processing system. The different models of tape units are similar in general appearance and operational use; differences are the speed at which the units transport tape and the quantity of data recorded per inch of tape.

IBM magnetic tape (Figure 1) is similar in principle to the tape used in home tape recorders. To produce this precision engineered product, microscopically small particles of iron oxide are mixed with a binding agent and the wet mixture is uniformly applied to the surface of long rolls of flexible plastic. The plastic base is about as thick as cigarette paper; the magnetic coating about one-third that thick. Recording occurs in this ferromagnetic coating.

After the magnetic layer hardens, the rolls are slit into ½-inch ribbons, wound on reels, and shipped to the IBM Magnetic Tape Center for testing (Figure 2). Untested tape can be used for many common types of magnetic recording, but the magnetic tape used for data processing must be of a particularly high quality. Tiny flaws, which would not interfere with the recording of music, could prevent the accurate recording of data. Small imperfections that result in lost data can cause an entire series of computations to be repeated — a waste of valuable machine time.

In every data processing installation, time is money. The cost of tested magnetic tape is insignificant when compared to the savings that result from its use.

The 10½-inch diameter plastic reels (Figure 3) can hold 2400 feet of tape. Shorter lengths — as short as 50 feet — may be used. A full reel weighs about four pounds and can contain data equivalent to that in 200,000 fully punched IBM cards. IBM Mylar* and IBM Heavy Duty magnetic tape may be used on all presently available standard IBM magnetic tape units.

Tape end retainers are used to prevent reels of tape from unwinding. The pressure-sensitive feature of the tape end retainers permits them to be affixed to the inside of the tape reel container for convenient access and re-use by the operator.

Reels are available in red, yellow, blue, and gray. Pressure sensitive identification labels for reels are available in matching colors.

Magnetic tape possesses a characteristic unique among data processing records — that of automatic erasure. Although recording is permanent, affecting

* Trademark of E. I. du Pont de Nemours & Co. (Inc.)

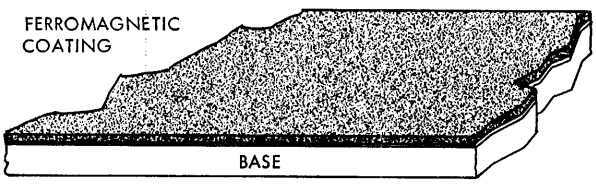


Figure 1. Section of IBM Magnetic Tape

Figure 2. Testing IBM Magnetic Tape

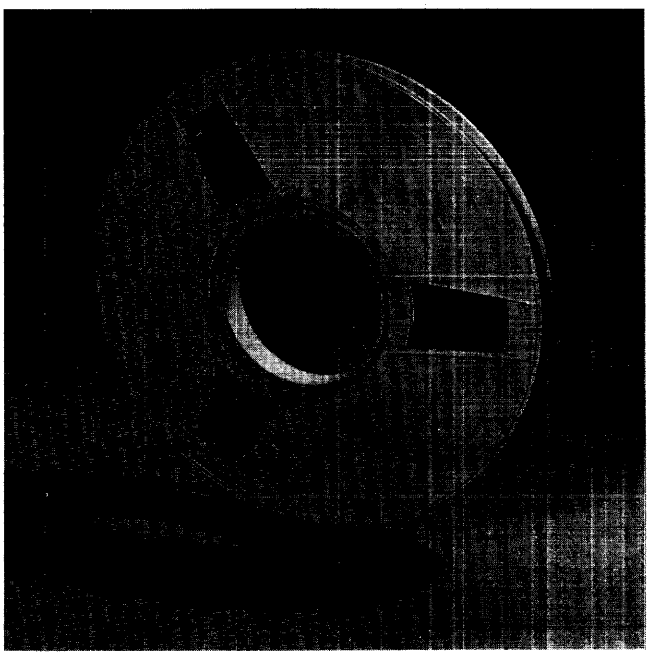


Figure 3. Magnetic Tape Reel

the magnetic state of the tape surface, any previous recording is destroyed by the writing operation. This means that tape can be used again and again, with significant savings in recording costs.

Writing and Reading Magnetic Tape

Figure 4 shows the arrangement of reels and tape on a 729 tape unit. The tape reels and head are accessible by opening the reel door. When the door is open, an interlock switch prevents operation of the drive motors.

The head assembly, located between the vacuum columns, is built in two sections. The lower section is stationary, and the upper section can be moved up or down under control of the tape-unit keys (on the IBM 7330 this is done manually). When the upper section is up, the operator can thread tape. When down, it causes the tape to be in close contact with the head for reading or writing.

Tape moves from file reel through the left vacuum column across the read-write head, through the right vacuum column to the machine reel. The loop in each vacuum column acts as a buffer for the sudden start and stop motion of the tape. Vacuum actuated switches in the columns control magnetic clutches that permit the two reels to rotate independently. The file reel feeds when the loop reaches a minimum reserve length in the left vacuum column, and the machine reel winds tape when the loop reaches a point near the bottom of the right vacuum column. Tape may be backspaced over a record or rewound to the beginning of the reel. No writing may take place while tape is moving backward.

Two types of reading and writing heads are used in present magnetic tape units. The single-gap head in the IBM 727 Magnetic Tape Unit has only one magnetic gap for each of the seven recording tracks. This gap is used for both reading and writing (Figure 5). The newer two-gap head has two magnetic gaps for each of the seven recording tracks (Figure 6). Writing occurs at one gap and reading at the other.

The general principles of writing and reading are the same, regardless of the head used. Information is written on tape by magnetizing areas in seven parallel channels or tracks along the length of the tape. Electrical current flowing through the recording coils (one for each track) magnetizes the iron oxide coating of the moving tape — and thereby erases previously written information. New data are written by changing the direction of current flow in some of the coils. This causes a change in the direction of magnetization in the affected track.

Although the tape moves at high speed (up to 112.5 inches per second), the current reversals in the write head coils are so rapid that the size of the area of tape that records the change in direction of magnetization is almost the same as if the tape were motionless.

The presence or absence of changes in direction of magnetization in the seven bit positions across the width of the tape represent coded data. During reading, a change in direction of magnetization in a track

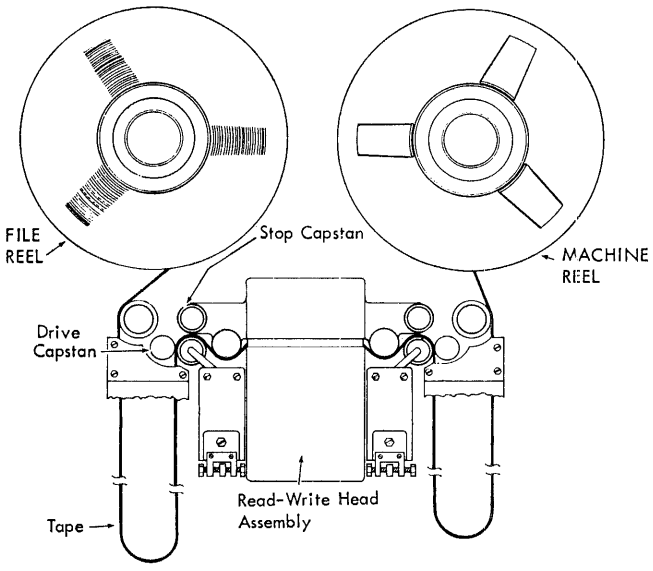


Figure 4. Tape Feed Schematic

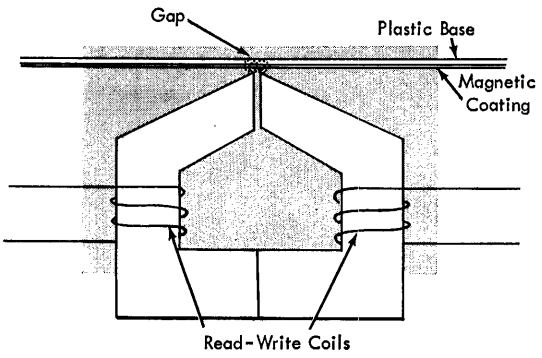


Figure 5. One-Gap Read-Write Head

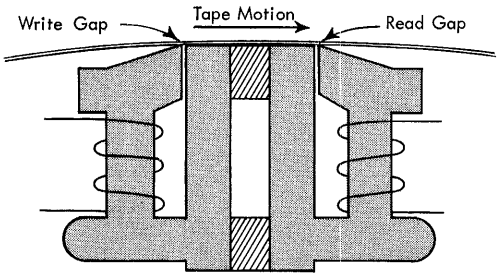


Figure 6. Two-Gap Read-Write Head

is sensed as a *one bit.* An absence of a change is sensed as a *zero bit.* Data coded in ones and zeros are made available to the computer when tape is read by tape unit circuitry.

Tape Codes

Data to be used by IBM computers are coded on magnetic tape in two forms: binary, and binary coded decimal (BCD).

The code used depends on the computer that will work with the data. Some computers use binary representation internally; others use variations of the binary method of symbolizing information (including BCD). Tape control equipment used with the tape unit provides circuitry to convert tape data to the proper form for internal use by the computer.

When data are recorded on tape in binary coded decimal form, the longitudinal tracks provide the seven bit writing positions necessary to represent a BCD character. A character is represented by one lateral column of bits across the width of the tape. In Figure 7, BCD coded characters on a section of tape are shown schematically; actual recording is not visible to the eye.

The enlarged area of Figure 7 illustrates that bits are represented on tape as a reversal in polarity of magnetization from north to south or vice versa. Recording on tape is actually a series of bar magnets of varying lengths laid end to end in seven parallel tracks. The seven recording tracks are identified C, B, A, 8, 4, 2, 1.

The C track on tape contains a check bit for characters that would otherwise have an odd number of bits (BCD code). Tape written in binary code has a check bit in the C track for each lateral column that would otherwise have an even number of bits. This arrangement provides a means of making a code check for the proper number of bits in each lateral column.

Interpretation of the data recorded in one lateral column depends on the code used in writing. For example, the bits in one column of tape written in the seven-bit alphameric code (BCD) represent one character; the bits in one column written in the binary system code represent part of a binary word.

Auxiliary equipment, such as card-to-tape, tape-to-card, and tape-to-printer units, requires information to be recorded on the tape as BCD characters.

There is a correlation between BCD and the IBM code used in punched cards: The AB bits in combination are equivalent to a 12-zone, the B bit without an A bit equals an 11-zone, the A bit alone equals the 0-zone; and combinations of the 8-4-2-1 bits comprise the digit values 0-9 (zero is represented by the 8 and 2 bit combination). C bits occur in BCD characters

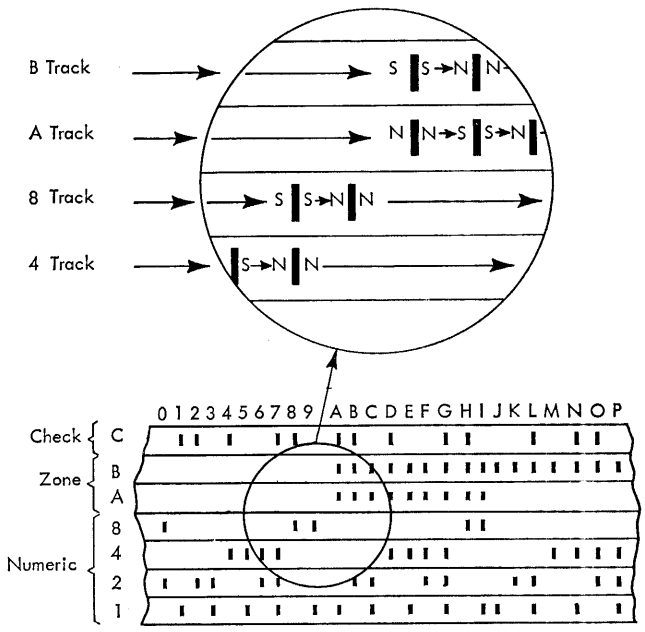


Figure 7. Magnetic Recording of BCD Code on Tape

Collating Number	Graphics	Card Code			Magnetic Tape BCD Code						
					C	B	A	8	4	2	1
00	Blank	No Punches			No Bits *						
01	.	12	3	8	C	B	A	8		2	1
02	¤)	12	4	8		B	A	8	4		
03	[	12	5	8	C	B	A	8	4		1
04	<	12	6	8	C	B	A	8	4	2	
05	ǂ	12	7	8		B	A	8	4	2	1
06	& +	12				B	A				
07	$	11	3	8		B		8		2	1
08	*	11	4	8	C	B		8	4		
09	]	11	5	8		B		8	4		1
10	;	11	6	8		B		8	4	2	
11	Δ	11	7	8	C	B		8	4	2	1
12	-	11			C	B					
13	/	0	1				A				1
14	,	0	3	8			A	8		2	1
15	% (	0	4	8	C		A	8	4		
16	Y	0	5	8			A	8	4		1
17	\	0	6	8			A	8	4	2	
18	ǂ	0	7	8	C		A	8	4	2	1
19	↑		2	8	C		A	*			
20	# =		3	8	C			8		2	1
21	@ '		4	8				8	4		
22	:		5	8	C			8	4		1
23	>		6	8	C			8	4	2	
24	✓		7	8				8	4	2	1
25	?	12	0			B	A	8		2	
26	A	12	1		C	B	A				1
27	B	12	2		C	B	A			2	
28	C	12	3			B	A			2	1
29	D	12	4		C	B	A		4		
30	E	12	5			B	A		4		1
31	F	12	6			B	A		4	2	
32	G	12	7		C	B	A		4	2	1
33	H	12	8		C	B	A	8			
34	I	12	9			B	A	8			1
35	!	11	0		C	B		8		2	
36	J	11	1			B					1
37	K	11	2			B				2	
38	L	11	3		C	B				2	1
39	M	11	4			B			4		
40	N	11	5		C	B			4		1
41	O	11	6		C	B			4	2	
42	P	11	7			B			4	2	1
43	Q	11	8			B		8			
44	R	11	9		C	B		8			1
45	ǂ	0	2	8	C		A	8		2	
46	S	0	2				A			2	
47	T	0	3		C		A			2	1
48	U	0	4				A		4		
49	V	0	5		C		A		4		1
50	W	0	6		C		A		4	2	
51	X	0	7				A		4	2	1
52	Y	0	8				A	8			
53	Z	0	9		C		A	8			1
54	0		0					8		2	
55	1		1		C						1
56	2		2		C					2	
57	3		3							2	1
58	4		4		C				4		
59	5		5						4		1
60	6		6						4	2	
61	7		7		C				4	2	1
62	8		8		C			8			
63	9		9					8			1

* A no-bit blank character cannot be written on tape; the substitute blank character is composed of a CA bit combination on tape.

Figure 8. Standard BCD Interchange Code

that would otherwise have an odd number of bits. In addition to alphabetic and numeric characters, the BCD format provides for punctuation marks and other special symbols. The two codes are shown in Figure 8.

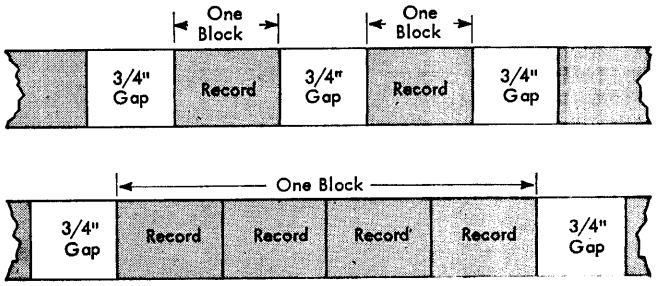


Figure 9. Single and Multiple Record Blocks

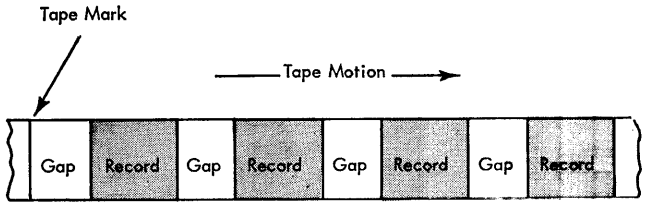


Figure 10. Tape Mark at End of File

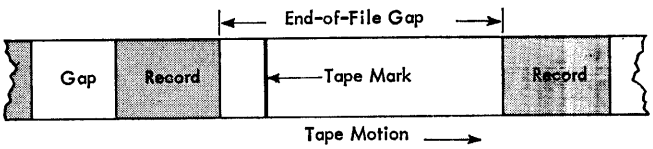


Figure 11. End-of-File Gap

Tape Records

Ordinary recording equipment normally handles records of fixed length. For example, the punched card is limited to a maximum length of 80 columns. If more information is needed, two or more cards are required. However, the recording capacity is not doubled, because identifying data — such as name or part number—must also be punched in all cards making up the multiple record.

Records on tape are not restricted to a fixed length of characters, fields, or words. Records may be of any practical size within the limits of capacity of the area assigned to the storage of data in the computer. This feature allows writing all information pertinent to an item in a single continuous data record. The need for repeating the identification in multiple records is eliminated. As much information as is needed can be conveniently included in its most compact form.

Records or blocks of records are separated on tape by a record gap — a length of blank tape about ¾ inch long. During writing, the gap is automatically produced at the end of a record or block. Reading of the record block begins with the first character sensed after a gap and continues without interruption until the next gap is reached. A single record or block of records is, therefore, defined or marked by an inter-record gap before and after the data (Figure 9).

An inter-record gap, followed by a special single-character record, is used to mark the end of a file of information. The character, a tape mark (Figure 10), is automatically generated and written on the tape following the last record of the file. One or more files may be written on a reel of tape.

Some systems recognize the end-of-file condition on tape as an elongated gap, about 3¾ inches long, called an end-of-file gap. A tape mark may or may not appear in the end-of-file gap, depending on the mode of operation (Figure 11). The tape mark can be a part of the end-of-file indication, or it may indicate the end of one of a number of reels that make up a complete file.

The computer can be instructed to rewind the first reel and resume reading from the next reel which may be ready on a second tape unit. In this way, operation of the system is not interrupted for a reel change.

Tape may be backspaced under computer control. Tape motion reverses until the previous inter-record gap is sensed. This feature provides for rereading or rewriting a record or block of data when an error condition is sensed. On some systems, multiple record block backspacing can be done by a single instruction.

If an error condition is detected during operation, the machine can be instructed to backspace and try again to correct the error. If an error cannot be corrected automatically by rewriting or skipping tape, instructions may stop the machine and indicate to the operator where the failure occurred so that appropriate action may be taken.

If an error has developed in storage, however, no rewriting operation can correct the condition. In this case, the machine is usually instructed to stop so that some manual correction to the record can be made. When this is not feasible, the error record may be written by an output unit for later correction.

Density and Character Rate

The major differences in IBM magnetic tape units are the density of the recorded information on tape and the speed at which tape is moved past the read-write head.

Tape Speed (inches/sec	Density (char/inch)	Character Time (microseconds)	Character Rate (char/inch)
36	200	139	7,200
	556	50	20,016
75	200	67	15,000
	556	24	41,667
	800	17	60,000
112.5	200	44	22,500
	556	16	62,500
	800	11	90,000

Figure 12. Character Rate

Density is the number of characters of data recorded on a unit length of tape. Densities presently used are 200, 556, and 800 characters per inch of tape.

Tape unit speed is stated as the length of tape that is transported past the read-write head in a unit of time. Three recording speeds are currently used: 36 inches per second, 75 inches per second, and 112.5 inches per second.

The faster the tape speed and the greater the density of recording, the higher is the rate at which information is recorded on or read from tape. The number of characters of data read or written in a unit of time constitutes the information rate for a tape unit. By combining speed and density, character rate is determined (Figure 12).

This rate is diminished by the record gaps on a reel of tape. Files with many characters per block will have few record gaps compared with a file with short blocks.

Density and character rate considerations are involved in estimating the tape processing time required by a particular application of a data processing system.

	200 Char/Inch	556 Char/Inch	800 Char/Inch
729 I - milliseconds per record block =	10.8 + .067N		
729 II - milliseconds per record block =	10.8 + .067N	10.8 + .024N	
729 V - milliseconds per record block =	10.8 + .067N	10.8 + .024N	10.8 + .017N
729 III - milliseconds per record block =		7.3 + .016N	
729 IV - milliseconds per record block =	7.3 + .044N	7.3 + .016N	
729 VI - milliseconds per record block =	7.3 + .044N	7.3 + .016N	7.3 + .011N
Inches per record block =	.75 + .005N	.75 + .0018N	.75 + .00125N
Record blocks per reel (all models) =	28440 inches divided by the number of inches per record block		

N = Number of characters in a record block

Figure 13. Estimating Tape Processing Time for 729 Magnetic Tape Units

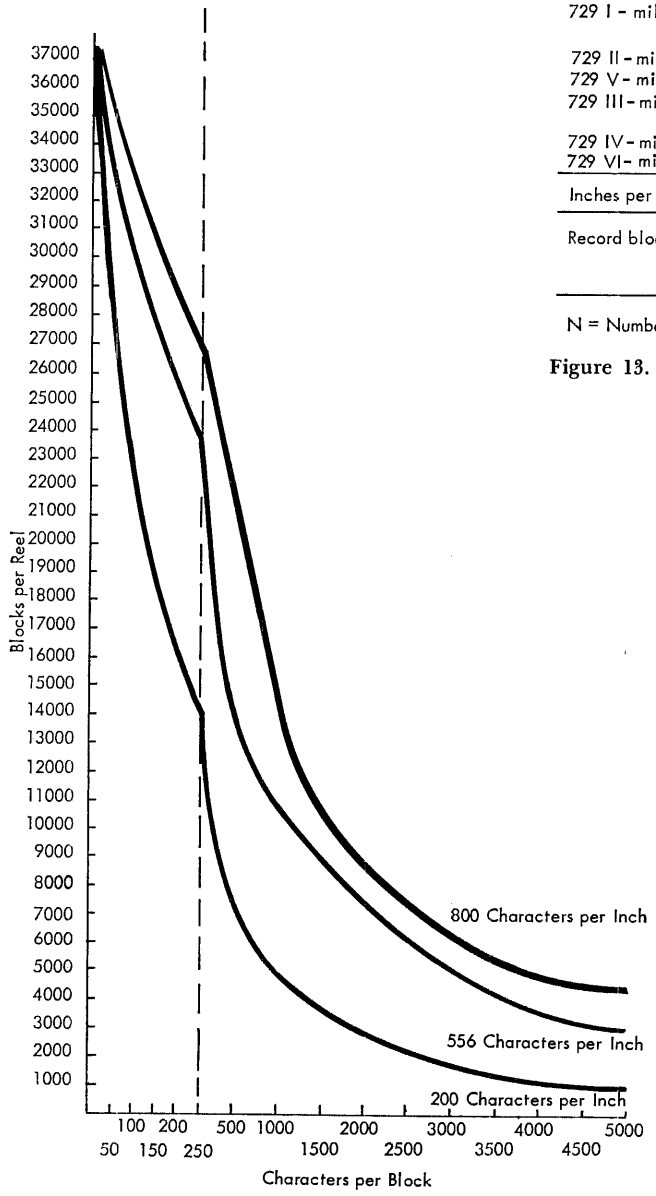


Figure 14. Reel Capacity Relationship to Density

Estimating Tape Processing Time

One of the cardinal characteristics of a data processing system is the total job time required for a particular application. In a system using magnetic tape units, this includes setup time, tape read and write time, central processing unit compute time, and rewind tape time. These factors receive careful attention when a job is programmed and scheduled.

Because a record gap is placed between each record or block of records on tape, the total time required to read a record or block must include time to space over one inter-record gap. A ¾-inch record gap moving at 75 inches per second will pass the read-write head in ten milliseconds. Reading a reel of tape will normally include some starts and stops between record blocks. Acceleration and deceleration require addi-

tional time to space over the particular record gap. An average time to move each tape record gap past the read-write head has been calculated:

Tape Speed	Average Tape Unit Record Access Time
36 inches per second	20.8 milliseconds
75 inches per second	10.8 milliseconds
112.5 inches per second	7.3 milliseconds

A formula using these factors has been developed for programmers' use in estimating the time required to process tape on 729 tape units (Figure 13). Figure 14 is based on the formulas of Figure 13.

Several different formulas are used to estimate tape processing time for 7330 tape units. The many formulas and their programming considerations for the 7330 are contained in detail in IBM systems literature for the computers using the 7330 tape unit.

Checking Tape Validity

As a record or record block is written, an odd or even count is made of the number of one bits written in each of the seven bit tracks. At the end of every record block, a bit is written in all tracks having an odd number of bits. The extra bits written produce a check character that follows the last character of the record or record block. This longitudinal check character has an even number of bits, and is used for checking purposes each time that the record block is read.

Validity checking of data recorded with the single-gap head on the 727 Magnetic Tape Unit is accomplished by either backspacing the tape over the record and reading it or by simply waiting until the record is read as it is used in some other operation.

Tape units with two-gap heads give increased checking while writing. Tape being written passes first over the write gap (to record data) and then over the read gap; the information that has been written is automatically read and checked.

When an error occurs during the writing operation, it is detected at the read gap and an error indication is made. Programming may test the indicator and halt writing. The machine does *not* stop with the error section of tape positioned over the read gap; tape motion continues past the end of the record block. Then the machine may be instructed to backspace the tape and rewrite, again checking for an error. Recommended procedures for handling errors are in the Tape Error Recovery Procedures section.

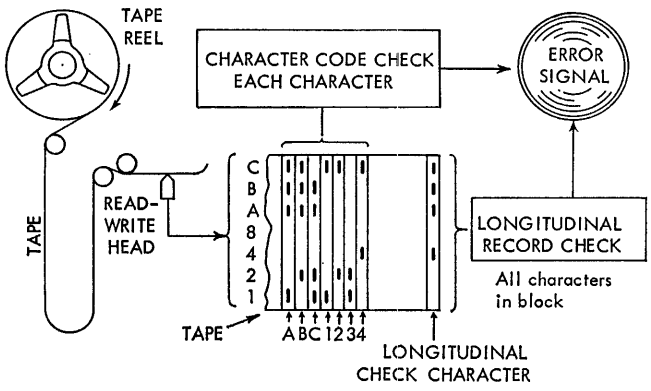


Figure 15. Tape Reading Validity Checks (BCD Mode)

Checking BCD Tape

Information read from tape is checked in two ways. A character code check is made on each lateral column of information to insure that an even number of bits exists for each character read (BCD). If an odd number of bits is detected for any lateral column of bits, an error is indicated. A longitudinal block check is made on the number of bits read in each of the seven bit tracks of the record block, including the bits of the check character. If any bit track of the record block is read as having an odd number of bits, an error is indicated (Figure 15).

Checking Binary Tape

A tape written in binary mode is checked for accuracy with the same methods as those used with BCD tapes, except that each lateral column of bits —including the check bit—must have an odd number of bits (lateral check). Each of the seven longitudinal tracks of a written record block should have an even number of bits, including any bits of the check character (longitudinal check). If these conditions are not satisfied, an error is indicated.

An attempt to process a BCD reel on a wholly binary system computer, or vice versa, is prevented by the difference of lateral check bits in the two modes (BCD, even; binary, odd). Some computers can operate in either mode.

Dual Level Sensing

The ability of the two-gap head on 729 tape units to read tape in both reading and writing operations affords another means of checking those operations —dual level sensing. A critical analysis is made of the signal strength of the recorded information. On the basis of this analysis, recorded information is

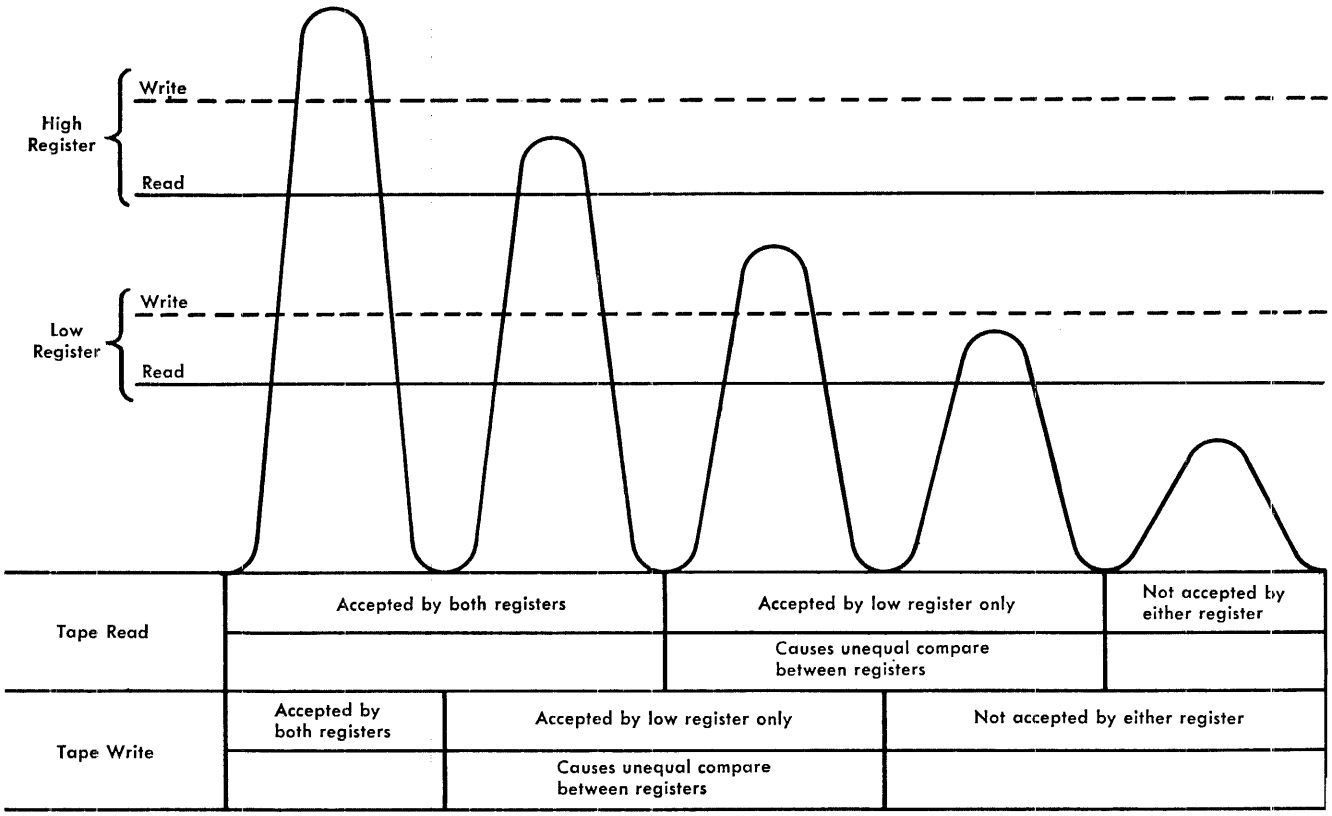


Figure 16. Dual Level Sensing

acceptable only if it meets certain standards. If it does not, corrective action is taken to improve it. If the corrective action fails to sufficiently correct the deficiency, an error is indicated.

A few milliseconds after a character has been written on tape, it is sensed by the read head. The bit impulses are amplified and placed in HI and LO registers provided by the tape control circuitry of the computer system. The HI register requires a stronger impulse from a bit position than the LO register does.

A legitimate but weak signal that enters the LO register but fails to reach the HI register indicates a parity discrepancy error. Random noise on the tape strong enough to enter the LO register, but too weak to enter the HI register, causes a parity discrepancy error. The contents of the HI and LO registers are compared, bit for bit, to check for compensating errors. Any one of these three possible error conditions turns on the tape check indicator.

During a dual level tape reading operation, each character is placed in the HI and LO registers and checked for an even (BCD) or odd (binary) number of bits in the LO register. In the absence of an error, the LO register is used. If an error is sensed in the LO register, the contents of the HI register are checked and used if correct. If both registers show an error, the contents of the HI register are used and the tape check indicator is turned on. These indicator circuits may be tested (interrogated) by the computer to prevent erroneous calculation. The IBM 709 Data Processing System uses a slightly different procedure when dual level read-checking.

Figure 16 illustrates relative levels of acceptable and unacceptable signal strength. The solid lines indicate the levels of pulse strength acceptable to the high and low registers on a tape-read operation. In a tape-write operation, the acceptance level of each register is heightened. The dotted lines in Figure 16 show the relative levels of pulse strength acceptable to the registers on a tape-write operation.

One of the many advantages of the two-gap read-write head is that it is highly critical of the recorded signal level when writing tape. When an installation using tape units with single-gap heads changes over to tape units with dual-level sensing, many existing programs will require modification to their write-check routines to take advantage of the new capabilities and to avoid excessive read error indications.

Tape Load, Unload

Tape Markers

Magnetic tape must have some blank space at the beginning and end of the reel to allow threading through the feed mechanism of the tape unit. Markers called reflective strips are placed on the tape by the operator to enable the magnetic tape unit to sense the beginning and the end of the usable portion of tape. Photo-electric cells in the tape unit (Figure 17) sense the markers as either the load point marker (where reading or writing is to begin), or as the end-of-reel marker (where writing is to stop). The tape unit does not recognize the end-of-reel marker when reading tape; a tape mark written on the tape signals an end-of-reel condition.

The markers are small pieces of transparent plastic with a thin, vapor-deposited film of aluminum on one side. Pressure-sensitive adhesive covers the aluminum film. The markers are fastened manually to the base (uncoated) side of the tape. New reels of tape obtained from IBM have these markers in position.

LOAD POINT MARKER

At least ten feet of tape must be allowed between the beginning of the reel and the load point marker as a leader for threading the tape on the tape unit. More than ten feet may be allowed by placing the marker at any desired distance from the beginning of the reel. To indicate the load point, the marker must be parallel to and not more than 1/32 inch from the channel 1 edge of the tape (the edge nearest the operator when the reel is mounted). See Figure 18.

END-OF-REEL MARKER

About 14 feet of tape are usually reserved between the end-of-reel marker and the end of the tape. This space includes at least ten feet of leader and enough tape to hold a record of 9,600 characters after the end-of-reel marker is sensed. New reels can be supplied

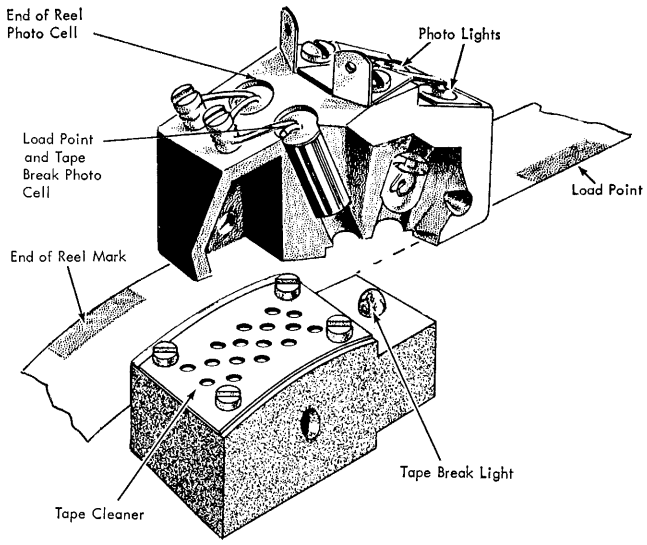
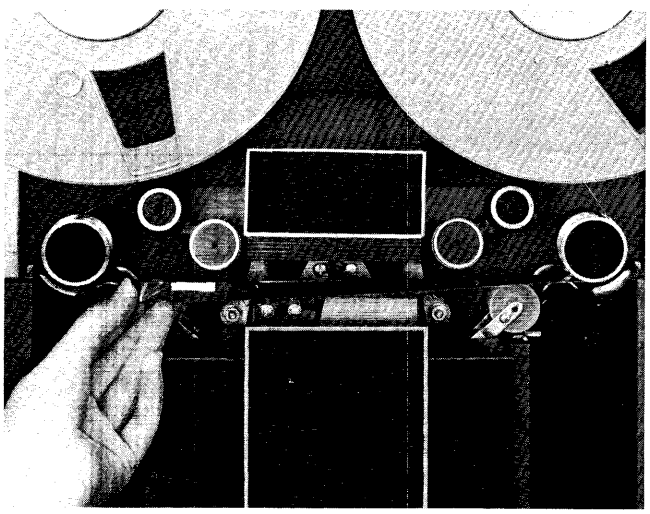
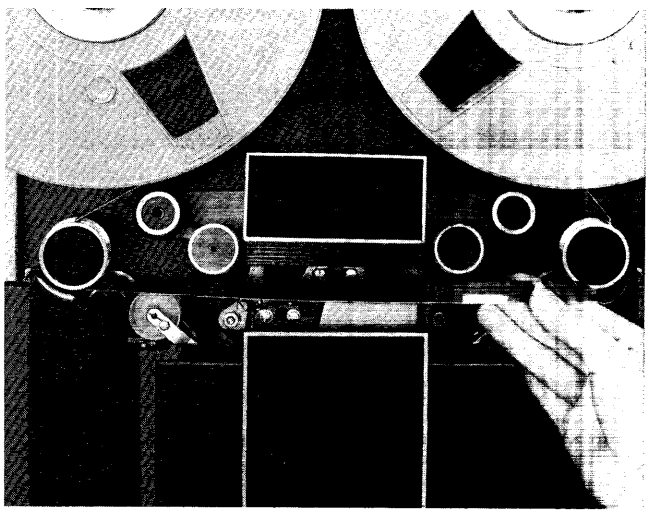


Figure 17. Photocell Sensing



End-of-Reel Marker



Load Point Marker

Figure 18. Reflective Tape Markers

with this marker placed wherever desired to accommodate check point records from different systems. During writing, the end-of-reel reflective marker indicates the end-of-reel. The marker is placed parallel to and no more than 1/32 inch from the C track edge of the tape (the edge nearest the tape unit when the reel is mounted). See Figure 18.

Place load point and end-of-reel markers on tape carefully. They should be properly aligned and pressed tightly onto the tape with the *back* of the fingernail. It is best to do this while the tape is loaded on a unit, to reduce the collection of dust on the unrolled tape. If this is done away from the unit, keep the unrolled end of tape off the floor and away from dust.

Markers are available in convenient roll form in a dispenser.

File Protection Device

Because the writing operation automatically erases any previous information on the tape, a file protection device is provided to prevent accidental erasure. A plastic file protection ring (Figure 19) fits in a circular groove molded in the back (machine side) of the tape reel. This ring must be in place to enable the machine to write on the tape in the reel.

When the reel is mounted, the ring depresses a switch protruding from the tape reel panel. After writing is completed, the file protection ring should be removed. This permits the spring-loaded switch to ride freely in the groove in the tape reel, and an interlock that prevents writing is automatically set. The file protection light on the tape unit control panel is also turned on and the program is informed that it is impossible for the program to write on the tape. However, tape may be read, backspaced, or rewound while the file protection light is on.

When the ring is removed, writing is suppressed and only reading can take place; the file is protected from accidental writing, which would erase valuable tape records. Never remove the file protection ring while tape is loaded in the vacuum columns of the tape unit; tape may be broken or damaged.

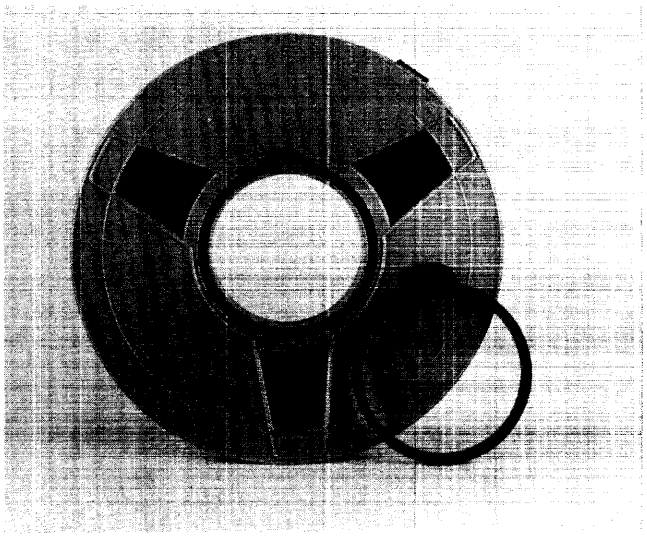


Figure 19. File Protection Ring

Tape Load Procedure

If the tape reel is improperly mounted, the edge of the tape receives undue wear and becomes burred. This burr causes one edge of the tape to be slightly thicker than the other. When wound on a reel, the tape edge with the burr winds to a larger diameter than the undamaged edge. In time, the edge of the tape will be permanently stretched and will appear to have a wavy edge. Such tape, after continued use, proves unpredictable and generally unsatisfactory; read errors, usually random and nonrepetitive, are encountered.

1. Determine if the reel to be loaded should have the file protection ring inserted or removed.

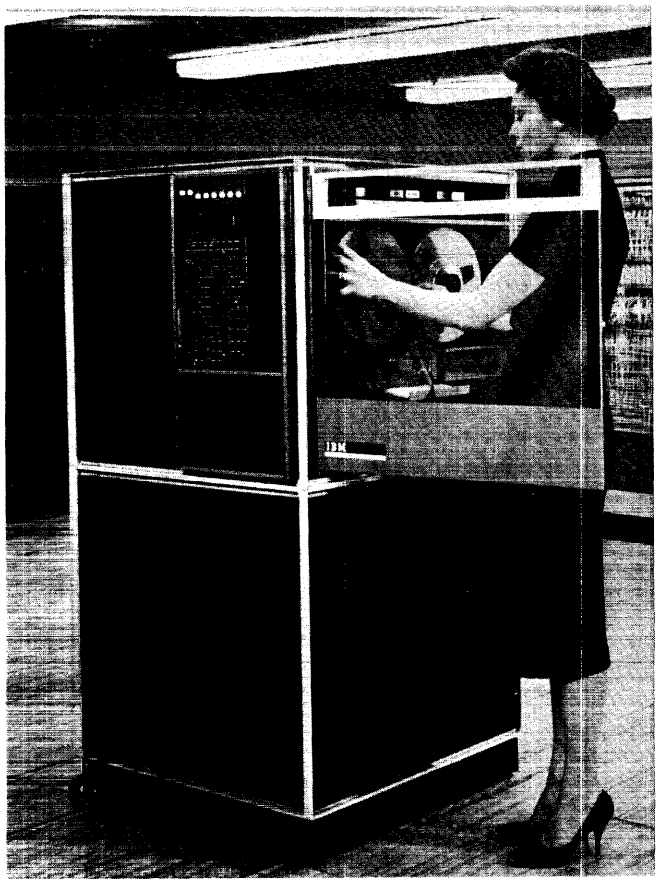


Figure 20. Loading Magnetic Tape Reel

2. Mount the reel to be loaded on the left mounting hub and tighten the hub knob (Figure 20). Place an empty reel on the right mounting hub and tighten the hub knob. The hub includes a rubber sleeve that grips the reel tightly when the knob in the center of the hub is tightened. When loading, place the hub of the reel firmly against the stop on the machine mounting hub to insure proper alignment. Always be careful that the hub knobs are tightened during loading. Do not use excessive force, however, for this tends to strip the threads.

3. Hold the reel release key depressed and rotate the file reel clockwise, unwinding about four feet of tape.

4. Place tape over the left roller, through the read-write head assembly, and over the right roller. Place and hold the end of the tape between the index finger and the hub of the machine reel. Pressing the reel release key, wind tape on the machine reel clockwise for at least two turns beyond the load point marker. When placing tape on the machine reel, align it carefully to prevent damage to the edge on the first few turns. When winding the tape, use the reel finger hold. Rotating the reel with one's finger in the cut-out area of the reel can result in nicking or curling the edge of the tape.

5. Close the reel door.

6. Set the address selector switch to the correct address position.

7. Depress the load rewind key to: (1) load tape into the vacuum columns, (2) lower the head assembly, and (3) rewind the tape to the load point. On the IBM 7330, (1) and (2) must be done manually.

8. Depress the start key. This places the unit under automatic control and turns on the ready light. If the file protection ring is removed, check to see if the file protection light is on. Notify the customer engineer if the ring is out and the light is not on.

NOTE: Do not turn off power with the tape unit in a load status because the head assembly must be up for removal of tape. Tape damage may occur if power is turned on with tape in the vacuum columns.

Tape Unload Procedure

To unload tape:

1. If the ready light is on, press the reset key to return the unit to manual control.

2. Depress the load rewind key to rewind the tape.

3. When the load point is reached, press the unload key.

4. Open the reel door when the head assembly is fully raised and the tape is out of the columns. (On the 7330, the head assembly is raised manually.) Do not open the door of the tape unit until the tape drive mechanism completes the unloading sequence.

5. Hold the reel release key depressed and manually rewind the file reel by turning it counterclockwise with the finger pressed in the finger hold of the reel.

6. When the tape is completely rewound, loosen the hub knob and remove the reel. If resistance is encountered in removing a reel, exert pressure from the rear of the reel with the hands as near the hub as possible. Never rock a reel by grasping it near the outer edge in a way that pinches the edges of the outer turns of tape.

7. Check the removed reel to determine if it is to receive a file protection ring and if it is labeled correctly. Place the reel in the container.

729V and 729VI Magnetic Tape Units

The 729v and 729VI Magnetic Tape Units operate at a character density of 800 characters per inch in addition to character densities of 200 and 556 characters per inch. Each 729v and 729VI tape unit is able to write or read at 200 or 556, 200 or 800, or 556 or 800 characters per inch. The maximum character rate is increased to 60,000 characters per second on the 729v, and 90,000 characters per second on the 729VI.

The 729v and 729VI tape units are identical to the 729II and 729IV tape units, except for recording characters at 800 per inch.

The pair of recording densities at which a given tape unit operates is controlled by a tape densities option switch for each tape channel used with magnetic tape. Program instructions or the change-density switch on the tape unit itself specify either high or low density recording. With the switch in position 1, tape units (both 729v and 729VI) attached to that tape channel operate in a density of either 200 or 556 characters per inch. With the switch in position 2, the recording density is 200 or 800 characters per inch; in position 3, the density is 556 or 800 characters per inch.

The locations of the tape densities option switches, and the tape control device used with each data processing system, are:

SYSTEM	SWITCH LOCATION	TAPE CONTROL
1401	1401 Processing Unit	800 cpi Feature
1410	1415 Console	800 cpi Feature on 1414 I-O Synchronizer, Model 1
7040	7106 Processing Unit	1414-1, -2, or -7 I-O Synchronizer
7044	7107 Processing Unit	1414-1, -2, or -7 I-O Synchronizer
7070-7074	CE Console	7604 Tape Control, Model 3 (2 Channels)
7080	7621 Tape Control, Model 4 (2 Channels)	
7090-7094	7617 Data Channel Console (Model 1 or 2)	

The 729VI Tape Unit cannot be used at 800 characters per inch on 1401 or 1410 systems. All possible switch settings, together with resultant character rates in characters per second, are:

	Tape Densities Option Switch	729v Density Mode Low	729v Density Mode High	729VI Density Mode Low	729VI Density Mode High
1.	200/556	15,000	41,667	22,500	62,500
2.	200/800	15,000	60,000	22,500	90,000
3.	556/800	41,667	60,000	62,500	90,000

Recording densities on the 729v are compatible with those on the 729VI tape unit. That is, a tape recorded at 800 characters per inch on a 729VI may be read on the 729v if the 729v is reading at 800 characters per inch. All other normal programming techniques apply with the increased recording density. For example, execution of a set density low instruction refers to the lower density specified by the density switch on the tape control device.

Program Timing Improvements

Phase I of a sort application is process-limited for many sorts at 800 characters per inch recording density. Phases II and III, however, generally remain tape-limited on the IBM 7074, 7080, and 7090 Data Processing Systems. For blocked 80-100 character records, a reduction of 25 per cent in sorting times may be achieved when using the 800 character per inch recording mode on 729VI tape units.

The use of the increased character rate also increases the maximum sort capacity of all sorts. This increase is usually in the range of 30-40 per cent.

When the higher recording densities are used for compiling, savings of 5 to 10 per cent may be realized, depending on the type and size of the program being assembled.

Effective data rates, calculated at various record lengths, are shown in Figure 21. The total job time improvement depends on the tape-limited nature of the work load at any given system installation. An actual billing application involving sorting, file maintenance, and editing shows an anticipated improvement factor of approximately 15 per cent.

Intermixed IBM 729II, IV, V, and VI, and 7330 Magnetic Tape Units

Use of the tape densities option switch with 729II, 729IV, and 7330 tape units intermixed with 729v and 729VI tape units can lead to systems problems.

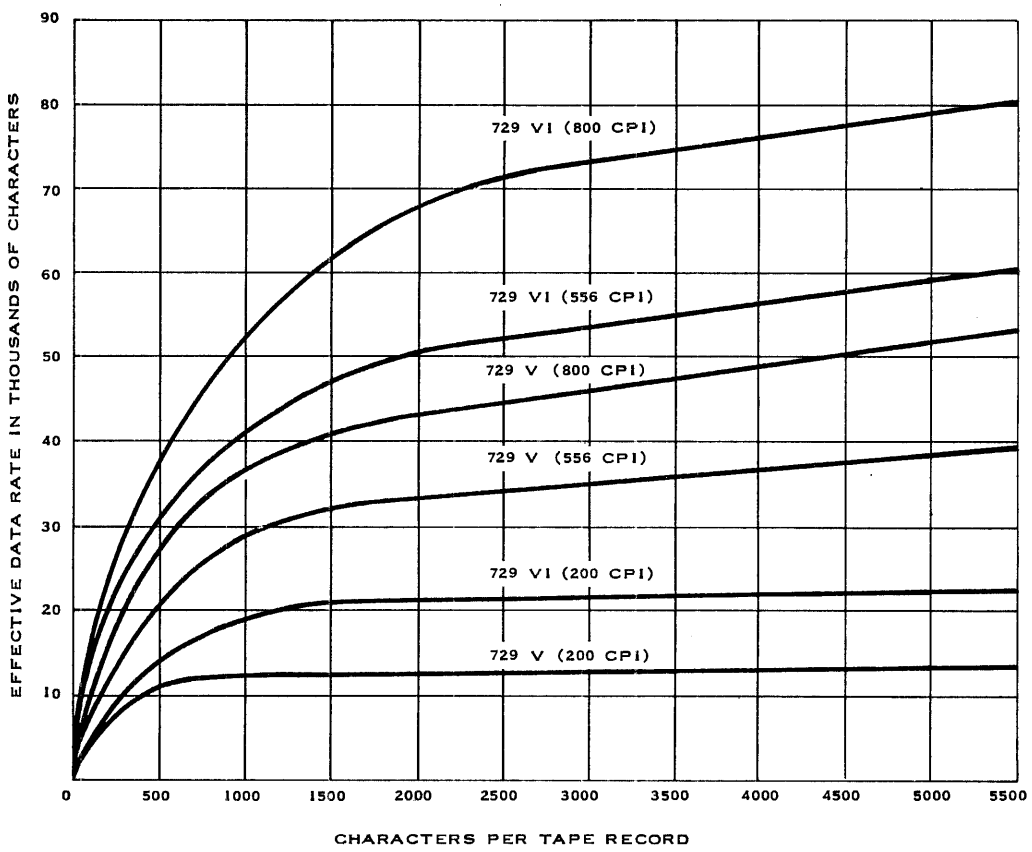


Figure 21. Effective Character Rates

Reaction of 729II, 729IV, and 7330 tape units to directions calling for 800-characters-per-inch recording depends on the system to which the tape units are attached.

With IBM 1401-1410 Data Processing Systems, 729II, 729IV, and 7330 tape units operate at either 200 or 556 characters per inch regardless of the tape densities option switch setting. For example, if a 729II tape unit is addressed for operation and the tape densities option switch is set at the 556/800 position, the tape unit operates as if the switch were set at the 200/556 position. A 729V tape unit attached to the same 1414 I-O synchronizer, however, assumes the recording density actually designated by the tape densities option switch.

With IBM 7000-Series Data Processing Systems, operation is normal when the tape densities option switch is set at the 200/556 position. When the 200/800 or 556/800 positions are used, all 729II, 729IV, or 7330 tape units attached to that tape control operate at the low density as specified by the switch but hang up if the high-density mode is attempted. For example, with the tape densities option switch set at the 556/800 position, a 729II tape unit addressed for low-density operation would operate at 556 characters per inch. If addressed for high-density operation, the 729II, 729IV, and 7330 tape units react as if they are not connected to the system or are not in ready status.

Operating Keys and Lights

IBM 727 and 729 I Magnetic Tape Units

The 729I Magnetic Tape Unit looks like the 727 Magnetic Tape Unit in Figure 22. The operating keys and lights of the two machines are identical. The 727 has a one-gap read-write head; the 729I has a two-gap head. The operator's panel is shown in Figure 23.

Address Selection Switch determines which of the tape addresses in the program may select the tape unit. This rotary switch may be set to any of the ten indicated positions, except when used with the IBM 720 or 730 Printer operations; in this case, it must be set to 2. This switch should not be rotated during any tape operation.

Select Light is turned on automatically when the unit is addressed by the computer (the address selection switch must be properly positioned).

Reset Key returns the tape unit to manual control. Pressing the key removes the machine from ready status, if it has not already been removed, and stops whatever machine operation is in progress, except for unload and high-speed rewind. The unload operation is always completed, once started; the high-speed rewind operation is shifted into low-speed rewind. After tape is loaded into the vacuum columns and low-speed rewind is in progress, pressing the reset key a second time stops the low-speed rewind.

Start Key places the tape unit in ready status and turns on the ready light if:

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

Depressing the start key disables all manual controls.

Ready Light shows that the tape unit is in ready status; that is, the tape unit is loaded (tape is in the vacuum columns and the read-write head is down), the reel door interlock is closed, and the tape unit is not in rewind status. The light is turned on by depressing the start key, but does not light unless the three required conditions are satisfied. Pressing the start key while tape is in motion, as in a load-rewind operation, does not light this indicator immediately; the

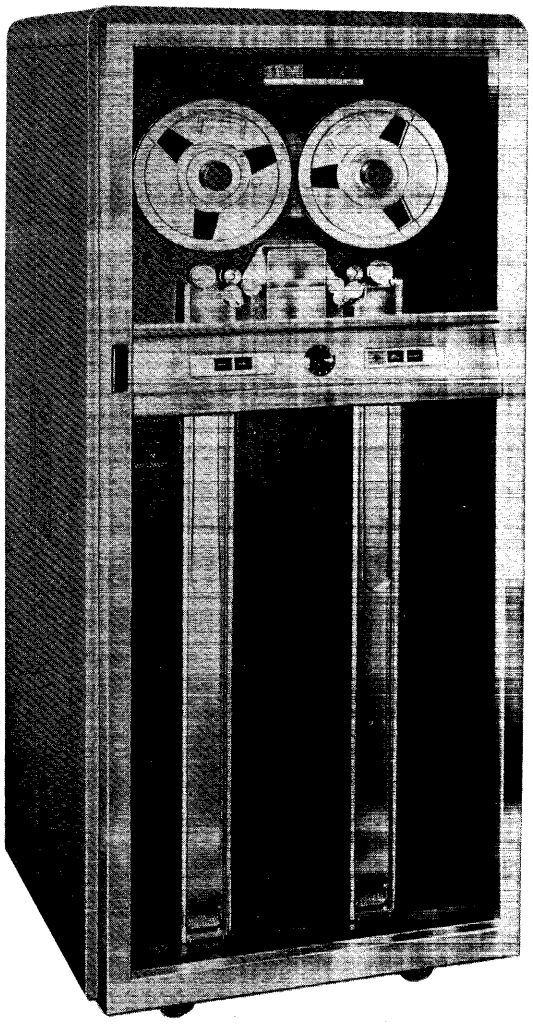


Figure 22. IBM 727 Magnetic Tape Unit

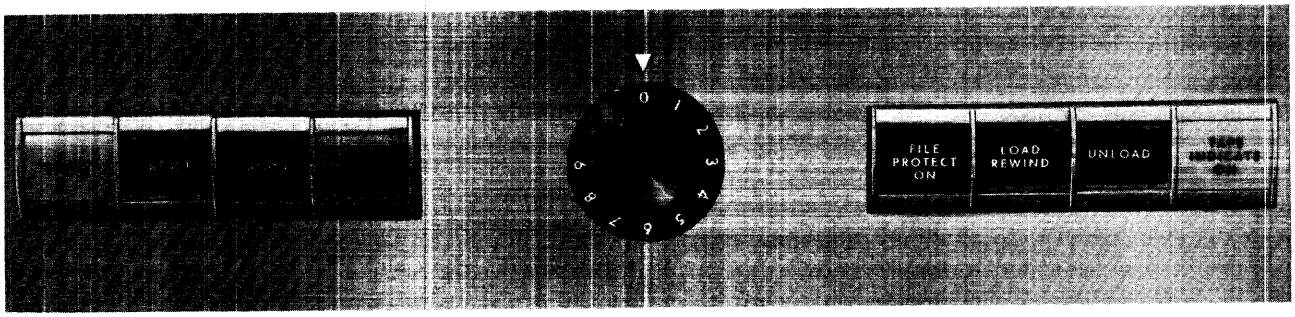


Figure 23. Operator's Panel, IBM 727 and 729I

light turns on when the load-rewind is completed. The reel door should not be opened when the ready light is on. Manual control is indicated when the ready light is off, if the tape unit is not rewinding or loading and the reel door is closed.

File Protection Light, when on, shows that the tape unit cannot be placed in write status. It is on when: no file reel is mounted, a file-protected tape reel is mounted, a load-rewind operation is in process, or an unload operation is in process. The indicator is turned off by mounting a tape reel that is not file-protected. If this light fails to go on when a reel without a file protection ring is mounted, notify the customer engineer immediately.

Load-Rewind Key is operative only when the reel door is closed and the ready light is off. Use of this key after tape is 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 marker is sensed. The usual purpose of this key is to set the tape into the machine at the starting point (load point), ready for either reading or writing.

Use of the load-rewind key with tape loaded and the machine reel containing more than one-half inch of wound tape (more than 450 feet) initiates a high-speed rewind operation (500 inches per second, average). The amount of tape to be rewound is measured automatically by a light-beam and photocell mechanism in the tape unit. The tape is removed from the columns, the head assembly is raised, and tape is rewound at high speed until less than 1/8 inch of wound tape remains on the machine reel. Tape is then lowered into the columns, the head assembly is lowered, and a low-speed rewind continues until the load point marker is sensed.

CAUTION

Do not open the reel door during rewind or load point searching. This could cause breaking or damaging of the magnetic tape.

Unload Key is operative only when the ready light is off, tape is in the vacuum columns, and the reel door is closed. Use of this key removes tape from the columns and raises the head assembly, 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. Depressing the unload key will also turn off the tape-indicate-on light, if it is on.

Tape Indicate On, when on, signifies that a tape mark has been read during a read operation or that a tape reflective marker has been photosensed during a write operation. It can also be turned on manually at the control console, or by a specific instruction. The tape indicator is turned off by pressing the unload key or by a specific instruction. During auxiliary operation, the indicator may be turned off as follows:

1. Card-to-tape operation—Depress reset key of card reader.
2. Tape-to-card operation—Depress restart key of punch.
3. Tape-to-printer operation—Depress restart key of printer.

Reel Door Interlock automatically prevents any normal operation of the tape unit when the door is open. The reel door should not be opened when the ready light is on or during any load-rewind operation.

Reel Release Key may be pressed to permit manually turning the reels for threading tape when the reel door is open.

IBM 729II, III, IV, V, and VI Magnetic Tape Units

The 729II and III Magnetic Tape Units look like the 729IV Magnetic Tape Unit in Figure 24. The operating keys and lights of the three machines are identical, except that the 729III does not have the change density key and lights. The operator's panel is shown in Figure 25. The address selection dial is at the left; the lights are all on the upper row, and the keys are on the lower row.

Address Selection Dial assigns a number, 0 to 9, to the tape unit, to identify it to the stored program.

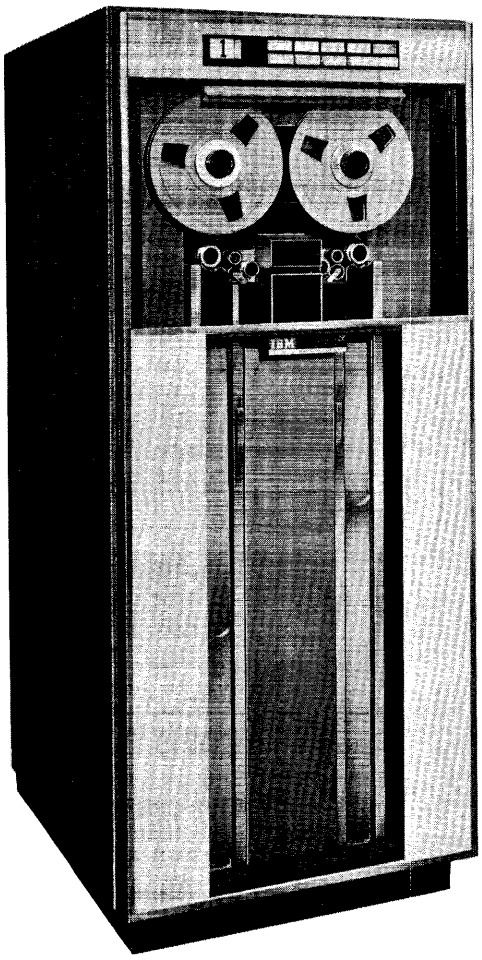


Figure 24. IBM 729IV Magnetic Tape Unit

If blank is set, the tape unit cannot be used by the stored program. The light-colored portion of the blank setting should be used. No setting should be changed when a tape operation is in progress.

Select Light is turned on automatically when the unit is addressed by the computer and the address selection dial is properly positioned.

Ready Light, when on, shows that the tape unit is in ready status; that is, the tape unit is loaded (tape in the vacuum columns and across the read-write head), the reel door interlock is closed, and the tape unit is not in the process of finding load point. The light is turned on by pressing the start key, but does not light unless the three required conditions are satisfied. Pressing the start key while the tape is in motion, as in a load-rewind operation, will not light this indicator immediately, but the light will turn on when the load-rewind is completed. The reel door should not be opened when the ready light is on. Manual control is indicated when the ready light is off, if the tape unit is not rewinding or loading and the reel door is closed.

Bit Density Indicators are on 729II, IV, V, and VI units. (729III reads and writes only in high-density mode.) There are two density indicators: low density and high density. When on, the high-density indicator signifies that the 729II or IV tape unit is set to write or read at 556 characters per inch; the low-density indicator signifies a rate of 200 characters per inch. On 729V and VI tape units the density indication is in relationship to the setting of the tape densities option switch for the tape control (see "729V and VI Magnetic

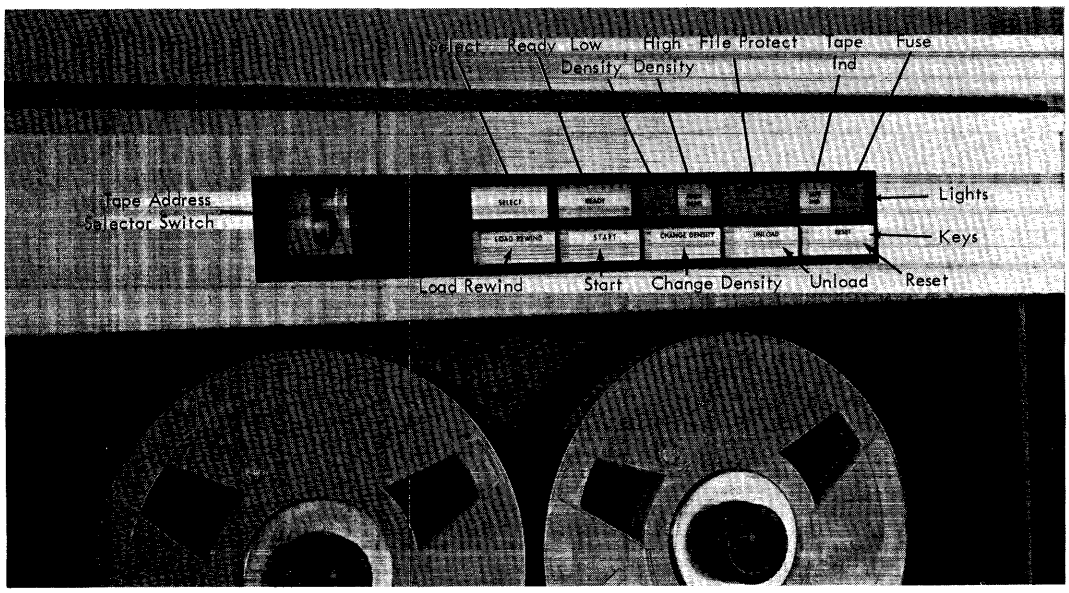


Figure 25. Operating Keys and Lights, IBM 729II and IV

Tape Units"). Only one indicator can be on at a time. Depressing the change-density key switches power from one indicator circuit to the other if the tape unit is in reset (manual) status. The high-density indicator turns on when power is initially applied to the machine.

File Protection Light, when on, shows that the tape unit cannot be placed in write status. It is on when: no file reel is mounted, a file-protected tape reel is mounted, a load-rewind operation is in process, or an unload operation is in process. The indicator is turned off by mounting a tape reel that is not file-protected. If the file protection ring has been removed and this light fails to go on, notify the customer engineer immediately.

Tape Indicate Light, when on, signifies that a tape mark has been read during a read operation or that an end-of-reel tape reflective marker has been photosensed during a write operation. It can also be turned on by a specific instruction, a tape break, or a backspace instruction at load point. The tape indicator is turned off by depressing the unload key or by a specific instruction.

Fuse Light indicates that a protective device has interrupted an excessive flow of current; operation cannot be resumed until the condition has been corrected by a customer engineer.

Load-Rewind Key is operative only when the reel door is closed and the ready light is off. Use of this key after tape is 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 marker is sensed. The usual purpose of this key is to set the tape into the machine at the starting point (load point), ready for either reading or writing.

Use of the load-rewind key with tape loaded and the machine reel containing more than one-half inch of wound tape (more than 450 feet) initiates a high-speed rewind operation (500 inches per second, average). The amount of tape to be rewound is measured automatically by a light-beam and photocell mechanism in the tape unit. Tape is removed from the columns, the head assembly is raised, and tape is rewound at high speed until less than one-eighth inch of wound tape remains on the machine reel. Tape is then lowered into the columns, the head assembly is lowered, and a low-speed rewind continues until the load point marker is sensed.

Use of the load-rewind key with tape loaded and the machine reel containing less than one-half inch of wound tape initiates a low-speed rewind until the load point marker is sensed.

CAUTION

Do not open the reel door during rewind or load point searching. This could cause breaking or damaging of the magnetic tape.

Start Key places the tape unit in ready status and turns on the ready light if:

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

Depressing the start key disables all manual controls.

Change Density Key is on 729II, IV, V, and VI units. Pressing this key changes the density mode of the tape unit from its previous mode setting. This key does not function when the ready light is on.

Unload Key is operative only when the ready light is off, tape is in the vacuum columns, and the reel door is closed. Use of 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 will also turn off the tape-indicate-on light, if on.

Reset Key is used to return the tape unit to manual control. Pressing the key removes the machine from ready status, if it has not already been removed, and stops whatever machine operation is in progress, except for unload and rewind. The unload operation is always completed, once started; the high-speed rewind operation is shifted into low-speed rewind. After the tape is loaded into the vacuum columns and low-speed rewind is in progress, press the reset key again to stop the low-speed rewind.

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

Reel Release Key may be pressed to permit manually turning the reels for threading tape when the reel door is open.

IBM 7330 Magnetic Tape Unit

The IBM 7330 Magnetic Tape Unit (Figure 26) may be used with the IBM 1401 D11-D16, E1-E6, F23-F26, and 1410, and 7072 Data Processing Systems. Most operating principles and procedures common to the IBM 727 and 729 tape units are retained, although a different tape transport mechanism is used. All tapes written on the 7330 are interchangeable with tapes of corresponding densities written by the 727 and 729 Magnetic Tape Units, the IBM 7701 Magnetic Tape

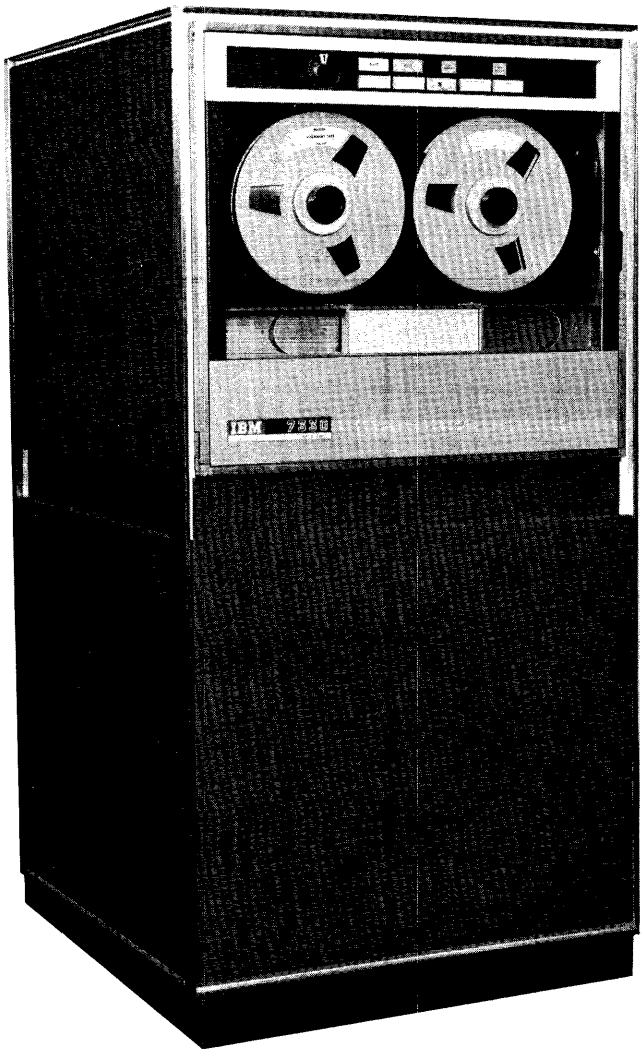


Figure 26. IBM 7330 Magnetic Tape Unit

Transmission Terminal, and the IBM 7765 Paper Tape to Magnetic Tape Converter.

The use of BCD or binary tape data codes is determined by the data processing system with which the 7330 tape unit is used. In the specified 1401 systems, the 7330 can be used with all present 1401 programming, including IBM Applied Programming routines for the 1401. IBM 7072 Applied Programming routines will operate with 7330 tape units. Changing density on the 7330 must be done manually with the density selection switch.

During reading or writing, tape is moved from the file reel through a horizontal vacuum column, across the two-gap read-write head, through a second horizontal vacuum column to the machine reel. During reading, writing, or backspacing, tape is moved at 36 inches per second.

Tape may be backspaced over a record or rewound to the beginning of the reel. While tape is moving backward—machine reel to file reel—no writing takes place. There are two speeds of rewinding: high speed (out-of-column) rewind and low speed (in-column) rewind. The time for a rewind-unload (high-speed rewind) function will not exceed 2 1/5 minutes per 2,400-foot reel of tape. After a high-speed rewind, the load arm must be manually positioned and the tape reinserted into the vacuum columns for further reading or writing. Low-speed rewind occurs at 36 inches per second. After a low-speed rewind, the tape is ready for further reading and writing without any manual intervention.

Dual recording densities of 200 and 556 characters to the inch provide reading or writing rates up to 7,200 or 20,000 characters per second. A lateral parity check for each character and a longitudinal parity check for each record is accomplished during both the read and write operations. The dual-level sensing feature is also provided. A skip operation erases 3¾ inches of tape.

The 7330 has solid-state circuitry. Air conditioning requirements are no greater than for 729II and IV tape units. The physical size of the 7330 is that of a two-cube 1401 Processing Unit, and the cover appearance matches it.

7330 KEYS AND LIGHTS

The operating keys and lights of the 7330 Magnetic Tape Unit are shown in Figure 27.

Address Selection Switch sets a tape unit to any one of ten possible tape addresses. Six addresses are effec-

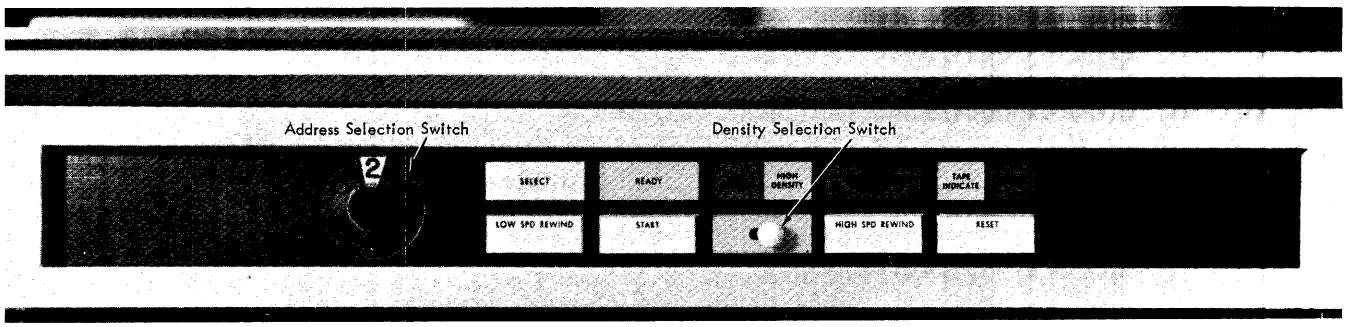


Figure 27. Operating Keys and Lights, IBM 7330

tive on the specified 1401 systems.

Select Light turns on when the computer executes a tape control instruction that contains the tape address corresponding to the setting of the address selection switch of a unit that is ready.

Ready Light indicates that tape unit is in operation or is ready for operation. The reel door should not be opened when the ready light is on.

Tape Indicate Light turns on when the unit detects a tape mark when reading or an end-of-reel reflective spot when writing. The light turns off after an unload operation and by instruction.

Fuse Light indicates that a protective device has interrupted an excessive flow of current; operation cannot be resumed until the condition has been corrected by a customer engineer.

File Protection Light turns on if the file reel is used without a file protection ring in it or if the unit is not ready or is rewinding. Writing on tape cannot occur when the file protection light is on.

Low Density Light turns on when density selection switch is manually set to low density. It must be on when the unit is reading or writing low-density tape.

High Density Light is turned on when the density selection switch is manually set to high density; it must be on when the unit is reading or writing high-density tape.

Reset Key resets the tape unit to manual control and stops any tape operation previously initiated; it does not change status of the tape indicate light.

Start Key turns on the ready light and places the tape unit in ready status. The start key is pressed only after tape has been positioned with the load-rewind key.

Low-Speed Rewind Key positions tape at the load point by causing a slow-speed (in-column) rewind until the load point marker is sensed. The low-speed rewind key is effective only if the load arm is positioned, tape is in the vacuum columns, the reel door is closed, and the ready light is off.

High-Speed Rewind Key removes tape from the vacuum columns, raises the upper read-write head assembly, and rewinds tape at high speed. Tape must be in the columns, the reel door must be closed, and the ready light must be off for the high-speed rewind key to be effective. The tape indicate light is turned off at the end of the operation.

Density Selection Switch places the tape unit in low-density mode when the toggle is moved to the left and in high-density mode when the toggle is moved to the right. The appropriate density light turns on.

Reel Release Key may be depressed to permit manually turning the reels for threading tape when the reel door is open.

Steps required to place a 7330 tape unit in ready status after a high-speed rewind are:

1. Open the reel door.
2. Press and hold the reel release button through step 5.
3. Manually rotate the take-up reel for a few times until the load point is on the reel.
4. Move the read-write head lever to a vertical position. This will lower the head.
5. Rotate each reel, as necessary, to move the tape into the vacuum columns properly.
6. Close the reel door.
7. Press the low-speed rewind and start keys.

TAPE LOADING PROCEDURE

Proper tape loading minimizes tape damage, tape contamination, and insures correct seating of the rewind arm:

1. Check for removal or insertion of file protection ring.
2. Place file reel firmly on machine mounting hub and tighten the hub knob.
3. Press reel release key and unwind about 18 inches of tape.
4. Open center cover and right column door.
5. Thread tape through tape transport as indicated on inside of center cover.
6. Close right column door.
7. Turn machine reel clockwise to move load point marker past the transport area; avoid slack in the tape.
8. Press reel release key and lower the rewind arm.
9. Remove pressure from reel release key for a few seconds.
10. After vacuum comes up, press reel release key and load tape into columns by turning the left reel clockwise and the right reel counterclockwise.
11. Seat rewind arm; close center cover and tape unit door.
12. Set the address selector switch to the correct address position.
13. Depress low-speed rewind and start keys.

7330 OPERATING PRECAUTIONS

High-Speed Rewind: To prevent damage to tape, never press the reset key or open the tape unit door during normal high-speed rewind.

If an emergency forces a violation of this rule, take steps afterward to remove undesirable tension from the tape on the file reel. Press the reel release key and manually wind at least 200 feet of tape from the file reel to the machine reel; then close the door and resume high-speed rewind.

High-Speed Rewind Arm: After tape is removed from the 7330, the high-speed rewind arm is in the up position; leave it in the up position. An arm that is in the down position when power is turned off may cause fuses to blow when power is turned on.

Off-Line Tape Units: An off-line tape unit that is receiving power from a computer system should never be turned on or off while the computer is in operation. If it is, computer errors may result.

Tape Unit Operating Pointers

Whenever a tape unit is in operation:

1. Do not change the address of a tape unit by turning the address selection dial during the execution of a program that uses other tape units. This applies whether or not the unit is in ready status.
2. Do not open the door of a tape unit unless the tape inside is out of the vacuum columns and the read-write head is raised. (The 7330 head is raised manually.)
3. In case of power failure when tape units are in loaded condition, have a customer engineer remove the tape from the read-write head and the vacuum columns of every loaded unit before power is restored.
4. Do not turn off power to the computer with tape in a vacuum column; extraneous noise may be recorded on the tape when power is reapplied.
5. An unused tape unit should not be set to the same address as one in use if the unused tape unit is at load point and not ready. The load point indication will continue to be sensed and the normal load point delay will be taken every time the ready tape unit is selected.

Inter-Record Gap Noise

It is recommended that the tape rewind unload instruction be used whenever it is desirable to dismount a reel of tape for inspection, for a later restart, or for other reasons. This procedure will eliminate inter-record gap noise records caused by manually unloading a tape unit that is in write status. This recommendation is based on the following considerations:

A tape unit in write status that receives a tape rewind unload instruction will automatically erase tape before rewinding. This insures a noise-free inter-record gap (IRG) past the last record written.

When a tape unit that is in write status is manually unloaded the tape unit does *not* automatically erase forward prior to rewinding. An attempt to reload the reel of tape to the position where writing was discontinued will involve reading forward to the last good record. When writing is resumed the IRG preceding the new record may contain some of the old information left on the tape from previous usage of the reel.

The reason for this is that tape moves farther past the write head after reading a record than it does after writing a record. This means that writing will be resumed past the point on tape where the end of the last IRG was written. The difference in stopping points is approximately 1/10 to 1/8 inch.

Use of the tape rewind unload instruction before dismounting a reel of tape will preclude possible IRG noise records due to manually unloading a reel of tape from a tape unit in write status.

The information in Figure 28 is divided into numbered sections:

1. Tape Speed refers to the rate of speed, in inches per second, at which the tape passes the read-write head. Each tape unit operates at a fixed speed, except the 7701 and 7765 units, which move tape in character-by-character increments at the demand of a control or adapter within the unit.

2. Record Density refers to the number of characters written per inch of tape. The 729II, 729IV, and 7330 units can be controlled to produce tape records at a density of either 200 or 556 characters per inch. The 729V and VI units handle 200, 556, or 800 characters per inch. A tape densities option switch (on the associated system) controls which two densities may be used. The 727, 729I, 7701, and 7765 operate with one density — 200 characters per inch. The 729III functions at 556 characters per inch. The 7070, 7074, 7080, and 7090 systems have instructions that set low or high density on the 729 tape units. The density selection switch on the 7330 unit is operated manually. Note again that tape speed remains constant for each unit, except the 7701, 7702, and 7765.

3. Character Time is the time in microseconds required to read or write one character.

4. Character Rate per Second is the maximum character rate of reading and writing in characters per second. The effective rate actually achieved during processing a reel of tape must take into account the access time, length of record, and record grouping.

5. Access Time to the record is shown in milliseconds. For 7701, 7702, and 7765 tape units, access time varies because these units move tape at varying speed. In some applications of the 7330, access time may be considerably less than stated (see "Estimating Tape Processing Time").

6. Solid State refers to circuitry using transistor and other non-thermionic devices with the inherent advantages of low power consumption and high reliability.

7. System Usage refers to the maximum number of tape units of each type usable with the specified control unit. In every case, fewer units may be used if desired. The number of tape controls used varies with each system. Note that with the 705III, ten tape units

may be used with one IBM 767 Data Synchronizer. Units may be either 729I or 729III with as many as five of each attached to one data synchronizer.

The 7040 and 7044 may use as many as ten 729II, IV, V, or VI tape units with each 1414-1 or 1414-7 Input-Output Synchronizer; an intermix feature is required for the 1414-1 or 1414-7 to use 7330 tape units. Each 1414-2 enables the 7040 and 7044 to use as many as ten 7330 tape units.

With the 7070 or 7074, as many as ten 729II or 729IV tape units (including four available as an optional feature) may be used with each data channel of the IBM 7604 Tape Control; one or two 7604 Model 1 (2 channels each) or 2 (1 channel each) controls are used. One 7604 Model 3 with two channels is used for 729V or VI units. Thus, as many as forty tape units can be used in these systems.

The 7072 system has one or two tape channels. The first channel uses an IBM 7624 Model 1 Power and Tape Control; the optional second channel uses an IBM 7625 Model 1 Tape Control. A standard tape channel handles six or fewer 7330 tape units; a channel equipped with the additional tape attachment optional feature handles as many as ten 7330 tape units. A maximum of twenty 7330 tape units may be used with the 7072.

With the 7080 system, twenty tape units may be used with each 7621 Tape Control. Units may be 729II, IV, V, or VI in any combination. IBM 727 tape units may be used with control devices as follows: as many as ten 727 units may be used with the combination of the 754 Tape Control and 7622 Signal Control; as many as eight 727 tape units may be used with the combination of the 777 Tape Record Coordinator and 7622 Signal Control. Either one or two 727 tape units may be used with the combination of the 760 Control and Storage and the 7622 Signal Control.

With the 7090 System, ten tape units may be used with each 7607 Data Channel. Units may be 729II, IV, V, or VI in any combination.

Each 1401 Model C1-C6, D1-D6, or F13-F16 may control up to six 729II or IV tape units. The tape unit models cannot be intermixed. An 800 character per inch feature for the 729V or VI units is available. The 729VI cannot be used at 800 cpi.

Each 1401 Model D11-D16, E1-E6, or F23-F26 may control up to six 7330 tape units.

With the 1410 system, ten 729II or IV tape units may be used with each 1414 Input-Output Synchronizer Model 1. An 800 cpi feature for 729V or VI units is available. The 729VI cannot be used at 800 cpi. The tape unit models can be intermixed. Ten 7330 tape units may be used with each 1414 Input-Output Synchronizer Model 2. Two such synchronizers are available so that up to twenty 7330 tape units may be used.

8. Auxiliary Operation. Either the 729I or 727 tape units may be used interchangeably. However, the dual-level sensing and the two-gap head features of the 729I are not active off-line.

Auxiliary Operation

Input-output and data conversion operations of the data processing system are slow compared with the speed of the central processing unit. Auxiliary, or off-line, operation provides a method by which many operations can be performed by machines not directly connected to the system. The advantage is to free the computer of routine, time-consuming mechanical procedures, providing more time for the prime functions of computing and data manipulation within the central processing unit.

The principal auxiliary operations are: converting data from cards to magnetic tape, magnetic tape to cards, and magnetic tape to printed reports (Figure 29). For example, all output data from a system could be placed on magnetic tape, the fastest method of recording data from a system. The tape could then, in an auxiliary operation, be converted to cards or printed as reports while the computer continues processing new data.

The importance of auxiliary operation has progressed to a point where it is now feasible, with some large computers, to use a small data processing system to perform the auxiliary operations.

For additional information, see IBM *Reference Manual, 700-70000 Series Auxiliary Operations,* Form A22-6502.

Characteristics and Systems Usage	TAPE UNIT MODEL																							
	727		729 I		729III		729 II				729 IV				729V*		729VI*		7330			7701	7702	7765
1. Tape Speed (inches per second)	75		75		112.5		75				112.5				75		112.5		36			Up to 3/4"	Up to 3/4"	Up to 3/4"
2. Record Density (characters per inch)	200		200		556		200		556		200		556		800		800		200		556	200	200	200
3. Character Time (μs per character)	67		67		16		67		24		44		16		17		11		139		50	Varies	Varies	Varies
4. Character Rate per Second	15000		15000		62500		15000		41667		22500		62500		60000		90000		7200		20016	75 or 150	150, 250, or 300	150
5. Average Tape Unit Record Access Time (milliseconds)	10.8		10.8		7.3		10.8				7.3				10.8		7.3		20.8			Varies	Varies	Not Applicable
6. Solid-State					X		X				X				X		X		X			X	X	X
7. System Usage																								
650 (max. no. each 652 Control Unit)	6																							
704 (max. no. each 753 Tape Control)	10																							
705 I, II, III (max. no. each 754 Tape Control)	10																							
(max. no. each 760 Control and Storage)	2																							
(max. no. each 777 Tape Record Coordinator)	8																							
705III (max. no. each 767 Data Synchronizer)			5 and/or		5																			
709 (max. no. each 755 Tape Control)			8																					
7040-7044 (max. each 1414-1 Input-Output Synchronizer)							10 or				10 or				10 or				10**					
(max. no. each 1414-2 Input-Output Synchronizer)																			10					
(max. each 1414-7 Input-Output Synchronizer)							10 or				10 or				10 or		10 or		10**					
7070-7074 (max. no. each 7604 Tape Control Channel)							10*** or				10*** or				10*** or		10***							
7072 (First Channel: max. no. with 7624 Power and Tape Control Model 1)																			10***					
(Second Channel: max. no. with optional 7625 Tape Control Model 1)																			10***					
7080 (max. no. each 7621 Tape Control)							20 or				20 or				20 or		20							
(max. no. with 754 Tape Control -- used with 7622 Signal Control)	10																							
(max. no. with 777 Tape Record Coordinator -- used with 7622 Signal Control)	8																							
(max. no. with 760 Control and Storage -- used with 7622 Signal Control)	2																							
7090-7094 (max. no. each 7607 Data Channel							10 or				10 or				10 or		10							
1401 C1-C6, D1-D6, F13-F16 (max. no. each system)							6 or				6													
1401 D11-D16, E1-E6, F23-F26 (max. no. each system)																			6					
1410 (max. no. each 1414 Model 1 Input-Output Synchronizer)							10 or				10 or				10 or		10							
(max. no. each 1414 Model 2 Input-Output Synchronizer)																			10					
8. Auxiliary Operation																								
Card to Tape--759 Card Reader Control	1 or		1																					
Tape-to Card--758 Card Punch Control	1 or		1																					
Tape to 717 Printer--757 Printer Control	1 or		1																					
Tape to 720, 730 Printer--760 Control and Storage	1**** or		1****																					
774 Tape Data Selector	1 or		1																					
1210 Reader Sorter, 1220 Reader Sorter Control							1																	
7701 Magnetic Tape Transmission Terminal or 1009 Data Transmission Unit as Remote Terminal																						1 or more	1 or more	
Independent Unit--Paper Tape to Magnetic Tape																								1 or more

* These units handle all three densities; 800 cpi shown
** Intermix feature required
*** Six are standard, four more optional
**** One additional tape unit may be attached for alternate loading

Figure 28. Tape Unit Characteristics and Systems Usage Chart

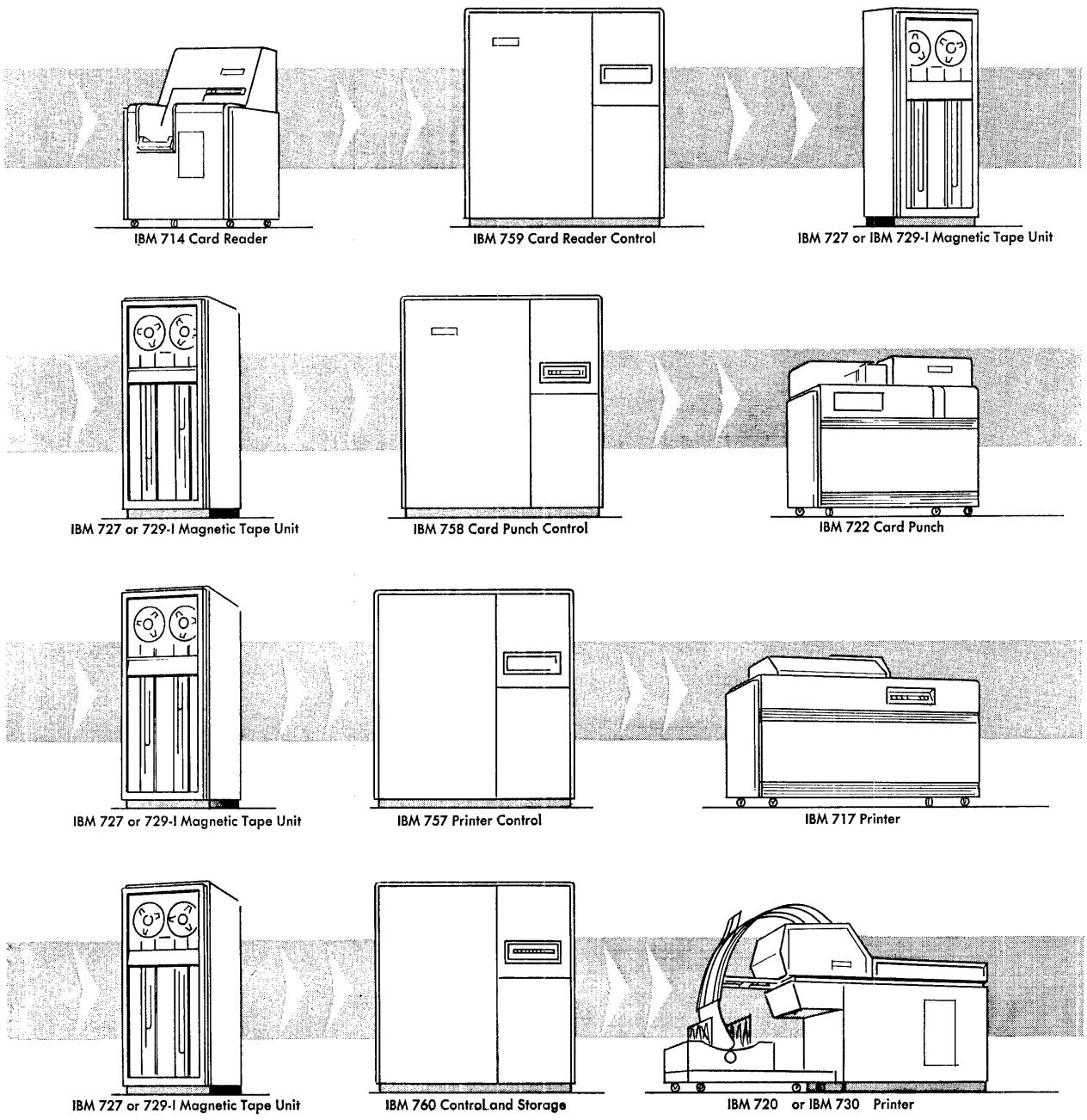


Figure 29. Machine Units for Auxiliary Operation

IBM magnetic tape is manufactured and tested under carefully controlled conditions to assure highest quality and reliability. An actual performance test is made on the entire length of each reel of tape. To assure that the high quality of IBM magnetic tape is maintained with usage, rigid reliability and life tests are made.

Dust, dirt, or damage to the tape can reduce or prevent the necessary physical contact between the oxide surface of the tape and the read-write unit. Signal strength may be sharply reduced or recorded information may be completely obliterated.

Foreign particles, wear products, a crease, or any condition that causes the tape to be lifted as little as 1/1000 inch from the read-write head will cause the signal to fall below the effective sensitivity of the read-write unit.

Daily cleaning of all tape units, particularly the read-write heads and transport mechanism, is recommended. Cleaning is also desirable before beginning any long sort. IBM customer engineering representatives will review existing instructions and practices with customer personnel to insure safe and proper cleaning techniques.

Cable Connectors

The tape units use different types of cable connectors. The 727, 729I, and 729III tape units use summary-punch type signal cable connectors with the locking lever arrangement on the tape unit. Their power cables use a round connector secured by a threaded ring. The 7330, 729II, 729IV, 729V, and 729VI tape unit signal and power cables use connectors with a locking lever on the cable part. To avoid damage, use care when engaging these connectors.

DANGER
Attempts to mismate connectors can result in serious injury to personnel. Consult with the customer engineer for the correct procedure for connecting the cables.

Machine Room Housekeeping

Dirt and dust in the machine room can be a major source of tape trouble; it is absolutely necessary that all possible precautions be taken. The following suggestions are offered to minimize this potential problem.

Materials

Experience shows that the type of material used in the furnishings of the machine room has an important bearing on the accumulation of dust and dirt.

1. Vinyl and rubber tile are more satisfactory floor coverings than asphalt tile, which has a tendency to crack and chip at the edges because it is brittle.
2. "Marbleized" tile patterns require extra effort to keep clean because it is difficult to distinguish dirt from the pattern.
3. Carpeting or drapes should be made of lint-free and static-free material.
4. Ceilings and walls should be finished with materials which do not dust or flake.

Daily Cleaning

The entire room should be vacuumed every 24 hours. For vacuuming under the various machine components, it is recommended that a nonconductor type of nozzle be used to minimize any possibility of an electrical accident. Either an external vacuum or an adequately sealed or filtered container within the room should be used. The entire floor should also be thoroughly cleaned every day with a damp mop. Under no circumstances can sweeping or the use of dust-cloths, dry mops, and the like be tolerated.

Floor Waxes

Keep waxing to a minimum. Some waxes tend to flake if not carefully applied, resulting in dust that can seriously jeopardize operating efficiency of the equipment. Any wax or other top dressing for the floor should be applied very lightly. Use caution to avoid coating exposed signal pins on the back of the tape unit, thereby causing unreliable connections. The floor should be machine buffed to remove excessive amounts of top dressing. Finally, the floor should be damp-mopped with cold water to harden the top dressing and machine-buffed again when dry. No steel wool or other metal abrasive should ever be used for buffing the floor.

Dust Prevention

While a reel of tape is on the machine, its container should be closed and placed where it is not exposed to dust and dirt. When a reel of tape is removed

from a tape unit, immediately place it in a dust-proof container. Always place tape end retainers on the reels as they are stored, to prevent the free end from unwinding in the container.

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. Materials placed on top of the units are exposed to heat and dust from the blowers in the unit. Interference with tape unit cooling will also result.

To label a reel of tape for identification, other than by means of the provided card holder, use a material that can be removed without leaving a residue. Adhesive stickers that can be applied and removed easily are satisfactory. Never use an eraser to alter the identification on a label.

Damage Prevention

Recorded information comes within .024 inch of the edge of the tape. Tiny nicks and kinks caused by careless handling of the tape or reel may seriously affect the quality of magnetic reading or recording. Damaged tapes are as ineffective as chipped or broken phonograph records.

Tapes that contain useful information must not be exposed to magnetic fields with an intensity greater than 50 oersteds.

Smoking should not be permitted in the machine room. Under no circumstances should a person who is smoking handle tape, attend the tape units, or work in the tape storage area. Ashes can contaminate tape and live ashes can produce permanent damage if they touch the surface of the tape.

Irregular Winding

Tape will normally wind on the reel with some of its edges slightly protruding. These irregularities usually result from high-speed rewinding. The great speed at which tape moves during rewinding causes air to be trapped between adjacent layers of tape and produces the slightly irregular wind.

In itself, this condition will not interfere with proper operation of tape, but it requires that proper care in handling tape be exercised by all operating personnel. The exposed tape edges can be badly damaged by squeezing them through the reel openings, or by pinching the edges of the reel. Handle reels near the hub whenever possible. In picking up reels, grip the reel between the center hole and the outer edge.

Wavy Edge

Two conditions may give magnetic tape the appearance of having a wavy edge. One of these is curvature. If a short length of tape is spread flat on a clean surface, its edge will not be perfectly straight but will show a slight curvature. This curvature should not exceed 3/16 inch in 36 inches of tape. Otherwise, the tape will tend to turn in the vacuum columns. A nominal curvature is present in almost all tapes.

Another condition that can cause magnetic tape to exhibit a wavy edge results from edge damage. If the tape reel is improperly mounted, the edge of the tape receives undue wear and becomes burred. This burr causes one edge of the tape to be slightly thicker than the other. When wound on a reel, the tape edge with the burr will wind to a larger diameter than the undamaged edge. In time, the edge of the tape with the burr will be permanently stretched. A tape in such condition proves unpredictable and generally unsatisfactory. Read errors, usually random and nonrepetitive, are encountered.

Reel Warpage

Reels must be properly supported when not in use. The plastic reel container is designed so that a reel is fully supported. A reel that is supported in any other manner may become warped.

One common reason for a reel to wobble or appear to be warped during use is that the reel may not be seated properly on the tape drive hub. The same effect is produced if the file protect ring is not inserted completely and the reel is prevented from seating. In either case, the reel behaves as if it is warped, and the edges of the tape can be damaged.

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

Cleaning Tape and Tape Containers

CAUTION

Tape transport cleaner should *never* be permitted to come into direct contact with IBM H-D magnetic tape because of interaction with tape and cleaner.

To clean Mylar tape, wipe it gently with a clean, lint-free cloth moistened with an IBM recommended tape transport cleaner. Carbon tetrachloride and vythene must not be used for cleaning magnetic tape under any circumstances.

Periodic inspection of reel containers should be established. Remove any accumulation of dust by washing containers with a household detergent.

Tape Break

If a tape break occurs, the reel should be divided into two smaller reels. Splicing is not recommended;

if it is necessary to make a temporary splice to recover information, special low cold flow splicing tape should be used.

Dropped-Tape Inspection

If a reel of tape is dropped, the reel may be broken or bent (bending is less likely, as a strain sufficient to bend a reel usually breaks it), the edge of the tape may be crimped, and the tape may be soiled. Inspect the tape reel immediately. Breaking or bending of the reel can usually be found by visual inspection. In addition, check the reel for bending by mounting it on the hub of a tape unit. If the reel has been bent or broken, it must not be used again. The tape may be serviceable, however.

If there is no evidence of crimping or other tape damage, and the reel is undamaged, thoroughly clean the reel and the exposed or unwound tape. A damaged reel without evidence of tape damage should be discarded after the exposed or unwound tape is thoroughly cleaned and rewound on a good reel. If possible, test the tape for proper functioning before using it on subsequent runs.

If crimped tape contains essential information, thoroughly clean the tape and attempt to reconstruct this information through a tape-to-printer or other machine operation. If reconstruction fails, the tape records in question must be rewritten from cards or other source material. Discard crimped footage.

Retest Service for Magnetic Tape

The IBM Retest Service provides customers with the opportunity of salvaging a good tape that has been contaminated with removable defects.

Retest Service enables customers to return reels of used IBM magnetic tape to the Magnetic Tape Testing Center for a complete retest. All removable defects are eliminated from the tape, and the customer receives a report indicating the location of permanent defects, if any. If a reel of tape contains a non-removable defect, the customer can elect, at the time the tape is sent in for retest, to:

Option A. Have the tape returned uncut with a report showing either the location of non-removable defects, or the length of the longest perfect section of tape.

Option B. Have the longest good length cut from the tape and returned; remaining portions are discarded.

Temperature and Humidity Precautions

The following conditions for long term storage of IBM magnetic tape are recommended:

	Relative Humidity	Temperature
Mylar Tape	20%-80%	50°-90° F
Heavy Duty	20%-80%	40°-120° F

Tape exposed to other conditions should be reconditioned to the operating environment for a length of time equal to the storage time (to a maximum reconditioning period of 24 hours). Reels of tape should always be stored vertically in their plastic containers when not in use.

When shipping tape-loaded reels, place them in containers and seal each in a plastic bag. Additional protection should be provided by packing in stiff cardboard shipping cartons. Plastic bags and cartons may be obtained from IBM.

Organizing Tape Records and Reels

Ungrouped Records

Records are ungrouped when each individual accounting record is separated on tape by an interrecord gap. They may be of fixed length or planned variable length.

Fixed length records have a set length, such as 100, 500, or 1,000 characters. If certain fields do not appear in all records, their space on tape must be occupied by zeros or blanks. These empty fields take up tape space and reading-writing time.

Variable length records contain no unused fields, saving tape space and machine time. It is usually necessary to know the maximum record size in a file of variable length records to provide an area in storage big enough to receive the largest record. The length of each incoming record may be indicated by a special character, or a control field within the record may be examined to determine the size of the record after it has entered the computer.

Fixed length records are usually easier to program than variable length records. When there are few irregularities in the length of records in a file, the shortened programming time may justify the additional tape space and machine time required by fixed length records. In other applications, variable length records may be chosen to effect savings in tape space and machine time.

Grouped Records

Accounting records may be grouped end to end into record blocks bounded by record gaps on the tape. The number of records placed in a record block is the blocking factor. Records and record blocks may each be fixed or variable in length.

Fixed-Fixed

When a record block encompasses a fixed number of records of fixed size, it may be called fixed-fixed (F-F, fixed blocking factor and fixed length records). This form is best for files with little variation in record size.

Fixed-Variable

This form (F-V) has a fixed number of records of variable length in each record block. Maximum length of records in the file must be known to establish sufficient space in storage for the incoming record blocks. A special character or control field may indicate the length of each record. F-V requires a more complex program than F-F.

Variable-Fixed

This form (V-F) has a variable number of fixed length records in each record block. This form is useful when a relatively small number of records in a file exceeds the fixed length. These few extra-large accounts are then made up into two or three grouped records—thereby increasing the blocking factor for that block. If necessary, the records or the block may be filled out with dummy characters. V-F entails a more complex program than F-F.

Variable-Variable

This form (V-V) has a variable number of records of variable length in each record block. When a file has considerable variation in the length of its records, this approach warrants consideration. A maximum record block size is selected to most efficiently complement the computer in use; for example, record block reading time could equal computer process time. The record block will be filled with as many of the variable length records as possible. V-V requires more programming effort than F-F, F-V, or V-F. Variations of these four methods are in use. Each application should be studied to choose an optimum method.

For convenience in processing, files of tape may be divided into logical divisions called segments. Segments are the records or record blocks contained between segment marks, which are single character records written on tape. A particular segment or group of segments on a reel may be quickly reached (in either forward or backward operation) by counting segment marks on the tape to the desired segment. (Some computers do not read or recognize tape segment marks.)

Updating Tape Records

When a single record of fixed length is read into storage, the appropriate fields are updated. Then, a write tape command sends the updated information to the receiving tape unit.

When a single record of variable length is read into storage, its length is analyzed so that the record may

be correctly updated and written on the receiving tape.

Updating grouped records requires additional programming because all of the records in the group must be considered before the updated tape can be written. Some records may have changes; some may not. Also, each record of the group is read into a different area of storage; this requires changing data addresses in the program to gain access to each record when writing. This change is straightforward when dealing with records arranged in the fixed-fixed manner; fixed-variable combinations require additional change to the program. The variable-variable arrangement offers the most challenge to the programmer because both factors used in changing the program are variable.

IBM Applied Programming has developed programs for some IBM Data Processing Systems that relieve the programmer of the foregoing considerations. When these programs are used, attention should be directed toward designing a record layout that will make most efficient use of the computer and the Applied Programming package of input-output routines.

Magnetic Labeling

Labels are short tape records added by the programmer to the beginning and end of a reel of tape for control purposes. The control record at the beginning of the reel is called a header label; the control record at the end of a reel is a trailer label. These records are written when the reel is written. When the reel is read, the program checks the header label to insure that the proper file is being used with the proper program, that the reel is in proper sequence in the program, and that the reel is not outdated.

A header label may contain the following fields:

Label Identifier identifies header labels.

Tape Serial Number identifies a particular reel of tape.

File Serial Number identifies a tape file. This number may often be the same number as the tape serial number of the first reel of tape in the file.

Sequence Number insures that reels within a file enter the system in sequence.

File Identification identifies the name of the file.

Creation Date dates the creation of the file.

Retention Cycle indicates the obsolescence data concerning a file.

These fields are basic to a header label. Additional control information may be desired in a particular application.

A trailer label is used by the program to insure that the entire reel has been accurately processed. A trailer label may contain the following fields:

Label Identifier identifies trailer labels.

Block Count is used by the program to insure that the indicated number of blocks have been processed.

Tape Data Record Count is used by the program to insure that the indicated number of tape records has been processed.

Hash Total of Main Control Field contains an arithmetic total of all specified fields in the reel. For instance, the customer number in each record could be accumulated and balanced to this control field. This insures that the proper customer's record has been processed. Some installations program to avoid excessively large hash totals.

Hash Total of Main Amount Field indicates sums of money used in the manner of a hash total of the main control field. Hash totals may be made of other fields.

Trailer labels may contain additional information necessary to a particular application.

End-of-Reel Condition

When a tape mark indicating an end-of-reel condition is sensed, the computer program enters an input end-of-reel routine to determine if it is dealing with the last reel of the entire file. If so, the end-of-file routine is entered: the reel may be rewound, and the program is adjusted to recognize that this particular input file is complete. If additional reels are indicated by the trailer label, the end-of-reel routine rewinds the reel and calls for a change to the next reel of tape. After the reel is changed or another tape unit is selected, the end-of-reel routine terminates and the regular program resumes.

When a tape unit senses an end-of-reel reflective marker while writing a block on tape, the program enters an output end-of-reel routine. This routine writes the tape mark, writes the label, rewinds the written reel, and selects another tape unit or notifies the operator to unload the written reel and load a new reel. It may check the label of the new reel to ascertain that the scratch date for the reel has occurred before it writes a new header label. (The scratch date indicates when the reel is considered out-of-date.) The regular program then continues.

Before the last block of records in a file is written, the program normally enters an end-of-file routine. This writes the last block, writes a tape mark, writes a label, rewinds the reel, and records the file completion in the program. If the file involved is the last file to be closed, the end-of-file routine enters an end-of-job routine, which terminates the run.

Sorting Tape Records

Changing the sequence of records in a tape file—sorting the file—is always necessary when the file is to be merged with existing files whose records are in a different sequence, or when the file contains the input data for an application but has records in the wrong sequence for processing.

Tape sorting programs are of two basic types: single-pass and multipass. A pass is one cycle of reading, processing, and writing the complete tape file. The single-pass program is for files that are small enough to fit entirely within computer storage along with the program itself. The multipass program is for files that are too large to fit entirely within computer storage. Because most tape files fall into this latter category, multipass sorts are used more often than single-pass sorts. With each pass of the multipass program, the sequence of records in the file improves in relation to the previous pass; that is, strings of in-sequence records become longer, so that eventually only one string remains—the sorted file.

One method of sorting fixed length records is:

The records in a segment are read into computer storage, sorted into rising sequence, and written on an output tape. Another unsorted segment is read into storage, sorted, and written on a second output tape.

The process continues with the writing of segments alternated between the two output tapes until all the records on the input tape are sorted and written on the output tape. The records *within each segment* are in ascending sequence. Note that these are logical segments—they have no physical boundaries; their size is sort of a mental one in that we know how many records make up the segment and, thus, how large the segment is.

Figure 30 shows a sort using tape units A, X, and Y; each segment contains four records. This first pass through the machine is usually called Phase I. All tapes are then rewound.

Phase II now begins (Figure 31). Tapes X and Y are used as input tapes and Tapes A and B as output tapes. Segment one is merged with segment two to form the first eight-record segment on tape A. Segment three is merged with segment four to form an eight-record segment on tape B. This continues until tapes X and Y are exhausted. The tapes are rewound. Tapes A and B become input tapes and X and Y become output tapes. Eight-record segments from A and B are merged to form 16-record segments on X and Y. This process continues with the segments doubling in size with each pass through the machine. Eventually, each of the output tapes will have one segment and it will contain all of the records on that tape in a rising sequence. This completes Phase II.

Phase III is a merge of the two segments from Phase II into one segment in a rising sequence. This pass completes the sort.

The previous discussion is an explanation of a four-tape sort. There are also six-tape, eight-tape, ten-tape, and twelve-tape sorts. With more tapes available for a sort, the number of passes through the machine is reduced because one pass can develop larger segments (Figure 32). With this six-tape sort, all three input tapes can be examined and a 24-record segment can go out on each output tape. If this were an eight-tape sort, then the output segment would be

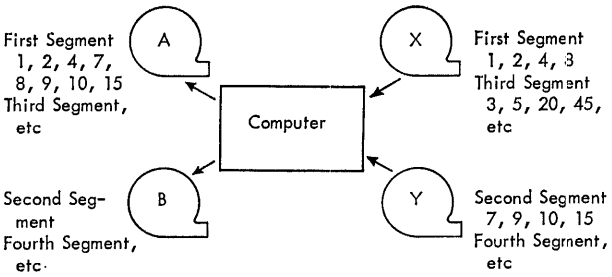


Figure 31. Phase II Sort of Four-Record Segments

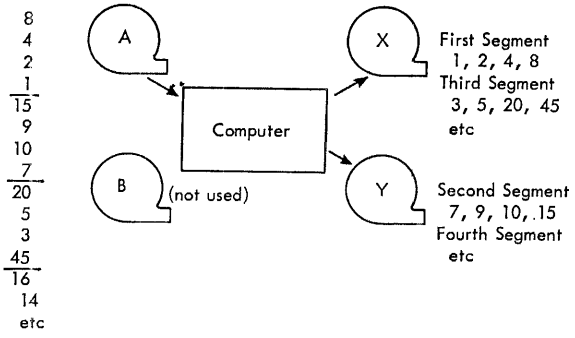


Figure 30. Phase I Sort of Four-Record Segments

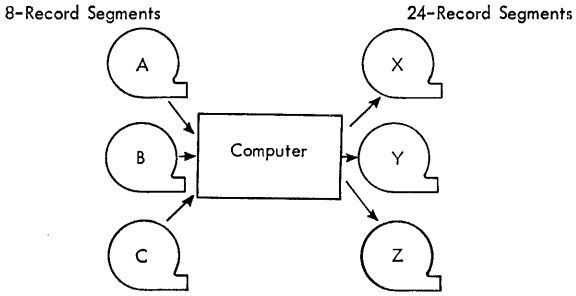


Figure 32. Sort Using Six Tape Units

32 records; ten-tape sort, 40 records; and twelve-tape sort, 48 records. With more tapes available, a large reduction in sorting time can be achieved.

Control of tape sorting is important. In most sorts, a count of the total number of records to be sorted is established at the beginning of the sort. During each pass through the machine, a new count is generated and balanced to the first or base count. Other controls can be used, such as hash totals of the control fields (the fields that determine the sequence). Just as the count was balanced for each pass, the hash totals can also be balanced. Hash totals of record count and control fields are just two of the many controls that can be placed on a sort. For a more detailed discussion of sorting, refer to *Sorting Methods for IBM Data Processing Systems* General Information Manual, Form F28-8001.

Tape Library Records

A tape library may contain a few hundred reels or several thousand reels of magnetic tape. These reels contain vital company records, and an adequate and rigorous system of control is essential to the filing and maintenance of records on tapes.

A system for controlling the tape library provides for:

1. Means of quickly determining the location of any tape file in the library. A tape file may consist of one or more reels of tape, each reel identified by its reel serial number.
2. Recording the identity of the person to whom a file is charged when it is issued from the library.
3. Making tape reels available when their scratch date occurs.
4. Having library records that are concise, easily understood, and requiring a minimum of entries.

Many systems of organization may be suitable for controlling the tape library; procedures are influenced by the size and activity of the library. Three printed forms are suggested in the library system described below.

FILE HISTORY

Each file requires a file history (Figure 33). The jobs for which this file is used and the input tape units for those jobs are shown in the top left corner. The retention cycle entry indicates the number of days the file is to be retained after being written.

Each page accommodates a file of up to four reels. The serial number of each reel of the file is placed in the four columns provided. If there are more than four reels, a 1 is placed in the MORE column whenever an additional page is required. When an additional page is not required, an A is placed in the MORE column.

The date the file was written is entered in the DATE WRITTEN column. The EFFECTIVE DATE refers to the data in the file. For example, Friday's payroll might be run on Monday. Friday's date would be the EFFECTIVE DATE and Monday's date would be the DATE WRITTEN.

The scratch date indicates the date the reels may be issued as scratch (outdated) reels for use as an output tape.

Whenever a file is issued, an entry is made of the person's name, number, or initials and the issuing date. When the file is returned, the return date is entered.

When a file is returned to the librarian, the file number and reel serial numbers should be matched against those on the sheet. When the reel serial numbers are different but the file number matches, a new entry line must be made in the file history and the

Job No.	Tape Unit
1723	0200
1861	0202
TAX TEN	0204

FILE HISTORY
TAPE LIBRARY

FILE NO. 362
PAGE 1 OF 1
RETENTION CYCLE 21 days

SER. NO. OF REEL								ISSUED AND RETURNED													
REEL: 1	2	3	4	More	Date Written	Effective Date	Scratch Date	To	Out	In	To	Out	In	To	Out	In	To	Out	In	To	Out	In
762	302	513		0	2/6	2/3	2/27	NY	2/7	2/7											

Figure 33. Typical File History Form

reel history, because the file has been updated and written on different reels. The old file which was checked out must be returned and checked in on the proper line.

The returned reels are then placed in their proper location in the storage cabinets according to serial number sequence.

REEL HISTORY

Each reel of tape in the library has a corresponding reel history record (Figure 34), based on the serial number assigned to the reel. This history records the numbers of the files that have been written on a reel. It also indicates the read errors reported on the reel, the age of the tape, and the current length of the tape.

When an entry is made on a new line of the file history, a new line is begun in the reel history for each reel of the file.

TAPES AVAILABLE

An entry is made on one of the tapes available pages (Figure 35) whenever a new entry line is made on any file history page. One of the entries on the new entry line in a file history is the scratch date. The serial number of the reel entered in the file history is also entered on the tapes available page for the date corresponding to the scratch date entered in the file history.

When the date of a page becomes the current date, the tapes listed on that page become available and may be issued as scratch tapes. At that time, an entry is made showing to whom issued, the date, and the job numbers for which they will be used as output tapes.

When the librarian receives a request for a particular tape file, he refers to the file history to determine if the tape has been checked out. If not, he notes the serial numbers, procures the reel(s) from the storage cabinet, checks them out, and issues them.

When the librarian receives a request for a reel of tape by its serial number, he may first look in the location where it is kept. If it is missing from the cabinet, he may refer to the reel history to determine the number of the last file written on the reel. The file history for that file may be used to ascertain to whom it has been issued. If the scratch date has been reached, the tapes available record for that scratch date may then be used to learn to whom it has been issued and the job upon which it is being used.

When issuing scratch tapes from the tapes available records, the tapes that have been available the longest

REEL HISTORY

TAPE LIBRARY

REEL SERIAL NO. 762
Date Received: 12/1/60
Present Length: 1200 ft.

FILE	REEL	OF	Date Written	Read Errors and Remarks
106	2	3	12/5/60	None
362	1	3	2/6/61	None

Figure 34. Typical Reel History Form

TAPES AVAILABLE AS OF THIS DATE 2/27/61

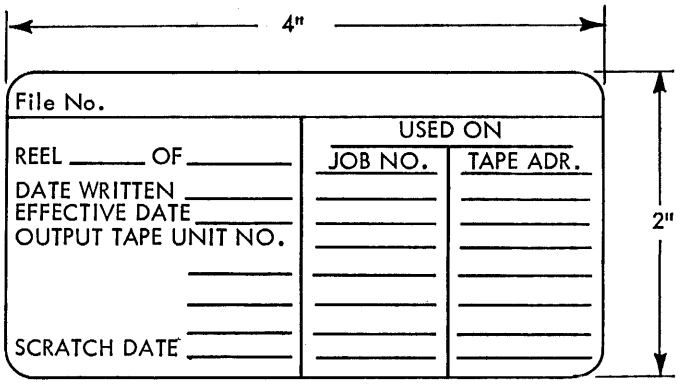
TAPE LIBRARY

Reel Serial No.	Reissued To	Date	For Job
762	FRC	2/28/61	2309
302	BN	3/3/61	2400
513	NY	3/6/61	2550

Figure 35. Typical Tapes Available Form

should be issued first. Thus, the librarian may be issuing scratch tapes from a tapes available page that is several weeks older than the current date page.

It may be desirable to maintain all tapes for a particular application in one area of the tape library storage cabinets. This may be accomplished by allocating blocks of reel serial numbers to the various applications. When issuing a scratch tape under these conditions, it is necessary to know the application for which the reel is being issued so that a reel from the block of serial numbers allocated to that application may be selected from the tapes available pages.



Temporary File Label

External Reel Labels

Two external labels are on each reel of magnetic tape:

PERMANENT REEL LABEL

This is a card inserted in the small pocket on the side of a new reel (Figure 36). The serial number of the reel, the date received from the manufacturer, and the current length of tape on the reel are recorded on the card. This card is never removed from the reel.

TEMPORARY FILE LABEL

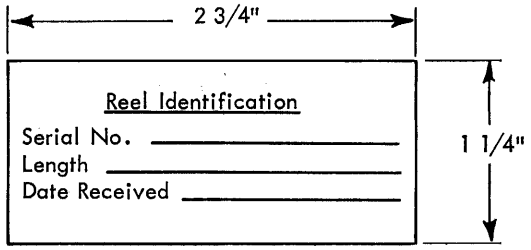
This is a paper label with reusable adhesive backing (Figure 36). When a file is written, the label is prepared and stuck on the door frame of the tape unit. When the tape unit is unloaded and the door opened to dismount the reel, the label is placed on the side of the reel before it is removed from the hub.

Effective Date on the face of the label is the date or period to which the file pertains.

Output Tape Unit No. is the address of the tape unit on which the file is written. When alternating tape units, more than one address would be entered.

Scratch Date is the date on or after which the reel may be released for use in another application. On the right half of the label, space is provided to list numbers of jobs on which the file may be used as an input, and the corresponding tape address it should have on the respective jobs.

Labels may be color-coded for different applications. For example, all files belonging to the payroll application may have green labels, all files belonging to inventory may have yellow labels, and all files belonging to cost accounting may have red labels.



Permanent Reel Label

Figure 36. External Reel Labels

Any reel bearing a file label should never have a file protection ring in it. Nevertheless, a file may be returned to the librarian bearing a file label and still have the file protect ring in the reel. This may indicate that the file has just been created. The librarian should immediately remove the ring (which should have been removed earlier by the operator).

Tape Error Recovery Procedures

The following procedures for 729II, III, IV, V, VI, and 7330 Magnetic Tape Units form the basis of the input-output programming used in IBM Programming Systems packages under development. Acceptance of these procedures facilitates the interchange of programs. For efficient utilization of data processing systems, the use of these procedures is recommended wherever possible in writing input-output routines. Specific error counts mentioned in connection with IBM Programming Input-Output Control System (IOCS) packages can be modified at an installation.

This subject is primarily of interest to programmers, and some of the terms used are not defined for other readers. The procedures and counts discussed are routines within programs.

Tape Reading Validity Checks

When a record that has been correctly written (and checked by the two-gap head) is not successfully read on the first or second attempt, further rereads will probably result in a valid reading of the record. A read that causes a validity check should be reread nine times (for a total of ten reads on a tape record).

If a validity check still occurs on the tenth try, the procedure in Figure 37 should be followed to move the tape past the tape cleaner to dislodge flecks of oxide on the tape. If the read is still invalid, the entire procedure should be repeated up to ten times for a total of 100 read attempts. If still invalid after 100 reads, the record is counted as a permanent read error and the operator should be notified. The particular application should determine the procedure for handling permanent read errors.

The 99 rereads mentioned may be effected by manual or automatic read error routine repetition for fewer rereads with or without multiple usage of the tape cleaning routine.

A count is also maintained for the number of times the check routine is entered; rereads are not included in this count. A maximum of 50 such entrances are permitted in IBM Programming Systems IOCS packages. A test should be made on each entrance so that on the entry following the maximum allowable, the operator is notified. Additional procedure at this point will be determined by the application.

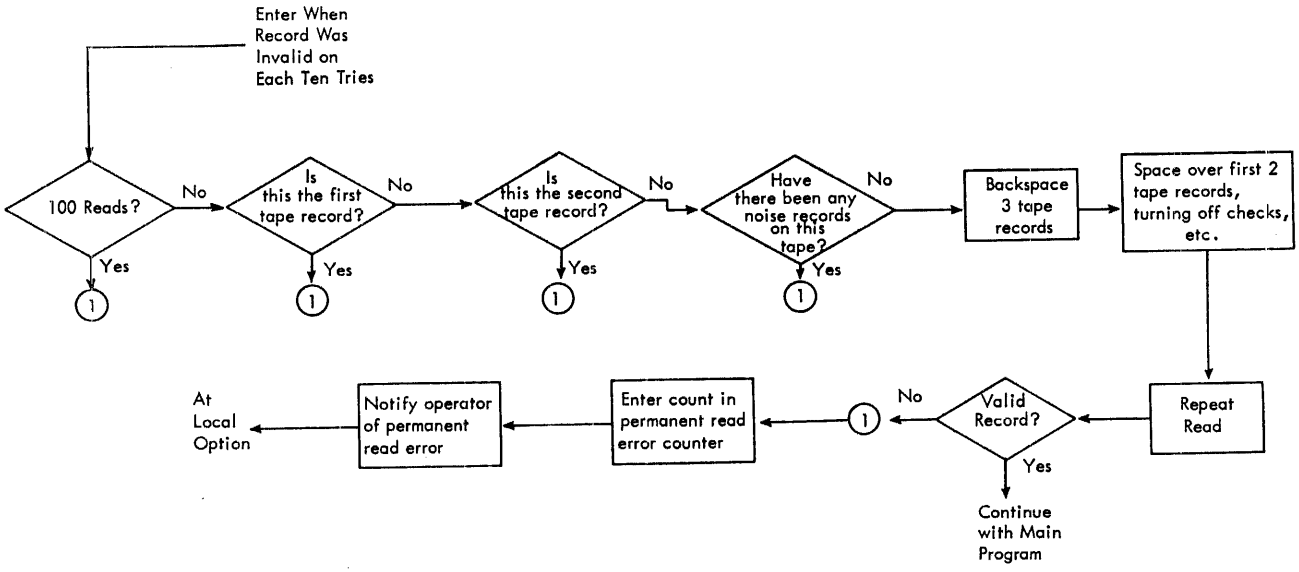


Figure 37. Procedure When Record Is Invalid on Tenth Try

Tape Writing Validity Checks

When an error is detected, the following procedure should be followed. See Figure 38.

1. Keep a count of each entrance into the check routine. A maximum of 29 such entrances is allowable in the IBM Programming Systems IOCS packages. When the count exceeds the predetermined figure, the operator is notified. Corrective action varies with the application.

2. Backspace over the error record and repeat the write.

3. If the write is again invalid, backspace over the error record.

4. Issue a skip tape instruction. This advances the tape beyond the beginning of the unsuccessful write area. The skip tape instruction erases 13 inches on the 729III; 3.6 inches on the 729II, IV, V, or VI; and 3.75 inches on the 7330. In general, it is recommended that one erase be done; however, no standard is established for the number of consecutive erases to be executed per skip because some applications have exceptionally long tape records. In such a case, it may be desirable to erase an area equivalent to the length of the record, if tape density and length are known.

A set of erases consists of one or more consecutive erase tape instructions issued without an intervening write instruction. On the 1401 or 1410, an erase instruction must be followed by a write instruction before the tape is erased.

The skip tape feature makes it possible to blank out a section of tape and relocate a written record when a defective section of tape is detected. This leaves a much longer record gap on the tape which the reading tape unit treats like the normal length record gap. In rare cases, a physical spot in this skipped area creates a pulse at the read head during a reading operation. To the program, this spot would appear to be a record of a very few characters and can be recognized as a noise record.

On the 7040, 7044, 7090, and 7094 Data Processing Systems, the tape check indicator should be turned off or the operator should be notified when an irregularity that cannot be erased is detected on the tape during a set of erases; the minimum record length check detects this noise record in the erased area when the tape

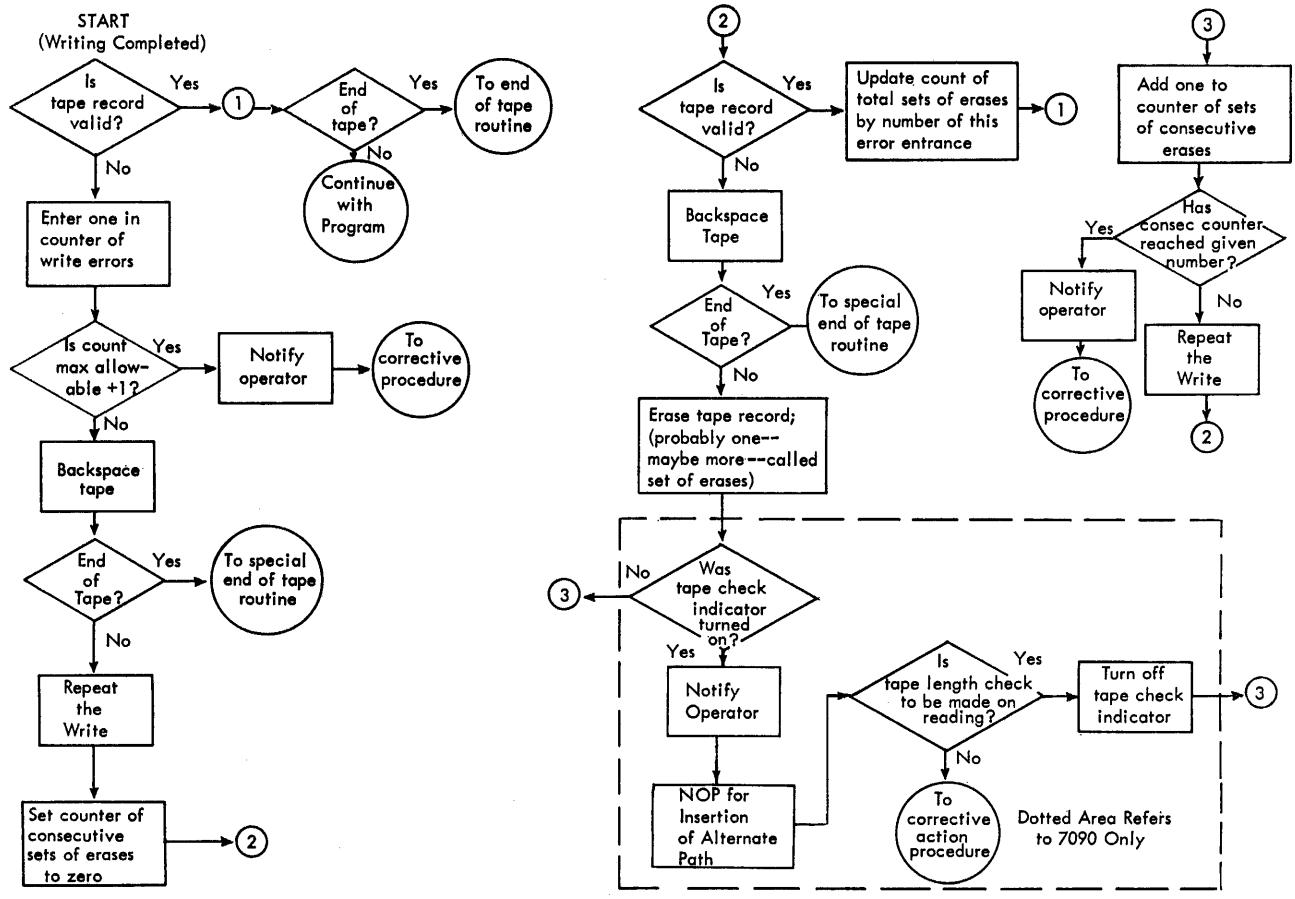


Figure 38. Write Test Routine

is read. When records are not checked for minimum record length, a message should be printed to permit a restart.

5. Determine if the count of the number of sets of consecutive erases for this particular error has exceeded a predetermined number (24 in IBM Programming Systems IOCS packages). If so, notify the operator. Corrective action varies with the application. If the count is not excessive, repeat the write operation.

6. An end-of-tape test should be made after each write.

Record Storage Area

When reading is terminated by the end of a record gap instead of by a word count, the storage allotted to the buffer area should be greater by at least one word or 5 characters (depending on the computer) than the largest record to be read.

Tape Record Length

Information in an inter-record gap or skip area is a noise record. To avoid treating noise records as data records, a minimum data record length is established in the table below, according to the characteristics of each machine. A minimum record length of 13 characters is to be written; a minimum record length of 11 characters is to be read.

Data Processing System	Minimum Record Length to Be Written (characters)	Minimum Record Length to Be Read (characters)	Record Length Treated as Noise (characters)
705 III, 7080	15 (3 words)	11	Less than 11
7040-7044-7090-7094	18 (3 words)	13	Less than 13
7070-7072-7074	3 words	3 words	Less than 3 words
1401-1410	13	13	Less than 13

Order of Testing

Actual record length should be tested after reading, prior to its use. Testing is recommended in the following order:

1. Test for end-of-file (tape mark record). If EOF condition exists, ignore and turn off the validity check indicator.

2. Test to detect and ignore noise records. Do not reread noise records. Keep a count of noise records for statistical purposes.

3. Test for validity check. Tape marks as well as data records should be tested for validity, if possible.

4. Test for correct length record.

The procedure for handling an incorrect length record may be determined by the application involved. Before a record is identified as an incorrect length record, the reread procedure described above for tape reading validity checks should be used.

The IBM 7040, 7044, 7070, 7072, 7074, 7090, and 7094 Data Processing Systems have an automatic machine check to insure that records read contain whole words. Also, these machines have an automatic machine check to insure that fixed length records contain the expected number of words.

Extreme caution should be used when moving multiple tape records under a string of instructions; special checking is required to insure accuracy of execution. Techniques such as initializing the last word of an input area with an invalid character or adding a sequence number to each tape record should be considered.

Statistics

For reading operations the statistical print-out should include:

Tape unit identification
Number of tape records read
Number of entrances into the read-error routine
Number of permanent read errors
Number of noise tape records

For writing operations the statistical print-out should include:

Tape unit identification
Number of tape records written
Number of entrances into the write-error routine
Number of sets of erases

Such statistics facilitate setting future procedures regarding the programmed limits for the number of allowable errors for a particular application. For example, in a scientific computing center, the number of allowable entrances into the write-error routine might be reduced from 50; heavy usage of the beginning of the tape reel may make 10 a more appropriate number.

The usage of tape units will determine a convenient time to print out statistics. For a run involving input or output reels that are specifically loaded or unloaded for a given job, or where batched input or output is contained on a reel, the statistics would usually be printed at the end of each reel. When the same reel and tape unit are used for many jobs, such as for work tapes, the statistics should probably be printed when the tape is assigned as output or at the end of a time interval. The necessity for tape replacement or tape head cleaning during a particular run may be pointed up by statistics.

Details of statistics maintained and printed by IBM Programming Systems Input-Output Control System packages are in the following IBM Programming System Reference Manuals:

For the 705, Form J28-6016

For the 705III, Form C28-6109

For the 7070-7072-7074, Form J28-6033

For the 7080, Form J28-6188

For the 709-7040-7044-7090-7094, Form C28-6100

For the 1410, Form J28-1432

Labeling

Label contents recorded on tape should be modeled after those specified in the above mentioned IBM control systems literature. It is recommended that all file data, including labels, be written in the same density because all tape operations, including backspace file, must be performed at the correct density to insure correct results.

Density Testing

Reliance should not be placed on an error indication to cause a programmed shift to another density.

Magnetic Tape Unit Selection

The IBM 7261 Tape Selection Unit (Figure 39) provides remote operation of all manual controls normally accomplished at the tape unit, exclusive of the actual handling of the magnetic tape reels. Modular design permits fitting tape selection to the particular IBM Data Processing System, as well as expansion when required. The basic cabinet and selection panels may be used with any IBM magnetic tape unit that has been modified for remote operation. This is a special feature; RPQ* W89489F modifies the 727 and 729I tape units, and RPQ W89489G modifies the 729II, 729III and 729IV tape units.

Three basic cabinets are available which provide for up to 4, 10, or 20 selection panels. Figure 40 shows an individual tape selection panel. The physical proportions of these cabinets permit mounting on a desk or table in the general area of the computer console. The 20-unit cabinet may be mounted in a console which provides for up to 10 additional selection panels, making a possible maximum of 30 selection panels in one console.

Each selection panel is cable-connected to the corresponding modified tape unit. Once connected, the tape unit may be controlled remotely from the selection panel, or locally by tape unit keys and lights. By turning the tape unit address selection switch to the new remote (R) position, the tape unit may then be addressed from the remote selection panel. Local address selection is done in the normal manner.

A complete description of *Magnetic Tape Unit Selection for IBM Data Processing Systems,* Form L22-6886, is available through IBM Regional Sales Engineering Departments.

* Request for price quotation. Availability of this feature can be determined by requesting a price quotation from IBM.

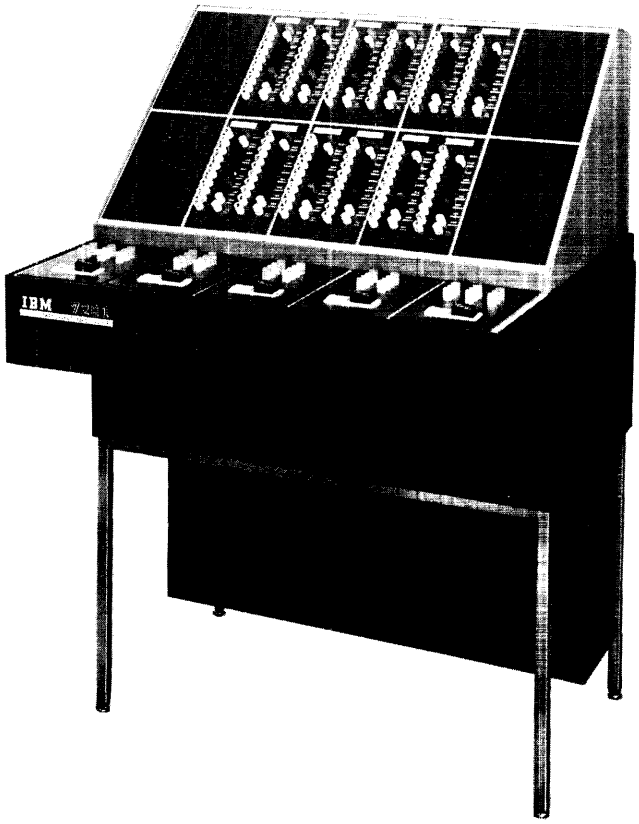


Figure 39. IBM 7261 Tape Selection Console

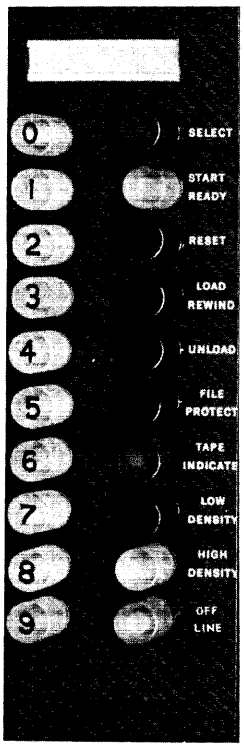


Figure 40. Tape Selection Panel

Magnetic Tape Unit Switching

IBM 729II and 729IV Magnetic Tape Units may be modified to permit switching magnetic tape units between tape channels under control of switch panels in an IBM 7155 Switch Control Console (Figure 41). This optional feature eliminates the necessity of physically changing cables when switching a tape unit to another channel.

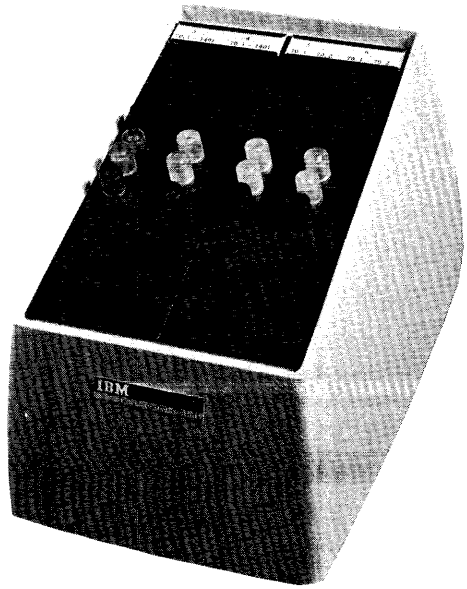


Figure 41. IBM 7155 Switch Control Console

Modified tape units may operate with two tape channels of an IBM Data Processing System or between tape channels of different IBM systems.

Tape units may be logically oriented between tape channels to complement a particular tape channel during special job applications that require a maximum number of tape units on a channel, or removed from the channel when fewer tape units are required on a channel.

A computer may write an output tape, which may then be switched to an IBM 1401 Data Processing System for further processing, editing, printing, or punching, without moving tape signal cables or physically handling the tape. Switching is effected by relays enclosed in the modified tape units. Each 7155 Switch Control Console can control two, four, six, or eight modified magnetic tape units.

A complete description of magnetic tape unit switching is in *IBM 729II and 729IV Magnetic Tape Unit Switching,* Form G22-6587.

Paper Tape to Magnetic Tape Converter

The IBM 7765 Paper Tape to Magnetic Tape Converter (Figure 42) converts paper tape data directly to magnetic tape recorded in BCD or binary code. This conversion provides input of paper tape data to a computer system faster than is possible with present on-line paper tape readers.

Data to be converted from paper tape may be written on magnetic tape in an off-line operation at 150 paper tape characters per second. Input to the converter may be eight-track IBM or five-track tele-

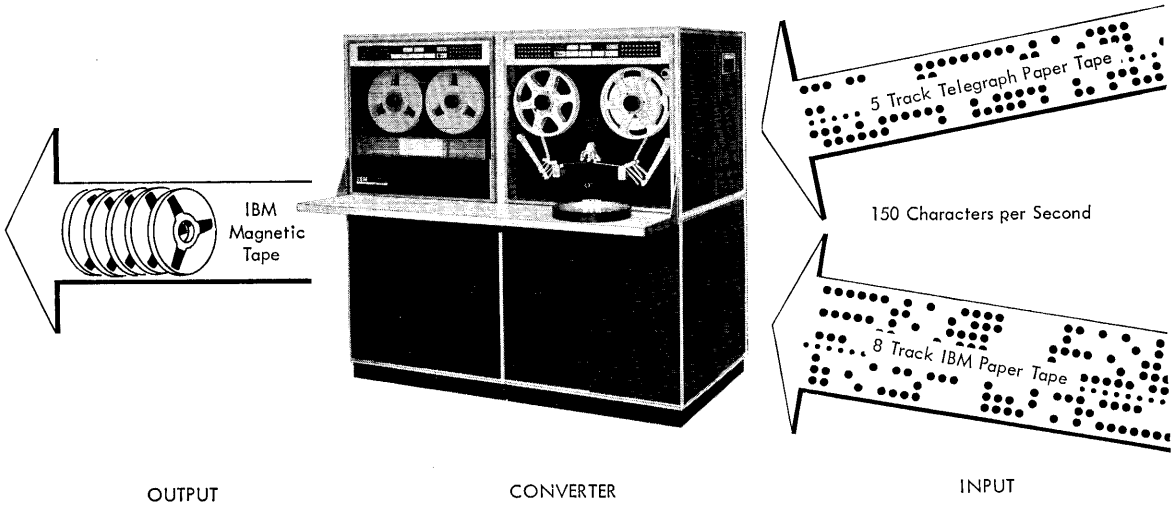


Figure 42. IBM 7765 Paper Tape to Magnetic Tape Converter

graphic, chad or chadless paper tape in strips, rolls, or reels. The recorded magnetic tape output may be read at 15,000 or 22,500 characters per second by an IBM magnetic tape unit functioning in low-density mode.

The converter writes one character at a time under control of paper tape characters and a removable IBM control panel. Specific characters may be eliminated or substituted when writing magnetic tape. Checking circuitry can cause an operator-determined character to be written as the last character in a valid magnetic tape record. Invalid records may be flagged with a different operator-determined character to initiate computer correction routines.

Other devices detect tape breaks or run-out and insure that tape is properly loaded. Standard paper tape reels and standard IBM magnetic tape reels are used.

A complete description of the 7765 is in the IBM Reference Manual, *7765 Paper Tape to Magnetic Tape Converter,* Form A22-6570.

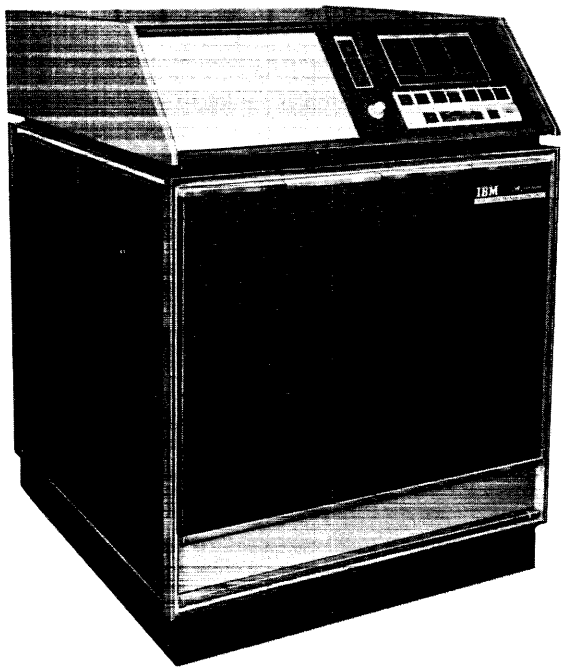


Figure 43. IBM 1009 Data Transmission Unit

Transmission Terminals

Many businesses with decentralized accounting operations have data processing installations at branch offices as well as at the headquarters location. The source data received from the branch offices enable the central office to prepare consolidated reports and to meet both internal and governmental accounting requirements. The branches need reports and processed facts from the central installation to control their operations efficiently.

The IBM 1009 Data Transmission Unit (Figure 43) permits high-speed, two-way communication between two IBM 1401 Data Processing Systems or between a 1401 and an IBM 7701 Magnetic Tape Transmission Terminal (Figure 44). All models of the 1401, except the Model A, can be used with the 1009.

The 1009 controls the movement of data, a character at a time, from 1401 storage, and the transmission of the data to another 1401 or a 7701 over message or leased wire service at 150 characters per second under stored program control. A complete description of the 1009 is in the IBM General Information Manual, *1009 Data Transmission Unit,* Form D24-1039.

The 7701 provides direct transmission of magnetic tape data over message or leased wire service. Two 7701 Magnetic Tape Transmission Terminals provide tape-to-tape transmission of either binary coded decimal (BCD) or binary data written at 200 character-per-inch density. Transmission rate may be 150 or 75 characters per second. Tapes prepared on the

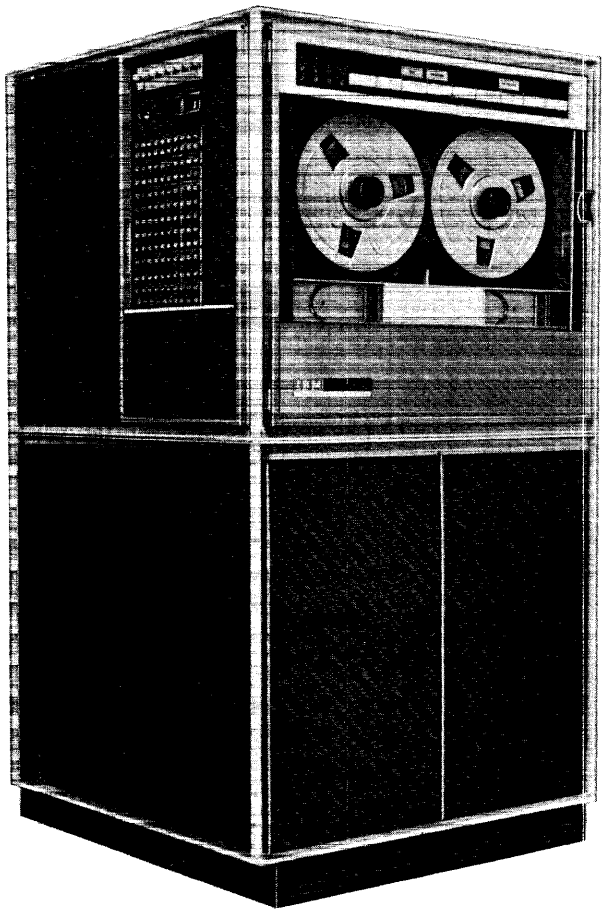


Figure 44. IBM 7701 Magnetic Tape Transmission Terminal

magnetic tape transmission terminals are compatible with IBM data processing equipment using IBM 727, 729I, II, or IV, and 7330 Magnetic Tape Units. The 7701 includes the basic circuitry of the 1009, and is completely compatible with a 1401-1009 configuration.

The IBM 7702 Magnetic Tape Transmission Terminal performs the functions of the 7701, but has data rate capabilities of 150, 250, or 300 characters per second.

Communications between outlying installations and a central data processing system without intermediate conversion steps result in fast and economical collection, processing, and return of data. The new tape terminal is particularly valuable when included in tape-oriented large-scale systems. Straight-line data flow from intermediate tape systems, such as the IBM 1401 or the IBM 650 Tape System, to a large-scale central system (IBM 700 or 7000 series Data Processing System) is now possible.

A complete description of the 7701 is in the IBM Reference Manual, *7701 Magnetic Tape Transmission Terminal,* Form A22-6527.

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