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IBM Systems Reference Library

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

Original Equipment Manufacturers' Information

The information in this manual is presented to assist designers of accessory equipment for IBM 729 II, IV, V, and VI Magnetic Tape Units. Additional details about operation and use of these tape units in integrated data processing systems may be obtained from the local IBM Sales Office.

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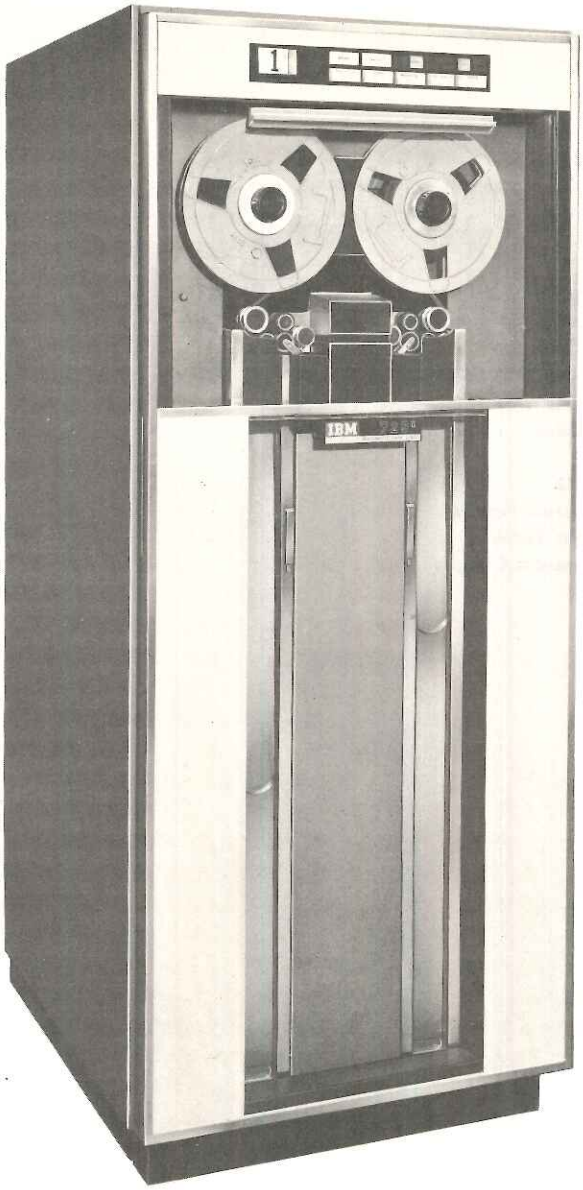


IBM 729 II Magnetic Tape Unit

IBM 729 Magnetic Tape Units write and read magnetic tape. The 729 units are identical in appearance and in function but differ in the speeds at which they transport magnetic tape and in the mechanisms and circuitry used in transporting the tape. Tape speed for the 729 II and 729 V is 75 inches per second and is 112.5 inches per second for the 729 IV and VI.

The magnetic tape is a plastic material coated on one side with a metallic oxide that is readily magnetized. It retains magnetization indefinitely. The tape is 1/2-inch wide and is packaged on reels that can accommodate tapes as long as 2,450 feet.

Magnetic tape is the principal input/output medium for a computer. In addition, tape is used for the storage of intermediate results and for the permanent storage of large files of data. Magnetic tapes may be reused many times because old data are automatically erased as new data are recorded.

The 729 units write and read magnetic tape at character densities of 200, 556, and 800 characters per inch (cpi). Tapes written at 200 cpi by the 729 II, IV, V, and VI may be read by IBM 727 or 729 I Magnetic Tape Units; tapes written at 556 cpi may be read by IBM 729 III Magnetic Tape Units.

IBM 729 units write or read moving tape by the use of a read-write head that records data on or reads data from seven parallel track areas on the magnetic tape. All 727 and 729 units use the non-return-to-zero-IBM (NRZI) method of recording data on tape. When electrical current flows through the recording head coil, the magnetic oxide particles on the tape are oriented in one direction. If the current in the coil reverses its direction, the particles on tape will be oriented in the opposite direction. In the NRZI method, a 1 is recorded by a reversal of flux polarity and a 0 by the absence of such a reversal. In this system, therefore, the magnetic tape is fully magnetized in each track, and the polarity is reversed as each 1 bit is written.

DATA REPRESENTATION

Data are represented on magnetic tape by the use of either a binary-coded decimal (BCD) code or a binary code. The BCD code has numbers, letters, and symbols (Figure 1); one discrete character is represented in each seven-bit column. The binary code has only binary numbers and sign information. Six seven-bit columns may be used to represent a 35-bit binary number with sign (Figure 2). The track areas on tape are referred to as C, B, A, 8, 4, 2, and 1 in both codes. The track labeled "C" (check) provides parity information for each character. BCD-coded tape has even parity; binary-coded tape may have odd (usual) or even parity.

ERROR CHECKING

Error checking is done by equipment external to the tape unit. To facilitate error checking, 729 units use read-write heads with 14 gaps: seven for writing and seven for reading. A write gap and a read gap are shown in Figure 3. The read-write head is preceded by an erase head that is energized only during writing. A write operation passes tape first under the erase head, at which point information previously recorded on the tape is erased; then past the write gap to record new data; and finally past the read gap to check for errors. Distance between the read and write gap is 0.300 inch ± 0.002 inch. Because the tape transport speed in the 729 II and 729 V is 75 inches per second, the read (check) operation occurs 4 milliseconds after writing. In the 729 IV and 729 VI, the read operation occurs 2.67 milliseconds after writing. The read-while-writing capability makes possible the detection of errors as they occur; the tape may be backspaced and the record rewritten or re-read.

Error checking equipment can be used to detect parity errors. The number of bits in each character is tested for being odd or even. Improper parity is an error condition. In addition to this vertical checking of each character, a longitudinal count of the bits written in each track can be made, and at the end of the record a longitudinal check character can be written which provides even parity for each track. Odd parity is an error condition.

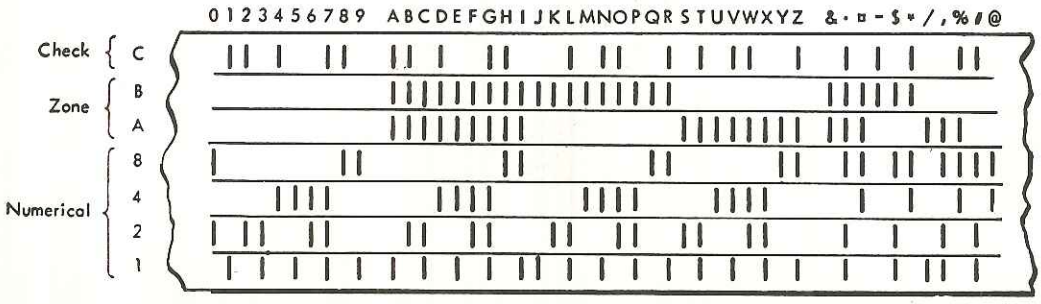


Figure 1. Tape Character Coding

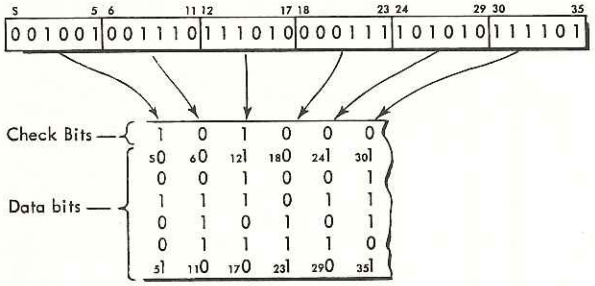


Figure 2. Binary Data Recorded on Tape

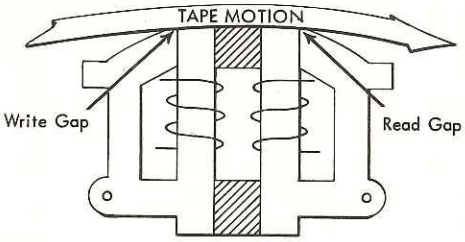


Figure 3. Two-Gap Recording Head

To increase the detection of errors or weak signals at the time of writing, dual-level sensing equipment, located outside the tape unit, may be used to check recording at two different energy levels (E1 and E2 in Figure 4). This checking ensures that:

1. The data are recorded at a level that will provide good information transfer when the tape is read later.
2. No unwanted information (noise) is on the recorded tape.
3. Parity-compensating errors in the two energy levels do not exist.

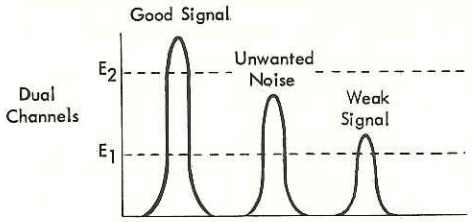


Figure 4. Error Detection

FILE PROTECTION

Because a write operation erases information previously recorded on the tape, means are provided for preventing accidental erasure of information. The back of a tape reel has a groove that accepts a plastic file protect ring (Figure 5). With the file protect ring in place, either writing or reading may be done. When the ring is not in place, only reading may be done.

RECORDS AND FILES

As determined by the program, columns of data on tape may be grouped into records, defined by inter-record gaps. An inter-record gap consists of a 3/4-inch section of erased and unrecorded tape. Records may be grouped together into files, which are separated by a special character tape mark. This is done by writing a single character tape mark record (accompanied by its longitudinal check character), which is preceded and followed by an inter-record gap. When the tape mark is read, an end-of-file condition can be signaled to the computer.

On the IBM 704 Data Processing System, the write-tape-mark operation causes an inter-record gap about 3-1/2 inches long to be written before the tape mark (Figure 6). When the tape is read by the 704 system, this long file gap is recognized as an

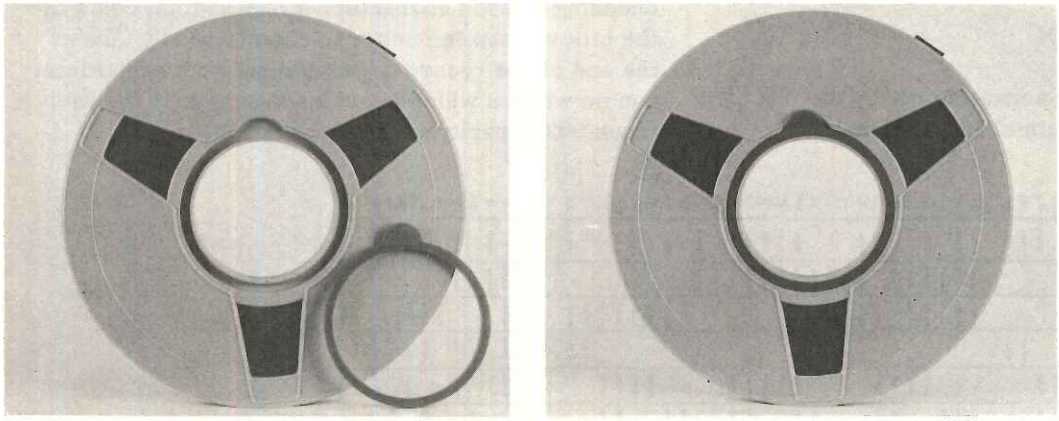


Figure 5. File Protect Ring

end-of-file indication. When the 704 tape is read by other systems, the long file gap has no significance, but the tape mark is recognized as an end-of-file indication.

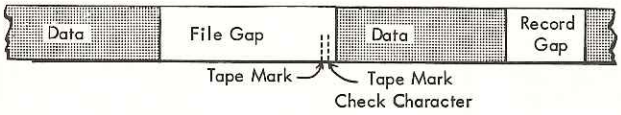


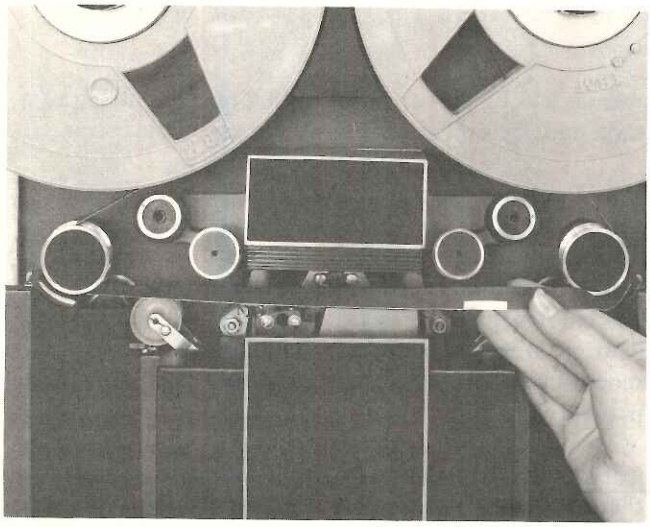
Figure 6. Record and File Gaps on Magnetic Tape

LOAD POINT AND END OF REEL

Approximately 10 feet of blank tape is left at the beginning of a reel of tape and approximately 14 feet at the end. A load point marker (Figure 7) is placed on the base (uncoated) side of the tape 10 feet (+1 foot, -0 feet) from the physical beginning of the tape and 1/32 inch from the track 1 (outside) edge of the tape. The long dimension of the marker is parallel to the length of the tape.

And end-of-reel marker is placed 14 feet (+1 foot, -0 feet) from the end of tape and 1/32 inch from the track C (inside) edge of the tape.

The load point marker and the end-of-reel marker are used during the write operation to indicate where writing on the tape should begin and end; their light-reflecting surfaces are sensed by photoelectric cells. The markers are pieces of transparent plastic with a thin, vapor-deposited film of aluminum covered with pressure-sensitive adhesive 1 inch by 3/16 inch.



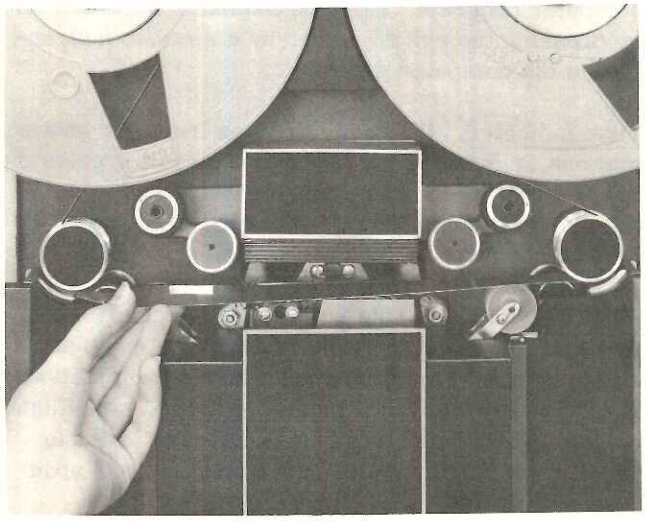


Figure 7. Reflection Tape Markers

TAPE FEED

Figure 8 shows the progression of magnetic tape from one reel to another. When either reading or writing is being done, the tape is transported from the file reel (left side), through a vacuum column, past the read-write head, through another vacuum column, to the machine reel (right side). Since it is impossible to start and stop high-speed motion of the tape without some slack in the tape, a loop of tape is held in the vacuum columns and acts as a buffer for this motion. As tape is drawn from one column, it is replenished from the reel above it. As it is fed into the opposite column, the associated reel takes up the slack.

The read-write head assembly has a lower part that is stationary and an upper part that moves up for tape threading, unloading tape from columns, and high-speed rewinding.

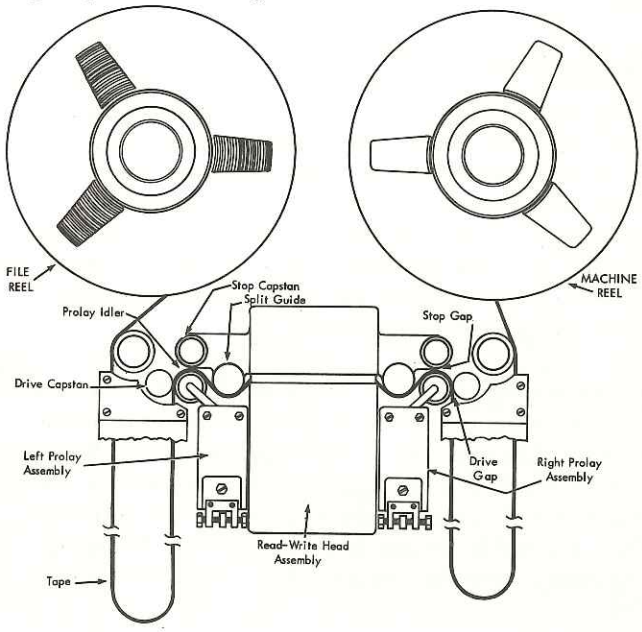


Figure 8. Tape Feed

TAPE UNIT KEYS AND LIGHTS

All keys and lights of the 729 II, IV, V, and VI are shown in Figure 9 and described below.

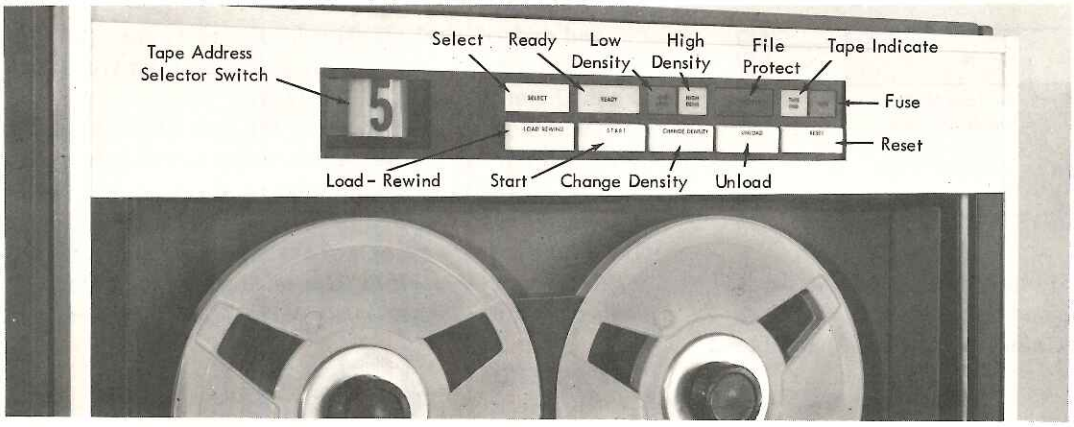


Figure 9. IBM 729 Keys and Lights

Address Selector Switch. This switch connects the tape unit to one of the ten select lines coming from a tape control. Select lines are numbered 0 through 9 and serve as the addresses for the tape units connected to the control unit. The selected address numeral is illuminated as soon as power is applied to the tape unit.

Select Indicator. When on, the select indicator signifies that the tape unit is the one selected to perform the next tape function. The indicator is turned on when the address selector is switched to a select line at a +P level. It is turned off when the select line is at a -P level.

Ready Indicator. When on, this indicator shows that the tape unit is in ready status, that is, the tape unit is loaded (tape is in the vacuum columns and across the read-write head), and all interlocks are closed. It is turned on by pressing the start key but will not light unless these two 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; the light will turn on when the load-rewind is completed.

Bit Density Indicators. There are two density indicators. When on, the high-density indicator signifies that the tape unit is set to write or read bits at a rate of 556 bits per inch and the low-density indicator that it is set for the rate of 200 bits per inch. Only one indicator can be on at a time. Pressing the change-density key switches power from one indicator to the other. The high-density indicator turns on as soon as power is applied to the machine. The high-density indicator on the 729 V and VI refers to 800 or 556 cpi, whereas the low-density indicator means 556 or 200 cpi, depending on the setting of a tape density option switch on the tape control unit.

File Protect Indicator. When on, this indicator shows that the tape unit cannot be placed in write status. It is on when (1) no file reel is mounted, (2) a file-protected tape reel is mounted, (3) a load-rewind operation is in process, or (4) an unload operation is in process. The indicator is turned off by mounting on the machine a tape reel that is not file-protected.

Tape Indicator. When on, this indicator 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 by a specific instruction inserted into the computer program. The tape indicator is turned off by pressing the unload key or by a specific instruction in the computer program.

Fuse Indicator. When on, the fuse indicator shows that one or more of the protective circuit breakers has been tripped. This indicator is turned on by tripping any one of the ac or dc circuit breakers except ac breakers 1, 2, and 3 or dc breaker 1.

Load Rewind Key. This key is operative only when the tape unit is not in ready status. The machine must be under manual control. It has two functions: (1) load tape into the column, (2) rewind tape (high or low speed) and locate load point. The order in which these functions are performed depends upon

how the tape is distributed in the machine when the key is pressed. If the tape is in the high-speed area, the machine will unload tape (if not already unloaded), perform a high-speed rewind to the low-speed area, stop, load tape, perform a low-speed rewind to load point, and stop. If the tape is in the low-speed area, the machine will load tape (if not already loaded), low-speed rewind to load point, and stop. 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.

Start Key. This key places the tape unit under automatic systems control. Pressing the start key disables all manual controls (except the reset key) and places the tape unit in the ready status only when the tape unit is loaded and all interlocks are closed.

Change Density Key. This key is operational only when the tape unit is not ready. This key changes the character rate at which the tape unit will write or read. Pressing this key changes the character rate from one density to the other. To change the density, circuitry in the tape unit is switched, indicating to the tape unit that the data it will write or read will be at the new density. This circuitry also sends a signal back to the tape control requesting data at the new density, if in write status, or informing the tape control that the tape unit will read data at the new density rate if it is in read status. It also causes the bit density indicators to change: the on indicator to off and the off indicator to on.

Unload Key. This key is operative only when the tape unit is not in ready status and not performing a load-rewind operation. Pressing the key causes the tape to be drawn out of the columns and the upper head to be raised, regardless of the distribution of tape on the two reels.

Reset Key. This 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, with the exception of unload and rewind. The unload operation is always completed, once started, while the high-speed rewind operation will be shifted into low-speed rewind. To stop the rewind operation completely, the reset key must be pressed a second time.

TAPE SWITCHING

Tape units with the tape switching optional feature may be switched between tape channels. Where a raised floor is not used, special cables are used. See the Installation Manual - Physical Planning, IBM Input-Output Components, 7000 Series and 1410 Data Processing Systems, Form C22-6681.

SPECIFICATIONS

Most of the specifications are the same for the 729 II, IV, V, and VI. When this is so, only one value is stated and should be interpreted as applying to all 729 tape units. When differences exist, specifications are indicated for each machine. Information concerning external power, air conditioning, weights, and dimensions is available from IBM Regional Sales Engineering through the IBM Branch Office. Also available for tape unit maintenance are the Customer Engineering Manual of Instruction, 729 II, III, IV Magnetic Tape Units, Form 223-6845, and the Customer Engineering Reference Manual, 729 II, III, IV Magnetic Tape Units, Form 223-6868.

READ-WRITE HEAD

1. Two-gap construction, which allows for checking while writing.
2. 0.300 inch ± 0.002 inch between gaps.
3. Track widths (read and write):
   Write gap: 0.0005 inch ± 0.00005 inch.
   Read gap: 0.00025 inch ± 0.00005 inch.
4. Write current:
   729 II, V: 70 milliamperes
   (+5, -8 milliamperes)
   729 IV, VI: 70 milliamperes
   (+3, -10 milliamperes)
   Rise time (fully loaded) is 2.3 microseconds to 65 percent amplitude point.
   Fall time (fully loaded) is 0.3 microsecond to zero point.
5. Read head output: 15 millivolts, minimum; 30 millivolts, maximum.

TAPE SPEED

1. Forward, backward, and low-speed rewind:
   729 II, V: 75 inches per second.
   729 IV, VI: 112.5 inches per second.
   Tolerances for both machines:
   Initial instantaneous speed ±5 percent
   Steady-state instantaneous speed ±2 percent
   Average steady-state speed ±1 percent
2. High-speed rewind:
   500 inches per second, average.

The specification for the reel hub control mechanism inertia is 0.0910 inch-pounds/second^2 maximum. This specification includes a safety factor to ensure maximum clutch life and reliability.

BIT DENSITY

1. 800 characters per inch, ±2 percent
2. 556 characters per inch, ±2 percent
3. 200 characters per inch, ±2 percent
4. Acceptable instantaneous variations: Either tape unit can be used to write at either bit density by its control unit. The values and tolerances given here are those specified for IBM tape controls to maintain complete interchangeability in all IBM computer systems. When reading tape written by these tape units under control of non-IBM control units, IBM tape controls for tape units will tolerate some variations in tape density from those specified and still perform free of errors, provided the following restrictions are maintained.
   a. The time interval between any two characters must be less than the record gate, minus 15 percent. See "Record Gate."
   b. The time interval between the record and the check character must be longer than the record gate, plus 15 percent, and less than the disconnect delay, minus 15 percent. See "Delays."
   c. All bits in one character must be within one character gate timing. See "Delays."
   d. The time interval between the first bit of any character and the preceding character gate must not be less than 1 microsecond under any allowable condition of skew, bit configuration, and tape speed.
   e. Density and skew are monitored during a write operation by a skew gate. All bits within a character must be received before the rise of the skew gate, and no bits from the following character can be received before the fall of the skew gate.

CHARACTER RATE

Characters per Inch	Characters per Second ±3 Percent			
	729 II	729 IV	729 V	729 VI
800			60,000	90,000
556	41,667	62,500	41,667	62,500
200	15,000	22,500	15,000	22,500

POWER REQUIREMENTS

1. Power-on contactor switch, on lower back side of unit, turns off power to the unit without disconnecting the power cable.
2. 208 or 230 volts ac ± 10 percent, 3 phase, 60 cycles per second at the 729 is required for input. Thermal-overload protection is provided.
3. Internal voltage requirements vary for the different series of 729 tape units. Identification below is by initial number in each series.
   NORLAY: 12,000 Series 729 II, V, and 61,000 Series 729 IV, VI.

NOR: 30,000 Series 729 II, V and 90,000 Series 729 IV, VI.

Relay: 40,000 Series 729 IV, VI and 70,000 Series 729 II, V.

Internally generated voltages are:

12,000 Series 729 II, V and 61,000 Series 729 IV, VI.

-6v dc	@	2.0 amp	15 mv peak-to-peak ripple max
+6v dc	@	3.0 amp	15 mv peak-to-peak ripple max
-12v dc	@	5.0 amp	100 mv peak-to-peak ripple max
+12v dc	@	2.0 amp	100 mv peak-to-peak ripple max

Three circuit protectors; maximum ratings:

-48v dc	@	3.0 amp	1.5 mv peak-to-peak ripple max
-48v dc	@	7.0 amp	1.5 mv peak-to-peak ripple max
-48v dc	@	8.0 amp	1.5 mv peak-to-peak ripple max

30,000 and 70,000 Series 729 II, V; 40,000 and 90,000 Series 729 IV, VI.

-6v dc	@	2.5 amp	±0.24v, < 40 mv ripple
+6v dc	@	3.0 amp	±0.24v, < 40 mv ripple
-12v dc	@	2.5 amp	±0.48v, < 40 mv ripple
+12v dc	@	2.0 amp	±0.48v, < 40 mv ripple
-48v dc	@	30.0 ma	±4.8v, < 100 mv ripple
-48v dc	@	2.2 amp	±4.8v, < 0.9v p-p ripple
+62v peak ac	@	165.0 ma	±3.4v
+140v dc	@	1.0 amp	±28v, < 7v p-p ripple
+140v dc	@	5.0 ma	±28v, < 100 mv p-p ripple
7.5v dc	@	20.0 amp	±1.5v, < 3.3v ripple, at 10 amp < 7.5v ripple, at 20 amp

MACHINE PROTECTION

The overloading of any circuit breaker de-energizes the run relay (R1) and, except for ac circuit breakers 1, 2, and 3 or dc breaker 1, causes the fuse indicator to turn on.

FILE PROTECTION

Recorded files of tape reels are protected from erasure when a file-protect ring is not inserted into the groove on the back of the file reel. When inserted, this ring actuates the not-file-protect mechanism and allows current to flow in the write heads when the tape unit is placed in write status.

TAPE MOTION START AND STOP TIMES

1. Full-speed coast (5 percent of nominal speed) after the fall of "go."	729 II and V: 1.2 ms 729 IV and VI: 0.9 ms
2. Time from start of tape motion to start of nominal speed.	1.3 ms (max)
3. Time from the rise of "go" until the signal reaches the 100 percent amplitude point.	<3.3 ms
4. Time from fall of "go" until the signal reaches 50 percent amplitude point:	
Forward	2.1 ms min; 0 percent amplitude no later than 3.0 ms max
Backward	1.8 ms; +.2,-.1 ms

READ PULSES

Peak sensing is used. Preamplifiers are adjusted to maintain an 8.8-volt peak-to-peak gain (729 II and IV) and 10.0-volt peak-to-peak gain (729 V and VI) of the read pulses (reading while writing) as measured at the read buses with a scope calibrated to within 5 percent. Preamplifiers are capable of providing a minimum gain of 10 volts peak-to-peak, with only one tape on the line, when measured at the read buses with a scope calibrated to within 5 percent.

INPUT/OUTPUT SIGNAL REQUIREMENTS

Reference Levels

Except for the read pulse outputs from the tape unit, all other input and output signal are current-switching levels. In the current-switching logic system, signal swings are made about two separate reference levels. The reference level for an N-line is ground. The reference level for a P-line is -6 volts. For reliable operation, a minimum swing of ±0.4 volt about either reference is required. A -3 volt swing below ground for an N-line and a +3 volt swing above -6 volts for a P-line is the maximum swing each line can tolerate before forcing the transistor to conduct into saturation. Voltage swings opposite to these place the transistors into the off condition and are limited only by the breakdown specifications of the transistors. In the 729 II, IV, V, and VI tape units, signal swings are maintained at a nominal level of ±1 volt about either the N or P reference level.

Current Requirements

Minimum current necessary for each N- or P-block (A, O or C) is 0.246 ma for an end-of-life α_{cB} and 0.164 for an initial purchase value of α_{cB}. When the blocks are off, all are considered to be at end-of-life I_{co} and I_{eo} limits (0.14 ma).

Signal levels are:

+N minimum level: +0.4 volt
-N minimum level: -0.4 volt
+P minimum level: -5.6 volts
-P minimum level: -6.4 volts

Input lines that have no rise time, fall, time or pulse width specifications are:

+P Select
-N Backward
+P Go
-N Write Check Character

Input lines that require a minimum pulse width of 1 microsecond are:

+P Set Read Status
-N Set Write Status

-N Turn on Tape Indicator
+P Turn off Tape Indicator
-N Write Pulse (See items 1 and 3 under "Specifications, Tape Motion Start and Stop Times" for values used in the tape control.)

Input lines whose pulses require either a response from the tape unit to indicate completion (approximately 10 milliseconds) or maintenance at the pulsed level for a minimum of 20 milliseconds without a response are:

-N Start Rewind
+P Rewind and Unload
+P Set High Density
-N Set Low Density

Input write bus lines (7) must be at the -N level 4.5 microseconds before the write pulse line begins to rise. The down time for the write buses is equal to the write pulse width time.

Output lines that require no rise time, fall time, or pulse width specifications are:

+P Select and Ready	+P Select Ready and Read
-N Select and Tape Indicate Off	+P Select Ready and Write
-N Select and Tape Indicate On	-N Select and Rewind
+P Select and Load Point	+P High Density
+P Select and Not at Load Point	-P Low Density

The -N Write Echo output line provides a minimum pulse width of 1 microsecond. Maximum capacitance on any output line is 3,000 micromicrofarads.

RECORD GATE

Characters per Inch	Microseconds 729 II	729 IV	729 V	729 VI
800			37.1	24.8
556	54	36	54	36
200	150	100	150	100

The inter-record gap, vertical bit spacing, tape skew, and general facts about recorded tape are shown in Figure 10.

NOISE

1. Write circuit feed-through is less than 400 millivolts, as measured at the read bus of each track of the tape unit, when continuous 1 bits are written in all tracks without tape movement.
2. Cross talk is less than 400 millivolts as measured at the read bus of each track of the tape unit when continuous 1 bits are written in all tracks, except the track being checked (with tape movement).
3. Total noise is equal to the sum of cross-talk and feed-through levels.
4. Minimum clipping levels of read pulses at input to final amplifiers of the control unit, to ensure no random low-noise pickup, are:
   a. 1.6 volts peak-to-peak when reading-while-writing.
   b. 0.6 volt peak-to-peak when reading only.

In IBM tape controls, each track has a dual set of final amplifiers; one set accepts a high-level input and the other a low-level input. All inputs are peak sensed. The outputs of these dual amplifiers are subsequently compared and checked in other circuitry for error checking. The minimum inputs to the dual amplifiers are:

Channel	Read	Write
A (High Clip)	2.4v peak-to-peak	2.8v peak-to-peak
B (Low Clip)	0.6v peak-to-peak	2.0v peak-to-peak

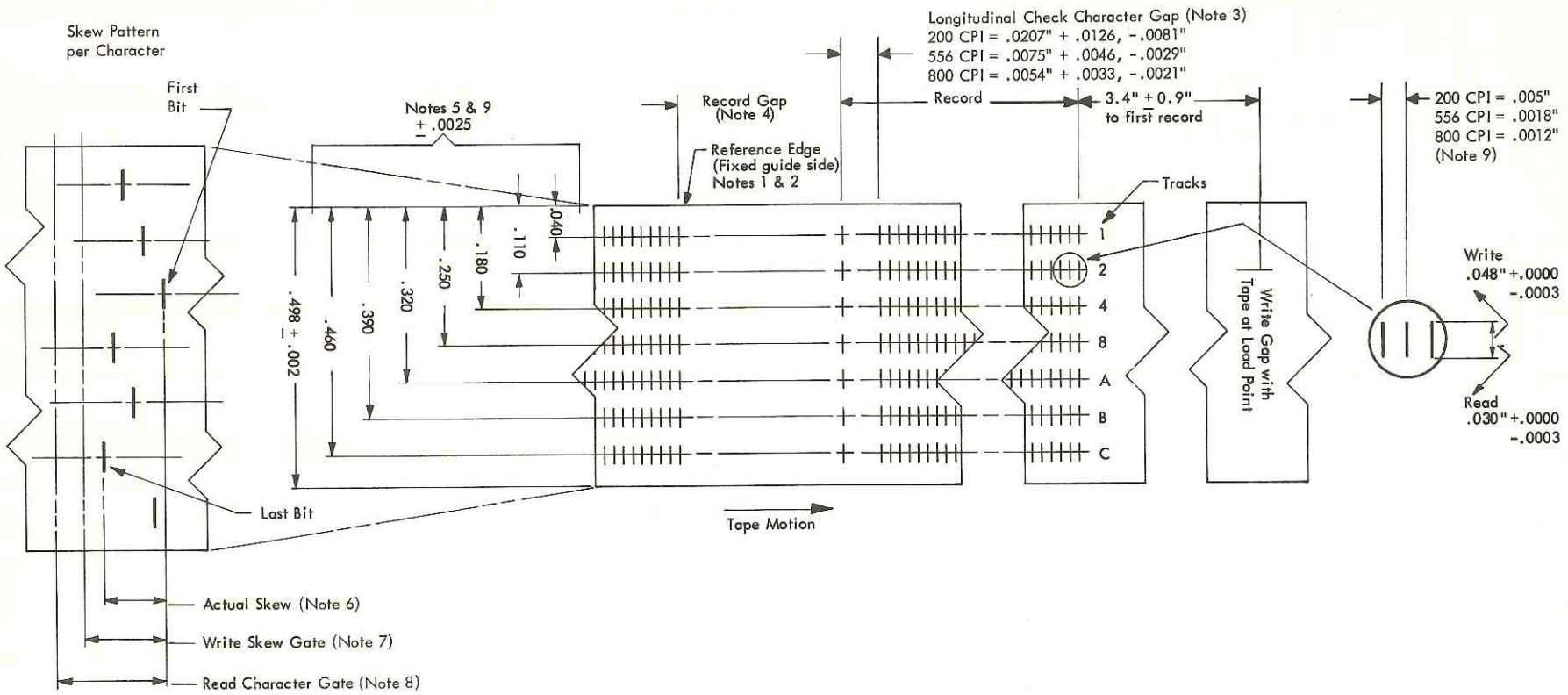
DELAYS

		729 II and V	729 IV and VI
Write delays:			
1. Write delay, ±1 percent		7.5 ms	5 ms
2. Write load point delay, ±1 percent		48 ms	32 ms
3. Write stop delay, ±3 percent		3.0 ms	2.0 ms
4. Write check character delay, ±1 percent			
	800 cpi	63 usec	42.3 usec
	556 cpi	90.6 usec	60.6 usec
	200 cpi	250 usec	166 usec
Read delays:			
1. Read delay, ±2 percent		4.5 ms	3.0 ms
2. Read load point delay, ±1 percent		24 ms	16 ms
3. Record gate, ±1 percent			
	800 cpi	37 usec	25 usec
	556 cpi	54 usec	36 usec
	200 cpi	150 usec	100 usec
4. Read disconnect delay, ±1 percent			
	800 cpi	150 usec	100.7 usec
	556 cpi	216 usec	144 usec
	200 cpi	600 usec	400 usec

TAPE OPERATING ENVIRONMENT

The following conditions for use of IBM magnetic tape are recommended:

Relative Humidity	Temperature	Maximum Wet Bulb Temperature
20% - 80%	60° - 90°F	78°F



NOTES:

1. Tape is shown with oxide side up, Read/Write head on same side as oxide.

2. Tape shown representing 1 bits in all tracks, NRZI recording; 1 bit produced by reversal of flux polarity, tape fully saturated in each direction.

3. Variation permitted in the location of the Check Character assuming nominal values for tape speed and all oscillator timings in the Tape Control. No longitudinal check bit is written if longitudinal count in the track is even.

4. Mylar Tape: 3/4", + 5/32", -1/16". Acetate Tape. 3/4", + 5/32", -1/8". Zero Backward creep. Forward creep less than 0.2" per cycle.

5. Dimensions of tape measured at 50% relative humidity and 70°F. Tape thickness (Mylar or IBM HD) is 0.0022", + .0003", -.0004".

6. To insure complete interchangeability, skew of each tape unit is adjusted to 0.25 usec or less at the read bus of the tape unit when reading-while-writing continuous 1 bits. Maximum skew for any reel of tape, read by any tape unit connected to any tape control, must be equal to or less than the read character gate for the bit density and tape speed at which the tape was written.

7. Write Skew Gate, ±5%

	Time from First Bit	
	Rise	Fall
729 II or V, 556 CPI	6.3 usec	16.1 usec
729 II or V, 200 CPI	16.9 usec	44.0 usec
729 IV or VI, 556 CPI	4.3 usec	10.8 usec
729 IV or VI, 200 CPI	11.4 usec	29.5 usec
729 V, 800 CPI	6.3 usec	10.4 usec
729 VI, 800 CPI	4.0 usec	6.8 usec

When reading, while writing coded information, all bits within a character must be received before the rise of the write skew gate.

8. Read Character Gate, ± 5%

729 II or V, 556 CPI	10.5 usec
729 II or V, 200 CPI	29.2 usec
729 IV or VI, 556 CPI	7.5 usec
729 IV or VI, 200 CPI	21.0 usec
729 V, 800 CPI	7.9 usec
729 VI, 800 CPI	5.4 usec

9. Time Between Characters: Writing--shall not be less than fall of the skew gate timing plus 1 usec, including variations due to tape speed, skew and bit configuration. Reading--shall not be less than read character gate timing plus 1 usec, including variations due to tape speed, skew, and bit configuration.

10. Tape purchased to IBM Engineering Specifications: 512459 for Mylar, 351527 for IBM HD.

Figure 10. Recorded Tape Specifications

TAPE STORAGE ENVIRONMENT

The following conditions for long term storage of IBM Heavy Duty and Mylar* magnetic tape are recommended:

Relative Humidity	Temperature	Maximum Wet Bulb Temperature
20% - 80%	40° - 90°F	80°F

An exception is unrecorded IBM Heavy Duty tape; it may be stored under the following conditions:

Relative Humidity	Temperature	Maximum Wet Bulb Temperature
20% - 80%	40° - 120°F	80°F

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

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.

* Trademark of E.I. duPont deNemours & Co. (Inc.)

INPUT/OUTPUT SIGNAL LINES

INPUT LINES

All input signals to the tape units have a level of either +P or -N. With the exception of the write check-character line, all input signals work into a standard IBM alloy transistor-circuit conversion block. The write check-character line works directly into a logical -OR circuit. In IBM tape controls, these signals are the outputs of N- or P-type transmission line drivers.

+P Select

This input (one of ten select lines) is used to select a particular tape unit from the group connected in line to the common control unit. This signal gates the tape unit selected, allowing it to receive all subsequent signals from the control unit. This line must be made positive before any tape unit operation can be started and must be held positive for the duration of the operation. Dropping the select line to a -P level immediately stops any tape operation except rewind or rewind unload.

+P Go

This input line is brought positive after the status lines have been set to establish the tape operation to be performed. Bringing Go to a +P level immediately starts the operation. Dropping Go to a -P level stops tape motion and operation, except for rewind or rewind unload.

+P Set Read Status

This input conditions the read circuits in the tape unit and deconditions its write circuits. It does this with a +P (1-microsecond minimum width) signal that sets the read-write trigger in the tape unit into read state. This line must be pulsed or held at a +P level before bringing up the Go line, whenever a read or backspace operation is performed. It is held at a -P level whenever a write operation is performed.

-N Set Write Status

This input conditions the write circuits in the tape unit and allows current to flow in the write head if a file-protect ring has been placed into the file tape reel. It does this with a -N (1-microsecond minimum width) signal that sets the read-write trigger in the tape unit into write status. This line must be pulsed or held at a -N level before bringing up the Go line every time a write operation is performed. It is held at a +N level whenever a read, rewind, or backspace operation is performed.

-N Backward

This line is changed to -N level and is AND'ed with Go, Select and Ready, and Not at Load Point to move tape backward. The Not at Load Point prevents backspacing when the tape is at load point.

-N Process

This line is changed to -N level when processing a tape.

-N Write Pulse

These input pulses are brought into the tape unit on a line common to the write circuits of all seven tracks. They are -N write pulses of 1-microsecond duration, at a frequency established by the tape control. The pulses must be delayed after the rise of Go until tape has attained full speed and the write buses (one for each track) have had sufficient time to gate each track. The pulses continue, one for each character, until the last character of the record has been written.

-N Write Buses

These seven input signal lines gate the write pulse to the write circuits of each track and write a 1 bit in that track. The up or down level of these lines is determined by the coded data sent to the tape unit. Gating the write circuits must be delayed after the rise of Go until tape has reached full speed. The pulses continue their gating action until the last character of the record has been written.

-N Write Check Character

This input is used at the end of writing a record to reset the seven write triggers (not the same as the read-write status trigger) in the tape unit so that the polarity of all the write heads will be the same. The input must be held at a -N level at all times except during the write operation. Then the write check-character line must be brought to a +N level with the rise of the first write pulse in the first character. It must be held positive for the full length of the record. The tape control delays dropping this line to a -N level until it has been assured that no further characters are to be written. This delay time is referred to as the "write check-character delay."

It is the fall of this line that resets the write triggers that have not been reset (odd bit longitudinal

count) by the last character of the record. This procedure permits longitudinal bit checking for write errors.

-N Turn on Tape Indicate

This line turns on the tape indicator in the tape unit under automatic control. It is a -N pulse of 1-microsecond width. This line is held at a +N level during all other operations and can be pulsed only after the tape unit is in select and ready status.

+P Turn off Tape Indicate

This line turns off the tape indicator when the tape unit is under automatic control. It is a +P pulse of 1-microsecond minimum width. This line is at a -P level during all other operations.

-N Start Rewind

This input line is used to start the rewind operation. It is one of two lines available for this purpose; the other is the rewind-and-unload line. The start-rewind line is held at the +N level during all operations except starting the rewind operation. To start a rewind operation, the line is brought to the -N level and held there a minimum of 20 milliseconds or until a response, active select and rewind, is received by the tape control (approximately 10 milliseconds). A start-rewind pulse is sent to the tape unit after it has been put into read status.

+P Rewind and Unload

This input line is similar to the -N start-rewind line. The difference between the two is that a +P pulse is used for this line, rather than the -N pulse, and that the operation does not stop when load point is reached. When the rewind operation is started with this line, the tape unit continues on after load point to unload the machine preparatory to changing reels.

+P Set High Density

When the tape unit is under automatic control, this line causes it to operate in the high-density mode. This line is held at a -P level for all operations in the low-density mode. When a tape unit is in select and ready status, it can be changed at any time into the high-density mode by bringing this line to a +P level and holding it there 20 milliseconds or until the response line (+P high density, -P low density) indicates a mode change (approximately 10 milliseconds). For manual control, the change-density switch (on tape unit) may be used.

-N Set Low Density

When the tape unit is under automatic control, this input line causes it to operate in the low-density mode. The line is held at the +N level for all operations in the high-density mode. When a tape unit is in select and ready status, it can be changed at any time into the low-density mode by bringing this line to a -N level and holding it there 20 milliseconds or until the response line (+P high density, -P low density) indicates a mode change (approximately 10 milliseconds). For manual control, the change-density switch (on the tape unit) may be used.

OUTPUT LINES

With the exception of the read signals, all other input lines from the tape unit are status or condition response lines. Their signals are either a +P or a -N pulse or level and are outputs of the same type of convert block as is used to receive the input signals from the tape control. In IBM tape controls, these signals work into N- or P-type line terminators.

+P Select and Ready

This line is at a -P level until the tape unit receives a +P select signal. Then, if all power supply interlocks are made and the address selector switch is at the corresponding number, the tape unit switches this line to a +P level to indicate that the machine is ready for the next instruction. This line is held at the +P level (except when the unit is rewinding) until the select line is dropped, the address selector switch is changed, the machine is reset to manual control, or any one of the interlocks is broken.

-N Select and Tape Indicate On

This line is changed to -N level whenever the tape unit is selected (under automatic control) and the tape indicator is turned on. This line is held at the -N level until either the select line drops or the tape indicator is turned off.

-N Select and Tape Indicate Off

This line is changed to -N level whenever the tape unit is selected (under automatic control) and the tape indicator is turned off. This line is held at the -N level until either the select line drops or the tape indicator is turned on.

+P Select and at Load Point

This line is changed to a +P level whenever the tape unit is selected and the load-point reflective spot is

is photosensed. This line is held at a +P level until either the select line is dropped or the tape moves from load point. This line must be at a -P level to permit a backspace operation. Circuits in the tape unit prevent it from backspacing beyond load point.

+P Select and not at Load Point

This line is changed to a +P level whenever the tape unit is selected (under automatic control) and the tape is in any position other than at load point. It is held at the +P level until either the select line is dropped or the load-point reflective spot is photosensed. This line must be at a +P level to permit backspacing.

+P Select Ready and Read

This line responds to the tape unit condition "set read status." The line changes from a -P to a +P level, indicating that the read-write trigger is set to the read state and that the tape unit is ready to start a read, backspace, or rewind operation. This line must always be at the +P level before any of these three operations can begin. It is held at this level (except when the unit is rewinding) until the select line is dropped, the machine goes out of ready, or the machine is changed to write status. The line is held at -P level for all other operations.

+P Select Ready and Write

This line responds to the tape unit condition "set write status." The line changes from a -P to a +P level, indicating that the read-write trigger is set in the write state and the tape unit is ready to start a write operation. The line is held at this level until the select line is dropped, the machine goes out of ready, or the machine is changed to read status. This line is held at a -P level for all other operations.

+P High Density, -P Low Density

This is a single line that remains at either the +P level or the -P level, depending upon the density mode selected for machine operation. Under automatic control, the density rates can be changed as described above under the +P set high-density and -N set low-density input lines. Under manual control, the density rates can be changed by depression of the change-density switch.

-N Select and Rewind

This is a signal to the tape control indicating that the tape unit has started to rewind. This line is changed from the +N level to the -N level as soon as the rewind relay circuitry is picked. It is held at the -N level until either the select line is dropped or the rewind operation is completed. To conserve computer time, the tape unit select line is usually dropped as soon as this response signal is received by the tape control. This line is at the +N level during all other operations.

-N Write Echo

This is a single line that is held at a +N level during all operations except when writing. A -N pulse (1/2 microsecond or more width) appears on this line every time a 1 bit is written into any one of the seven tracks; the pulse is common to all of the seven tracks. There is no echo pulse when the longitudinal check character bits are written.

Read Bus

These are seven lines, one for each track. The signals on this line are amplified outputs of the read heads. Each pulse, positive or negative, represents a 1 bit.

Select and Ready, Model V or VI

This line occurs only in 729 V and VI tape units. It is normally AND'ed with the select and ready Model II or select and ready Model IV in the tape control to provide 800-character-per-inch operation.

APPENDIX

SPECIFICATION FIGURES

Figures 11 through 16 show various tape unit operations. Each figure deals with one operation and lists all lines and conditions. Some abbreviations used are:

Bkwd	Backward
Char	Recorded character
Ckts	Circuits
Disc	Disconnect
Dly	Delay
LP	Load point
Max	Maximum
Min	Minimum
Ms	Millisecond
Rd	Read
Std	Standard
Usec	Microsecond
Wr	Write

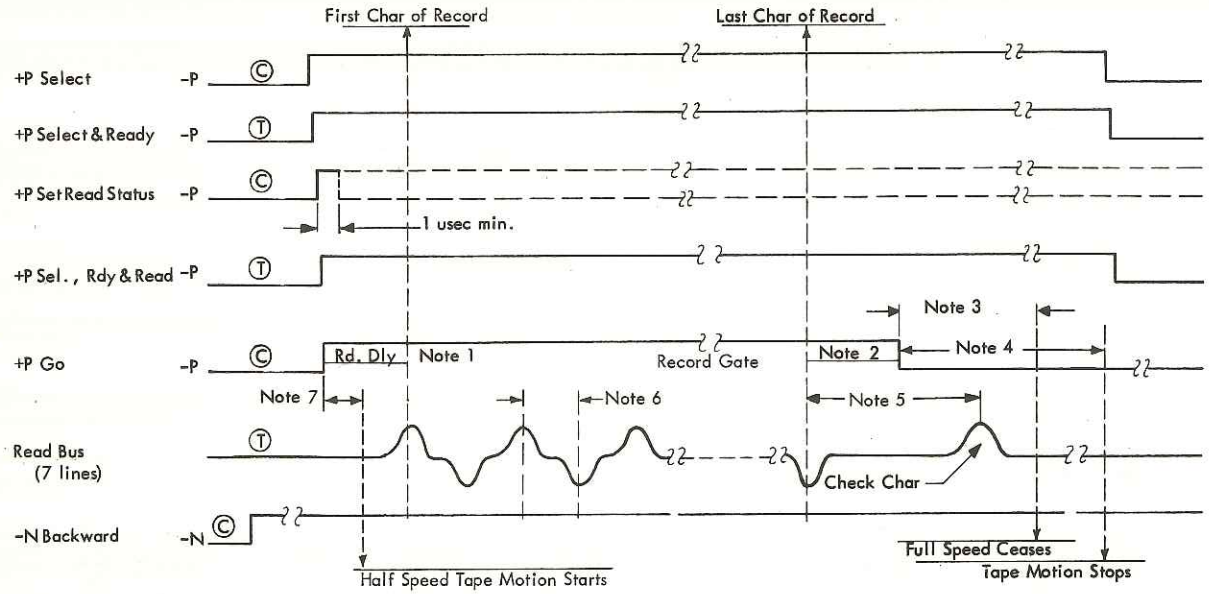
TAPE UNIT TESTER

In a customer installation, the 729 units may be tested for correct operation with a 729 tape unit tester, IBM P/N 460633, or with a 729/7330 field tester, IBM P/N 461390. These testers are used to simulate automatic control and make possible a check of all tape unit operations under either automatic or manual control. Proper connections for using the testers are shown in Figures 17 and 18. Figures 19, 20, and 21 show power and signal connections. Assignments for the power plug and tape control receptacle pins are shown in Figures 22 and 23. The 208-volt ac lines (pins 5 and 10) are provided for remote operation of the tape unit's internal contactor when connected to a tape control unit.

Figures 24, 25, and 26 show cable connections between the tape control and tape units.

IBM TRANSISTOR CIRCUITS

Figures 27 through 34 show various transistor circuits used in both the magnetic tape and tape control units. The circuits are dc-coupled.



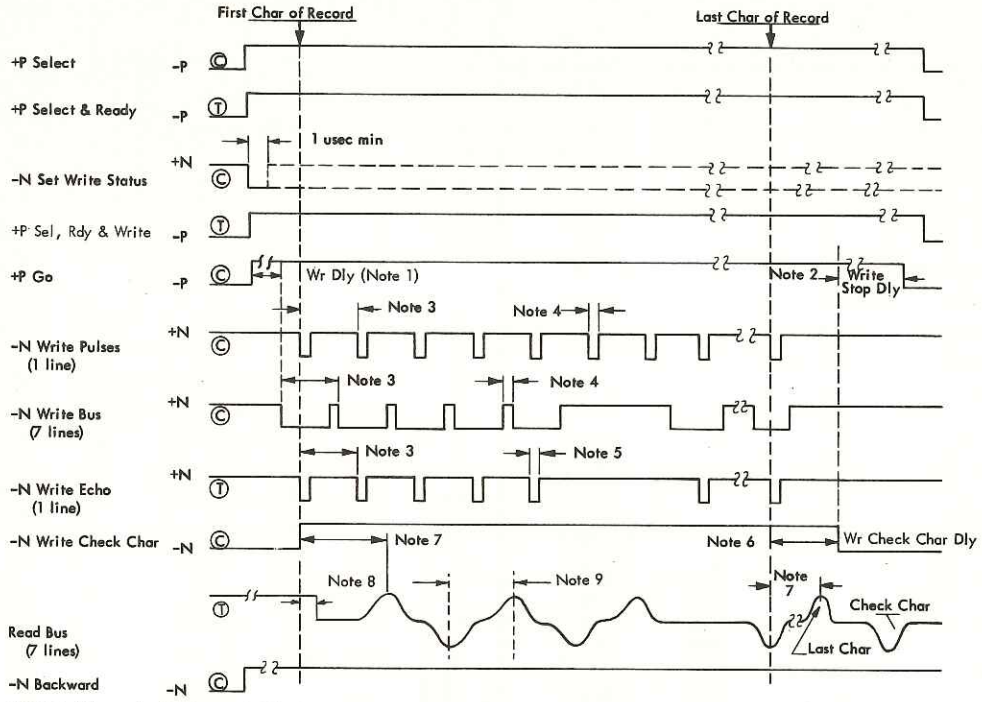
	729 II and V	729 IV and VI
1. Read Delay, ±2%	4.5 ms	3.0 ms
Read Load Point Delay, ±1%	24.0 ms	16.0 ms
2. Record Gate, ± 1%		
800 CPI	37.0 usec	25.0 usec
556 CPI	54.0 usec	36.0 usec
200 CPI	150.0 usec	100.0 usec
3. Full speed coast ± 5% of nominal speed) after fall of Go.	1.2 ms min	0.9 ms min
4. Time from fall of Go to tape motion stop	See items 1 and 4 under "Specifications, Tape Motion Start and Stop Times."	
5. Check Character, ±11%		
800 CPI	69.5 usec	46.0 usec
556 CPI	97.5 usec	65.0 usec
200 CPI	271.0 usec	181.0 usec

6. Time between first bit of any character and the preceding character gate must not be less than 1 usec under any allowable condition of skew, tape speed, and bit configuration.
   Character Gate, ±5%

800 CPI	7.9 usec	5.4 usec
556 CPI	10.5 usec	7.5 usec
200 CPI	29.2 usec	21.0 usec

7. Time from rise of Go to start of tape motion: See Items 2 and 3 under "Specifications, Tape Motion Start and Stop Times."
8. Notes 3, 4, & 7 apply for all tape unit functions, for both forward and backward tape motions.
9. Lines marked © are from Tape Control to Tape Unit. Lines marked Ⓣ are from Tape Unit to Tape Control.
10. Timings and tolerances are those when the Tape Unit is connected to an IBM Tape Control.

Figure 11. Read Operation



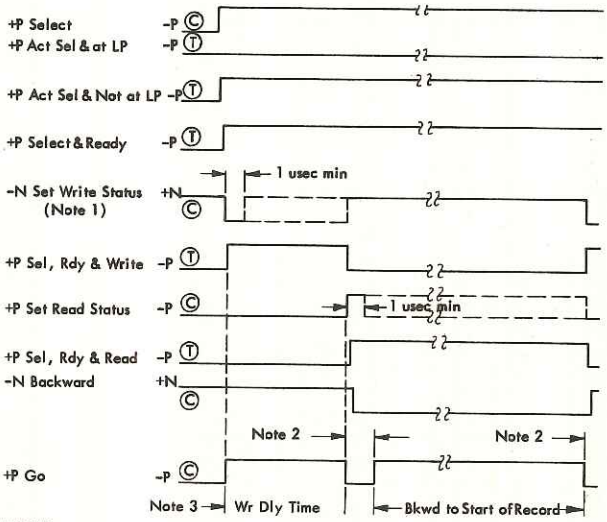
NOTES: When at load point, total delay is Wr LP Dly. For tape motion start and stop times see Note 8 of Figure 11.

	729 II and V	729 IV and VI
1. Write Delay, ± 1%	7.5 ms	5.0 ms
Write Load Point Delay, ± 1%	48.0 ms	32.0 ms
2. Write Stop Delay, ± 3%	3.0 ms	2.0 ms
3. Rep Rate, ± 1%		
800 CPI	16.6 usec	11.1 usec
556 CPI	24.0 usec	16.0 usec
200 CPI	66.7 usec	44.5 usec
4. Write Pulse Width, ± 1%		
800 CPI	1.0 usec	1.0 usec
556 CPI	1.5 usec	1.0 usec
200 CPI	4.16 usec	2.78 usec

	729 II and V	729 IV and VI
5. Wr Echo Pulse Width, ± 1%		
Constant for both character rates	1.0 usec	1.0 usec
6. Write Check Character Delay, ± 1%		
800 CPI	63 usec	42.3 usec
556 CPI	90.6 usec	60.6 usec
200 CPI	250 usec	166 usec
7. Read Delay While Writing, ± 1% (Distance from write to read gap)	4.0 ms	2.67 ms
8. Read Condition, ± 1%	7.5 ms	5.0 ms

9. Time Between Characters: refer to Note 9, Figure 10
10. Lines marked Ⓒ are from Control to Tape Unit, Lines marked Ⓣ are from Tape Unit to Control.
11. Timings and tolerances are those when the Tape Unit is connected to an IBM Tape Control.

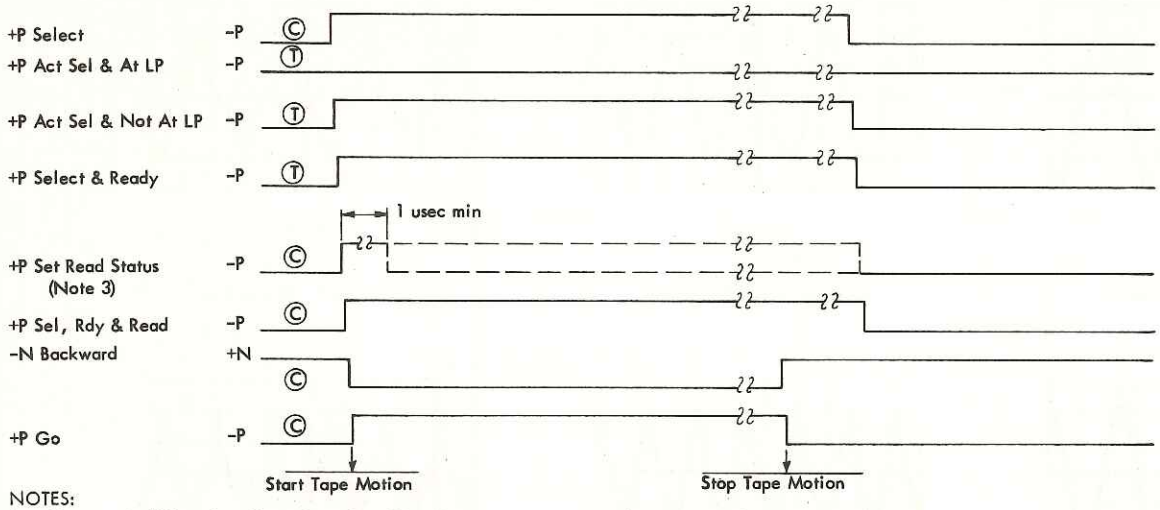
Figure 12. Write Operation



NOTES:

1. When originally in write status and a backspace instruction is received, the tape unit must be spaced forward while in write status for a time interval greater than a normal inter-record gap. Thus, when Write Status is dropped and Read Status is picked, the resulting noise bits are written into tape in an area that will be rewritten by the next new record.
2. Minimum Go down time: 16.5 ms for II and V; 11 ms for 729 IV and VI.
3. For write delay times, see Note 1 of Figure 12. No 1 bits are written during this period.
4. Lines marked Ⓒ are from Tape Control to Tape Unit. Lines marked Ⓣ are from Tape Unit to Tape Control.
5. Timings and tolerances are those when the Tape Unit is connected to an IBM Tape Control.

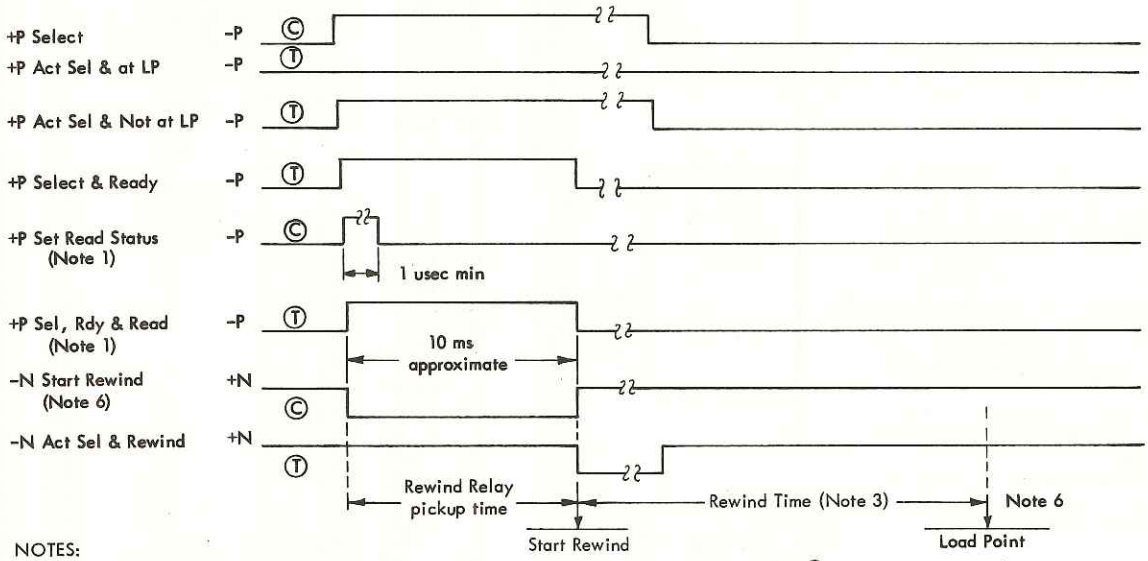
Figure 13. Backspace Operation (When Originally in Write Status)



NOTES:

1. Lines marked Ⓒ are from Tape Control to Tape Unit. Lines marked Ⓣ are from Tape Unit to Tape Control.
2. For tape motion start & stop times see Note 8 of Figure 11.
3. Tape Control must always place Tape Unit into read status to avoid record erasure, because the Tape Unit does not automatically prevent writing when moving tape backward.
4. Timings and tolerances are those when the Tape Unit is connected to an IBM Tape Control.

Figure 14. Backspace Operation (When Originally in Read Status)

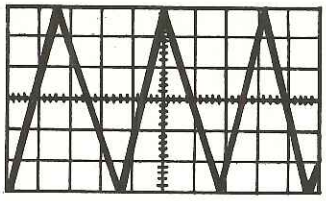


NOTES:

1. Set Read Status line is not essential for the rewind operation, inasmuch as the logic circuits in the Tape Unit automatically prevent writing when rewinding. If tape unit is in write status when rewind instruction is originated through the control unit, the tape unit is spaced forward as in back-space after write sequence.
2. Start Rewind line from the Tape Control is usually held up by the Tape Control until the rewind status 1 relay (R 104) in the Tape Unit is picked and noted by its response line to the Tape Control. Once the Tape Unit begins rewinding, it can be dis-connected from automatic control by dropping the Select line.
3. Rewind time depends upon the amount of tape on the reels. When tape is in its high-speed-rewind area, the Tape Unit goes through Unload, High-Speed Rewind, Stop, Load, Low-Speed Rewind to Load Point and Stop. When tape is in the low-speed rewind area, the unit rewinds at low speed to load point, and stops.
4. Lines marked Ⓒ are from Tape Control to Tape Unit. Lines marked Ⓣ are from Tape Unit to Tape Control.
5. For tape motion start and stop times, see Note 8 of Figure 11.
6. Rewind operation can also be started by a +P Rewind & Unload line from the Tape Control. In such cases, the only apparent difference would be that the Tape Unit, instead of stopping when load point was reached, would continue on, unload the machine, and then stop.
7. Timings and tolerances are those when the Tape Unit is connected to an IBM Tape Control.

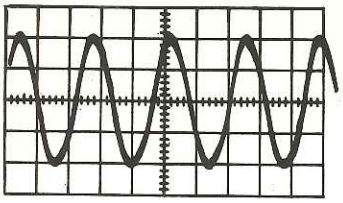
Figure 15. Rewind Operation

729 II and V



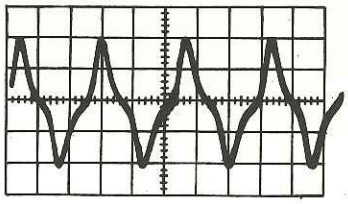
800 CPI

Vert. Defl: 2.5v/cm
Horiz. Defl: 10 usec/cm



556 CPI

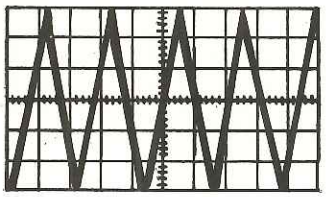
Vert. Defl: 2v/cm
Horiz. Defl: 20 usec/cm



200 CPI

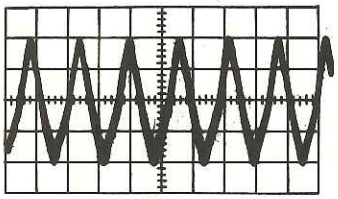
Vert. Defl: 2v/cm
Horiz. Defl: 50 usec/cm

729 IV and VI



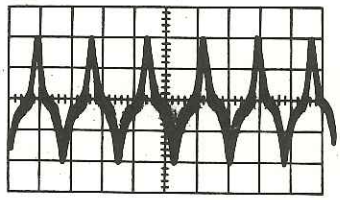
800 CPI

Vert. Defl. 2.5v/cm
Horiz. Defl: 10 usec/cm



556 CPI

Vert. Defl: 2v/cm
Horiz. Defl: 20 usec/cm



200 CPI

Vert. Defl: 2v/cm
Horiz. Defl: 50 usec/cm

Figure 16. Oscilloscope Patterns (Read Bus Outputs)

NOTES:

1. T/C Signal Connector cable (460673) is used only to connect the Tape Unit Tester to the Tape Unit. It differs from the one used in the systems installation (Figures 25 and 26) in that 460673 must carry the +6v, -6v, & -12v to the Tester as supply voltages. The cable is available in 8 foot lengths only.
2. CE Control Box (460605) can be used in place of the Tester when motion control only is required.
3. Terminating Shoe (529285) must be connected to Tape Unit for operation with the Tester.
4. Test Box (570043) must be connected to Tape Unit for checking tape switching feature.

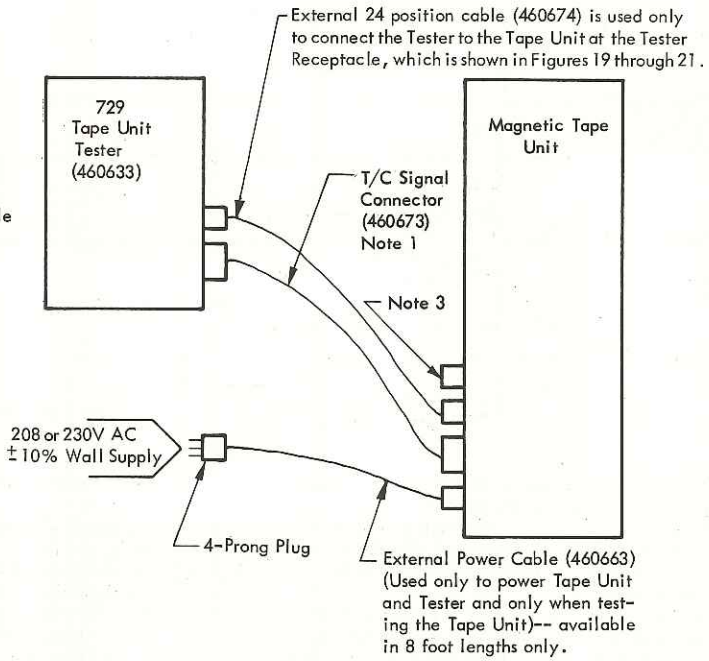


Figure 17. Tape Tester and Tape Unit Connections

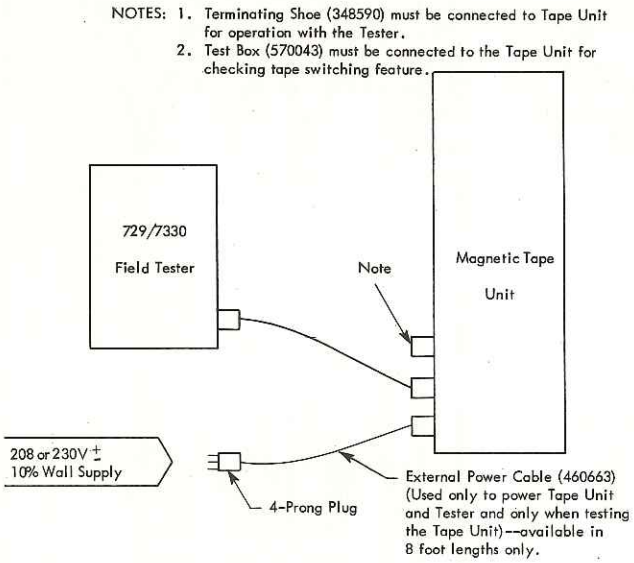
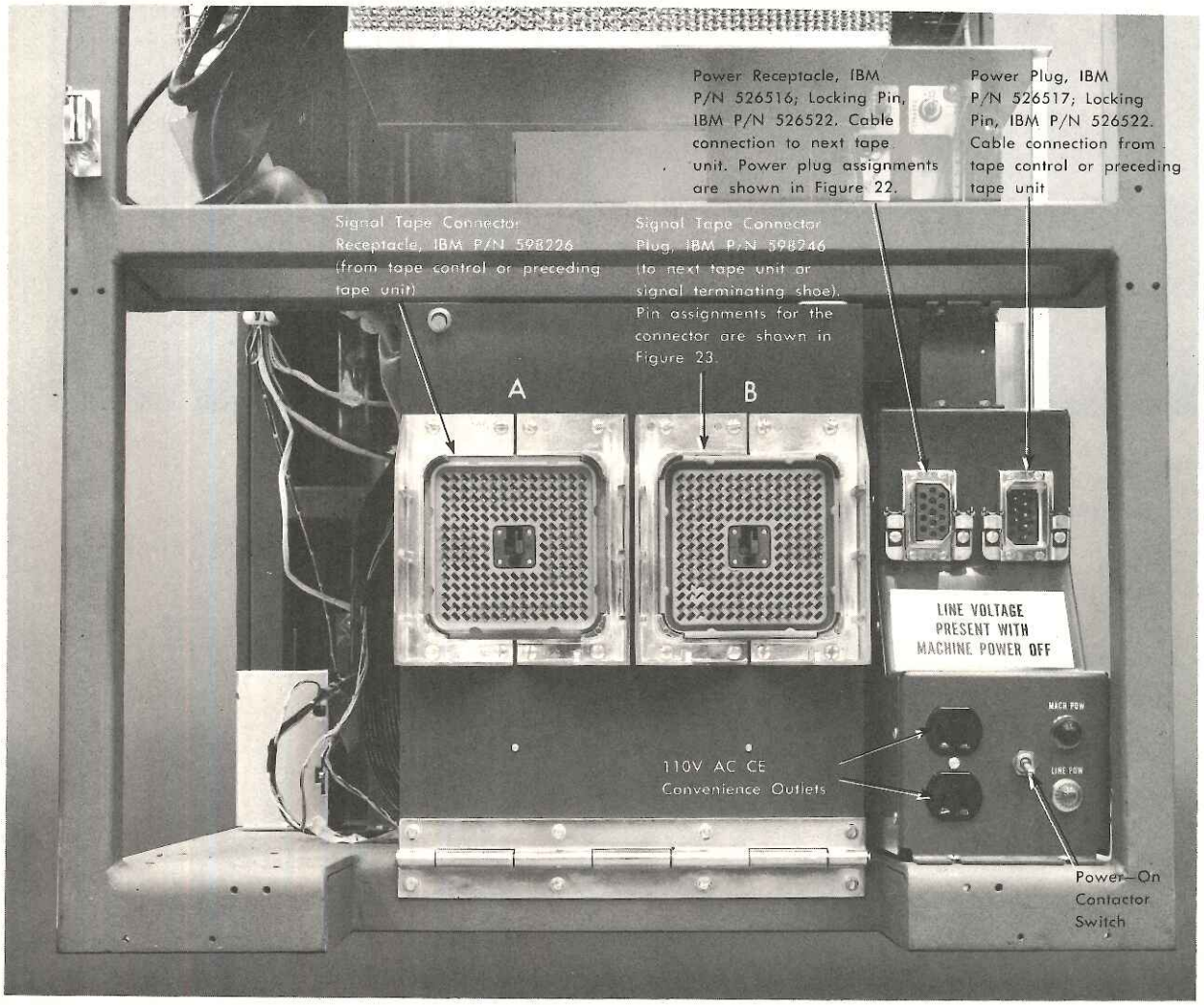
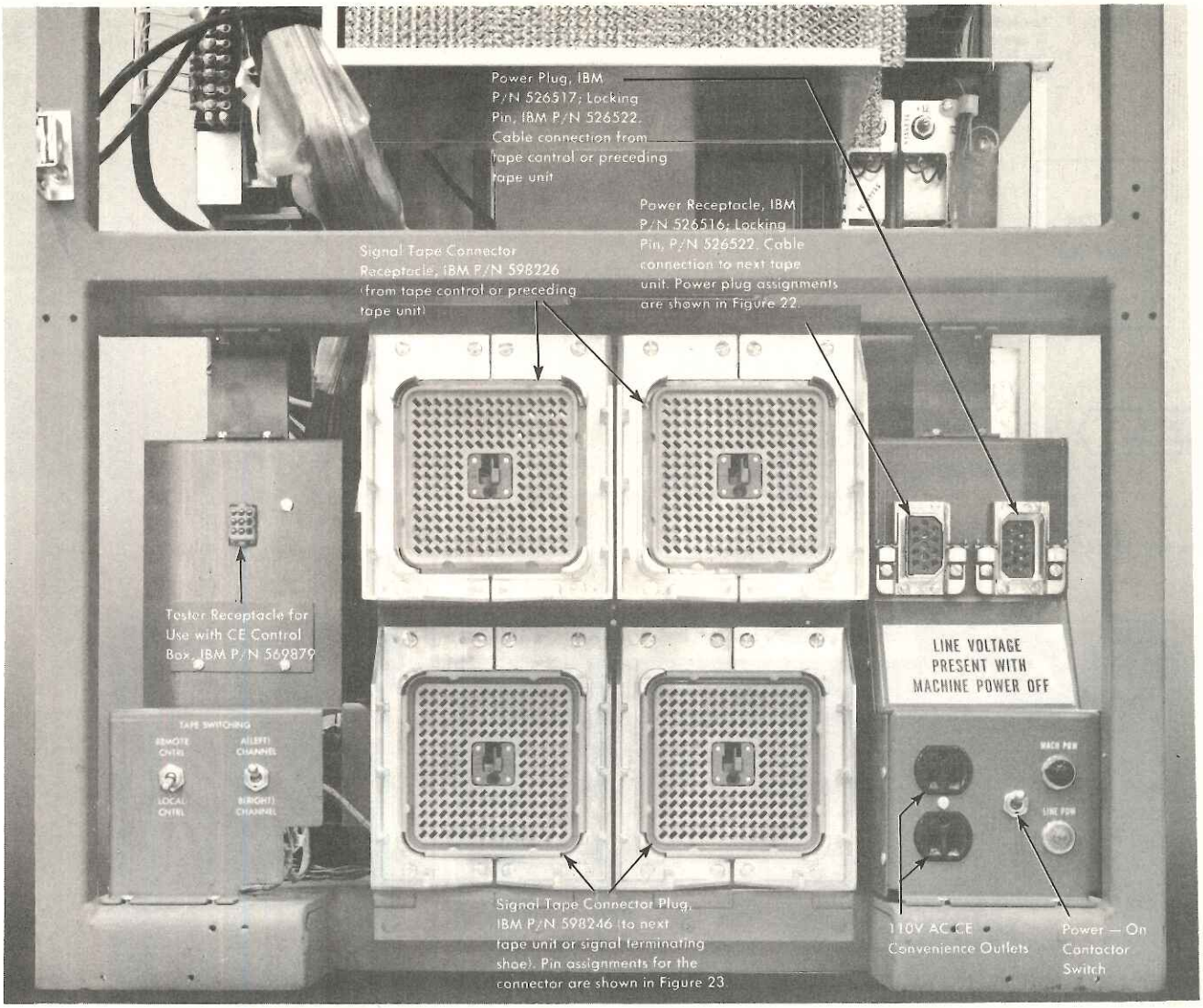


Figure 18. Field Tester and Tape Unit Connections



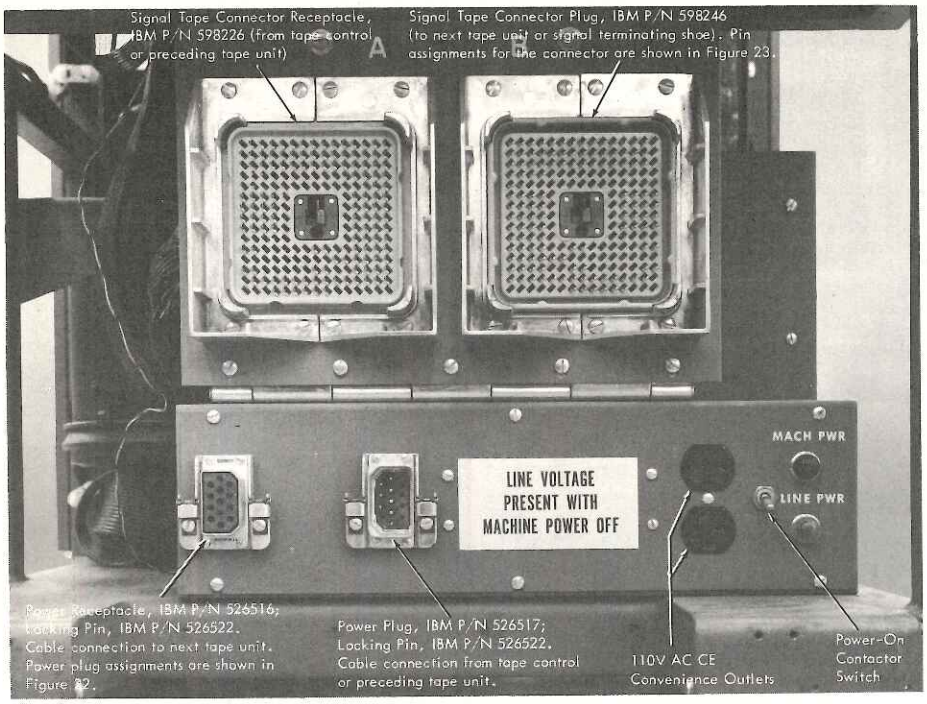
A. Without Switching

Figure 19. Power and Signal Connections (NORLAY) - Part A

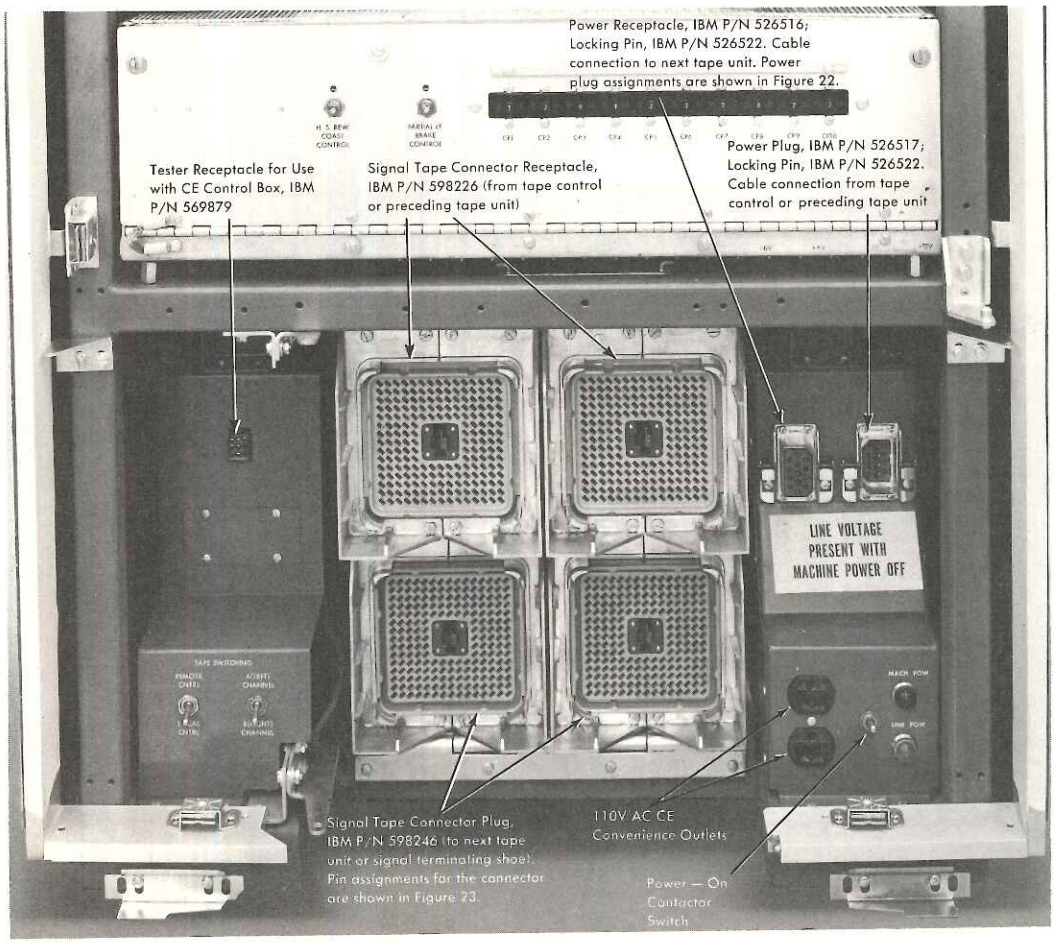


B. With Switching

Figure 19. Power and Signal Connections (NORLAY) - Part B

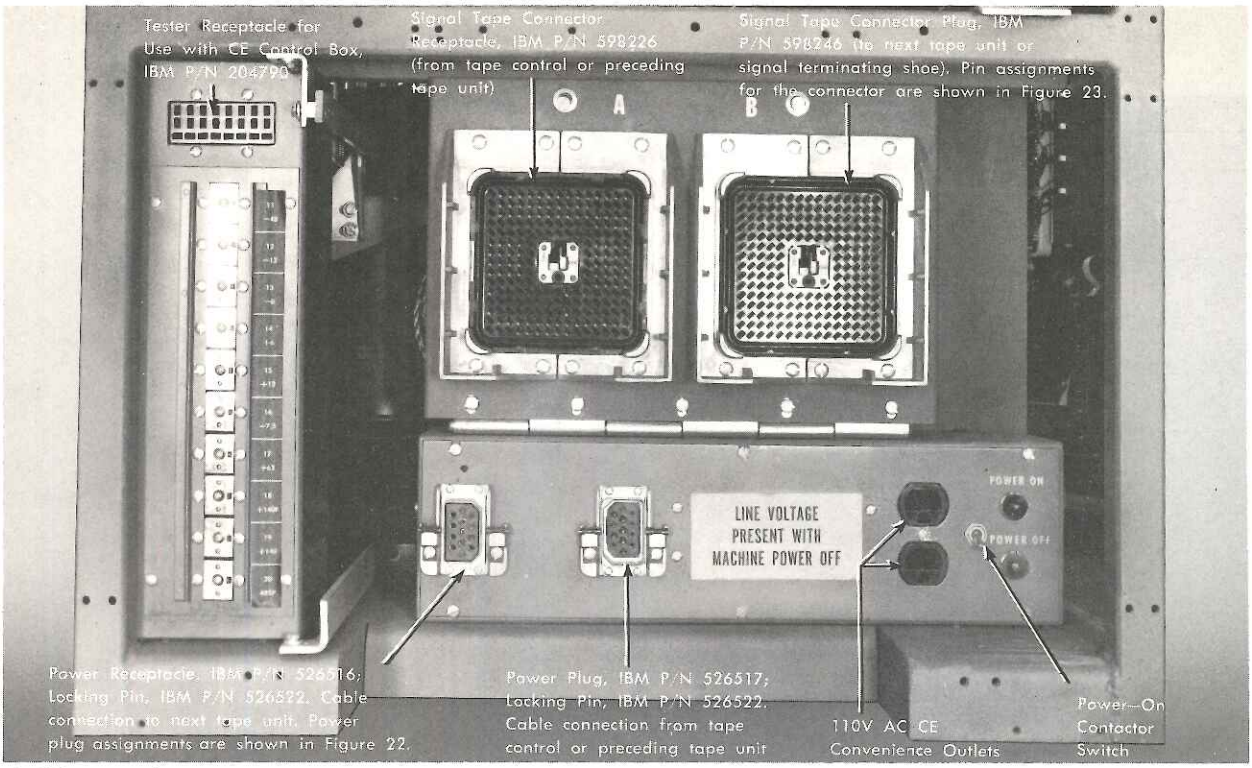


A. Without Switching

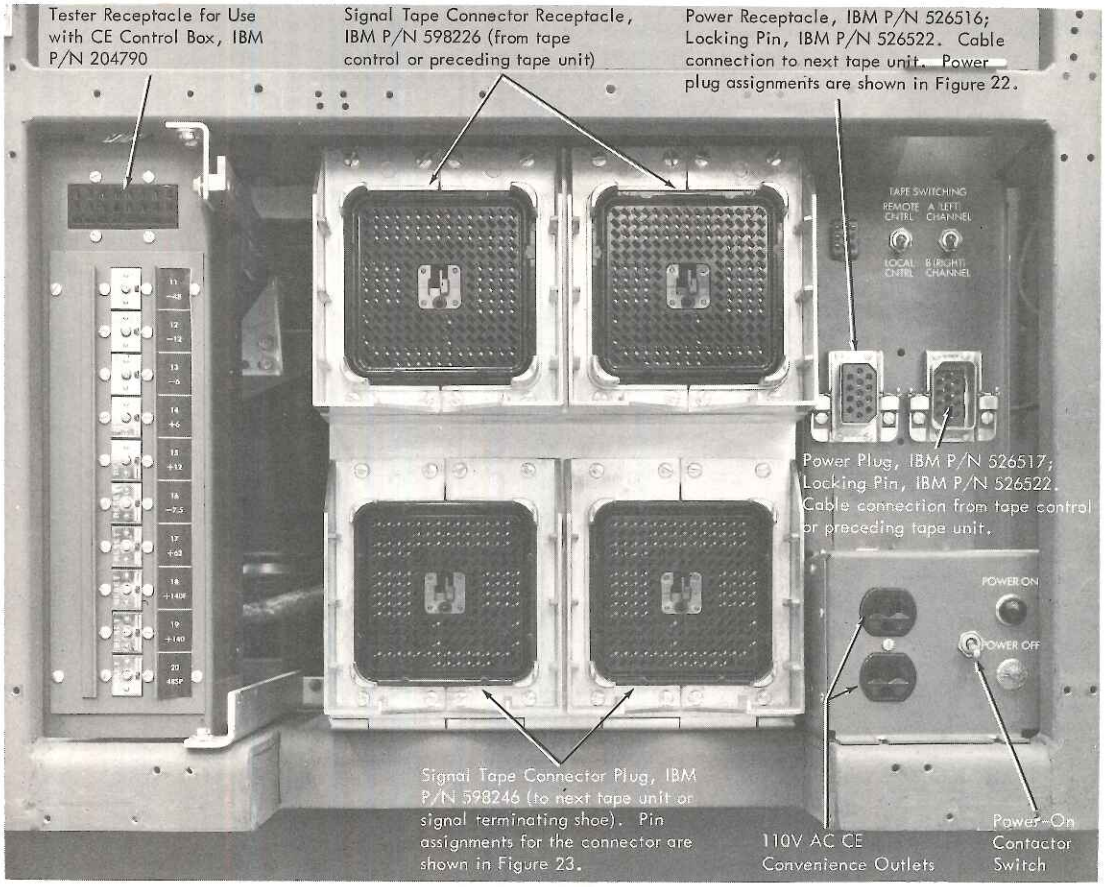


B. With Switching

Figure 20. Power and Signal Connections (NOR)



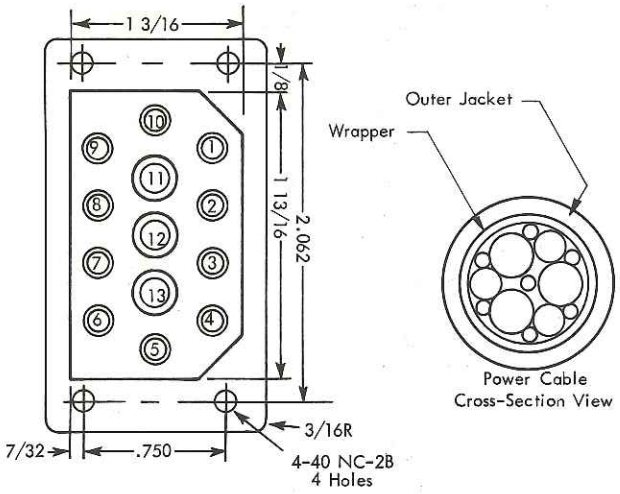
A. Without Switching



B. With Switching

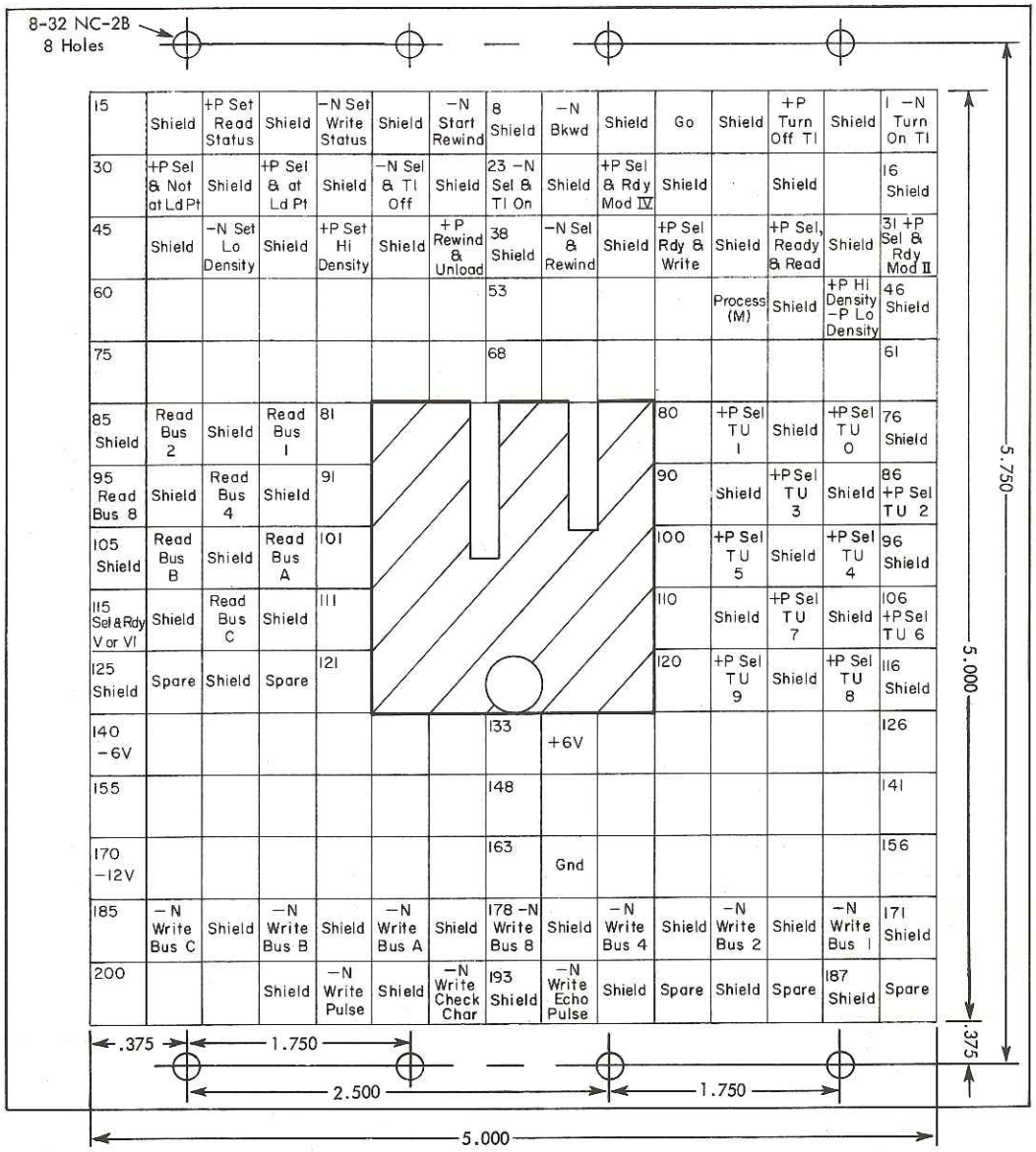
Figure 21. Power and Signal Connections (Relay)

POWER PLUG PIN ASSIGNMENTS			
TAPE UNIT		POWER CABLE	
Pin No	Voltage or Control	Wire Size	Type
1	AC outlet - 115 volts	14	AC
2	AC outlet - 115 volts	14	AC
3	Bond	14	
4	Spare	18	
5	Model II & IV reset - 208 volts	18	AC
6	Spare	18	
7	Spare	18	
8	Spare	18	
9	Spare	18	
10	Model II & IV reset - 208 volts	18	AC
11	Unreg AC Ø1	10	AC
12	Unreg AC Ø2	10	AC
13	Unreg AC Ø3	10	AC



Pin Layout, Power Plug - Male
Wiring Side

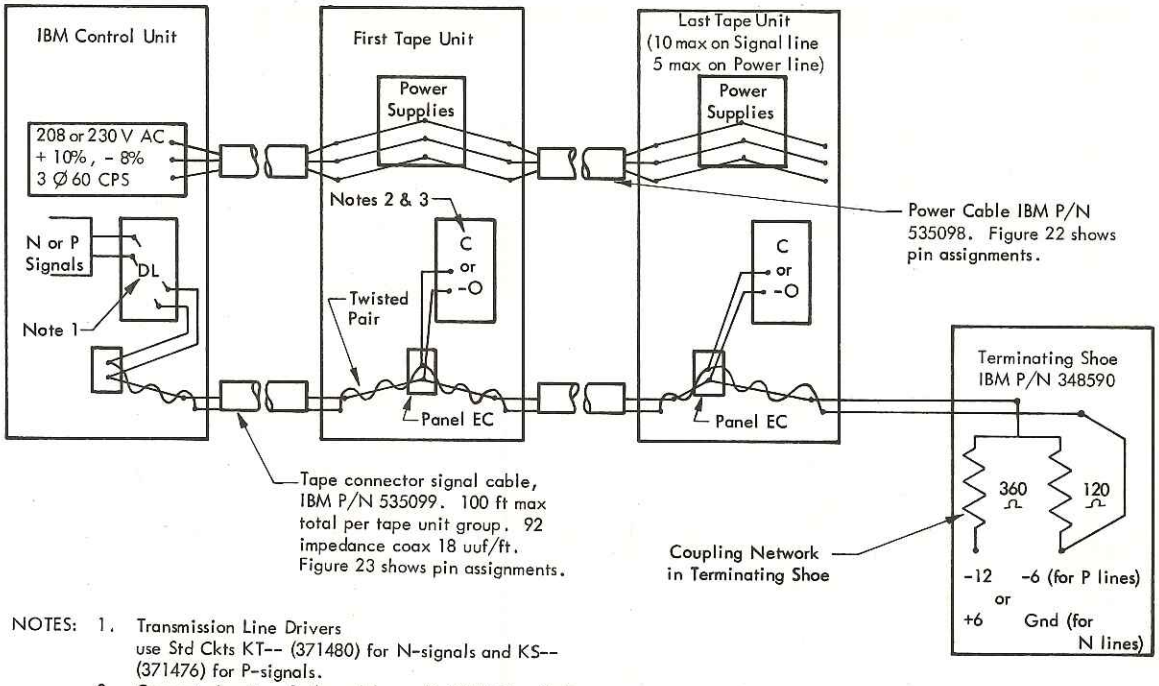
Figure 22. Power Plug Assignments



15	Shield	+P Set Read Status	Shield	−N Set Write Status	Shield	−N Start Rewind	8 Shield	−N Bkwd	Shield	Go	Shield	+P Turn Off TI	Shield	I −N Turn On TI
30	+P Sel & Not at Ld Pt	Shield	+P Sel & at Ld Pt	Shield	−N Sel & TI Off	Shield	23 −N Sel & TI On	Shield	+P Sel & Rdy Mod IV	Shield		Shield		16 Shield
45	Shield	−N Set Lo Density	Shield	+P Set Hi Density	Shield	+P Rewind & Unload	38 Shield	−N Sel & Rewind	Shield	+P Sel Rdy & Write	Shield	+P Sel, Ready & Read	Shield	31 +P Sel & Rdy Mod II
60							53				Process (M)	Shield	+P Hi Density −P Lo Density	46 Shield
75							68							61
85 Shield	Read Bus 2	Shield	Read Bus 1	81						80	+P Sel TU 1	Shield	+P Sel TU 0	76 Shield
95 Read Bus 8	Shield	Read Bus 4	Shield	91						90	Shield	+P Sel TU 3	Shield	86 +P Sel TU 2
105 Shield	Read Bus B	Shield	Read Bus A	101						100	+P Sel TU 5	Shield	+P Sel TU 4	96 Shield
115 Sel & Rdy V or VI	Shield	Read Bus C	Shield	111						110	Shield	+P Sel TU 7	Shield	106 +P Sel TU 6
125 Shield	Spare	Shield	Spare	121						120	+P Sel TU 9	Shield	+P Sel TU 8	116 Shield
140 −6V							133	+6V						126
155							148							141
170 −12V							163	Gnd						156
185	−N Write Bus C	Shield	−N Write Bus B	Shield	−N Write Bus A	Shield	178 −N Write Bus 8	Shield	−N Write Bus 4	Shield	−N Write Bus 2	Shield	−N Write Bus 1	171 Shield
200			Shield	−N Write Pulse	Shield	−N Write Check Char	193 Shield	−N Write Echo Pulse	Shield	Spare	Shield	Spare	187 Shield	Spare

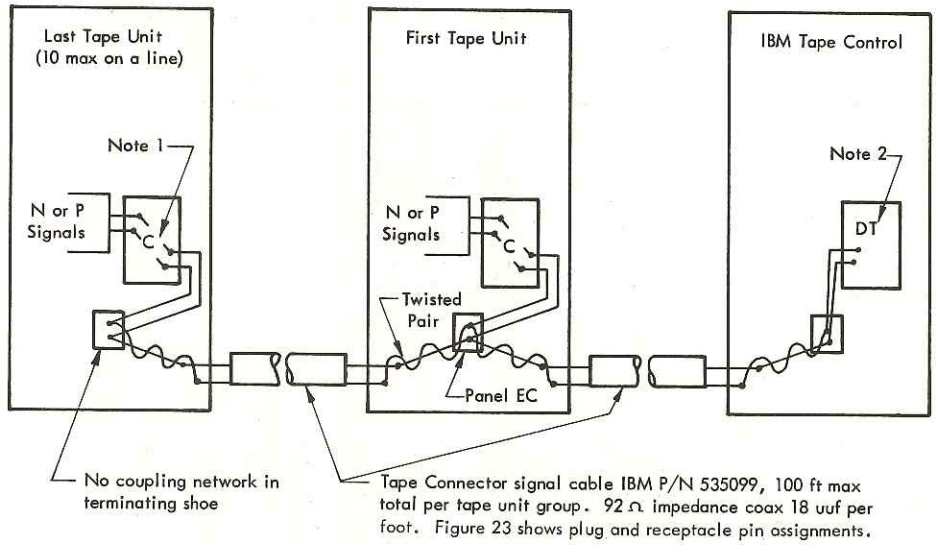
NOTE: Although pins 132, 140, & 170 are designated for +6v, -6v, & -12v, no lines are provided in the coax cable (535099) to carry these voltages from Tape Unit to Tape Unit.

Figure 23. Tape Control Connector Receptacle Pin Assignments (Wiring Side)



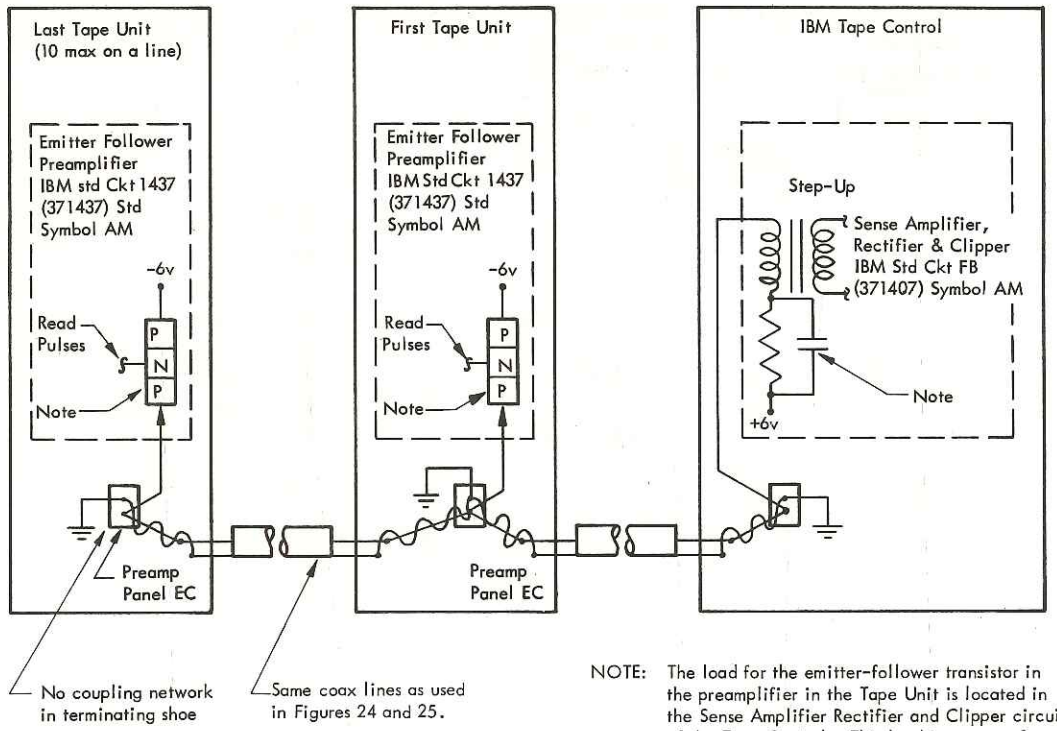
NOTES:
1. Transmission Line Drivers use Std Ckts KT-- (371480) for N-signals and KS-- (371476) for P-signals.
2. Convert circuits. Both models use Std IBM Ckts ANZZ (371209) for P lines and AMZZ (371200) for N lines (or equivalent).
3. All input lines except Wr Check Char terminate in a Convert circuit. Wr Check Char works directly into a -OR Ckt, IBM Std Ckt AAZU (371206).

Figure 24. Signals and Power from Control to Tape Unit



NOTES:
1. Convert Circuit. Both models use Std IBM Ckts ANZX (371211) for P lines and AMZX (371202) for N lines (or equivalent).
2. Line Driver Terminator Circuit uses Std Ckt AI-- (371243) for P lines and AF-- (371242 for N lines.

Figure 25. Signals from Tape Unit to Control



NOTE: The load for the emitter-follower transistor in the preamplifier in the Tape Unit is located in the Sense Amplifier Rectifier and Clipper circuit of the Tape Control. This load is common for all Tape Units connected to the Tape Control on that line. There are seven lines, one for each track.

Figure 26. Read Signals from Tape Unit to Control

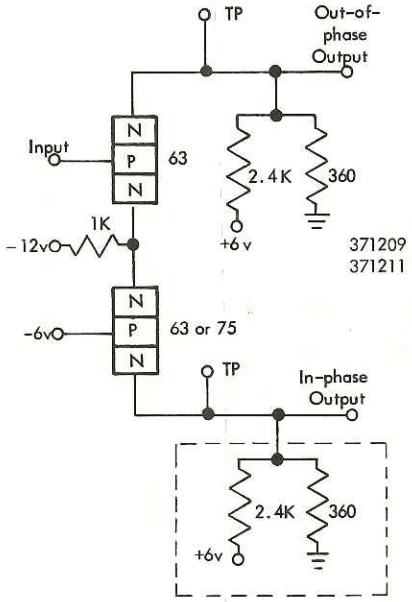
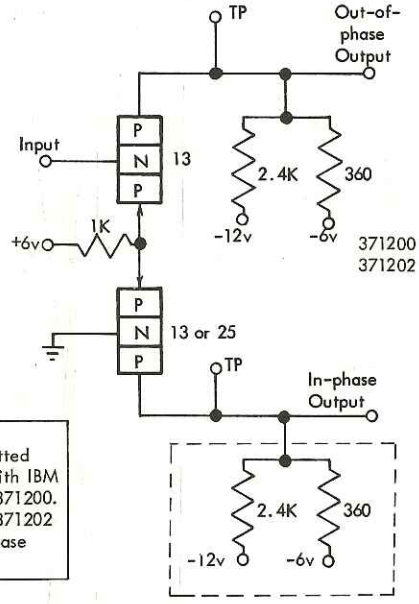


Figure 27. P Converter Block



NOTE:
In-phase load (dotted area) used only with IBM P/N 371209 and 371200. P/N 371211 and 371202 do not have in-phase load.

Figure 28. N Converter Block

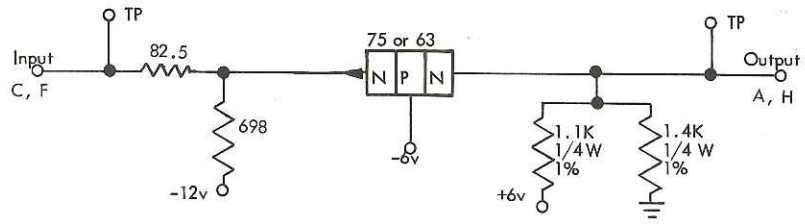


Figure 29. P Line Terminator, IBM Part No. 371243

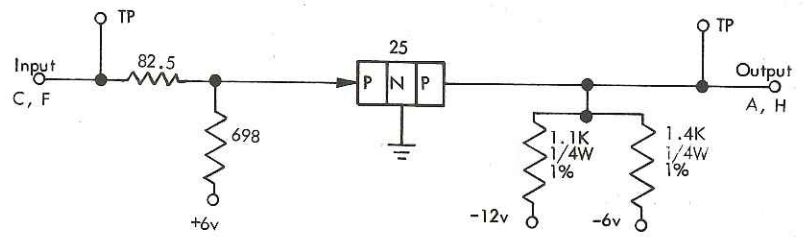


Figure 30. N Line Terminator, IBM Part No. 371242

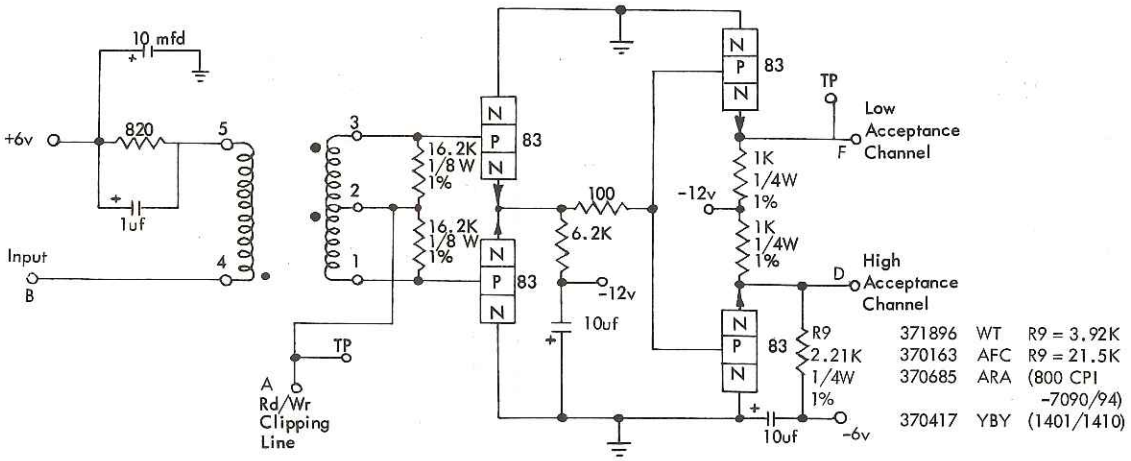


Figure 31. Alloy Sense Amplifier Rectifier and Clipper, IBM Part No. 371407FB

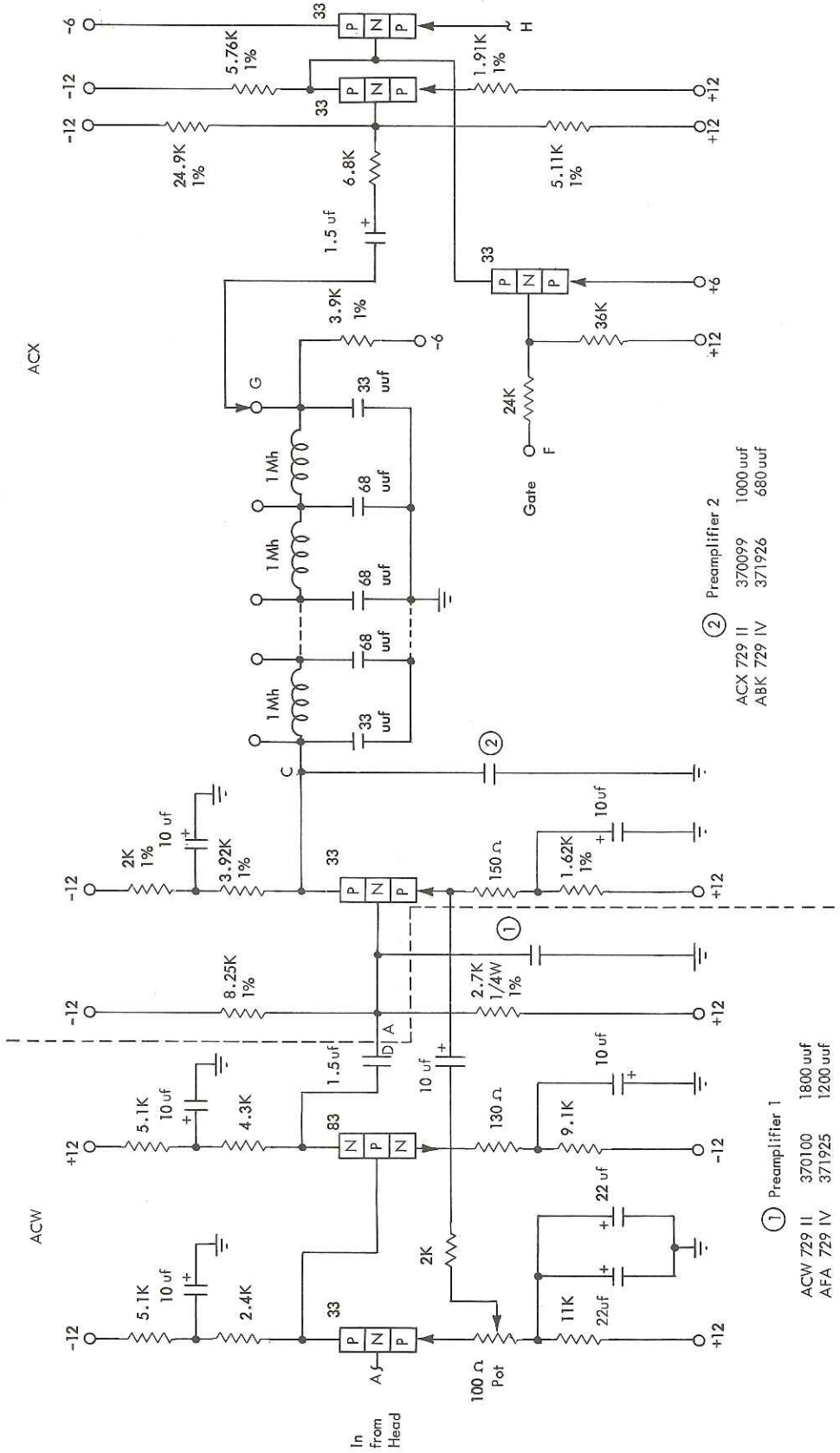


Figure 32. Preamplifier for IBM 729 II and IV

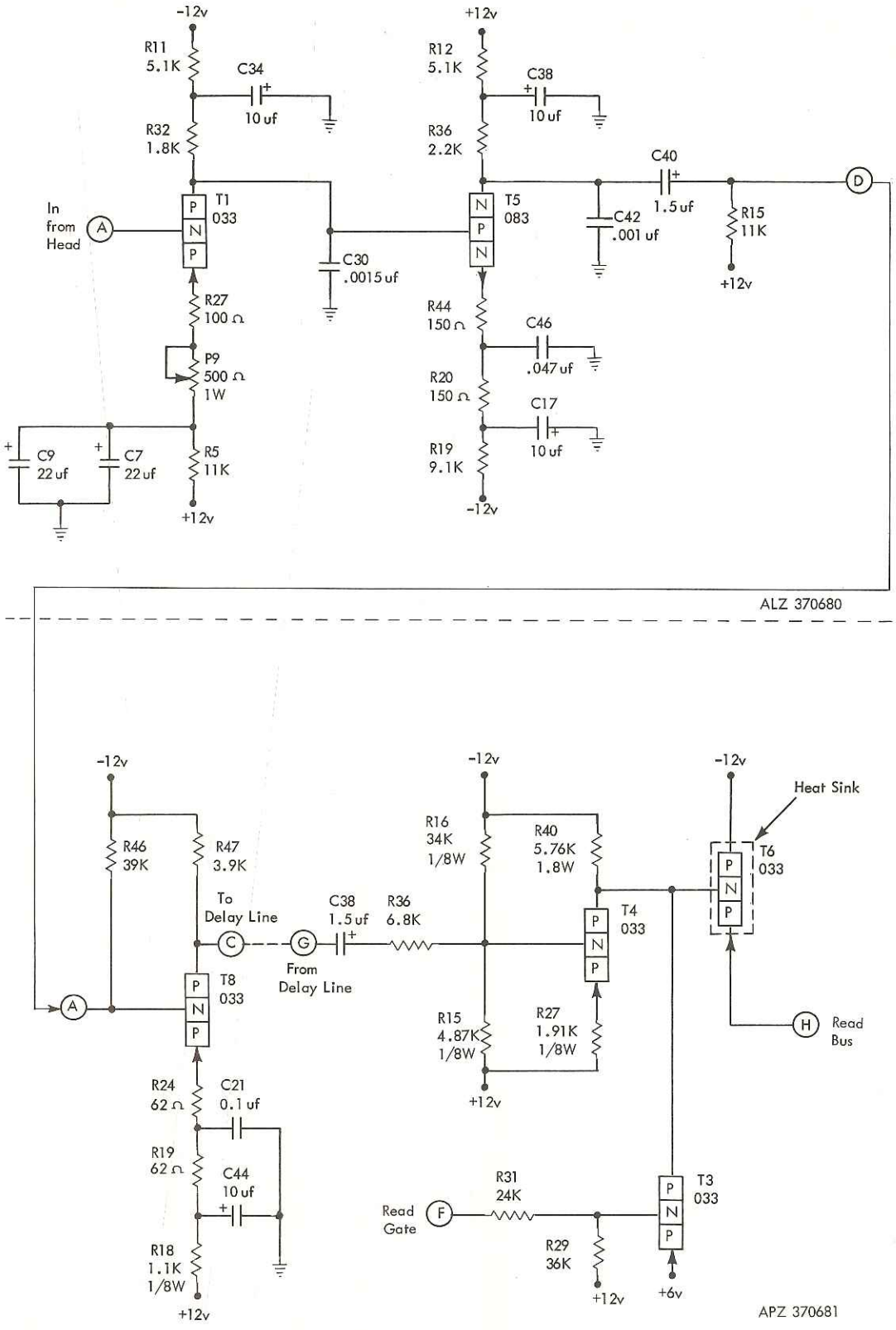


Figure 33. Preamplifiers for 729 V

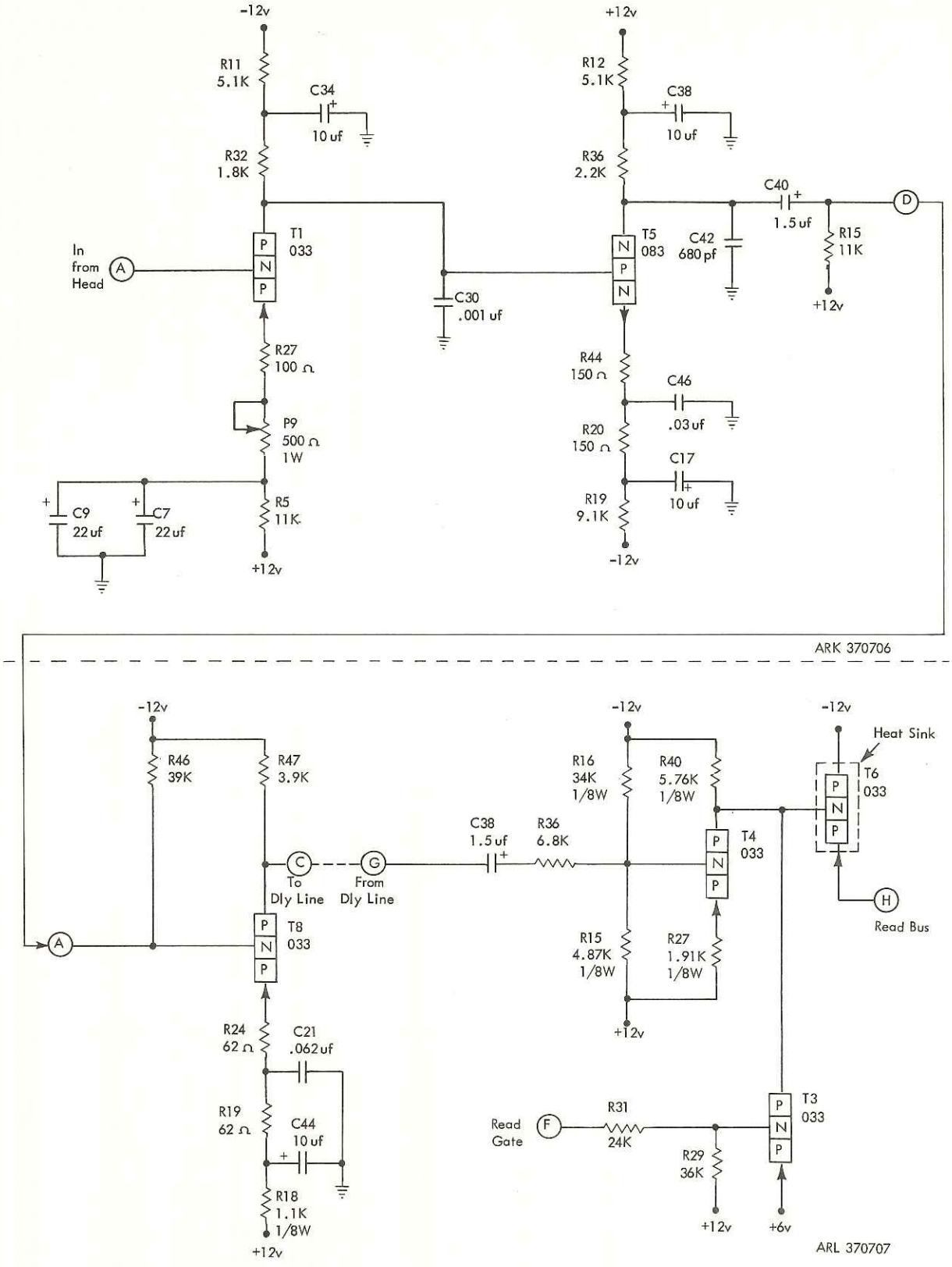


Figure 34. Preamplifiers for 729 VI

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