MAINTENANCE MANUAL

Tape Transport Subsystem

Part No. 949613-9701 *A
February 1980

TEXAS INSTRUMENTS

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PAGE NO.	CHANGE NO.	PAGE NO.	CHANGE NO.	PAGE NO.	CHANGE NO.
Cover	0				
Effective Pages	0				
iii - x	0				
1-1 - 1-14	0				
2-1 - 2-42	0				
3-1 - 3-8	0				
4-1 - 4-44	0				
5-1 - 5-54	0				
A-1 - A-4	0				
B-1 - B-14	0				
C-1 - C-12	0				
D-1 - D-6	0				
E-1 - E-10	0				
F-1 - F-2	0				
User's Response	0				
Business Reply	0				
Sales and Service	0				
Cover	0				

PREFACE

This manual provides detailed information and instructions for installing, operating, and maintaining the Texas Instruments Model 979A Tape Transport Subsystem, including information on controllers operating in a 960, 980, or 990 System environment. The information is presented in the following sections and appendices:

Section

1 General Description — This section contains a physical and functional description of the subsystem and the various system configurations.

2 Installation — This section contains installation and checkout procedures for the 979A Tape Transport and related controllers.

3 Operation — This section describes controls and indicators, tape loading and unloading procedures, and general operating procedures for the 979A Tape Transport.

4 Theory of Operation — This section contains theory of operation of the 979A Tape Transport and functional descriptions of the interface/controllers.

5 Maintenance — Preventive and corrective maintenance procedures, troubleshooting, removal and replacement procedures as well as operational checkout and adjustments for the 979A Tape Transport are included in this section.

Appendix

A Signal Mnemonics

B Software Documentation for Motion Control Logic Assembly Number 937027

C Logic Element Diagrams

D 979A Field Tester Controls and Indicators

E SDP, PDT979, Magnetic Tape Transport, 800/1600 BPI-PDT960/980

F Glossary of Magnetic Tape Recording Terms

The *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702, should be used as a supplement to this manual.

Additional information related to the use of the tape transport and controllers may be found in the following documents:

Title	Part Number
Model 960/980 Computers Direct Memory Access Channel Manual	966312-9701

Title	Part Number
Model 960/980 Computers Direct Memory Access Channel Controller Manual	966312-9702
Block Transfer Controller Maintenance Manual	240802-9701
Model 990 Transport Interface Unit Maintenance Manual	240976-9701
1600 BPI Transport Command Controller Maintenance Manual	941689-9701
Model 979 Tape Transport Controller Maintenance Manual	240801-9701
Model 990 Computer Model 979A Magnetic Tape System Installation and Operation	946229-9701
Model 979A Tape Transport Installation and Operation	949612-9701
Model 979 Tape Transport Maintenance Manual	216318-9701
Model 990/10 Computer System Hardware Reference Manual	945417-9701
Model 990/10 Computer System Depot Maintenance Manual	945404-9701
Model 990 Computer Family Maintenance Drawings, Volume I — Processors	945421-9701
Model 990 Computer Family Maintenance Drawings, Volume II — Peripherals	945421-9702
Model 990 Computer Diagnostics Handbook	945400-9701
PD, TAPTST	945437-9901

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF APPENDIXES

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 979A Magnetic Tape System (figure 1-1) provides facilities for serial access mass data storage with the 960 or 980 computer systems, or with the 990 computer systems employing TILINE.* The magnetic tape systems consist of an interface/controller, up to three transports (for 990 systems), interconnect cabling, and a resistive-terminator module.

The transport, used as a digital data recorder/reproducer, is capable of operating continuously under intensive tape activity.

1.2 SYSTEM CONFIGURATIONS

A diagram of the various configurations that may include a 979A Tape Transport is shown in figure 1-2.

1.3 RECORDING FORMATS

Either of two types of recording/reproducing formats may be employed by any single transport: nonreturn-to-zero, inverted (NRZI) or phase-encoded (PE). No single unit may employ both formats, simultaneously. However, in a 990 system with more than one transport, and with an appropriate controller (PE/NRZI type), formats may be mixed.

A brief summary of the characteristic of the tape transports follows:

Characteristic	PE	NRZI
Tape type	1/2 inch certified computer grade	1/2 inch certified computer grade
Tape speed	952.5 mm (37.5 in.)/sec.	952.5 mm (37.5 in.)/sec.
Record/Playback Mode	Phase encoded (PE)	Nonreturn to zero, inverted (NRZI)
Bit density	1600 bpi (one track)	800 bpi (one track)
Tracks	9	9
Compatibility	ANSI,IBM	ANSI,IBM

Figure 1-3 is a comparison of idealized NRZI and PE waveforms for a sample bit stream. For ease of comparison, the bit density is the same for both waveforms. The drawing is divided into bit cells, where a bit cell is the time allotted to record a single data bit. The flux transition which represents the data bit falls in the middle of the bit cell.

The NRZI waveform uses a flux transition to represent a one, and the absence of a transition represents a zero. The PE waveform uses the direction of the transition to represent the data. A positive-to-negative transition represents a zero, and a negative-to-positive transition represents a one. An additional transition at the bit cell boundary is inserted between successive zeros or successive ones.

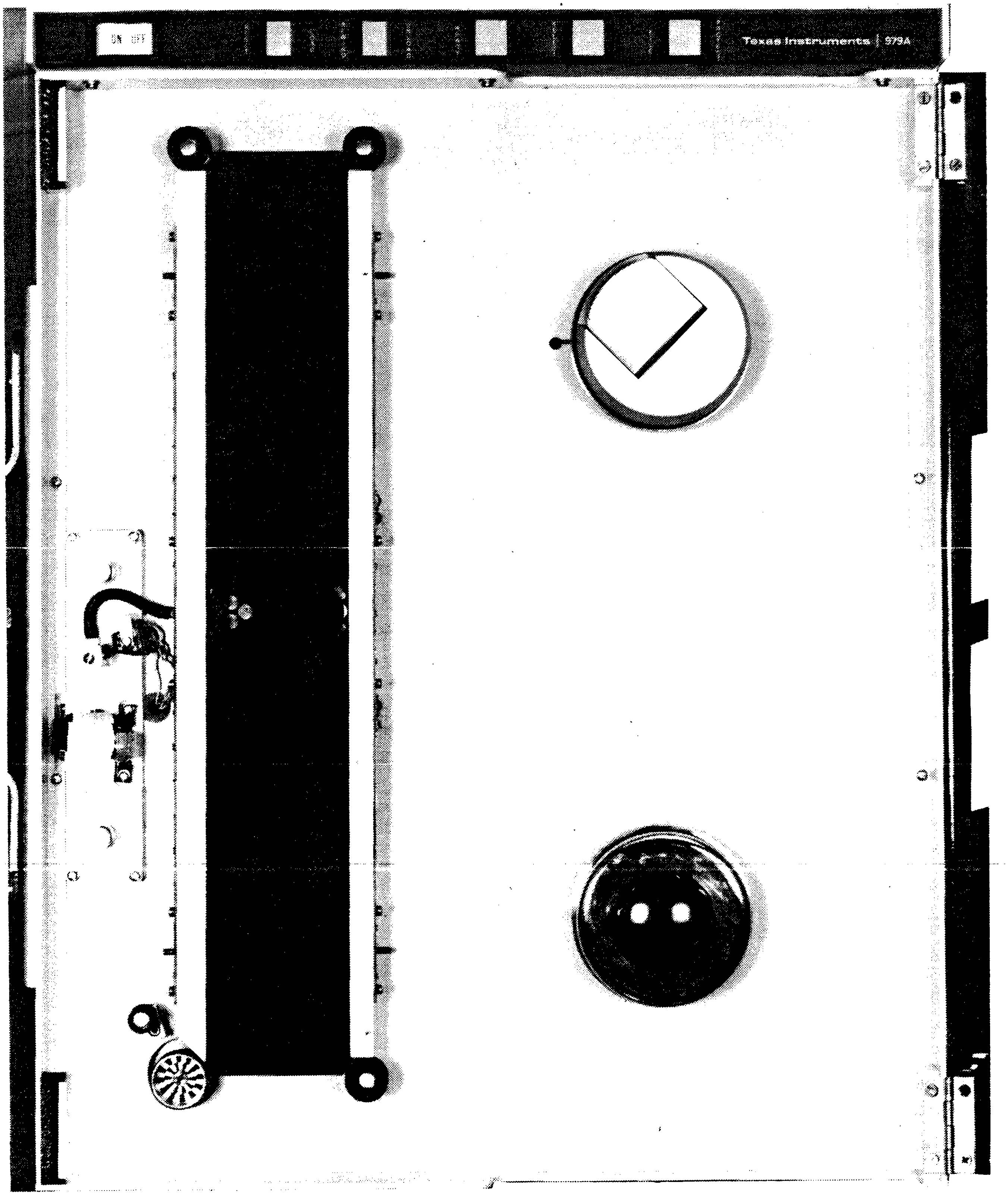

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Figure 1-1. Model 979A Tape Transport (tape guard removed)

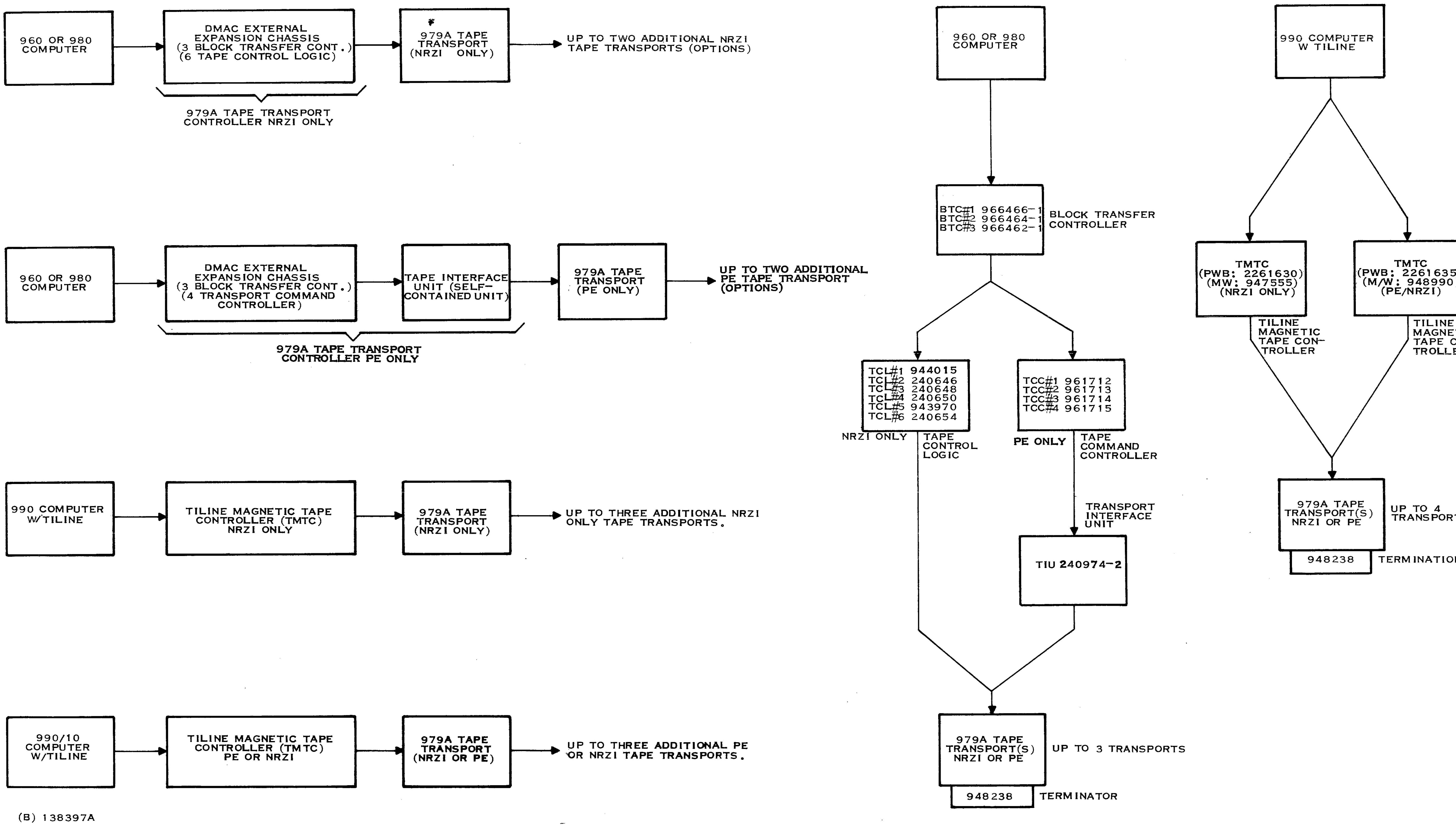

Figure 1-2. 979A Tape Transport - Computer System Configurations

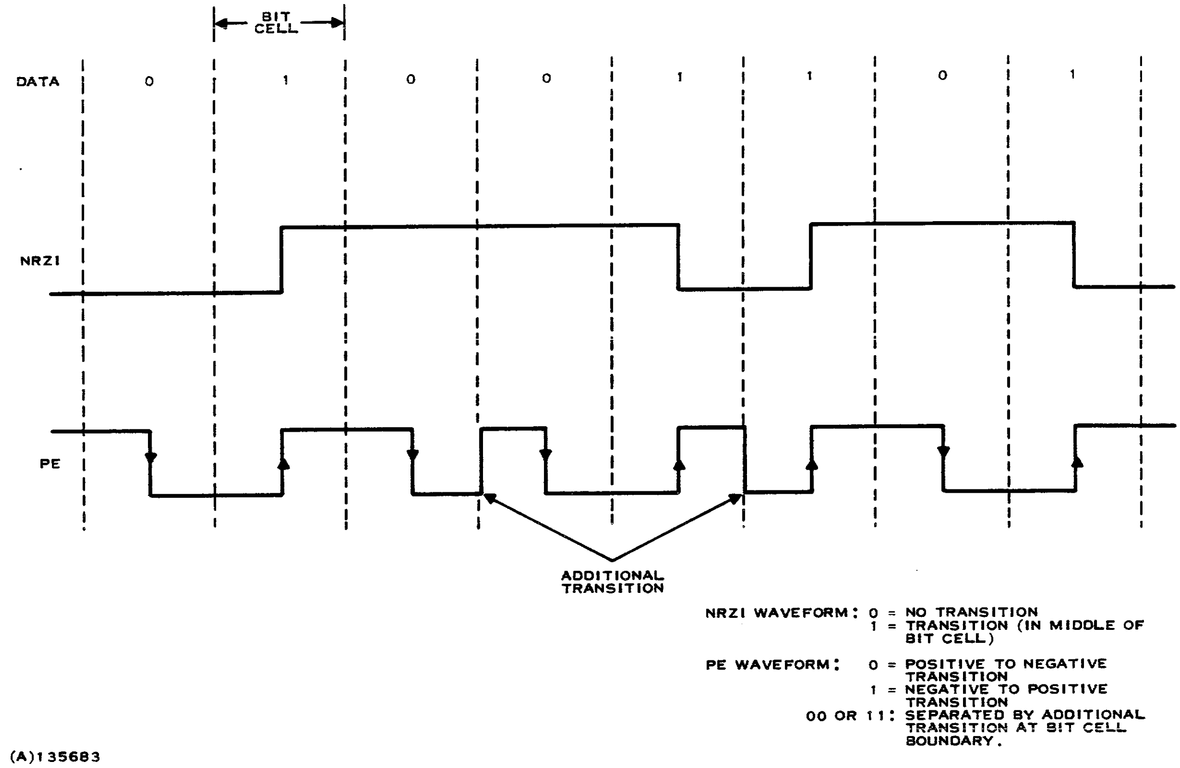

Figure 1-3. Comparison of NRZI and PE Recording Waveforms

1.3.1 HEAD LAYOUT. Figure 1-4 shows the head spacing for the 979A Transport. As the tape moves forward, it encounters the heads and photocells in the following order:

- BOT/EOT sensors
- Erase head
- Write head
- Read head

1.3.2 NRZI FORMAT. Figure 1-5 shows the format of a 9-track, 800 bpi NRZI tape. The start of the actual recording area on a tape is identified by a reflective beginning-of-tape (BOT) marker, which is sensed by a photocell. The BOT marker is at least 3.1 metres (10.0 feet) from the start of the tape to allow an adequate leader. Notice that the BOT is offset below the centerline of the tape. The BOT is approximately 101.6 mm (4.0 inches) from the start of the first record. The end of the tape is identified by a reflective EOT marker, which is also sensed by a photocell. The EOT marker is displayed off the tape centerline in the direction opposite the BOT displacement. The EOT marker should be at least 4.3 metres (14.0 feet) from the end of the tape.

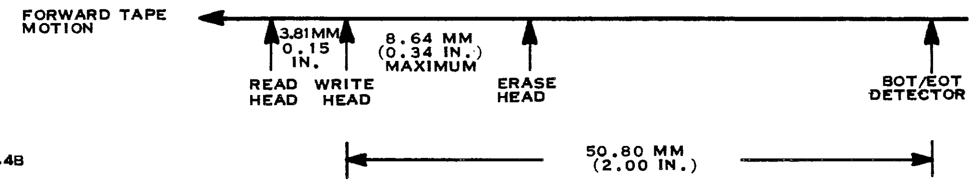

Figure 1-4. Head Spacing for Model 979A Transport

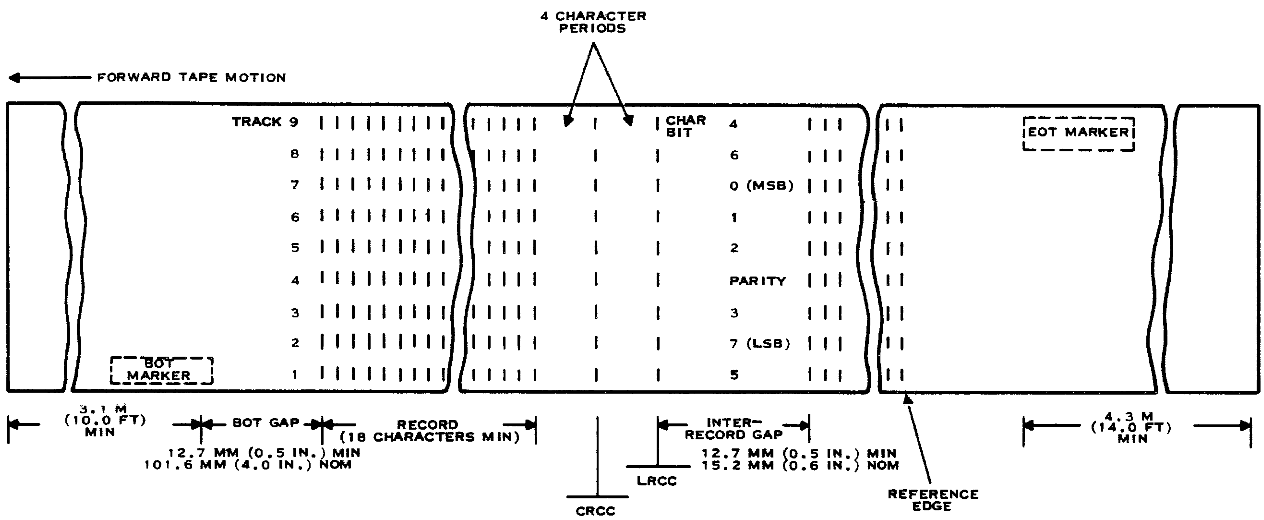

Figure 1-5. NRZI Tape Format

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The tape tracks are numbered sequentially, 1 to 9, starting at the reference edge of the tape. The track numbering corresponds directly to the numbering of the read data and write data signals between the controller and the transport. The track numbers do not correspond directly to the bit positions of the data characters from the computer. The conversion between character bit positions and tracks is performed in the controller as shown below:

CHARACTER/TRACK ASSIGNMENTS:

CHARACTER BIT	0	1	2	3	4	5	6	7
	TRACK 7	TRACK 6	TRACK 5	TRACK 3	TRACK 9	TRACK 1	TRACK 8	TRACK 2

TRACK 4 = ODD PARITY (LSB)

A NRZI record must consist of at least 18 characters. The maximum record size is determined by the capabilities of the controller and the length of tape on the reel.

The end of a NRZI record is identified by a unique configuration of spaces and check characters. The last data character is followed by four characters which are all zeros, including zero parity. No flux transitions occur in these four character positions. The CRCC is followed by four more all-zeros characters and the LRCC. An interrecord gap (IRG) of 15.2 mm (0.6 inch) separates the LRCC from the beginning of the next record.

The cyclic redundancy check character (CRCC) is based on a modified cyclic code. This code, which is based on the theory of polynomials, provides a rigorous means of detecting and correcting errors in a record. The CRC code is developed as the record is written on the tape, and the completed CRCC is written onto the tape at the end of the record. During read operations, the controller develops a CRC code as the record is read. The new CRC code is compared to the CRCC on the tape to determine if they are equal. If the codes do not compare, there is an error in the read operation. The CRCC has odd parity if the number of characters in the record is even; even parity if the number of characters is odd. It is possible for the CRCC to be an all zeros character.

The longitudinal redundancy check character (LRCC) consists of 9 even parity bits, 1 for each track. Each bit of the LRCC is chosen so that the total number of ones in that track is even. The LRCC includes the entire record and the CRCC. The LRCC cannot be an all-zeros character.

The file mark is a special character group which is used to separate files. The terms EOF (end-of-file) and file mark are used interchangeably throughout the industry. Figure 1-6 shows the format of the file mark for a NRZI tape. The file mark is preceded by an erased gap of approximately 127.0 mm (5.0 inches). The mark itself consists of two 13_{16} characters separated by 8 all-zeros (no flux change) characters. The usual interrecord gap separates the file mark from the first record of the next file.

1.3.3 PE FORMAT. Figure 1-7 shows the format of a 9-track, 1600 bpi, phase-encoded tape. The beginning of the recorded area of the tape is identified by a reflective beginning-of-tape (BOT) marker. This marker, which is sensed by a photosensor on the transport, must be 3 metres (10 feet) or more from the physical beginning of the tape. The end of the tape is identified by a reflective EOT marker which is at least 4.3 metres (14.0 feet) from the physical end of the tape. The BOT and EOT markers are displaced from the tape center line as shown.

A phase-encoded tape is identified by a burst of alternating ones and zeros in the parity track. The identification burst starts a minimum of 43 mm (1.7 inches) from the trailing end of the BOT marker, and extends beyond the marker. The BOT gap, which starts at the end of the ID burst, must be at least 12.7 mm (0.5 inch), and is nominally 101.6 mm (4.0 inches) for the 979A Transport.

A PE record is preceded by a preamble which consists of 40 all-zeros characters and a single all-ones character. The preamble is useful for time synchronization within the transport PE decoder logic. The PE record is followed by a postamble which is a mirror image of the preamble, a one followed by 40 zeros. The postamble is useful in read reverse operations, which are not implemented in the TMTC.

The interrecord gap is a 15.2 mm (0.6 inch) erased area which separates the postamble of one record from the preamble of the next record.

A PE file mark, as shown in figure 1-8, separates successive files. An erased gap of approximately 127.0 mm (5.0 inches) precedes the file mark. The file mark consists of 40 special characters which have dc erasure in tracks 3, 6, and 9, and all zeros in track pairs 1 and 2, 4 and 5, 7 and 8. The all-zeros tracks have 80 flux transitions at 3200 frpi. This file mark is compatible with the IBM standard, which is more restrictive than the ANSI standard.

A normal interrecord gap separates the file mark and the first record of the next file.

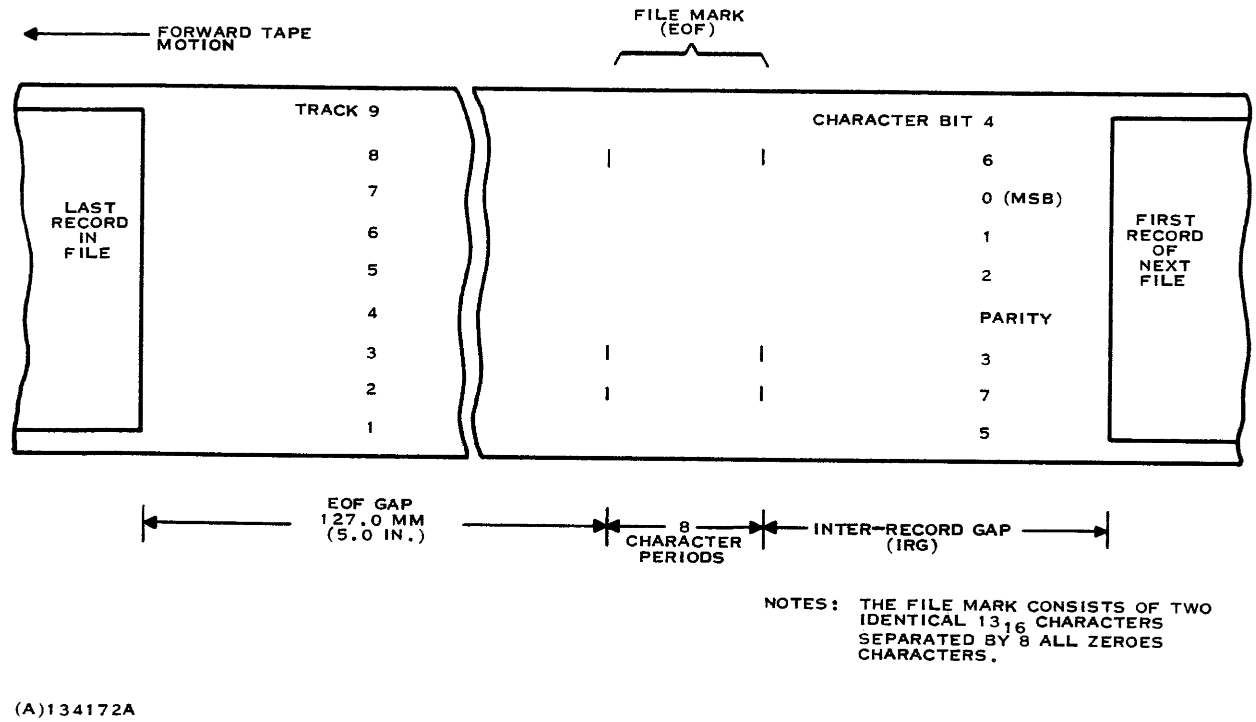

Figure 1-6. NRZI File Mark

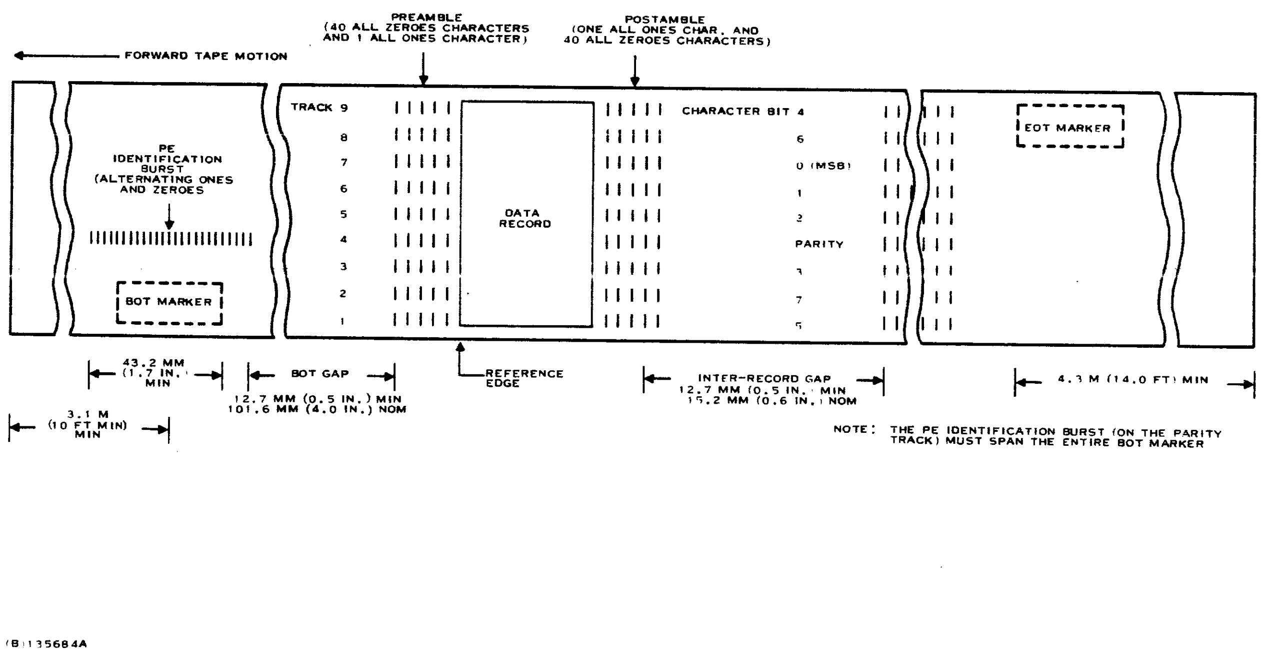

Figure 1-7. PE Tape Format

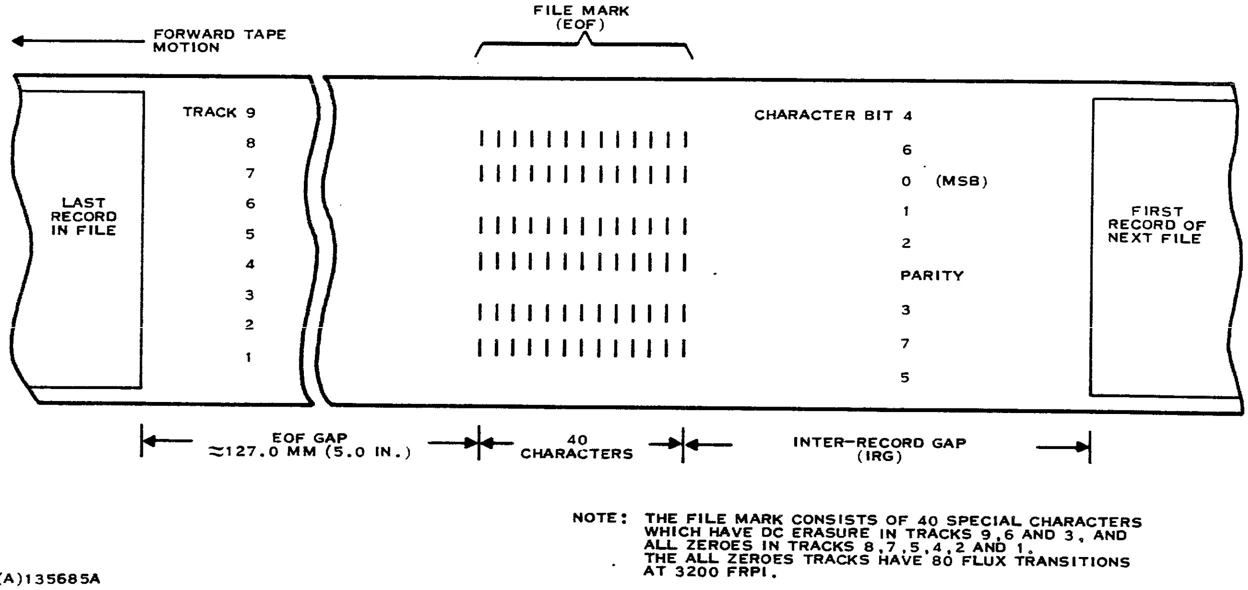

Figure 1-8. PE File Mark (EOF) Format

1.4 TRANSPORT FUNCTIONAL DESCRIPTION

The following paragraphs are brief descriptions of major subassemblies of the 979A Tape Transport. Refer to the block diagram (figure 1-9). A more detailed description will be found in Section IV, Theory of Operation.

1.4.1 CARD CAGE FUNCTIONAL DESCRIPTION. All control and data handling circuits are contained on eight printed circuit cards mounted in the card cage (A1A4) at the rear of the transport assembly. General descriptions of circuits and the functions they perform are outlined by card type.

1.4.1.1 Capstan/Regulator, card A1A4A1. Two major functions performed by this card are: 1) control of forward and reverse drive directions of the capstan motor, and, 2) power supply output voltage regulation. Forward or reverse drive signals received from the motion control card are processed by linear elements in the capstan control circuits to supply appropriate forward or reverse drive currents to the capstan motor. Mechanically ganged to the capstan motor is a tachometer to supply feedback (correction) voltages back to the motion control card, thereby closing the capstan control loop.

Unregulated power supply outputs of +12, -12, +20, and -20 volts are applied to four regulator circuits. These circuits supply +12, -12, -6, and +5 volts regulated power to logic and control circuits in the transport. The +5V and -6V regulators are adjustable and independent regulators containing their own reference voltage supplies. The +12V and -12V regulators are nonadjustable and dependent regulators relying upon the +5V and -6V supplies as their reference. All regulators have foldback current limiting circuits. Additionally, the +5V regulator has a crowbar circuit to prevent the regulator from exceeding a 6.5V limit. If the crowbar circuit is triggered, the tape transport ac power must be switched off, the problem cleared, and then power switched on to restore normal operation. In addition to the main functions of capstan control and voltage regulation, the capstan/regulator card contains lamp driver circuits for the READY, SELECT, and FILE PROTECT indications, relay driver circuits for the fast reverse and the wind relays, and detector driver circuits for beginning-of-tape (BOT) and end-of-tape (EOT) sensors.

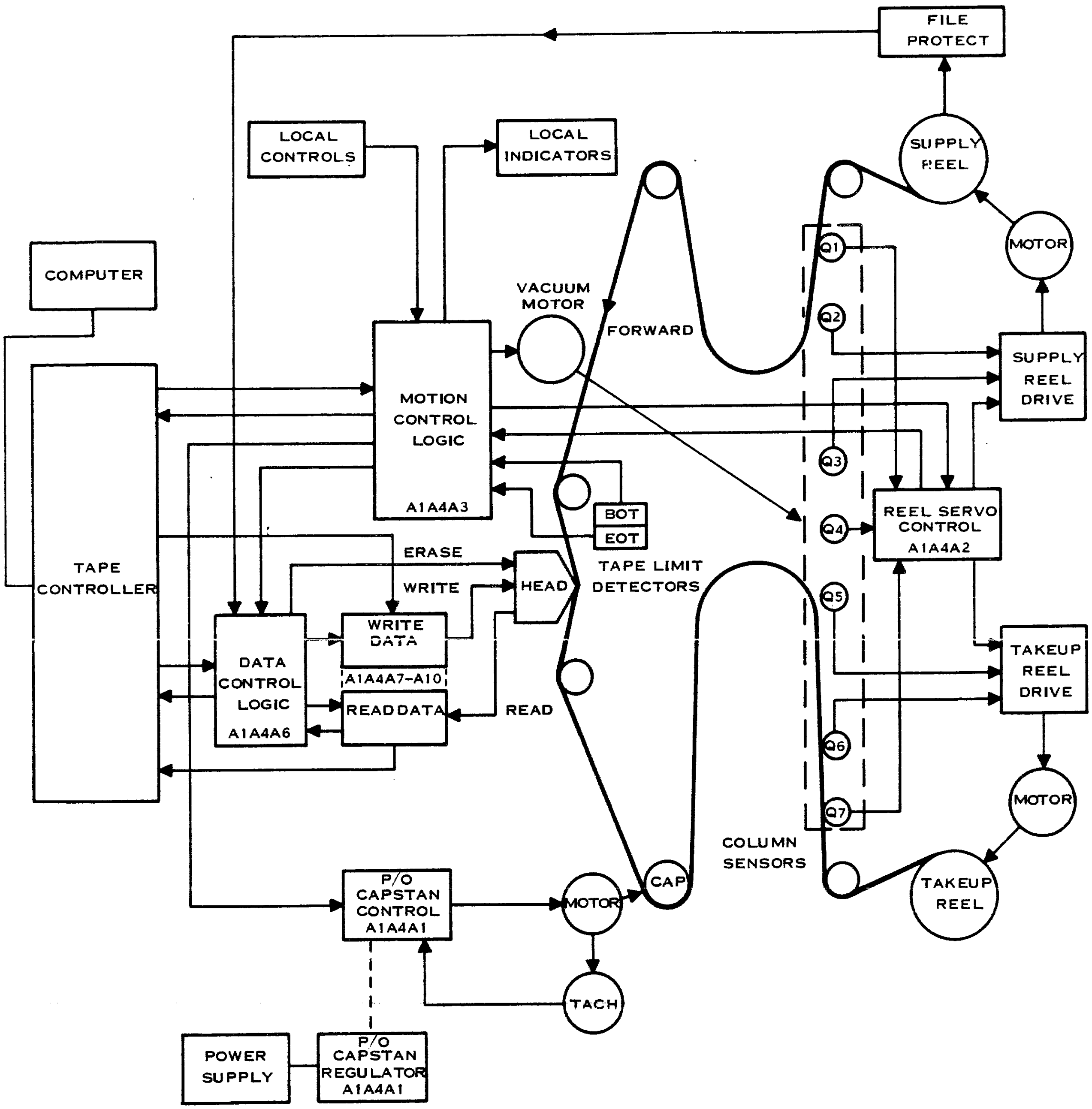

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Figure 1-9. Model 979A Functional Block Diagram

1.4.1.2 Reel Servo Control, card A1A4A2. The reel servo card controls speed and direction of the take-up reel and supply reel motors. Digital control signals from sensors in the vacuum column inform the reel servo card about the vertical position of tape in the column. If too much tape is being dumped into the column, sensors notify the reel servo control of the condition and a counter-voltage is then supplied to the appropriate motor. The counter-voltage causes the motor to slow down, reverse its direction, or to completely shut down in case of fatal malfunction such as a tape out of control condition. Likewise, if not enough tape is in the column to satisfy the sensors, the reel servo card supplies voltage to accelerate the motor, reverse direction or effect shutdown, if necessary to protect the tape.

There is also a dynamic braking control circuit on this card to react to "shutdown" signals from vacuum column sensors, or if forward or reverse motion of the reel motor stops.

1.4.1.3 Motion Control Logic, card A1A4A3. There are two types of motion control logic cards: one type containing IC's and discrete components for decoding, switching, and storing control signals; another type consisting of microprocessor, memory elements, and drivers to perform the same functions. These cards are completely interchangeable.

Motion control logic reacts to local, remote, or internally generated commands to issue commands controlling tape movement. These commands are used to control forward read or write tape drive, reverse drive (backspace), rewind, and unload operations.

1.4.1.4 Data Control (NRZI or PE), card A1A4A6. The data control card contains logic to process data and control signals with the tape controller/interface card in the computer chassis. Computer commands received via the controller/interface condition data circuits to record or playback data betweeen computer and tape. As a result of these commands, a circuit on the data control card generates timing signals for read and write operations and status signals for the controller/interface. The data circuit for transferring track 1 data with the computer is located on this card. The circuit for track 1 data is similar to the eight track circuits on data cards A1A4A7 through A1A4A10.

There are two types of data control cards: NRZI (nonreturn to zero, inverted) and PE (phase-encoded). Operationally, the main difference between cards is the recording/reproducing format on tape.

1.4.1.5 NRZI or PE Data Cards (A1A4A6 and A1A4A7 → A1A4A10). Track 1 data is processed by circuits on A1A4A6 in addition to control signals. The remaining eight data tracks are processed by cards A1A4A7 through A1A4A10. Even track numbers 2, 4, 6, and 8 are on the upper half of the cards, while odd track numbers 3, 5, 7, and 9 are processed on the bottom half of the cards.

NRZI data cards (and track 1 data circuit) format the data for NRZI recording/reproducing, while PE data is formatted on the tape controller and presented to the PE data cards in this form.

1.4.2 DRIVE MOTORS FUNCTIONAL DESCRIPTION. There are three drive motors in the tape transport assembly. Two identical servo motors are used to drive tape reels: one for the takeup reel and one for the supply reel. The third motor is a dc control motor mechanically ganged with a tachometer. This motor drives the tape across the read/write and erase heads. Due to the geometry of the tape path, the capstan does not touch the oxide surface (data bearing surface) of the tape; it contacts the mylar surface. The capstan motor receives drive signals from the capstan/regulator card under instructions issued by the motion control card. Feedback from the motor is supplied to the motion control card by the tachometer mechanically connected to the motor. Capstan drive speed (both forward and reverse) is adjustable on the reel servo card. Instructions for speed adjustment are contained in the checkout procedures of the maintenance section. The reel servo motors are controlled by the reel servo card. The reel servo control card receives instructions from sensors in the vacuum column on the status of tape quantity. Reel motor speed and direction is varied depending upon the amount of tape in the vacuum blocking, or allowing light to reach the infrared light detectors. If either too much or too little tape is in the column, an immediate shutdown results. More information on sensors and limits is described in the following description of the vacuum buffer.

1.4.3 VACUUM BUFFER FUNCTIONAL DESCRIPTION. The primary purpose of the vacuum buffer is to ensure uniform tape tension in the reel-to-reel transfer of tape. This is done by drafting a quantity of tape into the column and maintaining this quantity within certain limits by using infrared light sources and detectors. The vacuum pump is a five-stage motor capable of (re)moving 0.57 m^3/min. (20 cfm) of air from the column. The pump is located at the column center. This effectively divides the column in half: the upper portion holds tape from the supply reel motor, and the bottom section holds tape going to the takeup reel.

There are seven light sources and seven light detectors: one in the center of the column, three in the top portion, and three in the bottom portion. Sensor operation is described from top to bottom of the upper portion of the vacuum column. The lower portion operates similarly. Tape is first manually installed and threaded across the top and bottom turnaround rollers. Tape must be slack-free across the top and bottom turnaround rollers.

When the LOAD button on the control panel is pressed, the vacuum pump energizes and control circuits go into an 11-second delay waiting for vacuum buildup. After the 11 second delay the supply reel dumps tape into the upper vacuum column. As tape is drawn into the upper portion of the vacuum column, light is blocked from sensor 1. Then the capstan starts loading tape into the lower portion of the column. Characteristics of reel motors tend to dampen large fluctuations of tape in the columns due to CW and CCW switching of the motor. The tape approaches a virtual steady state in the vertical direction near the light line from the source to sensor 2 when tape is traveling in the forward direction. In the reverse direction steady state is approached near the sensor 3 light line. Automatic shutdown of motors and the drive occurs when light reaches sensors 1 or 7 indicating insufficient quantity of tape in column; or when light is blocked from sensor 4 indicating too much tape in the column.

1.4.4 FILE PROTECT AND TAPE LIMIT DETECTORS FUNCTIONAL DESCRIPTION. The file protect circuit prevents recording on a "file protected tape" containing data that is not to be altered. This is also called write protect. File protected tapes have the write protect ring removed from the center of the reel, this prevents a latching switch located next to the supply reel hub from being activated. Signals from this switch are supplied to the file protect lamp driver on the capstan/regulator card and to the data control card. When the switch is not closed (file protect ring missing), the FILE PROTECT lamp on the control panel lights, and an inhibit signal is sent to the data control card to prevent writing on tape.

Tape limit detectors are placed near the tape cleaner and heads in the tape path. The detectors sense the beginning-of-tape (BOT) and end-of-tape (EOT) markers affixed to the tape. The detectors operate identically. Detectors units have a built in light source that senses reflected light from tape markers. Each of the sensors detects reflected light from one-half the tape width. The markers themselves are 25.4 mm (1.0 inch) lengths of highly reflective tape. Signals from these detectors are sent to buffer/driver circuits on the capstan/regulator card.

1.4.5 POWER SUPPLY FUNCTIONAL DESCRIPTION. The power supply assembly is located at the top of the transport unit. Primary unregulated dc voltages are supplied by this assembly and distributed to the card cage, servo amplifier assembly and the file protect switch. (The vacuum pump gets its voltage from the ac source via relay K1.)

The capstan/regulator card in the card cage contains four regulator circuits which supply base drive to series-pass regulator transistors mounted on the rear of the power supply assembly. These transistors use the power supply chassis as a heat sink. Mounted to the right under the rear of the power supply chassis are six fuses to protect circuits from excessive currents of unregulated voltages. The transport is protected from ac overcurrent by a fuse located on the top rear behind the front plate.

Table 1-1. 979A Tape Transport Leading Characteristics

Characteristic	Description
Functional:	
Tape Speed:	952.5 mm (37.5 in.)/sec.
Start/Stop Characteristics:	Start: 10.1 ms, 4.83 mm (0.190 in.)
	Stop: 10.1 ms, 5.59 mm (0.220 in.)
Rewind Speed:	3657.6 mm (144.0 in.)/sec. (min.)
Read/Write Head:	9-track read-after-write dual gap with edge relief slots
Static Skew:	0.0019 mm (75.0μ in.) relative to outside tracks of read head
Dynamic Skew:	0.0032 mm (125.0μ in.) pk-pk, typical
Tape Tension:	2.2 N (8.0 oz.) nominal
File Protection:	File-protect-ring sensor
BOT, EOT Detection:	Photosensing detectors; built-in command sequence to assure accurate positioning on BOT regardless of approach direction.
Configuration:	
Height:	622.3 mm (24.5 in.)
Width:	482.6 mm (19.0 in.)
Depth:	368.3 mm (14.5 in.) overall, 373.4 mm (14.7 in.) behind panel, including connectors
Weight:	61.2 kg (135.0 lb)
Mounting:	Standard 482.6 mm (19.0 in.) rack mount
Tape Width:	12.7 mm (0.5 in.)
Tape Thickness:	0.0381 mm (0.0015 in.)

SECTION 2

INSTALLATION

2.1 GENERAL

This section provides installation procedures for the 979A Tape Transport and interface/controllers required in a 960, 980, or 990 environment. These procedures include site preparation, unpacking, installation of controllers and tape transport(s), and interconnection cabling. Examine this entire section before proceeding with the installation. Circumstances unique to a user's site may dictate that these procedures be performed in modified order. Familiarity with the contents of this section will provide a rational basis for planning the installation work.

CAUTION

Do not connect or disconnect any plug or circuit board when power is applied to the computer system or to the 979A Tape Transport.

2.2 SECTION ORGANIZATION

Due to the various configurations available, an explanation of how this section is arranged will assist installation personnel in rapidly locating areas of interest.

Paragraphs 2.3 through 2.5 outline procedures for installing the 979A Tape Transport that are common to all systems. Paragraph 2.6 outlines installation procedures for the 960 or 980 interface/controller using NRZI recording/reproducing format, only. Paragraph 2.7 outlines installation procedures for the 960 or 980 interface/controller using both PE and NRZI recording/reproducing formats. Paragraph 2.8 covers procedures for 990 interface/controllers using either NRZI only, or PE/NRZI recording/reproducing tape formats.

2.3 SITE PREPARATION FOR THE TAPE TRANSPORT

The 979A mounts in an EIA standard 482.6 mm (19.0 inches) rack. It requires 622.3 mm (24.5 inches) panel height, and 330.2 mm (13.0 inches) depth behind the panel. Workspace greater than the 533.4 mm (21.0 inches) open door clearance will be determined by the user. Installation is recommended at the top of a standard 1778.0 mm (70.0 inches) cabinet, part number 945080-0001. A convenient work height in a taller cabinet may require equipment mounting above the 979A. If the 979A is not installed at the uppermost rack position, a means of restricting upward movement of the transport should be considered.

2.4 UNPACKING

The tape transport is shipped on a plywood pallet in a corrugated cardboard container as illustrated by figure 2-1. A packet of mounting hardware is included.

WARNING

The tape transport shipping weight is in excess of 68.0 kg (150 pounds). A power lift is recommended for handling the transport. Use proper handling procedures to avoid backstrain.

Upon receipt of the tape transport, inspect the container for evidence of abuse during shipment. After preliminary inspection, the container may be opened from its upright position as illustrated by the figure.

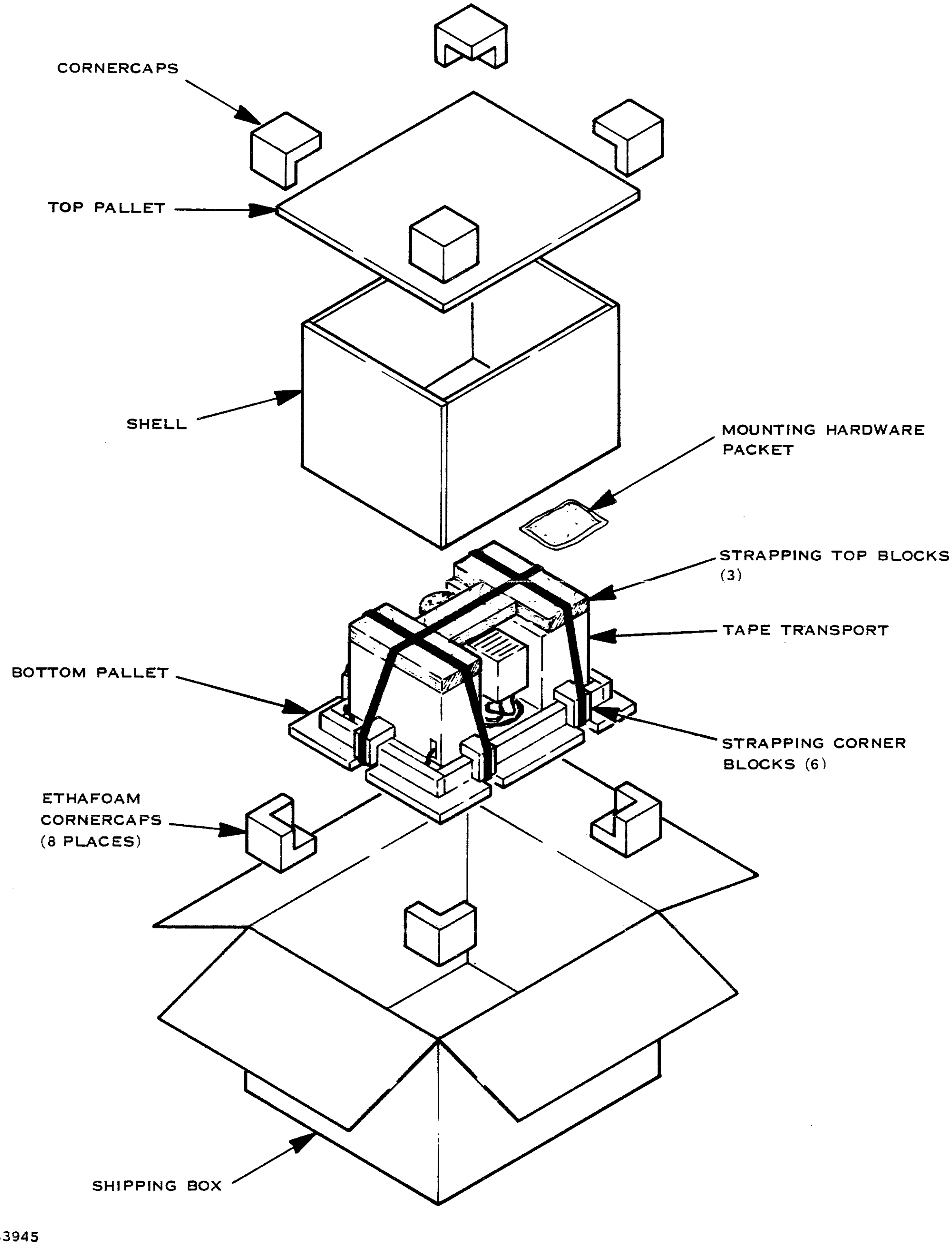


Figure 2-1. Model 979A Tape Transport Shipping Container

The two end strapping blocks may be employed for initial handling of the unboxed transport unit. Do not use the center separator block for handling purposes. This center separator should be removed immediately to preclude its use as a handhold. Avoid unnecessary handling of the transport by first preparing the cabinet for rackmounting (see paragraph 2.5) before removing the transport from its shipping container.

After the rackmounting preparations, the transport may be lifted from the container, positioned near the intended mounting location, and then removed from the shipping pallet.

2.5 MOUNTING THE 979A

These instructions describe the mounting of the 979A Tape Transport at the top location in an EIA standard 482.6 mm (19.0 inches) rack. Where other than the topmost location is required, relative positioning of the mounting hardware can be made.

2.5.1 HARDWARE ATTACHMENT. Counting down from the topmost hole of each rail, attach a hanger "point up" in holes 10 and 11, using two 10-32 × 0.44 flathead screws provided. See figure 2-2. The square end of the hanger should split a 15.875 mm (0.625 inch) hole pair of the rail. Attach a second hanger "point up" on each rail 444.5 mm (17.5 inches) below a corresponding point of the upper hanger. Four mating hangers on the 979A are attached "point down" at the inside corners of the transport base plate as shown in figure 2-3.

2.5.2 RACKMOUNTING. The following instructions are intended for rackmounting the 979A Tape Transport using a power lift to lift the 979A vertically between the cabinet rails.

WARNING

The 979A Tape Transport weighs 61.1 kg (135.0 pounds). A power lift is recommended for installation.

1. Remove equipment installed below the tape transport mounting location to provide clearance.

2. If other equipment is to be mounted above the 979A, it may be removed to provide clearance to engage the mounting hangers. In this case, the control panel need not be removed from the transport during the mounting procedure. Otherwise, detach the tape transport control panel (three #6 screws inside the top rail of the door frame) and temporarily secure it at the front or rear of the transport assembly. Save the control panel attachment hardware.

3. Close the door, position the transport on the power lift, and raise the transport to a level that will provide clearance between points of mating rack hangers. Move the transport horizontally into the cabinet between the rails. When maneuvering into the cabinet from the front side, make sure that the cabinet is blocked at the rear to prevent its backing away.

4. When the transport base panel rack hangers are touching the cabinet rails, ascertain that all rack hangers will engage properly and then gently lower the transport into position to mate the four hanger pairs. Check that all hanger pairs have engaged properly. The transport is now supported on the cabinet rails.

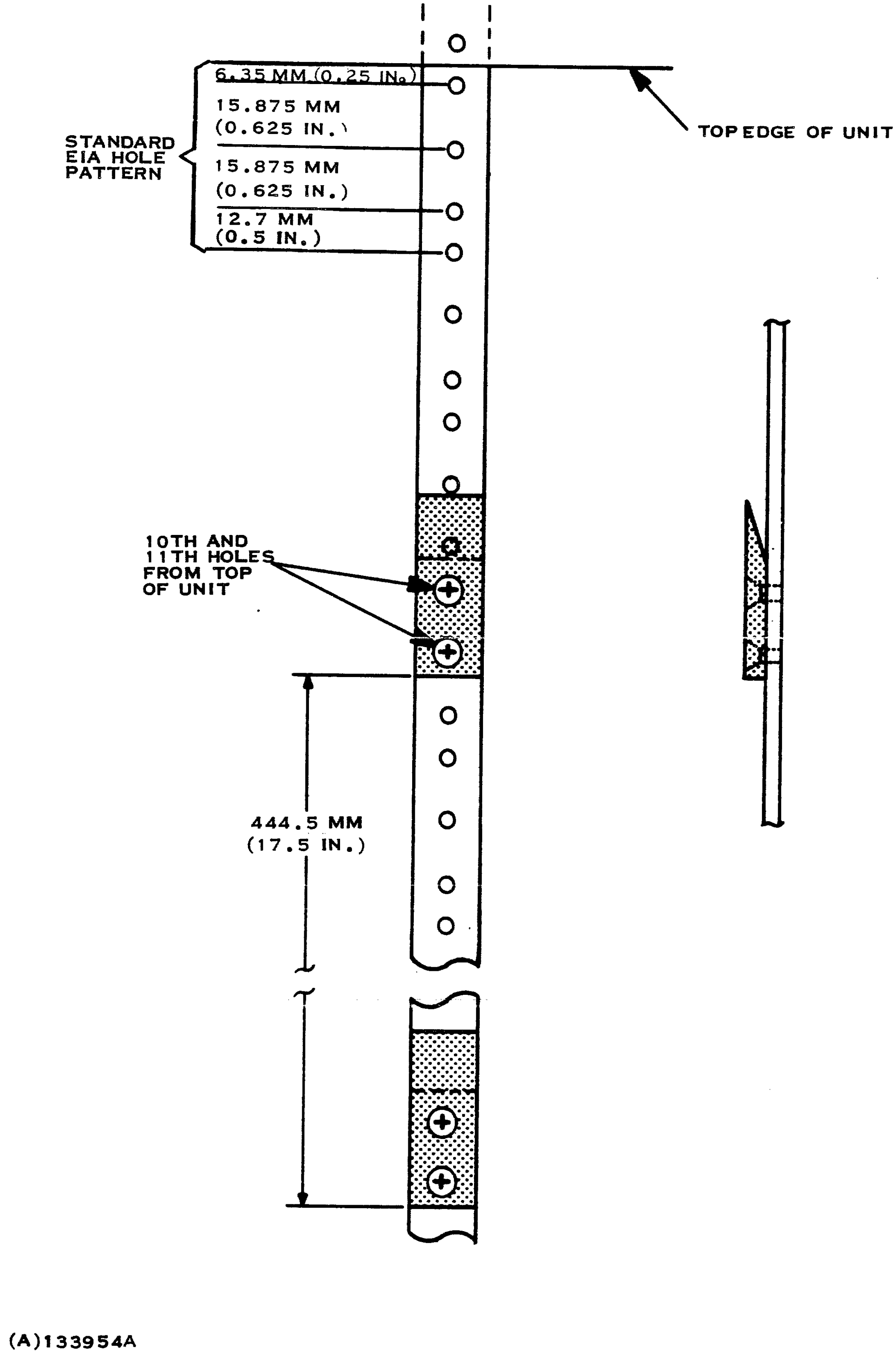


Figure 2-2. Mounting Rack Hangers in EIA Standard Rack

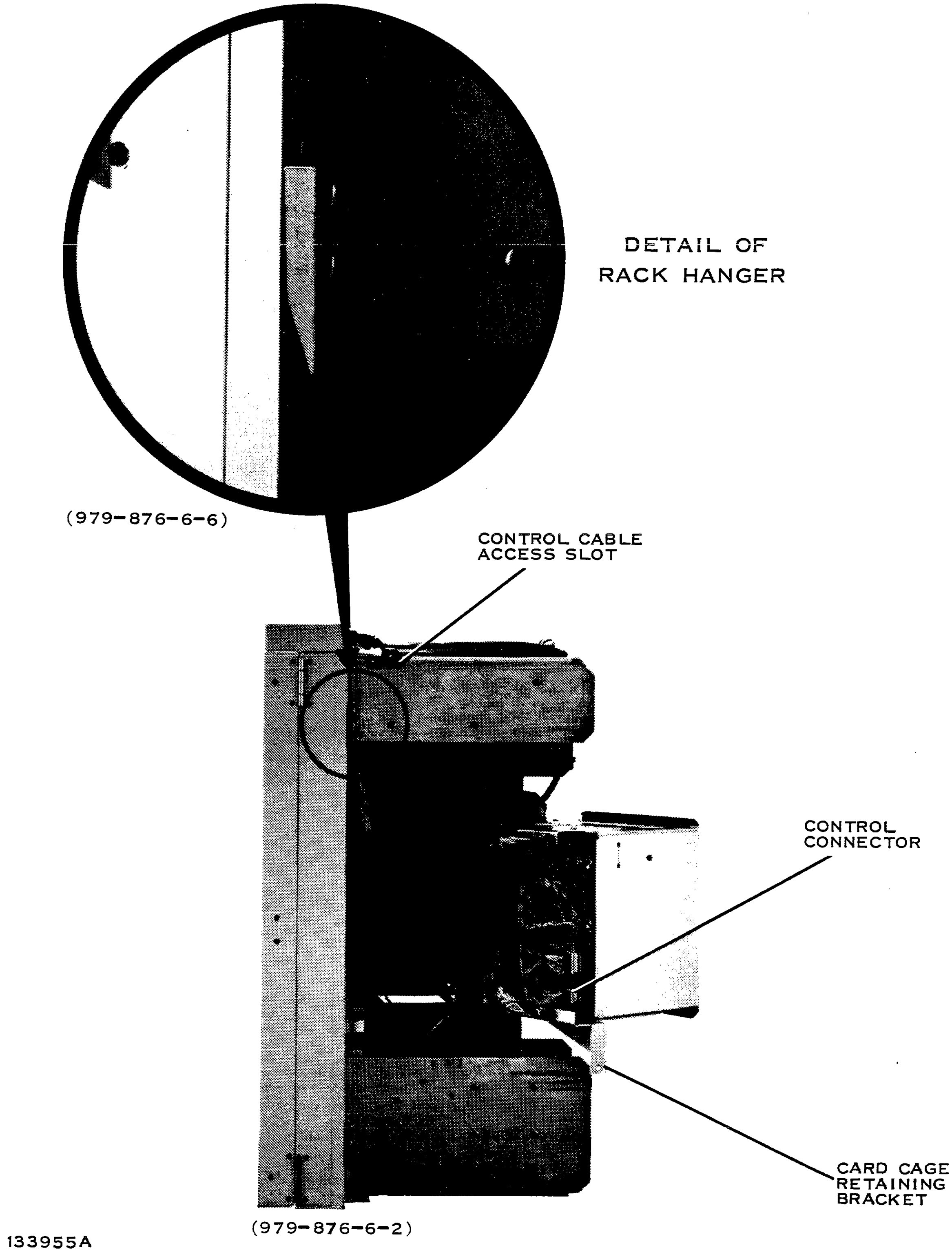


Figure 2-3. Model 979A Tape Transport Mounting and Connection Provisions

NOTE

The transport is secured into the cabinet by mounting the control panel into the remaining space above the transport. When the control panel mounts flush under the top of the panel opening in the cabinet, the transport is then secured. If the control panel is not in the uppermost location in the cabinet or directly below other mounted equipment, an alternate means should be provided to secure the transport in the cabinet when there exists any possibility of upset.

5. Install the control panel above the transport with the three #6 screws and washers (from step 2) through the upper door frame.

2.6 960/980 INTERFACE/CONTROLLER, NRZI ONLY

The tape transport controller for the Model 979A Tape Transport provides an interface to the direct memory access port (DMAP) expander for the Model 960 or Model 980 Computers. The recording/reproducing format used with this interface/controller is NRZI format, only.

Figure 2-4 is a block diagram relationship of the tape transport controller and tape unit to the Model 960 or Model 980 Computer.

2.6.1 TAPE CONTROLLER ORGANIZATION. The Model 979A Tape Transport Controller consists of two major logic sections: the block transfer control (BTC) logic and the tape control logic (TCL). The BTC is the interface to the DMAP expander and the TCL is the interface to the tape transport unit.

Figure 2-5 illustrates the tape controller organization.

2.6.2 TAPE CONTROLLER FUNCTIONS. The tape transport controller performs two primary functions.

1. It is capable of independently retrieving blocks of data from memory and transferring them to the tape transport for writing on tape.

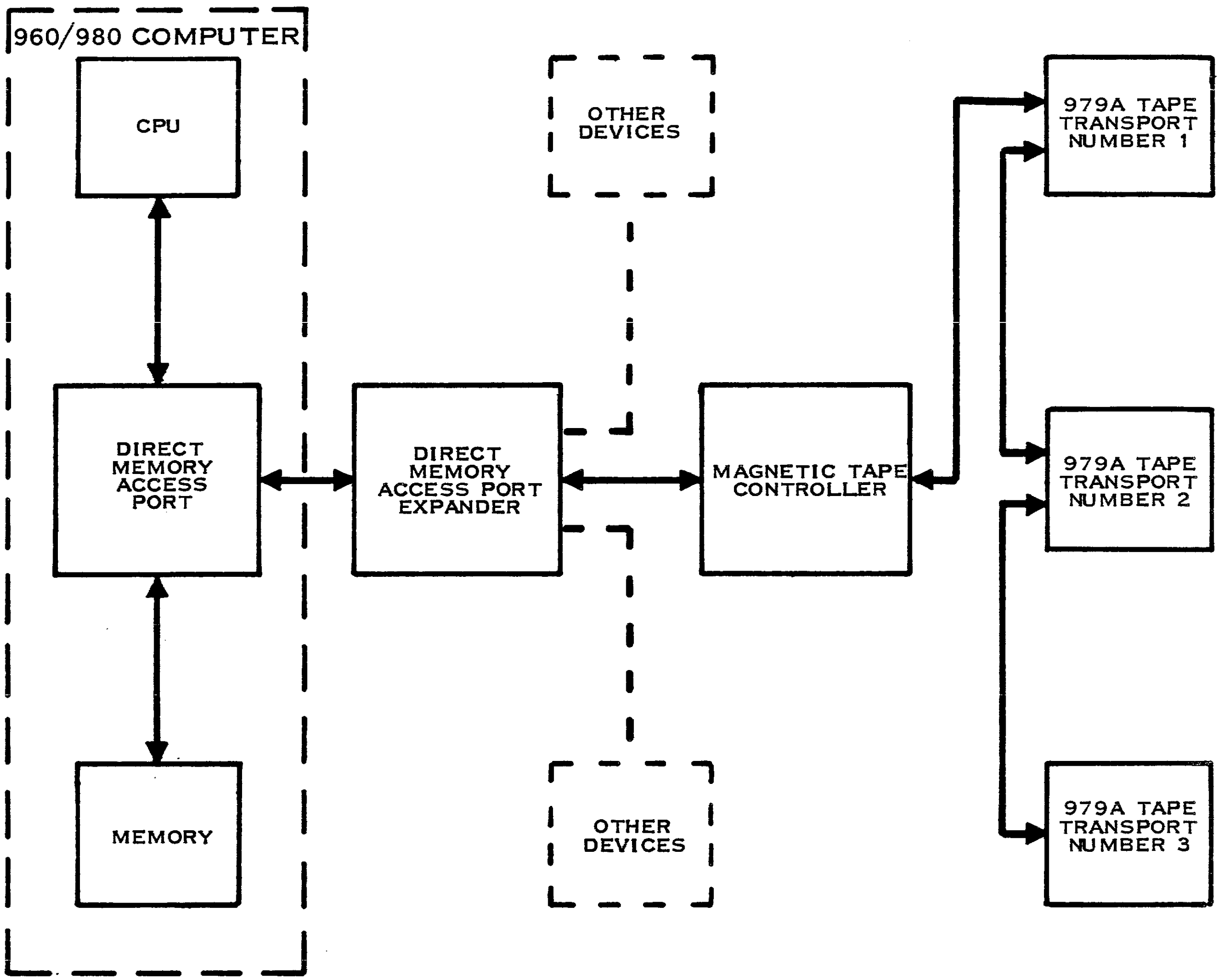
2. It is capable of independently accepting blocks of data read from tape by the tape transport and storing them in memory.

At any one time, only one nonrewind operation may be in progress on any one transport. Any combination of the remaining transports may be rewinding simultaneously.

All tape operations are initiated via the Automatic Transfer Instruction (ATI) in the Model 980 Computer or the Activate Direct Access Channel (ADAC) command in the Model 960 Computer.

Rewind commands to the controller require only the execution of an ATI or ADAC command by the CPU for activation of the controller and the appropriate transport. Nonrewind commands require execution of an ATI or ADAC command by the CPU and acquisition of a list by the Block Transfer Control (BTC) portion of the tape transport controller.

Controller/transport status is reported at appropriate times as either one or two words. Two words are stored only when a data transfer operation has been executed.



(A) 138382

Figure 2-4. Tape Transport Controller, Tape Transport, and Computer Relationship Block Diagram

The following commands are executable in the nine-track tape system.

REWIND
UNLOAD
READ BINARY (FORWARD)
RECORD SKIP (FORWARD or REVERSE)
WRITE BINARY (FORWARD)
WRITE END OF FILE (FORWARD)
ERASE (FORWARD)

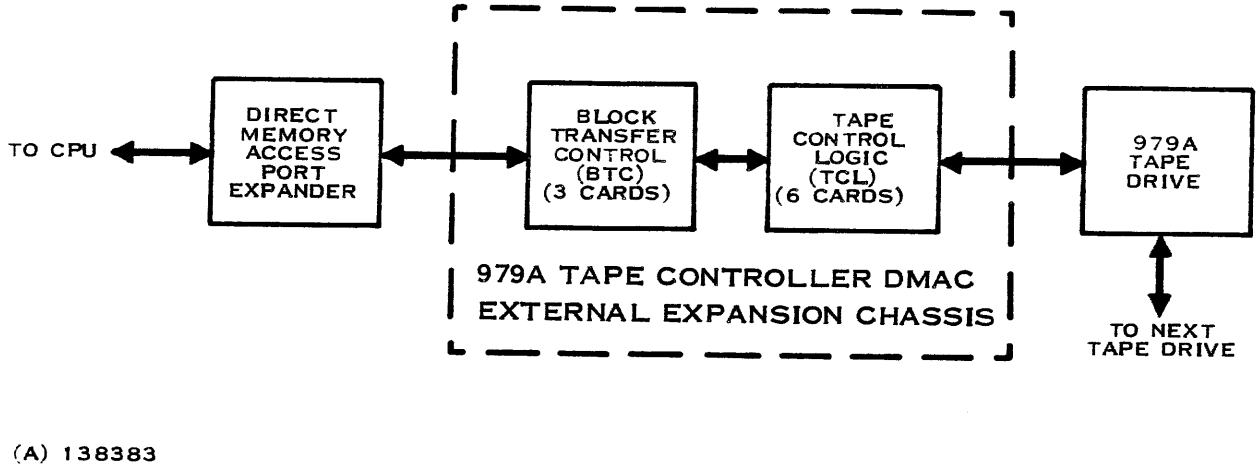


Figure 2-5. Tape Controller Organization

2.6.3 CHANNEL ADDRESSING. The controller may be assigned any channel (DMAP) address from channel 0 through channel 7. Circuitry within the BTC section of the tape controller uses the assigned (hard-wired) address to determine when to respond to an ATI or ADAC command. This circuitry also determines which request lines to drive and which acknowledge lines to monitor as explained in paragraphs 2.6.4 and 2.6.5. Refer to the BTC manual referenced in preface for detailed information.

2.6.4 ADDRESS SELECTION. The channel addressing scheme utilized permits assignment of any channel address and enables the address to be changed, if required. The assigned channel address is selected on the circuit board by either a jumper wire address plug or a dual-in-line (DIP) switch package. Figure 2-6 illustrates the selection using the address plug. Figure 2-7 illustrates the selection using either of the two types of DIP switch packages. The decoding and comparison of the assigned address to the address in ATI1 or ADAC1 is shown functionally in figure 2-8.

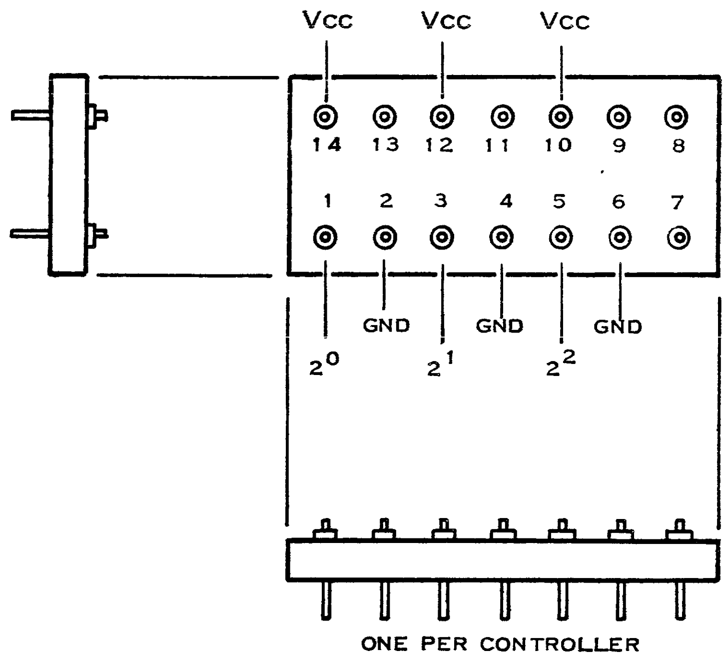
2.6.5 ADDRESS MODIFICATION. In order that the channel address may be changed without altering the controller logic or connector plate wiring, the BTC section of the tape controller picks up eight sets of channel control lines. However, only one line from each group is utilized, the one corresponding to the assigned channel.

The circuitry for driving the appropriate memory access line and interrupt request line is shown in figure 2-9. The circuitry for monitoring the memory access grant line and interrupt acknowledge line is shown in figure 2-10. Using this channel addressing scheme makes address modification a simple matter of altering the address select plug wiring.

2.6.6 BTC AND TCL CIRCUIT CARD LOCATIONS. The BTC and TCL cards are located in the DMAC external expansion chassis in card slots shown in figure 2-11.

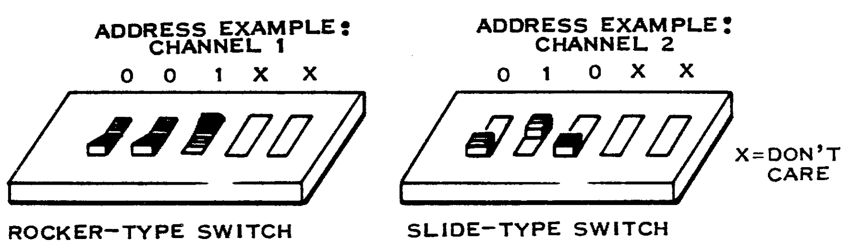
2.6.7 979A MAGNETIC TAPE SYSTEM, INTERCONNECTION CABLING. Figure 2-12 shows an interconnection diagram for the tape transport operating in a typical 960 or 980 computer system environment where recording/reproducing format is NRZI, only.

ADDRESS PLUG WIRING	
CHANNEL	CONNECTIONS
7	1-2, 3-4, 5-6
6	1-14, 3-4, 5-6
5	1-2, 3-12, 5-6
4	1-14, 3-12, 5-6
3	1-2, 3-4, 5-10
2	1-14, 3-4, 5-10
1	1-2, 3-12, 5-10
0	1-14, 3-12, 5-10



(A) 138384A

Figure 2-6. Channel Address Plug



CHANNEL NUMBER	SWITCH SETTINGS				
	1	2	3	4	5
0	OFF	OFF	OFF	DON'T CARE	DON'T CARE
1	OFF	OFF	ON		
2	OFF	ON	OFF		
3	OFF	ON	ON		
4	ON	OFF	OFF		
5	ON	OFF	ON		
6	ON	ON	OFF		
7	ON	ON	ON		
NOTE: OFF = LOGIC 1; ON = LOGIC 0					

(A)131415A

Figure 2-7. Multilayer Circuit Board Address Data

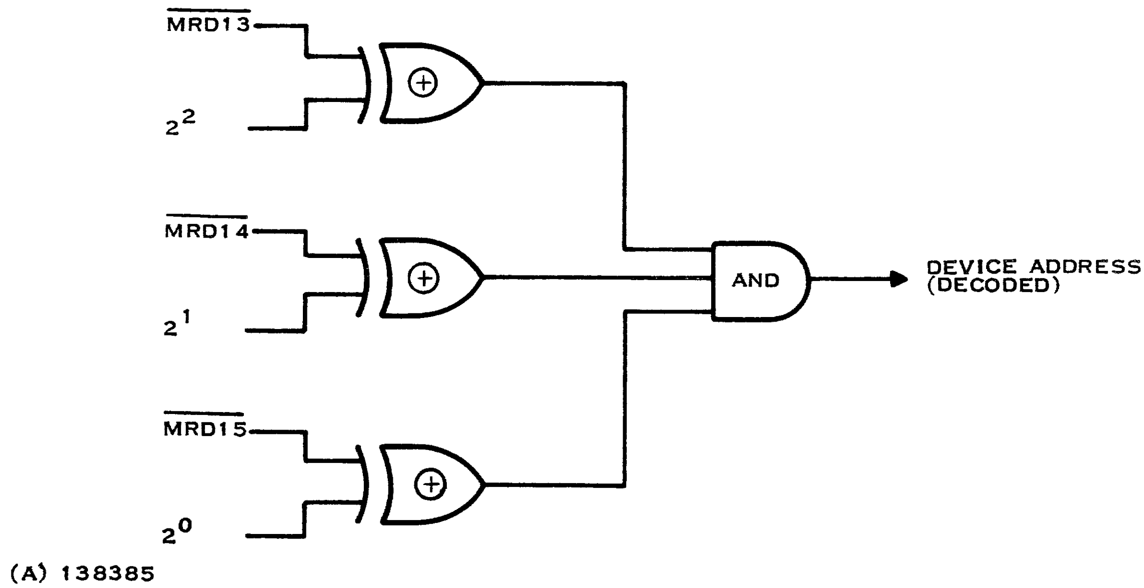


Figure 2-8. Channel Address Decoding

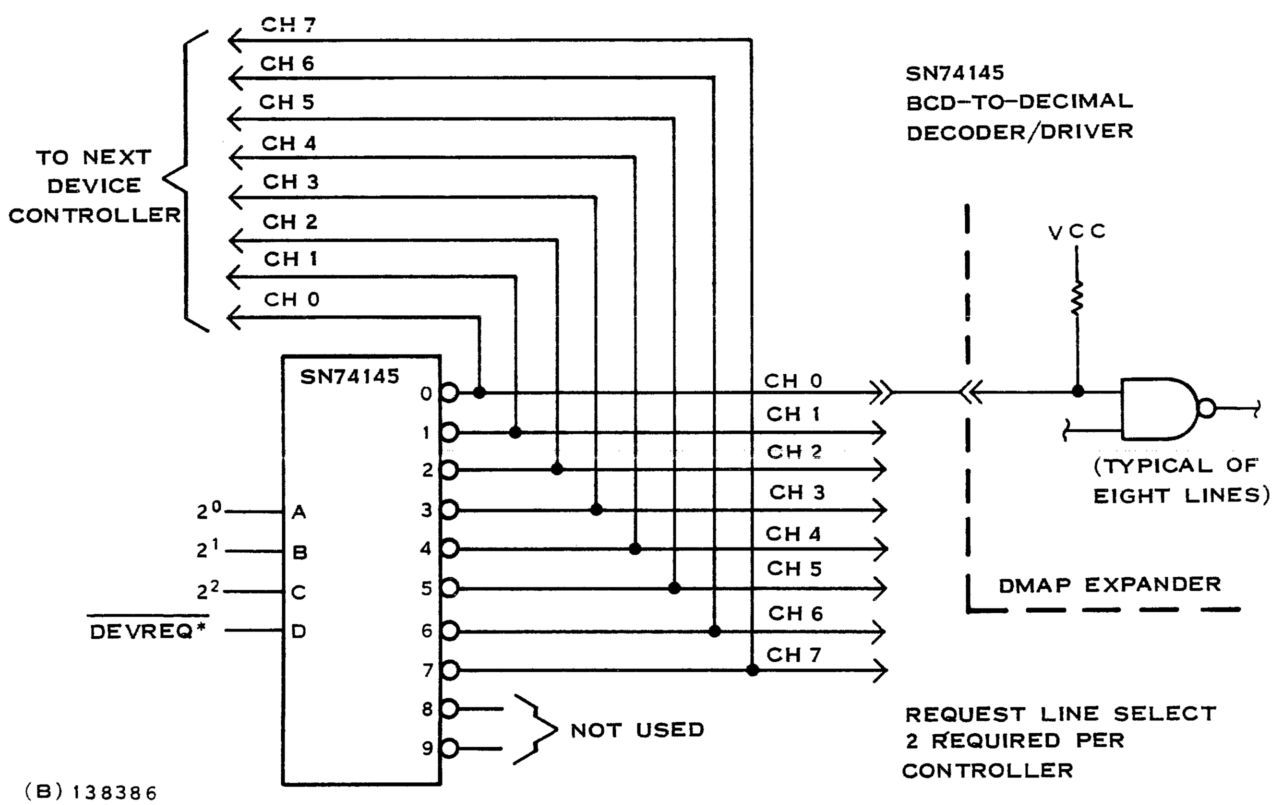


Figure 2-9. Request Line Select

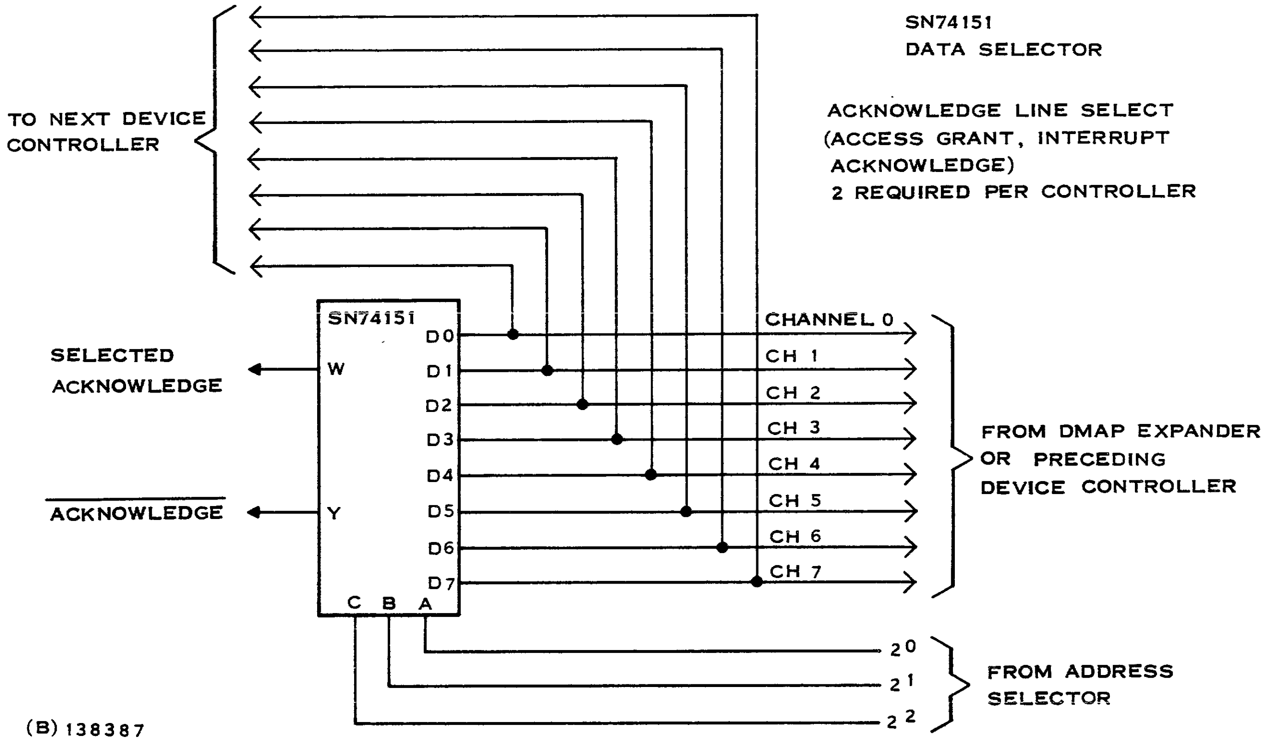


Figure 2-10. Acknowledge Line Select

2.6.8 960/980 SYSTEM CHECKOUT PROCEDURES FOR THE 979A TAPE TRANSPORT. Checkout procedures for 979A Tape Transport and interface/controllers are outlined in Section V.

2.7 960/980 INTERFACE/CONTROLLER PE

The interface/controller used in this system consists of seven boards in the DMAC external expansion chassis and a tape interface unit, see figure 2-13. That portion of the interface/controller installed in the DMAC expansion chassis consists of three block transfer controller cards and four tape command controller cards. The tape interface unit is contained in its own chassis and may be mounted in a standard EIA equipment cabinet.

2.7.1 BLOCK TRANSFER CONTROLLER FUNCTIONAL DESCRIPTION. A BTC consists of either three multilayer printed circuit boards or three wire-wrapped circuit boards as shown in figure 2-14. The two types are directly interchangeable. All interface signal lines to and from the BTC come through 80-pin connectors at the bottom of the circuit boards. The BTC provides direct access to CPU memory for high speed peripheral devices such as the 979A Tape Transport. The BTC is part of a peripheral controller which consists of a BTC for CPU interface and a TCC to control the tape interface unit and subsequently the tape transport. Routine tasks such as CPU command and monitoring, list acquisition, memory management, status storage, interrupt control, data word counting, and data buffering, as directed by the device controller, are all performed by the BTC.

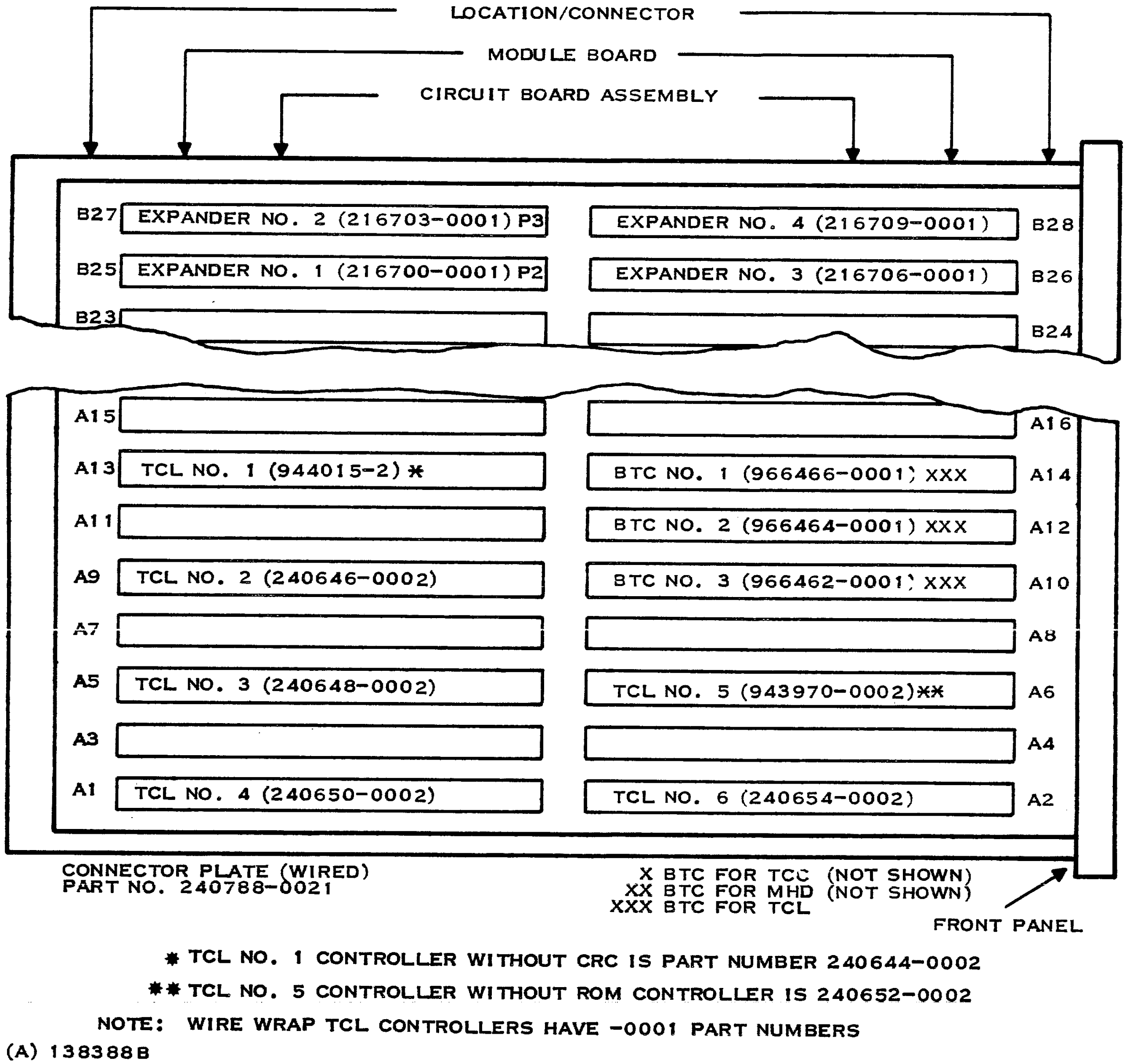


Figure 2-11. DMAC External Expansion Chassis 979A Tape System Interface/Controller, 960/980 System, NRZI Format Only

2.7.2 TAPE COMMAND CONTROLLER FUNCTIONAL DESCRIPTION. The TCC consisting of four wire-wrapped circuit boards as shown in figure 2-15 operates in conjunction with the block transfer controller (BTC) to function as a direct memory access channel (DMAC) controller. The DMAC controller is the functional interface between the CPU direct memory access (DMA) port of either a Model 960 or Model 980 Computer and the Model 990 Transport Interface Unit. The TCC decodes commands from the CPU and provides proper commands to the TIU, monitors status information from the TIU and generates and stores appropriate status words into CPU memory. The TCC also packs and unpacks the 16-bit computer data word to provide 8-bit tape transport data.

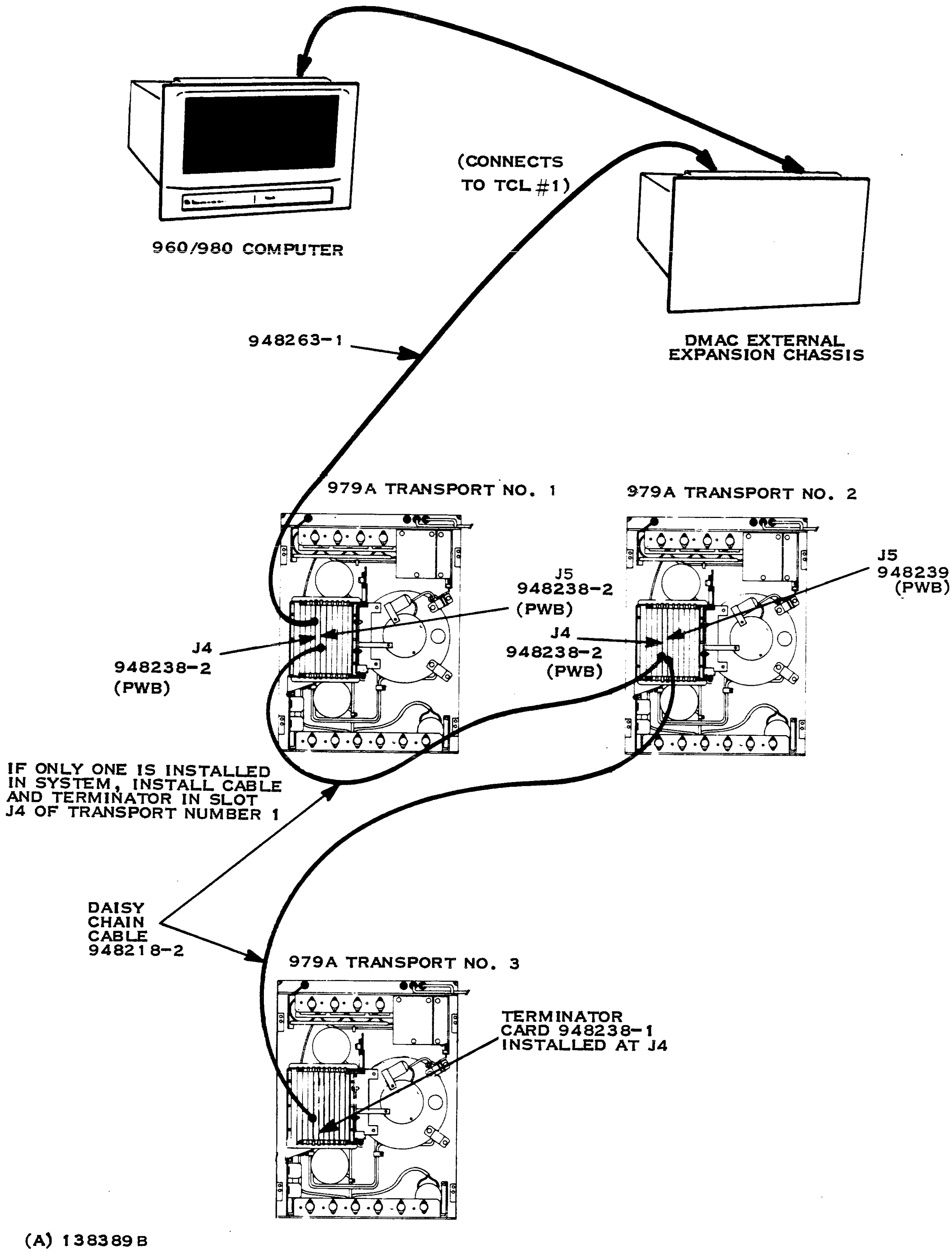


Figure 2-12. 979A Interconnection 960/980 System, NRZI Only

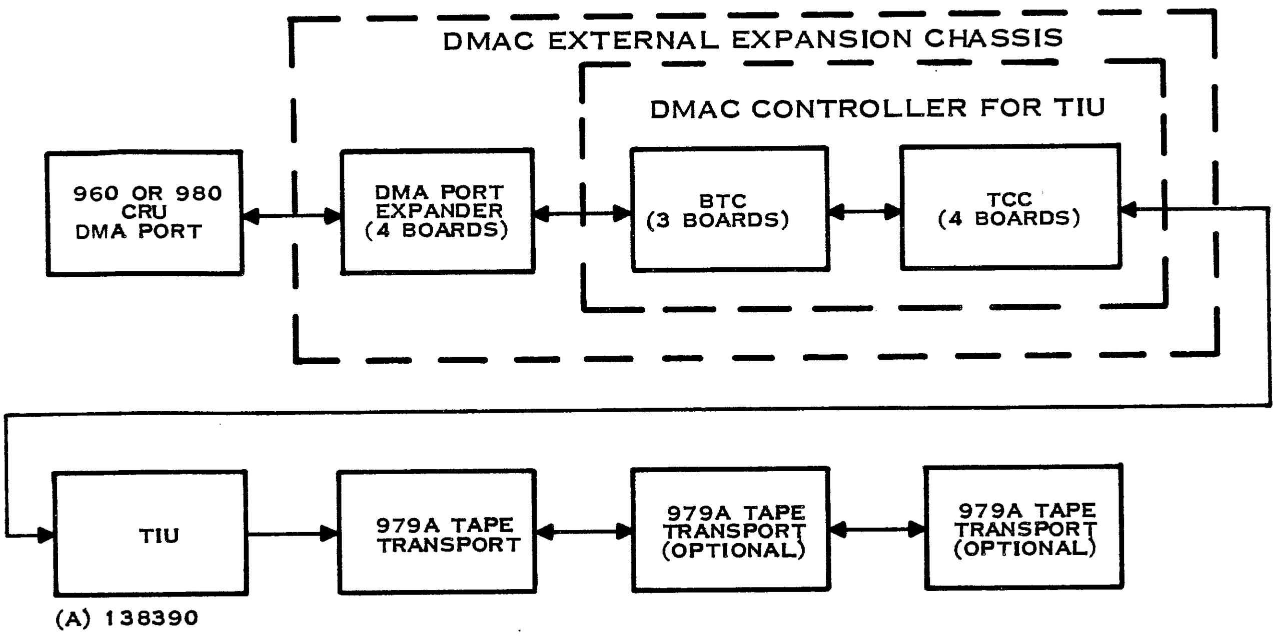


Figure 2-13. Block Diagram Showing Application of TCC

2.7.3 TAPE INTERFACE UNIT FUNCTIONAL DESCRIPTION. The TIU is a subsystem of a tape controller which handles all format dependent functions of the phase-encoded (PE) operation and control of up to three tape transports read/write electronics for 1600 bpi PE data format. An outline drawing of the tape interface unit is shown in figure 2-16.

2.7.4 BTC AND TCC CIRCUIT CARD LOCATIONS. Locations of BTC and TCC circuit cards in the DMAC external expansion chassis are shown in figure 2-17.

2.7.5 CHANNEL ADDRESS DATA (Block Transfer Controller #1). The channel address is set on the BTC #1 located in the DMAC external expansion chassis. Channel address is established on the wire-wrapped circuit boards by a wired, 14-pin platform. Refer to figure 2-18 for address data. The channel address for the multilayer printed wiring circuit boards is set by using either a rocker or a slide switch mounted on the circuit board. Refer to figure 2-19 for address data.

2.7.6 979A MAGNETIC TAPE SYSTEM, INTERCONNECTION CABLING. Figure 2-20 is an interconnection diagram for the PE format tape transport operating in a typical 960 or 980 computer system environment. Figure 2-21 is an expanded view of the connections.

2.7.7 960/980 SYSTEM CHECKOUT PROCEDURES FOR THE 979A TAPE TRANSPORT. Checkout procedures for 979A tape transport and interface/controllers are outlined in Section 5.

2.8 990 TILINE INTERFACE/CONTROLLERS, NRZI ONLY AND NRZI/PE
There are two types of interface/controllers that may be used between a Model 990 Computer and the 979A Tape Transport. One type may be used for operations involving NRZI recording/reproducing formats; the other for PE or NRZI formatted data. Both interface/controllers are described in the following paragraphs.

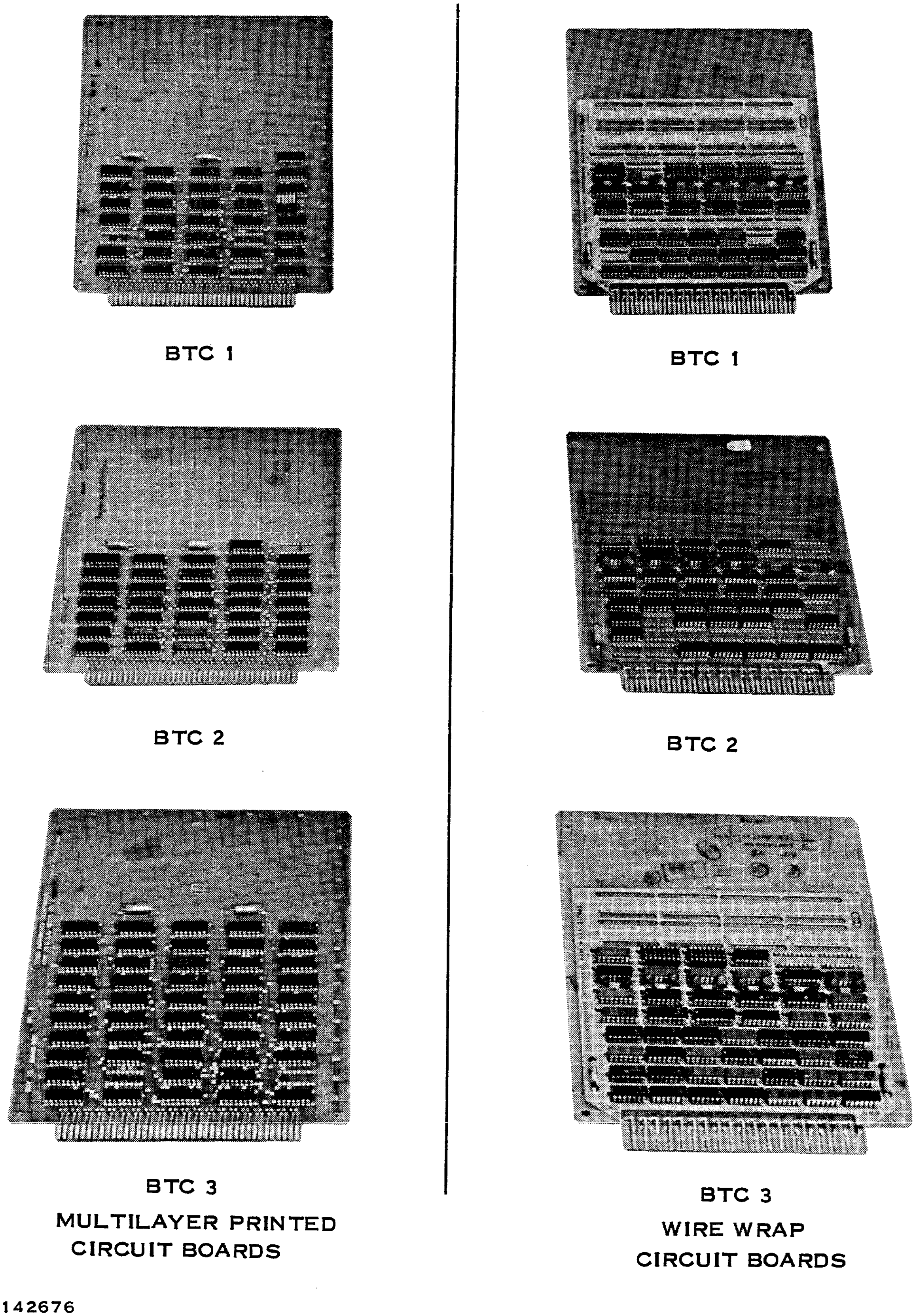
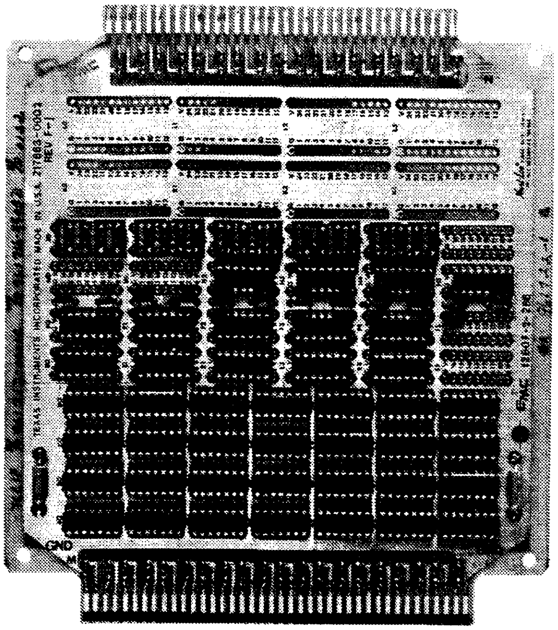
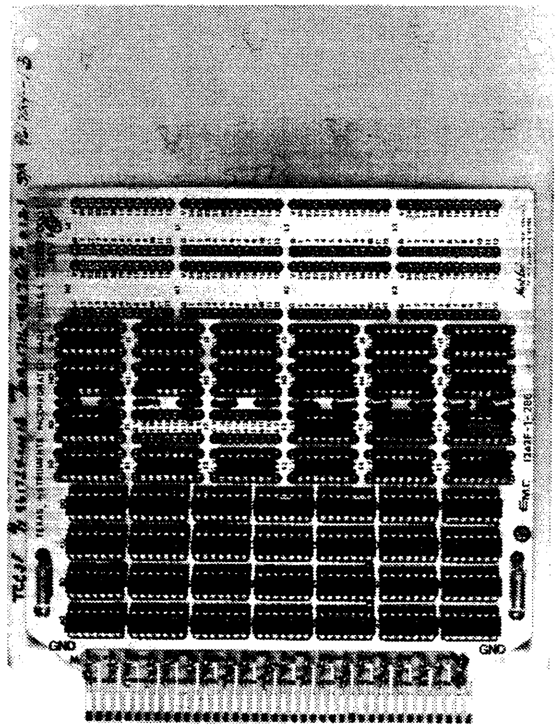


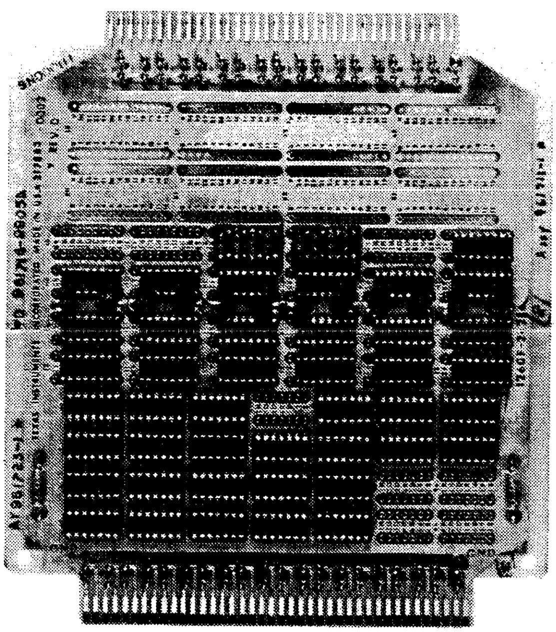
Figure 2-14. Block Transfer Controller



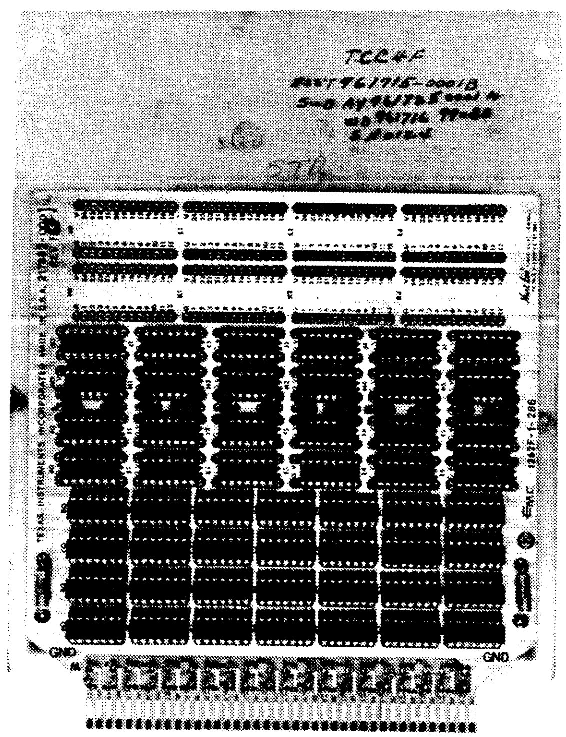
TCCI
PART NUMBER 961712-0001
(979A-1277-42-5)



TCC3
PART NUMBER 961714-0001
(979A-1277-42-7)



TCC2
PART NUMBER 961713-0001
(979A-1277-42-8)



TCC4
PART NUMBER 961715-0001
(979A-1277-42-11)

(A) 138280

Figure 2-15. Transport Command Controller

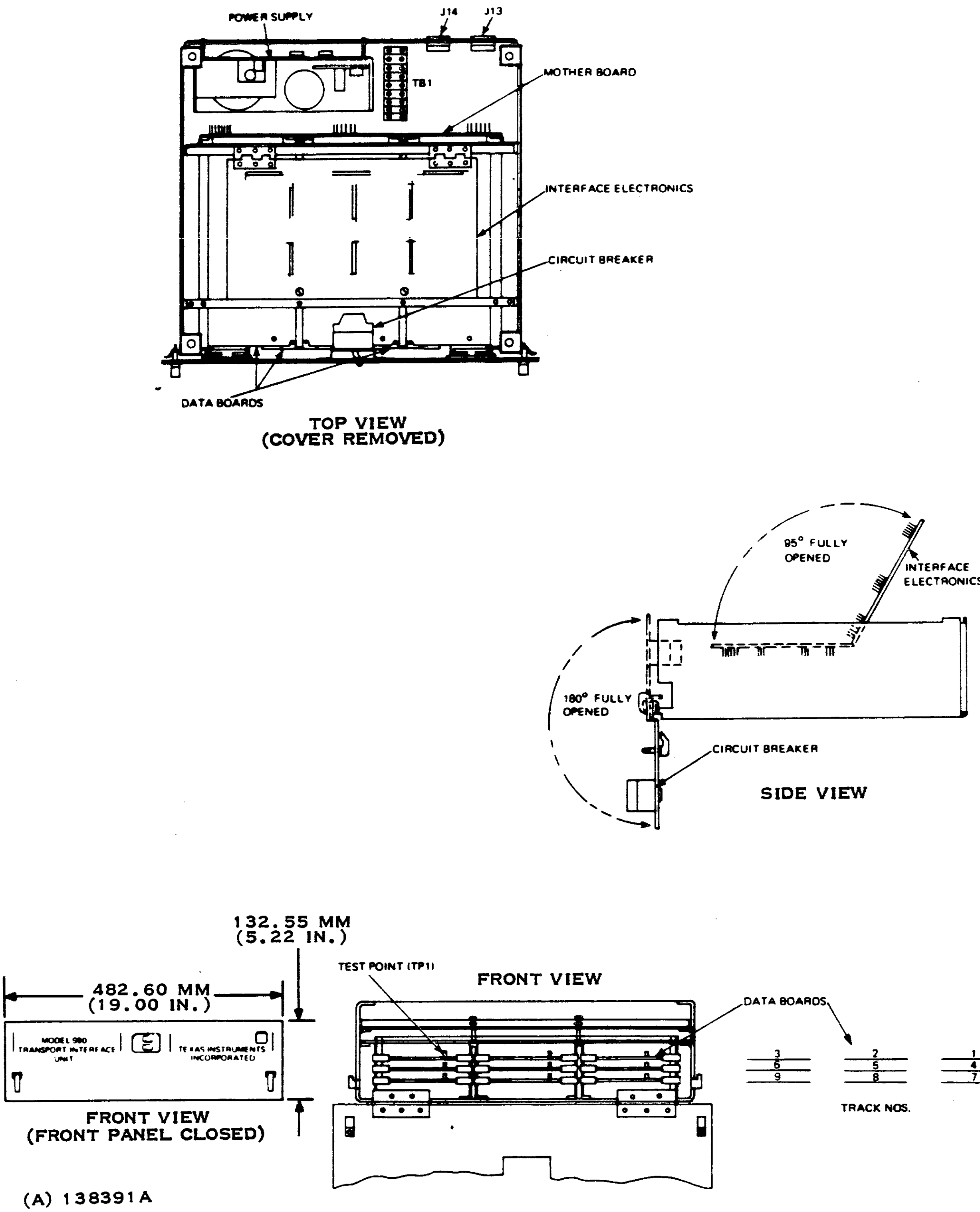


Figure 2-16. Model 990 Transport Interface Unit

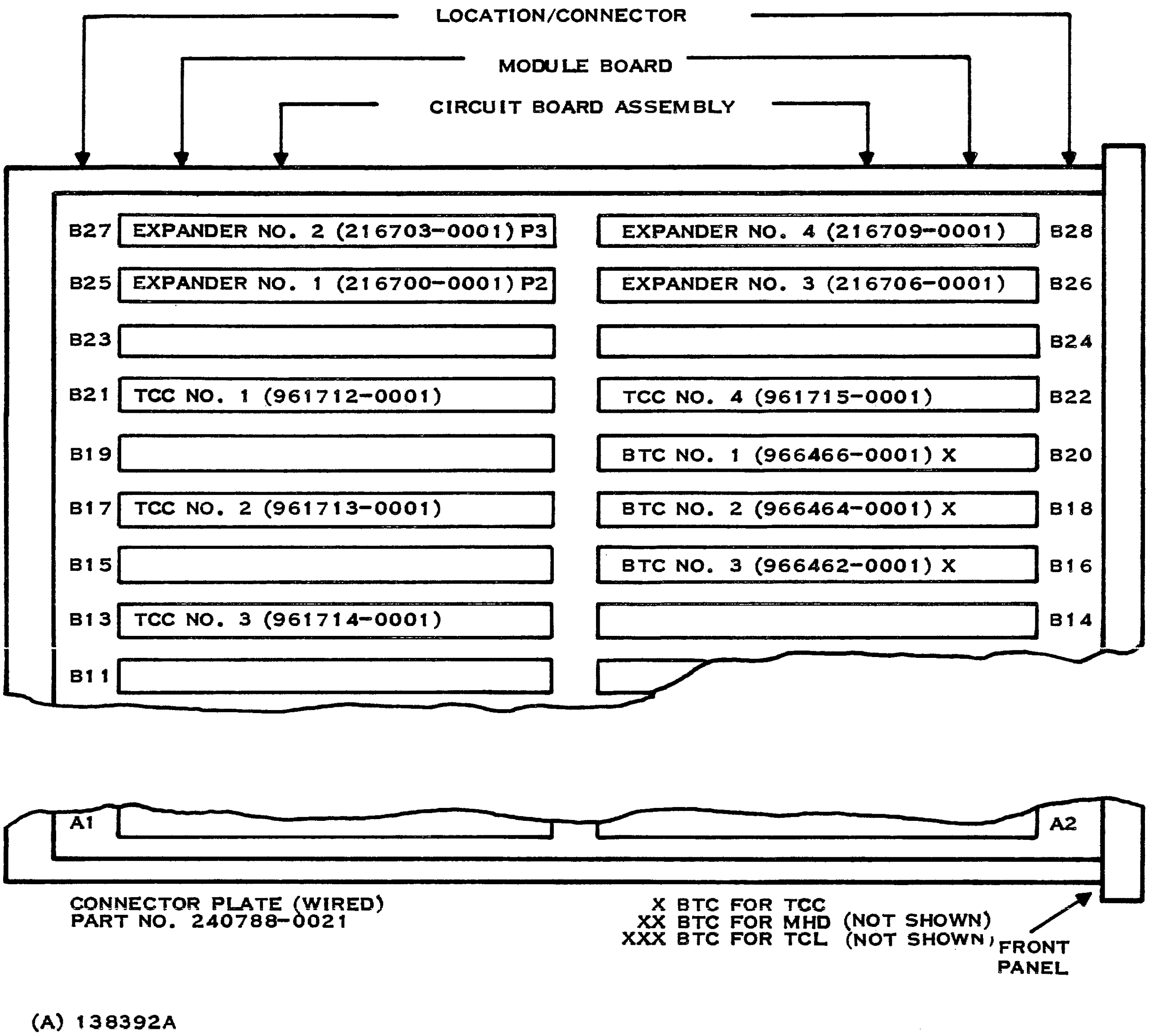
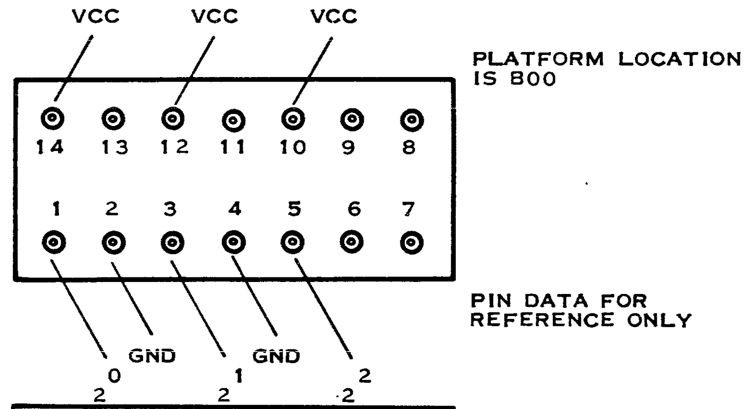


Figure 2-17. DMAC External Expansion Chassis 979A Tape System Interface/Controller, 960/980 PE Format

2.8.1 PREINSTALLATION PREPARATIONS. This paragraph describes preparations which are most conveniently performed before the units are mounted, especially if physical access is limited in the final location. These preparations fall into the following categories:

- 990/10 Chassis preparations
- TILINE magnetic tape controller preparation

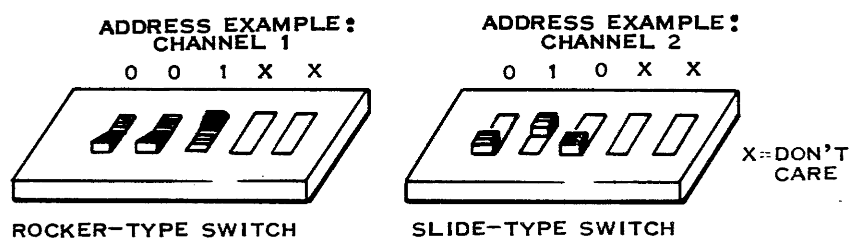
2.8.1.1 990/10 Computer Chassis Preparation for the TILINE Magnetic Tape Controller. This paragraph describes 990/10 chassis preparation which is unique to the TILINE magnetic tape controller. Comprehensive installation data for the 990/10 is located in *Model 990/10 Computer System Hardware Reference Manual,* part number 945417-9701.



ADDRESS PLUG WIRING			
CHANNEL NO.	CONNECTIONS		
0	1-14	3-12	5-10
1	1-2	3-12	5-10
2	1-14	3-4	5-10
3	1-2	3-4	5-10
4	1-14	3-12	5-6
5	1-2	3-12	5-6
6	1-14	3-4	5-6
7	1-2	3-4	5-6

(A)131414

Figure 2-18. Wire Wrapped Circuit Board Address Data



CHANNEL NUMBER	SWITCH SETTINGS				
	1	2	3	4	5
0	OFF	OFF	OFF	DON'T CARE	DON'T CARE
1	OFF	OFF	ON		
2	OFF	ON	OFF		
3	OFF	ON	ON		
4	ON	OFF	OFF		
5	ON	OFF	ON		
6	ON	ON	OFF		
7	ON	ON	ON		
NOTE: OFF = LOGIC 1; ON = LOGIC 0					

(A)131415A

Figure 2-19. Multilayer Circuit Board Address Data

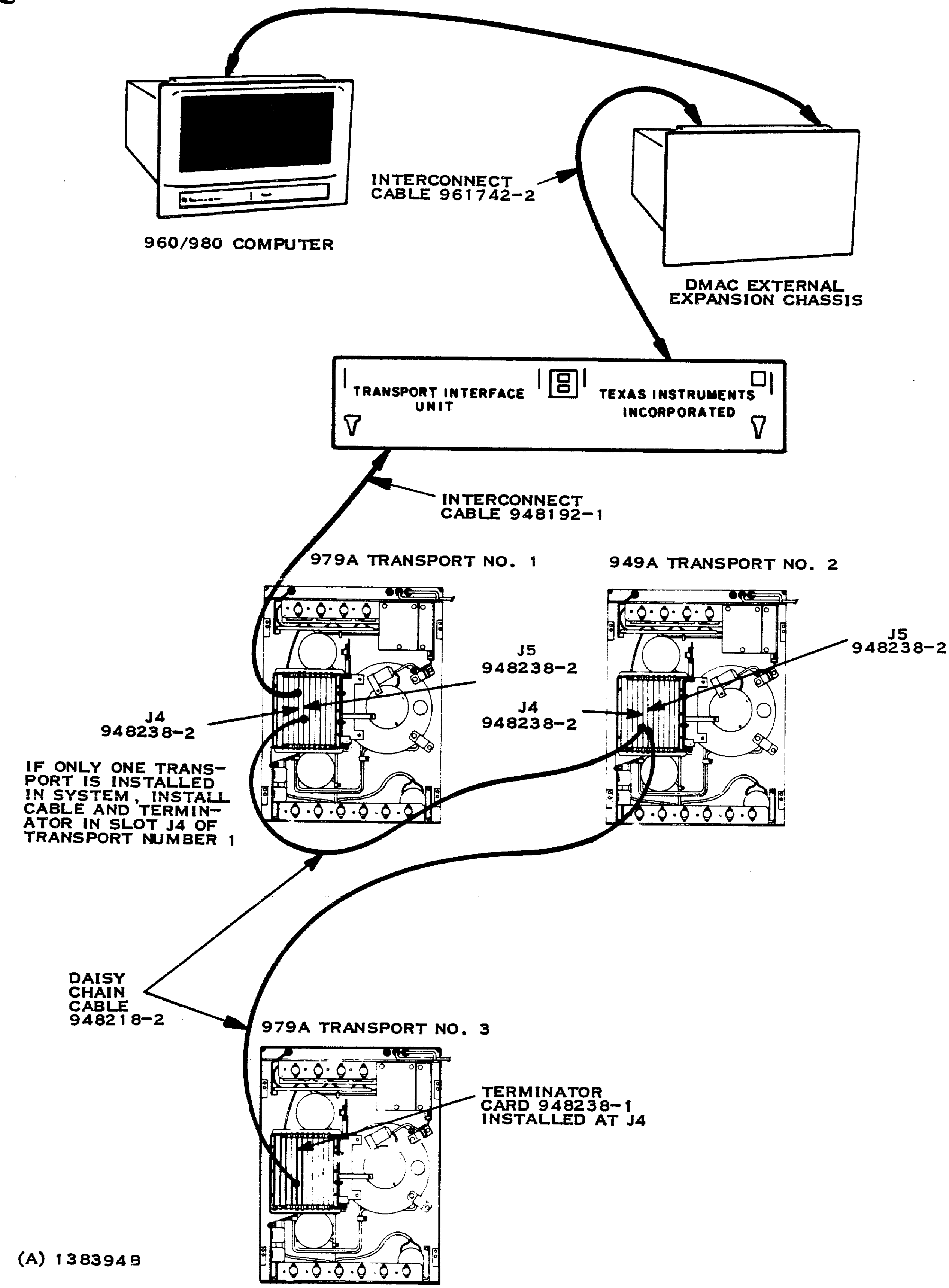


Figure 2-20. 979A Interconnection 960/980 System, PE Format

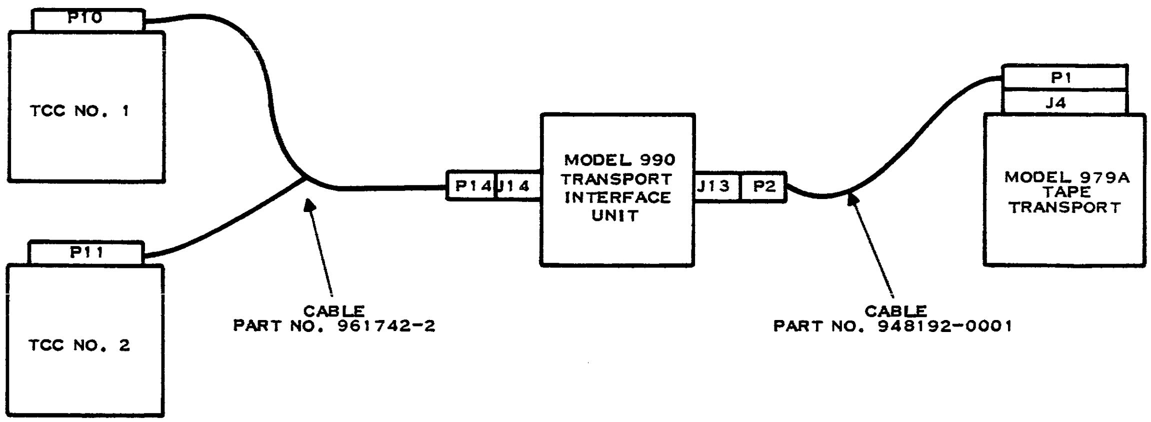


Figure 2-21. TCC-to-TIU-to-979A Interconnect Cabling

If the TILINE magnetic tape controller is shipped as part of a 990/10 Minicomputer System, much of this preparation is done at the factory. The controller will be assigned to a slot location (identified by a label on the chassis), the interrupt jumpers will be installed, and any backplane etch modifications will be incorporated. After the controller board switch settings are verified, the hardware will be compatible with the supplied software.

The next three paragraphs may be skipped if the TMTC was purchased as part of a complete 990/10 Minicomputer System.

2.8.1.2 Selecting a Chassis Slot for the TILINE Magnetic Tape Controller (TMTC). Chassis slot 8 (in a 13-slot chassis) is the first choice for the TMTC location, unless the factory has made another assignment or the location is unavailable for use. Slots 9 and 11 are the second and third choices, respectively. To select a compatible location in the computer chassis, it is helpful to know the general path of the TILINE access granted signals.

The TILINE is a common data path which is connected to all slot positions in the 990/10 chassis. Users of this bus fall into two major types, masters and slaves. Slave devices are addressed by master devices and commanded to accept or transmit data. Some TILINE peripherals, including the TILINE magnetic tape controller, have both master logic and slave logic.

In order to resolve conflicts between multiple masters contending for TILINE control, a positional priority scheme is used. The TILINE access granted signal which establishes positional priority among masters is wired along the P2 side of the chassis. The TILINE master installed in the highest numbered slot has the highest priority, with priority decreasing with each slot toward the central processor location (or slot 1).

The TILINE access granted signal from a higher priority master enters each master on P2, pin 6. The signal leaves the master on P2, pin 5. Logic on the master allows it to block the output to lower priority masters. Jumpers are installed on the backplane to assure line continuity across slots not occupied by TILINE masters. TILINE masters may be inserted at desired slot positions by removing the jumper between P2-5 and P2-6 (TILINE access granted) at the selected slot location.

Installing a board with TILINE master logic, such as the TMTC, requires that:

- The TILINE access granted jumper (P2-5 to P2-6) must be removed from the chosen slot.
- Continuity of the TILINE access granted lines between the highest priority master and the central processor board must be preserved. This means that if an intermediate slot is assigned to a TILINE master, that master must be installed to preserve continuity and to allow the priority system to function.

2.8.1.3 Preparing a Slot Location for the TMTC. Current production assemblies have the TILINE access granted jumpers accessible from the connector side of the motherboard when all boards are removed from the chassis. These jumpers are shown in figures 2-22 and 2-23. Simply remove the jumper plug (or cut the jumper, if the jumper is a wire) for the selected TMTC slot, and reinstall all circuit boards in their proper location. As noted previously, the continuity of the TILINE access granted line from the highest TILINE master to the central processor must be preserved. Therefore:

1. All slots other than those containing TILINE master controllers must have the TILINE access jumper installed.
2. All master controllers must be installed in their proper location.

If the chassis is an early production version (i.e., it does not have jumpers as shown in figures 2-22 or 2-23), it is necessary to remove the back cover and power supply to gain access to the TILINE access granted jumpers. For these chassis, the following steps should be followed:

1. Turn off power and unplug the ac line cord.

WARNING

Lethal voltages are exposed when the access cover is removed. Power supply capacitors may retain charges long after ac power is removed.

2. Remove the left access cover (as viewed from the front of the chassis). The cover is fastened by four or six hex head machine screens.
3. If the chassis is a 13-slot unit with a 20-amp power supply, slots 1 through 6 are visible above the power supply. To work on them, move ahead to step 5.
4. Remove the power supply as follows:
   a. Disconnect the color-coded connectors from the component side of the power supply board.
   b. Unscrew the machine screws and standoffs which secure the power supply to the frame and to the motherboard.
   c. Carefully pull the power supply board straight forward until the connector at the bottom center of the power supply board is disengaged from the pins protruding from the motherboard. Lift the power supply board out of the chassis.
5. The rear of the motherboard is now exposed. The P2 connectors are at the left side, closest to the fan. Refer to figure 2-24, which gives detailed views of the left end of the P2 connector in a 13-slot and a 6-slot chassis.

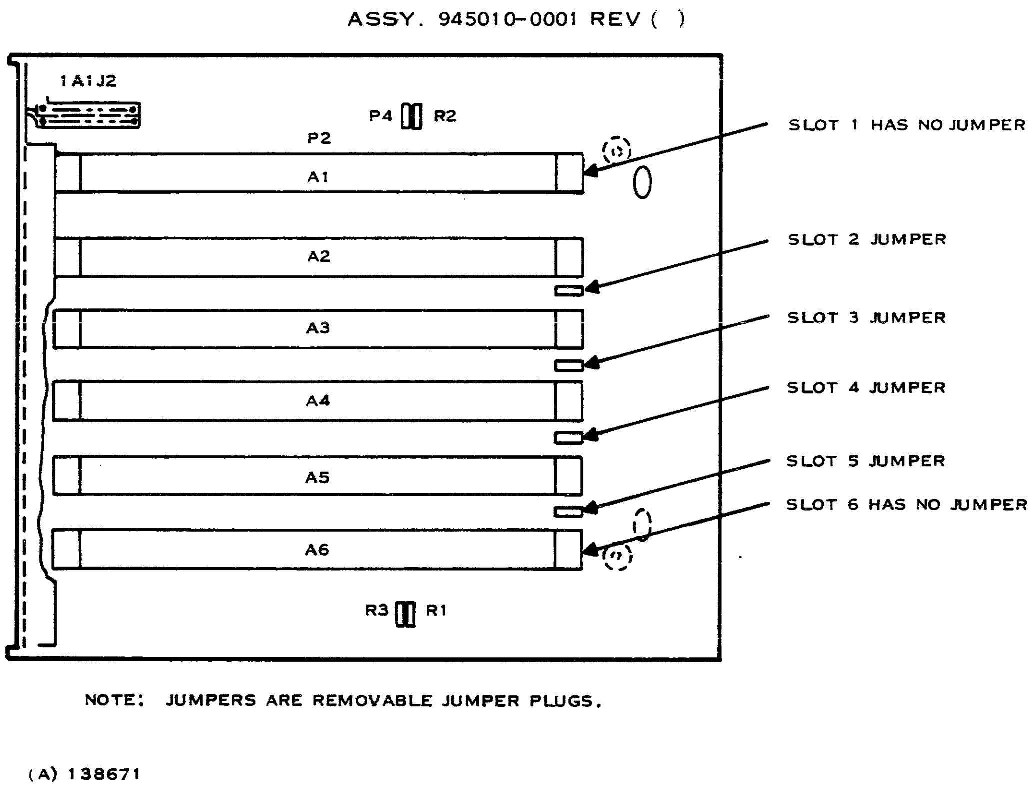


Figure 2-22. TILINE Access Granted Jumper Locations for 6-Slot Chassis (Current Production)

In a 13-slot chassis, the TILINE access granted jumpers (P2-5 to P2-6) are wire loops soldered to the connector pins, as shown in view A.

In a 6-slot chassis, the jumpers are part of the printed circuit board etch, as shown in view B. Note that pins 1 and 2 are concealed by the ground plane.

To remove a jumper in the 13-slot chassis, clip the wire loop in two places and remove the excess wire. To remove a jumper in the 6-slot chassis, cut the jumper etch at two points with an X-acto* knife and lift or scrape away the excess conductor.

To install a jumper, solder a short length of #26 AWG wire between P2-5 and P2-6.

6. To reinstall the power supply, proceed as follows:

CAUTION

The male pins protruding from the lower center of the motherboard are subject to bending if the mating connector on the power supply is not properly aligned with these pins.

*X-acto is a registered trademark of X-acto Corporation.

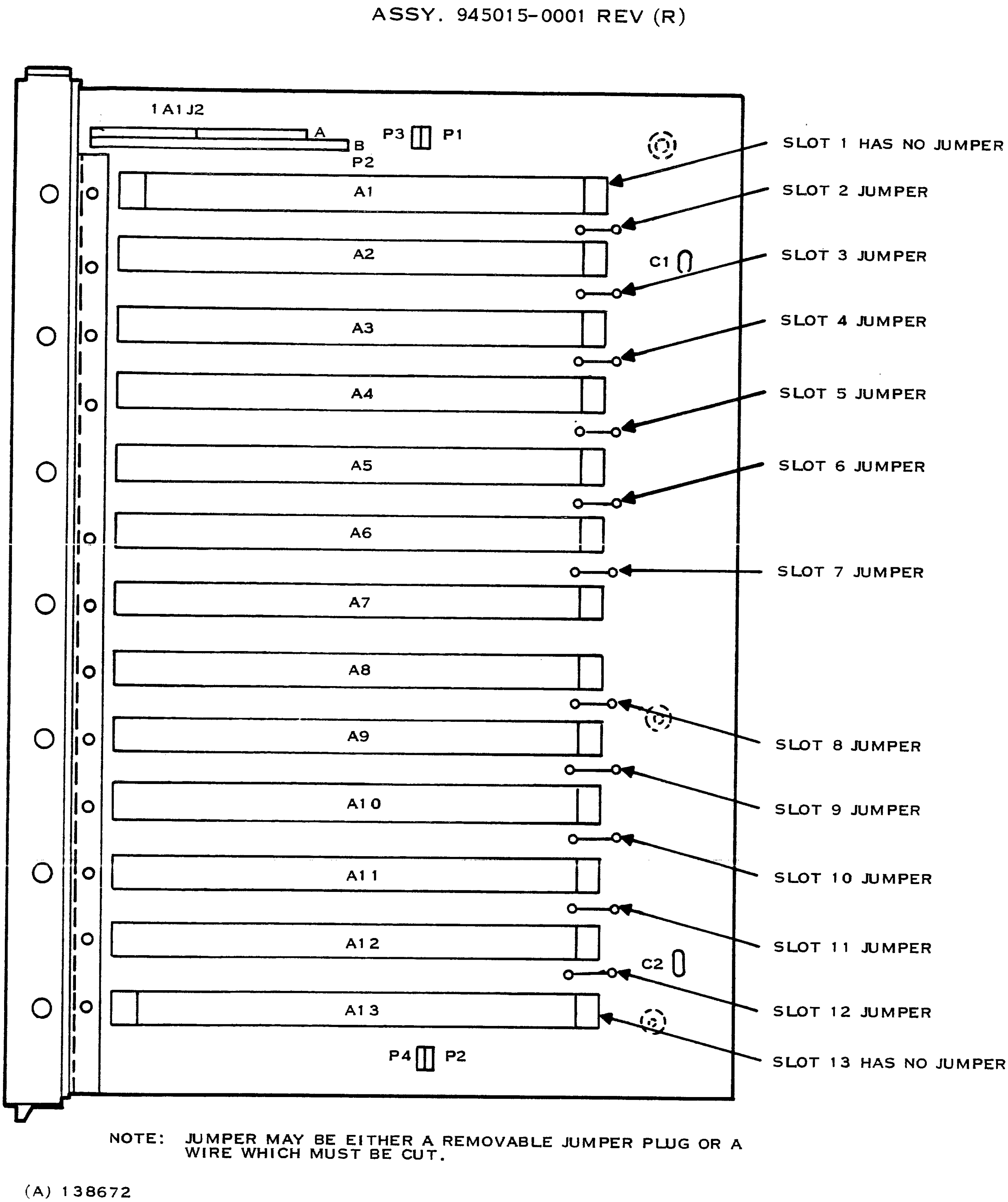


Figure 2-23. TILINE Access Granted Jumper Locations for 13-Slot Chassis (Current Production)

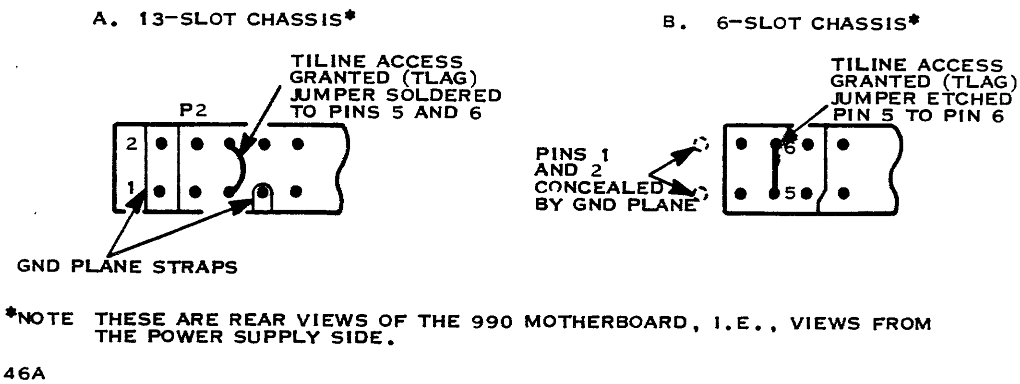


Figure 2-24. TILINE Access Granted Jumpers on the 990/10 Motherboard

a. Slip the power supply over the cable harness and into the side of the chassis. The metal-shell jumper connector (for the standby power supply) should appear at the bottom center of the power supply board.

b. Align the power supply circuit boards on the two alignment pins and *carefully* slide the board straight back so that the pins protruding from the motherboard slip into the connector on the power supply circuit board. View of these pins is blocked by the power supply board.

c. Reinstall the machine screws and standoffs which hold the power supply in place. Do not omit the lockwashers, as both mechanical and electrical connections are made by the machine screws and standoffs.

d. Reconnect the power supply to the wiring harness by installing the color-coded plastic connectors.

7. Replace the access cover.

2.8.1.4 Interrupt Connections. Interrupt connections required to interface peripheral equipment to the 990/10 processor are usually made before the system is delivered to the customer. These interrupt assignments are coordinated with the software supplied with the system. However, if a controller, such as the TMTC, is not purchased as part of a system, the user may have to make the interrupt connections as part of the board installation. Standard Texas Instruments software expects to find the TILINE magnetic tape controller interrupt assigned to interrupt level 9, which is connected to slot 8 in the standard chassis configuration. If the controller is installed in slot 9 or 11, the interrupt jumpers will have to be changed, or a different interrupt level assigned to the software.

The 990/10 processor has 16 interrupt levels, numbered 0 through 15. Interrupt level 0, which is internal to the processor, has the highest priority. Interrupt levels 3, 4, and 6 through 15 are external inputs which are available for assignment to peripheral controllers installed in the chassis. Interrupt level assignments must be coordinated with the software, so that the processor may correctly respond to (and clear) the interrupts.

Chassis backplane wiring brings the interrupt output lines from slots 2 through 13 and the processor interrupt inputs lines to wire-wrapped pin headers adjacent to slot 1. Jumper wires between the pins connect the circuit board interrupt outputs to the processor interrupt inputs. These jumpers may run directly from pin-to-pin, or may be mounted on jumper plugs which slip over the pins. Figure 2-25 shows the jumper plugs installed in the chassis. The jumper wires are omitted for clarity.

There are two rows of pins in the header. The top row has 15 pins connected through the motherboard to the 15 interrupt levels of the processor. Additional pins on the top row are provided in the 13-slot chassis for special configurations such as CRU expansion. The bottom row contains 48 pins in a 13-slot chassis or 20 pins in a 6-slot chassis. Two of these pins are wired to each of the possible circuit board interrupt outputs. This allows multiple interrupts to be connected to one interrupt level.

Interrupt pin assignments are shown in figures 2-26 and 2-27, which is a view of the jumper plugs as seen from the jumper wire side. The X marks identify jumper plug positions which have no corresponding pins on the header. The O marks identify jumper plug positions which have no corresponding pins on the early production header.

The configuration chart on top of the chassis details the interrupt level and chassis slot assignments. Any modifications should be recorded on the chart.

The detailed procedure for assigning and changing interrupt levels is presented in *Model 990/10 Computer System Hardware Reference Manual,* part number 945417-9701. The information presented here is a brief summary of that procedure.

CAUTION

Do not remove or install any circuit board or modify any jumper while power is applied to the 990/10.

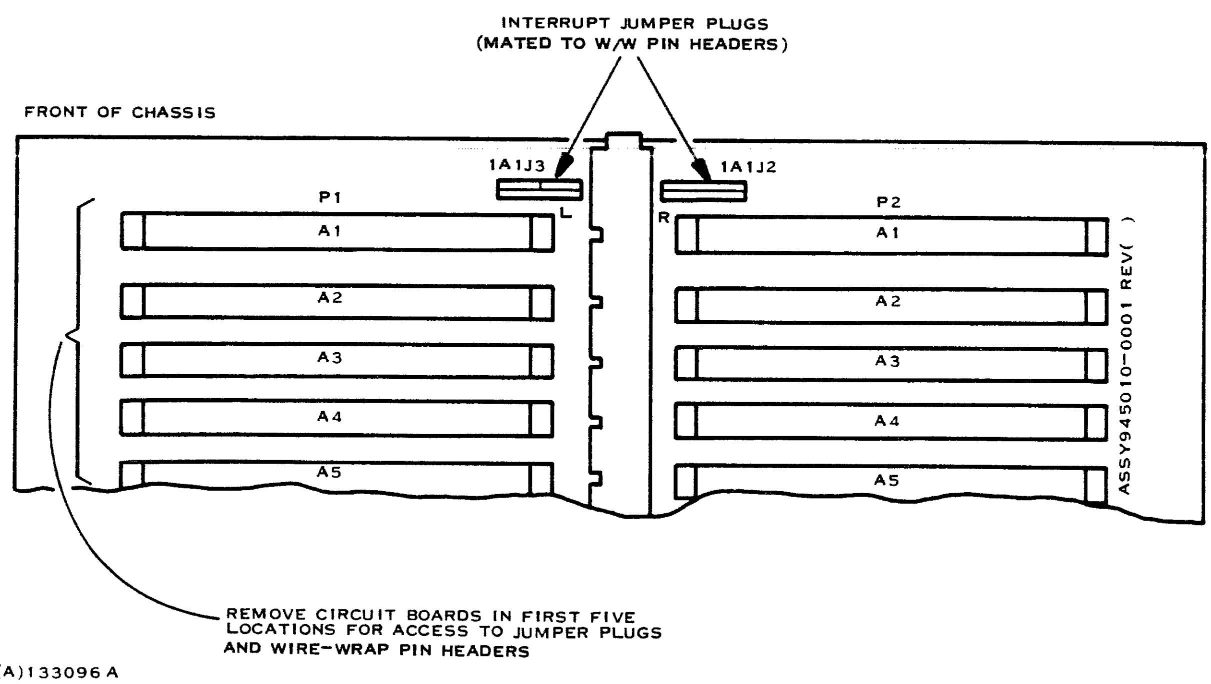


Figure 2-25. Location of Interrupt Jumpers (6 and 13-Slot Chassis)

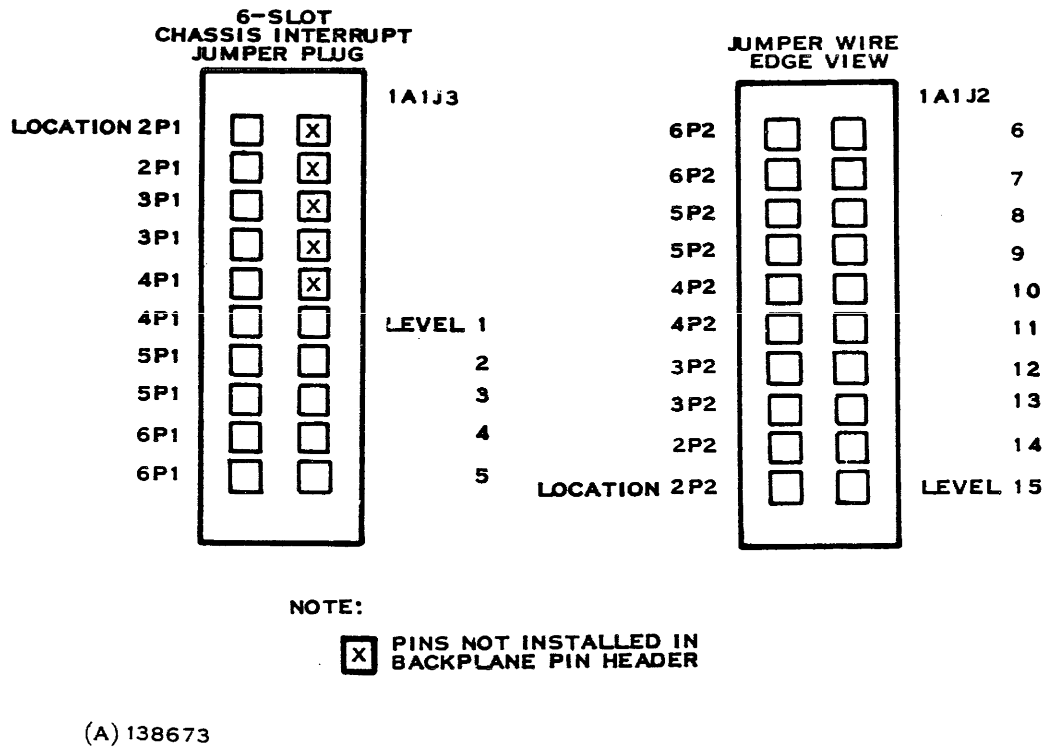


Figure 2-26. 6-Slot Interrupt Jumper Plugs

To gain access to the interrupt jumpers, remove the circuit boards installed in slots 1 through 5. The interrupt jumpers will be visible on the motherboard just above the slot 1 connectors. The interrupt output of a full-sized board, such as the TMTC, is on P2 of the assigned slot location. Therefore, if slot 8 is chosen for the TMTC, the interrupt output will be found at 8P2 of the wire-wrapped pin header. A single jumper should be run from 8P2 pin to the selected interrupt level input to the processor. Level 9 is standard for Texas Instruments tape control software. A jumper is installed between 8P2 and level 9 as part of the standard 990 chassis configuration.

After completing any interrupt jumper modifications, carefully reinstall the removed circuit boards (component side up) according to the configuration chart fastened to the top of the computer. Update the configuration chart to correspond to the interrupt jumper modifications.

NOTE

System software is highly dependent on the interrupt structure of the computer. Any deviations from standard interrupt configurations must be brought to the attention of the system programmer before or during software installation.

2.8.1.5 NRZI TILINE Magnetic Tape Controller Preparations. Figure 2-28 is a photograph of the basic NRZI version of the TMTC printed wiring board (PWB) circuit board, part number 2261630; figure 2-29 is a photograph of the basic NRZI version of the TMTC multiwire (MW) circuit board, part number 947555. Connectors J5 and J6, which mate with the controller/transport cable, are on the top left edge of the circuit boards, as viewed from the component side.

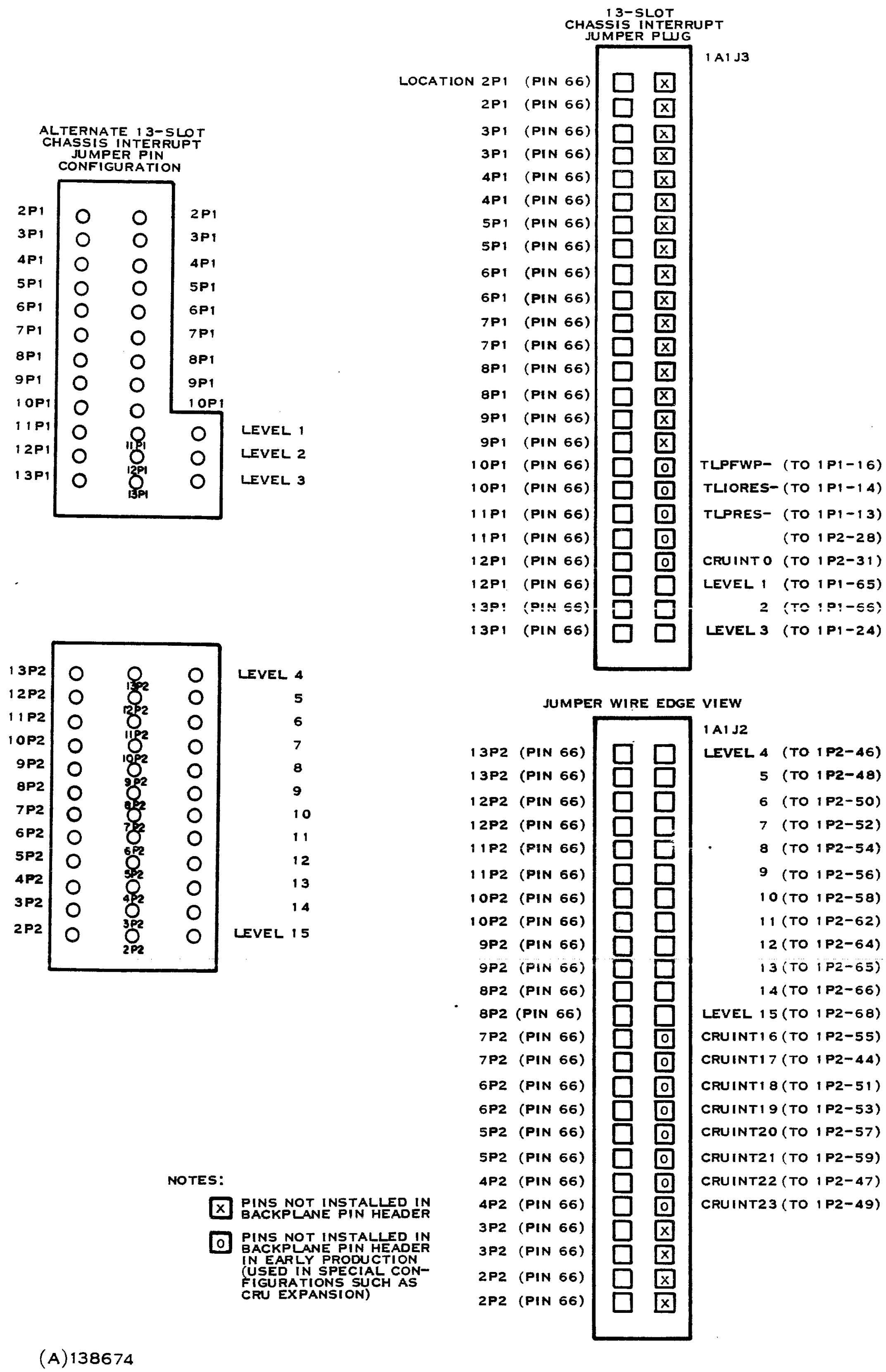


Figure 2-27. 13-Slot Chassis Interrupt Jumper Plugs

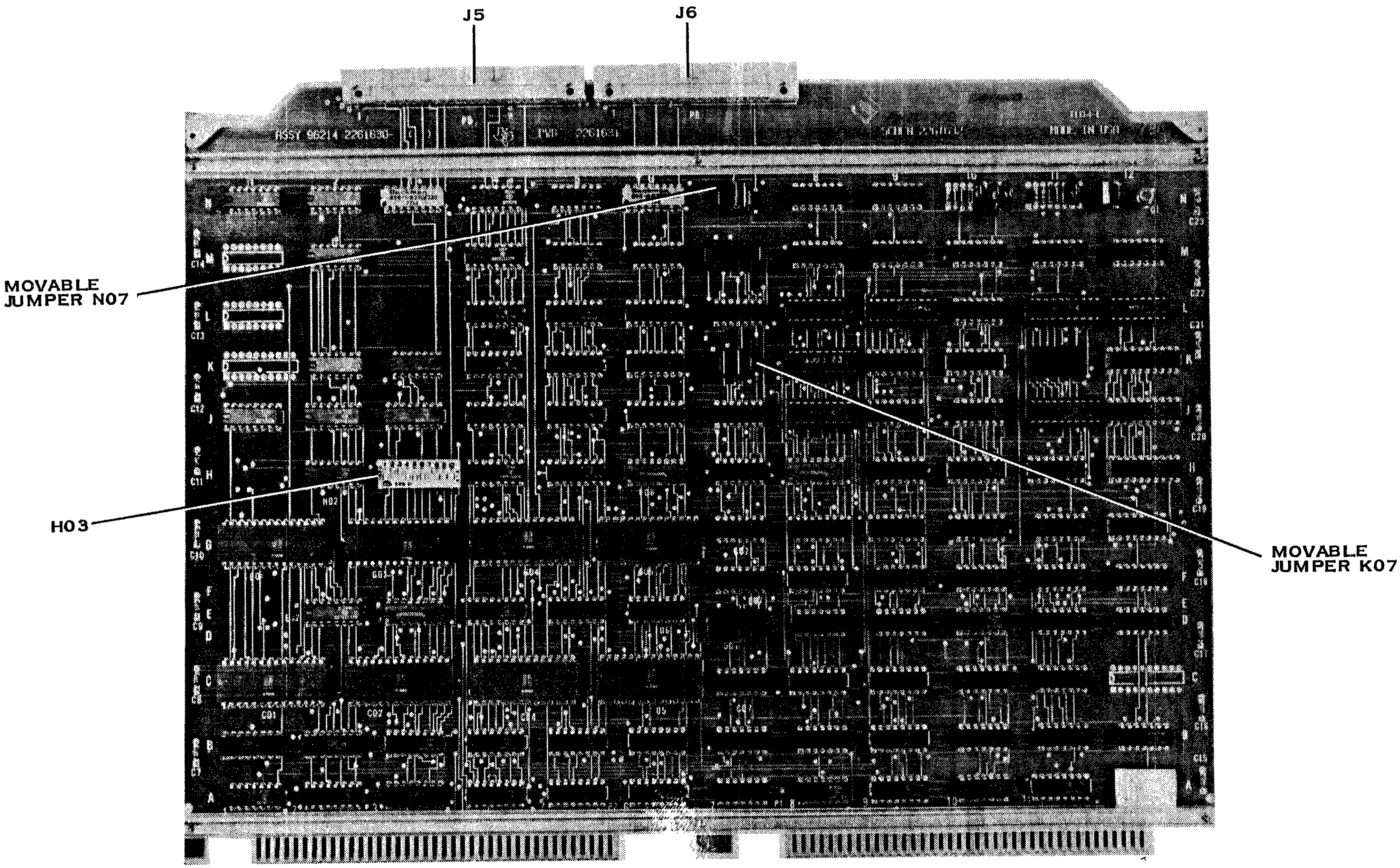


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Figure 2-28. TILINE Magnetic Tape Controller (NRZI), PWB

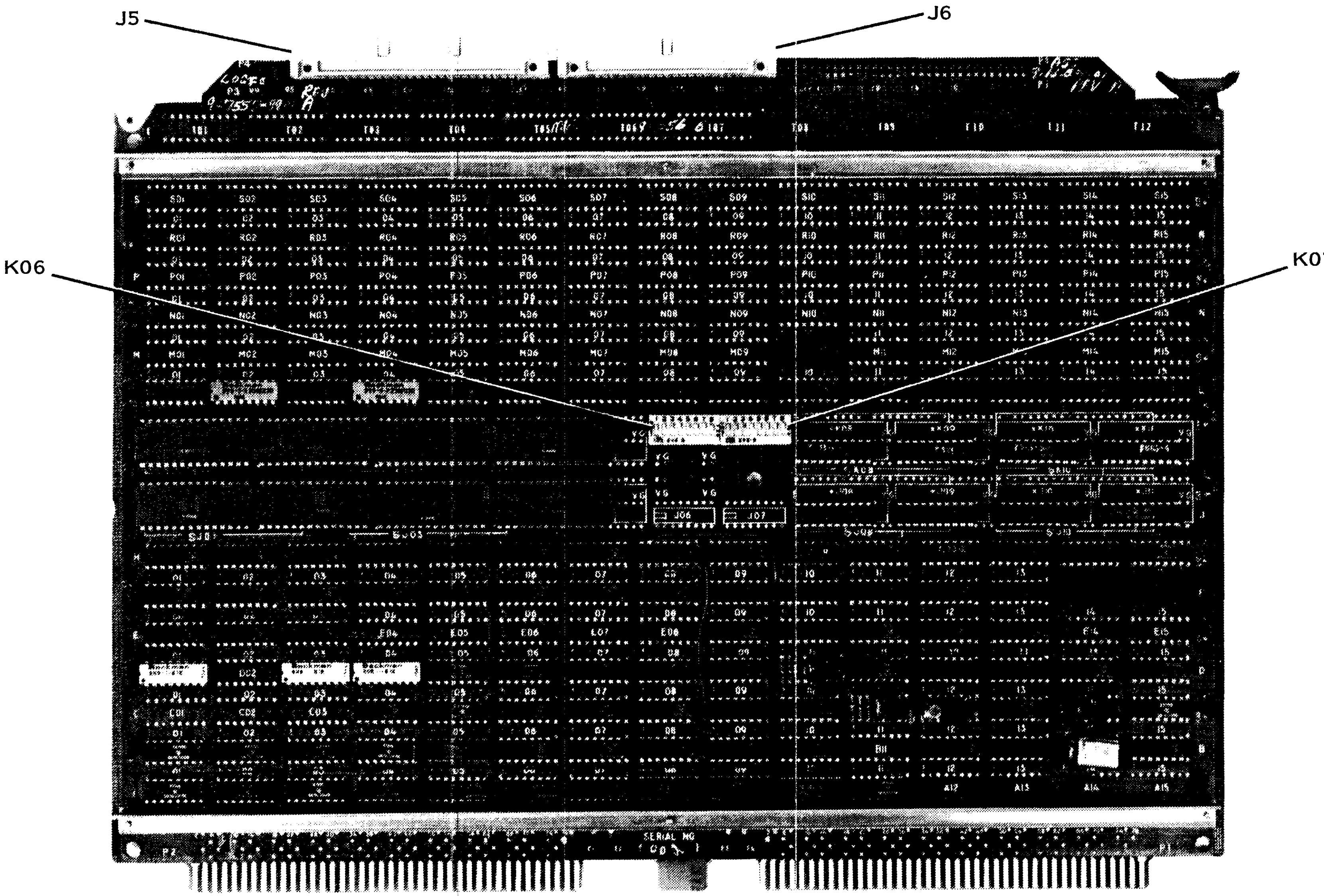

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Figure 2-29. TILINE Magnetic Tape Controller (NRZI), MW

On the NRZI PWB controller board, there is one DIP (dual in-line package) switch module located at H03; on the NRZI MW controller board, there are two DIP switch modules, one at K06 and one at K07. Figures 2-30 and 2-31 show the correct settings for these switches. They must be manually set up prior to operation. Even if the tape system was purchased as part of the 990/10 Minicomputer system, the switch settings must be verified because the switch settings may have been changed during the packing, shipping, or unpacking stages.

The NRZI PWB controller board has two groups of movable jumpers; one group is located at K07 and the other is located at N07 (see figure 2-28). Figure 2-32 shows the jumper configuration at each location. The NRZI MW controller board has no movable jumpers.

The DIP switch settings fall into four basic categories:

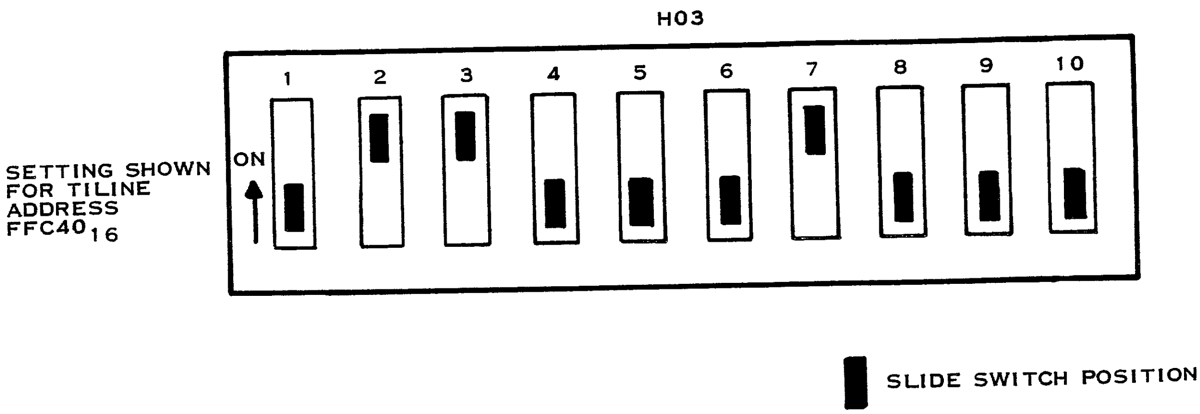
- TILINE base address (PWB and MW)
- 990/10 computer selection (PWB and MW)
- Tape speed (MW only)
- Transport types: 800/1600 bpi (MW only)

Setting NRZI Controller TILINE Base Address Switches. The controller must be assigned a TILINE base address so that the 990/10 processor can control the TMTC. There are eight individual 16-bit TILINE words which the processor can write to, or read from, the TILINE slave logic of the TMTC. Each of these words is assigned a unique address in the TILINE address space. These word addresses run sequentially from the TILINE base address to the base address +7 word addresses.

The TILINE base address assignment for the controller must be coordinated with the operating software. Standard Texas Instruments software expects to find the TMTC at TILINE base address $FFC40_{16}$, which corresponds to CPU byte address $F880_{16}$. The tables illustrated in figures 2-30 and 2-31 show how to set the address switches on the board to $FFC40_{16}$. Other address settings should not be used except on advice from an authorized Texas Instruments' representative, or as specified as part of the system package.

Additional TILINE information may be found in the *990 Computer Family Systems Handbook,* part number 945250-9701 and *Model 990/10 Computer System Hardware Reference Manual,* part number 945417-9701.

Setting the Other NRZI Controller Switches. The first three switch positions at H03 for the PWB (at K07 for the MW; see figures 2-30 and 2-31) adapt the NRZI controller board to 990/10 timing and power failure reset signals. The mandatory positions for these three switches are indicated on the figure. The heavy black line identifies the position of the slide switch.



HEXADECIMAL ADDRESS		TILINE ADDRESS SWITCHES									
TILINE	CPU BYTE	1	2	3	4	5	6	7	8	9	10
FFC40	F880	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
FFC48	F890	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
FFC00	F800	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF

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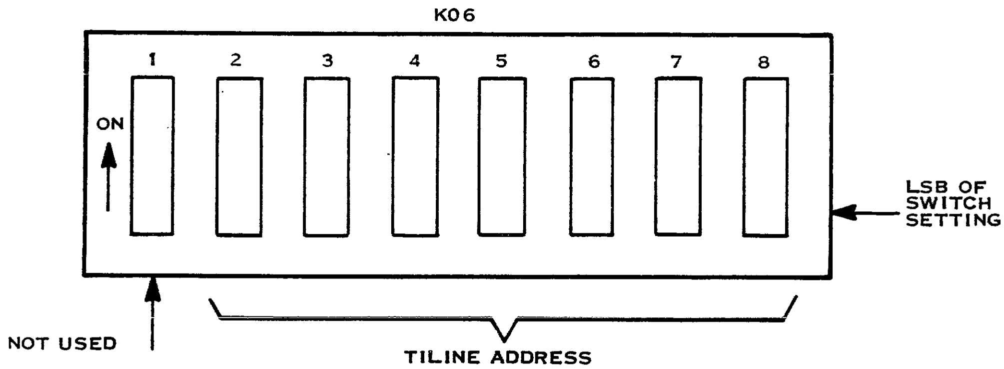
Figure 2-30. NRZI Tape Controller Switch Settings, PWB



HEXADECIMAL ADDRESS		TILINE ADDRESS SWITCHES							
TILINE	CPU BYTE	1	2	3	4	5	6	7	8
FFC40	F880	X	OFF	OFF	OFF	ON	OFF	OFF	OFF
FFC48	F890	X	OFF	OFF	OFF	ON	OFF	OFF	ON

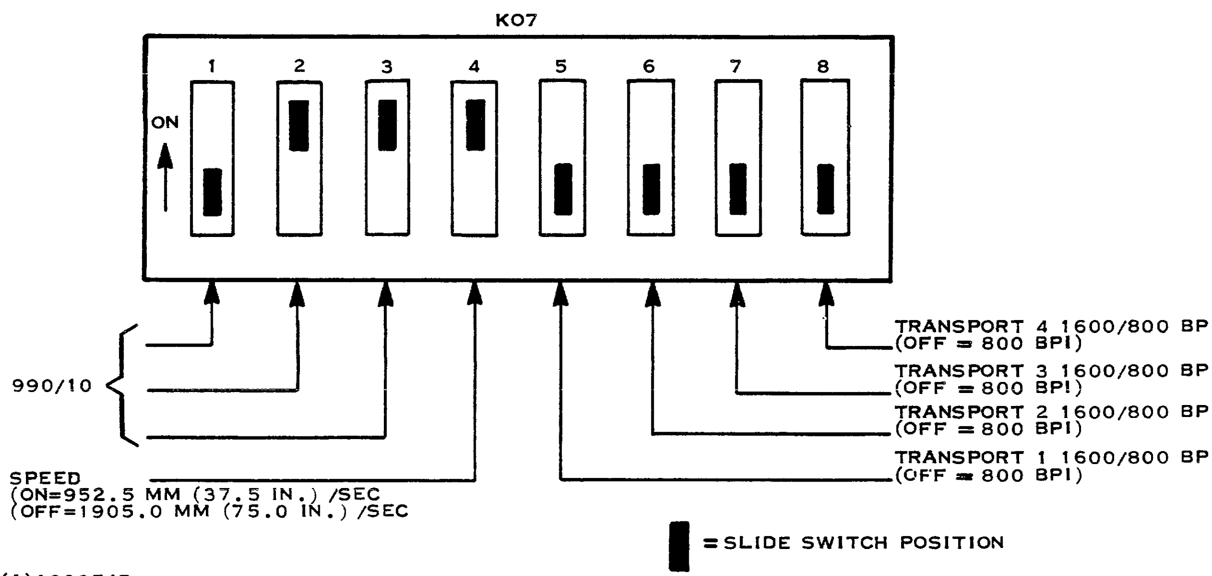


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Figure 2-31. NRZI Tape Controller Switch Settings, MW

NOTE

The remainder of this paragraph discusses only the MW switches 4 through 8 because PWB switches 4 through 10 are TILINE base address switches which are discussed in the preceding paragraph.

Switch section 4 of K07 must be ON for the 952.5 mm (37.5 inches) per second speed of the standard 979A magnetic tape transports.

Switch sections 5, 6, 7, and 8 are the type selection switches for transports 1, 2, 3, and 4, respectively. The possible type selections for a transport are:

ON = 1600 bpi, PE

OFF = 800 bpi, NRZI

In a multiple transport daisy chain configuration, transport 1 is the transport closest to the controller and transport 4 is the last transport in the daisy chain. NRZI and PE transports may not be mixed in the daisy chain, unless the 800/1600 bpi TMTC is installed.

In a single transport system, the type selection switch for transport 1 must be set to correspond to the transport type. The remaining three type selection switch settings may be either ON or OFF in this case.

2.8.1.6 PE/NRZI TILINE Magnetic Tape Controller Preparations. Figure 2-33 is a photograph of the PE/NRZI version of the TMTC PWB circuit board, part number 2261635; figure 2-34 is a photograph of the PE/NRZI version of the TMTC MW circuit board, part number 948990. Connectors J5 and J6, which mate with the controller/transport cable, are on the top left edge of the circuit board. There is a single DIP switch module, located at K08 on the PWB (at K07 on the MW), on the PE/NRZI controller board.

The switch module contains eight SPST slide switch sections, as shown in figure 2-35. These switches must be manually set up prior to operation. Even if the tape system was purchased as part of the 990/10 minicomputer system, the switch settings must be verified because the switch settings may have been changed during the packing, shipping, or unpacking stages.

The DIP switch settings fall into three basic categories:

- 990/10 computer selection
- TILINE base address
- Transport types (800/1600 bpi)

The first three switch positions at K08 for the PWB (at K07 for the MW) adapt the controller board to 990/10 timing and power failure reset signals. The mandatory positions for these three switches are indicated in figure 2-35. The heavy black line identifies the position of the slide switch.

Switch section 4 selects the TILINE base address so that the 990/10 processor can control the TMTC. There are eight individual 16-bit TILINE words which the processor can write to, or read from, the TILINE slave logic of the TMTC. Each of these words is assigned a unique address in the TILINE address space. These words addresses run sequentially from the TILINE base address to the base address +7 word addresses.

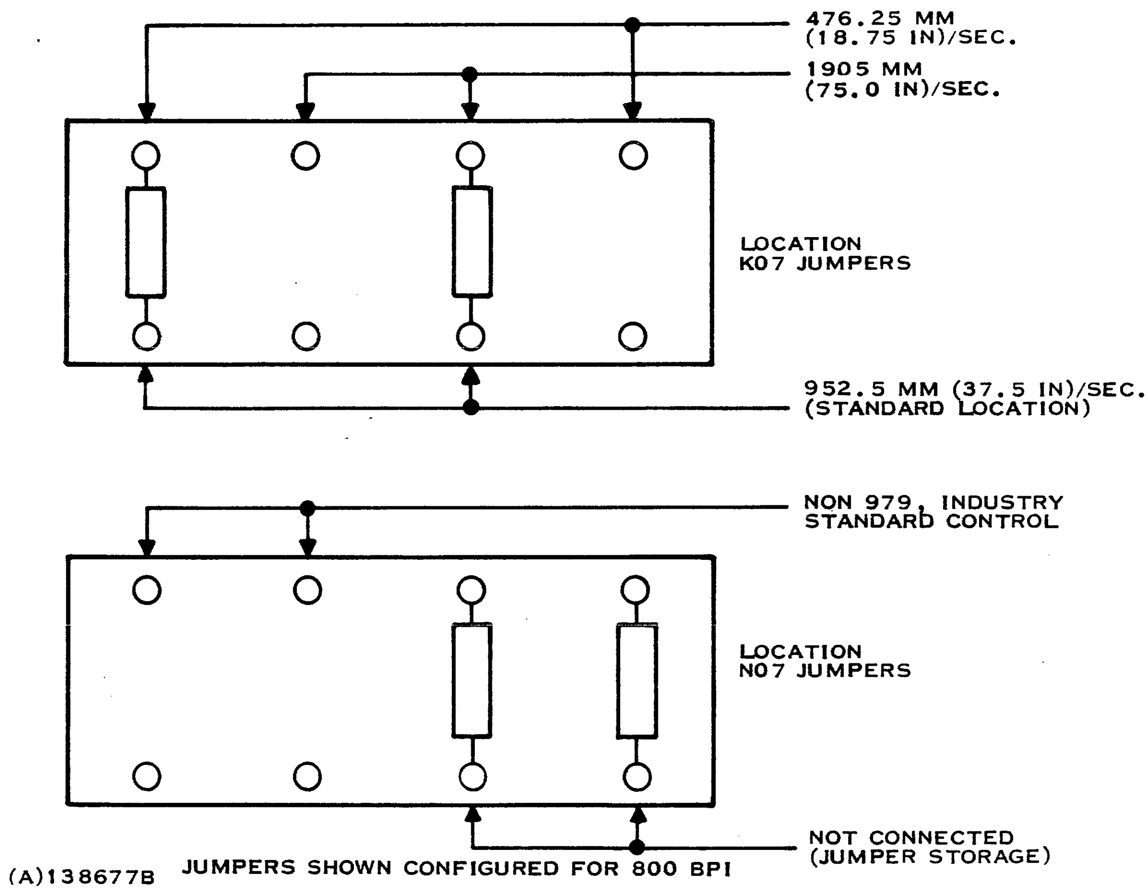

Figure 2-32. NRZI Tape Controller Movable Jumper Configuration, PWB

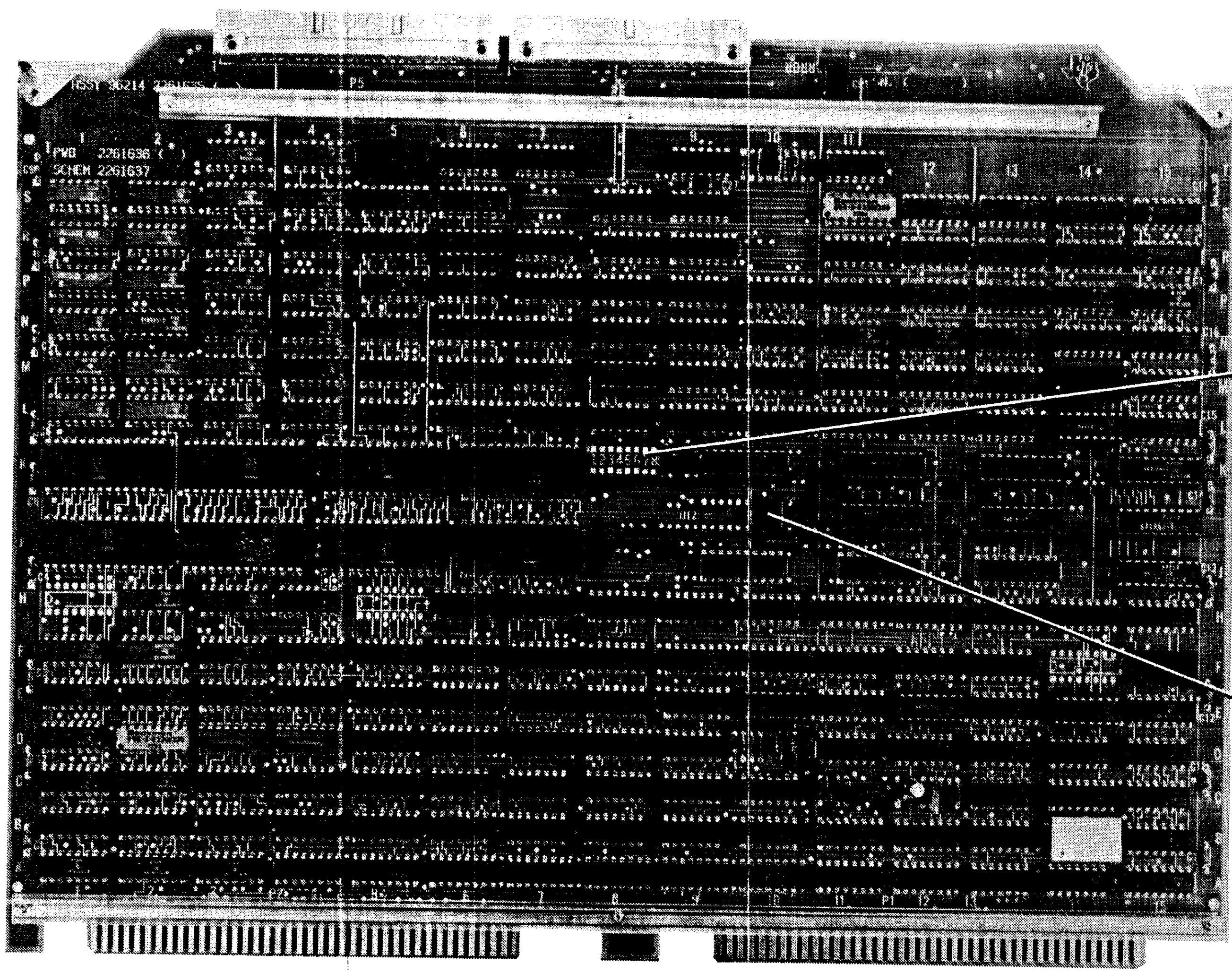

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Figure 2-33. TILINE Magnetic Tape Controller (PE/NRZI), PWB

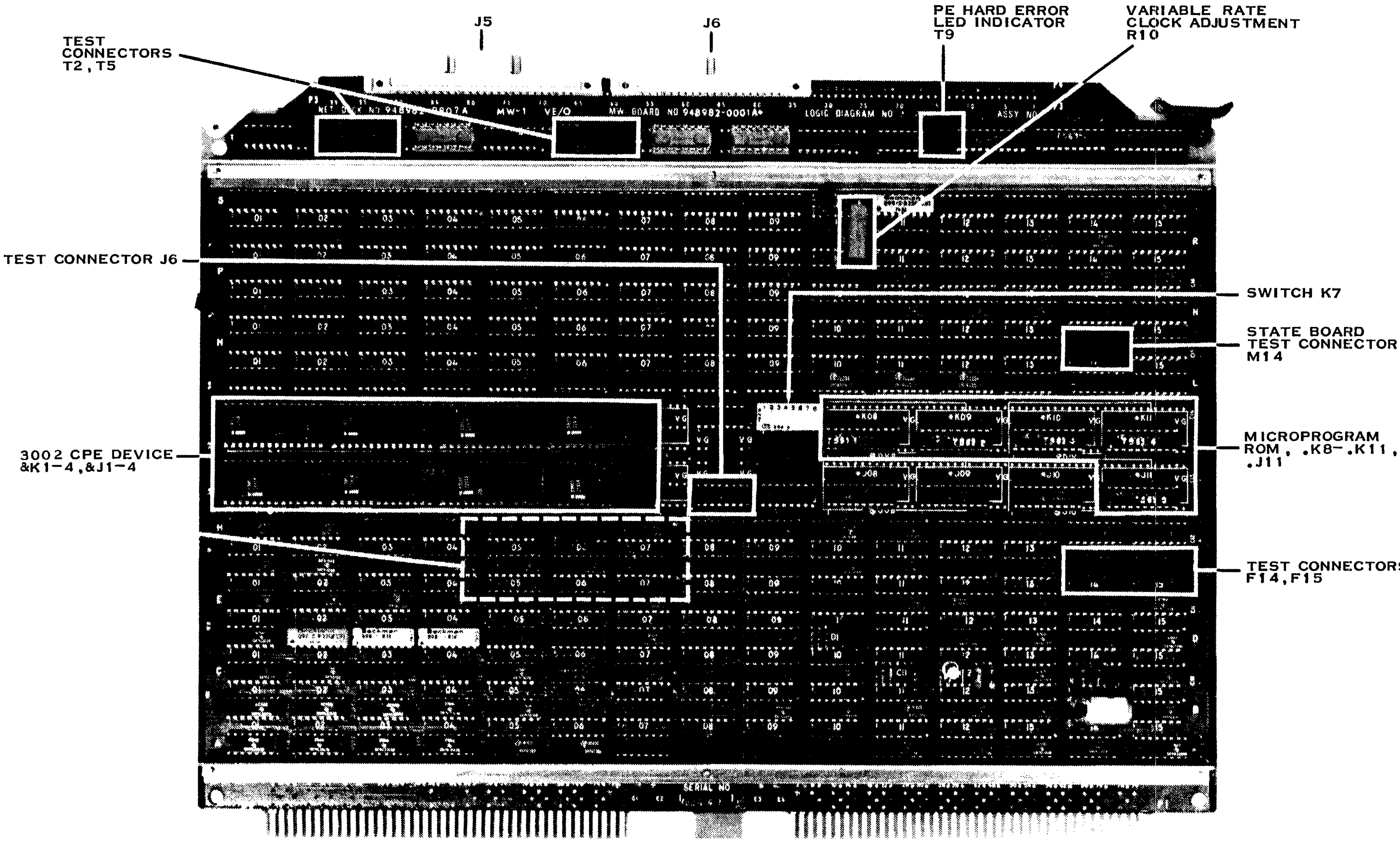

Figure 2-34. TILINE Magnetic Tape Controller (PE/NRZI), MW

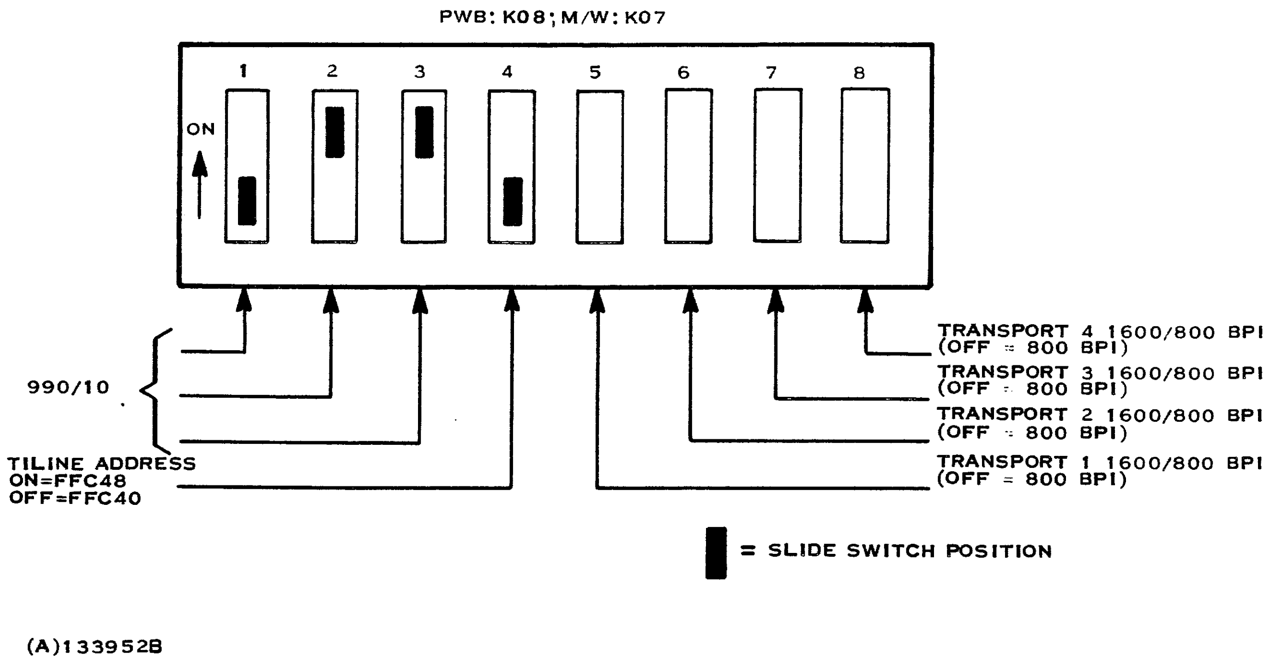

Figure 2-35. PE/NRZI Tape Controller Switch Settings

The TILINE base address assignment for the controller must be coordinated with the operating software. Standard Texas Instruments software expects to find the TMTC at TILINE base address $FFC40_{16}$, which corresponds to CPU byte address $F880_{16}$.

If two magnetic tape controllers are installed in a system, standard software expects to find the second controller at TILINE base address $FFC48_{16}$, which corresponds to CPU byte address F890.

Switch section 4 allows selection of TILINE base address FFC40 (OFF) or FFC48 (ON).

Additional TILINE information may be found in the *990 Computer Family Systems Handbook*, part number 945250-9701 and *Model 990/10 Computer System Hardware Reference Manual*, part number 945417-9701.

Switch sections 5, 6, 7, and 8 are the type selection switches for transports 1, 2, 3, and 4, respectively. The possible type selections for a transport are:

ON = 1600 bpi, phase encoded

OFF = 800 bpi, NRZI

In a multiple transport daisy chain configuration, transport 1 is the transport closest to the controller. Transport numbers increase as distance from the controller (along the chain) increases. NRZI and PE transports may be mixed in the daisy chain.

In a single transport system, the type selection switch for transport 1 must be set to correspond to the transport type. The remaining three type selection switch settings may be either ON or OFF in this case.

The PE/NRZI PWB controller board has a group of movable jumpers located at JJ12 (see figure 2-33). The PE/NRZI MW controller board has no movable jumpers.

2.8.1.7 Installing the TILINE Magnetic Tape Controller Board.

CAUTION

Do not remove or insert any circuit board or cable connector while operating power is applied to the system.

With system power off, install the controller circuit board in the assigned slot location of the 990/10 chassis. Circuit boards are installed with the component side up. Make sure that the circuit board edge connectors mate firmly with the motherboard connectors and the circuit board tab ejectors fit snugly against the chassis frame.

2.8.2 SYSTEM CABLING.

2.8.2.1 Cabling a System with a Single Transport. Refer to figure 2-36 and proceed as follows:

1. Disconnect all power from the 990 chassis and the Model 979A Tape Transport.

2. The controller/transport cable, part number 949003, may already be connected to the controller. If not, carefully align the molded arrowhead on cable connector P5 with the arrowhead on controller connector J5, and mate the connectors. Do the same for J6 and P6. Dress the cable to the rear of the 990 chassis, and clamp firmly in the U-shaped plastic cable clamp.

3. The transport end of the controller/transport cable is a printed circuit card with an edge connector. This printed circuit card fits into a card slot in the 979A transport card cage. The card cage is located at the rear of the transport, as shown in figure 2-36. With the cable dressed downward, carefully insert the connector card into slot location J4.

4. Install the terminator card, part number 948238-1, into slot location J5, with the component side on the left.

2.8.2.2 Cabling a System with Multiple Transports. Refer to figure 2-37 and proceed as follows:

1. Disconnect all power from the 990 chassis and all the transports.

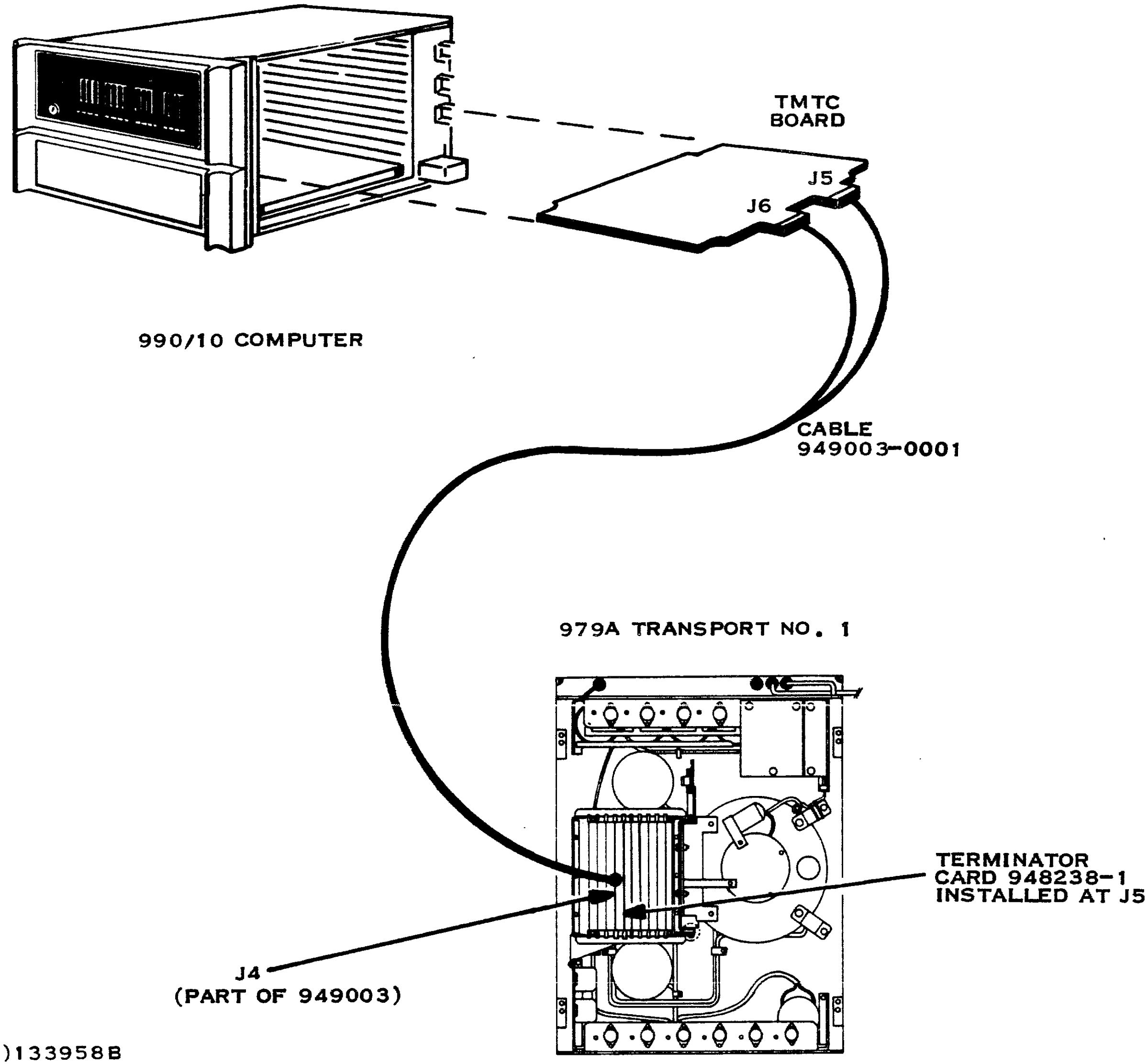

Figure 2-36. Single — Transport System Cabling

2. The controller/transport cable, part number 949003-0001, may already be connected to the TMTC. If not, carefully align the molded arrowhead on cable connector P5 with the corresponding arrowhead on controller connector J5, and mate the connectors. Align the arrowheads on cable connector P6 and J6 and mate the connectors. Dress the cable to the rear of the chassis and clamp firmly in the cable clamp.

3. The transport end of the controller/transport cable is a printed circuit board with an edge connector which goes into the 979A card cage. Face the rear of transport #1, with the cable dressed downward from the PC board. Carefully insert the PC board into slot J4, as shown in figure 2-37.

4. Interconnections between the other units in the chain are made by daisy chain cables, part number 948218-0002, and daisy chain terminator, part number 948238-0002. These cables are symmetrical, with identical connectors at the ends. The daisy chain terminator is the

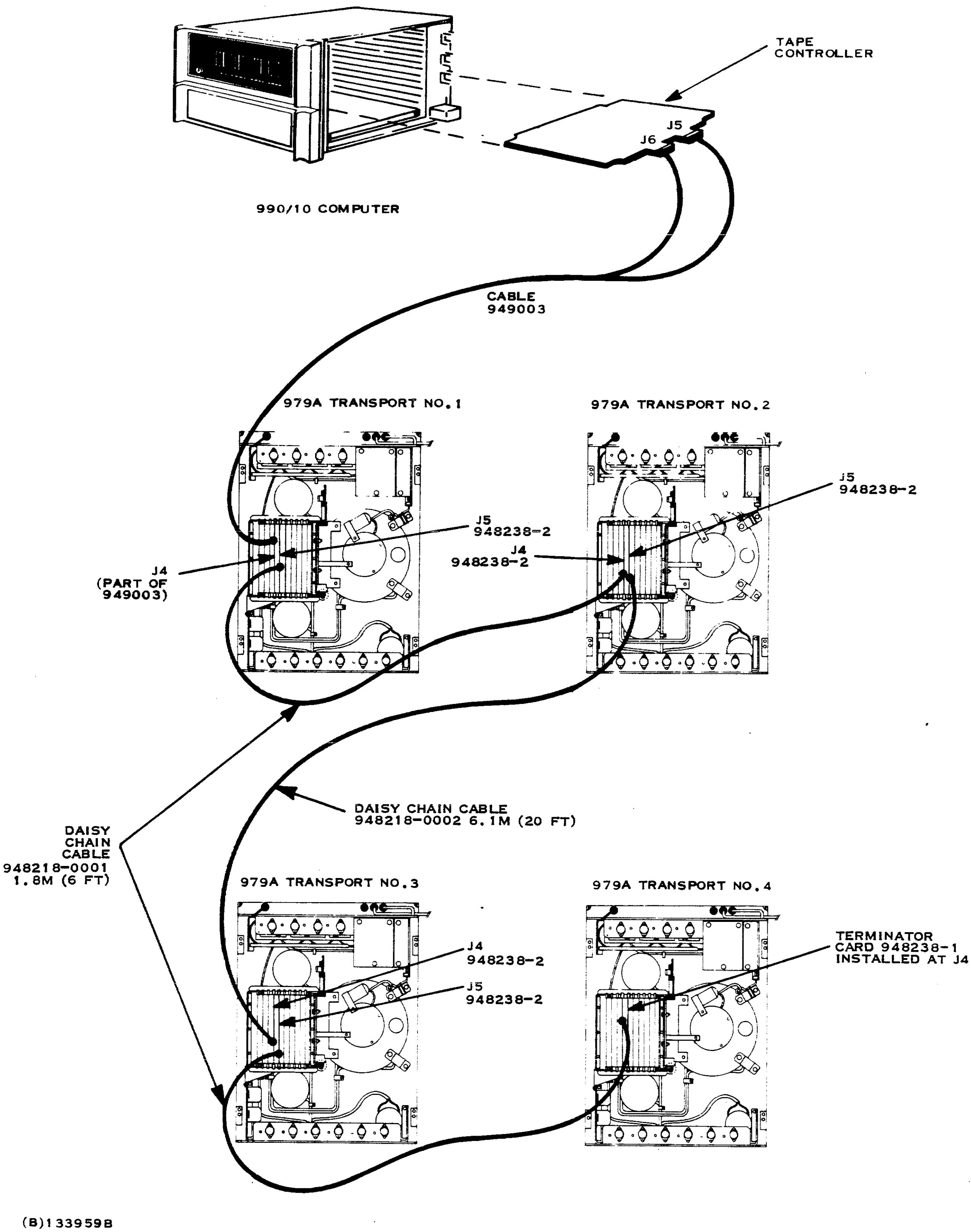

Figure 2-37. Multiple — Transport System Cabling

same as the terminator but without components mounted on the board. Facing the rear of transport #1, the daisy chain terminator is inserted into J5, with the component side (side with component designation markings) on the left. With the daisy chain cable dressed downward, seat the cable edge connector on the daisy chain terminator in J5.

5. The other end of the cable along with another daisy chain terminator, should be installed in slot J4 of the next transport. This transport is now transport unit 2.

6. Repeat steps 4 and 5 until all the transports have been connected.

7. Install the terminator card, with the component side facing left, in slot J5 of the last transport in the chain.

8. Check to assure that there is a continuous cable path from the controller through all transports to the terminator. The transport unit number assignments are automatically made by permutations in the daisy chain wiring of the transports.

SECTION 3

OPERATION

3.1 GENERAL

The 979A Tape Transport may be locally operated from the control panel and remotely controlled by means of computer-controller. Some specific controller interface characteristics and programs for the 979A are described in the reference publications listed in the Preface.

The following paragraphs describe cleaning procedures, local controls and indicators, tape threading and loading, rewind and unloading, and write and read.

3.2 CLEANING PROCEDURES

Clean heads and tape guides are a prerequisite for optimum performance of the 979A Tape Transport.

3.2.1 DAILY CLEANING. The cleaning procedure specified in table 3-1 should be performed on a daily basis. Refer to figure 3-1.

Table 3-1. Daily Cleaning Procedures

CAUTIONS

1. Before cleaning, the transport should be unloaded and the tape removed.
2. Use only denatured alcohol on the tape heads.
3. Avoid finger contact with tape heads or other surfaces which contact the tape.
4. Care must be taken not to misalign or scratch the tape heads, cross-talk shield, BOT sensor, or tape guides.
5. Do not use abrasive, highly alkaline cleansers or organic solvents on Lexan® door or vacuum column cover.

Item	Materials	Methods
Transport door interior, mounting plate	Lint-free cloth	Open transport door, and wipe all exposed surfaces including door interior.
Internal guides, ceramic guide rings	Denatured alcohol, lint-free cloth, small brush	Wipe off internal guides. Check for loose oxide under the ceramic guide rings. Brush out if necessary.
Tape heads, cross-talk shield	Denatured alcohol, cotton swabs	Wipe off surfaces.
Tape cleaner	Small brush	Inspect tape cleaner, and lightly brush off dust and oxide contaminants as necessary.

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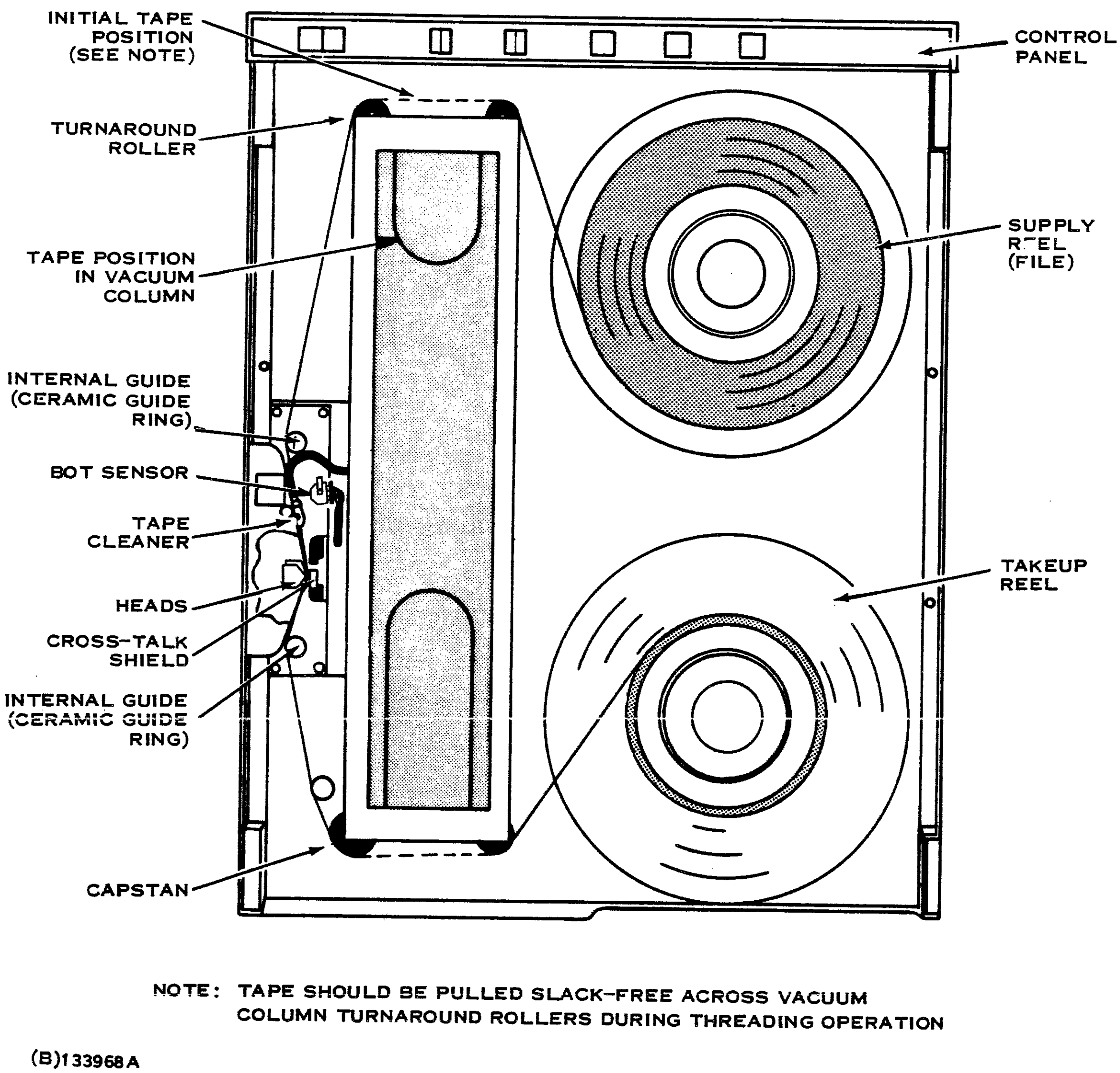

Figure 3-1. Tape Cleaning and Threading Details

NOTES

1. All motors, guides, and bearings are permanently lubricated. No lubricants are required for any of the transport assemblies.
2. Hairline scratches and minor abrasions in the transport door may be polished and filled with mild automobile polish.

3.2.2 PERIODIC CLEANING. The vacuum column and capstan should be cleaned on a periodic schedule of approximately 150 hours operation in a dust-free environment. Refer to figure 3-1 and table 3-2 for the periodic cleaning procedures.

3.3 CONTROLS AND INDICATORS

Figure 3-2 depicts the front panel controls and indicators which provide for local manual control and status indication of the 979A Tape Transport. Table 3-3 defines the functions of the controls and indicators.

Table 3-2. Periodic Cleaning Procedures

NOTE

The vacuum column and capstan should be cleaned on a periodic schedule of approximately 150 hours operation. This assumes operation in a dust-free environment with the transport door closed. Those users who operate under more severe environmental conditions will need to clean more frequently to assure best reliability.

CAUTIONS

1. The vacuum column cover is glass-type plate retained under a metal trim cover. Take care not to chip or scratch the plate or twist it against the guide pins during assembly or disassembly.

2. Use only denatured alcohol on the capstan assembly. Other cleaners may damage the rubberized surface.

3. Do not use abrasive, highly alkaline cleansers or organic solvents on transport door or vacuum column cover.

Disassembly: Remove vacuum column trim cover by pressing inward and sliding upward about one-quarter inch off the cover retaining pins. Remove the glass-type plate by lifting straight outward off its guide pins, taking care not to twist or drop the glass-type plate during disassembly.

Reassembly: After completing cleaning procedures, carefully replace the vacuum column glass-type plate and trim cover.

Item	Materials	Methods
Vacuum Columns	Denatured alcohol, lint-free cloth	Clean vacuum column tape tracks.
Vacuum Column Cover	Lint-free cloth	Wipe the glass-type plate.
Turnaround Rollers	Denatured alcohol, cotton swabs	Check the rollers for oxide deposits and foreign matter. Clean with denatured alcohol and cotton swabs as necessary.
Capstan	Denatured alcohol, lint-free cloth or cotton swabs	Inspect the capstan for oxide deposits and other contamination. Wipe clean with denatured alcohol and lint-free cloth (or cotton swabs) as necessary. Do not substitute other cleaners as they may damage the rubberized surface of the capstan.

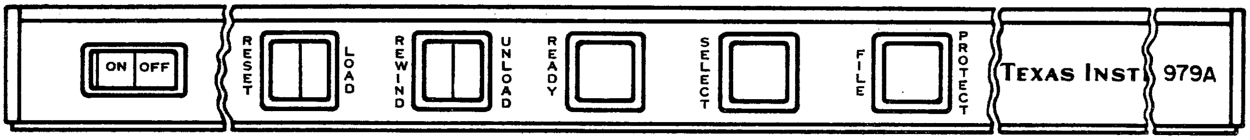

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Figure 3-2. Model 979A Tape Transport Control Panel

Table 3-3. 979A Controls and Indicators

Control	Function
ON/OFF	Switches ac power to tape transport.
RESET/LOAD	The RESET switch stops tape motion, takes the transport out of the remote mode, and enables local control. After tape reels are installed and tape is threaded, the LOAD switch initiates the automatic loading action. Tape is pulled into the vacuum column, and the transport drive automatically searches and positions the tape at the BOT marker. If the BOT marker is positioned too near the BOT sensor to permit sufficient tape to load the lower vacuum loop, BOT sensing will precede vacuum column sensing and the tape drive electronics will lock out further tape motion. To recover, press RESET switch, move tape forward so that the BOT marker is on the takeup reel side of the BOT sensor, and reinitiate the LOAD sequence. Providing the tape is loaded, the LOAD switch will reestablish remote mode, after remote has been terminated by RESET. While the transport is in the unload mode, the RESET/LOAD switch will not stop the unload operation after the BOT marker has been sensed.
REWIND/UNLOAD	The REWIND switch initiates a high-speed (3810.0 mm (150.0 inches) per second) tape rewind onto the file reel. Rewind is terminated by sensing and automatically positioning the BOT marker in the same location as in the load sequence. The UNLOAD switch initiates high-speed rewind until the BOT marker is sensed. At BOT, vacuum decays while tape is rewound slowly onto the file reel.

Table 3-3. 979A Controls and Indicators (Continued)

Indicator	Function
READY	The READY lamp indicates that the tape transport is in the remote mode and not rewinding.
SELECT	The SELECT lamp indicates that the particular transport is selected by the control unit.
FILE PROTECT	The FILE PROTECT lamp indicates that the transport is inhibited from writing because the write enable ring is not on the file reel.

3.4 TAPE LOADING

Tape loading and threading for the 979A is performed in the following manner:

NOTE

If power is turned "off", wait five seconds before reapplying power to establish proper preset operation.

1. Turn power ON/OFF switch "on".

2. If a fixed reel is not present, install a takeup reel on the lower hub, seating it firmly against the hub lip and locking it into place.

3. If file protection is required, verify that the write enable ring is not on the file reel before installing the reel. Place the file reel onto the upper hub, seating it firmly against the hub lip and locking it into place.

NOTE

If data is to be written on tape, the write enable ring must be installed on the file reel to enable the write electronics. This ring is placed in the groove backside of the reel just around the hub opening. When the reel is installed, the ring should engage the write enable sensor pin.

4. Thread the tape from the file reel to take up reel over the guide rollers, head, and capstan and onto the takeup reel so that clockwise rotation will wind tape onto the takeup reel. See figure 3-1. The cross-talk shield is spring loaded against the heads and should be swung away from head while threading the tape through the opening. Wrap three to five turns of tape around the takeup reel.

   When tape is first loaded, it must be pulled free of slack so that the tape lies straight across the top and bottom roller guides of the vacuum column.

NOTE

To ensure that sufficient tape is provided to establish the lower loop in the vacuum chamber, verify that the BOT marker does not fall between the upper guide roller and the BOT sensor. BOT sensing prior to lower loop vacuum column sensing will lock out the tape drive electronics.

5. Press the LOAD switch. After a brief delay to pull vacuum, tape loops will form in the vacuum column, tape will be wound on the takeup reel, and the transport drive will position the tape at the BOT marker. If the BOT marker is placed beyond the BOT sensor during threading, forward search will cease after 11 seconds and reverse search for the BOT marker will automatically be initiated.

3.5 MID-REEL RELOADING

If during tape mid-reel operation, power is removed or vacuum is lost, a mid-reel reloading sequence will be required. The tape should be threaded around the guides, heads, and capstan as shown in figure 3-1 and all slack tape wound onto the supply reel (from the vacuum column). Push RESET, then LOAD, and wait for automatic loading to start. When tape starts forward search, push RESET and tape motion will stop. The transport is now ready for local mode operation. For remote control, press LOAD.

3.6 REWIND AND UNLOAD

The rewind and unload operations may be remotely controlled for any transport in a single or multiple unit installation. When the transport is in the remote mode (ready status true) and selected, a low level on the remote rewind interface line initiates the rewind sequence. The ready line is high and the rewind status line is low during the rewind sequence, and at completion, both these status lines toggle to opposite states.

The interface cables have five select and five rewind status lines for individual remote control of each transport in a multiple unit configuration. All other control interface lines are common to all transports. A given transport can rewind (and show rewind status) without maintaining select status, so that the controller can select another transport and still monitor rewind status of the given transport.

The rewind operation performs fast tape rewind at approximately 3.8 metres (12.5 feet) per second until BOT sensing, which initiates tape reversal to position the tape at the BOT marker as in the load operation described in paragraph 3.4. A full reel of tape (731.5 metres = 2400.0 feet) will rewind in less than 200 seconds.

When the transport is in the remote mode, a low level on the remote unload line initiates the unload sequence. The ready line is high during unload. The unload sequence performs fast tape rewind until the BOT is sensed. The tape is then slowly wound onto the supply reel until the takeup reel is empty.

The only recovery from the unload sequence after the BOT sensing is manual rethreading and manual initiation of the load sequence. Prior to detection of BOT, the unload sequence can be terminated by pressing the RESET switch.

The local REWIND/UNLOAD switch has control only when the transport is in the local mode, which is established by pressing the RESET switch.

3.7 WRITE

To write data on tape, the transport must be loaded, ready, and selected. The write enable ring must have been installed on the supply reel. The tape controller must initiate write set and tape drive commands. The write analog threshold is set at a high level to insure recorded data integrity. Data must be restricted until 15.2 mm (0.6 inch) of tape has passed the head, and then high-to-low transitions of the write clock signal will record data from the write data lines. At the completion of a data block, write-reset and write-clock signals are used to generate the Longitudinal Redundancy Check Character (LRCC) on tape. After write-reset, tape motion may be stopped; however, write current is maintained to prevent switching transients in the inter-record gap. Write data rate is 30,000 characters per second (800-BPI at 37.5 ips).

In the PE format, phase encoded write data is applied directly to the write amplifiers. A write clock is not used. A high write data line magnetizes the tape with the erase polarity; a low write data line magnetizes the tape with the nonerase polarity.

The write function is inhibited by any of the following actions:

- Removing the write enable ring
- Pressing the local RESET switch
- Making set read line low
- Reversing tape motion by REWIND, UNLOAD, or REVERSE commands.

3.8 READ

Two read signal threshold values are used, depending on the write or read operation. During write, the read threshold is high to insure recorded data integrity. In the read only mode, the threshold is made half its value during the write mode to permit detection of marginal data. When valid data is detected by the read circuitry, data and clock are presented to the controller.

SECTION 4

THEORY OF OPERATION

4.1 GENERAL

This section describes the theory of operation for the Model 979A Tape Transport system. The description is covered in two parts: 1) control and data transfers between transport and system tape controller and, 2) control and data signals processed within the tape transport.

Interface control signals transferred between controller and transport are essentially the same regardless of the system type being supported, 960, 980, or 990. However, there are two different types of data signals that may be transferred depending upon the format type being used in a transport, NRZI or PE. These formats are described in Section 1.

Methods or functions performed within the transport are further divided into descriptions of subassemblies and their interaction.

4.2 SYSTEM-TAPE TRANSPORT, INTERFACE

A general block diagram of system and tape transport interface is shown in figure 4-1. A description of the signals carried on these lines follows.

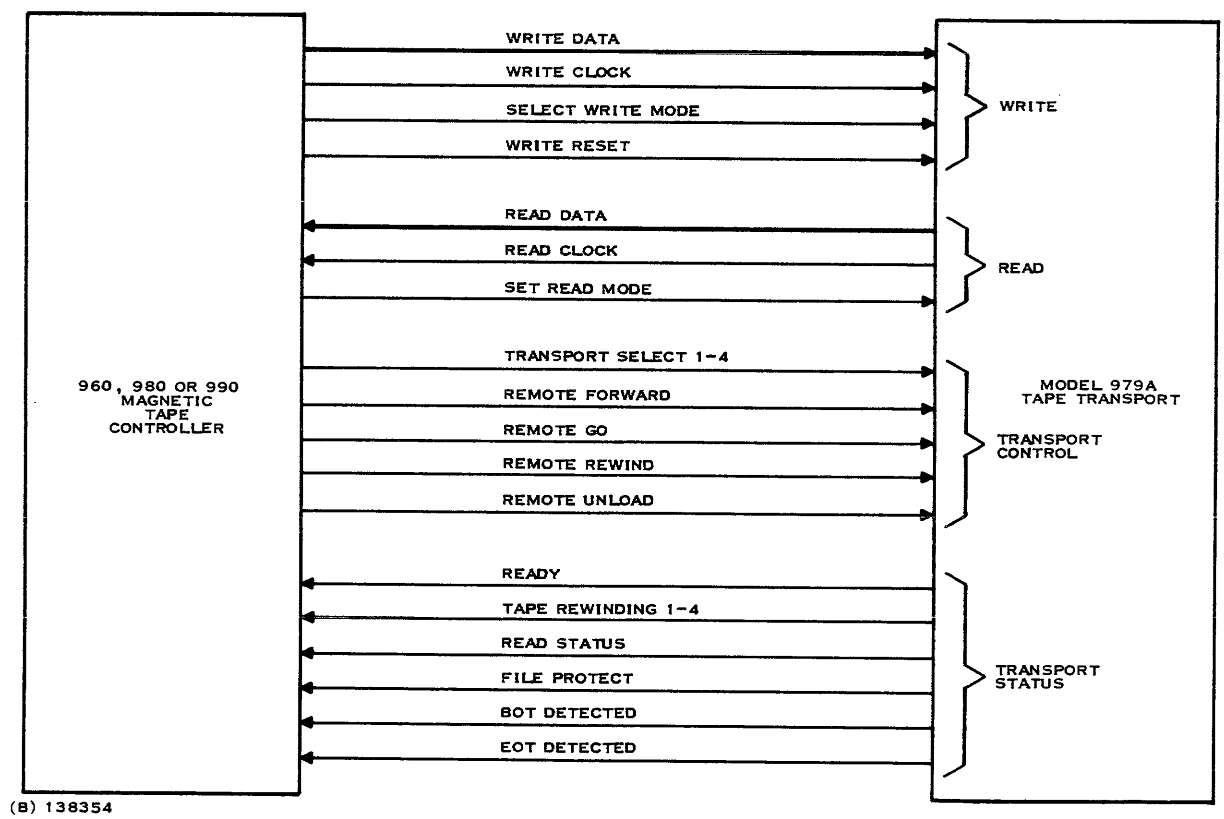


Figure 4-1. System - Tape Transport, Interface Lines

4.2.1 INTERFACE SIGNAL FUNCTIONS. Signals exchanged between controller and tape transport(s) fall into four categories; write, read, transport control, and transport status. All of these signals are active low TTL levels.

The transport control signals allow the controller to select one of four possible transports when supporting a 990 system, or one of three transports when supporting either a 960 system or a 980 system. When selected by the controller, the transport is in the remote mode. The RESET/LOAD switch must, however, be in the LOAD position to allow remote control.

The transport control signals are:

- Transport Select 1—4 (SELECT— to SELECT4—)*. These signals are used to select transport 1, 2, 3, or 4 for an operation. Only one of these lines should be low at a time. The transport select signal for a given transport enables it to accept the other signals from the controller and to send signals to the controller. The tape rewinding status signals are the sole exception. They are generated without regard to which transport, if any, is selected.
- Remote Forward (RFWD—). This signal controls the direction of motion of the selected tape drive. Logic zero indicates forward direction and logic 1 indicates reverse. (NRZI operations only.)
- Remote Go (RGO—). This signal enables tape motion in the direction specified by RFWD—.
- Remote Rewind (RREW—). This signal will initiate rewind action in a selected and ready transport. The rewind operation will continue to completion once initiated by RREW—.
- Remote Unload (RUNL—). This signal will initiate a rewind and tape unload operation on a selected and ready transport. Once initiated, the rewind and unload operation continues to completion.

The transport status signals are:

- Ready (READYSTAT—) or (XRDY). This signal indicates that the selected transport is ready and not rewinding.
- Tape Rewinding 1 — 4 (REWINDSTAT1 — to REWINDSTAT4 —) or (XRWD). A low REWINDSTAT(N)— signal indicates that transport N is rewinding. The transport does not have to be selected.
- Read Status (READSTAT—) or (XREAD). This signal indicates that the selected and ready transport is in the read mode.
- File Protect (FPST—) or (XFPT). This signal indicates that there is not a write ring on the selected transport.
- BOT Detected (BOTSTATOUT—) or (XBOT). This signal indicates that the beginning-of-tape (BOT) sensor on the selected transport has detected the BOT marker on the tape.
- EOT Detected (EOTSTATOUT—) or (XEOT). This signal indicates that the end-of-tape (EOT) sensor on the selected transport has detected the EOT marker on the tape.

*When supporting a 960 or 980 system, three transports may be selected.

The write signals are:

- Write Data 1—9 (WRITEDATA1 — to WRITEDATA9 —). These are the data lines which carry the information to be written on tracks 1—9. Data on these lines must be valid 0.5 microsecond before and after the write clock pulse occurs for a NRZI system. The binary weights of these signals are:

Binary Weight	WRITEDATA(N)
2^7(MSB)	7
2^6	6
2^5	5
2^4	3
2^3	9
2^2	1
2^1	8
2^0	2
Parity	4

- Write Clock (WRITECLOCK—) or (WCLK). This causes the character on the write data lines to be written on the tape. (NRZI only)

- Set Write Mode (SETWRITE—). This signal causes a selected and ready transport to go into the write mode of operation. It causes the read status signal from the transport to go inactive.

- Write Reset (WRITERESET—) or (WRSET). This signal resets the write register of the selected and ready unit if a write clock occurs when it is active. This signal is used to write all-zeros characters (including zero parity) on the tape. (NRZI only)

The read signals are:

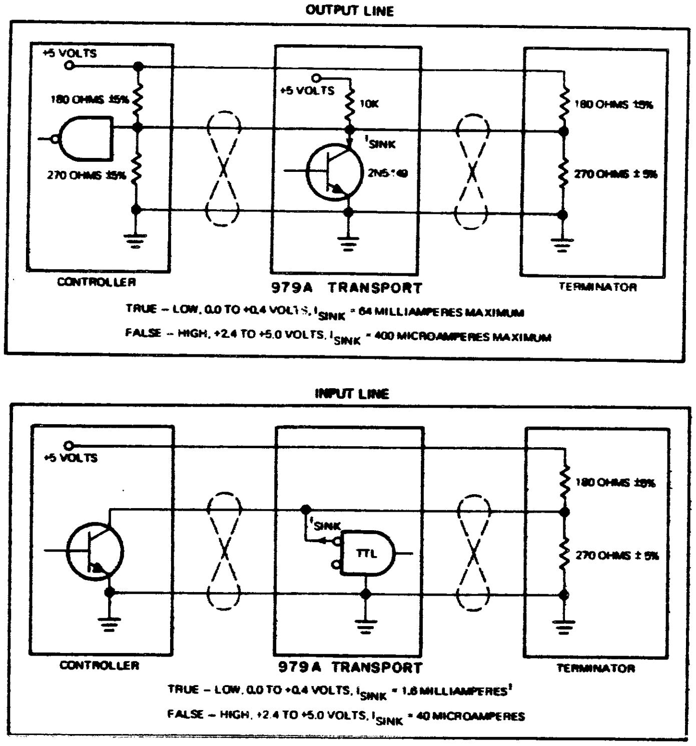
- Read Data 1—9 (READDATA1— to READDATA9—) or (RDDAT). These lines are used to read a 9-bit character (8 data + 1 parity) from the transport. The data is valid approximately 0.5 microseconds before the read clock pulse in a NRZI system.

- Read Clock (READCLOCKOUT—) or (RDCLOCK). This pulse is generated by a NRZI transport to indicate that data is present on the read data lines. (NRZI only)

- Set Read Mode (SETREAD—). This signal places the selected and ready transport in the mode. The transport responds with a read status signal.

4.2.2 INTERFACE SIGNAL LEVELS. Standard logic levels for interface lines are defined and illustrated in figure 4-2. Turnaround time is 20.2 ± 2 milliseconds as measured from the drop of the GO signal to the attainment of 96 percent of the steady state speed in the opposite direction at 952.5 mm (37.5 inches) per second.

Up to four transports may be connected in a daisy chain configuration to one controller in a 990 system; up to three transports in a 960 or 980 system. There are two types of cables required when transports are connected in a daisy chain configuration. One cable connects the interface/controller to the first transport in a system and the second cable connects the transports. A terminator card is required in the last transport of the chain.



(A)138355

NOTE
[1]THE SELECT LINE HAS THREE TTL LOADS AND WILL SINK 4.8 MA.

Figure 4-2. Interface Logic Levels

4.3 TAPE TRANSPORT CIRCUITS

The following paragraphs describe processing of control and data signals at a subassembly level within the tape transport. Each subassembly is described by highlighting functions performed by the circuit and by generally describing the cause and effects related to these functions. Figure 4-3 is a functional block diagram of the tape controller. All descriptions are based upon operation at 115 Vac, 60 Hz with a tape speed of 952.5 mm (37.5 inches) per second. Both recording formats, PE and NRZI, are described under descriptions of data and data control circuits.

NOTE

Only one type format is used per transport. However, in a magnetic tape system with multiple transports and the appropriate controller, formats may be mixed.

The descriptions are arranged in the following order:

- Power supply and power distribution
- Logic card descriptions

  a. Capstan/regulator card

  b. Reel servo control card

  c. Motion control logic cards (two types)

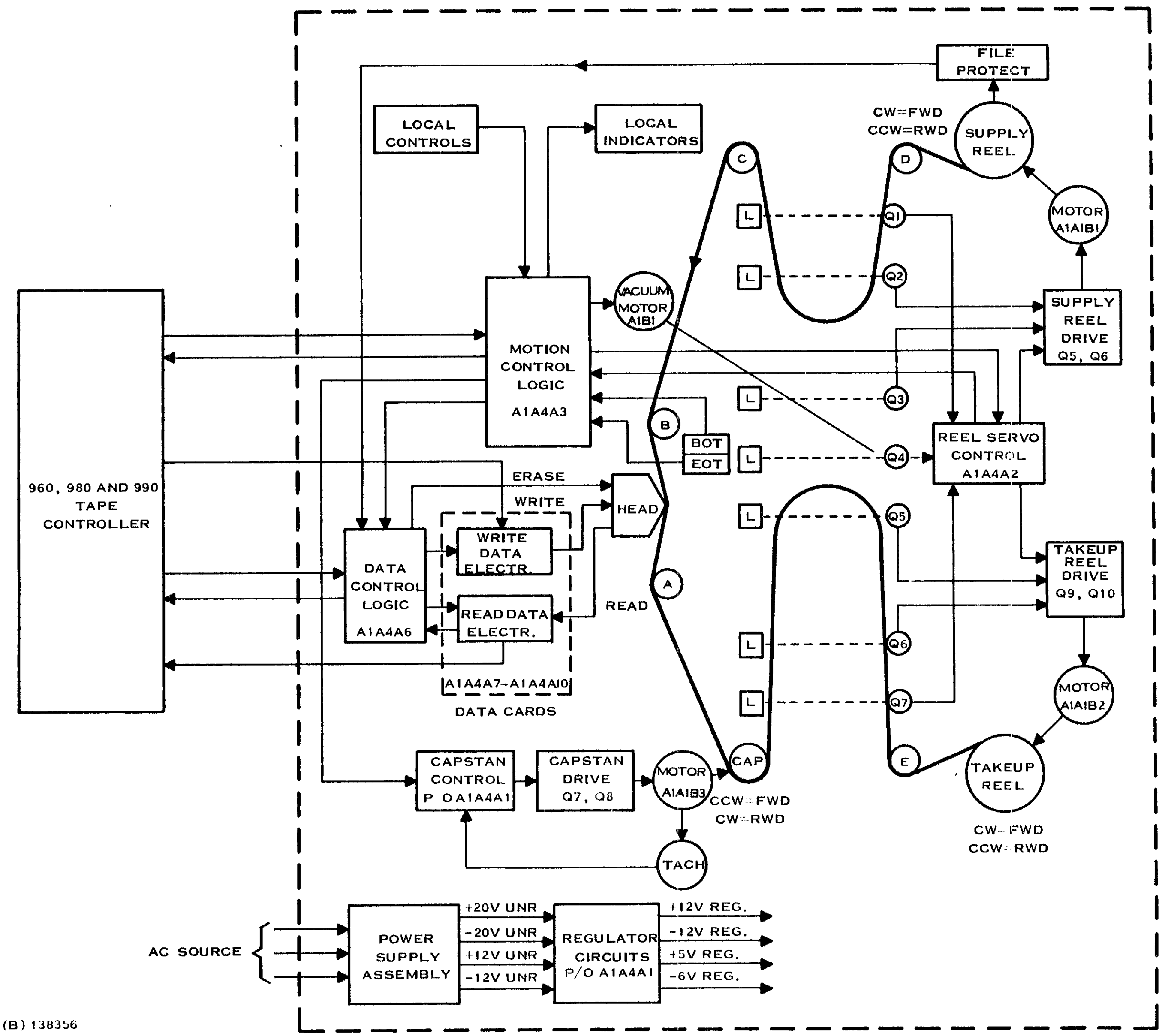


Figure 4-3. Model 979A Functional Block Diagram

d. NRZI data control with track 1 data circuit

e. NRZI data dual channel cards (four cards, each containing two track data circuits)

f. PE data control with track 1 data circuit

g. PE data dual channel cards (four cards, each containing two track data circuits)

4.3.1 POWER SUPPLY AND POWER DISTRIBUTION. See assembly 948212 and schematic 948159, in the *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702. The 979A tape transport power supply chassis is located at the top rear of the transport assembly and contains transformer, rectifiers, filters, fuses and series-pass-transistor regulators Q1 through Q4. Next to each pass transistor is a test point for monitoring the regulated voltages. Secondary voltages from input transformer T1 are applied to bridge rectifiers CR2 and CR1 where ± 20V unregulated and ± 12V unregulated, respectively are developed (figure 4-4). These rectifiers are located on the lower right side of the power supply assembly. All unregulated voltages from the rectifiers have fuses mounted on the rear of the power supply assembly at the right side. The 20-volt unregulated voltages are sent in parallel to: 1) motor circuits via relay K1 and, 2) regulator circuits on the capstan/regulator board. The 12-volt unregulated voltages are sent to the capstan/regulator, only.

Circuits on the capstan/regulator supply feedback voltages to the series-pass transistors Q1 through Q4. As the value of feedback voltages changes, conduction through the pass transistors changes and maintains voltages at less than ± 10 percent of the rated output.

4.3.2 LOGIC CARD DESCRIPTIONS.

4.3.2.1 Capstan/Regulator Board. See assembly 216545 and schematic 216508 in the *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702. Four functions are performed by this card:

- Speed and directional control of the capstan motor
- Power supply voltage regulation and protection
- Drive circuits for lamps and relays
- Sensor amplifiers for BOT and EOT detectors.

Capstan Drive Control Circuit. This circuit, shown in figure 4-5, controls tape drive in the forward and reverse directions across the read/write head at a constant 952.5 mm (37.5 inches) per second. Drive speed is governed by a tachometer mechanically ganged to the capstan motor. (Reverse drive is used when searching for records, and the transport is not in the record mode.) Transistors Q8 and Q10 generate a stable reference input to Z2 for forward speed control; for reverse speed, Q7, Q9 and Q11 generate the reference to Z2. These voltages are adjustable and are set by monitoring the capstan wheel with a precision tachometer or strobescope and adjusting FWD SPEED and/or REV SPEED potentiometers. (Procedures are outlined in the maintenance section.)

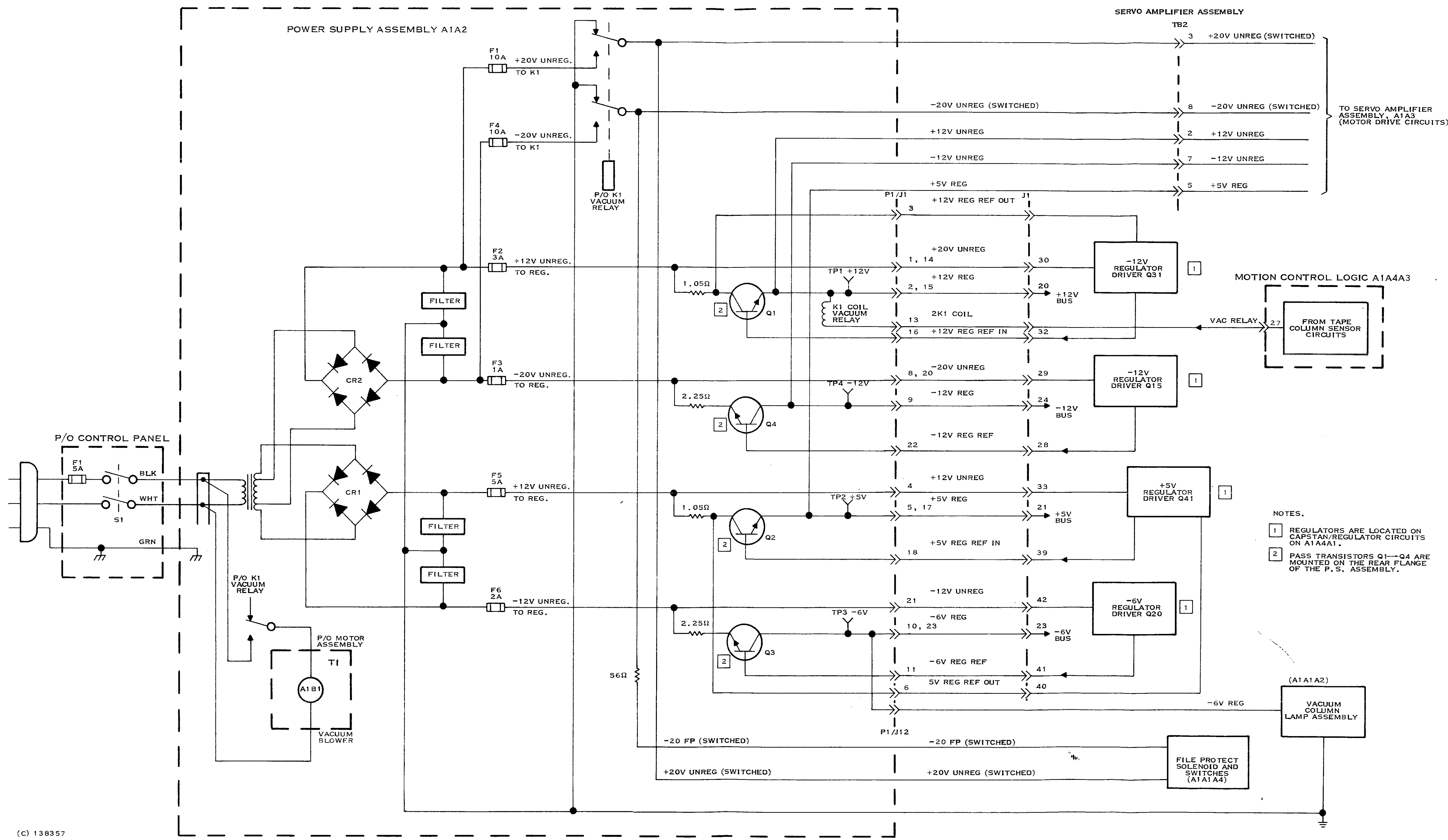
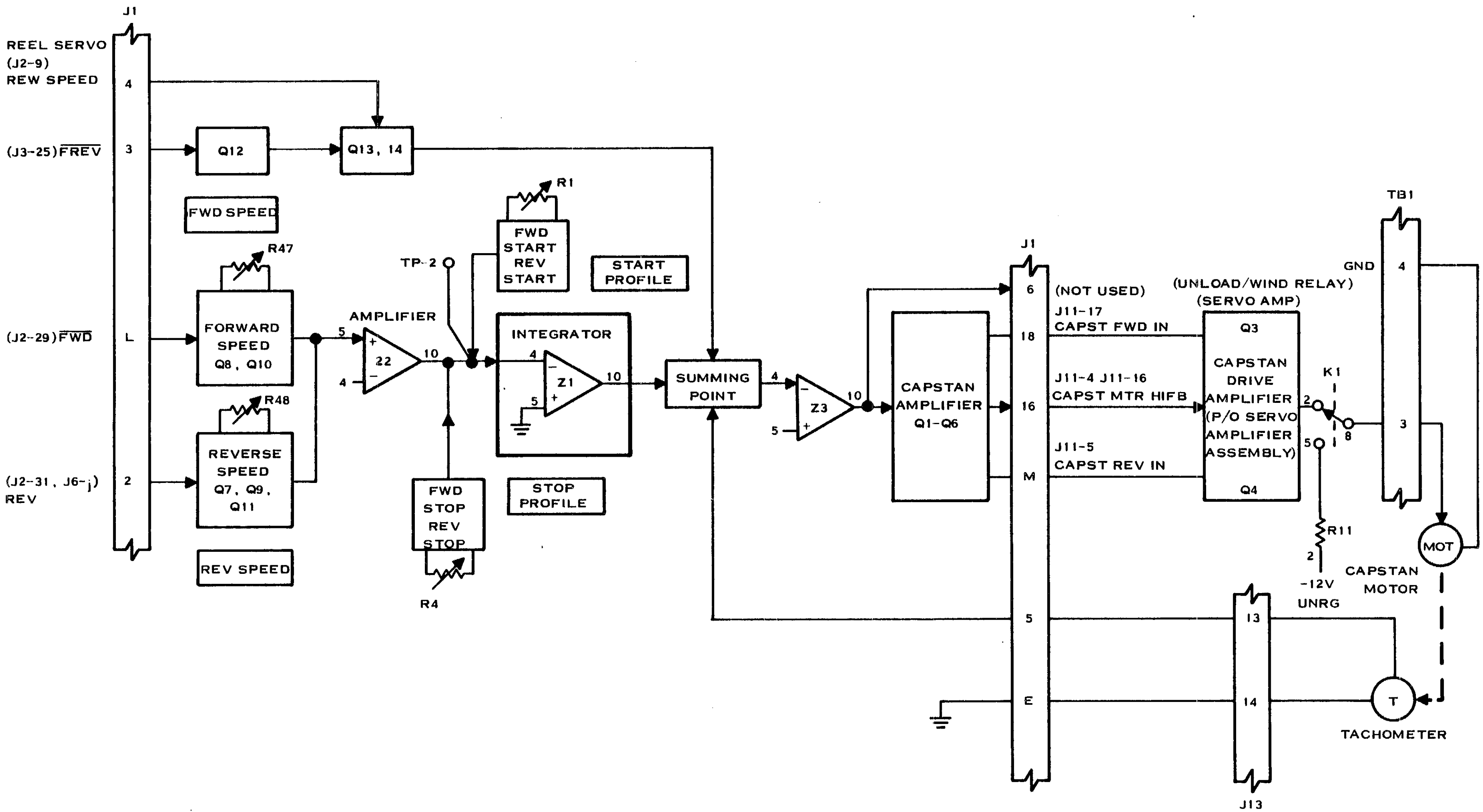


Figure 4-4. 979A Power Supply Diagram and Power Distribution



(B) 138558A

Figure 4-5. Capstan Drive Control Circuit, Simplified Diagram

Amplifiers Z1 and Z2 combine to establish the power amplifier reference input. The outputs from Z1 and Z2 are applied to the summing point along with feedback signals from the tachometer, and logic signals from the reel servo and motion control cards. The resulting voltages from the summing point are applied to summing amplifier Z3. The Z3 output is inverted but equal to the weighted algebraic sum of the inputs, and is applied to power amplifiers Q1 through Q6 on the capstan/regulator board and to power transistors Q3 and Q4 mounted on the servo amplifier assembly. The servo amplifier is the lower assembly in the tape transport.

Voltage Regulators. There are four regulator circuits on the capstan/regulator board: +12V, -12V, +5V and -6V (figure 4-6). The +5V and -6V regulators are adjustable and independent, containing their own reference voltage supplies consisting of zeners CR21 and CR27. The +12V and -12V regulators are nonadjustable, dependent supplies using the +5V and -6V supplies as reference. All regulators have foldback current limiting circuits. Additionally, the +5V regulator has a crowbar circuit to prevent the regulator from exceeding approximately +6 volts. If the crowbar circuit is triggered, the tape transport ac power must be switched off, the problem cleared, and then the power switched on before the regulator returns to normal operation.

Lamp and Relay Driver Circuits. See figure 4-7. Five driver circuits located on the capstan/regulator board control indicator lamps on the transport front panel, or relays mounted on the left side of the servo amplifier assembly (when viewed from the rear of the transport).

Lamp drivers light the READY, SELECT and FILE PROTECT indicators; relay drivers energize the UNLOAD/REWIND or FAST REVerse relays in the servo amplifier circuit (A1A3) and transmit signals to the motion control logic card for processing.

BOT/EOT Sensor Amplifier and Gating. The beginning-of-tape (BOT), and end-of-tape (EOT) sensor is mounted on the transport assembly between the tape guide and the tape head. The sensor (or detector) is a single unit containing two light sources and two phototransistors. One phototransistor detects the BOT, the other the EOT.

Two reflective 25.4 mm (1.0 inch) markers, one at the beginning of the tape and one at the end of the tape, cause light from the source to be reflected back to one of the phototransistors, depending upon the position of the marker (figure 4-8). When the BOT is detected, the resulting signal is amplified by Q36 and Q37 and sent to the motion control logic card, and to the gated output drivers Q38 and Q39 (figure 4-9). On the motion control logic card, an active BOT signal causes the following actions depending upon the drive mode immediately preceding BOT detection.

- In the forward search mode (FWDS) tape searches in the forward direction, passes the BOT, stops, then enters a reverse search mode and stops immediately upon detecting BOT.
- In the reverse search mode (REVS) tape also stops immediately upon detecting BOT.
- In the high speed rewind mode (REW), tape drives at high speed in reverse past the BOT, stops, forward searches at high speed past BOT again; then approaches BOT in reverse search mode (REVS). As soon as BOT is detected, drive stops immediately.

BOT gated with $\overline{\text{SEL} \cdot \text{RDY}}$ indicates that the tape transport has been selected by the computer, is ready, and on BOT. Actions performed when EOT is detected are dependent upon the computer program.

4.3.2.2 Reel Servo Control. See assembly 216542 and schematic 216543 in the *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702. The reel servo card controls speed and direction of the supply reel and takeup reel motors, see figure 4-10.

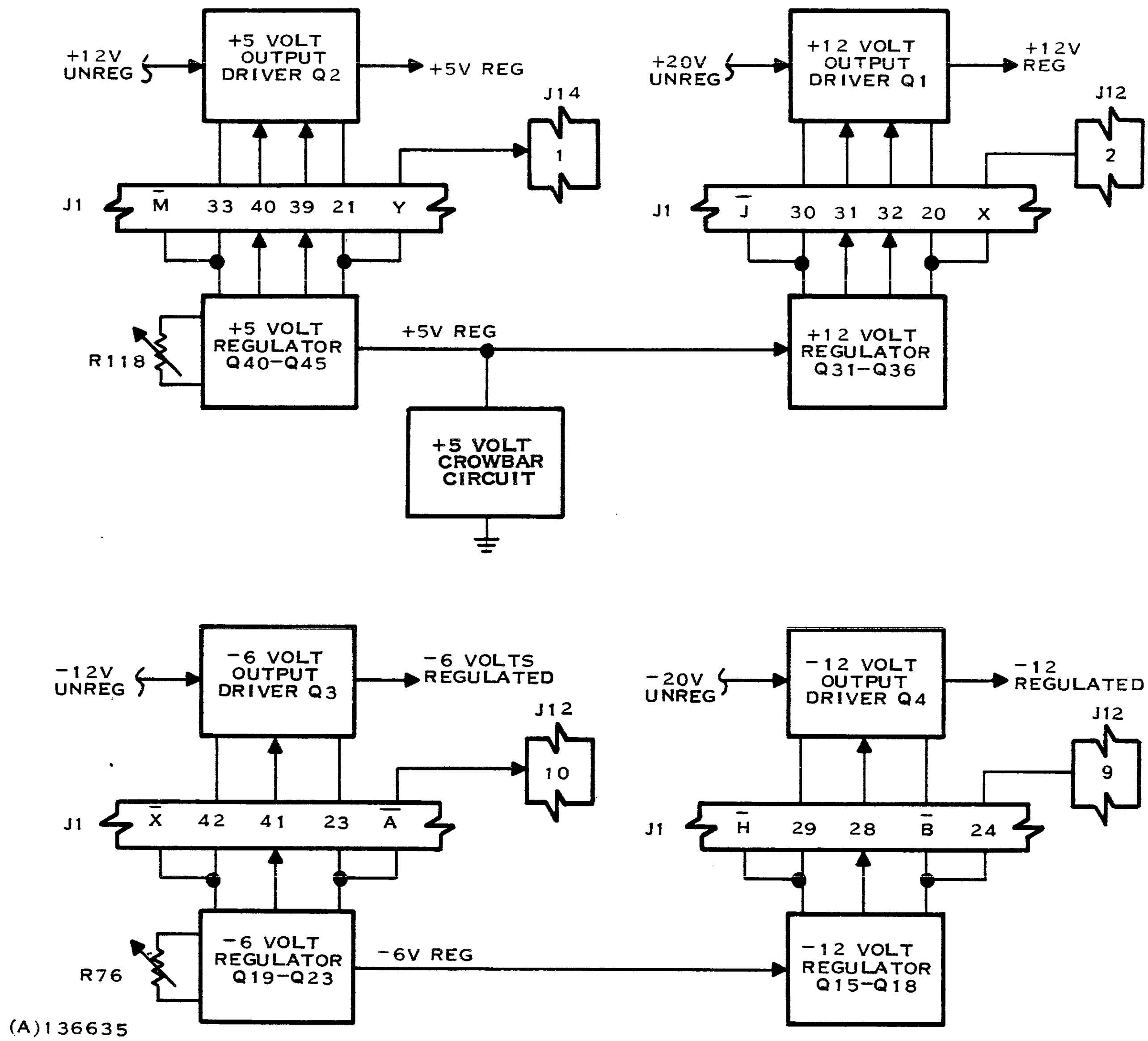


Figure 4-6. Regulator Circuits, Simplified Diagram

NOTE

Tape drive across the read/write heads is supplied by the capstan drive motor controlled by the capstan drive circuit on card A1A4A1.

There are seven IR light sources and seven IR light sensors in the tape transport vacuum column. Signals from the sensors start and stop rotational movement of the reel motors depending upon position of the tape in the column. The upper half of the vacuum column captures tape from the supply reel; the lower half of the column captures tape before it is wound on the takeup reel.

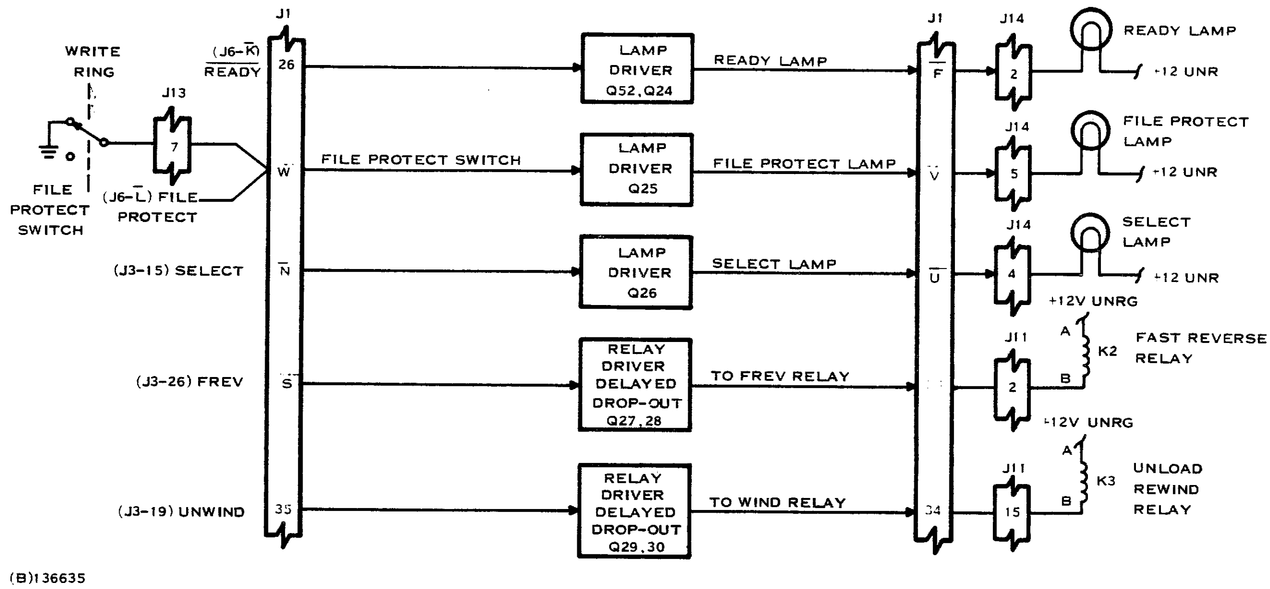


Figure 4-7. Lamp and Relay Driver Circuits, Simplified Diagram

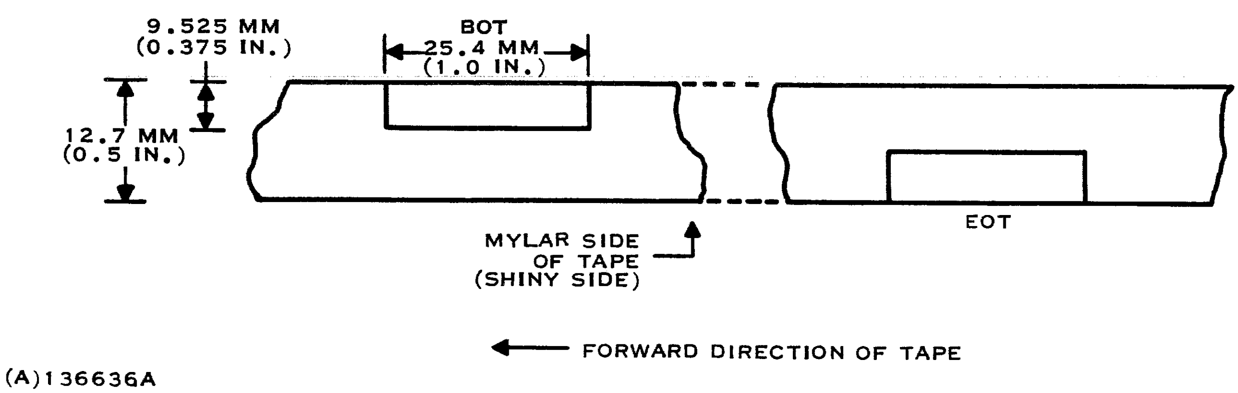


Figure 4-8. BOT/EOT Tape Marking Positioning

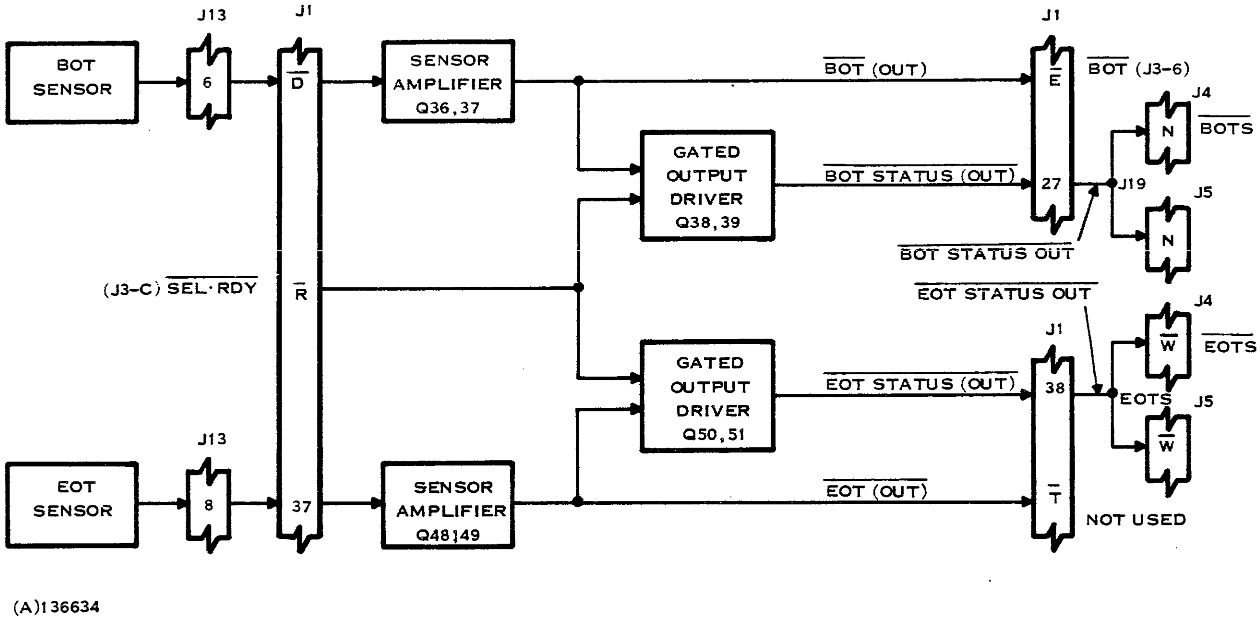


Figure 4-9. BOT/EOT Circuits, Simplified Diagram

NOTE

Vacuum column sensor locations and functions performed are described under controls and indicators in Section 3.

The following is a description of functions performed during a load operation. Since the supply and takeup reel motor control circuits operate similarly, this description outlines operation of the supply reel circuit with major differences between the supply reel and takeup reel drives described where they occur.

Loading Operation. As long as tape has not been drawn into the vacuum column, sensors Q1, Q4, and Q7 are inactive (low) holding signals $\overline{\text{SUL VAC}}$ and $\overline{\text{TUL VAC}}$ high, see figure 4-11. These signals, when low, indicate to control logic circuits that the supply reel and takeup reel are loaded and that a vacuum is present. After tape has been installed on the supply reel hub, threaded onto the takeup reel, and the tape transport operator has pressed the LOAD control, the following sequence of events occurs.

NOTE

Tape must be taut (i.e., slack free) across the upper and lower portions of the vacuum column before pressing LOAD.

1. Vacuum motor energizes and tape transport enters a delay of approximately 11 seconds while vacuum builds up in column.

2. The motion control logic set $\overline{\text{SUD}}$ low which causes the reel servo control to apply approximately -1V to the supply reel motor. This dumps tape into the vacuum column. As tape is being drawn into the upper portion of the vacuum column, light to the Q1 sensor is blocked by the tape and switches Q1 sensor off, causing $\overline{\text{SUL VAC}}$ to go active (low).

3. As $\overline{\text{SUL VAC}}$ goes low, a high $\overline{\text{SUD}}$ is returned from the motion control logic card which turns off DUMP BIAS at Q55. The reel servo control to the supply is now enabled. With Q2 sensor being light, the reel servo control drives the supply reel to dump more tape into the column.

NOTE

Negative voltages cause the motors to turn in a clockwise direction. This is the direction required to dump tape from the supply reel into the upper portion of the vacuum column.

4. As tape lowers into the vacuum column, light to Q2 is blocked by the tape. This causes the DUMP AMPLIFIER (Q3 and Q5) to stop dumping tape into the column.

5. The capstan now starts driving tape in the forward direction to start supplying tape to the lower portion of the vacuum column.

6. Sensors Q7, Q6 and Q5 work in a similar manner to Q1, Q2, and Q3; there is no dump bias required, however. The capstan keeps driving forward until the lower portion of the vacuum column has captured the tape. In this case, tape will approach a vertical steady state near the light line from light source to sensor Q5.

If sensors Q1 or Q7 are exposed to light sources, the transport begins an immediate automatic shutdown. This condition would occur under any of the following conditions.

1. Loss of vacuum.
2. Tape breaks or pulls off a reel.
3. A reel binds.
4. Motor runaway.
5. Power interruption.

If the light source is blocked from sensor Q4, the transport also begins an immediate automatic shutdown. This would occur, primarily, if too much tape is in the column.

When tape is captured in both the upper and lower portions of the vacuum column, the transport is ready to begin searching for the BOT marker. When BOT is found, the loading operation is complete.

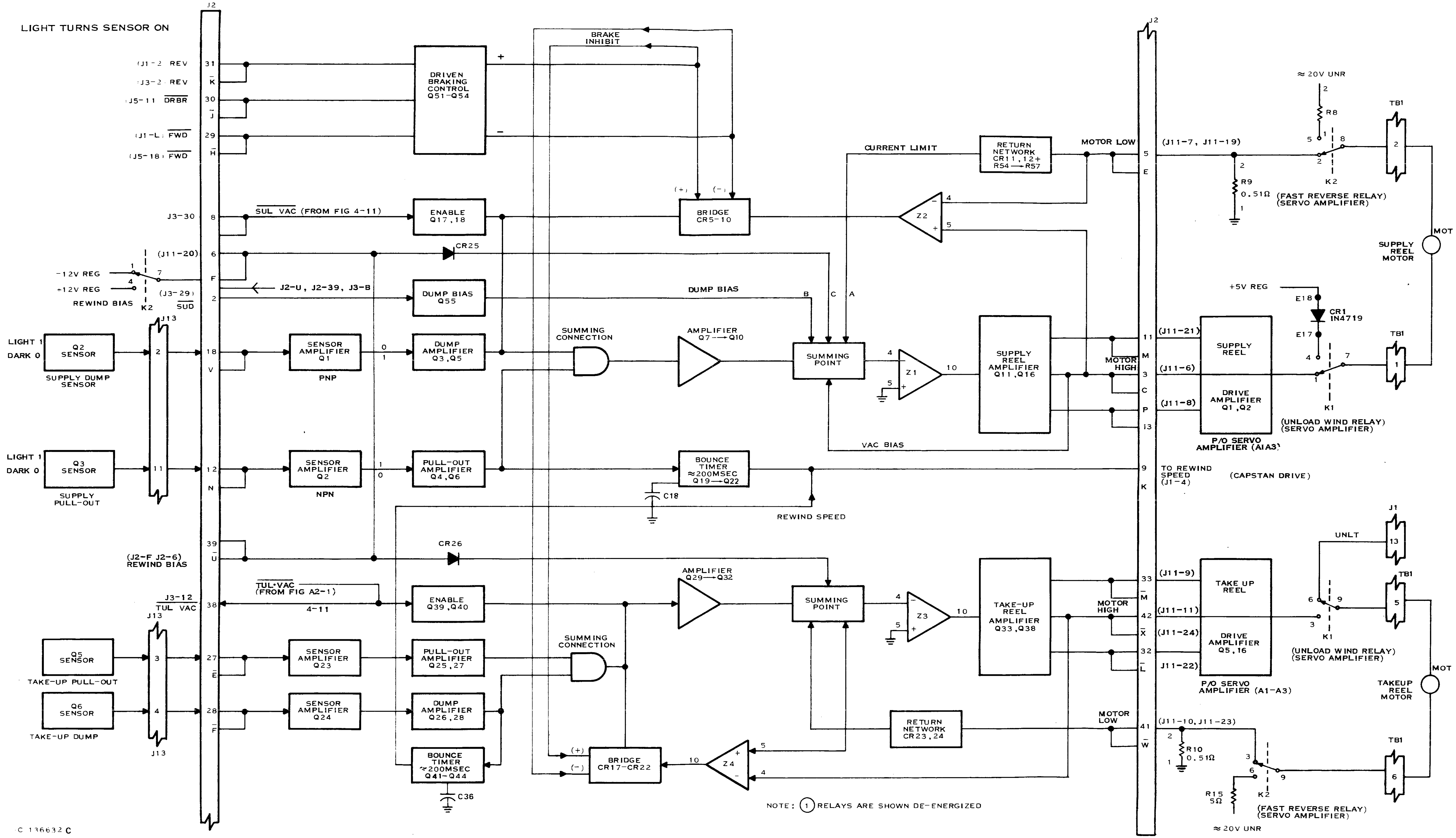


Figure 4-10. Supply and Take-up Reel Drive Circuit, Simplified Diagram

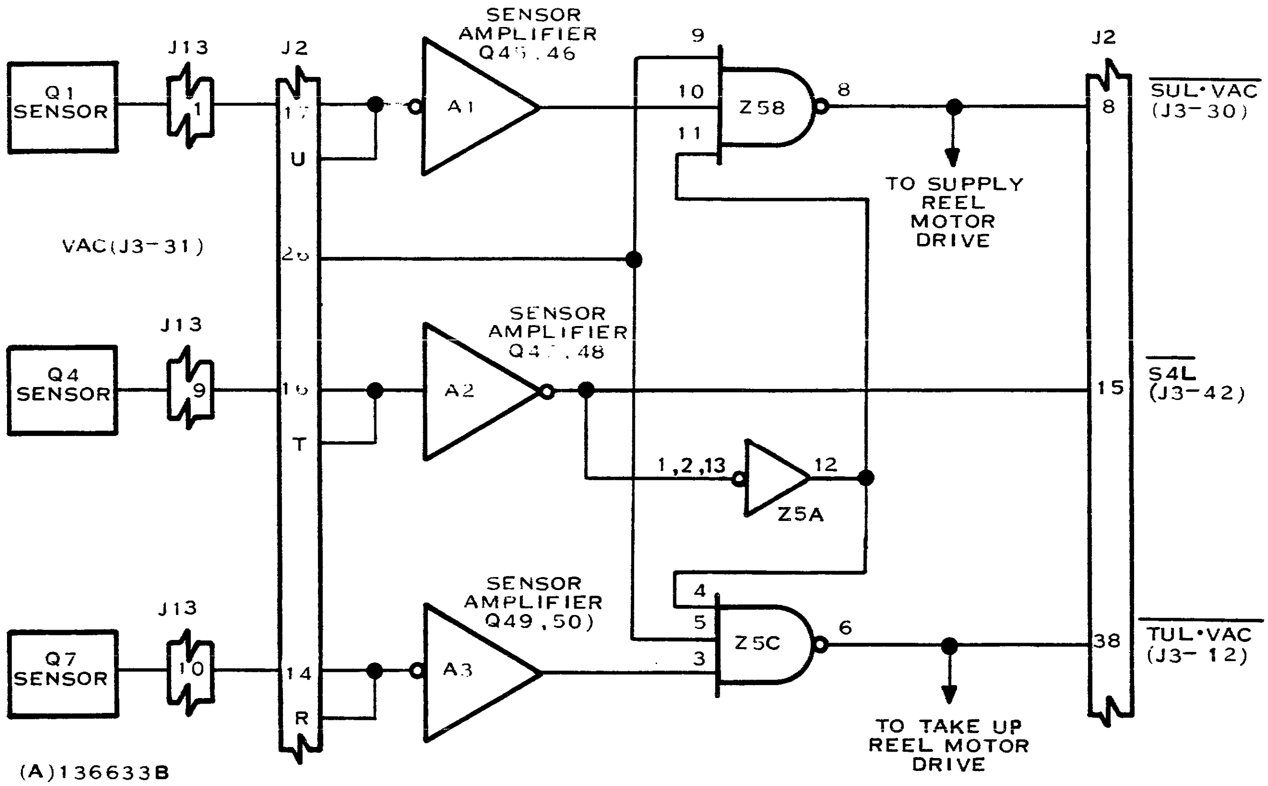


Figure 4-11. Vacuum Column Limit Sensors, Simplified Diagram

Normal Operation. The drive amplifier circuit employs a feedback limiter return network (CR11, CR12 and R54 through R57) and limits motor current to approximately 2 amperes as monitored through a 0.5 ohm external resistor in series with the motor. This motor current feedback signal is also used as an indicator of the motor IR drop. With appropriate scale factors, this signal is subtracted from the applied motor voltage producing an output signal from Z2 proportional to the back emf of the motor and thus proportional to the motor speed. Diodes CR5 through CR10 and resistors R41 and R42 are used as switching elements and limiters to apply this signal to the control circuits to brake the supply motor if the capstan direction is opposite to the supply reel direction. Otherwise, the reel is allowed to coast to a normal stop.

When a rewind is initiated, the capstan speed is allowed to rise to a maximum and remain there until an upper column pull out command requested by the sensor Q3 is blocked, or a lower column dump command is generated when sensor Q6 is exposed to its light source. Either of these conditions must remain stable for the bounce timer to time out ($\approx$200 msec). The capstan drive speed is reduced to 40 percent of maximum until pullout control is restored.

For both takeup and supply reel control, the rewind bias (input at J2-F) establishes the amplifier output at -20V steady state value during rewind rather then 0V steady state. This compensates for placing the low side of both reel motors at -20V instead of at ground to obtain a higher rewind speed.

The action of the takeup reel circuitry is similar to the description of the supply reel motor with two exceptions.

1. As mentioned earlier, DUMP BIAS is not used during the load operation.

2. Output polarity is reversed so that negative output to the takeup reel motor pulls tape out of the column instead of dumping tape into the column. Column sensor Q5 in the off state requests tape pullout from the lower column and sensor Q6 in the on state requests tape dump into the lower column.

The dynamic braking circuit consists of elements Q51 through Q54. Inputs to this circuit are developed by circuits on the motion control logic card (A1A4A3). Inputs are assigned mnemonics $\overline{\text{DRBR}}$, $\overline{\text{FWD}}$ and $\overline{\text{REV}}$. $\overline{\text{DRBR}}$ disables braking when the transport is in a load or fast rewind operation, ($\overline{\text{DRBR}}$ at logic 1). Braking is enabled when $\overline{\text{DRBR}}$ is at logic 0. The braking direction is then determined by $\overline{\text{FWD}}$ (forward) or $\overline{\text{REV}}$ (reverse). If the capstan drive and supply reel drive (or takeup reel drive) are in the same direction, no braking takes place. Counter-rotating directions of the capstan drive and supply or takeup reel drives cause braking action.

4.3.2.3 Motion Control Logic. There are two types of motion control logic: one type containing IC's and discrete components for decoding, switching and storing control signals; the other type consisting of microprocessor, memory elements and drivers to perform the same functions. These cards are interchangeable.

Motion control logic reacts to either local or remote commands and begins execution of instructions controlling tape movement. Operator-controlled local commands are used manually to load, rewind and unload tapes. The commands are issued when the operator presses front panel controls. The remote commands are issued by the computer. These commands cause forward read or write, backspace, rewind, and unload tape operations. Reading and writing operations directed by the computer are processed by the data control logic card.

After tape is manually installed on the transport and the LOAD switch pressed, the tape transport searches for the beginning-of-tape marker (BOT). When BOT is located the tape stops and the transport automatically switches to remote operation. The operator may return the transport to the local mode by pressing RESET. To return to remote, press LOAD.

4.3.2.4 Motion Control Logic (IC's and Discrete Components). See assembly 216548 and schematic 216549 in the *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702.

Load Operation. A load operation is initiated when the LOAD switch is pressed. The load flip-flop (shown in figure 4-12) sets, i.e., Z7-3 goes high. This puts the signal LOAD at logic 1. The vacuum latch (Z14-8 and Z15-8) is reset applying power to the vacuum motor via a vacuum relay. An 11-second interval is allowed for vacuum to build up in the vacuum column. Then, the supply reel servo starts feeding tape into the upper vacuum column to a point where light is blocked from sensors Q1 and Q2. (A diagram of sensor positions is shown in figure 4-3.) The forward search flip-flop sets (Z5-9) FWDS high. The complement of this signal, $\overline{\text{FWDS}}$, is low and generates $\overline{\text{FWD}}$. This signal starts the capstan motor, which drives forward at a standard operating speed of 952.5 mm (37.5 inches) per second to move the tape into the bottom vacuum column. When sufficient tape has been drawn into the bottom column, i.e., both Q7 and Q6 are blocked from light, the takeup reel starts pulling tape from the bottom column as soon as tape covers sensor Q5. The forward search continues until a beginning-of-tape (BOT) marker is detected by the BOT sensor. After a short delay, the forward search flip-flop is reset and the reverse search flip-flop (Z5-12) is set to drive the tape in the reverse direction. Tape motion is stopped when the BOT marker is again detected. The remote flip-flop Z9-6 is set and the READY lamp is lighted to complete the load sequence. If the tape has been wound beyond the BOT marker during threading, the transport will forward search for a nominal interval of 11 seconds, then reverse search until the BOT marker is detected. If the BOT marker is missing, all tape will be taken off the takeup reel and all motors will stop. The only way a tape can be loaded

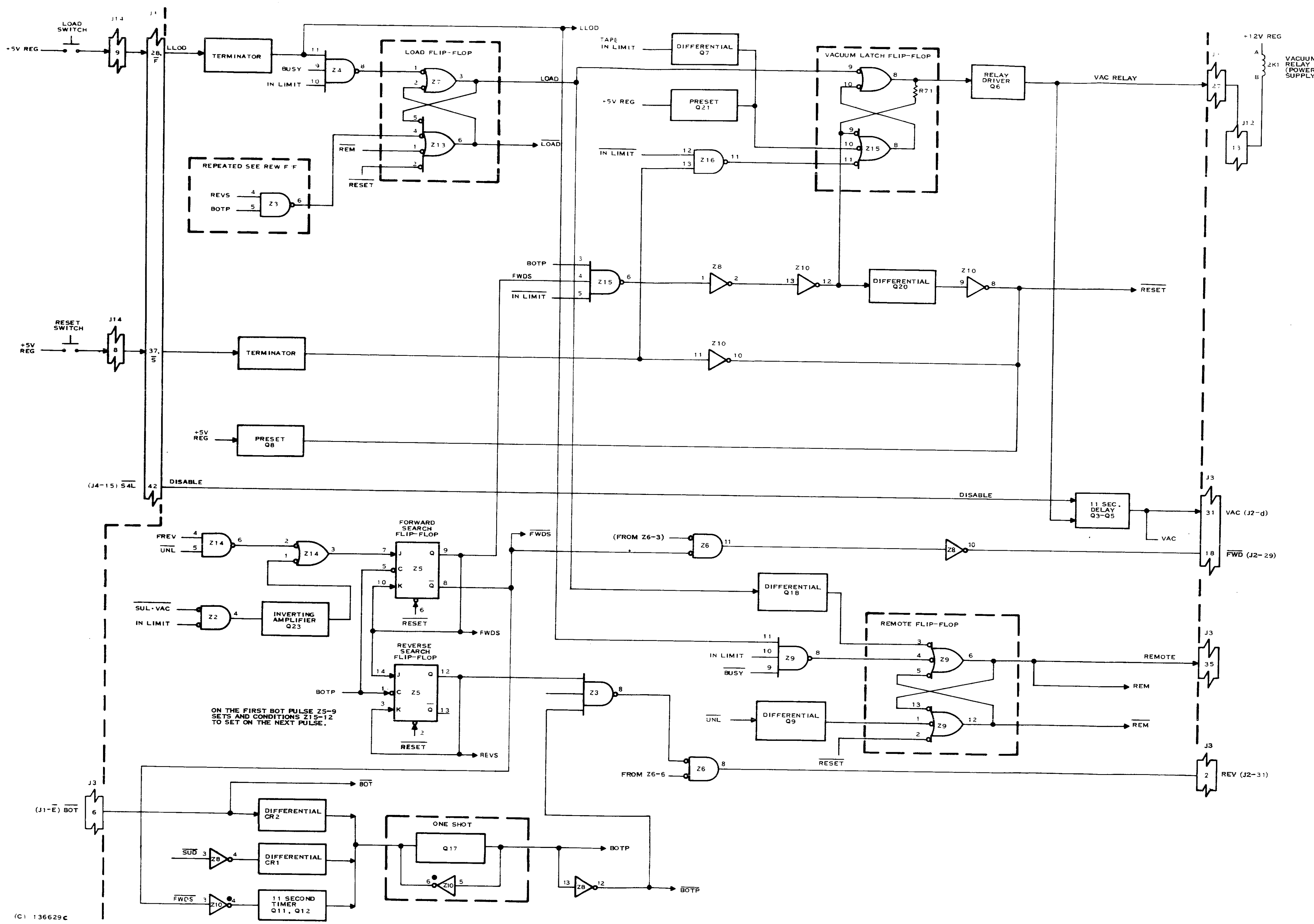


Figure 4-12. Motion Control Logic Simplified Diagram

without a BOT marker is by defeating the BOT detect sensor. The tape always stops at the BOT marker when moving in the reverse direction. When the BOT marker is approached in the forward direction, the tape passes the detector, the transport reverses and the marker approaches the detector in the reverse direction. When the remote flip-flop is set, the local REWIND and UNLOAD switches are disabled. To enable the local REWIND and UNLOAD switches, the RESET switch is pressed. This resets the remote flip-flop. The RESET switch stops any operation which is in progress. When the tape is loaded and the READY lamp is extinguished, the LOAD switch may be pressed to place the transport in the remote mode.

Tape Motion Detectors. There are three detector circuits to monitor tape movement:

a. Vacuum column limit sensors.

b. BOT/EOT (beginning-of-tape, end-of-tape) sensors.

c. Tape-off-reel sensor.

All of the above sensors and associated circuitry control the direction and speed of motors.

Vacuum Column Limit Sensors. These sensors are located in the vacuum column and supply inputs to the reel servo control. The limit sensors consist of seven light sources and seven phototransistors to determine the amount of tape in the supply column and takeup column. See Section 3 for location of sensors, and a description of each sensor. If limits in either column are exceeded, signals $\overline{\text{TUL} \cdot \text{VAC}}$ and/or $\overline{\text{SUL} \cdot \text{VAC}}$ go to logic 1 and cause the motors to compensate by either dumping in more tape or taking more tape from the columns. If some limits defined in Section 3 are exceeded, complete shutdown of the drive system will occur until the problem has been corrected.

BOT/EOT Sensors. This sensor is located near the head assembly and detects reflective pieces of tape at the beginning and end-of-tape. When the transport detects a BOT mark, a pulse (BOTP) of approximately 0.033 second is generated to indicate that tape has reached the beginning of the tape. When the EOT is reached at the other end of the tape, a signal is sent to the computer indicating that the end-of-tape has been reached. EOT is not used by tape transport circuitry but is transmitted to the computer for action. If the computer is in the HALT condition, drive will not stop when EOT is reached but will continue until all tape is off the supply reel.

Tape Off-Reel-Sensor. In a rewind operation, the tape reverses motion and is taken up by the supply reel. When the BOT is reached, the tape stops. Pressing the UNLOAD switch causes the tape to continue reeling onto the supply reel but at a much slower speed than normal rewind. As long as there is tape on the takeup reel, the takeup motor acts as a generator. This causes relay K1 (unload wind relay in servo module) to remain energized via logic circuits on this card and capstan/regulator, A1A4A1, (UNLT/ULWIND and ULWIND/TO WIND RELAY circuits, respectively). As soon as rotational movement of the takeup reel stops (such as when tape leaves the takeup spool), the drive to relay coil K1 is lost causing K1 to deenergize, thereby removing all power to the motors. The same effect occurs when EOT is missed and tape is pulled off the supply reel; back emf is lost and relay K1 is deenergized.

Tape Drive Operations. When a tape is installed and the load operation is complete, the tape transport is in the remote mode and READY for reading or writing with tape (see figure 4-13). When the tape transport is selected ($\overline{\text{SELECT}}$) by the computer, SELECT gates with READY to inform the computer of the tape transport status ($\overline{\text{READY STATUS}}$). Upon computer command, the tape transport begins a forward or reverse search depending upon the state of REMOTE FORWARD, (RFWD). $\overline{\text{RFWD}}$ is at low level for forward motion, high level for reverse motion. Remote Go (RGO) signals the tape drive to begin motion, either forward or reverse, depending upon the state of

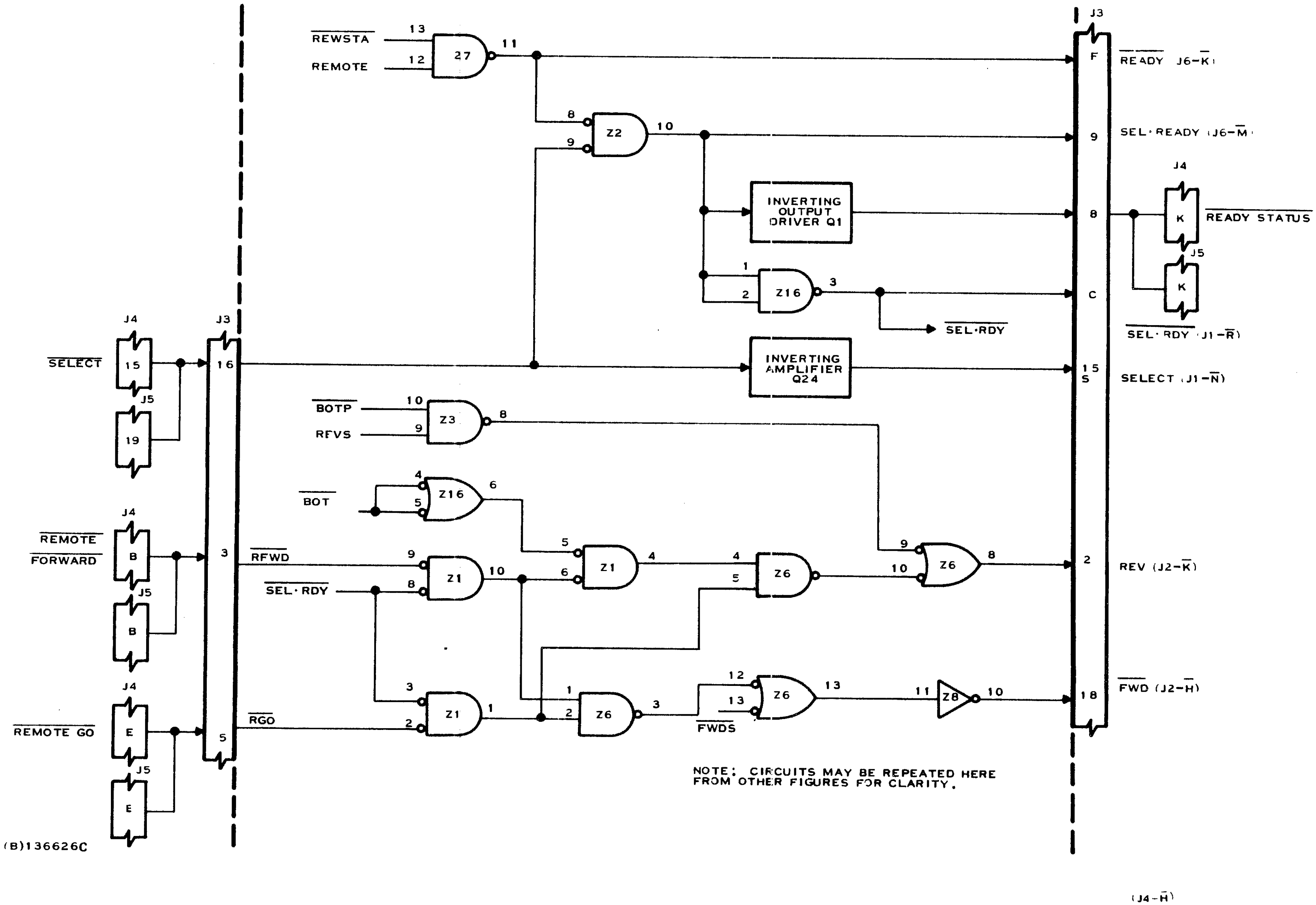


Figure 4-13. Tape Drive Circuit, Forward/Reverse Simplified Diagram

RFWD. Tape then travels in the forward or reverse direction at 952.5 mm (37.5 inches) per second until the operation is complete.

Rewind Operation. A rewind operation may be started remotely by the CPU or locally by pressing RESET and then the REWIND switches (see figure 4-14). With the remote flip-flop set (Z9, figure 4-12) the rewind sequence is initiated by the presence of a low level on the remote rewind interface line (REMOTE REWIND). This condition sets the rewind flip-flop and the fast reverse flip-flop. The tape will rewind at a rate of approximately 3810.0 mm (150.0 inches) per second. Rewind continues until the BOT marker is detected. The fast reverse flip-flop is reset and the BOT marker is positioned as described in paragraph 4.3.2.3 dealing with load operation. The remote flip-flop remains set during rewind. The ready status line is high during the rewind and returns to a low level when the rewind sequence is completed, indicating current status to the computer. The rewind status line becomes a low level when rewind is initiated and returns to a high level when rewind is completed. The transport will produce a rewind status independent of being selected when in the local mode. By pressing RESET, the tape transport is placed in the local mode. A full reel of tape (731.5 metres = 2400.0 feet) will rewind in less than 200 seconds (measured from initiation of the remote rewind command to the return of ready status).

Unload Operations. Tape may be unloaded in either the remote or local mode (refer to figures 4-15 and 4-16). The unload function provides for the complete unreeling of tape from the takeup reel at low speed. If the tape transport is to rewind tape in the remote mode, REMOTE UNLOAD (RUNL) is low causing the unload flip-flop to set, i.e., UNL goes to logic 1. The complement of this signal, UNL, causes the one-shot which consists of Q13 and Q15 to fire. The one one-shot insures that ULWIND remains high for at least three seconds after UNL becomes active.

The inputs from sensors, BOT, TUL · VAC, and SUL · VAC, shown in figure 4-16, are derived from sensors on the tape transport. TUL · VAC indicates that a vacuum is present and that tape in the takeup vacuum column is within limits. SUL · VAC indicates presence of vacuum and that tape in the supply vacuum is within limits. When BOT is low (BOT), the beginning-of-tape marker has been detected. These sensor signals inform the motion control logic card of tape transport status.

BUSY. If any one of the four inputs to gate Z13 in figure 4-16 is low, a busy condition is signaled by a low BUSY. The four conditions creating BUSY are:

a. Remote flip-flop, Z9 in figure 4-12 is set signifying transport is in the remote mode. (REM = Logic 0.)

b. Load flip-flop, Z7 and Z13 in figure 4-12 is set when the transport is in a load sequence. (LOAD = Logic 0.)

c. Unload flip-flop, Z15 and Z14 in figure 4-15 is set when the transport is unloading tape from the takeup reel. (UNL - Logic 0.)

d. Rewind flip-flop, Z12 in figure 4-16 is set during a rewind operation. (REW = Logic 0.)

4.3.2.5 Motion Control Logic (Microprocessor). See assembly 937027 and schematic 937029 in the *Model 979A Tape Transport Subsystem Drawings Manual,* part number 949613-9702.

NOTE

Assembly listing and program description for the 8080 microprocessor used on this card may be found in Appendix B.

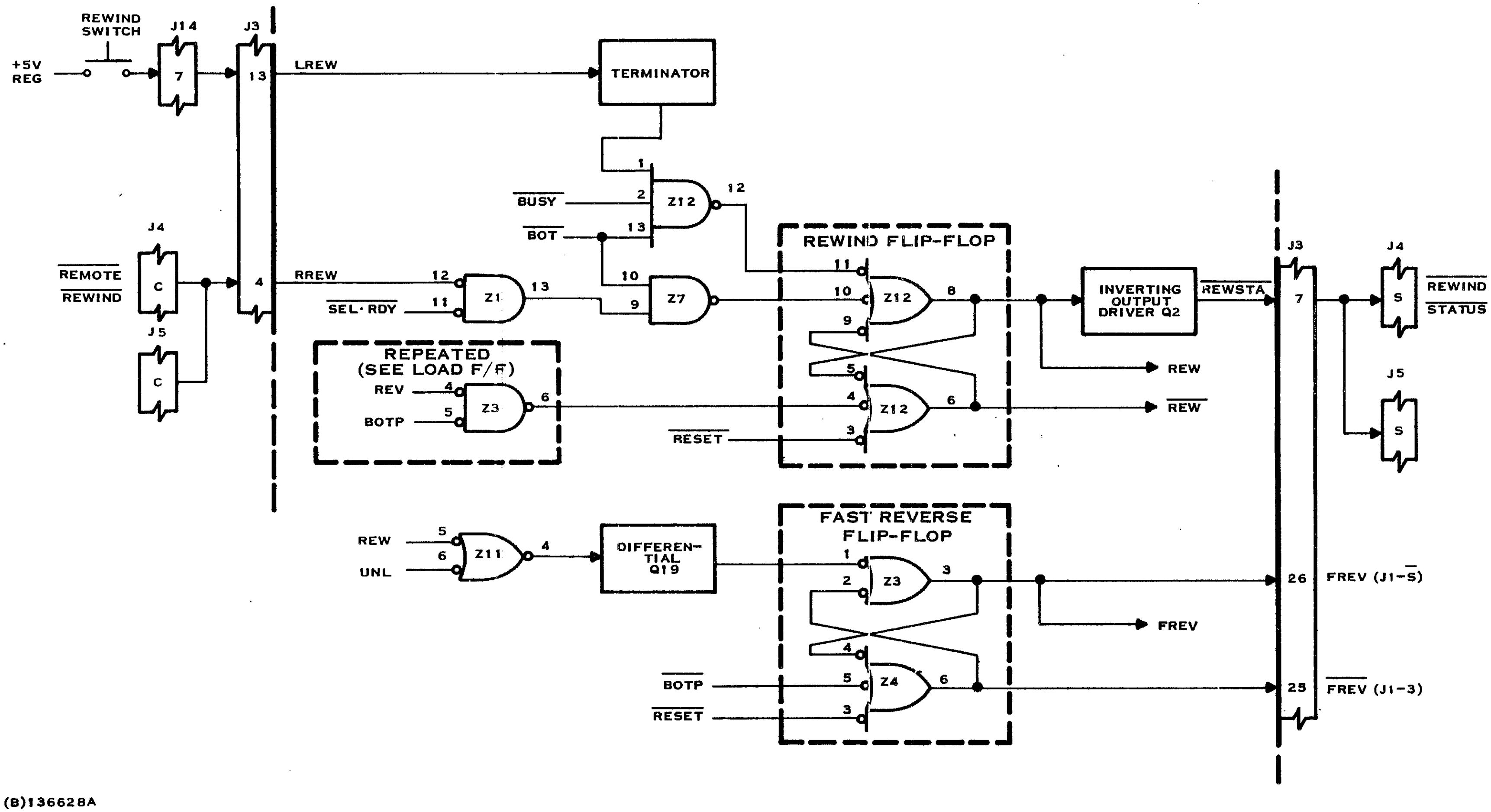


Figure 4-14. Rewind Circuit, Simplified Diagram

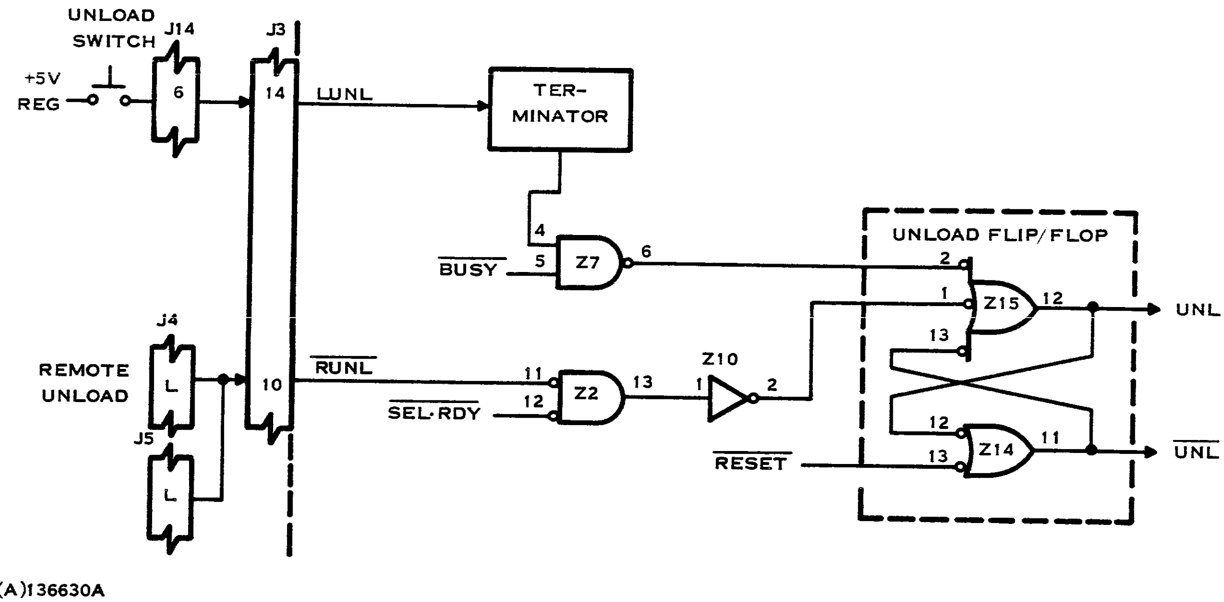


Figure 4-15. Unload Circuit, Simplified Diagram

This type motion control logic board is a microprocessor based controller for tape motion control and is directly interchangeable with the board described in the preceding paragraphs. Functions performed are identical and include the following:

Load Sequence. After tape has been threaded, pressing the LOAD switch will cause the following sequence of events to occur:

1. Vacuum motor is energized.
2. Nominal 11-second delay while vacuum motor starts.
3. Supply reel dump bias is applied to load tape into top portion of vacuum column.
4. When top portion of vacuum column is loaded, the dump bias is removed and the capstan is driven forward to load tape in the bottom column and to start a search for the beginning-of-tape mark (BOT).
5. After BOT is detected, the tape direction is reversed until the BOT marker is again sensed. Tape motion is then stopped to position the tape on BOT.
6. If, during threading, the tape is wound beyond the BOT marker, a reverse search occurs after a nominal 11-second forward search.
7. When load sequence is complete, the transport enters the remote mode.

Remote Mode. In the remote mode, a selected transport will respond to commands from the tape controller. Forward or reverse tape motion, or unload or rewind sequence commands can be specified. While a forward or reverse command is being performed, the logic board will recognize an unload or rewind command and execute that command instead of the previous forward or reverse command. When the RESET switch is pressed the transport will reset the remote mode and enter the local mode.

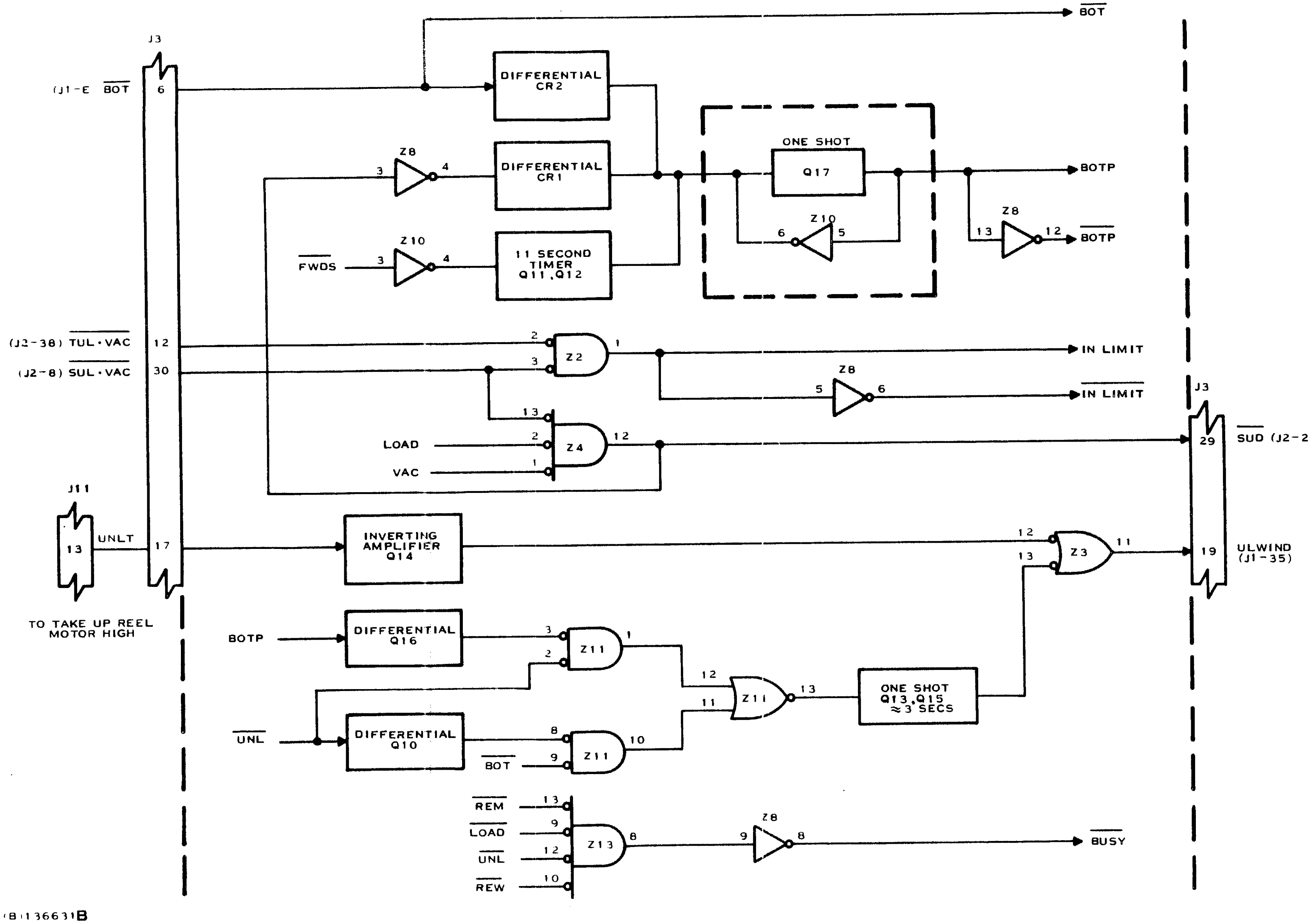


Figure 4-16. Sensor and Busy Circuit, Simplified Diagram

Local Mode. In the local mode the transport will respond to commands from the transport control panel switches. Load, unload, or rewind commands can be selected. If the transport is loaded, pressing the load switch will reset the local mode and initiate the remote mode.

Rewind Sequence. The following rewind sequence can be initiated from either the local or remote mode.

1. If on BOT, no action is initiated and the transport returns to the originating mode, local or remote.
2. If not on BOT, READY status is reset, REWIND status is set, and fast reverse tape motion is initiated.
3. When BOT is detected, fast reverse is stopped and forward search for BOT is initiated.
4. When BOT is passed over in the forward search, a reverse search for BOT is initiated.
5. Immediately upon detecting BOT in the reverse direction, tape motion is halted. This positions the tape on BOT.
6. REWIND status is reset and READY status is set. The transport returns to the mode of operation (local or remote) which initiated the command except when the rewind was initiated from the local mode and subsequently the LOAD switch was pressed, which returns the transport to the remote mode when rewind is complete.

Unload Sequence. The following unload sequence can be initiated from either the local or remote mode.

1. READY status is reset.
2. If the tape is not on BOT, a fast reverse is initiated until BOT is detected at which time the reverse is stopped.
3. Unload/wind is initiated.
4. When the tape is pulled out of the vacuum column, the vacuum motor is turned off.
5. Nominal four-second delay.
6. When tape is pulled clear of the takeup reel, the unload wind is complete. During the unload operation tape is being pulled from the takeup reel. The takeup reel acts as a generator during this time and keeps relay K1 energized. As soon as tape clears the takeup reel, rotational movement of the takeup reel (and drive) stops and relay K1 deenergizes.

In-limits Sensing. From the time the tape has been loaded into the vacuum column during the load sequence until the time the tape has been pulled out of the vacuum column during an unload, the tape in-limit sensors are sampled to verify that the tape is within the proper limits in the vacuum column. If an out-of-limits condition is sensed, all outputs are reset and the transport is returned to the unload condition.

Operational Specifics. A block diagram of the motion control circuit is shown in figure 4-17. The description that follows is keyed to this diagram.

a. Microcontroller Circuit. The 8080 microcontroller portion of this motion control logic board consists of the microprocessor (U5), clock generator (U18), system controller (U12), 512 8-bit bytes of read-only-memory (U1), and power reset circuits (U19). The clock generator uses a 9.8304 mHz crystal oscillator and divider network to provide a two-phase clock to the microprocessor with a period of 0.916 μsec. The system controller is a bidirectional device with the data bus (DB0 → DB7) and the 8080A microprocessor. The system controller (U12) includes the internal status latch and decoder to provide the I/O control signal.

Power up reset is provided by U19 generating $\overline{\text{RESIN}}$. This signal is synchronized to the clock supplied by the generator U18. When the reset signal is removed from the microcontroller circuit, program execution begins at memory address 0000. The nine least significant bits of the address bus (A0 → A8) are used to address the 512 bytes of ROM as well as the input/output ports. Interrupts are not used.

Internal microprocessor registers are used for storage instead of random access memories. There are some selected control and clock lines buffered by three-state buffers to provide for automated production testing. These buffers are continuously enabled for normal operation.

b. Addressing. The nine least significant address lines from the microprocessor address the ROM when enabled by $\overline{\text{MEMR}}$. The two least significant address bits enable the selected input port when I/OR is true and clock the selected output port when I/OW is true.

	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
ROM ($\overline{\text{MEMR}}$)	X	X	X	X	X	X	X	A	A	A	A	A	A	A	A	A
Input Port 1 ($\overline{\text{I/OR}}$)									X	X	X	X	X	X	0	1
Input Port 2 ($\overline{\text{I/OR}}$)									X	X	X	X	X	X	1	0
Output Port 1 ($\overline{\text{I/OW}}$)									X	X	X	X	X	X	0	1
Output Port 2 ($\overline{\text{I/OW}}$)									X	X	X	X	X	X	1	0

X = don't care

A = address   NOTE: I/O Ports use A0 → A1 only.

c. Inputs. Microprocessor inputs are enabled to the data bus by enabling the appropriate input buffers (U8/U11) and appropriate I/O port address with an I/OR instruction (or address). In this manner, the microprocessor can poll input bits to determine their state.

d. Outputs. The microprocessor outputs are clocked into output registers U16/U17 and then buffered to output pins or sent directly to the combinational logic in the remote circuits.

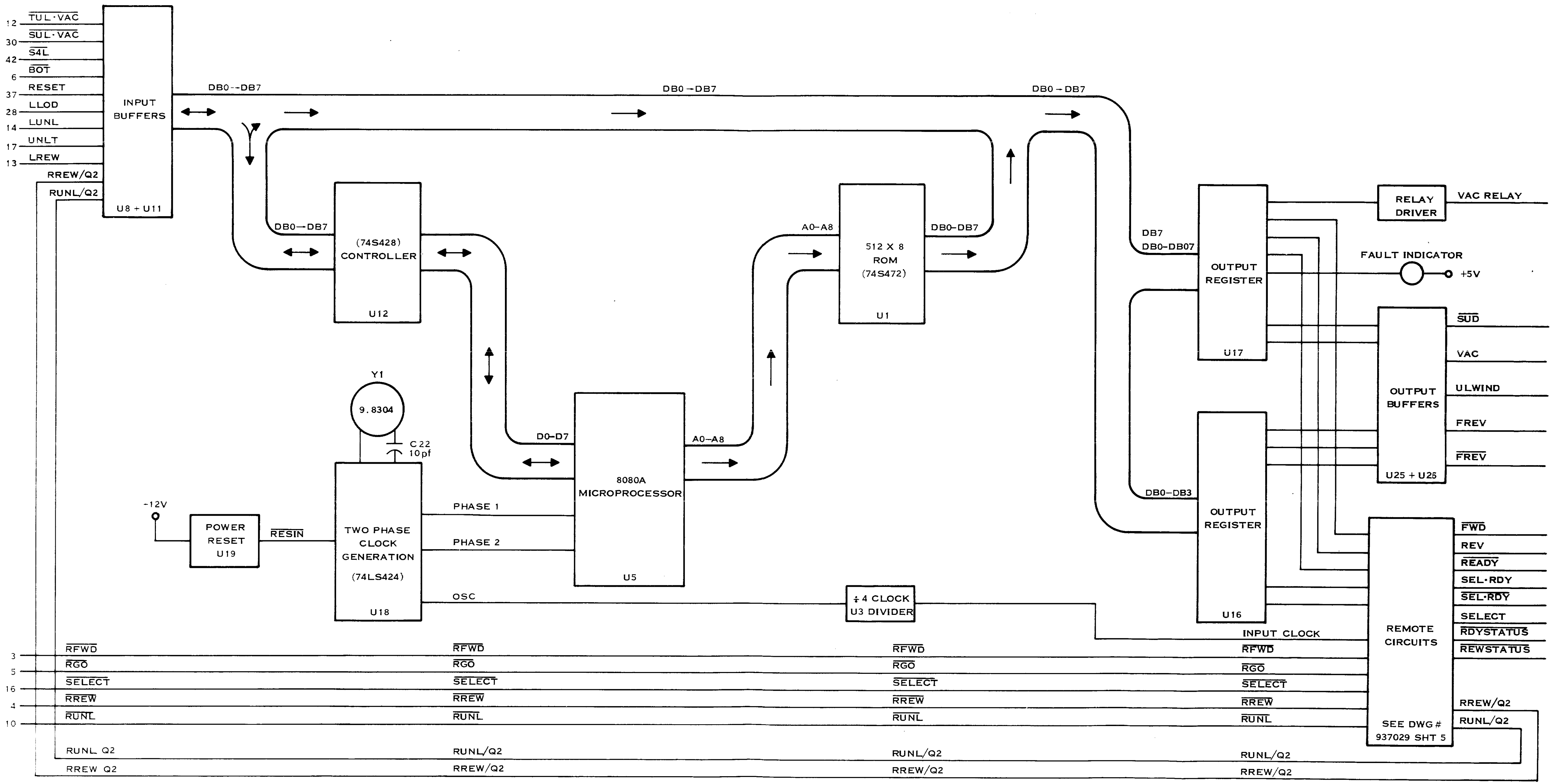


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Figure 4-17. Motion Control Logic (Microprocessor Type) Block Diagram

e. Remote Logic Circuits. The remote section recognizes rewind or unload commands, drives transport status lines, and decodes forward and reverse directional commands. These functions are performed by discrete logic because of speed requirements.

The rewind and unload circuits in the remote logic section consist of two flip-flop controllers requiring rewind or unload commands be present for two clock times before rewind or unload commands are recognized. The clock driving this circuit is derived from the crystal oscillator circuit and divided by four to obtain a clock period of 0.406 μsec.

4.3.2.6 PE Data Control. See assembly 216540 and schematic 216539 in the *Model 979A Tape Transport Subsystem Drawings Manual*, part number 949613-9702.

PE Data (four cards). See assembly 216536 and schematic 216537 in the *Model 979A Tape Transport Subsystem Drawings Manual*, part number 949613-9702. The technique used in PE (phase-encoded) recording/reproducing is described in Section 1.

There are five cards used in recording/reproducing PE data on tape. The card located in slot A1A4A6 is the PE data control. Two functions are performed on this card: 1) control for all nine track data circuits and, 2) track 1 record/reproduce circuit. Cards located in slots A1A4A7 through A1A4A10 contain reproduce/record circuitry for tracks 2 through 9, two tracks per card.

Control Circuit. For PE data, all formatting is performed on the interface/controller circuit, specifically the TIU or the appropriate TILINE controller. The PE data control card controls functions and timing for reading and writing data on magnetic tape. This card receives read/write command signals from the system controller (located in 960, 980, or 990 chassis or expansion unit), and returns status to the system controller. Outputs from the control circuit to the track data channels are applied in parallel to all data channels, see figure 4-18.

Read Circuits. Signals picked up by the read head receive amplification by Z1 (figure 4-19) and are phase shifted approximately 90 degrees by Q1, Q2. The phase-shifted output is then applied in parallel to two networks. The output of the first network is applied to a zero crossover detector (Z3) to digitize the original signal at the signal peaks. The zero crossover detector then drives the data output line driver, Q11. The output of the second phase shift network is applied to a level detector circuit (Z2). This circuit compares the phase shifted signal with an established threshold level. When the desired comparison is achieved, the zero crossover detector makes a decision. If the signal amplitude is too low, it is inhibited at the data output driver, Z4.

Write Circuits. Encoded data received from the interface/controller is presented to the write data interface lines and appears at input to Z4. When a write data line changes level, the magnetic flux direction for that channel is reversed on tape.

4.3.2.7 NRZI Data Control. See assembly 948235 and schematic 948237 in the *Model 979A Tape Transport Subsystem Drawings Manual*, part number 949613-9702.

NRZI Data (four cards). See assembly 948232 and schematic 948234 in the *Model 979A Tape Transport Subsystem Drawings Manual*, part number 949613-9702. The technique used in NRZI (non-return-to-zero, inverted) recording/reproducing is described in Section 1.

There are five cards used in recording/reproducing NRZI data on tape. The card located in slot A1A4A6 is the NRZI data control. Two functions are performed on this card: 1) control for all nine track-data circuits and, 2) track 1 record/reproduce circuit. Cards located in slots A1A4A7 through A1A4A10 contain reproduce/record circuitry for tracks 2 through 9, two tracks per card.

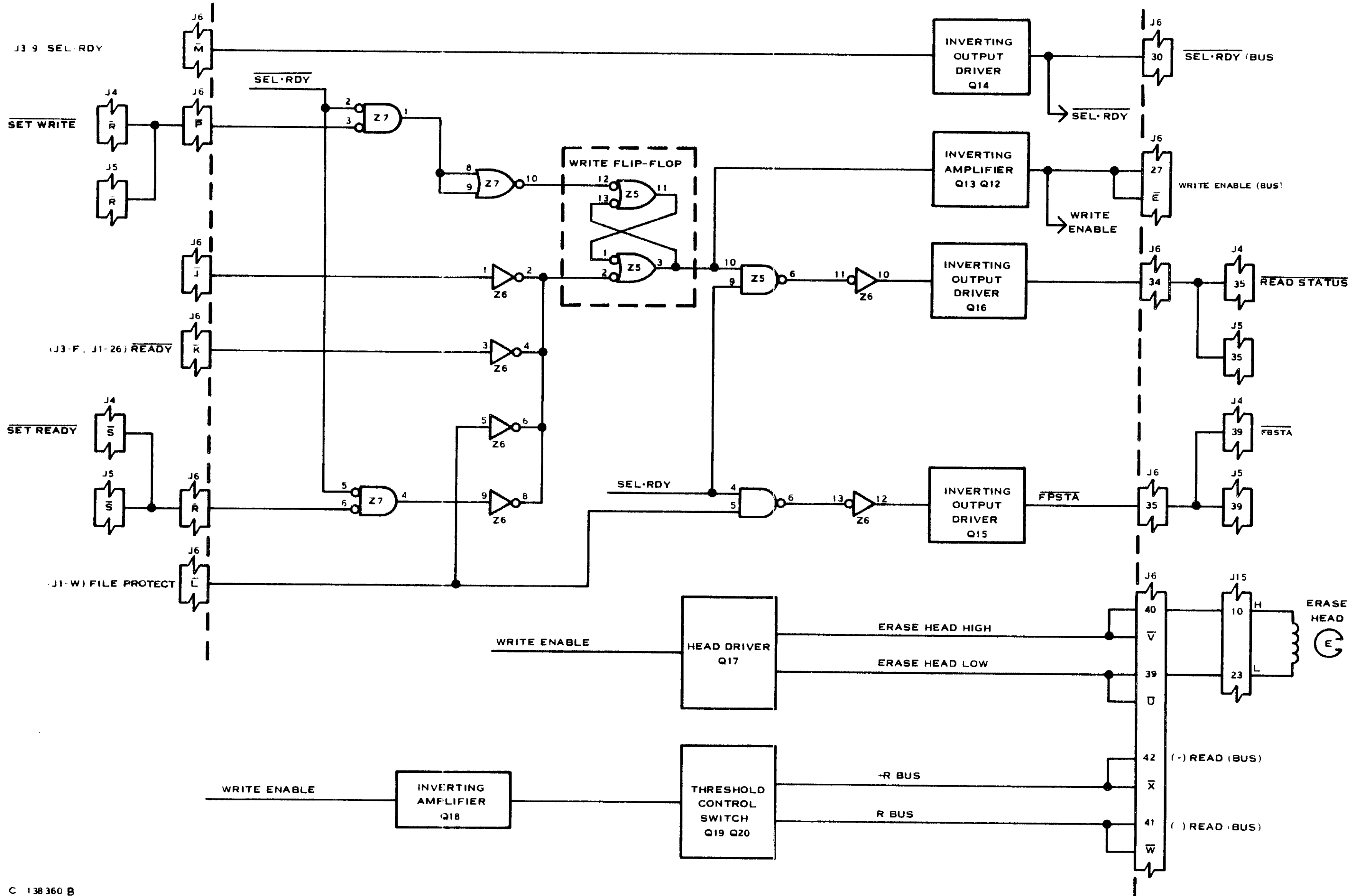


Figure 4-18. PE Control, Control Outputs

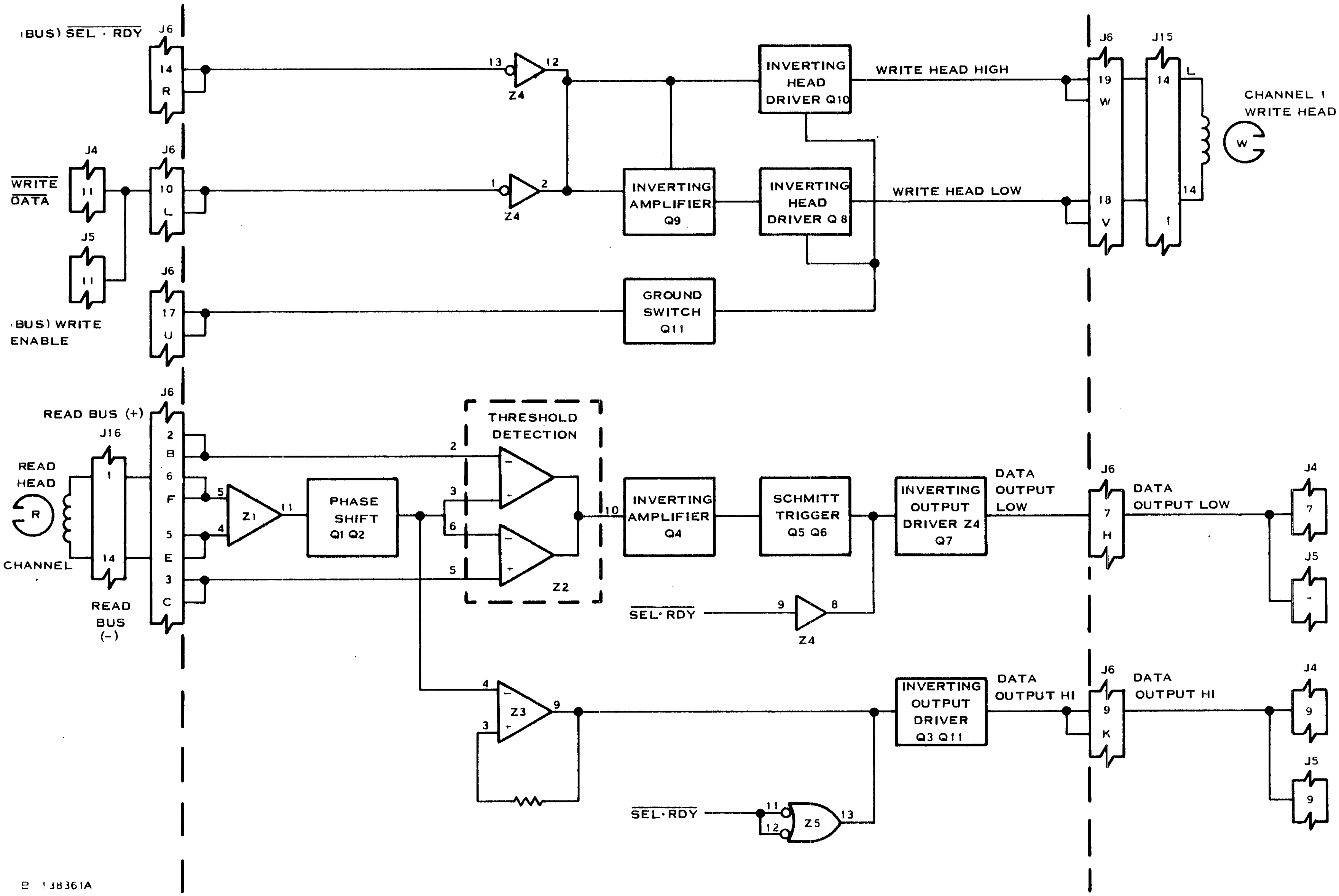


Figure 4-19. PE Control, Read/Write Circuit

Control Circuit. The NRZI control card controls functions and timing for reading and timing for reading and writing on magnetic tape. This card receives read/write command signals and transmits status. Outputs from this card to the data cards are applied in parallel to all data channels (tracks on tape). The data control card also contains track 1 electronics for reading and writing on tape track 1. The control portion of the card consists of the following functions.

Clock Generator Circuit. See figure 4-20. The clock source of 4 MHz ±0.05% is generated by a hybrid crystal oscillator in location U8. The 4 MHz signal is divided by flip-flop U14 down to 2 MHz. This 2 MHz signal is buffered by U15-8 for distribution to the nine data channels using the mnemonic $\overline{\text{SKEW CLOCK}}$. The data channel portion of this board contains a split 220/330 ohm terminator for this clock line.

Dynamic Skew Delay Circuit. See figure 4-21. After the first single bit of a tape character has been detected and the associated skew register has been set, a delay of 17 μsec is provided to allow all remaining track signals to be detected. The outputs of all nine skew register flip-flops are wireORed to produce the signal CHAR GATE to remove the reset to counter U10. After the 16 μsec delay, the control shift register is enabled and the counter enabled. One clock period (0.5 μsec) after the 16 μsec delay, the signal $\overline{\text{READ TRANSFER CLOCK}}$ goes low and is distributed to all nine data channels (tracks) to transfer data from the skew register to the read data register.

One clock period after $\overline{\text{READ TRANSFER CLOCK}}$ goes low, the $\overline{\text{READ CLOCK OUT}}$ signal to the controller goes low (assuming the transport is selected and ready) implying that data is available on the interface. $\overline{\text{READ CLOCK OUT}}$ is buffered with a 100 ma open collector driver for connection to the interface bus. After 3 μsec, the SEQUENCE RESET signal is generated to unlatch the counter enable, reset the counter and reset the shift register, thus terminating $\overline{\text{READ TRANSFER CLOCK}}$ and $\overline{\text{READ CLOCK OUT}}$. Data bits, however, are available on the output lines until the next character is ready to transfer to the read data register, a minimum of 16 μsec at 952.5 mm (37.5 inches) per second and typically 33 μsec.

Write Mode, U23-6 and U23-7. See figure 4-22. The write mode flip-flop (U23) is set by the controller/interface (assuming the unit is selected and ready) to enable the write function. The write mode may be reset by the controller or it is automatically reset if the transport $\overline{\text{READY}}$ signal goes high or the capstan direction is reversed (REV high). If the write enable ring is not present on the supply reel, the signal FILE PROTECT is high forcing a continuous reset to the write mode flip-flop, thus absolutely inhibiting the write mode selection. When WRITE mode is true, the erase head has approximately 50 ma current through it (U17-3 and R61 and R62) in the direction required to produce a north pole toward the BOT end of the tape. READ (complement of WRITE) and FILE PROTECT signals are ANDed with select and ready (U32) to produce $\overline{\text{FILE PROTECT STATUS}}$ and $\overline{\text{READ STATUS}}$ signals to the controller/interface.

R BUS Reference Source. See figure 4-23. The reference voltages for the peak amplitude discrimination as performed by each data channel are generated by the two amplifiers of U26. The outputs are +3 and -3 volts in the READ mode and +6 and -6 volts in the WRITE mode and are controlled by Q3. The +12-volt supply is used as a reference source for the R Bus amplitudes.

Write Register Enable Circuits. See figure 4-24. The write register toggle action must be enabled for only one skew clock period during the $\overline{\text{WRITE CLOCK}}$ low state from the controller/interface. Flip-flops U14-9 and U23-9 comprise a digital one-shot with U14-9 being true for the first full 2 MHz skew clock period following the leading edge of $\overline{\text{WRITE CLOCK}}$ low state. This output is then buffered for distribution to the nine data channels as $\overline{\text{WRITE REG IN}}$. A 220/330 ohm termination is provided on the data channel portion of the control card (track 1 data circuit).

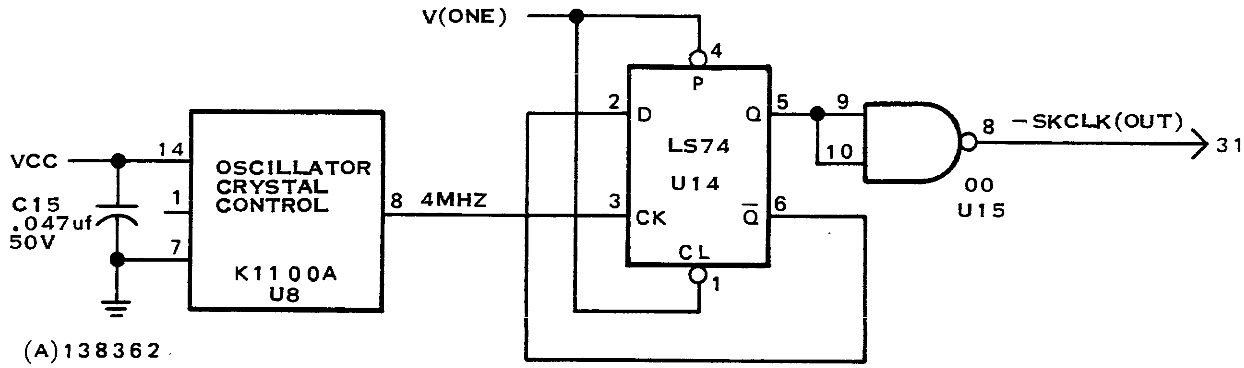


Figure 4-20. Clock Generator Circuit, NRZI Control

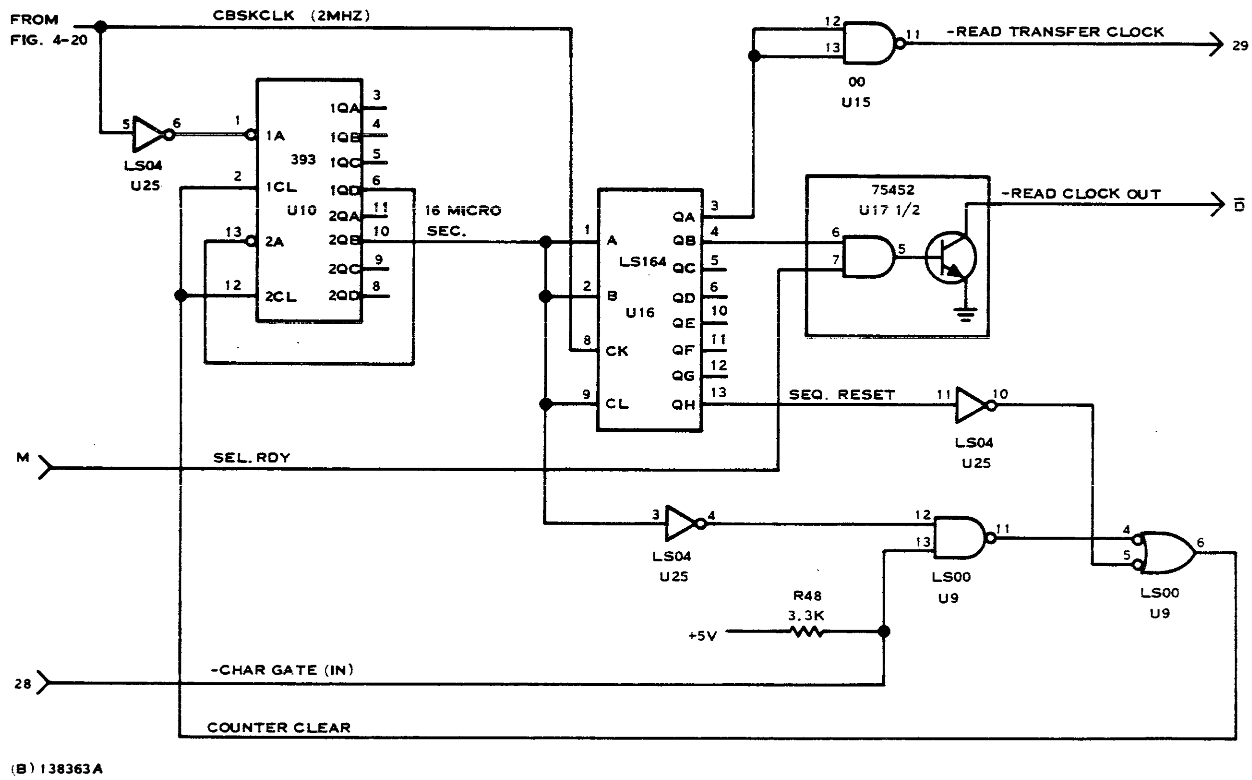


Figure 4-21. Dynamic Skew Delay Circuit

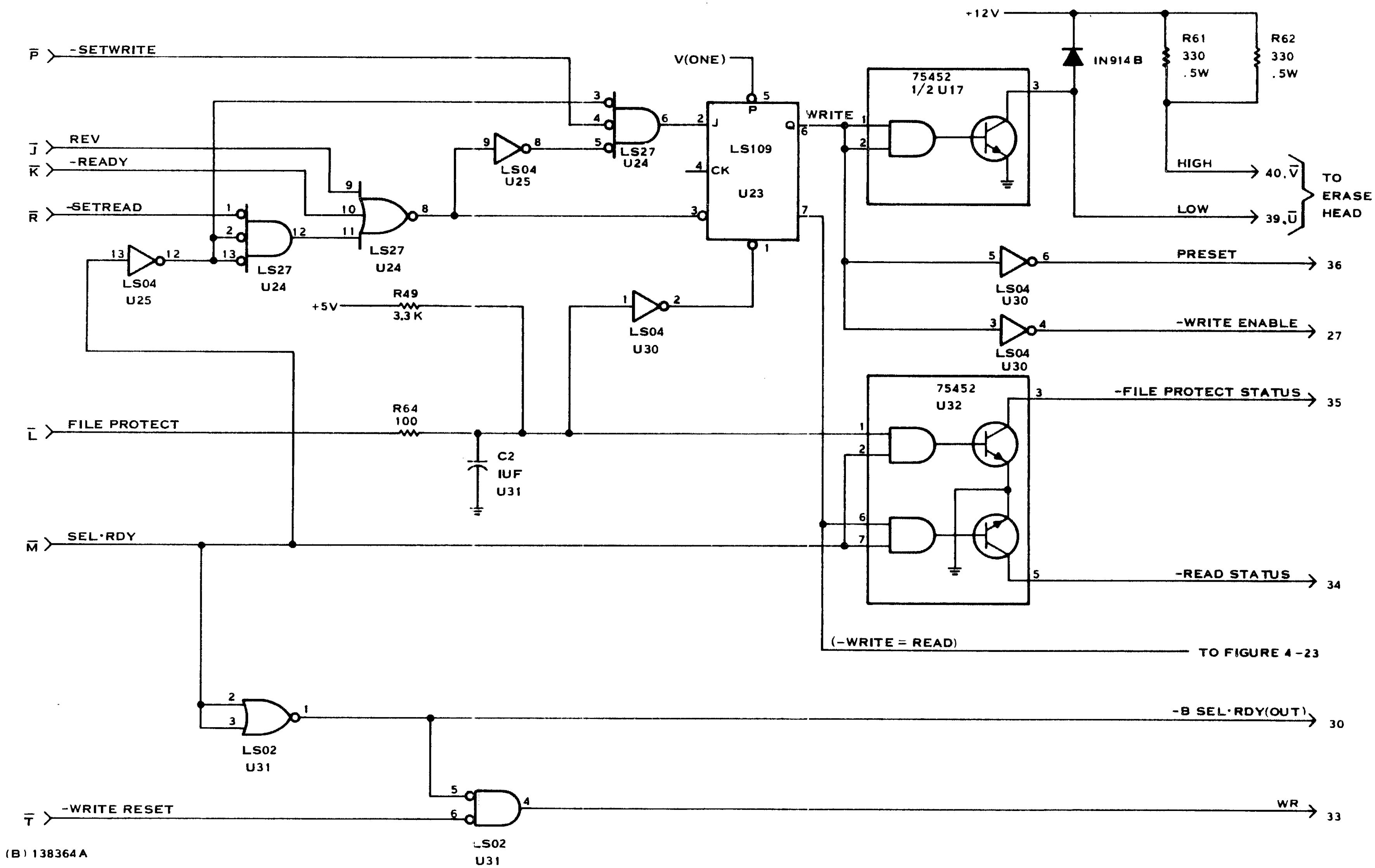


Figure 4-22. NRZI Write Select Circuit

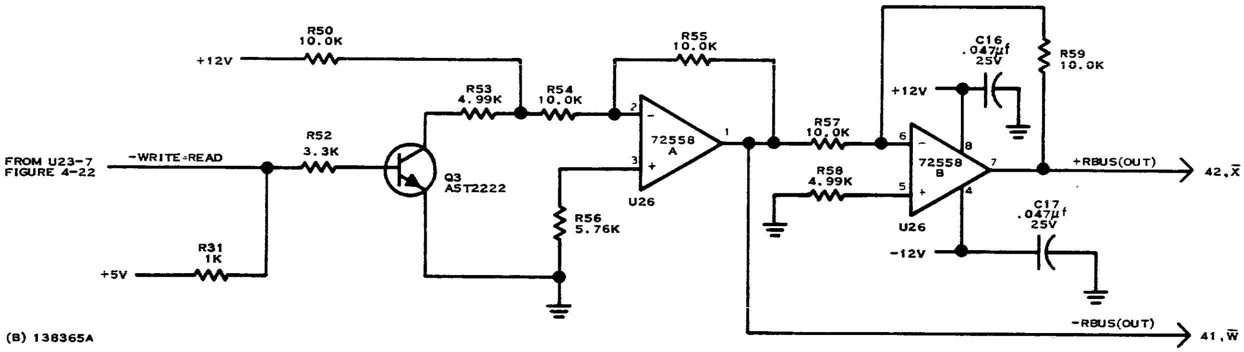


Figure 4-23. R - Bus Reference Source

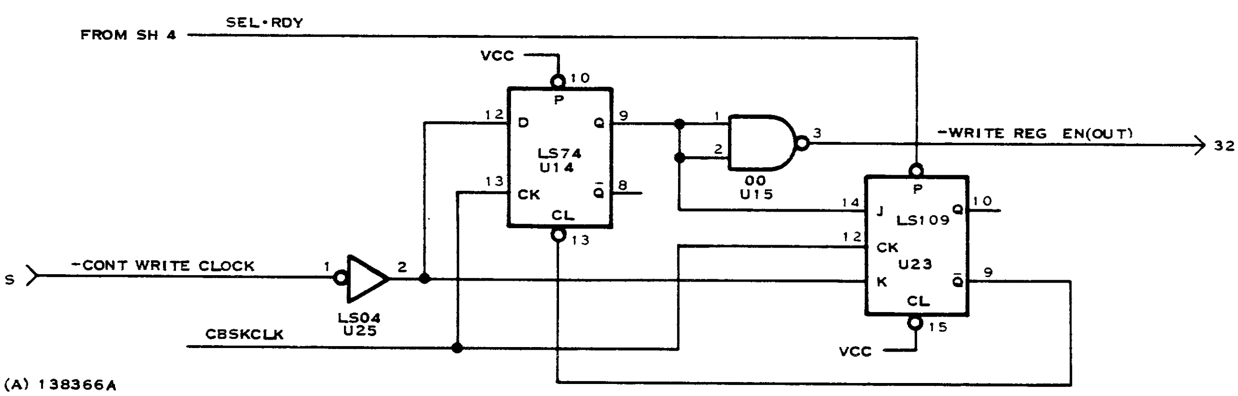


Figure 4-24. Write Register Enable Circuit

Write Register Reset. See figure 4-22. The low state of the signals WRITE RESET from the controller is ANDed with select and readied to produce the write register reset (WR) signal for distribution to the nine data channels. When this signal is true, along with WRITE REG EN, the longitudinal check character is written onto tape.

NOTE

> All nine data channels (tracks) operate similarly. In the following descriptions of reading and writing data with the tape, reference designators are for tracks 2, 4, 6, or 8 and are representative of all tracks.

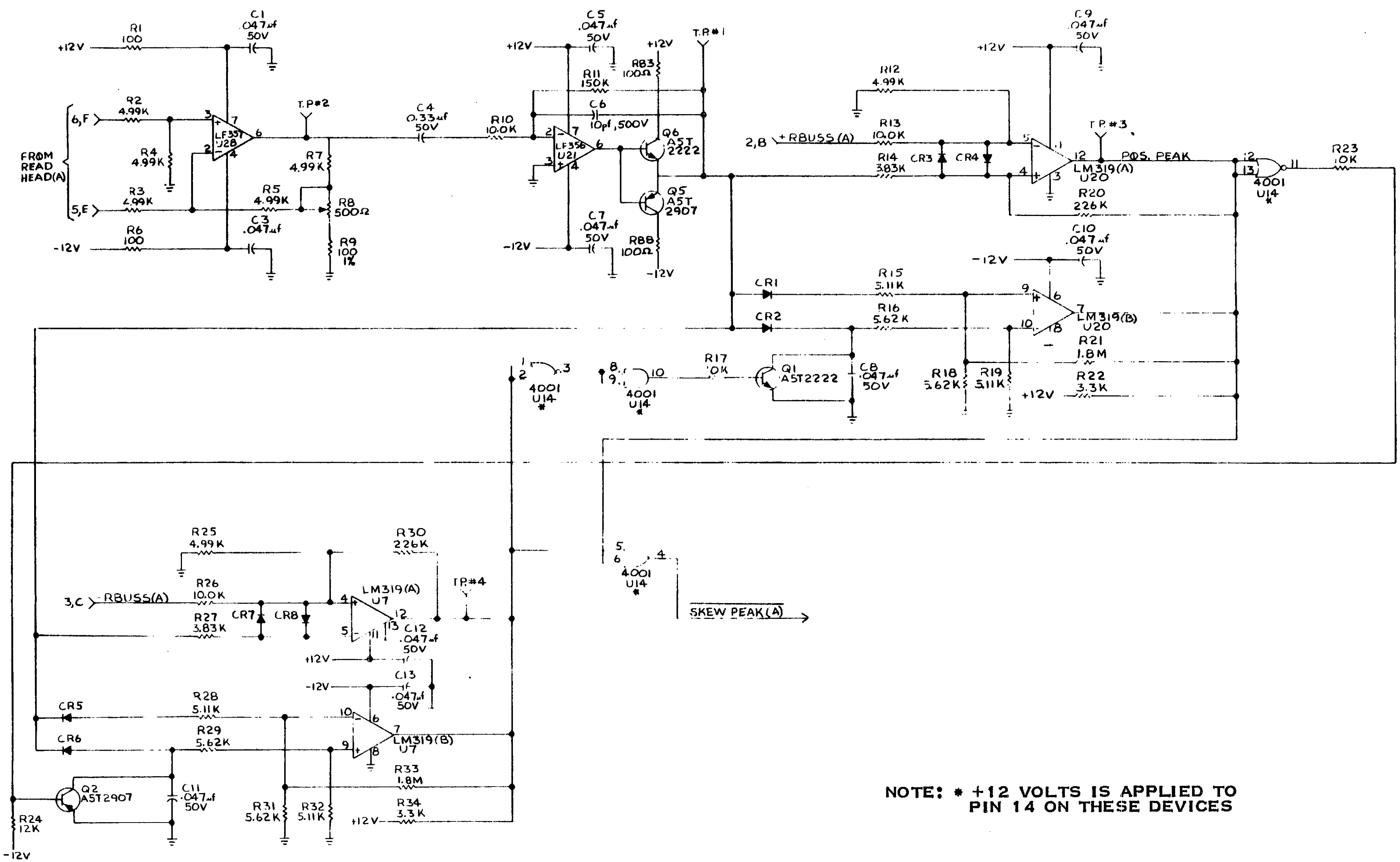
Read Data. See figure 4-25. Linear bandpass amplification with adjustable gain (R8) is provided to convert the floating input read head signal to a 10-volt pk-to-pk nominal signal with capability to drive high capacitance loads. Nominal input at 952.5 mm (37.5 inches) per second is 24 mv pk-to-pk. The bandpass breakpoints are set at 48 Hz on the low end and 106 kHz on the high end.

Positive Peak Detector, U20. The technique used for peak detection is shown in waveforms of figure 4-26. The input signal must exceed a preset threshold to qualify as a valid peak at U20 pin 12. To establish the time of the peak in a manner independent of signal amplitude and thus reduce dynamic skew, the input signal is compared at U20 pin 10 to the stored peak maximum at CR2 and C8. When the input drops below 85 percent of the peak maximum, the peak signal (wire-AND of U20 pins 12 and 7) is terminated. The trailing edge of this signal is thus the skew measurement time. The positive threshold level is set by the +R BUS input signal. This level is changed by a factor of two depending on whether the write mode or the read only modes are active. In the read only mode, the detection threshold is set at approximately 20 percent of the nominal maximum input signal level and in the write mode the detection limit is set at approximately 40 percent of the nominal maximum input signal level. This is to insure data integrity on read if no errors are detected on read-after-write in the write mode.

Negative Peak Detector (U7). Negative peak detection is identical to positive peak detection except for the polarity. Positive and negative peaks are ORed at U14-4 producing SKEW PEAK (A).

Read Static Skew Correction (U8, S1, R38). See figure 4-27. Static skew correction for read data is accomplished by adjusting the delay through a variable length shift register (U8) with miniature switches (DIP switches). The skew clock input to the shift register is 2.0 MHz resulting in an adjustment resolution of 0.5 μsec or approximately 0.5 micron (19.0 microinches) at 952.5 mm (37.5 inches) per second tape speed. With a maximum delay of 64 clock periods, up to 30.5 microns (1200.0 microinches), or almost 1 frame (1 frame = 31.8 microns = 1250.0 microinches) of static skew compensation may be made. In the adjustment process, all leading tracks are delayed to coincide with the most lagging of the nine tracks. The adjustments are outlined in the maintenance section.

Read Dynamic Skew Correction (U23). See figure 4-28. Up to 16 μsec of dynamic read skew can be compensated for by the action of the two halves of U23 in conjunction with a control signal and delay on the NRZI data control card. When the deskewed output of read skew delay goes false the dynamic skew register (U23-5 and 6) is clocked signaling the data control board via the CHAR GATE line that this track has detected a logic 1 bit from the tape. When the first of the nine, wire-OR CHAR GATE outputs comes true, a 16 μsec delay on the control is started. At the end of the delay the READ TRANSFER CLOCK signal is generated to clock the states of the skew register flip-flops into the READ DATA REGISTER for transfer to the controller. Odd vertical parity on tape assures that a READ TRANSFER CLOCK will be generated for each recorded character on tape. Conversely, all zero characters will not produce clocks. The read data register outputs are buffered by a 100 ma open collector driver for connection to the interface bus.



NOTE: * +12 VOLTS IS APPLIED TO PIN 14 ON THESE DEVICES

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Figure 4-25. Peak Detectors, Read Track Data

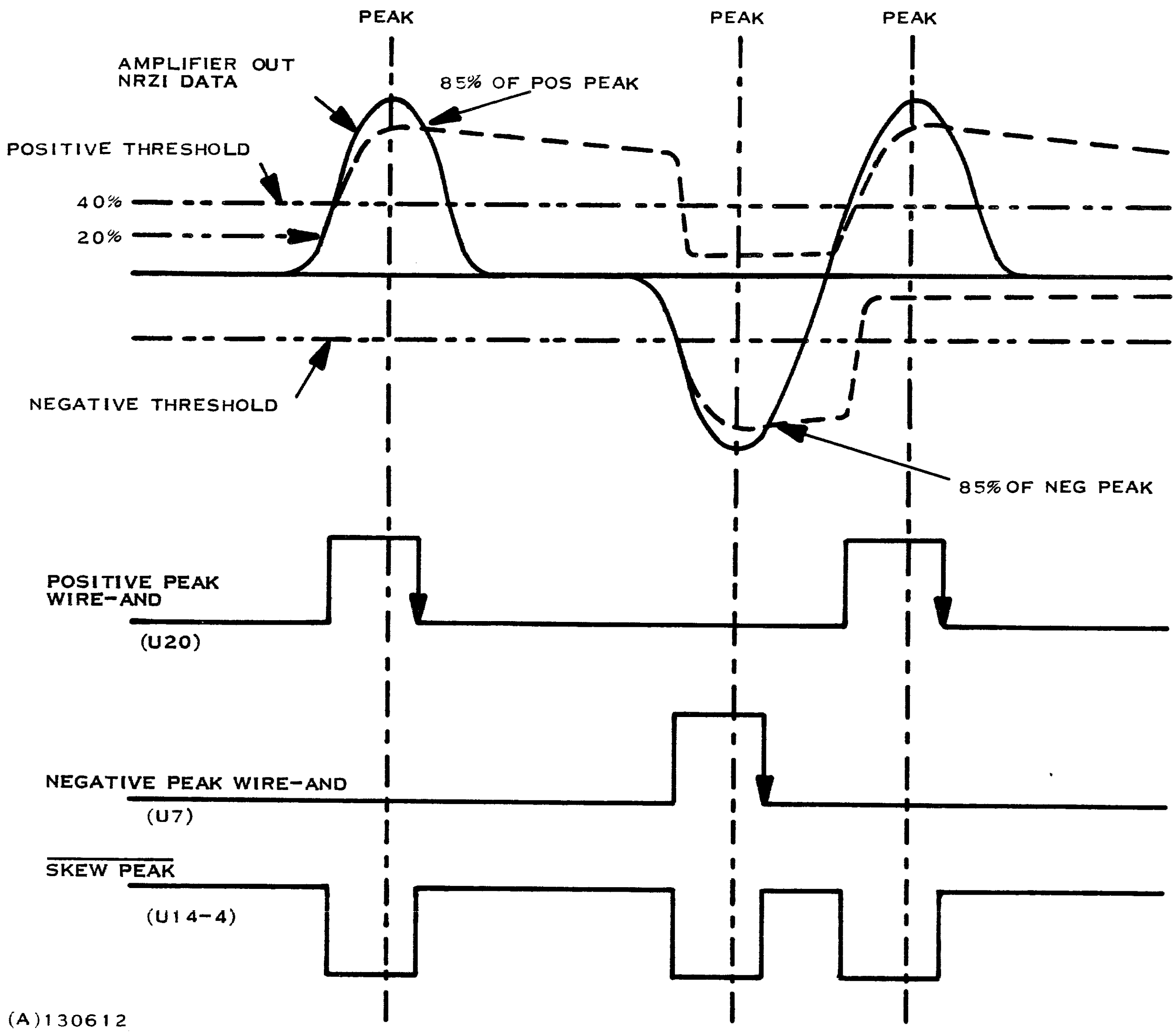


Figure 4-26. NRZI Peak Detector Waveforms

Write Data. Data to be written on tape is processed in an identical manner for all nine tracks.

Write Register (U22-9 and 10). See figure 4-29. Write data from the controller (WRITE DATA) is used in conjunction with WRITE REGEN from the interface/controller as a toggle enable for the write register (i.e., for NRZI operation a transition on tape is interpreted as a logic 1, thus the write register state is changed from one to zero, or zero to one for a true data output from the interface/controller). The WRITE REGEN signal as generated on the interface/controller board, is used to enable this toggle action only for a 2 MHz skew clock period for each WRITE CLOCK from the controller.

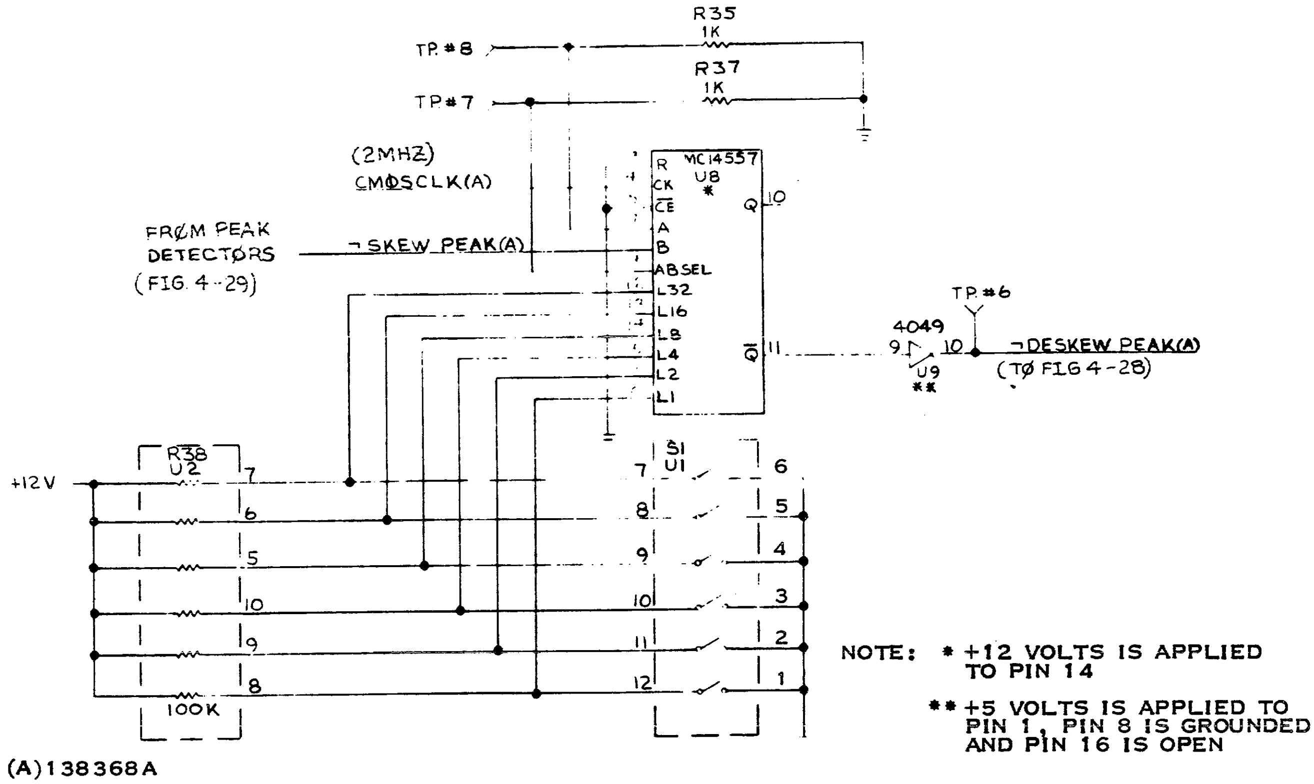


Figure 4-27. Read Static Skew Compensation Network

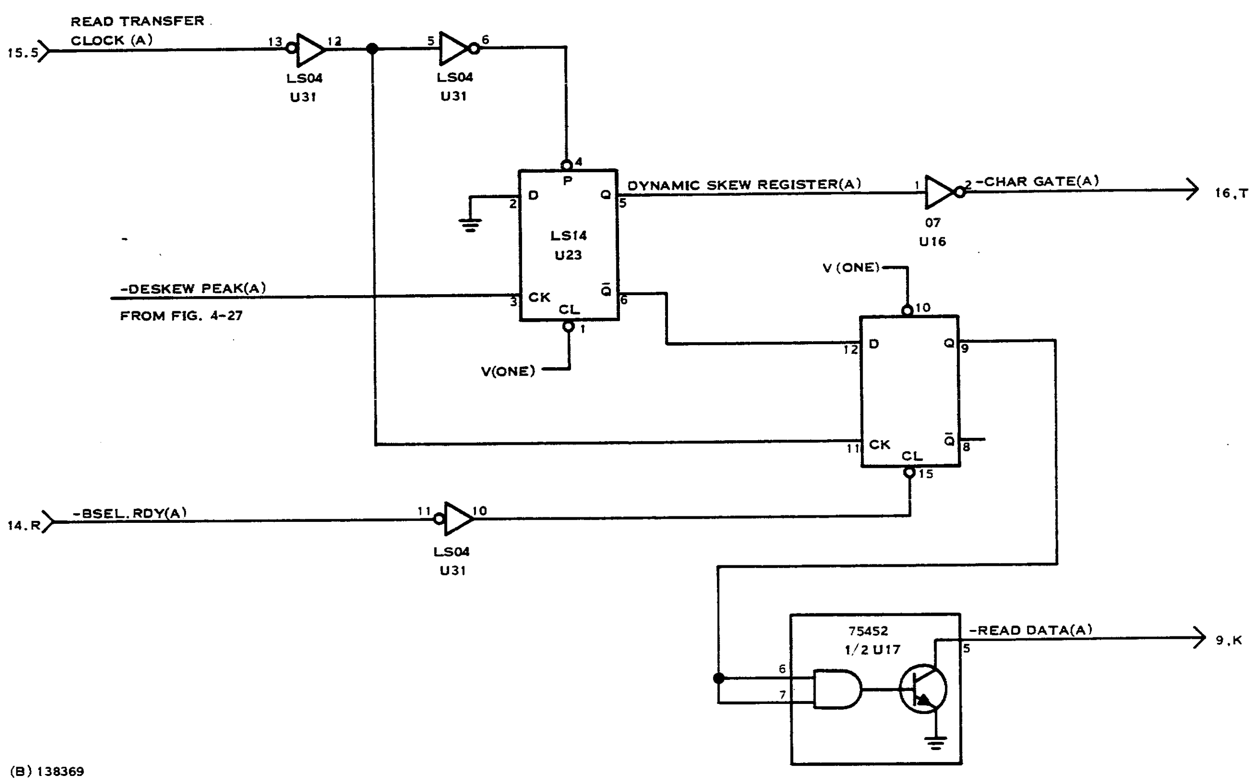


Figure 4-28. Read Dynamic Skew Compensation Network

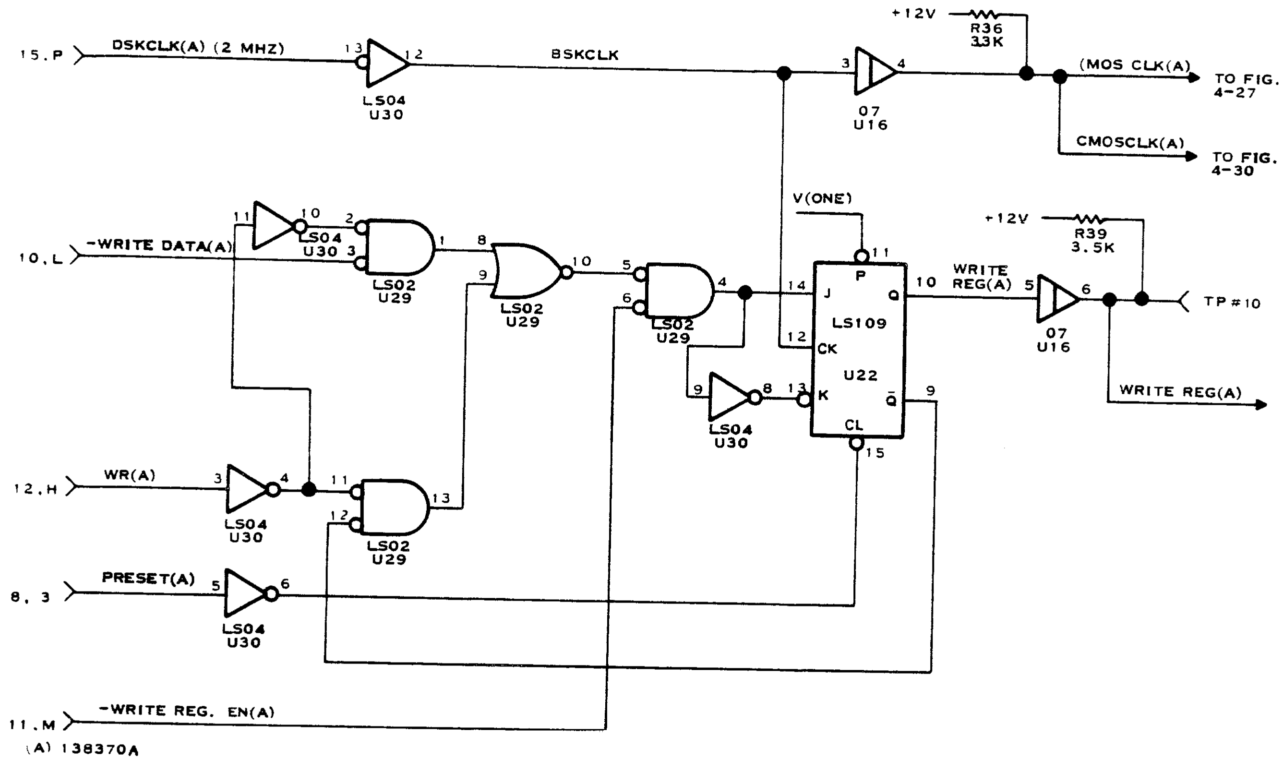


Figure 4-29. Write Register Circuit

Since the write register always starts from the reset state (U22 pin 10 at logic 0), the longitudinal redundancy check character (LRCC) may be written by selectively toggling only those bits of the write register which are true after the record has been written. This is done when write reset (WR) is true while WRITE REG EN is also true. The LRCC produces an even number of bits on each track of a record.

Write Static Skew Correction. See figure 4-30. Static skew correction for data to be written on tape is accomplished by adjusting the delay through a variable length shift register (U10) with DIP switches, S2. The adjustment range is the same as for read static skew above.

Write Amplifier (U16 pins 10 and 12). The signal from the write skew register is ANDed with write enable then buffered by U16 to produce the write current for the write head winding. The nominal write current is 14.5 ma and conventional current into the high side of the write head will produce tape saturation of the same polarity as the erase head, i.e., north pole towards the BOT end of the tape.

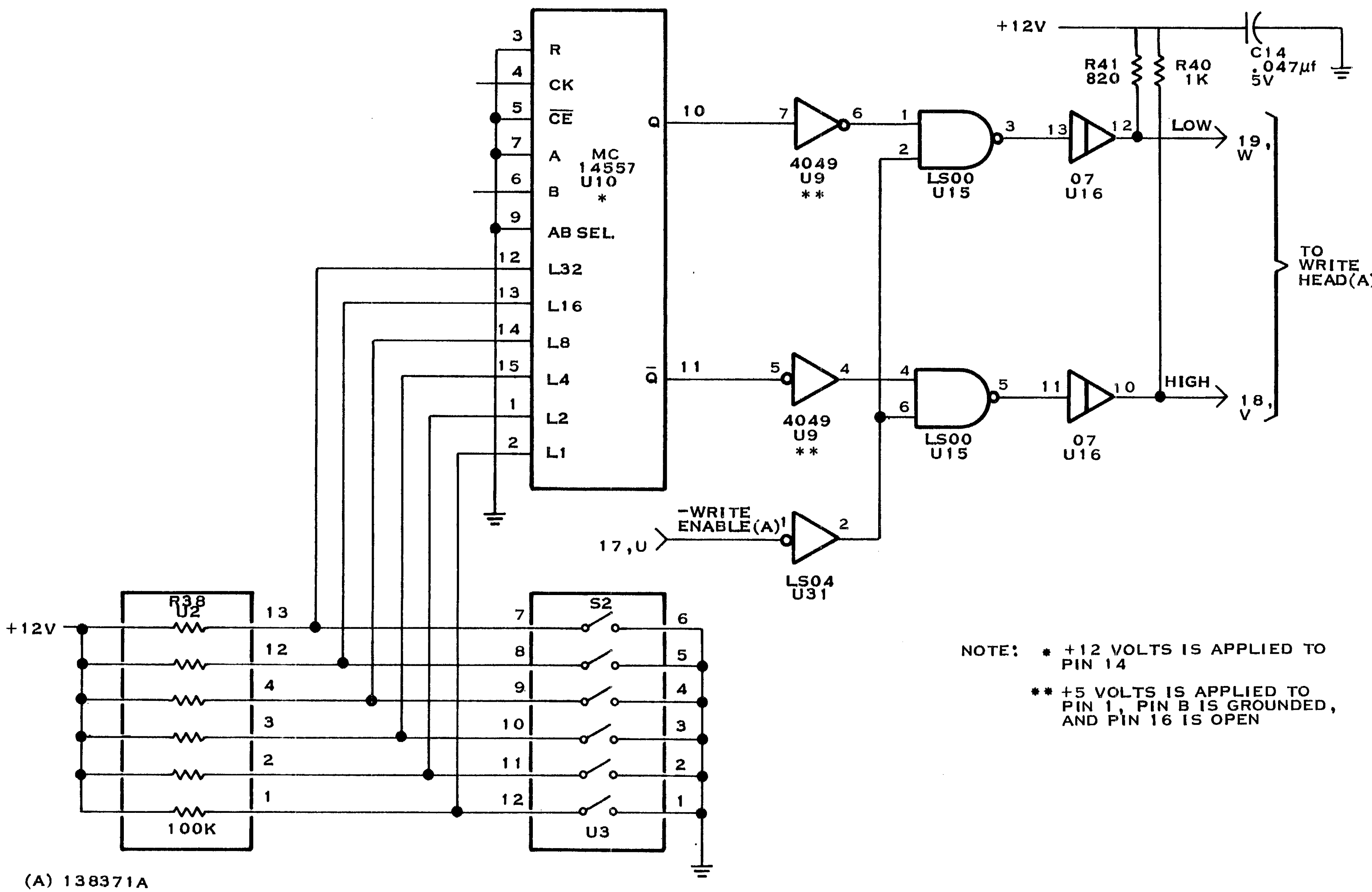


Figure 4-30. Write Skew Correction and Drive Amplifier Circuit

SECTION 5

MAINTENANCE

5.1 GENERAL

This section describes maintenance procedures for the 979A Tape Transport and related units operating in a 960, 980, or 990 computer system environment. Procedures for performing on-line diagnostic tests, and off-line tests using the 979A Field Tester, are included in this section to assist in isolating faults and also to insure correct operation at installation time or when equipment has been returned to service. While it is intended primarily for 979A Tape Transport maintenance, this section will assist personnel in locating system related problems.

5.2 MAINTENANCE PHILOSOPHY

This section provides assistance in locating faults within the magnetic tape system. A magnetic tape system includes a tape interface/controller operating under the discipline (requirements) of an I/O bus system, formatting devices which may be an integral part of the interface/controller or a separate unit (e.g., tape interface unit, TIU, in the 960/980 1600 bpi, PE, recording/reproducing system), and a tape drive unit such as the 979A Tape Transport.

If a failure occurs in a magnetic tape system, the first item to be determined is what is causing the fault(s). To obtain this information diagnostics are used. The next procedure involves isolating the trouble to a readily exchangeable subunit (such as a printed circuit board, unit subassembly, cable, fuse, plug-in component, etc.) so that the system may be returned to proper operation as soon as possible. Finally, this maintenance section will assist experienced personnel in locating faults to the component level so that the faulty item may be repaired/replaced and the subassembly returned to service.

NOTE

> If a fault cannot be isolated to a component or a circuit, please be sure to document symptoms in detail when returning the item to a repair facility. This is especially necessary when faults are intermittent. If, for example, a problem occurs with a tape transport and replacing the reel servo card clears the problem, but further diagnosis of the board reveals no faulty component, include this information on the repair ticket. This will greatly reduce the amount of time required to return the board to proper operation.

Once the faulty component(s) has been identified, the board shall be properly tagged, describing the corrective maintenance to be performed, and sent to the corrective maintenance work station for repair. The repaired board is then returned to the troubleshooting work station and tested for further probes. If diagnostic tests run to completion five consecutive times without an error message printout, the board is returned to normal use.

The maintenance section is arranged according to the following scheme.

1. Preventive maintenance. Items listed in the preventive maintenance paragraph should be performed at the given intervals and whenever a service call is received for the tape transport. Successful completion of the listed procedures may eliminate a problem. This is especially true when a service call is made because of data dropouts or erratic tape drive operation.

2. Operational checkout and adjustments. Procedures are listed for testing the tape system on-line using performance demonstration tests (PDT's). Off-line tests and adjustments are outlined using the 979A Field Tester. Using the field tester, problems directly related to the tape transport may be isolated.

3. Troubleshooting procedures. Methods that may be used in locating and correcting faults are itemized in this paragraph.

4. General fault analysis. Possible recorder troubles and general steps required to clear difficulties.

5. Removal and replacement procedures. Detailed procedures on removing and replacing subunits of the tape transport.

5.3 SPECIAL TEST EQUIPMENT

Table 5-1 contains a list of special test equipment that may be required in addition to a standard technicians tool kit.

Table 5-1. Test Equipment Required/Suggested

Test Equipment	Part No. or Model No.
VOM - Weston	Model 663
Digital Multimeter - Fluke	Model 8000A
Power Supply Load Simulator	937009-0001
Field tester, 979A	948272-0001
Oscilloscope - Tektronix	Model 475
Logic Analyzer	Hewlett-Packard Type 1600A, Biomation type 810D, or equivalent
Extender Board - Texas Instruments (2 recommended)	196226-0001
Inspection Mirror	532832-0001
Flashlight	
EOT/BOT Sensor Tape 979/979A	943849-0711
Tape, Master Output	235778-3090
Tape, Master Skew	235778-3100
Tape, Tracking	948271-0001
Tape, Compatibility	949572-1230
Tape, Magnetic Recording, 731.5 m (2400.0 ft)	973718-0005
TAPTST Diagnostic Test (for 990)	937773
PDT979 Diagnostic Test (for 960)	948124 (PDT960)
PDT979 Diagnostic Test (for 980)	942944 (PDT980)
733/ASR Card Reader ROM Loader	945134 (990)
ASR 733 Data Terminal Kit	945070

5.4 PREVENTIVE MAINTENANCE

Preventive maintenance consists primarily of keeping the unit and especially the tape paths and read/write/erase heads free of dirt, oxide and other foreign material. The capstan drive and all working parts should be periodically examined for wear or noticeable faults. Cleaning procedures are given in tables 5-2 and 5-3.

Table 5-2. Transport Cleaning Procedures, Daily

CAUTION

1. Before cleaning, the transport should be unloaded and the tape removed.
2. Use only denatured alcohol on the tape heads.
3. Avoid finger contact with tape heads or other surfaces which contact the tape.
4. Care must be taken not to misalign or scratch the tape heads, cross-talk shield, BOT sensor or tape guides.

Item	Materials	Methods
Transport door interior, Mounting plate	Lint-free cloth	Open transport door and wipe all exposed surfaces, including door interior.
Tape guides	Denatured alcohol, lint-free cloth, small brush	Wipe off tape guide surfaces, check for loose oxide under the lower ceramic guide ring. Brush out if necessary.
Tape heads, cross-talk shield	Denatured alcohol, cotton swabs	Wipe off surfaces.
Tape cleaner	Small brush	Inspect tape cleaner and lightly brush off dust and oxide contaminants as necessary.
Capstan	Denatured alcohol, lint-free cloth or cotton swabs	Inspect the capstan for oxide deposits and other contamination. Wipe clean with denatured alcohol and lint-free cloth (or cotton swabs) as necessary. Do not substitute other cleaners as they may damage the rubberized surface of the capstan.

NOTE

All motors, guides, and bearings are permanently lubricated. No lubricants are required for any of the transport assemblies.

Table 5-3. Transport Cleaning Procedures, Periodic

NOTE

The vacuum column and capstan should be cleaned on a periodic schedule of approximately 150 hours operation. This assumes operation in a dust-free environment with the doors closed. Those users who operate under other environmental conditions will need to clean more frequently to assure best reliability.

CAUTIONS

1. The vacuum column cover is made in two parts, one of which is a plastic plate. Take care not to drop the cover plate or twist it against the guide pins during assembly or disassembly.

2. Use only denatured alcohol on the capstan assembly. Other cleaners may damage the rubberized surface.

Disassembly: Remove vacuum column trim cover by pressing inward and sliding upward about one-quarter inch off the cover retaining pins. Remove the vacuum column cover plate by lifting straight outward off its guide pins, taking care not to twist or drop the cover plate during disassembly.

Item	Materials	Methods
Vacuum columns	Denatured alcohol, lint-free cloth	Wipe the cover plate and vacuum column tape tracks.
Turnaround rollers	Denatured alcohol, cotton swabs.	Check the rollers for oxide deposits and foreign matter. Clean with denatured alcohol and cotton swabs as necessary.
Vacuum column lamps and sensors	Denatured alcohol, cotton swabs.	Carefully clean lamp and sensor holes; seven holes on left and seven holes on right sides of vacuum column.

Reassembly: Carefully replace vacuum column cover plate and trim cover.

Clean with denatured alcohol and cotton swabs as necessary.

5.5 OPERATIONAL CHECKOUT AND ADJUSTMENTS

Either of two methods may be used to test the Model 979A Tape Transport: 1) on-line tests using diagnostic programs; 2) tests using the 979A field tester. Diagnostics check 979A operation through a series of routines running under computer control. The field tester checks operation of tape transport in an off-line condition. The field tester is a card size unit that connects directly into card cage slot J4 in place of line-side I/O cable. When the field tester is used, the terminator in slot J5 must also be removed.

5.5.1 TAPE TEST (TAPTST) DIAGNOSTICS, 990 COMPUTER ON-LINE TESTS. Tape test diagnostics (part number 937773) are part of the 990 computer diagnostic tests. These tests are described in detail in Volume III of the *Model 990 Computer Diagnostics Handbook* (part number 945400-9701).

TAPTST diagnostics provides tests of the following transport functions:

- Tests of the transport interface controller located in the 990 computer
- Rewind and erase tests
- Read and write tests (NRZI and PE)
- Data checks
- Power fail tests

The controller test (test part 0) is a quick test of the universal TILINE controller. A tape unit does not have to be present because no commands are issued to a tape unit. If errors occur during the running of this part, there is a problem with the controller and the rest of the test probably will not run correctly.

The tape transport is exercised by test parts 1 though 8. Commands for tape motion and data control are issued via the controller to the tape transport. Data bits are written on tape, read back, and compared to check for tape system data integrity.

The last test (part 9) verifies that when the system has battery support, failure of the power supply will not cause data to be written on tape. This part should not be used if the computer does not have battery support, otherwise memory will be destroyed and the program lost.

5.5.1.1 Test Preparation, TAPTST. To perform TAPTST diagnostics, one of the following two types of operation interface units are required:

- MDU Maintenance Unit or,
- 733 ASR Data Terminal with a Model 990 Computer Programmer Panel.

NOTE

The 990/10 computer must have at least 24K bytes of memory to run TAPTST.

5.5.1.2 Test Execution, TAPTST. Details for executing the TAPTST are outlined in Volume III of the *Model 990 Computer Diagnostics Handbook,* part number 945400-9701.

5.5.1.3 Error Messages and Numbers. When an error occurs in the execution of any part of the test, an error message will be printed out but only if the software error print flag is on. The error message indicates which error has occurred. The number of the error will also appear on a programmer panel. The error messages are listed in table 5-4 in numerical order. It should be noted that the same message text may appear more than once with different error numbers. The reason for this is that some data checking routines are used by more than one part of the test. When an error is found, a message is output if the print error flag was set during initialization. In all cases, the appropriate error count is incremented. There are three error counts: one for status errors, one for data errors, and one for timing errors.

Table 5-4. TAPTST Error Messages and Numbers

Number	Message
1-3	CONTROLLER FAILURE
4-7	ERROR X REWIND INTERRUPT TEST
8-10	ATTEMPT TO WRITE XXXX IN XXXX RESULTED IN XXXX BEING RETURNED
11	ADDRI = XXXX COUNT = XXXX ADDR2 = XXXX CONT = XXXX
12	COMPARE ERROR-CHAR WRITTEN = XXXX CHAR READ = XXXX
13	DID NOT FILL LAST CHAR WITH FF
14	TOO MANY CHARACTERS WERE TRANSFERRED TO MEMORY
15	OFFSET DID NOT DECREMENT TO ZERO
16	OVERFLOW COUNT WAS 000000 BUT SHOULD HAVE BEEN 00 00 00
17	ERROR PART 6A XXXX MISCOMPARES WITH RECORD LENGTH = XXXX
18	ERROR PART 6B RECEIVED VRC ERROR IN WRITE OPERATION
19	ERROR PART 6B EXPECTED R7 ERROR PATTERN = XXXX RECEIVED = XXXX
20	ERROR PART 6C WROTE RECORD OF XXXX CHARACTERS ATTEMPTED TO READ 160 CHARACTERS DATA TRANSFER DID NOT STOP AFTER XXXX CHARACTERS
21	ERROR PART 6D AN ERASE OF 0 LENGTH DESTROYED LESS THAN 300 CHAR OF A 1600 CHAR RECORD
22	ERROR PART 6D AN ERASE OF 0 LENGTH DESTROYED MORE THAN 700 CHAR OF A 1600 CHAR RECORD
23	ERROR PART 6E A WRITE OF 0 LENGTH TRANSFERRED DATA TO TAPE
24	ERROR PART 7A FAILED TO READ RECORD XXXX
25	ERROR PART 7B FAILED TO READ FOLLOWING RECORDS WITHOUT ERROR RECORD NO XX

Table 5-4. TAPTST Error Messages and Numbers (Continued)

Number	Message
26	PART 7C NO CREEP IN 20 BACKSPACE/WRITE OPERATIONS
27	PART 7C NEGATIVE CREEP RECORD 2 CREPT BACKWARD AND DESTROYED RECORD 1 IN 12 HEX BACKSPACE/WRITE OPERATIONS
28	E8 DATA ERROR XXXX MISCOMPARES WITH DATA LENGTH = XXXX
29	PART 9 RECORD 1 ERROR DATA WRITTEN = XX DATA READ = XX
30	PART 9 RECORD 2 ERROR DATA WRITTEN = XX DATA READ = XX
38	DID NOT GET EXPECTED INT WHEN TESTING R7
39	GOT FALSE INT WHEN TESTING R7
40	DID NOT RECEIVE INT IN 17 SEC
41	DID NOT GO IDLE IN 02 MIN
42	DID NOT REACH BOT ON REWIND IN 4 MIN
43	OFF LINE BIT DID NOT COME ON DURING REWIND AND UNLOAD IN 4 MIN
44	**STATUS ERROR TMTC REGS TAPE STAT COM STAT/CT OFFSET NO CHAR MEM AD UNIT R7 STAT 0010 06 000000 0000 0000 001EDC 02 A880 COMMAND ISSUED TAPE STAT COM STAT/CT OFFSET NO CHAR MEM AD UNIT R7 STAT 0000 06 000000 0000 0100 003CB8 02 1000
45	***END OF TAPE*** OPERATOR MUST START TEST OVER
46	FAILED TO GET TILINE TIMEOUT WHEN WRITING TO A NON-EXISTENT MEMORY ADDRESS (1FFBFE)

5.5.2 PDT979 DIAGNOSTICS, 960/980 COMPUTER ON-LINE TESTS. The PDT runs standalone on either the 960 or the 980 computer. Operating instructions, messages, tests, and error interpretation are identical on both computers and are discussed in Appendix E of this manual.

5.5.2.1 General Description of PDT979. PDT979 is a comprehensive program designed to verify with a high degree of reliability the proper performance of the 979A Tape Transport unit (either 800 or 1600 BPI) and its associated control logic (either DMAC, BTC, and TCL for 800 BPI, or DMAC, BTC, TCC, and TIU for 1600 bpi). The PDT is composed of 20 tests which are structured around a building block principal whereby each test introduces a minimum amount of new functions; operations proven to work in a previous test are used to verify the new functions being introduced. Although the tests are designed to run in sequential order, each is independent of the others and each is independently selectable by the user. The 20 tests are subdivided into three groups. The first group contains test 1 though 15. These tests require no operator intervention and are referred to as the automatic tests. The second group contains tests 16 through 18. These tests require user assistance and are referred to as the manual intervention tests. The last group containing tests 19 and 20 is referred to as optional tests.

5.5.2.2 Test Preparation, PDT979. PDT979 requires a keyboard/display device such as an ASR 733 or 912 CRT for communication with the user. The baud rate of the interface module is calculated by the PDT and can be either 300, 1200, or 9600. On the 960 computer, the interface module is expected in CRU slot EFO. This may be changed by patching relative address 4 and restarting the PDT from relative address 0. On the 980 computer, the interface module is expected to be I/O BUS ADDRESS 5. A minimum of 12K of memory is required. An error free scratch tape with at least 21.3 metres (70 feet) between BOT and EOT is also required.

5.5.2.3 Loading Procedures, PDT979. To load PDT979, follow standard loading procedures. After the last record of the object media has been read, PDT979 will go into execution and print a title message on the logging device giving part number and revision level. It then prints a request for a user supplied parameter and waits for a keyboard response. At that time, verify the scratch tape is loaded, ready, and at the BOT marker.

5.5.2.4 Operating Procedures and Error Messages. For operation of PDT979, refer to Appendix E, paragraph 3.0. Appendix E contains document number 941662-9901, SDP, PDT979, Magnetic Tape Transport, 800/1600 bpi - PDT960/980.

5.5.3 TESTS AND ADJUSTMENTS USING THE 979A FIELD TESTER. The field tester is a portable, logic-card sized unit that plugs into slot J4 in the tape transport card cage. A description of field tester controls and indicators is contained in Appendix D.

In addition to using the following tests as a confidence check, these tests will assist field maintenance personnel in performing corrective adjustments and in isolating faults to the replaceable assembly. These tests are essentially standalone. It is not necessary to perform all tests nor is it necessary to perform the tests in any specific order, except in the case of data and data control cards and where specifically noted. Except for fault isolation, all internal circuits may remain interconnected.

The field tester, a standalone portable tester, allows the transport to be tested in an environment isolated from computer and controllers, thereby eliminating faults that may be external to the tape transport. The tester connects directly to the I/O input connector in card cage slot J4. A built-in terminator in the field tester eliminates the requirement for a terminator to be installed in card cage slot J5 as required in normal operation; therefore, the terminator should be removed from slot J5.

Table 5-5 outlines tests and adjustments. Test equipment required or suggested is listed in table 5-1.

Table 5-5. Tests and Adjustments, 979A Tape Transports

Table	Test/Adjustment
5-6	Power Supply Tests and Adjustments
5-7	Servo System and Control Tests
5-8	Motion Control Check
5-9	Capstan Speed Adjustments
5-10	Crosstalk Shield Adjustments
5-11	Start/Stop Time Adjustment
5-12	Rewind Time Test
5-13	Read Amplifier Gain Adjustments
5-14	Tape Tracking and Static Skew Adjustments
5-15	Read Skew Adjustments
5-16	Write Skew Adjustments
5-17	1600 BPI PE Data Tests

Table 5-6. Power Supply Tests and Adjustments

NOTE

Tests are performed using normal equipment loads. If a fault is suspected in external wiring, isolate the suspected fault before running this test. Do not run this test under a no-load condition, otherwise parameters will fall outside of limits and may point to erroneous faults. If all except the source is to be isolated, it will be necessary to use a load simulator such as the Power Supply Load Simulator, part number 937009-0001 (or equivalent) listed in table 5-1.

Step	Procedure
1.	Set transport ac POWER to OFF, disconnect ac power cable from source, remove capstan/regulator board from card cage slot A1A4J1 (GREEN DOT). Mount an extender board and reinsert in A1A4J1.
2.	Using schematic for capstan/regulator (see schematic 216508 in the *Model 979A Tape Transport Subsystem Drawings Manual*, part number 949613-9702) and an ohmmeter, check for shorts between regulators, between regulators and logic ground, and logic ground and chassis.
3.	Disconnect I/O cables (or terminator) from connectors A1A4J4 and A1A4J5 in card cage.
4.	Connect transport ac cable to ac source. Check that capstan/regulator is inserted in an extension card and connected to A1A4J1; then set ac POWER to ON.

Table 5-6. Power Supply Tests and Adjustments (Continued)

Step	Procedure
5.	At the rear of the power supply assembly (A1A2 at the top of the transport) there are four test points for monitoring regulated voltages. Use ground bar on capacitors for return lead from voltmeter. With digital voltmeter, check the following test points in the order listed. Check +5V and if necessary adjust R118 on capstan/regulator for 5.0 Vdc ±0.1 Vdc. If voltage cannot be adjusted within limits, check +12V UNR at the fuse block. If unit cannot be adjusted replace capstan/regulator. Check +12V and if unit does not read 11.7 to 12.3 Vdc, replace capstan/regulator (this card contains no adjustment for +12V). Check -6V and if necessary adjust R76 on capstan/regulator for 6.0 Vdc ± 0.1 Vdc. Check -12V test point and if necessary replace capstan/regulator (the card contains no adjustments for -12V).

Table 5-7. Servo System and Control Tests

Step **Procedure**

NOTE

Servo System and Control Logic Tests. These tests check operation of various sensors and controls circuits governing drive direction and speed of reel motors.

Preliminary Checks:

a. All cards inserted in proper slots, A1A4A1 on extender board and inserted into slot J1.

b. I/O cables disconnected from slots J4 and J5.

c. Transport connected to ac source.

d. Remove any existing supply tape from transport.

1. Set transport ac POWER to OFF.

2. Remove vacuum column cover and glass.

3. Install 979A field tester (part number 948272-1) into slot J4.

Table 5-7. Servo System and Control Tests (Continued)

Step **Procedure**

4. Set field tester controls as follows:

FWD/OFF/REV	OFF
OFF/SEL	OFF
UNL/OFF/REW	OFF
SET-WRT/OFF/SET RD	OFF
1/⎍⎍/0	1
AUTO REV	OFF
GO-STOP/OFF/FWD-REV	OFF

5. Set transport POWER to ON. Only the FILE PROTECT indicator should light. If it does not check file protect switch and circuitry.

6. Install a small reel of tape with BOT and EOT markers located approximately 305 mm (12 inches) apart.

NOTE

The vacuum column cover is not required because no tape is loaded in this operation.

7. Thread tape normally onto take up reel and position BOT/EOT markers as described in the following steps.

8. Connect voltmeter or oscilloscope to pin d on capstan/regulator board (voltage to be measured is not critical). Pin d is the output of the BOT detector.

9. Position tape so that BOT marker is under BOT detector. See below for BOT marker positions.

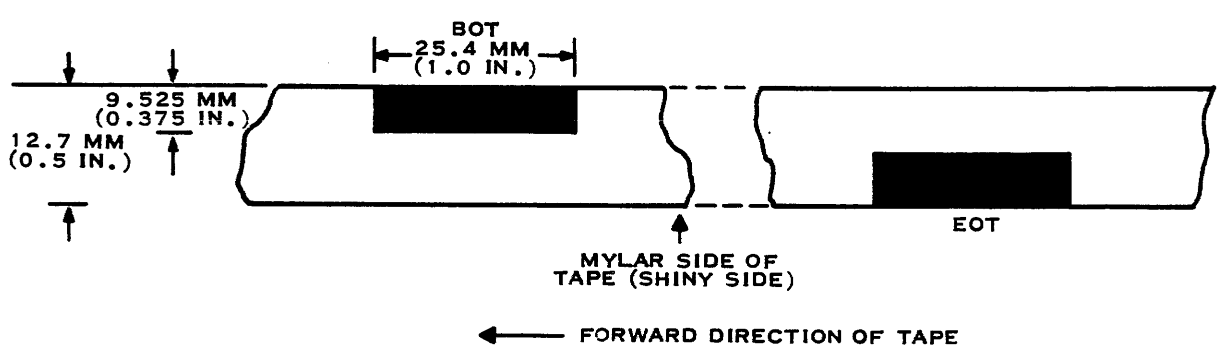


Table 5-7. Servo System and Control Tests (Continued)

Step **Procedure**

10. Observe increase of voltage when BOT marker is positioned under detector.

    When BOT marker is under sensor indication shall be >+4 Vdc. When BOT marker is not under sensor indication shall be <-4 volts (more negative).

    If measurements fall outside of limits, mechanically adjust the BOT detector. If voltage level is not satisfactory, check BOT detector and circuitry on capstan/regulator.

11. Connect oscilloscope or voltmeter to pin 37 on capstan/regulator board. This is the output of the EOT detector.

12. Position EOT marker under EOT detector and note voltage when EOT marker is and is not under the detector.

    When the EOT marker is under sensor indication shall be >+4 Vdc. When EOT marker is not under sensor <−4 Vdc (more negative).

    If necessary, mechanically adjust EOT detector. If required, adjust BOT/EOT marker so that both the conditions of steps 11 and 13 are met.

13. Remove small reel of tape from transport.

14. Press LOAD on tape transport. The vacuum motor should start and the supply reel hub should tend to turn in the CCW direction. This tendency can be verified by turning the supply reel hub by hand: the supply reel hub should require slightly more torque to turn in the CW than in CCW direction. After 8 to 15 seconds, the supply reel starts turning slowly clockwise.

    Check servo amplifier assembly (A1A3). Reel servo card (A1A4A2) and wiring before suspecting motor.

15. Press RESET.

16. Press LOAD. When the supply reel hub starts turning, CCW, place black tape over vacuum column sensor Q1 (sensors one on the right-side rail; Q1 is topmost).

    Supply reel hub starts turning faster in CW direction and capstan turns in CCW direction.

    Check wiring and switch.

17. Place black tape over vacuum column sensor Q2 (next sensor down from top on right-side rail).

    Supply reel hub stops but capstan continues turning CCW. After 10 to 20 seconds capstan stops and vacuum motor turns off.

18. Remove tape from Q1 and Q2 sensors.

19. Press LOAD. When supply reel starts turning place tape over Q1 and Q2 sensors.

20. Place tape over sensor Q7 (lowest sensor on right-side rail).

    Take-up reel starts turning CW.

Table 5-7. Servo System and Control Tests (Continued)

Step	Procedure
21.	Place tape over sensor Q6 (second sensor from bottom on right-side rail). Take-up reel should stop. Approximately 10 seconds after the above occurs, capstan reverses to a CW direction. **NOTE** In the next step, it is convenient to use a pocket scale with the EOT/BOT reflective strips near one end.
22.	Place a reflective surface approximately 4 mm (0.15 inch) in front of BOT sensor. The capstan stops and the READY indicator lights.
23.	Momentarily cover sensor Q3, top of center group. The supply reel hub turns CCW while Q3 is covered.
24.	Momentarily cover sensor Q5 bottom of center group. The take-up reel should turn CW.
25.	Momentarily cover sensor Q4, center sensor. Vacuum motor and READY indicator shut off.
26.	Remove tape from all sensors.
27.	Press LOAD switch and quickly place tape over sensors Q1, Q2, Q6 and Q7. Tape starts driving in forward direction.
28.	Before the 10 second timeout and reversal of tape direction, place a reflective surface in front of BOT sensor. After BOT detection the capstan reverses to the CW direction.
29.	Remove, then replace the reflective surface in front of the BOT sensor. Capstan stops immediately and READY indicator lights.
30.	On the field tester, set the OFF/SEL switch to SEL. SELECT indicates or tape transport lights. If not, check control logic card A1A4A3 input circuit at pin 16. Check lamp on tape transport control panel.
31.	Quickly twist the supply reel hub and the takeup reel hub in both directions (CW and CCW). Dynamic braking should be felt in both directions.

Table 5-7. Servo System and Control Tests (Continued)

Step	Procedure
32.	On the field tester, set the FWD/OFF/REV switch to FWD. Capstan drives in forward direction (CCW).
33.	Quickly twist the supply reel hub and the takeup reel hub in both directions (CW and CCW). Dynamic brake only applied in CCW direction.
34.	On the field tester, set the FWD/OFF/REV switch to REV. Capstan drives in reverse direction (CW).
35.	Quickly twist the supply reel hub and the takeup reel hub in both directions (CW and CCW). Dynamic brake only applied in CW direction.
36.	On the field tester, set the FWD/OFF/REV switch to OFF. Capstan drive stops.
37.	On the tape transport control panel press RESET. READY indicator goes out.
38.	Press the control panel REWIND switch. Capstan turns CW and slowly increases speed to maximum.
39.	Remove tape from sensor Q6. Takeup reel hub turns CW and capstan speed decreases.
40.	Place tape over Q6. The takeup reel hub stops and capstan speed increases.
41.	Place tape over Q3. The supply reel hub turns CCW and capstan speed decreases.
42.	Remove tape from Q3. The supply reel hub stops and capstan speed increases to maximum.
43.	Press RESET switch on control panel. Capstan stops.
44.	Press the LOAD switch on control panel. READY indicator lights.
45.	On the field tester press the REWIND switch. Capstan turns CW and increases speed to maximum, and READY indicator goes out.

Table 5-7. Servo System and Control Tests (Continued)

Step **Procedure**

46. Using the reflective strip, generate three BOT's.

    1. Capstan reverses direction to CCW. If not, check motion control card.

    2. The second BOT causes the capstan to reverse to CW direction. If not, check motion control card.

    3. On the third BOT the capstan should stop.

47. Set the file tester FWD/OFF/REV to the REV position.

    Capstan turns in CW direction.

48. Using the reflective strip, generate a continuous BOT.

    Capstan stops.

49. Remove the reflective strip from BOT detector.

    Capstan turns CW.

50. Press RESET switch on control panel.

    Capstan stops and ready lamp goes out.

51. Press the UNLOAD switch.

    Capstan turns in CW direction and slowly accelerates to maximum speed.

52. Using reflective strip, generate a BOT.

    Capstan momentarily stops, then resumes CW rotation at less than maximum speed.

53. On the control panel, press RESET then LOAD.

    READY indicator lights.

54. On the field tester, set UNL/OFF/REW to UNL.

    Capstan momentarily stops, then accelerates CW to maximum speed, and READY indicator goes off.

55. Using the reflective strip, generate a BOT.

    Capstan momentarily stops then resumes CW rotation at less than maximum.

56. Within 2 seconds of step 55, quickly twist takeup reel hub in the CCW direction. While manually rotating takeup reel, remove tape from sensor Q1.

    Vacuum motor turns off but the capstan and supply reel should continue rotating for 1 to 2 seconds after takeup reel is stopped.

Table 5-7. Servo System and Control Tests (Continued)

Step	Procedure
57.	Alternately press REWIND and UNLOAD switch. Nothing happens.
58.	Remove all tape from vacuum column sensors.
59.	Remove tape from tape cleaner.
60.	Replace vacuum column cover.

Table 5-8. Motion Control Check

Step	Procedure
1.	Set field tester FWD/OFF/REV to the OFF position.
2.	Switch tape transport ac POWER to ON.
3.	Install a reel with 731.5 metres (2400.0 feet) of scratch tape; thread tape onto takeup reel. Be sure tape is taut across top and bottom portions of vacuum column.
4.	Press LOAD switch on tape transport control panel.
5.	After an 8 to 15 second delay while building up a vacuum, the tape is drawn into the top portion of the vacuum column.
6.	Forward search for the BOT begins. When BOT is detected, lower portion of vacuum has drawn a loop of tape. (If BOT is found too soon, load sequence will abort.)
7.	Forward search continues until BOT is found, or until a delay of 10 to 15 seconds is reached. Reverse search then starts until BOT is found. If the BOT is not detected during reverse search, tape goes off takeup reel, vacuum motor stops and tape transport enters shut down sequence.

Table 5-9. Capstan Speed Adjustments

Step **Procedure**

NOTE

This adjustment uses a fluorescent light source (area lighting is acceptable) and a strobe disk. The strobe disk is shown in figure 5-1. These disks may be cut out, mounted on stiff paper, and used for this adjustment.

If 60 Hz power is in use at the site, use outer ring on strobe disk; for 50 Hz use inner ring.

Table 5-9. Capstan Speed Adjustments (Continued)

Step **Procedure**

NOTE

If a more precise control of capstan speed is required, use a strobescope lamp, or a precision tachometer for these adjustments.

1. Set ac POWER to ON.

2. Load a reel with 731.5 metres (2400.0 feet) of scratch tape on transport.

3. Install strobe disk in capstan drive wheel.

4. Set field tester FWD/OFF/REV to FWD.

   Tape starts driving in forward direction.

5. Note ring of interest on strobe disk when lighted by fluorescent lamp.

   Ring appears motionless.

   If necessary, adjust R-47 on capstan/regulator, A1A4A1. Second potentiometer from top of board. Apparent motion of the strobed disk of less than 10 RPM is acceptable.

6. Set field tester FWD/OFF/REV to REV.

   Tape reverses direction.

7. Again, note ring on strobe disk.

   Ring appears motionless.

   Adjust R-48 (A1A4A10). Top potentiometer on board. Apparent motion of the strobed disk of less than 10 RPM is acceptable.

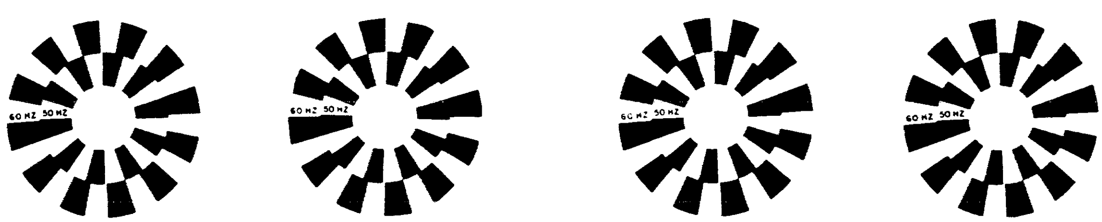


Figure 5-1. Capstan Speed Strobe Disks

Table 5-10. Crosstalk Shield Check and Adjustment

The crosstalk shield is mounted on the head plate assembly and held against the heads by spring action. If in the following procedure it is necessary to adjust the shield, loosen the two screws holding the shield and then make adjustments to the shield.

Crosstalk adjustments are necessary for PE transports as well as for NRZI transports. To adjust a PE transport, use NRZI control boards, then reinstall PE control boards.

Step **Procedure**

1. Set switches on field tester as follows:

FWD/OFF/REV	OFF
SET-WRT/OFF/SET-RD	SET-WRT
OFF/SEL	SEL
AUTO REV	REV
1/⊓⊔⊓/0	1
GO-STOP/OFF/FWD-REV	OFF
DATA TRACKS	All 9 tracks to "1"
PE/NRZI	NRZI

(located on right side of field tester)

2. Connect an oscilloscope channel to track 5 amplifier output (A1A4A8-TP16). Adjust oscilloscope to monitor a signal less than 200 mV p-p. If the waveform is not less than 200 mV p-p, adjust tape head shield until waveform amplitude is less than 200 mV p-p.

NOTE

In addition to adjusting the shield, it may be necessary to separate the read and write head cables better to achieve this low reading.

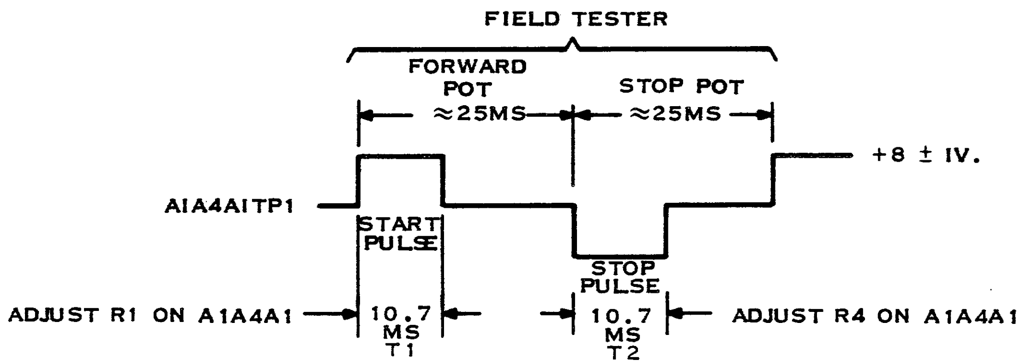
3. Refer to figure 5-5 for location of test points and check all other track amplifier outputs for similar or lower levels of write-to-read crosstalk.

Table 5-11. Start/Stop Time Adjustment

Step **Procedure**

1. Connect oscilloscope probe to TP1 on capstan/regulator. TP1 is just above the third potentiometer from the top of the board, behind the diodes (CR1-CR4). Oscilloscope settings: 5V/DIV, +SLOPE, AC TRIG. 2ms/DIV. Change oscilloscope slope setting to —SLOPE when checking negative component of signal.

2. Set field tester GO-STOP/OFF/FWD-REV to GO-STOP, and FWD/OFF/REV to FWD. Waveform shall be adjusted as shown below.



Adjust FWD and/or STOP potentiometers on field tester for start/stop cycles. Adjust R1 on A1A4A1 (third potentiometer from top on capstan/regulator) for start pulse width; adjust R4 on A1A4A1 (fourth potentiometer on capstan/regulator) for stop pulse width.

NOTE

The following steps show waveforms that are not readily adjustable; they are included as part of the confidence test for information only. If waveforms are not present or are grossly out of limits, use regular troubleshooting techniques to isolate unit or board for replacement.

3. Connect oscilloscope to TP2 (between R47 and R48 at the top of the board) and observe the following waveform.

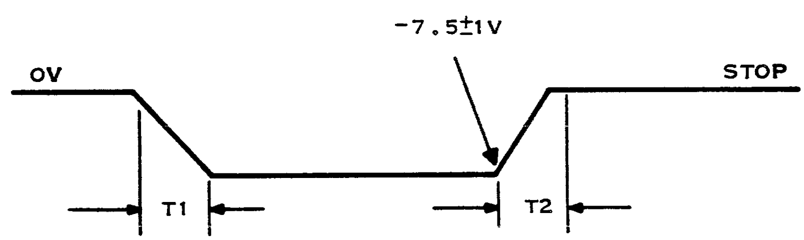
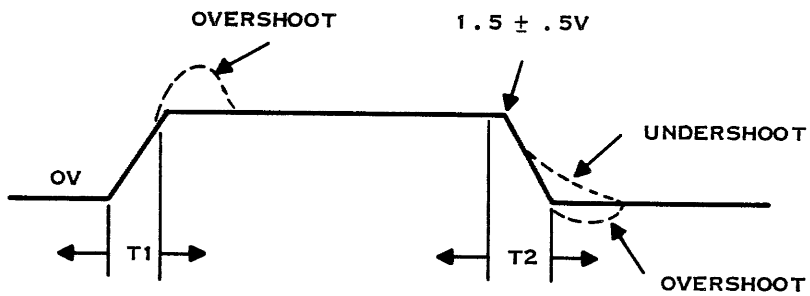


Table 5-11. Start/Stop Time Adjustment (Continued)

Step **Procedure**

4. Connect oscilloscope to black tachometer lead and check capstan response per following waveform. Verify that there is no overshoot or undershoot which exceeds 2 percent of steady state value. Check to see that the output at time T1 and T2 is within 2 percent of steady state value.



5. Set field tester GO-STOP/OFF/FWD-REV to FWD-REV and again observe the black lead to the tachometer for a waveshape similar to the following:

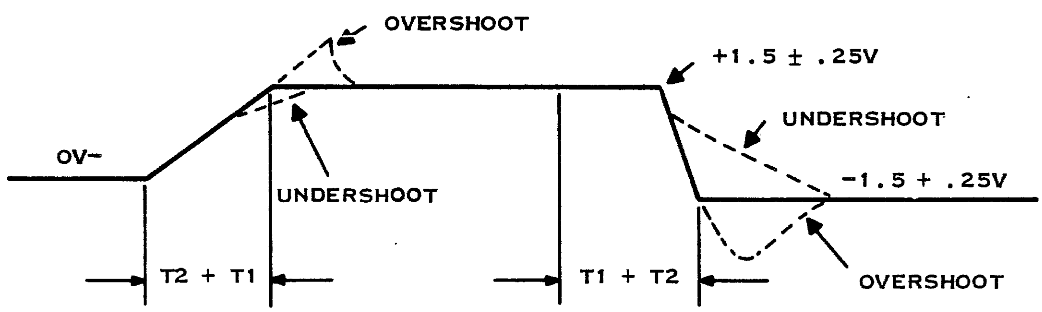


Table 5-12. Rewind Time Test

Step **Procedure**

1. Set field tester for continuous forward motion (FWD/OFF/REV to FWD) without automatic rewind (REW/OFF/REV set to OFF). Allow tape to run to EOT.

2. On tape transport control panel, press RESET, REWIND and LOAD. Start a stopwatch or other timer.

   With 731.5 metres (2400.0 feet) of tape, tape rewinds in less than 200 seconds.

3. When test is complete, press UNLOAD, remove scratch tape and turn ac POWER to OFF.

4. Remove extender board and replace capstan/regulator board in slot J1.

Table 5-13. Read Amplifier Gain Adjustments (NRZI Only)

Step **Procedure**

1. Set the field tester to the following settings.

FWD/OFF/REV	OFF
OFF/SEL	SEL
AUTO REV	OFF
UNL/OFF/REW	OFF
UNL/OFF/REW	OFF
SET WRT/OFF/SET RD	OFF
1/⊓⊔/0	1
GO-STOP/OFF/FWD-REV	OFF

2. Load a master output level test tape or other good quality tape on transport.

NOTE

Only make complete passes with this test tape, i.e., do not stop and start the tape between BOT and EOT. Do not rewind the tape at fast speed, instead use the transport's reverse drive capability.

3. Set the oscilloscope as follows: 2V/DIV; 20 μsec/DIV; + SLOPE, AC TRIGGER.

4. Connect oscilloscope probe to TP1 on NRZI control card (see figure 5-2 for location). This is track (channel) #1 amplifier output.

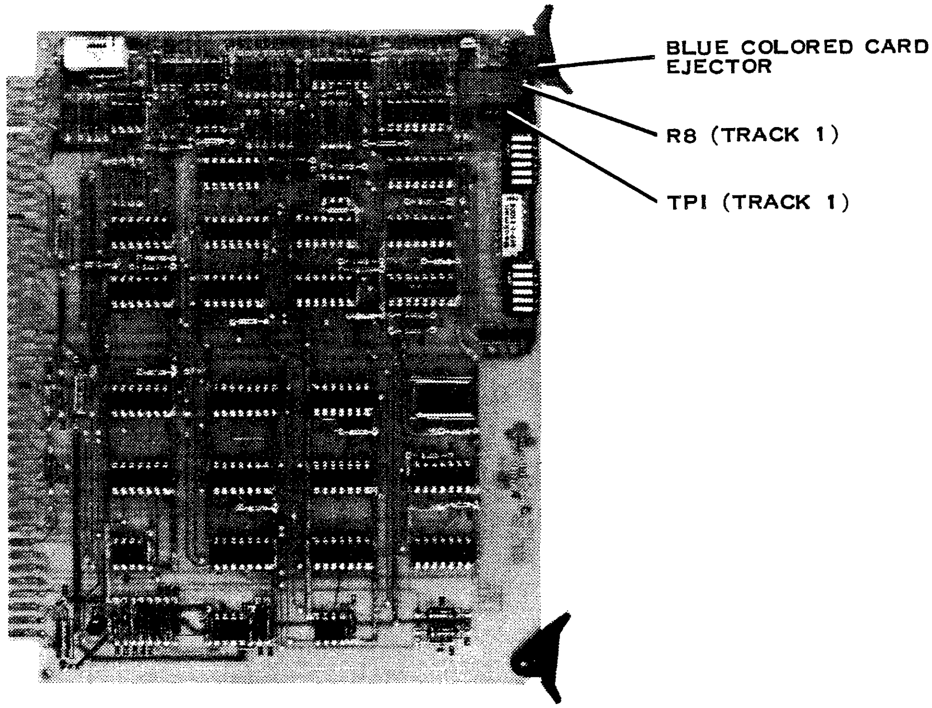
5. Set field tester FWD/OFF/REV to FWD. Indication shall be 10V pk-to-pk. If not, adjust R8 for 10V pk-to-pk.

NOTE

If read amplifier gain is increased for any channel, recheck the crosstalk adjustment, as shown in table 5-10.

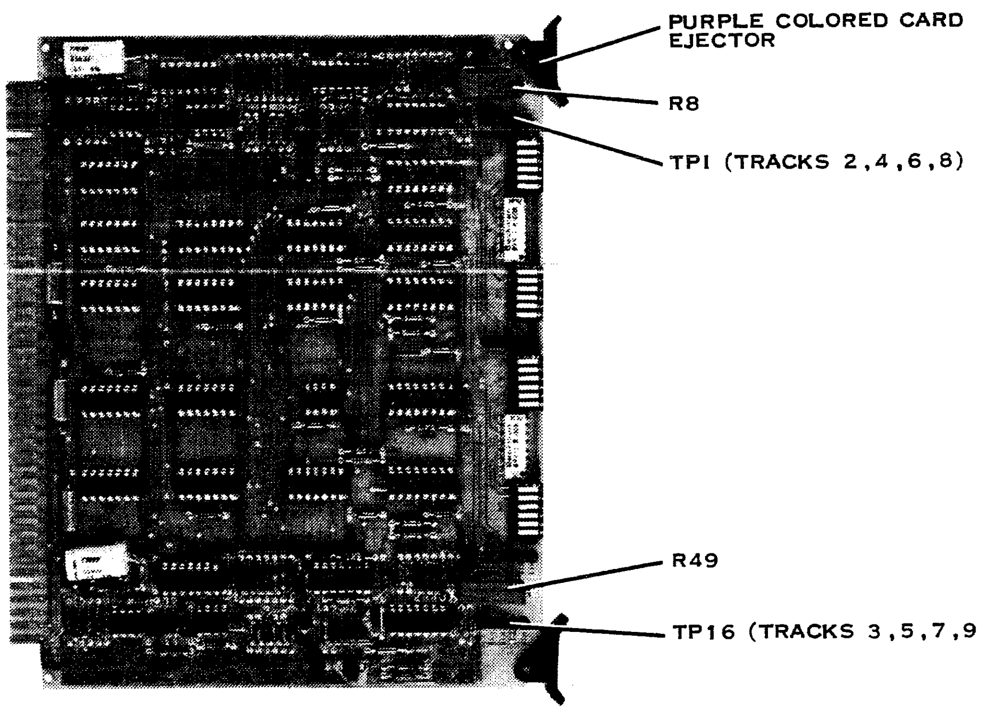
6. Repeat the above for the remaining eight channels; test points and adjustments are shown in figure 5-3.

7. When tape reaches EOT, set field tester FWD/OFF/REV to REV and wait for tape to reach BOT, then unload tape, or continue testing until complete. Wait for EOT, set REV and then unload tape when EOT is reached.



(979A-1277-42-9)

Figure 5-2. NRZI Control Card A1A4A6



(979A-1277-42-12)

Figure 5-3. NRZI Data Card A1A4A7

Table 5-14. Tape Tracking and Static Skew Adjustments (NRZI Only)

Step **Procedure**

NOTE

These procedures are normally performed at the depot.

1. Set tape transport ac POWER to OFF.

2. Remove holding screw from card cage and swing card cage out.

3. Disconnect write-head cable P1 from connector J15 mounted on the right rear of the card cage.

NOTE

Leads from connector P1 consist of a wire bundle from the write head laced with a single wire from the erase head.

4. On the one NRZI control card (A1A4A6) and on the four NRZI data cards (A1A4A7 through A1A4A10) there are a total of 18 6-function DIP switches: two on one half of the control card (see figure 5-2) and four on each of the data cards (see figure 5-3). Set all 108 switches to ON. (Figure 2-35)

5. Set tape transport ac POWER to ON.

6. Load master tracking test tape.

7. Connect oscilloscope probe to TP16 on NRZI data card A1A4A8. TP16 in this position represents track #5 analog amplifier output. TP16 is the first pin on the lowest test point strip.

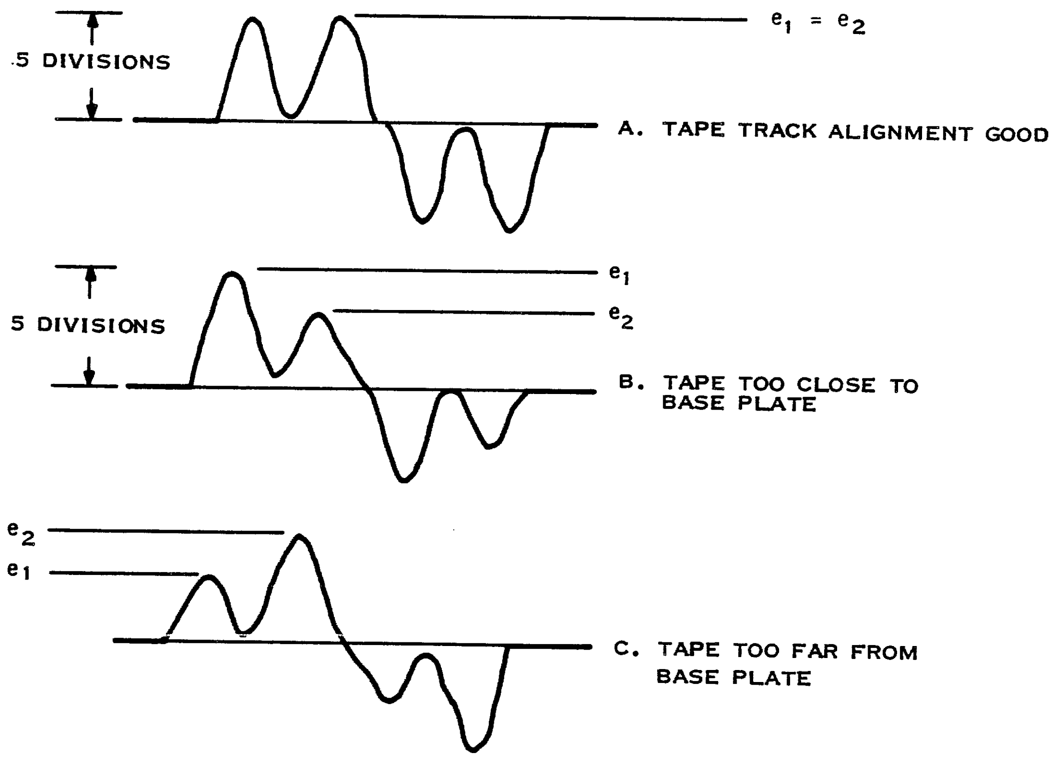
8. Set field tester FWD/OFF/REV to FWD.

9. Adjust oscilloscope settings for 0.2 V/DIV and 50 μsec/DIV. Adjust vertical control to produce 5 divisions peak amplitude for the two largest positive peaks.

10. Compare the oscilloscope waveform with those in this table, and follow instructions for determining shim thickness.

Table 5-14. Tape Tracking and Static Skew Adjustments (NRZI Only) (Continued)

Step Procedure



11. If oscilloscope presentation is not similar to waveform A, use the table that follows to determine shim thickness, or use formula a or b to calculate the thickness. Record thickness but DO NOT change shim at this time.

    a. Tape too close to base plate

    $$\frac{e_1 - e_2}{e_1 + e_2} \times 18 = \text{TRACK ERROR IN THOUSANDTHS OF AN INCH}$$

    b. Tape too far from base plate

    $$\frac{e_2 - e_1}{e_1 + e_2} \times 18 = \text{TRACK ERROR IN THOUSANDTHS OF AN INCH}$$

(When First Peak = 5 Divisions) PEAK #2 HEIGHT =	GUIDE SHIM THICKNESS (in.)	(When Second Peak = 5 Divisions) PEAK #1 HEIGHT =	GUIDE SHIM THICKNESS (in.)
5.0	0.010 (nominal)	5.0	0.010 (nominal)
4.5	0.011	4.5	0.009

Table 5-14. Tape Tracking and Static Skew Adjustments (NRZI Only) (Continued)

Step **Procedure**

4.0	0.012	4.0	0.008
3.6	0.013	3.6	0.007
3.2	0.014	3.2	0.006
2.8	0.015	2.8	0.005

12. On field tester, set FWD/OFF/REV to REV and run tape to BOT.

NOTE

Do not use the rewind function on a Master Skew Tape. Excessive tension may cause tape distortion.

13. Connect oscilloscope channel #1 to TP6 on NRZI Data Control card, A1A4A6. This is tape track #1. Connect oscilloscope channel #2 to TP11 on NRZI Data card, A1A4A10. This is tape track #9.

14. Set oscilloscope display mode to ALTERNATE, 2V/DIV. (both channels), 2 μsec/DIV, trigger on CH #1, NORMAL trigger mode, AC TRIG detection and —SLOPE.

15. On the field tester, set the FWD/OFF/REV switch to FWD, check that AUTO REV is set to OFF.

16. Observe waveforms on oscilloscope, they should be essentially the same shape. However, one may lead the other. The time between leading edges is static skew.

17. Adjust variable sweep rate and horizontal position controls on oscilloscope until one complete cycle covers ten divisions; each division now represents 10 percent in static skew.

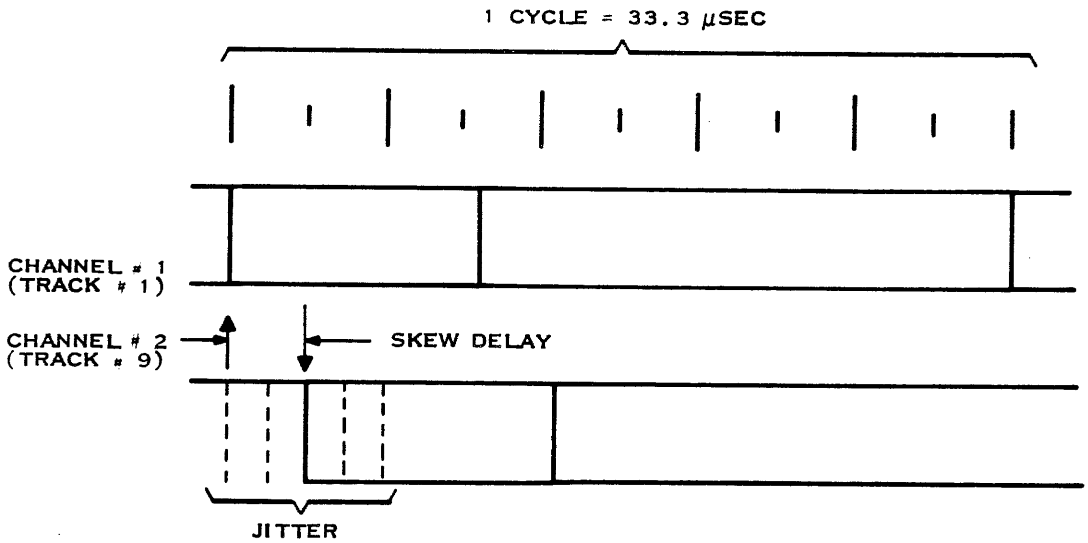
18. Measure the skew from leading edge (negative going) of one waveform to the leading edge of the other waveform. Note which track is leading (track #1 is connected to oscilloscope channel #1; track #9 connects to channel #2). If oscilloscope channel #1 leads channel 2, note the skew as a positive value. If #2 leads #1, switch trigger source to channel #2 and note skew as a negative value.

19. Check the skew on tracks 2 through 8 by comparing signals from these tracks with the reference established in step 18 above, either track #1 or track #9. The largest skew delay should be between track #1 and track #9 with no wild variations among the other 7 tracks.

20. Jitter will be evident on the trailing waveshape and will increase as the delay increases. If jitter exceeds 15 percent, check heads and guides for cleanliness, proper spring action of the guide ceramic washers and the four tape exit/entrance points of the vacuum column to insure that tape is not dragging against the sides. If necessary, perform steps 21 through 24 to check tape alignment in the path. The following figure represents typical skew and jitter waveforms.

Table 5-14. Tape Tracking and Static Skew Adjustments (NRZI Only) (Continued)

Step **Procedure**



21. Exchange master tracking tape with a scratch tape. If tracking tape must be rewound, use REVerse drive. Load scratch tape and set FWD/OFF/REV to FWD.

22. Using a small (65 x 75 mm ≈ 2.5 x 3.0 inches) mirror and inspection light, check tape position relative to the four exit/entrance points of the vacuum column. Verify tape does not touch either edge of vacuum column at all four locations. Tape may appear to touch the vacuum column somewhere in the bend of the tape.

23. Set field tester GO-STOP/OFF/FWD-REV switch to FWD-REV and adjust the GO-FWD and STOP-REV potentiometers to approximately 10 seconds forward and 8 seconds reverse, respectively.

    Set FWD/OFF/REV to FWD.

    Set OFF/SEL to SEL.

    Set AUTO REV to REV.

24. Recheck tape position in column at four points. Also verify that tape does not vary more than 0.127 mm (0.005 inch) on the capstan between forward and reverse directions. Check guide roller position at three places, reel position at two places and capstan guide roller at one place. Make any corrections necessary. After tracking checks and adjustments, if necessary, unload scratch tape.

25. Using the noted "percent of skew" between tape track #1 and track #9, and the guide shim thickness recorded in step 11, determine actual required shims for the tape guides (A and B) from the chart shown in figure 5-4.

26. If additional shimming is not required and steps 21 through 24 were performed, unload scratch tape and proceed to Read Skew Checks and Adjustments in table 5-15.

27. If it is determined that additional shimming is required, unload tape.

Table 5-14. Tape Tracking and Static Skew Adjustments (NRZI Only) (Continued)

Step **Procedure**

NOTE

Do not rewind a Master Skew tape. Instead set the FWD/OFF/REV on the field tester to REV and reverse drive the tape to BOT and then unload.

28. Install shim(s) as calculated in step 25. If shims were installed at time of assembly, be sure to include the value of shim in calculations.

Table 5-15. Read Skew Checks and Adjustments (NRZI Only)

Step **Procedure**

1. Load tape transport with the Master Skew tape.

NOTE

Do not perform a rewind operation on this tape. Use reverse drive to wind tape onto supply reel (Master Skew tape reel).

2. Set both channels of oscilloscope to 2V/DIV., 2 μsec/DIV., Trigger on CH1, AC trigger, +SLOPE, and ALT. Mode.

3. Set field tester FWD/OFF/REV to FWD and SET-WRT/OFF/SET-RD to SET-RD.

4. Connect oscilloscope channel 1 probe to A1A4A6 at TP6 (tape track 1) and channel 2 probe to A1A4A10 at TP11 (tape track 9). Observe waveforms and connect the test point with the leading waveform to oscilloscope channel 1. This may be either track 1 or track 9.

5. Now, referring to Digital Data column in the chart of figure 5-5 probe all other track test points with the channel 2 probe while looking for the track digital data output which presents the greatest delay relative to channel 1 waveform. Leave the probe connected to the track with the most delay.

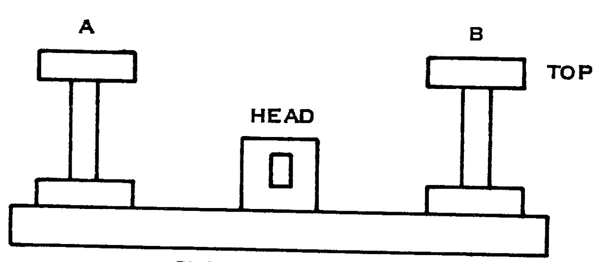
NOTE

There may be a significant amount of jitter between the two waveforms. If the jitter is greater than 4 μsec, check all guides and the vacuum column for causes of jitter and correct. In all the following measurements choose the average transition time on channel 2 as the time mark. The average transition time is usually the brightest trace in the jitter field.

6. With the most delayed track connected to oscilloscope channel 2, connect the oscilloscope channel 1 probe to the test point of the lowest numbered track available (either track #1 or track #2). Measure the delay from leading edge (negative going) of channel #1 to leading edge of channel #2. Normally this delay should be less than 4 μsec. If this delay is excessive, check mechanical head alignment.

TRACKING SHIM	5		6		7		8		9		10		11		12		13		14		15		
% SKEW	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	GUIDE LOCATIO
100	X	X	X	X	X	X	X	X	X	X	16	0	17	1	18	2	19	3	20	4	21	5	
90	X	X	X	X	X	X	X	X	14	0	15	1	16	2	17	3	18	4	19	5	20	6	
80	X	X	X	X	X	X	12	0	13	1	14	2	15	3	16	4	17	5	18	6	19	7	
70	X	X	X	X	11	0	12	1	13	2	13	3	15	4	16	5	17	6	18	7	19	8	
60	X	X	9	0	10	1	11	2	12	3	13	4	14	5	15	6	16	7	17	8	18	9	
50	8	0	9	1	10	2	11	3	12	4	13	5	14	6	15	7	16	8	17	9	18	10	
40	7	1	8	2	9	3	10	4	11	5	12	6	13	7	14	8	15	9	16	10	17	11	
30	7	2	8	3	9	4	10	5	11	6	12	7	13	8	14	9	15	10	16	11	17	12	
20	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	15	12	16	13	
10	5	4	6	5	7	6	8	7	9	7	10	9	11	10	12	11	13	12	14	13	15	14	
0	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	
-10	5	5	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	15	
-20	4	7	5	8	6	9	7	10	8	11	9	12	10	13	11	14	12	15	13	16	14	17	
-30	3	8	4	9	5	10	6	11	7	12	8	13	9	14	10	15	11	16	12	17	13	18	
-40	3	9	4	10	5	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	
-50	2	10	3	11	4	12	5	13	6	14	7	15	8	16	9	17	10	18	11	19	12	20	
-60	2	11	3	12	4	13	5	14	6	15	7	16	8	17	9	18	10	19	11	20	12	21	
-70	1	12	2	13	3	14	4	15	5	16	6	17	7	18	8	19	9	20	10	21	11	22	
-80	1	13	2	14	3	15	4	16	4	17	6	18	7	19	8	20	9	21	10	22	11	23	
-90	0	14	1	15	2	16	3	17	4	18	5	19	6	20	7	21	8	22	9	23	10	24	
-100	X	X	0	16	1	17	2	18	3	19	4	20	5	21	6	22	7	23	8	24	9	25	

ALL VALUES ARE SHIM THICKNESS IN THOUSANDTHS OF AN INCH.

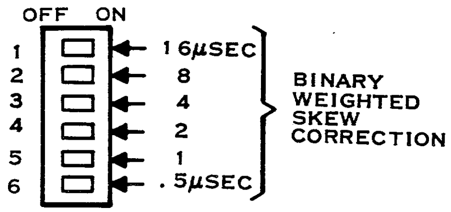


GUIDE LOCATION

(A) 138245

Figure 5-4. Tape Tracking and Skew Corrections Shims

TAPE TRACK #	BOARD #	AMP. OUT	DIG. DATA	POS. PEAK	NEG. PEAK
1. (OUTSIDE EDGE OF TAPE)	A1A4A6	TP1	TP6	TP3	TP4
2.	A1A4A7	TP1	TP6	TP3	TP4
3.	A1A4A7	TP16	TP11	TP18	TP19
4.	A1A4A8	TP1	TP6	TP3	TP4
5.	A1A4A8	TP16	TP11	TP18	TP19
6.	A1A4A9	TP1	TP6	TP3	TP4
7.	A1A4A9	TP16	TP11	TP18	TP19
8.	A1A4A10	TP1	TP6	TP3	TP4
9. (INSIDE EDGE OF TAPE)	A1A4A10	TP16	TP11	TP18	TP19



NOTE: 16 µSEC AND 8µEC SWITCH SHOULD ALWAYS BE IN THE "ON" POSITION. IF IT IS NECESSARY TO SET ONE OF THESE SWITCHES TO "OFF" IN ORDER TO ELECTRONICALLY DESKEW THE HEAD, THE MECHANICAL HEAD ALIGNMENT SHOULD BE CHECKED AND CORRECTED.

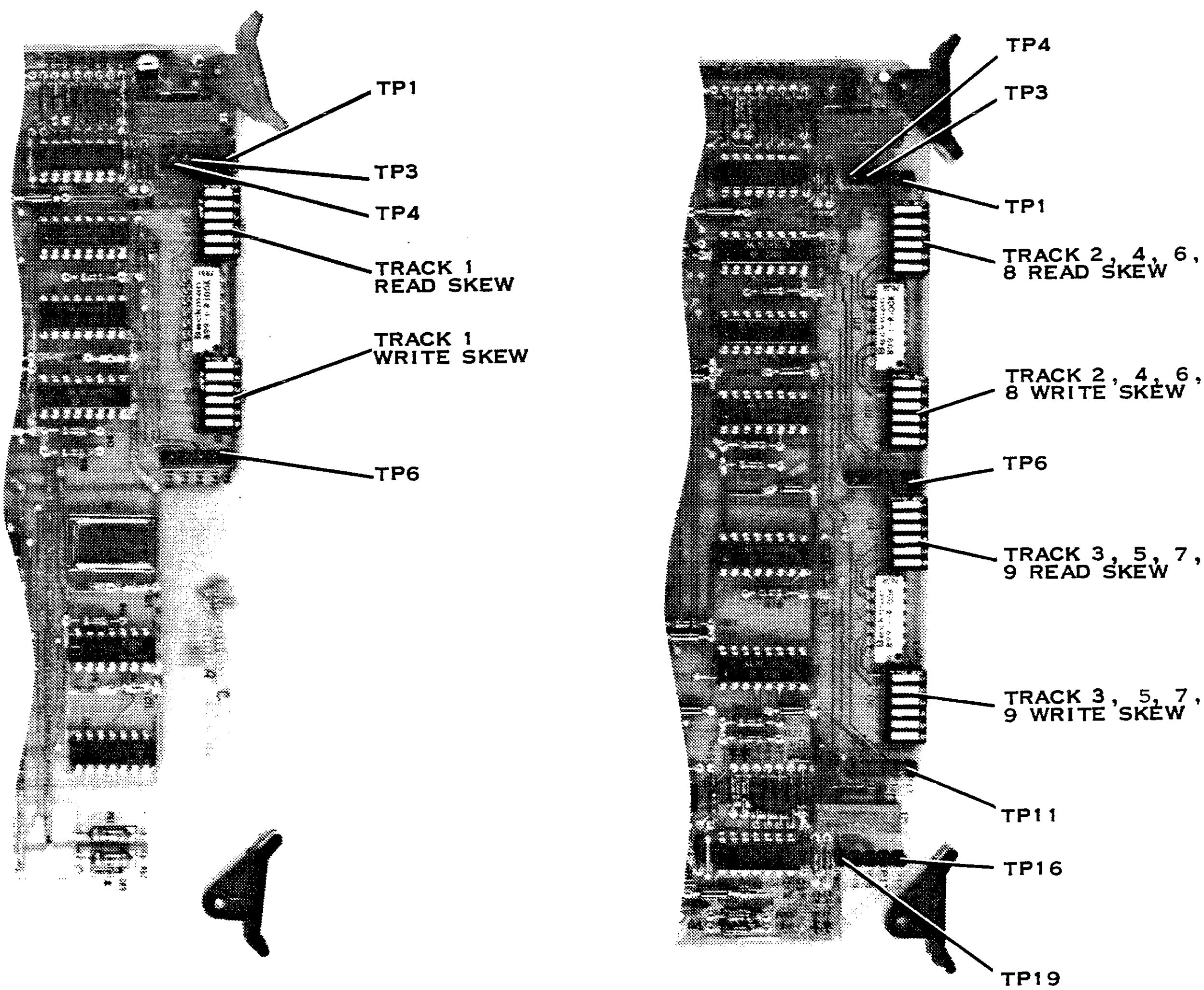


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Figure 5-5. Skew Switch and Testpoint Layout

Table 5-15. Read Skew Checks and Adjustments (NRZI Only) (Continued)

Step	Procedure
7.	Refer to figure 5-5 and set the read-skew DIP switches of the track connected to oscilloscope channel 1 to the delay measured in step 6. For example: if the delay time measured in 3.5 μsec set switches 6, 5, and 4 to OFF. This corresponds to $0.5 + 1.0 + 2.0 = 3.5$ μsec. Check oscilloscope to see that the two waveforms are essentially coincident.
8.	Move the oscilloscope channel 1 probe to the remaining track test points (except track test point connected to oscilloscope channel 2) and correct skew as outlined in step 7, if necessary.
9.	After setting track delay, recheck all tracks to see that they are correctly skewed.

NOTE

Skew correction is only valid in the forward direction.

NOTE

Check the setting of all switches. If the 8 μsec or 16 μsec switch is used, i.e., set to OFF, then mechanical skew correction is not valid. Perform procedures for static skew, table.

Step	Procedure
10.	Record the skew switch settings on the table on the left side of the card cage.
11.	Wind tape back onto the supply reel using reverse drive and unload master skew tape.
12.	Reconnect the write-head connector (P1/J15, step 3, table 5-14).

Table 5-16. Write Skew Checks and Adjustments (NRZI Only)

Write skew checks and adjustments are performed in essentially the same manner as read skew adjustments. First, a determination is made on whether track 1 or track 9 presents the longer delay. That track is then used as a reference and monitored on oscilloscope channel 2. All delays are made in reference to the channel 2 waveform, the appropriate delay switches are set to OFF, and delay data is recorded on the table affixed to the left side of the card cage. In this test data bits are read immediately after writing, instead of reading a master skew tape. For this reason, use a good quality scratch tape.

Step	Procedure
1.	Load a good scratch tape.
2.	Set field tester FWD/OFF/REV to FWD. Set SET-WRT OFF SET-RD to SET WRT. Set 1/⎍⎍/0 to 1. Set all track DATA switches to 1 (data switches are located in the right side of the field tester). Set AUTO REV to REW (automatic rewind).
3.	Set oscilloscope as follows: 2V/DIV. (both channels), AC TRIGGER, +SLOPE, ALT MODE and trigger on channel 1.

Table 5-16. Write Skew Checks and Adjustments (NRZI Only) (Continued)

Step	Procedure
4.	Connect oscilloscope channel 1 probe to TP6 on A1A4A6 (tape track 1 digital data output) and channel 2 probe to A1A4A10 at TP11 (tape track 9). Now connect the test point with the leading waveform to oscilloscope channel 1. This may be either track 1 or track 9.
5.	Now, referring to the chart in figure 5-5 probe all other digital data track test points with the channel 2 probe while looking for the track digital data output which presents the greatest delay relative to channel 1 waveform. Leave the probe connected to the track with the most delay.
	NOTE There may be a significant amount of jitter between the two waveforms. If the jitter is greater than 4 μsec, check all guides and the vacuum column for causes of jitter and correct. In all the following measurements choose the average transition time on channel 2 as the time mark. The average transition time is usually the brightest trace in the jitter field.
6.	With the most delayed track connected to oscilloscope channel 2, connect the oscilloscope channel 1 probe to the test point of the lowest numbered track available (either track #1 or track #2). Measure the delay from leading edge of channel #1 to the leading edge of channel #2.
7.	Refer to figure 5-5 and set the write-skew DIP switches of the track connected to channel 1 to the delay measured in step 6 above. For example: if the delay time measured is 3.5 μsec set switches 6, 5, and 4 to OFF. This corresponds to $0.5 + 1.0 + 2.0 = 3.5$ μsec. Check oscilloscope to see that the two waveforms are essentially coincident.
8.	Move the oscilloscope channel 1 probe to the remaining track test points (except track test point connected to oscilloscope channel 2) and correct skew as outlined in step 7, if necessary.
9.	After setting track delay, recheck all tracks to see that they are correctly skewed.
10.	Record the skew switch settings on the table affixed to the left side of the card cage.

Table 5-17. 1600 BPI PE Data Tests (PE Only)

NOTE

Phase encoded control and data cards have no adjustments. Deskewing for PE data is under control of the 979A Magnetic Tape Controller in the 990 system on the TIU in a 960/980 system. These checks may be used to isolate PE problems after completing diagnostic tests or troubleshooting procedures.

Step	Procedure
1.	Set tape transport ac POWER to OFF and check that PE control card is located in slot for A1A4A6; PE Data cards in slots for A1A4A7, A8, A9, and A10.
2.	Set field tester as follows: FWD/OFF/REV: OFF SET-WRT/OFF/SET-RD: SET-WRT NRZI/PE: PE (Located on right side of field tester.) Track DATA switches: Set all switches to "1".
3.	Install field tester in slot J4 in card cage.
4.	Remove card A1A4A8, install on extender board and reinsert in slot J8 (tracks 4 and 5 are on this board).
5.	Set tape transport POWER to ON. Load a scratch tape on transport but do not set tape to drive after reaching BOT.
6.	Connect an oscilloscope probe to C27 (-) (amplifier output, track 5). Adjust oscilloscope to display a waveform less than 1.0 V p-p. See figure below.
7.	Monitor amplifier output for a voltage less than 1.0 V p-p. If voltage exceeds this limit, check read head cables for proper shielding and separation from write head cable, particularly at the base of the heads. If necessary, adjust the crosstalk shield as outlined in table 5-10.
8.	Check all other track amplifier outputs. Refer to figure 5-6 for locations and reference designators.
9.	Set field tester FWD/OFF/REV to FWD.
10.	Monitor the data output connector pins for all tracks, shown in figure 5-6.
11.	Change the data pattern switches (on right side of field tester), and check that appropriate tracks change. Check tape head wiring (J15 and J16) and appropriate logic card if no error results.
12.	After satisfactory completion of tests, unload tape, set tape transport ac POWER to OFF, remove field tester, replace all data and control cards in card cage, check that all connections are properly made including I/O cables (or terminator).

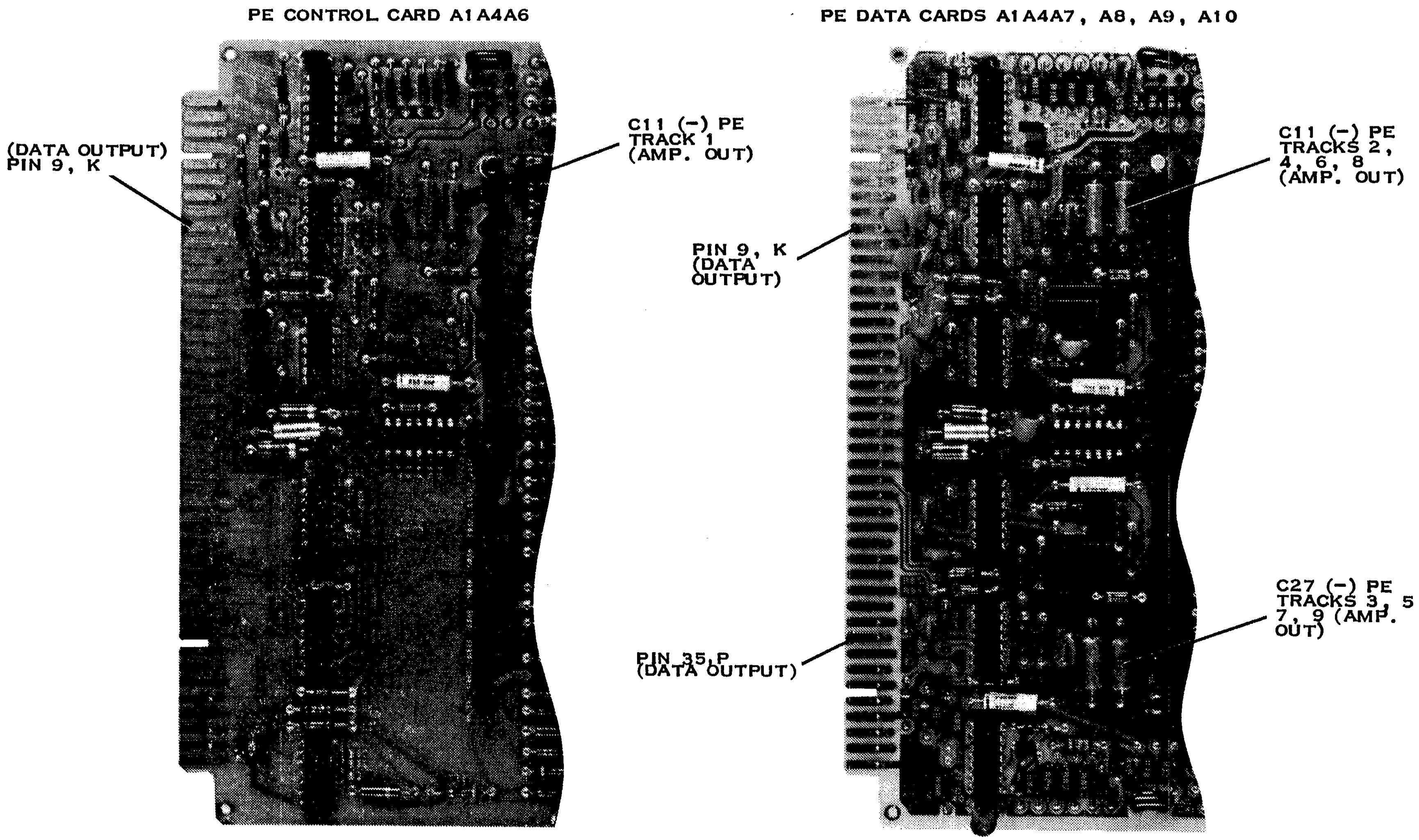

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Figure 5-6. PE Control and Data Cards, Test Points

5.6 TROUBLESHOOTING PROCEDURES

Repairing the magnetic tape system in the field is relatively easy because the problem is usually resolved to a replaceable assembly, or to cleaning or adjusting operation as described in preventive maintenance (paragraph 5.4). Troubleshooting this system under the diagnostic test program is described in the previous paragraph. However, the steps of table 5-18 give a list of possible problems connected with a malfunction. This table primarily serves as an aid in repairing the tape transport. The interface controller is checked out with the diagnostic tests. For the tape transport further isolation of a suspected fault may be necessary to identify the replaceable subassembly.

Table 5-18. Model 979A Tape Transport Troubleshooting Procedures

Step	Malfunction	Probable Cause	Remedy
1.	No power to transport.	a. Power not available at source.	a. Check power at source.
		b. Fuse F1 open.	b. Replace fuse at top rear of chassis next to ac power inlet.
		c. Transformer T1 open	c. Check pins 1 and 3 on TB1 in power supply assembly.
2.	Some or all dc voltages missing.	a. Transformer T1 open	a. Check voltages at fuse block (unregulated DC Fuses), check input to rectifiers CR1 and CR2. Use schematic 948159 to isolate fault.
		b. Rectifiers CR1 and/or CR2 open.	b. Replace defective rectifiers.
		c. Capstan/regulator circuit card. defective.	c. Replace circuit card A1A4A1.
3.	No vacuum.	a. Relay K1 on power supply assembly does not energize.	a. Check operation of VAC relay circuit on Logic card. Check voltage across relay coil K1. Replace K1 if necessary. Check DC power supply voltages. Replace capstan/regulator card if necessary.
		b. Blower motor defective.	b. Replace blower motor assembly.

Table 5-18. Model 979A Tape Transport Troubleshooting Procedures (Continued)

Step	Malfunction	Probable Cause	Remedy
4.	Tape does not enter vacuum column	a. Tape incorrectly threaded. b. No vacuum.	Check: 1. Vacuum column cover correctly installed. 2. Vacuum column seals. 3. Motor operation. 4. Time-out circuit on motion control logic card assembly 216548 (A1A4A3) defective (Q3 and Q5 circuits). Replace card. 5. Defective VAC relay circuit on motor control logic assembly 937027 (A1A4A3). Replace card.
5.	Excessive tape in supply vacuum column with subsequent system shut-down.	a. Supply/take-up reel motors malfunctioning.	a. Go to step 16.
		b. Vacuum column lamps or sensors defective.	b. Replace defective components: lamp strip or sensor strip.
6.	Excessive tape in take-up vacuum column with subsequent system shut-down.	a. Supply/take-up reel motors malfunctioning.	a. Go to step 15.
		b. Vacuum column lamps or sensors defective.	b. Replace defective components: lamp strip or sensor strip.
7.	Excessive tape build-up in either column, no system shutdown.	a. -20 volts not available.	a. Check: 1. Fuse F4. 2. -20 volt regulator (A1A4A1, capstan/regulator).
		b. Defective sensor board.	b. Replace vacuum column sensor strip.
		c. One or more defective lamps.	c. Replace defective lamp strip.

Table 5-18. Model 979A Tape Transport Troubleshooting Procedures (Continued)

Step	Malfunction	Probable Cause	Remedy
8.	Tape rewinds off take-up reel at high speed rewind	a. BOT marker missing.	a. Affix new BOT marker to tape.
		b. BOT detector lamp assembly	b. Replace BOT lamp/detector assembly.
		c. Logic card (Motion Control A1A4A3)	c. Replace logic card
9.	Tape winds off supply reel at high speed.	a. Transport not under computer control.	a. Computer operating and in RUN mode.
		b. EOT marker missing.	b. Affix new EOT marker to tape.
		c. EOT detector/lamp assembly.	c. Replace EOT detector/ lamp assembly.
		d. Computer software not checking for $\overline{EOT}$ status	d. Verify software checks for $\overline{EOT}$.
10.	Tape does not unload.	a. Relay K1 (Power supply module) does not energize.	a. Suspect capstan/regulator assembly, A1A4A1. Use schematic 948176 and 216508 in drawing manual, part number 949613-9702, as an aid in isolating fault.
		b. Control circuits on capstan/ regulator assembly.	b. Replace capstan/regulator card, A1A4A1.
		c. Unload logic on logic card	c. Replace logic card (A1A483).
11.	FILE PROTECT does not light with protected tape installed.	a. Switch defective.	a. Check switch action at P2-3 and 4; refer to schematic 948226 and 948230 in drawing manual, part number 949613-9702.
		b. Lamp defective.	b. Replace lamp.
		c. Lamp driver defective.	c. Replace capstan/regulator card, A1A4A1.
12.	No channels read and/or write.	Data control logic.	Replace NRZI or PE data control assembly, A1A4A6.

Table 5-18. Model 979A Tape Transport Troubleshooting Procedures (Continued)

Step	Malfunction	Probable Cause	Remedy
13.	No read and/or write on certain channels.	NRZI or PE data assembly	Perform test outlined in applicable tables 5-10 through 5-16 to determine which channels are faulty; replace faulty data cards, A1A4A7-A1A4A10.
14.	No capstan drive.	a. Capstan/regulator, A1A4A1.	a. Replace capstan/regulator assembly.
		b. Capstan motor/tachometer.	b. Replace capstan motor and tachometer assembly
		c. Logic forward/reverse logic.	c. Replace logic card (A1A483).
15.	Supply or take-up reel motors inoperative.	a. Reel servo assembly.	a. Replace reel servo assembly, A1A4A2.
		b. Supply or take-up reel motors	b. Replace motor assembly.

5.7 TROUBLESHOOTING AIDS

Reference figures 5-7 through 5-14 for aid in performing troubleshooting procedures.

5.8 TRANSPORT SUBASSEMBLIES, REMOVAL AND REPLACEMENT PROCEDURES

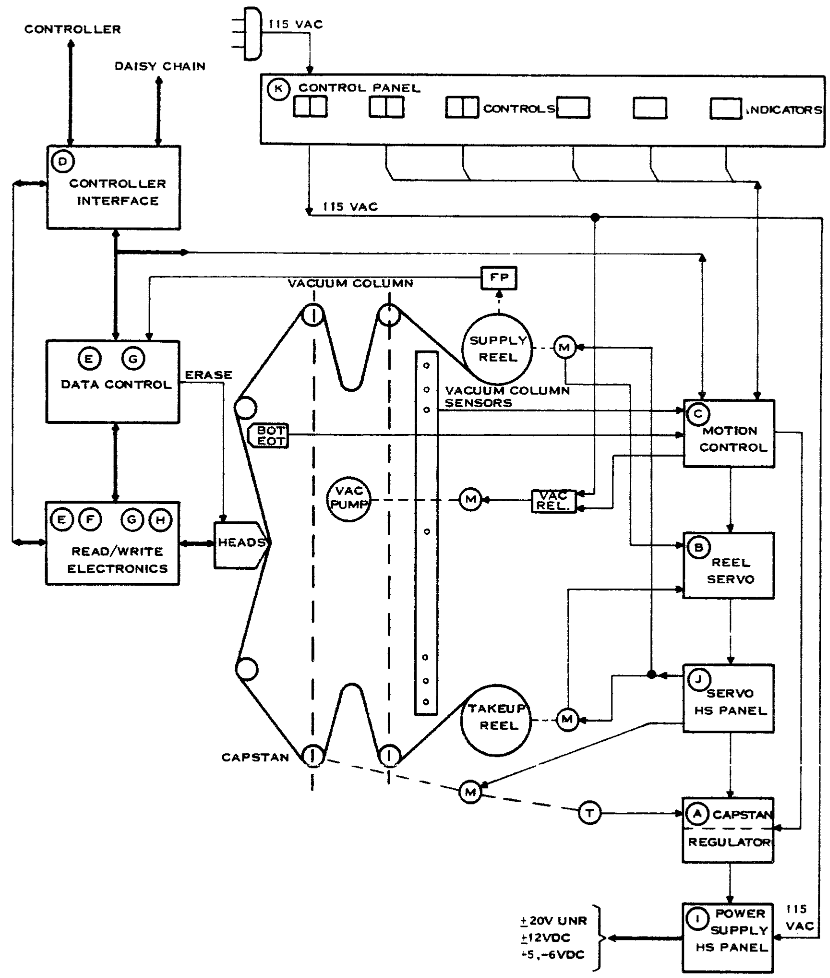
The following procedures facilitate removal and replacement of major subassemblies of the 979A Tape Transport. When a major subassembly is found to be defective, remove and replace with a known-to-be-good unit, and return the defective subassembly to the nearest depot repair facility for disposition.

5.8.1 PRINTED CIRCUIT CARD, REMOVAL AND REPLACEMENT. Printed circuit cards are located in the card cage mounted in the rear of the assembly, see figure 5-15. Remove printed circuit cards from the card cage as follows:

1. Set tape transport power to OFF.
2. Place thumbs under card ejectors towards the inside of the card, and pull out on ejectors. Slide card from cage.

Install printed circuit cards in card cage as follows:

1. Check that tape transport power is OFF.
2. Locate the appropriate card cage slot for the card to be inserted. The colored dots at the top of the card cage match the color of the top ejector on the card.



KEY	SLOT	SCHEMATIC	THEORY PARA.	TITLE/FUNCTIONS PERFORMED
A	J1	216508	4.3.2.1	CAPSTAN/REGULATOR. CAPSTAN SERVO AMPLIFIER, POWER SUPPLY REGULATORS, BOT/EOT SENSOR AMPLIFIERS, PANEL LAMP DRIVERS, RELAY DRIVERS.
B	J2	216543	4.3.2.2	REEL SERVO. CONTROLS SPEED AND DIRECTION OF REEL MOTORS, DYNAMIC BRAKING CIRCUIT.
C	J3	216549 OR 937029	4.3.2.3 4.3.2.4 4.3.2.5	MOTION CONTROL LOGIC. MOTION CONTROL, VACUUM CONTROL AND STATUS LOGIC; REACTS TO LOCAL, REMOTE, OR INTERNALLY GENERATED COMMANDS TO CONTROL TAPE MOVEMENT.
D	J4, J5	948180	-	INTERFACE/TERMINATOR SLOTS. INPUT FROM CONTROLLER CONNECTS TO J4. OUTPUT TO NEXT TRANSPORT (DAISY-CHAINING) OR TERMINATOR CONNECTS TO SLOT J5.
E	J6	948237	4.3.2.7	NRZI CONTROL. CONTAINS LOGIC TO PROCESS DATA AND CONTROL SIGNALS FOR THE NINE DATA TRACKS. ONE HALF OF NRZI CONTROL CONTAINS TRACK 1 DATA CIRCUITS.
F	J7-J10	948234	4.3.2.7	NRZI DATA. CIRCUITS TO RECORD AND PLAYBACK DATA FOR TRACKS 2 THROUGH 9. RECORD OR PLAYBACK FORMAT IS 800 BPI/TRACK.
G	J6	216540	4.3.2.6	PE CONTROL. PERFORMS FUNCTIONS SIMILAR TO NRZI CONTROL. FORMAT IS PHASE-ENCODED, 1600 BPI/TRACK.
H	J7-J10	216537	4.3.2.6	PE DATA. RECORD/PLAYBACK CIRCUITS FOR PE DATA.
I	-	948159	4.3.1	POWER SUPPLY ASSEMBLY (HS = HEAT SINK ASSEMBLY). CONTAINS TRANSFORMER, RECTIFIERS, AND PASS TRANSISTORS MOUNTED ON A HEAT SINK.
J	-	948176	1.4.2 4.3.2ff	SERVO DRIVER PANEL (HS = HEAT SINK ASSEMBLY). CONTAINS DRIVERS FOR REEL MOTORS AND CAPSTAN MOTOR. LOWER ASSEMBLY AT REAR OF TRANSPORT.
K	-	948164	-	CONTROL PANEL. CONTAINS SWITCHES AND INDICATORS. SEE FIGURE 3-2.

M = MOTOR
T = TACHOMETER
FP = FILE PROTECT SWITCH
VAC = VACUUM

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Figure 5-7. Model 979A Functional Block Diagram

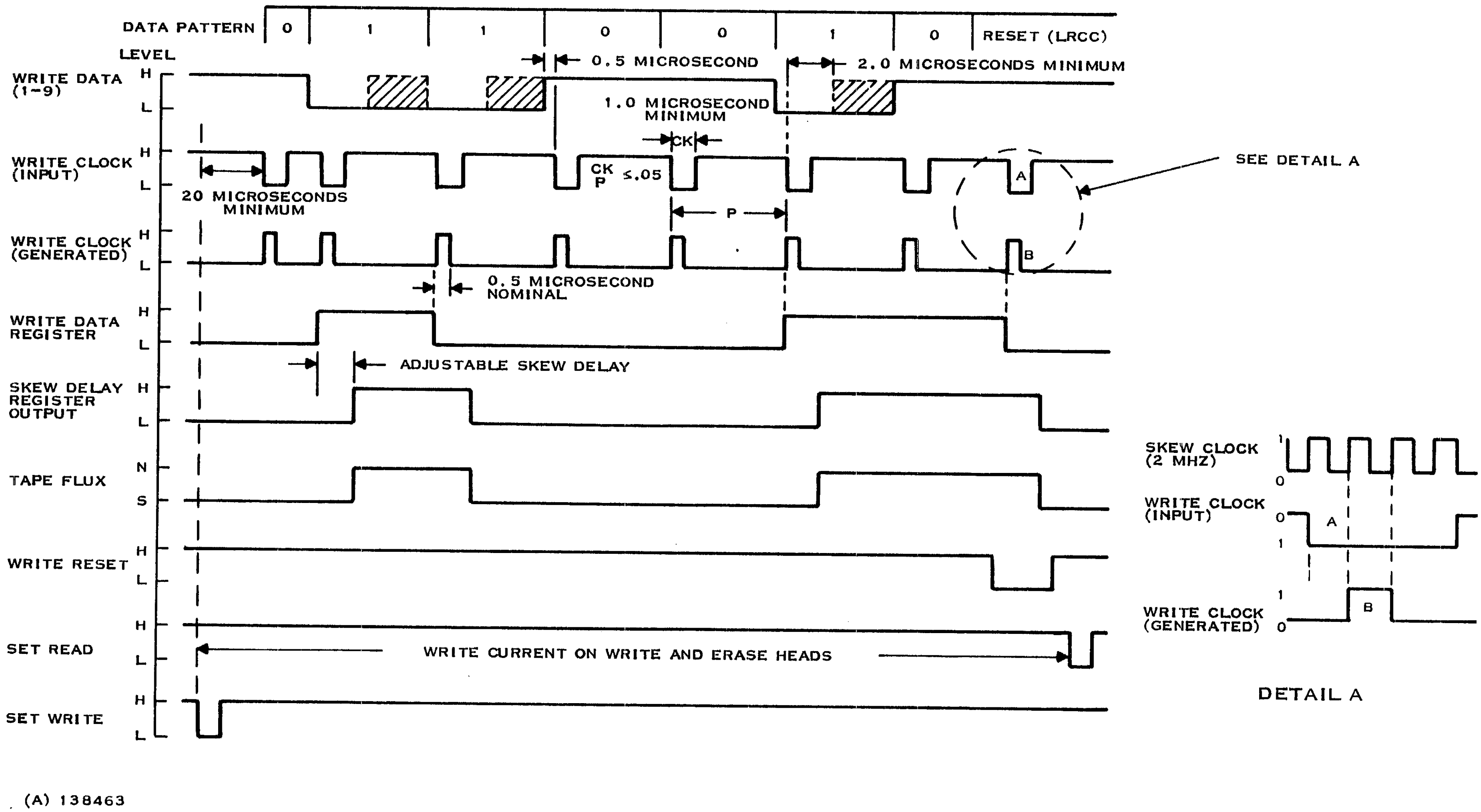
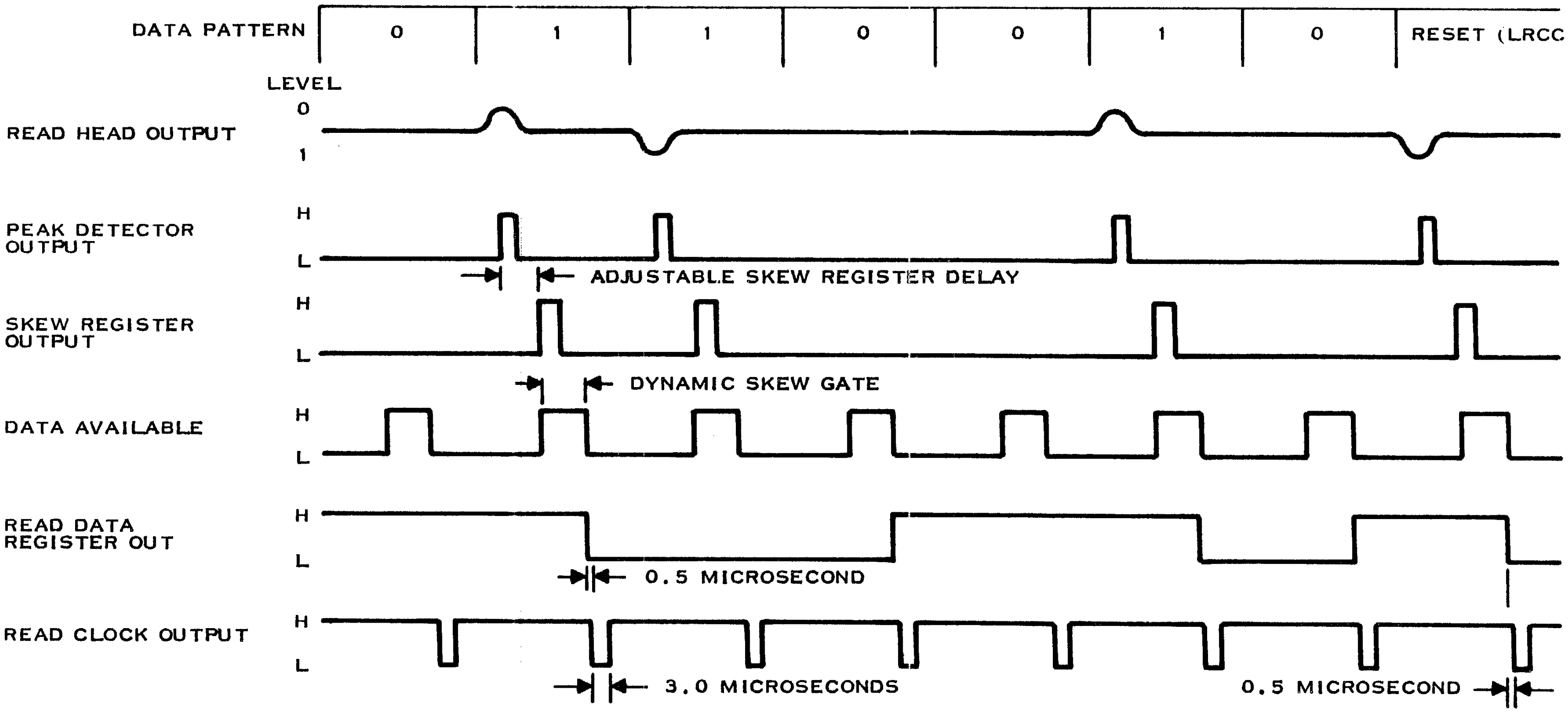


Figure 5-8. NRZI Write Channel Timing



NOTE: DATA AVAILABLE TIMES AND READ CLOCK OUTPUT PULSES ARE GENERATED BY DATA IN CHANNELS NOT SHOWN. PRESENCE OF CONSECUTIVE CLOCK PULSES IS GUARANTEED BY ODD PARITY DATA. WHEN A CHARACTER ON TAPE CONSISTS OF ALL ZEROS, A READ CLOCK OUTPUT IS NOT PRODUCED.

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Figure 5-9. NRZI Read Channel Timing

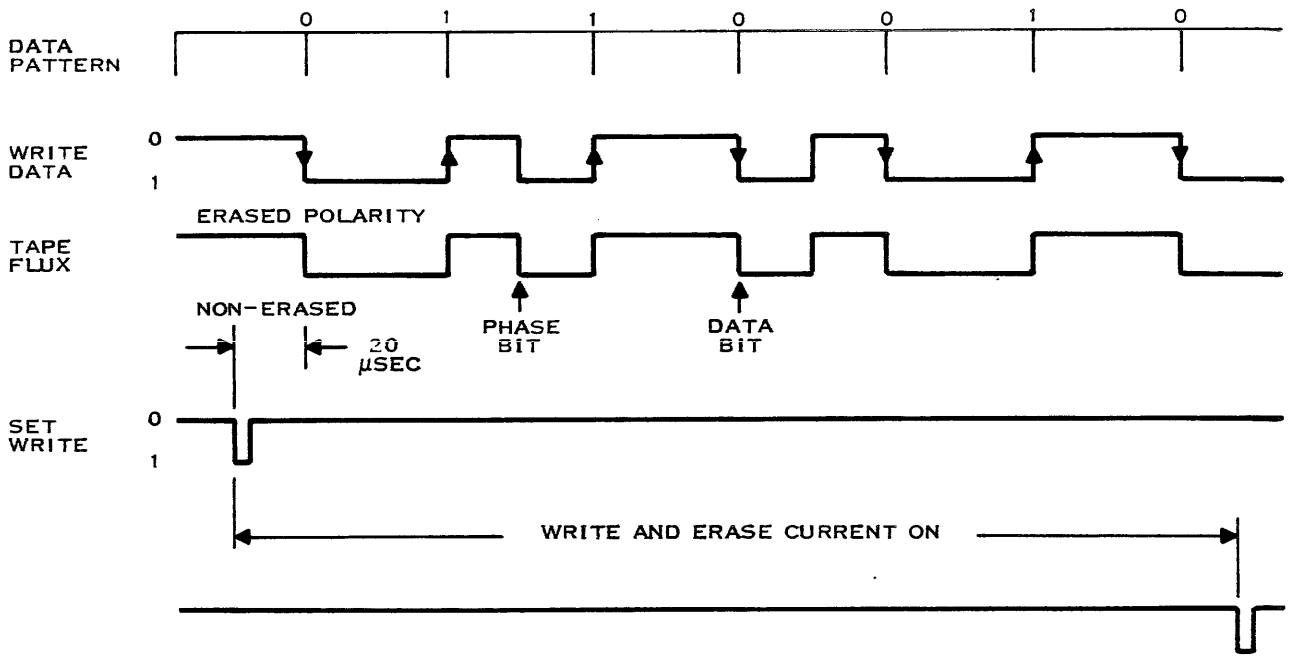

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Figure 5-10. Phase Encoded Write Timing

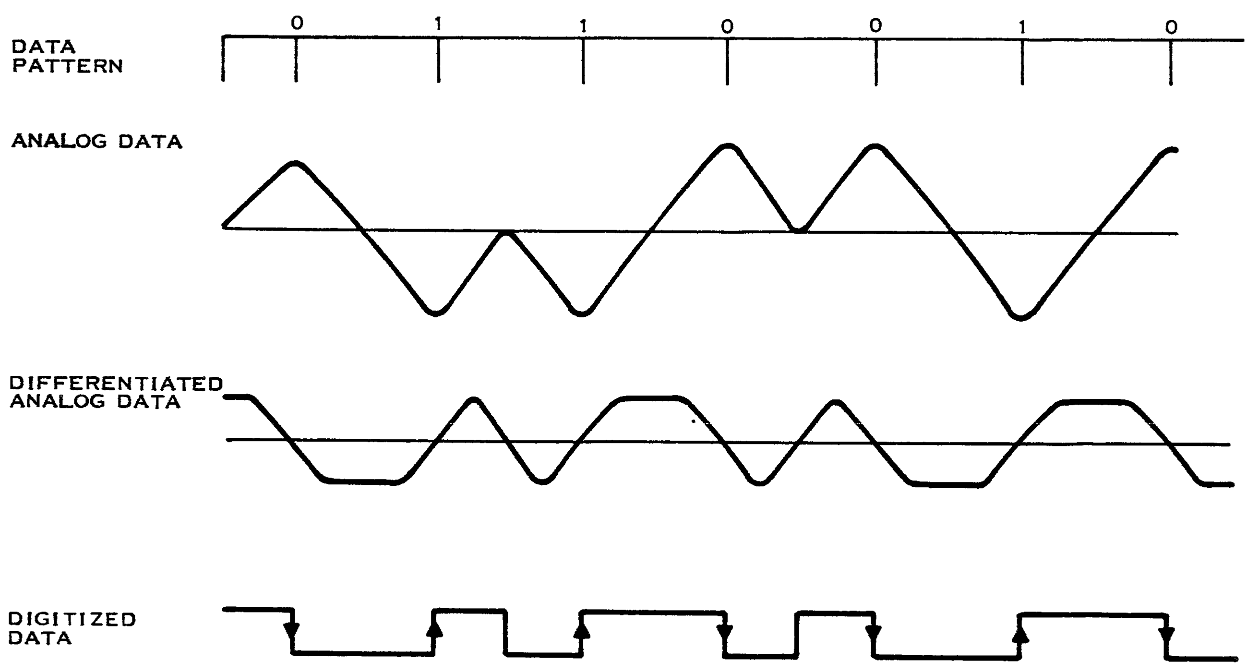

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Figure 5-11. Phase Encoded (PE) Read Timing

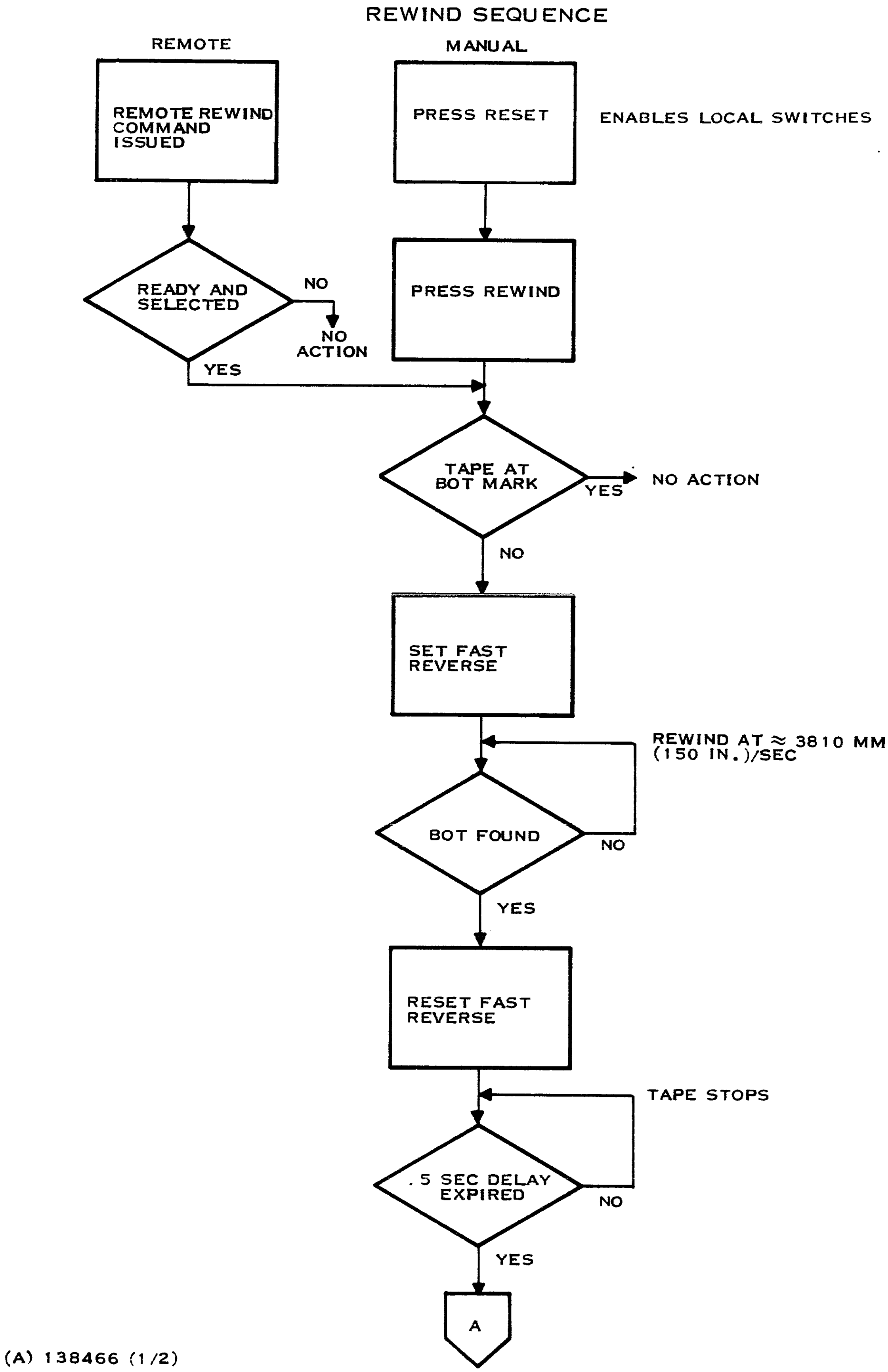

Figure 5-12. Rewind Sequence (Sheet 1 of 2)

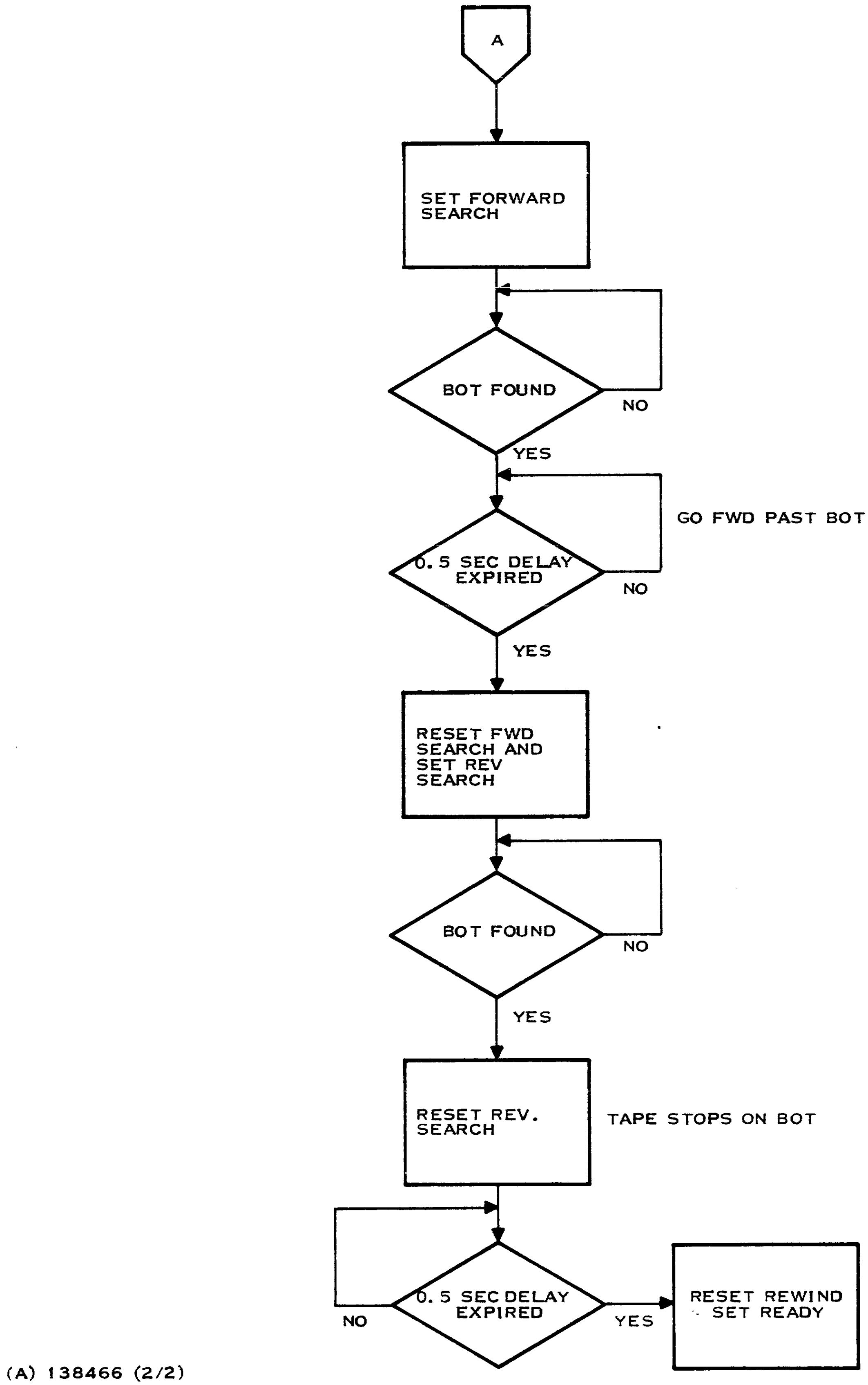

Figure 5-12. Rewind Sequence (Sheet 2 of 2)

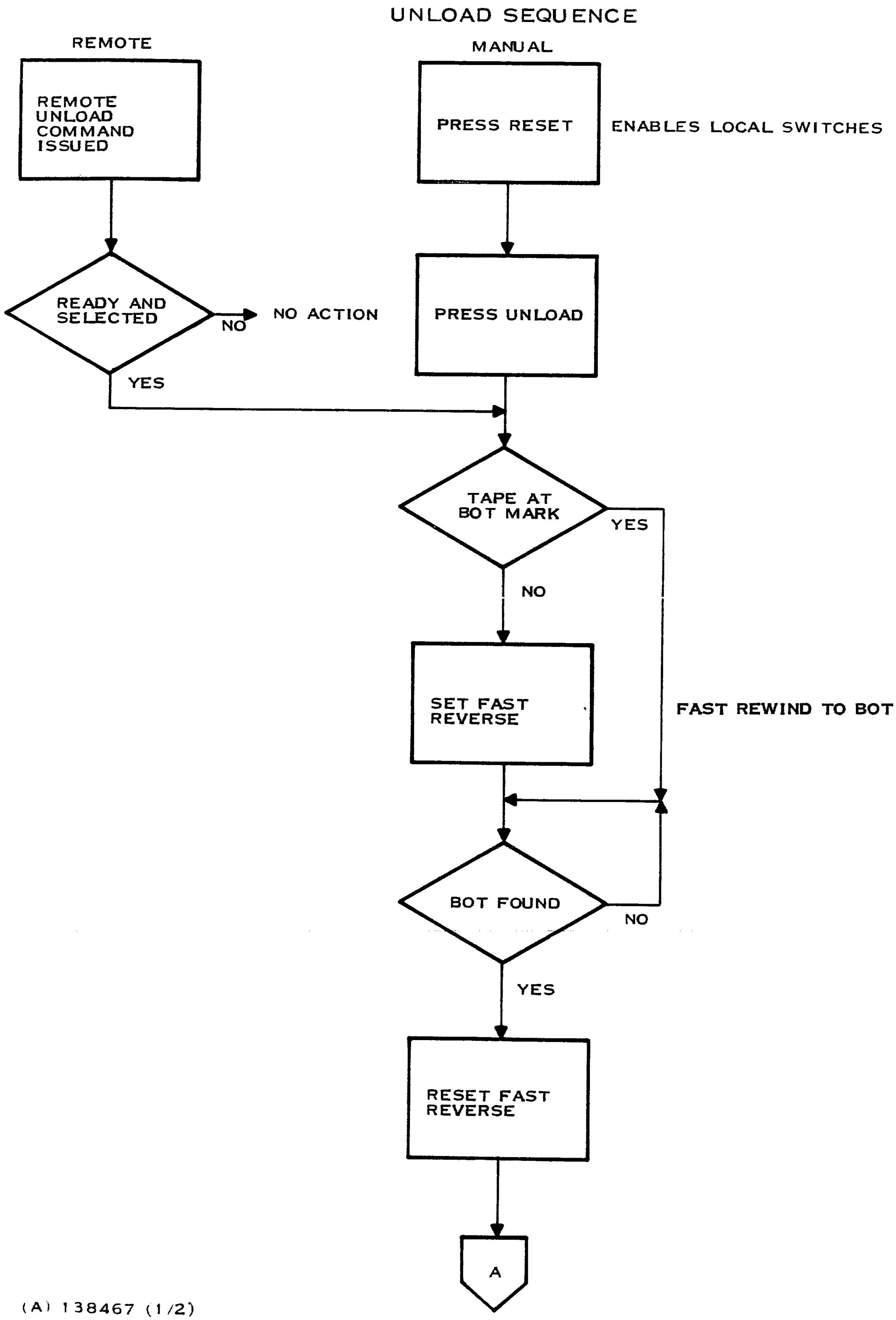

Figure 5-13. Unload Sequence (Sheet 1 of 2)

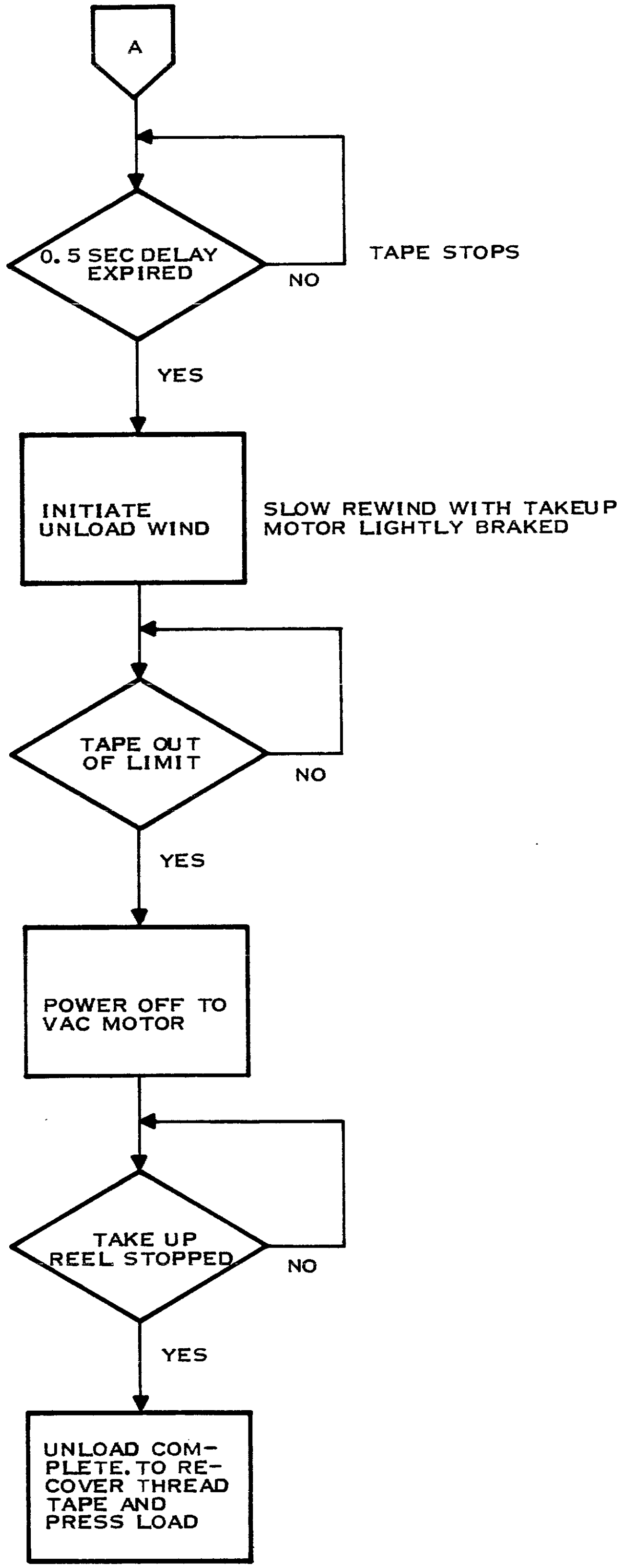

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Figure 5-13. Unload Sequence (Sheet 2 of 2)

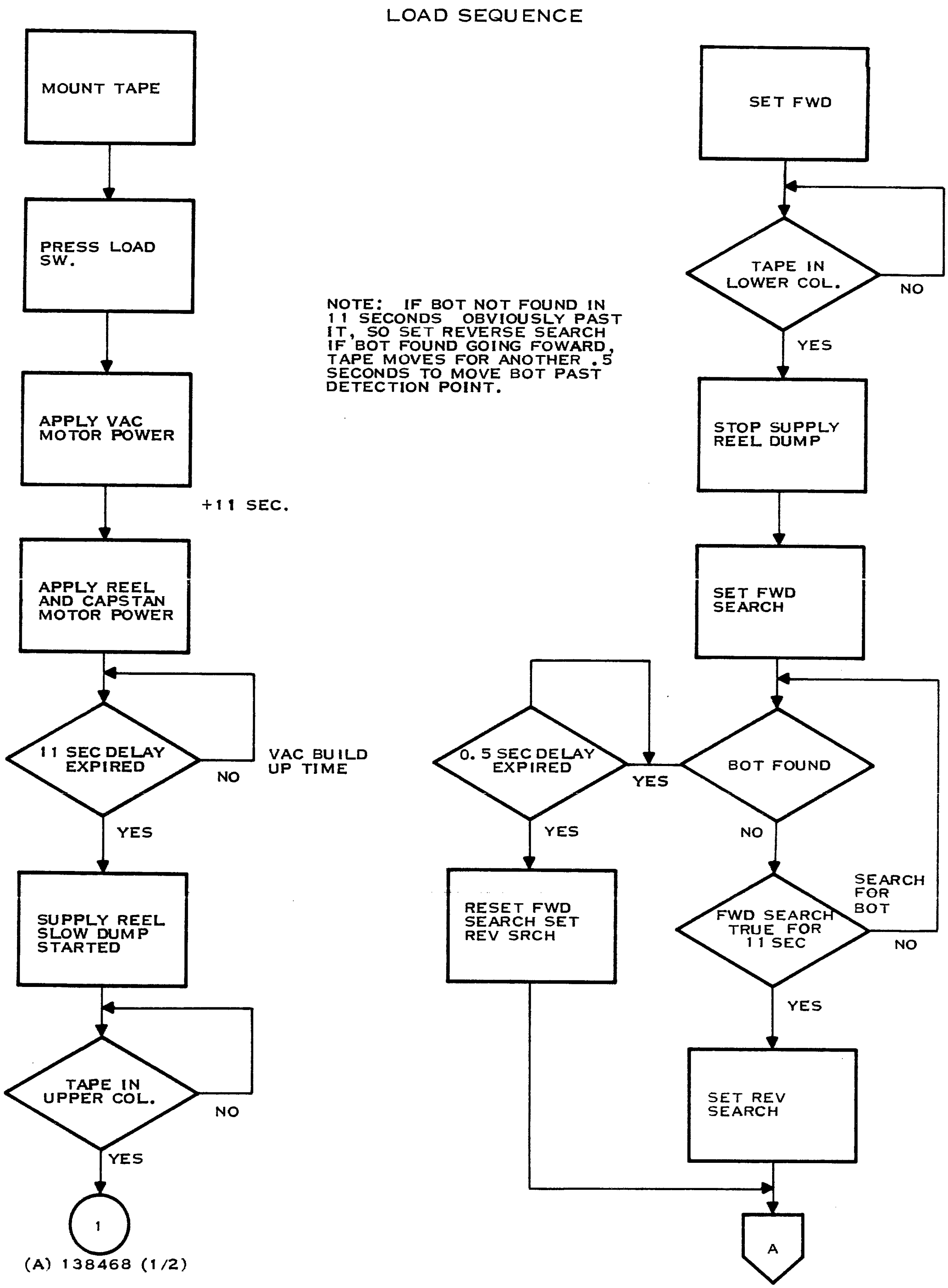

Figure 5-14. Load Sequence (Sheet 1 of 2)

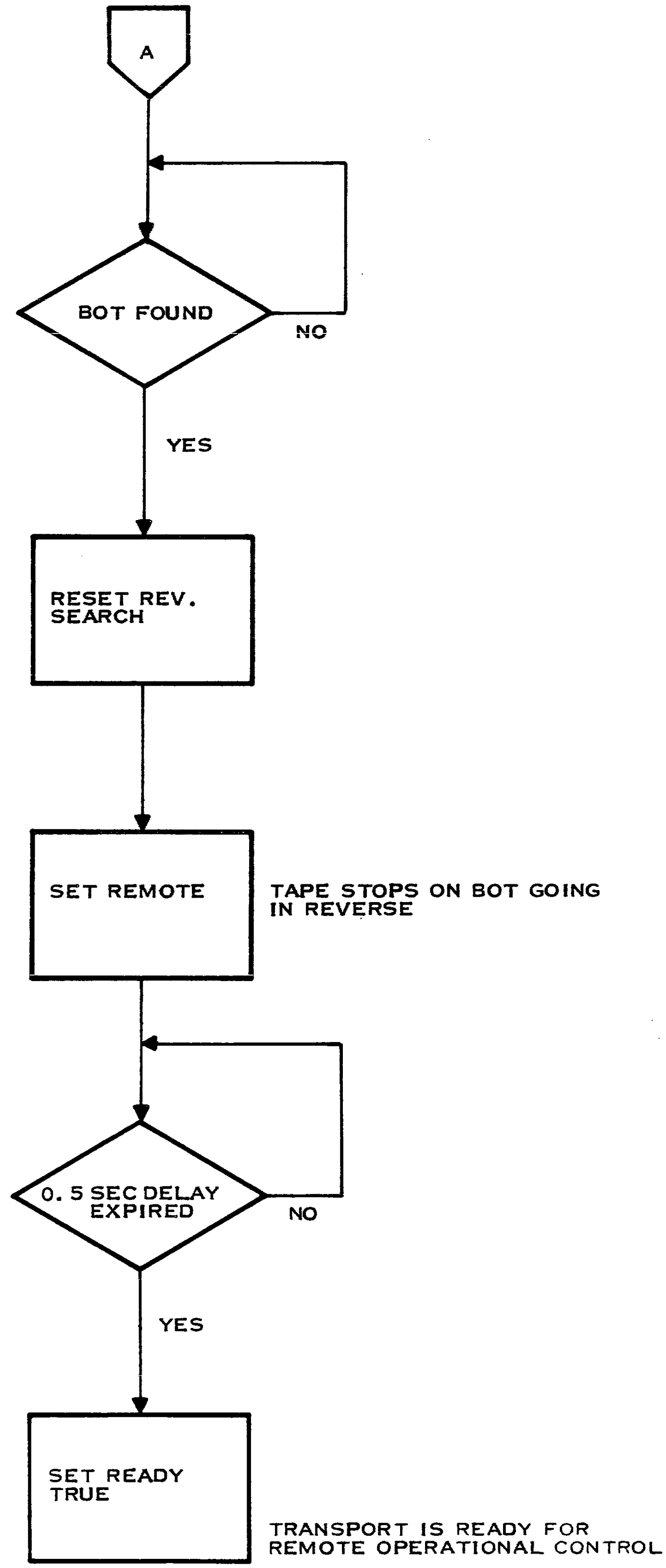

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Figure 5-14. Load Sequence (Sheet 2 of 2)

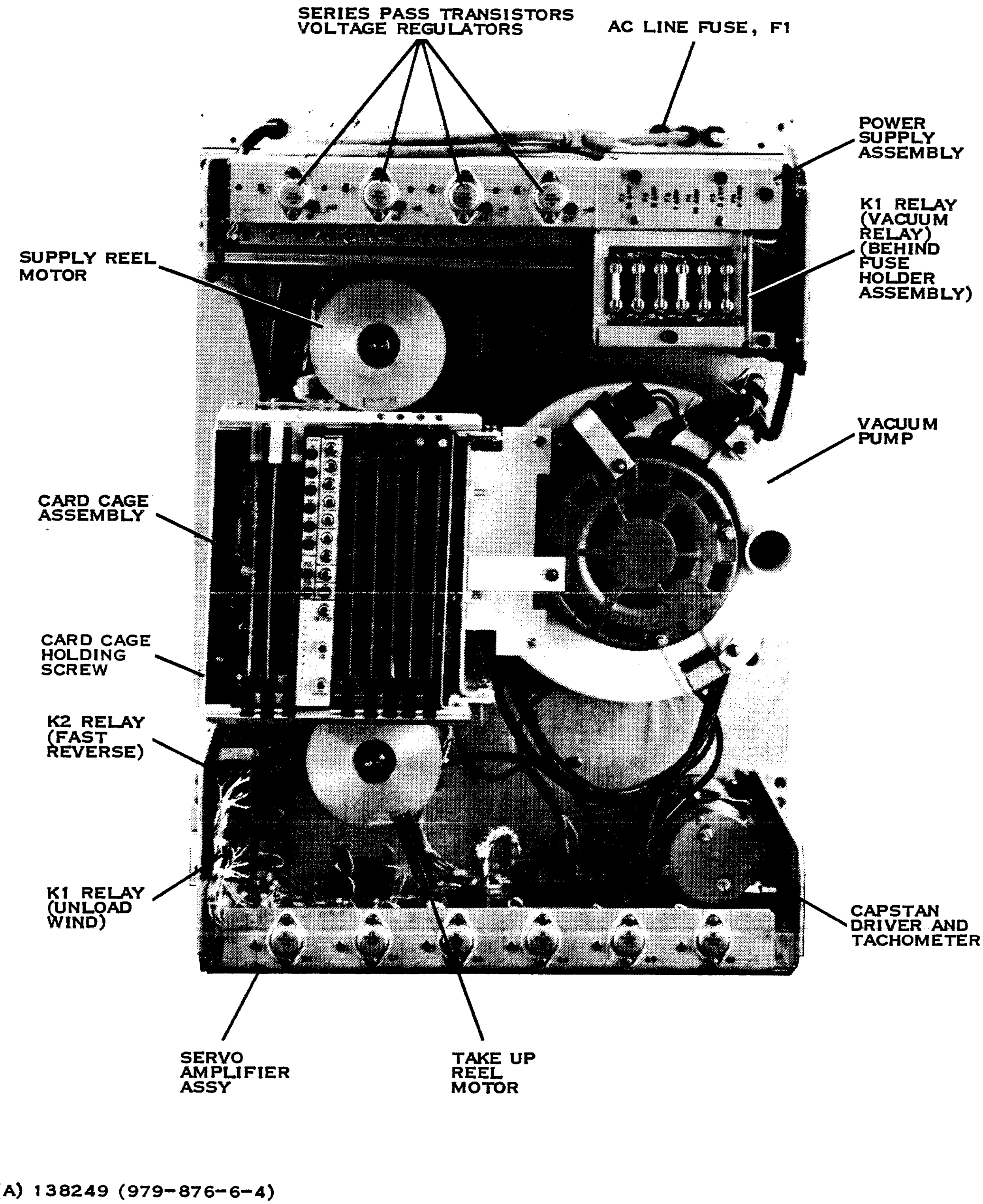


Figure 5-15. Location of Regulators

NOTE

Slots J4 and J5, brown and red colored dots respectively, are used for I/O cables and, when necessary, the 979A Field Tester. (The field tester slides into slot J4, when used.)

3. Slide the card into the card cage slot and press it firmly into the connector by applying equal pressure to the card ejectors. Be sure card is correctly and securely seated.

4. Restore power to tape transport.

5.8.2 SUPPLY REEL MOTOR (SUP), REMOVAL AND REPLACEMENT. The supply reel motor is the top left motor unit when transport is viewed from rear. To remove the supply reel motor unit, proceed as follows:

1. Set transport ac power to OFF.

2. Remove tape supply reel from the quick release hub, see figure 5-16.

NOTE

On the flange at the rear of the hub is a notch scribed on the flange edge. This notch indicates the location of an allen head set screw underneath black rubber compression ring.

3. Position the hub so that the notch marking the set screw hole is in the three o'clock position.

4. Lift rubber ring and remove from hub.

5. Loosen set screw.

6. Rotate hub so that the set screw hole is at the six o'clock position and tap hub to remove the brass locking pin (items 9 and 8 in figure 5-16).

7. Remove card cage holding screw, see figure 5-16, and swing card cage outward.

8. Disconnect motor wires from motor terminal board pins 1 (red wire) and 2 (black wire).

9. With another person supporting the motor, remove the four socket head screws holding the motor to transport face plate assembly.

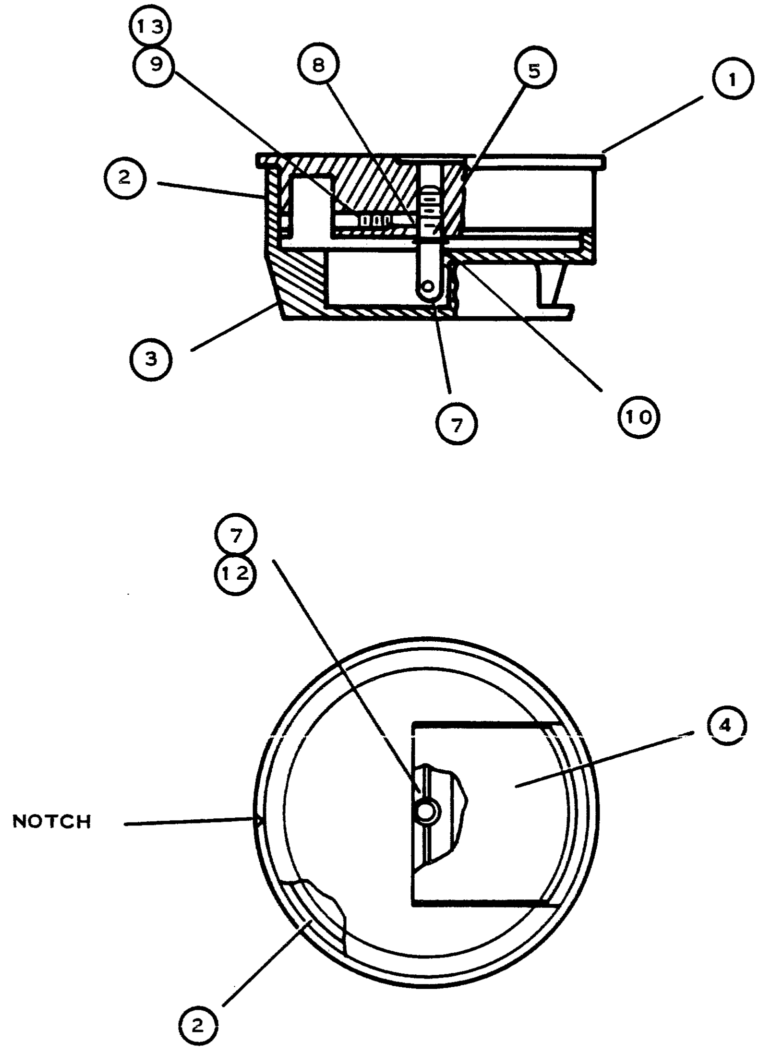
10. Remove motor from chassis.

To install supply reel motor, proceed as follows:

NOTE

Return any shims that were originally used to mount the motor on hub, to their original positions.

11. With one person holding the motor from the rear, tighten the four socket head screws to hold the motor to the face plate assembly.



NOTE: 1. NOTCH IN HUB INDICATES LOCATION OF ACCESS HOLE FOR SET SCREW

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Figure 5-16. Quick Release Hub

12. Connect motor terminal lugs to motor terminal board on bottom rear of assembly. Connect red wire to terminal 1 (SUP RED) and black wire to terminal 2 (SUP BK).

13. Refer to figure 5-14 and install the reel mounting hub (item 1) to the plate on the motor shaft using three socket head screws.

14. Slip rubber compression ring (item 2) over the hub.

15. Lift latch handle (item 4) and screw on compression hub (item 3) to a point close to, but not touching, the rubber compression ring.

16. Drop brass locking plug (item 8) into the set screw hole.

17. Insert set screw into hole and tighten.

18. Rotate housing (item 3) one quarter turn in each direction.

NOTE

This cuts threads into the brass locking plug to ensure good material contact.

19. Loosen set screw one full turn.
20. With latching handle (item 4) in open position, tighten housing (item 3) until it is snug against the rubber compression ring (item 2), but not compressing the ring.
21. Close and open the latching handle a few times and allow the rubber ring to relax for a few seconds when handle is open.
22. Again tighten housing until it touches the ring but does not cause the ring to compress.
23. Check operation by installing an empty reel on the hub and alternately open and close the latching handle while checking reel slippage.
24. If reel slips on the hub when latching handle is closed, tighten compression housing and recheck.
25. If reel binds on hub when latching handle is open, loosen compression housing and recheck.
26. Firmly tighten set screw and apply a few drops of lock tight sealant to the set screw hole. Force the sealant into the set screw hole by using the allen wrench.
27. Load tape and run tape forward and reverse to verify tape is stacking properly on the reel (i.e., uniformly in the middle of the reel). If the tape does not stack properly on the reel, additional shimming must be done to properly align the reel with the tape path.

5.8.3 TAKE-UP REEL MOTOR (T/U), REMOVAL AND REPLACEMENT. The take-up reel motor is the lower left motor unit when viewed from the rear. To remove the take-up reel motor proceed as follows:

1. Remove reel from take-up reel hub by unscrewing the compression ring knob.
2. Completely remove the compression ring knob and compression hub.
3. Remove three allen head screws holding the reel mounting hub to plate on motor shaft.
4. Disconnect motor lugs from terminal board pin 5 (T/U RED) and pin 6 (T/U BK).
5. With another person supporting the motor at the rear, remove the four allen head screws holding the motor to the faceplate assembly.
6. Remove motor from chassis.

To install take-up reel motor, proceed as follows:

NOTE

Return any shims that were originally used to mount the motor on hub to their original positions.

7. With one person supporting the motor from the rear, tighten the allen head screws holding the motor to the faceplate assembly.

8. Connect motor wire lugs to motor terminal board pin 5 (T/U RED) and pin 6 (T/U BLK).

9. Install the reel mounting hub to the plate on motor shaft with three allen head screws.

10. Slip compression ring over mounting hub and install the compression hub and knob.

11. Load tape and run tape forward and reverse to verify tape is stacking properly on the reel (i.e., uniformly in the middle of the reel). If the tape does not stack properly, additional shimming must be done to properly align the reel with the tape path.

5.8.4 CAPSTAN MOTOR AND TACHOMETER, REMOVAL AND REPLACEMENT. To remove the capstan motor and tachometer, proceed as follows:

NOTE

When disconnecting leads from capstan motor/tachometer, be careful to loosen only the terminal screws and slide the spade lugs out from under the screws. Do not loosen the terminal posts.

1. Disconnect wires from motor and tachometer (four). Make a note of the wire color code and the terminals to which they attach.

2. Loosen the four screws holding the clamp washers to the collar of the capstan assembly.

3. Pivot the clamp washers so they clear the collar of the assembly and remove the motor/tachometer assembly from the front plate.

To install capstan motor/tachometer assembly proceed as follows:

NOTE

Return any shims that were originally used to mount the motor to their original positions.

4. Insert the motor shaft through the front plate housing.

5. Position the split clamp washers over the collar of the assembly so that the motor/tachometer is held in place, then tighten screws.

6. Connect wires to motor and tachometer; be sure color code of wires and appropriate terminal match as recorded in step 1, above. (Generally, on each unit of the capstan assembly, the black/white wire of a pair goes to the right terminal (as viewed from rear) and the red/white wire from the same pair attaches to the left terminal.

NOTE

When placing tape transport in operation for the first time after the capstan motor/tachometer has been replaced, check tracking on capstan. If tape wanders on capstan pully, shimming may be necessary. Refer to TI document SI948211 for procedures.

5.8.5 VACUUM MOTOR AND PUMP, REMOVAL AND REPLACEMENT. To remove the motor and pump assembly, proceed as follows:

1. Be sure ac power is OFF and disconnected from source.
2. Disconnect blower motor wires from AC POWER terminal block (upper right rear; white and black wires).
3. Remove green chassis ground wire from chassis next to terminal block.
4. Remove wire clamp holding blower wire to right side of chassis.
5. Remove card cage retaining screw and swing card cage out.
6. Remove four hex head screws holding motor bracket to side of card cage support.
7. Remove two screws holding blower housing to two brackets on right side of motor.
8. Cut tie wrap and remove blower motor and housing.

To replace blower motor and housing, proceed as follows:

9. Slip motor housing onto vacuum column seal.
10. Attach blower housing to brackets on right side with screws; do not tighten screws.
11. Insert four hex head screws through card cage into bracket on blower motor and housing.
12. Firmly seat blower and motor housing into vacuum column seal on front panel and tighten the four hex head screws into motor and housing bracket.
13. Tighten screws through the two braces on right side of motor.
14. Connect motor wires to AC POWER terminal board: black wire to terminal 4, PUMP BLK; white wire to pin 1, COMMON; green wire with ring lug to chassis.
15. Swing card cage closed and fasten with retaining screw.
16. Dress blower power cable to upper right housing bracket.

5.8.6 READ/WRITE/ERASE HEAD ASSEMBLY, REMOVAL AND REPLACEMENT. Read/write and erase heads, tape cleaner, crosstalk shield, BOT/EOT mount clamp and tape guide assemblies comprise the head assembly. The following procedures outline removal and replacement of the complete unit.

1. Following the procedures outlined in paragraph 5.8.5, remove vacuum motor and blower housing.
2. Remove vacuum column cover.
3. Disconnect read connector P2/J16 and write/erase connector P1/J15 at card cage assembly.

4. On head plate assembly, remove vacuum tubing from tape cleaner.

5. Remove clamp screw holding BOT/EOT detectors to head assembly and remove detectors. Do not remove any wires from detectors, unless detector(s) is defective.

6. Remove four screws holding head assembly plate to front panel. Take care not to lose the insulating strips, tubing, and washer.

7. Pass read and write/erase head connectors through hole in front panel and remove head assembly and connectors from transport.

To replace head plate assembly, proceed as follows:

8. Pass read and write/erase connectors through hole in face plate and connect P2 with J16 (read), and P1 with J15 (write/erase).

9. Mount head assembly plate onto front panel with the four screws and insulating hardware removed previously.

10. If BOT/EOT detectors wiring has been disconnected, make appropriate connections before proceeding.

11. Mount BOT/EOT detectors on head plate assembly.

12. Re-install vacuum motor and chamber per paragraph 2.6.5.

13. Install vacuum tubing between tape cleaner and vacuum chamber.

14. Perform procedures outlined in tables 5-14, 5-15, and 5-16 and adjust if necessary.

5.8.7 TAPE COLUMN LIGHT SOURCES/DETECTORS, REMOVAL AND REPLACEMENT. When facing front of transport light sources and printed circuit strip is on left side of column under cover; detectors and printed circuit strip are on left.

1. Remove vacuum column cover.

2. Before removing either printed circuit strip and attached light sources or detectors, make a note of wire color code and connection terminals.

3. After recording wire color code and terminal, unsolder wires from terminals.

4. Remove six screws, lockwashers and flatwashers holding strip(s) to side(s) of vacuum column.

To replace source/detector strips, reverse above procedure. Check first to see that the tape between printed circuit strip and column rails is good, replace if necessary. Restore power to tape transport, load a scratch tape and check operation.

APPENDIX A

SIGNAL MNEMONICS

Mnemonic	Source	Signal Name	Definition
$\overline{BOT}$	J1-$\overline{E}$ J1-27	Beginning of Tape (Not) BOT Status Out	BOT marker is not under photo detector circuit.
$\overline{BOTP}$	J3(Q17-C) (Assy. 216548)	Beginning of Tape Pulse	The BOTP pulse rises to a ONE level for approximately 1/3 second when triggered by the following. a. BOT going from a ONE to a ZERO. b. SUD going from ZERO to ONE. c. FWDS timer.
$\overline{BUSY}$	J3(Z8-8) (Assy. 216548)	Busy (Not)	A zero level when transport is in REW. UNL. LOAD. or REM.
CGT	All Read Channels	Character Gage Trigger	The CGT line is connected to all read channels. The signal on this line contains a pulse when a ONE is detected on tape.
$\overline{DRBR}$	J3-11	Driven Reel Breaking (Not)	This signal is a ONE and driven reel breaking is disabled when the transport is in a load or fast reverse sequence.
$\overline{EOT}$	J1-T	End-of-Tape	A zero level when end-of-tape marker has been detected.
$\overline{EOT\ STAT}$	J1-38	EOT Status Out	Signal returned to CPU signifying end-of-tape has been detected
EH	J6-39, $\overline{u}$ J6-40, $\overline{v}$	Erase Head Low Erase Head High	Differential voltage applied to erase head.
FP	J13-11	File Protect	The FP signal is at a ground level when a write enable ring is installed on the file reel.
FPS	J6-35	File Protect Status	Returned to controller specifying presence or an absence of file protect ring.

APPENDIX A SIGNAL MNEMONICS (Continued)

Mnemonic	Source	Signal Name	Definition
FREV	J3-26	Fast Reverse	Controls high speed portion of rewind and unload sequences.
$\overline{\text{FREV}}$	J3-25	Fast Reverse (Not)	Inverted FREV signal.
FREV Relay	J1-36	FREV Relay	Signal to energize fast reverse relay
FWD	J3-18	Forward (Not)	Commands capstan to move tape forward when low level is present.
FWDS	J3(Z5-8) (Assy. 216548)	Forward Search (Not)	An internally controlled signal that drives tape forward to the BOT marker when at a zero level. This signal is used in the load and rewind sequences.
LIMIT	J3(Z2-1) (Assy. 216548)	In Limit	Tape loops are within operating limits and the transport has vacuum.
IN LIMIT	J3(Z8-6) (Assy. 216548)	In Limit (Not)	Inverted LIMIT signal.
LLOD	Switch S3 Output	Local Load	Front panel switch output that sets load flip-flop.
LOAD	J3(Z7-3) (Assy. 216548)	Load	Load flip-flop output that is set when the transport is in the LOAD sequence.
LREW	Switch S2 Output	Local Rewind	Front panel switch output that sets the rewind flip-flop.
LUNL	Switch S2 Output	Local Unload	Front panel switch output that sets the unload flip-flop.
$\overline{\text{PRESET}}$	J6-36	Preset (Not)	The PRESET signal is a zero level momentarily after power is applied to reset all of the write data register.
(+) READ (-) READ	+ R BUS READ - R BUS READ	J6-42, $\overline{x}$ J6-41, $\overline{w}$	Threshold control switch outputs to set the bias on the read head threshold detectors.
$\overline{\text{READ Clock Out}}$	J6-$\overline{D}$	Read Clock Out	Clock signal returned to CPU.

APPENDIX A SIGNAL MNEMONICS (Continued)

Mnemonic	Source	Signal Name	Definition
$\overline{\text{READ DATA}}$	J6-9K	Read Data	Signals from read head, track 1.
$\overline{\text{READ DATA}}$	J7, 8, 9, 10	Read Data	Signals from read head, tracks 2 through 9.
READ STA	J6-34	Read STA	Signal returned to CPU signifying transport is in the read mode.
$\overline{\text{READY}}$	J3-F	Ready (Not)	The transport is on the remote mode and not rewinding when READY is a zero.
$\overline{\text{READY STATUS}}$	J3-8	Ready Status	Signal returned to CPU signifying state of ready.
REMOTE	J3-35	Remote	The remote flip-flop is set. The REMOTE signal is required for remote operation.
RESET	Switch S3 Output	Reset	Manual reset controlled by front panel switch.
REV	J3-2	Reverse	Commands capstan to move tape in the reverse direction.
REVS	J3(Z5-12) (Assy. 216548)	Reverse search	An internally controlled signal that drives tape in a reverse direction to the BOT marker. This signal is used in the LOAD and REWIND sequences.
REW	J3(Z12-8) (Assy. 216548)	Rewind	The rewind flip-flop output that is set when the transport is rewinding.
REWIND BIAS	K2-7	Rewind Bias	This signal is +12 volts when the transport is rewinding and -12 volts when not rewinding.
RTC	J6-29	Read Transfer Clock	The RTC pulse is applied to all read channels. The signal transfers data from the read skew latches to the output registers.
$\overline{\text{S4L}}$	J2-15	Sensor Number 4 Illuminated (Not)	This signal is a logic ONE when the center column sensor (Q4) is not illuminated.

APPENDIX A SIGNAL MNEMONICS (Continued)

Mnemonic	Source	Signal Name	Definition
SELECT	J3-15	Select	The inverted SELECT 1 signal (interface line).
$\overline{\text{SEL.RDY}}$	J1-R		Inverted SEL.RDY signal.
SEL.RDY	J6-30		The transport is selected and ready.
SELECT LAMP	J1-$\overline{\text{u}}$	Select Lamp	Signal to front panel, SELECT indicator.
$\overline{\text{SUD}}$	J3-29	Supply Reel Dump (Not)	The supply reel vacuum bias is overcome to load tape into the supply column.
$\overline{\text{SUL.VAC}}$	J2-8	Supply Reel In Limits and Vacuum (Not)	This signal is a logic zero level when the tape loop in the supply column is in limits and the transport has vacuum.
$\overline{\text{TUL.VAC}}$	J2-38	Takeup Reel in Limits and Vacuum (Not)	This signal is a logic zero level when the tape loop in the take-up column is in limits and the transport has vacuum.
ULWIND	J3-19	Unload Wind	Relay driver input that activates unload relay.

APPENDIX B

SOFTWARE DOCUMENTATION FOR MOTION CONTROL LOGIC ASSEMBLY NUMBER 937027

B.1 INTRODUCTION

This document provides a description of the micro-code for the 979A LOGIC BOARD (937027-0001). This board utilizes an 8080 microprocessor to provide control functions for a 979A Tape Transport in place of hard-wired logic. The micro-code program is stored in read only memory (ROM). The functional behavior of the 979A Logic Board is defined in the 979A Logic Board Specification (937031-9901). The micro-code is written in 8080 assembly language. The TI "TMS8080A Microprocessor" manual or Intel "8080 Microcomputer Systems User's Manual" provides a definition of the 8080 instruction set. See the *Model 979 Tape Transport Maintenance Manual,* part number 216318-9701, for a description of the physical configuration of the transport. The basic physical configuration of the 979A is similar to the 979 transport.

B.2 PROGRAM ORGANIZATION

B.2.1 8080 INTERFACE DEFINITION. The programming interface to the 8080 consists of a 512 × 8 ROM, two input ports and two output ports. The addresses recognized by each device are shown below:

		15 ADDRESS 0
1.	ROM (ENABLED BY MEMR—)	XXXXXXXAAAAAAAAA
2.	INPUT PORT 1 (ENABLED BY I/OR—)	XXXXXX01
3.	INPUT PORT 2 (ENABLED BY I/OR—)	XXXXXX10
4.	OUTPUT PORT 1 (ENABLED BY I/OW—)	XXXXXX01
5.	OUTPUT PORT 2 (ENABLED BY I/OW—)	XXXXXX10

X = don't care
A = address

The I/O ports can be addressed by executing an input or output instruction while the ROM is addressed for memory read instructions and instruction fetches. Note that only the nine least significant address bits are used to address the ROM and two least significant bits are used to address the I/O ports. The 8080 provides a 16 bit address for memory and an 8 bit address for I/O ports. The I/O bit definitions are as follows:

INPUT PORT 1

DB0	TUL—	0 =	Tape is covering vacuum column sensor Q7 (Tape is in limits) and vac (output) is true.
		1 =	Vacuum column sensor is light (Tape is not in limits) or vac (output) is false.
DB1	SUL—	0 =	Tape is covering vacuum column sensor Q1 (Tape is in limits) and vac (output) is true.
		1 =	Vacuum column sensor Q1 is light (Tape is not in limits) or vac (output) is false.
DB2	S4L—	0 =	Vacuum column sensor Q4 is light (Tape in limits).
		1 =	Vacuum column sensor Q4 is dark (Tape not in limits).
DB3	BOT—	0 =	BOT mark is under detector.
		1 =	BOT mark is not under detector.
DB4	RESET	0 =	No manual Reset.
		1 =	Manual Reset switch is pressed.
DB5	LLOD	0 =	No local Load.
		1 =	Manual Load switch is pressed.
DB6	LUNL	0 =	No local Unload.
		1 =	Manual Unload switch is pressed.
DB7	LREW	0 =	No local Rewind.
		1 =	Manual Rewind switch is pressed.

INPUT PORT 2

DB0 Unassigned

*DB1	RREW	0 =	No remote Rewind command received.
		1 =	Remote Rewind command received.
*DB2	RUNL	0 =	No remote Unload command received.
		1 =	Remote Unload command received.

DB3	Unassigned		
DB4	Unassigned		
DB5	Unassigned		
DB6	UNLT	0 =	Supply reel not turning (valid only during Unload/Wind).
		1 =	Supply reel turning (valid only during Unload/Wind).
DB7	Unassigned		

*These are set by a pulse from the controller and must be reset by Input Reset—

OUTPUT PORT 01

DB0	REW STATUS	0 =	Indicates not in Rewind mode
		1 =	Indicates in Rewind mode
DB1	SUD	0 =	Supply reel dump bias off
		1 =	Supply reel dump bias on
DB2	VAC	0 =	Inhibits reel servo control and TUL and SUL inputs
		1 =	Enables reel servo control and TUL and SUL inputs
DB3	VAC RELAY	0 =	Vacuum motor OFF
		1 =	Vacuum motor ON
DB4	RDY	0 =	Transport not Ready
		1 =	Transport Ready
DB5	Unassigned		
DB6	Unassigned		
DB7	INPUT RESET—	0 =	Reset active to input circuit for RREW and RUNL and FAULT light on.
		1 =	Reset not active to input circuit for RREW and RUNL. Input enabled to sense new RREW or RUNL pulse. FAULT light off.

OUTPUT PORT 02

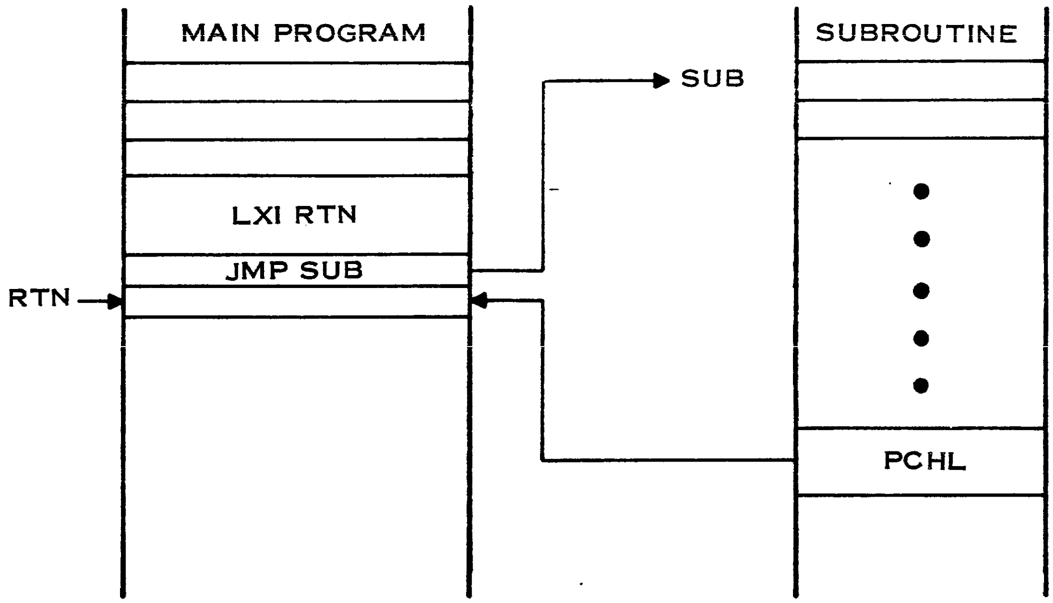
DB0	ULWIND	0 = Unload/Wind OFF
		1 = Unload/Wind ON
DB1	FREV	0 = Rewind not active
		1 = Fast Reverse tape motion activated
DB2	FWD	0 = Forward tape motion not activated
		1 = Forward tape motion activated
DB3	REV	0 = Reverse tape motion not activated
		1 = Reverse tape motion activated
DB4	Unassigned	
DB5	Unassigned	
DB6	Unassigned	
DB7	Unassigned	

B.2.2 I/O PROGRAMMING. Input signals, except remote rewind (RREW) and remote unload (RUNL), may require debouncing for switch contacts or de-glitching. This is performed by requiring an input to be at the same state for a number of samples before the signal is recognized to be at that state.

The remote unload (RUNL) and rewind (RREW) inputs have special hardware to de-glitch the signal and therefore may be considered valid whenever sampled. These signals are latched when they are true and must be reset by the software by writing a 0 on the INPUTRESET output bit. Since the INPUTRESET output is also used to light the fault indicator, input reset must normally be set to a 1 and then toggled to reset the RUNL and RREW input hardware prior to sampling for these inputs.

Since the output ports are parallel rather than bit oriented, the state of all unchanged output bits must be addition to the desired bit(s) to be changed. Thus the state of all output bits must be known by the location in the program.

B.2.3 SUBROUTINES. Since the 979A Logic Board has no RAM, conventional 8080 subroutines cannot be used. By using internal registers in the 8080 one level of subroutines can be obtained. The calling sequence loads the subroutine return address in the HL registers and then an absolute branch to the subroutine is executed. To return from the subroutine, the return address is loaded into the PC from the HL register.



B.2.4 FLAGS. One flag is used to indicate remote mode. The remote flag is located in Register D. Register D = FF indicates transport is in the remote mode. Register D = 00 indicates transport is in the local mode.

B.3 PROGRAM DETAILS

B.3.1 SELF TEST. The self test program is executed following a power up reset. The fault light is turned on by the power reset and is turned off (by setting input reset to 1) when the self test is successfully completed. The self test program consists of performing an exclusive OR of all ROM memory data. Special check sum characters are inserted at memory locations 01FC and 01FD. These check sum characters, in conjunction with the 0F and F0 characters at memory locations 01FE and 01FF, make the expected check sum of all memory to equal FF. If the check sum does not equal FF, the program loops on the self test without turning off the fault light. Therefore, the fault light remains on for an error condition. If the check sum is equal to FF, the fault light is turned off and the main program begins execution.

B.3.2 LOAD SEQUENCE. The load sequence performs the control and timing functions to wait for the load switch to be depressed, turn on the vacuum motor, wait for the vacuum motor to be up to speed, load the tape into the vacuum column and wait for the beginning of tape (BOT) marker to be detected. The load sequence is completed by executing code in the Rewind section.

One unique coding technique in this section is the use of the stack pointer register (SP) to store a delay count. This is required since the input subroutine uses all other available registers.

B.3.3 REMOTE IDLE. While in the remote mode the transport can respond to forward and reverse commands via the hardware or rewind or unload commands which are controlled by the software sequencing. The remote idle loop polls RRUN and RREW inputs and branches to the proper code when one of these inputs is received.

The remote idle loop calls the Input Port 1 subroutine to allow for checking of in limits and reset. Data from this subroutine are not used in the remote idle loop.

B.3.4 LOCAL IDLE. In the local mode the controller is sampling front panel switches on the transport for rewind, unload, or load. Rewind and unload inputs produce a branch to the proper control sequence. The load input will place the transport in the remote mode.

B.3.5 REWIND. The rewind code controls the rewind sequence of high speed rewind and then searches for BOT.

B.3.6 UNLOAD. The unload sequence consists of rewinding the tape to BOT, turning off vacuum, and winding tape onto the supply reel. When this operation is complete the transport is ready to perform the load sequence again.

B.3.7 PORT 1 INPUT SUBROUTINE. This subroutine performs several input functions that are frequently used in the program.

B.3.7.1 Delay. Port 1 Input Subroutine allows selection of two sample periods over which the data must be constant in order to be recognized. These delays are selected by the entry point into the subroutine.

Entry at IN1A requires inputs to be the same for two successive samples spaced 28 μs apart; entry at IN1B requires inputs to be the same for two successive samples spaced about 3.5 ms.

B.3.7.2 In Limits. Port 1 Input Subroutine tests S4L, TUL, and SUL input bits to verify that the tape is in the proper region of the transport vacuum column. If the tape is not in the proper region the transport is shut down by branching back to the load sequence which resets all outputs.

B.3.7.3 Reset. The reset input bit is tested to determine whether the reset switch has been pressed. If the reset input is 1, the program branches to the local idle loop.

B.3.7.4 Load. The load input bit is tested to determine whether the load switch has been pressed. If the load (LLOD) input is 1, the remote flag is set.

B.3.7.5 BOT. The BOT Input bit is placed into the zero condition code flag for use in calling program.

B.3.7.6 Returned Data. Input data from port 1 is returned in the A and B registers and the zero condition code flag contains the BOT input.

B.4 NOTES

B.4.1 UNUSED ROM LOCATIONS. All unused ROM locations are filled with RST 0 instructions to force a proper restart in the event the PC get into an illegal region of memory. As discussed in the self test description, the last 4 locations of ROM must contain check sum information. Therefore the number of RST 0 instructions added must make the program exactly 512 bytes long.

B.4.2 INPUT SAMPLE TIMES. As noted in the Input Port 1 Subroutine two delay counts are available. Whenever switches are being sampled the long delay count may be used. The short delay must be used when BOT is being tested since the long delay may prevent BOT detection in some cases (i.e., fast rewind).

B.4.3 TESTING OF HL REGISTER COUNTS. In some cases the register pair HL is used as a delay connector with the H register (most significant byte) being tested for zero. Therefore the HL register is decremented to 00FF and not 0000. This difference must be considered in setting up delay counts, (i.e., a delay count of 00FF will not give any delay).

B.4.4 ASSEMBLY. The source deck 941665-1201 for the 979A Logic Board is first assembled on the 8080/960 cross assembler (942855). The object from the cross assembler is used as input to the 960 check sum generator program (CKSUM 941663-1201) which generates a new object deck which has the check sums inserted in the proper locations. The new object deck is used as input to the 980 High/Low deck generator program (LTHILO 941664-1201) which generates a High/Low deck to be used in programming the 745472 PROM.

B.5 ASSEMBLY LISTING

The following is an assembly listing of AL, 979LOG, 979A Logic Board S/W - 960/8080.

INPUT PORT 01

LREW	LUNL	LLOD	RESET	$\overline{BOT}$	$\overline{S4L}$	$\overline{SUL}$	$\overline{TUL}$
DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0

INPUT PORT 02

	UNLT				RUNL	RREW	
DB7							DB0

OUTPUT PORT 01

INPUT RESET			RDY	VAC RLY	VAC	SUD	REW STATUS
DB7							DB0

OUTPUT PORT 02

				REV	FWD	FREV	ULWIND
DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0

DOCUMENT NUMBER   REVISION

941665-9901   **

```
$$OFIO**0010**000E
$$SWJC**009C
*
*  979A LOGIC BOARD SOFTWARE  941665-9901
*
* AUTHOR= RICHARD BAKER
*
* REVISION= 8/1/77 ORIGINAL RELEASE AT **
*           1/25/79 CHANGE ONE BY RICHARD BAKER **
*
* ASSEMBLER= 960/8080 CROSS ASSEMBLER (942855)
*
* ABSTRACT= THIS PROGRAM GENERATES ROM RESIDENT CODE FOR
*       MICROPROGRAMMING THE 8080 MICROPROCESSOR ON THE
*       979A LOGIC BOARD (937027-0001) TO PERFORM CONTROL
*       FUNCTIONS FOR THE 979A TAPE TRANSPORT.
*
*
******************************
*
******  979 LOGIC BOARD ******
*
******************************
*
979LOG EQU  $             TITLE TO APPEAR ON HILO DECK
DELAYA EQU 02H
DELAYB EQU 0FFH
BOTCNT EQU  0170H         BOT COUNT
O11CNT EQU 08H            11 SEC OUTER COUNT
O11SEC EQU  5500H         1  SECOND DELAY (2 B) (46 CK/LP)
O3SEC  EQU  0A000H        3 SECOND DELAY  (2 B) (75CK/LOOP)
O10SEC EQU  0800H         10SECOND DELAY  (2 B) (4 MS/LOOP)
COUNT  EQU  0FFH          CHECK FOR INPUT COUNT (1B)
OHALFS EQU  67C0H         HALF SECOND DELAY (2 B) (19C,/LP)
OONES  EQU  8C80H         ONE SECOND DELAY (2 B) (28CK/LP)
OTHREE EQU  0CE00H        1 SECOND INNER DELAY(2B)(19CK/LP)
O3CNT  EQU  03H           THREE SECOND OUTER DELAY COUNT
*
***********************************
*
****** SELF TEST ******************************************************
*
*******************************************
*  FAULT TEST IS EXECUTED FOLLOWING POWER UP RESET
* THE FAULT LIGHT IS ON (TURNED ON BY POWER RESET) DURING
* THIS TEST AND TURNED OFF BY INPUTRESET THROUGHOUT THE
* REMAINDER OF THE PROGRAM.
*
       ORG  00H
ERROR  XRA  A             CLEAR A
       MOV  H,A           START SELF TEST AT LOCATION 0000
       MOV  L,A
       MOV  B,A           CLEAR CHECK SUM ACCUMULATOR
TLOOP  MOV  A,B           GET PREVIOUS CHECK SUM
       XRA  M             GENERATE CHECK SUM
       MOV  B,A           SAVE CHECK SUM IN B
       INX  H             INCREMENT TEST ADDRESS
       MOV A,H            CHECK MS BYTE OF ADDRESS FOR TEST COMPLETE
       CPI  02H                  (TEST ROM THRU 1FF)
       JNZ  TLOOP         CONTINUE TEST LOOP UNTIL COMPLETE
       INR  B             CHECK FOR EXPECTED CHECK SUM
```

DOCUMENT NUMBER   REVISION

941665-9901   **

```
*                           VALUE (EXPECTED=FF; FF+1=00)
        JNZ  ERROR          LOOP ON CHECK SUM ERROR
*
******************************
*
****** START LOAD SEQUENCE ******
*
******************************
START   MVI  A,80H          RESET OUTPUT PORT 01
        OUT  01H            OUTPUT INPUTRESET
        XRA  A              CLEAR A
        OUT  02H            RESET OUTPUT PORT 02
*
****** TEST LOCAL LOAD *******
        MVI  E,COUNT        LOAD COUNT IN E
LOAD    IN   01H            GET INPUT
        ANI  20H            LOOK AT LOCAL LOAD
        JZ   START          IF NO LOAD GO TO START
        DCR  E              DECREMENT COUNT
        JNZ  LOAD           CONTINUE IF LOAD TRUE FOR COUNT
*
****** SET REMOTE FLAG *******
        MVI  D,0FFH         SET REMOTE FLAG
*
*
****** TURN ON VACUUM MOTOR ***********
        MVI  A,88H          SET VACRELAY
        OUT  01H            OUTPUT VACRELAY+INPUTRESET
*
****** DELAY 11 SECONDS ******
        MVI  E,D11CNT       LOAD  OUTER COUNT
D11CT   LXI  H,D11SEC       LOAD HL REG WITH 11 SEC DELAY
DEL11S  IN   01H            GET INPUT
        ANI  10H            LOOK AT RESET
        JNZ  START          ABORT IF RESET TRUE
        DCX  H              DECREMENT REG PAIR HL
        ADD  H              ADD H (MS BYTE) TO A REG(=00)
        JNZ  DEL11S         JMP IF DELAY NOT COMPLETE
        IN   01H
        ANI  04H            LOOK AT S4L*
        JNZ  START          ABORT ON MIDDLE SENSOR COVERED
        DCR  E              DECREMENT OUTTER LOOP COUNT
        JNZ  D11CT          LOOP IF OUTER  DELAY NOT COMPLETE
*
****** VAC=1  SUD=1  ******
        MVI  A,8EH          OUTPUT VAC+VACRELAY+SUD
*                             +INPUTRESET
        OUT  01H
*
****** WAIT FOR SUL* ******
SULCT   MVI  E,COUNT        LOAD COUNT
SUL     IN   01H            GET INPUT
        MOV  B,A            SAVE INPUT IN B
        ANI  14H            LOOK AT RESET AND S4L*
        JNZ  START          ABORT ON RESET OR S4L*
        MOV  A,B            GET SAVED INPUT
        ANI  02H            LOOK AT SUL*
        JNZ  SULCT          IF SUL*=1 LOAD COUNT AGAIN
        DCR  E              DECREMENT COUNT
        JNZ  SUL            WAIT FOR SUL*=0 FOR COUNT
*
****** SUD=0   FWD=1 ******
CONT2   MVI  A,8CH          OUTPUT VAC+VACRELAY+INPUTRESET
```

DOCUMENT NUMBER   REVISION

941665-9901   **

```
        OUT   01H
        MVI   A,04H         OUTPUT FNO=1
        OUT   02H
*
****** WAIT FOR TUL= ******
        LXI   H,D3SEC       LOAD HL REG WITH 3 SEC DELAY
TULCT   MVI   E,COUNT       LOAD COUNT IN E
TUL     IN    01H           GET INPUT
        MOV   B,A           SAVE INPUT IN B
        ANI   18H           LOOK AT RESET,SUL=,AND S4L=
        JNZ   START         ABORT ON RESET,SUL=, OR S4L=
        DCX   H             DECREMENT TIME OUT DELAY COUNT
        ADD   H             LOAD H
        JZ    START         TIME OUT TO START
        MOV   A,B           GET SAVED INPUT
        RAR                 ROTATE TUL= TO CARRY
        JC    TULCT         IF TUL==1 LOAD COUNT AGAIN
        DCR   E             DECREMENT COUNT
        JNZ   TUL           WAIT FOR TUL==0 FOR COUNT
*
****** WAIT FOR BOT= ******
CONT3   LXI   SP,D10SEC     LOAD SP REG WITH 10 SEC DELAY
LDFWDS  LXI   H,RTN1        LOAD RETURN ADDRESS
        JMP   IN18          GO TO INPUT SUBROUTINE
RTN1    JZ    REWBOT        GO TO REWBOT IF BOT==0
        XRA   A             CLEAR A
        MOV   H,A           CLEAR HL REG
        MOV   L,A
        DAD   SP            MOV SP TO HL (SP+HL=HL)
        DCX   H             DECREMENT HL
        ADD   H             GET MS BYTE OF DELAY COUNTER(A=0)
        SPHL                MOV HL TO SP
        JNZ    LDFWDS         DO AGAIN IF NO TIME OUT
        JMP   REVS          TIME OUT TO REVERSE SEARCH
*
******************************
*
****** REMOTE IDLE LOOP ******
*
******************************
REMOTE  MVI   A,0CH         RESET INPUT (TOGGLE INPUTRESET=)
        OUT   01H           OUTPUT VAC+VACRELAY
        MVI   D,0FFH        SET REMOTE FLAG
REMLOP  XRA   A             CLEAR A
        OUT   02H           OUTPUT
        MVI   A,9CH         RESET OUTPUTS (INPUT RESET==1)
        OUT   01H           OUTPUT VAC+VACRELAY+INPUTRESET
*                                  +READY
        LXI   H,RTN2        LOAD RETURN ADDRESS
        JMP   IN18          GO TO INPUT SUBROUTINE
RTN2    IN    02H           GET INPUT
        RAR
        RAR                 ROTATE REMOTE REWIND TO CARRY
        JC    REWIND        GO TO REWIND ON REWIND COMMAND
        RAR                 ROTATE REMOTE UNLOAD TO CARRY
        JC    UNLOAD        GO TO UNLOAD ON UNLOAD COMMAND
        JMP   REMLOP        CONTINUE REMOTE IDLE LOOP
*
******************************
*
****** LOCAL IDLE LOOP *******
*
```

DOCUMENT NUMBER   REVISION

941665-9901   **

```
********************************
LOCAL   MVI  A,8CH          RESET OUTPUT 80
        OUT  01H            OUTPUT VAC+VACRELAY+INPUTRESET
        XRA  A              CLEAR A
        OUT  02H            RESET OUTPUT 2
        MOV  D,A            CLEAR REMOTE FLAG
        LXI  H,RTN4         LOAD RETURN ADDRESS
        JMP  IN1B           GET INPUT
RTN4    RAL                 ROTATE LOCAL REWIND TO CARRY
        JC   REWIND         GO TO REWIND ON REWIND CMD
        RAL                 ROTATE LOCAL UNLOAD TO CARRY
        JC   UNLOAD         GO TO UNLOAD ON UNLOAD CMD
        RAL                 ROTATE LOCAL LOAD TO CARRY
        JNC  LOCAL          STAY IN LOCAL LOOP IF NO LOAD CMD
        JMP  REMOTE         GO TO REMOTE IDLE LOOP
*
********************************
*
****** REWIND ******
*
*************************
REWIND LXI   H,RTN5         LOAD RETURN ADDRESS
        JMP  IN1B           GET INPUT
RTN5    JZ   EXITRN         EXIT ON BOT DETECTED (BOT=0)
        MVI  A,80H          SET REWIND STATUS, RESET READY
        OUT  01H            OUTPUT VAC+VACRELAY+REWINDSTATUS
*                                  +INPUTRESET
        MVI  A,02H          SET FREV
        OUT  02H            OUTPUT FREV
*
****** WAIT FOR BOT *****
RWBOT1 LXI   H,RTN6         LOAD RETURN ADDRESS
        JMP  IN1A           GET INPUT
RTN6    JNZ  RWBOT1         WAIT FOR BOT=
*
****** WAIT FOR BOT TO PASS UNDER DETECTOR ******
RWBOT2 LXI   H,RTN7         LOAD RETURN ADDRESS
        JMP  IN1B           GET INPUT
RTN7    JZ   RWBOT2         WAIT FOR BOT= TO GO AWAY
RWBOT3 XRA   A              OUTPUT FREV=0
        OUT  02H            OUTPUT FREV
        LXI  SP,80H         LOAD DELAY COUNT INTO STACK
*                           REGISTER  ( .5 SECONDS)
DLYLP   LXI  H,RTNX         LOAD RETURN ADDRESS
        JMP  IN1B           TEST IN LIMITS (SUL,S4L,TUL)
RTNX    XRA  A              CLEAR A
        MOV  H,A            CLEAR H AND L REGISTERS
        MOV  L,A
        DAD  SP             MOVE SP TO HL (SP+HL=HL)
        DCX  H              DECREMENT DELAY COUNT IN HL
        ADD  L              GET LSB FOR DELAY COUNT
        SPHL                MOVE HL TO SP
        JNZ  DLYLP          WAIT FOR DELAY COUNT=0
*
        MVI  A,04H          OUTPUT FWD=1,FREV=0
        OUT  02H            OUTPUT FWD
*
****** FORWARD SEARCH FOR BOT ******
RWBOT4 LXI   H,RTN8         LOAD RETURN ADDRESS
        JMP  IN1B           GET INPUT
RTN8    JNZ  RWBOT4         WAIT FOR BOT=0
*
```

DOCUMENT NUMBER   REVISION

941665-9901   **

```
****** WAIT FOR BOT TO PASS UNDER DETECTOR ******
REWBOT LXI SP,BOTCNT       LOAD SP WITH COUNT
RWBOT5 LXI  H,RTN9         LOAD RETURN ADDRESS
       JMP  IN1B           GO TO INPUT SUBROUTINE
RTN9   JZ   REWBOT         WAIT FOR BOT=1
       XRA  A              CLEAR A
       MOV H,A             CLEAR HL
       MOV  L,A
       DAD  SP             MOV SP TO HL (HL=HL+SP)
       DCX  H              DECREMENT HL
       ADD H               MOV MS BYTE OF HL TO A AND SET
*                            CONDITION CODE FLAGS
       SPHL                MOV HL BACK TO SP
       JNZ  RWBOT5         CONTINUE IF BOT GONE FOR COUNT
*
****** START REVERSE SEARCH ******
REVS   MVI   A,08H           OUTPUT FWD=0,REV=1
       OUT  02H            OUTPUT REV
RWBOT6 LXI  H,RTN10        LOAD RETURN ADDRESS
       JMP  IN1A           GET INPUT
RTN10  JNZ  RWBOT6         WAIT FOR BOT=0
*
****** RETURN TO LOCAL/REMOTE IDLE LOOP ******
* (OUTPUTS RESET ON ENTERING LOCAL/REMOTE IDLE LOOP)
EXITRW MOV   A,D             GET FLAGS (REG D)
       RLC                 ROTATE REMOTE FLAG TO CARRY
       JNC  LOCAL          GO TO LOCAL IF REMOTE FLAG NOT
*                            SET
       MVI  A,00H          TOGGLE INPUTRESET(INPUTRESET=0)
       OUT  01H            OUTPUT VAC+VACRELAY+REWINCSTATUS
       JMP  REMLOP         GO TO REMOTE IF REMOTE FLAG SET
*
*************************
*
****** UNLOAD ******
*
*************************
UNLOAD MVI  A,8CH          RESET READY
       OUT  01H            OUTPUT VACRLY+VAC+INPUTRESET
       XRA  A              CLEAR A
       OUT  02H
       MOV  D,A            CLEAR REMOTE FLAG (REG D)
       IN   01H            GET INPUT
       ANI  08H            MASK LOOK AT BOT*
       JZ   UNLD1          DO NOT DO FAST REV FROM BOT
       MVI  A,02H          OUTPUT FREV=1
       OUT  02H
*
****** WAIT FOR BOT ******
UNLD2  LXI  H,RTN11        LOAD RETURN ADDRESS
       JMP  IN1B           GET INPUT
RTN11  JNZ  UNLD2          WAIT FOR BOT=0
*
****** STOP FAST REWIND *
       XRA  A              CLEAR A
       OUT  02H            OUTPUT FREV=0
       LXI  H,DHALFS       LOAD HALF SEC DELAY COUNT
UNLD3  DCX  H              DECREMENT DELAY COUNT
       XRA  A              CLEAR A
       ADD  H              GET H (MS BYTE (A=00)
       JNZ  UNLD3          CONTINUE ON DELAY COMPLETE
*
```

DOCUMENT NUMBER REVISION

941665-9901 **

```
****** UNLOAD WIND ******
UNLD1  MVI  A,01H         OUTPUT ULWIND=1
       OUT  02H           OUTPUT ULWIND
UNLD4  IN   01H           GET INPUT
       ANI  03H           LOOK AT INLIMTS (Q1,Q7).
       JZ   UNLD4         WAIT FOR TAPE TO PULL OUT OF
*                           COLUMN
*
****** TURN OFF VACUUM **
       MVI  A,04H         OUTPUT VAC RELAY=0
       OUT  01H           OUTPUT VAC+INPUTRESET
       LXI  H,DONES       LOAD ONE SEC DELAY COUNT
UNLD5  DCX  H             DECREMENT DELAY COUNT
       XRA  A             CLEAR A (A,EXCLUSIVE OR,A = 0)
       ADD  H             GET H (MS BYTE)
       JNZ  UNLD5         CONTINUE IF DELAY COMPLETE
UNLD6  IN   01H           GET INPUT
       ANI  03H           LOOK AT Q1,Q7
       JZ   UNLD6         CONTINUE ON TAPE OUT OF COLUMN
*
****** RESET VAC ********
       MVI  A,00H         OUTPUT INPUTRESET, VAC=0
       OUT  01H           OUTPUT INPUTRESET
       MVI  E,D3CNT       LOAD OUTER COUNT
D3CT   LXI  H,DTHREE      LOAD THREE SEC DELAY COUNT
UNLD7  DCX  H             DECREMENT DELAY COUNT
       XRA  A             CLEAR A
       ADD   H              GET H (MS BYTE OF DELAY COUNT)
       JNZ  UNLD7         IF NOT ZERO  CONTINUE INNER LOOP
       DCR  E             DECREMENT OUTER LOOP COUNT
       JNZ  D3CT          IF NOT ZERO CONTINUE LOOP
*
****** WAIT FOR TAPE TO UNWIND FROM TAKEUP REEL ******
UNLD8  MVI  E,COUNT       LOAD COUNT
UNLD9  IN   02H           GET INPUT
       ANI  40H           LOOK AT UNLT
       JNZ  UNLD8         WAIT FOR UNLT TO GO AWAY
       DCR  E             DECREMENT COUNT
       JNZ  UNLD9         LOOP UNTIL COUNT=0
       JMP  START         GO TO START IF UNLT FALSE FOR
*                                COUNT
*
*****************************************************************************************
*
****** PORT 1 INPUT SUBROUTINE ******
*
**************************************
*      REGISTERS USED ARE A,B,C,D,E
*
IN1A   MVI  E,DELAYA      LOAD DELAYA
       JMP  INPUT1
IN1B   MVI  E,DELAYB      LOAD DELAYB
INPUT1 IN   01H           GET INPUT
INPUT2 MOV  B,A           SAVE INPUT IN B
       MOV  C,E           LOAD DELAY COUNT
INPUT3 DCR  C
       JNZ  INPUT3        DO UNTIL COUNT=0
       IN   01H           GET INPUT
       CMP B              COMPARE A TO B
       JNZ INPUT2         CONTINUE IF EQUAL
       ANI 07H            LOOK AT SUL,S4L,TUL
       JNZ START          ABORT ON OUT-OF-LIMITS
```

DOCUMENT NUMBER   REVISION

941665-9901   **

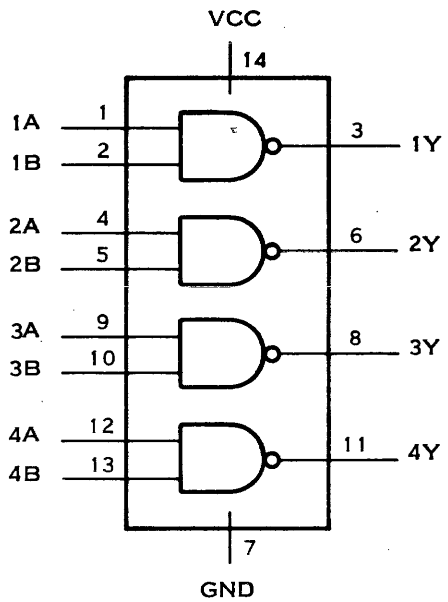
```
        MOV A,B
        ANI 10H            LOOK AT RESET
        JNZ LOCAL          GO TO LOCAL ON RESET
        MOV A,B
        ANI 20H            LOOK AT LOCAL LOAD
        JZ INPUT4          SET REMOTE FLAG
        MVI D,0FFH           ON LOCAL LOAD
INPUT4  MOV A,B
        ANI 08H            SET ZERO FLAG= BOT=
        MOV A,B
        PCHL               RETURN FROM SUBROUTINE
*                            A AND B = INPUT
*                            ZERO FLAG = BOT=
*
******************************************************************
*
* FILL UNUSED ROM LOCATIONS WITH RST 0 TO FORCE PROPER
*       RESTART IN THE EVENT THE PC GETS INTO ILLEGAL
*       REGION OF MEMORY
*
******************************************************************
*
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
        RST  0
*
******************************************************************
*
* RESERVE CHECK SUM MEMORY LOCATIONS
*
        ORG  1FCH
CKSUMS  DB   00H           COMPUTED CKSUMS STORED AT THESE
        DB   00H             TWO LOCATIONS BY CKSUM 941663
        DB   0FH           LAST TWO BYTES OF MEMORY CHECK
        DB   0F0H                SUM MEMORY (0000-01FF)
*                            TO MAKE ACCUMULATED CKSUM=FF
        END
$$JCOF**
```

APPENDIX C

LOGIC ELEMENT DIAGRAMS

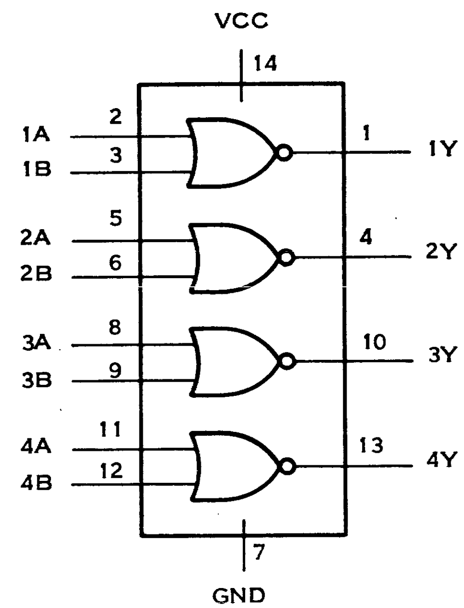
C.1 The elements in the following list are arranged primarily in numerical order and secondarily in alphabetical order.

LM	319			733	L	SN	7474	
LM	339		DM	930	J	SN	74LS74A	
LF	356		DM	930	L	SN	7476	
LF	357		DM	936	J	SN	7483A	
	376		DM	936	N	SN	7493A	
SN72	558	N	DM	944	J	SN	74LS93	
SN72	702	AJ	DM	944	N	TMS	8080	A
LM	709		DM	946	J		8281	
SN72	709	CJ	DM	946	N		9601	
LM	709	CH	DM	962	J	SN2	9601	
LM	709	CJ	DM	962	N	SN	15858	
LM	709	CN		4001		SN	74LS109A	
LM	709	CN-8		4049		SN	74121	
LM	709	H	SN	7400		SN	74LS164	
LM	709	J	SN	74LS00		SN	74LS174	
LM	709	L	SN	7402		SN	74LS174	
SN72	709	P	SN	74LS02		SN	74LS175	
SN72	709		SN	74LS04		SN	74LS367	A
	710	L	SN	7405		SN	74393	
	710		SN	7410		SN	74S428	
SN72	710		SN	74LS10		SN	74S472	
SN72	711		SN	74LS27		SN	75452	B
	733		SN	74LS32				



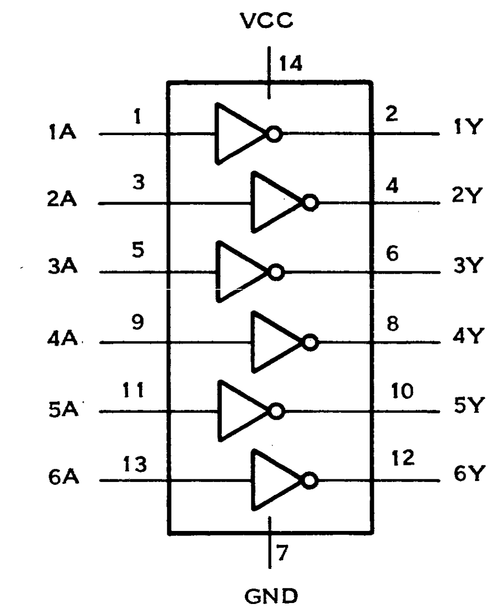
SN7400, SN74H00, SN74L00, SN74LS00, SN74S00

QUADRUPLE 2-INPUT POSITIVE-NAND GATES



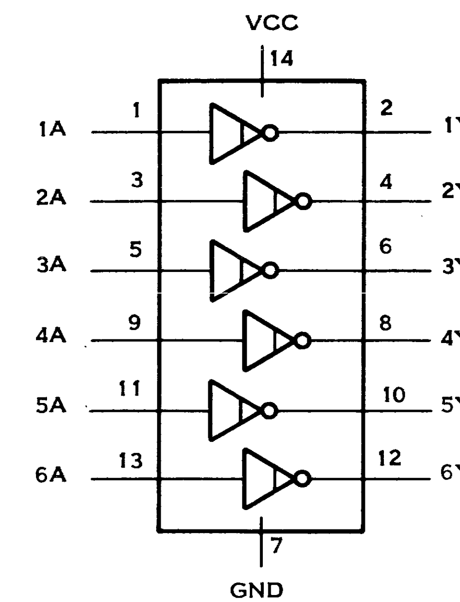
SN7402, SN74L02, SN74LS02, SN74S02

QUADRUPLE 2-INPUT POSITIVE-NOR GATES



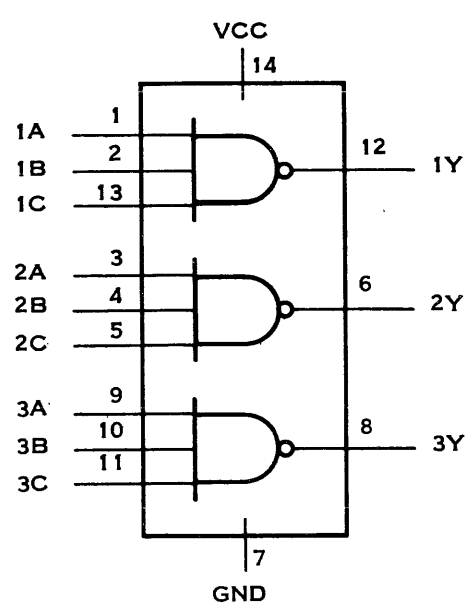
SN7404, SN74H04, SN74L04, SN74LS04, SN74S04

HEX INVERTERS



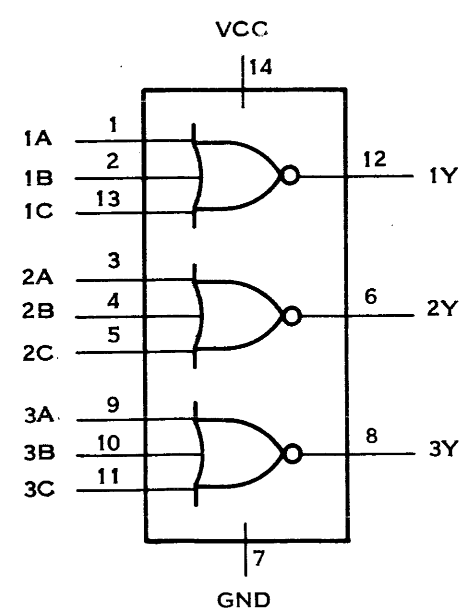
SN7405, SN74H05, SN74LS05, SN74S05

HEX INVERTERS WITH OPEN-COLLECTOR OUTPUTS



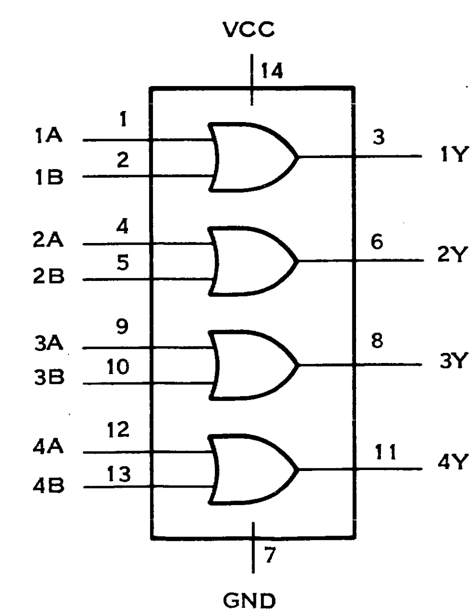
SN7410, SN74H10, SN74L10, SN74LS10, SN74S10

TRIPLE 3-INPUT POSITIVE-NAND GATES



SN7427, SN74LS27

TRIPLE 3-INPUT POSITIVE-NOR GATES



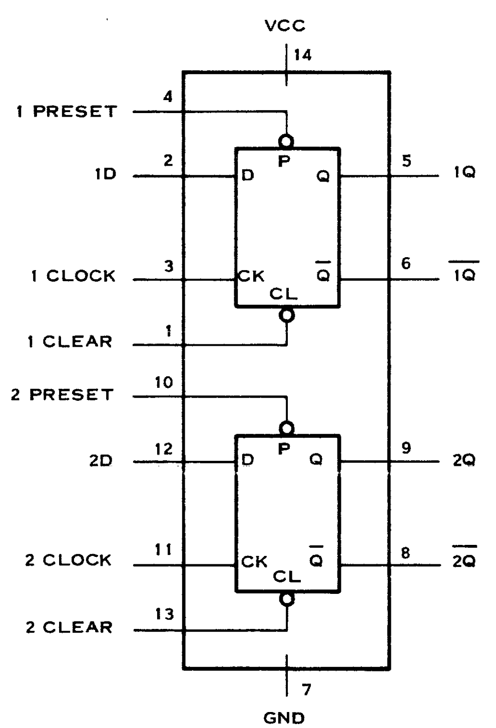
SN7432, SN74LS32, SN74S32

QUADRUPLE 2-INPUT POSITIVE-OR GATES

FUNCTION TABLE SN7474

INPUTS				OUTPUTS	
PRESET	CLEAR	CLOCK	D	Q	$\bar{Q}$
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	H*	H*
H	H	↑	H	H	L
H	H	↑	L	L	H
H	H	L	X	Q_0	$\bar{Q}_0$

H HIGH LEVEL (STEADY STATE)
L LOW LEVEL (STEADY STATE)
X IRRELEVANT
↑ TRANSITION FROM LOW TO HIGH LEVEL
Q_0 THE LEVEL OF Q BEFORE THE INDICATED INPUT CONDITIONS WERE ESTABLISHED
*THIS CONFIGURATION IS NONSTABLE; THAT IS, IT WILL NOT PERSIST WHEN PRESET AND CLEAR INPUTS RETURN TO THEIR INACTIVE (HIGH) LEVEL.



SN7474, SN74H74, SN74L74, SN74LS74, SN74S74

DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

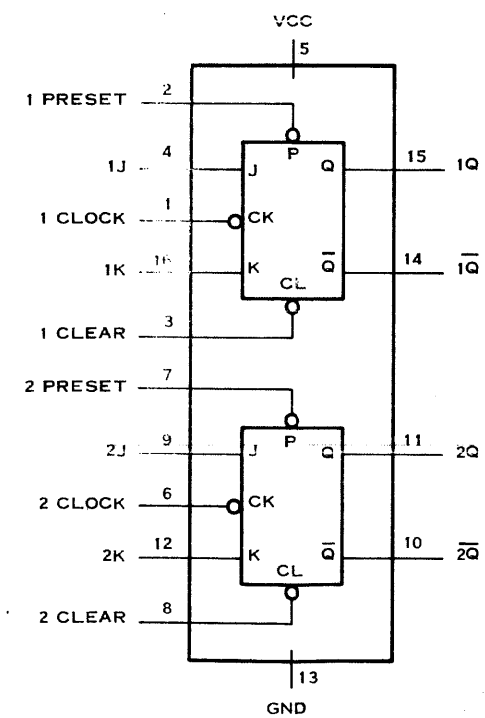
FUNCTION TABLE SN7476, SN74H76

INPUTS					OUTPUTS	
PRESET	CLEAR	CLOCK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	⎍	L	L	Q_0	$\bar{Q}_0$
H	H	⎍	H	L	H	L
H	H	⎍	L	H	L	H
H	H	⎍	H	H	TOGGLE	

FUNCTION TABLE SN74LS76

INPUTS					OUTPUTS	
PRESET	CLEAR	CLOCK	J	K	Q	$\bar{Q}$
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	↓	L	L	Q_0	$\bar{Q}_0$
H	H	↓	H	L	H	L
H	H	↓	L	H	L	H
H	H	↓	H	H	TOGGLE	
H	H	H	X	X	Q_0	$\bar{Q}_0$

H HIGH LEVEL (STEADY STATE)
L LOW LEVEL (STEADY STATE)
X IRRELEVANT
⎍ HIGH LEVEL PULSE; DATA INPUTS SHOULD BE HELD CONSTANT WHILE CLOCK IS HIGH; DATA IS TRANSFERRED TO OUTPUT ON THE FALLING EDGE OF THE PULSE.
↓ TRANSITION FROM HIGH TO LOW LEVEL
Q_0 THE LEVEL OF Q BEFORE THE INDICATED INPUT CONDITIONS WERE ESTABLISHED.
TOGGLE: EACH OUTPUT CHANGES TO THE COMPLEMENT OF ITS PREVIOUS LEVEL ON EACH ACTIVE TRANSITION (PULSE) OF THE CLOCK.
*THIS CONFIGURATION IS NONSTABLE; THAT IS, IT WILL NOT PERSIST WHEN PRESET AND CLEAR INPUTS RETURN TO THEIR INACTIVE (HIGH) LEVEL.



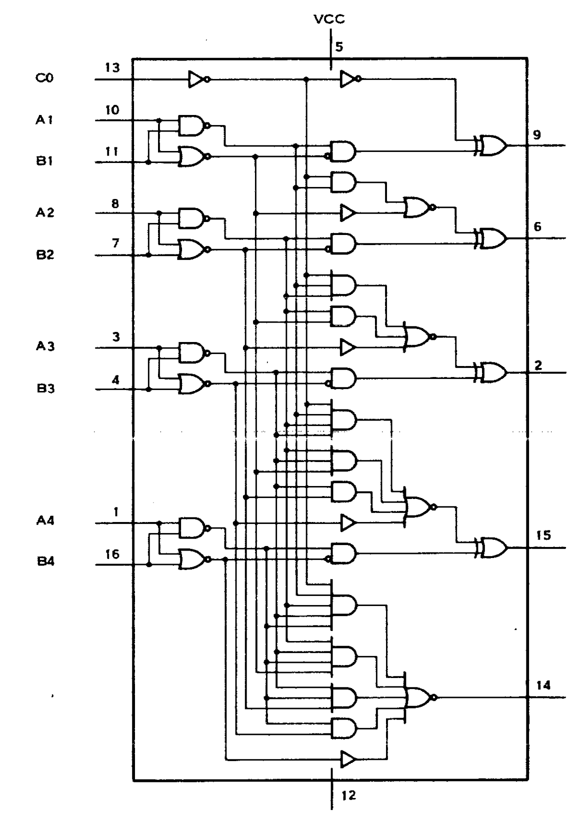
SN7476, SN74H76, SN74LS76

DUAL J-K FLIP-FLOPS WITH PRESET AND CLEAR

FUNCTION TABLE SN7483A

INPUT				OUTPUT					
				WHEN C0=L / WHEN C2=L			WHEN C0=H / WHEN C2=H		
A1 / A3	B1 / B3	A2 / A4	B2 / B4	Σ1 / Σ3	Σ2 / Σ4	C2 / C4	Σ1 / Σ3	Σ2 / Σ4	C2 / C4
L	L	L	L	L	L	L	H	L	L
H	L	L	L	H	L	L	L	H	L
L	H	L	L	H	L	L	L	H	L
H	H	L	L	L	H	L	H	H	L
L	L	H	L	L	H	L	H	H	L
H	L	H	L	H	H	L	L	L	H
L	H	H	L	H	H	L	L	L	H
H	H	H	L	L	L	H	H	L	H
L	L	L	H	L	H	L	H	H	L
H	L	L	H	H	H	L	L	L	H
L	H	L	H	H	H	L	L	L	H
H	H	L	H	L	L	H	H	L	H
L	L	H	H	L	L	H	H	L	H
H	L	H	H	H	L	H	L	H	H
L	H	H	H	H	L	H	L	H	H
H	H	H	H	L	H	H	H	H	H

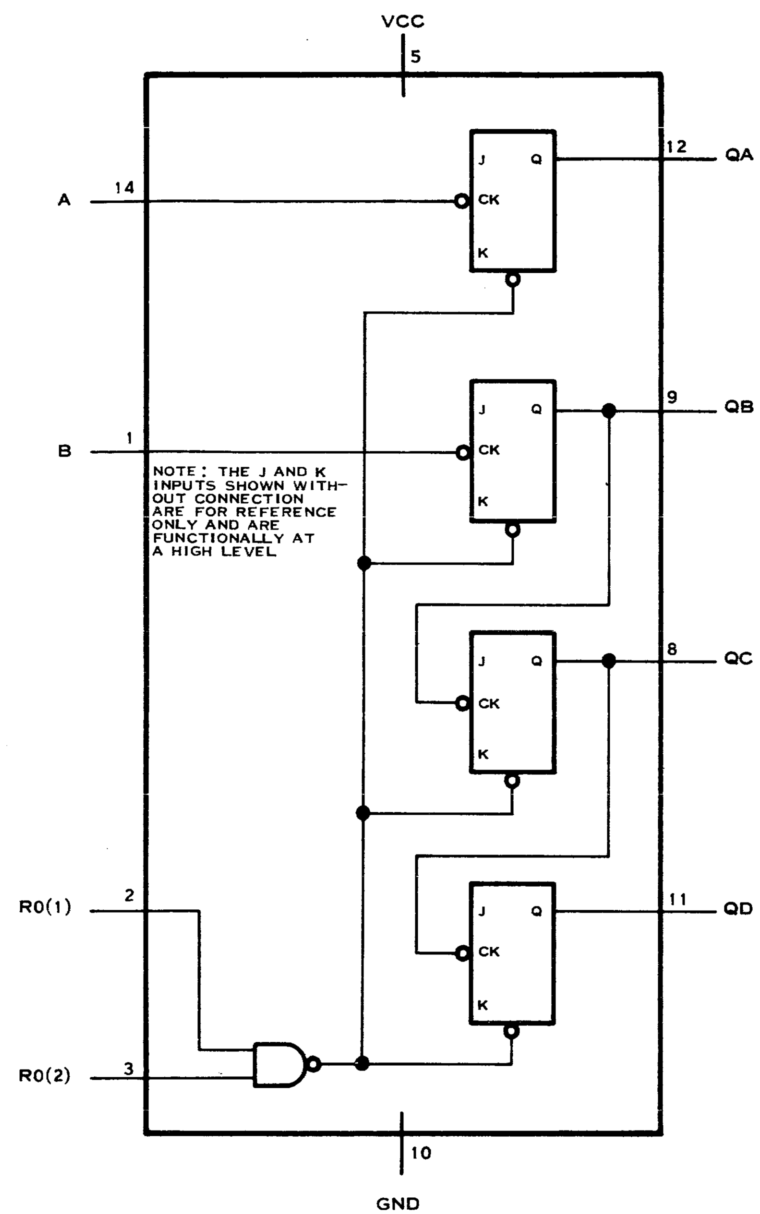
H HIGH LEVEL
L LOW LEVEL
NOTE: INPUT CONDITIONS AT A1, B1, A2, B2, AND C0 ARE USED TO DETERMINE OUTPUTS Σ1 AND Σ2 AND THE VALUE OF THE INTERNAL CARRY C2. THE VALUES AT C2, A3, B3, A4, AND B4 ARE THEN USED TO DETERMINE OUTPUTS Σ3, Σ4, AND C4.



SN7483A

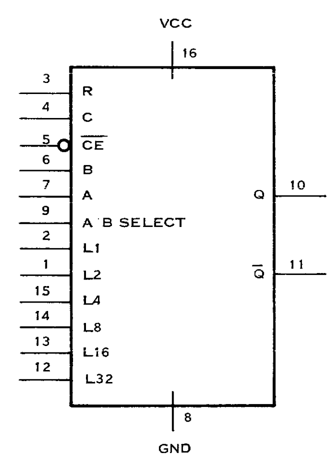
4-BIT BINARY FULL ADDERS

NOTE: SEE NEXT PAGE FOR FUNCTION TABLE



SN7493A, SN74LS93

4-BIT BINARY COUNTER

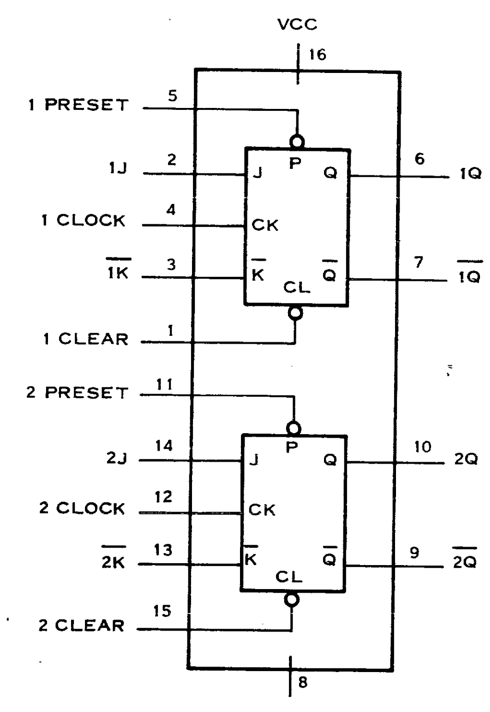


MC14557B

FUNCTION TABLE SN74109

INPUTS					OUTPUTS	
PRESET	CLEAR	CLOCK	J	K̄	Q	Q̄
L	H	X	X	X	H	L
H	L	X	X	X	L	H
L	L	X	X	X	H*	H*
H	H	↑	L	L	L	H
H	H	↑	H	L	TOGGLE	
H	H	↑	L	H	Q_0	$\bar{Q}_0$
H	H	↑	H	H	H	L
H	H	L	X	X	Q_0	$\bar{Q}_0$

H = HIGH LEVEL (STEADY STATE)
L = LOW LEVEL (STEADY STATE)
X = IRRELEVANT
↑ = TRANSITION FROM LOW TO HIGH LEVEL
Q_0 = THE LEVEL OF Q BEFORE THE INDICATED INPUT CONDITIONS WERE ESTABLISHED.
TOGGLE: EACH OUTPUT CHANGES TO THE COMPLEMENT OF ITS PREVIOUS LEVEL ON EACH ACTIVE TRANSITION (PULSE) OF THE CLOCK.
* THIS CONFIGURATION IS NONSTABLE; THAT IS, IT WILL NOT PERSIST WHEN PRESET AND CLEAR INPUTS RETURN TO THEIR INACTIVE (HIGH) LEVEL.



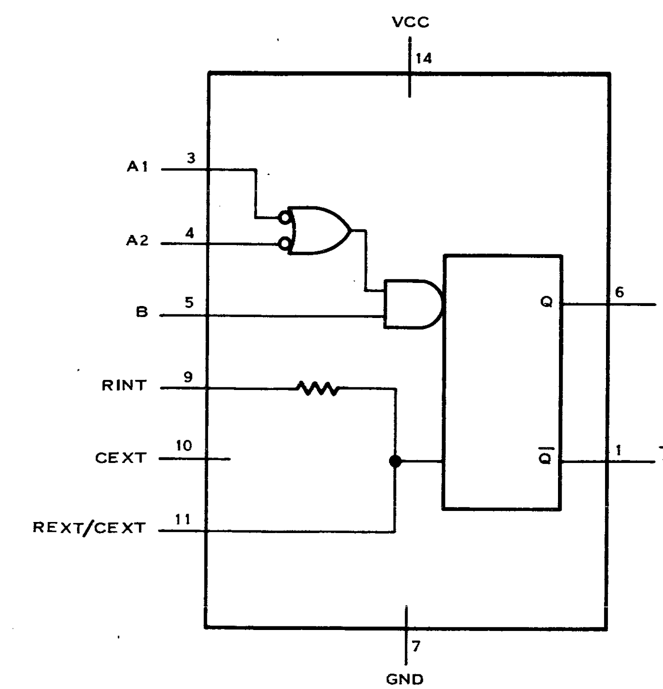
SN74109, SN74LS109

DUAL J-K̄ POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR

FUNCTION TABLE SN74121, SN74L121

INPUTS			OUTPUTS	
A1	A2	B	Q	Q̄
L	X	H	L	H
X	L	H	L	H
X	X	L	L	H
H	H	X	L	H
H	↓	H	⎍	⊔
↓	H	H	⎍	⊔
↓	↓	H	⎍	⊔
L	X	↑	⎍	⊔
X	L	↑	⎍	⊔

NOTES:
A. H = HIGH LEVEL (STEADY STATE)
L = LOW LEVEL (STEADY STATE)
↑ = TRANSITION FROM LOW TO HIGH LEVEL
↓ = TRANSITION FROM HIGH TO LOW LEVEL
⎍ = ONE HIGH-LEVEL PULSE
⊔ = ONE LOW-LEVEL PULSE
X = IRRELEVANT (ANY INPUT, INCLUDING TRANSITIONS)
B. TO USE THE INTERNAL TIMING RESISTOR CONNECT R_{INT} TO V_{CC}.
C. AN EXTERNAL TIMING CAPACITOR MAY BE CONNECTED BETWEEN C_{EXT} AND R_{EXT}/C_{EXT} (POSITIVE)
D. FOR ACCURATE REPEATABLE PULSE WIDTHS, CONNECT AN EXTERNAL RESISTOR BETWEEN R_{EXT}/C_{EXT} AND V_{CC} WITH R_{INT} OPEN-CIRCUITED.
E. TO OBTAIN VARIABLE PULSE WIDTHS, CONNECT EXTERNAL VARIABLE RESISTANCE BETWEEN R_{INT} OR R_{EXT}/C_{EXT} AND V_{CC}



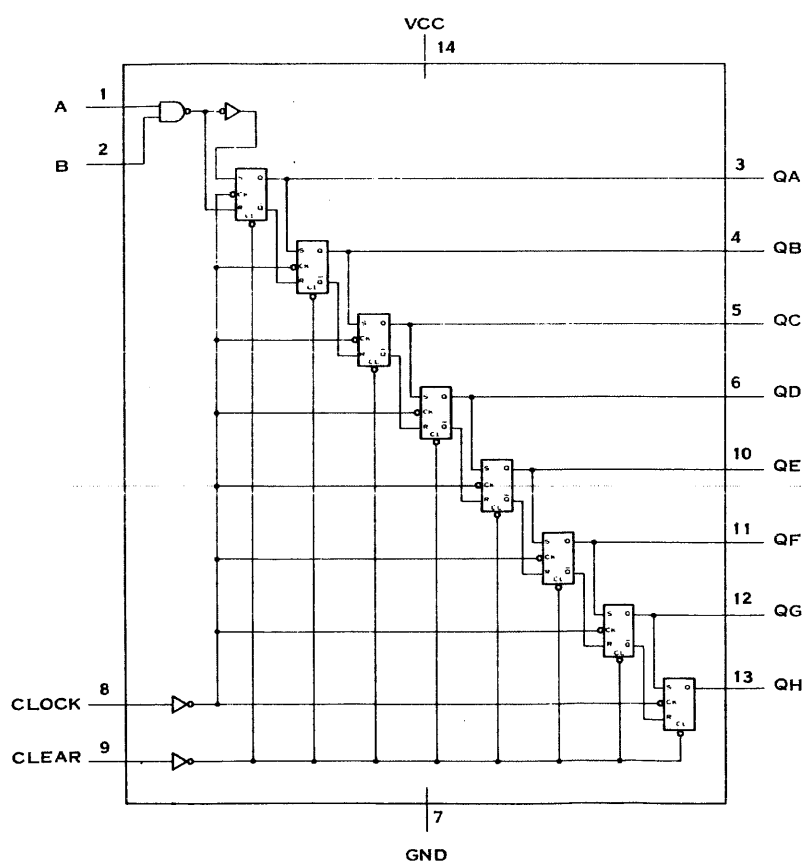
SN74121, SN74L121

MONOSTABLE MULTIVIBRATORS

FUNCTION TABLE SN74164, SN74L164, SN74LS164

INPUTS				OUTPUTS		
CLEAR	CLOCK	A	B	Q_A	Q_B	. . Q_H
L	X	X	X	L	L	L
H	L	X	X	Q_{A0}	Q_{B0}	Q_{H0}
H	↑	H	H	H	Q_{AN}	Q_{GN}
H	↑	L	X	L	Q_{AN}	Q_{GN}
H	↑	X	L	L	Q_{AN}	Q_{GN}

H = HIGH LEVEL (STEADY STATE)
L = LOW LEVEL (STEADY STATE)
X = IRRELEVANT (ANY INPUT, INCLUDING TRANSITIONS)
↑ = TRANSITION FROM LOW TO HIGH LEVEL
Q_{A0}, Q_{B0}, Q_{H0} = THE LEVEL Q_A, Q_B, OR Q_H, RESPECTIVELY, BEFORE THE INDICATED STEADY-STATE INPUT CONDITIONS WERE ESTABLISHED.
Q_{AN}, Q_{GN} = THE LEVEL OF Q_A OR Q_G BEFORE THE MOST-RECENT ↑ TRANSITION OF THE CLOCK, INDICATES A ONE-BIT SHIFT



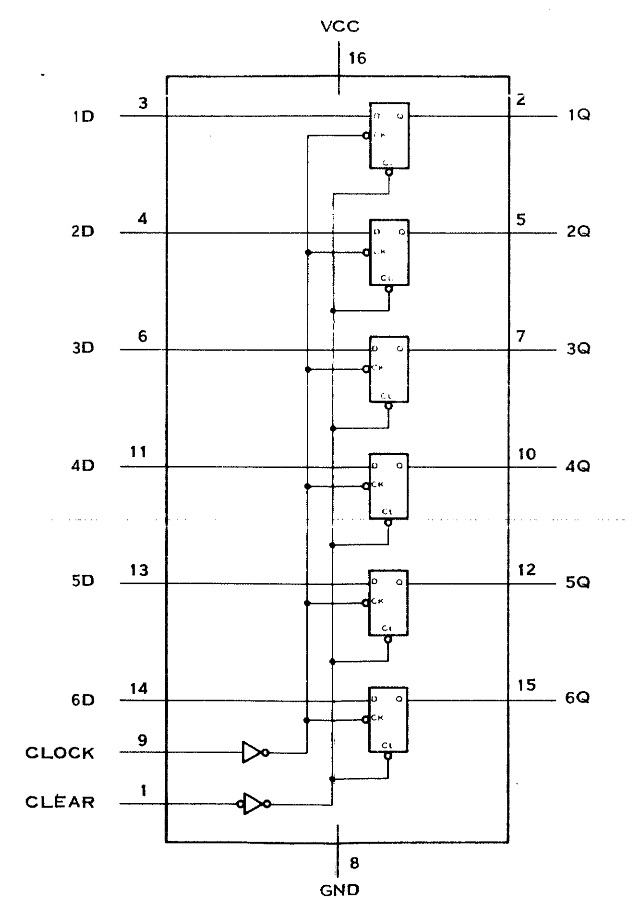
SN74164, SN74L164, SN74LS164

8-BIT PARALLEL-OUT SERIAL SHIFT REGISTER

FUNCTION TABLE SN74174, SN74LS174, SN74S174 (EACH FLIP-FLOP)

INPUTS			OUTPUTS
CLEAR	CLOCK	D	Q
L	X	X	L
H	↑	H	H
H	↑	L	L
H	L	X	Q_0

H = HIGH LEVEL (STEADY STATE)
L = LOW LEVEL (STEADY STATE)
X = IRRELEVANT
↑ = TRANSITION FROM LOW TO HIGH LEVEL
Q_0 = THE LEVEL OF Q BEFORE THE INDICATED STEADY-STATE INPUT CONDITIONS WERE ESTABLISHED.



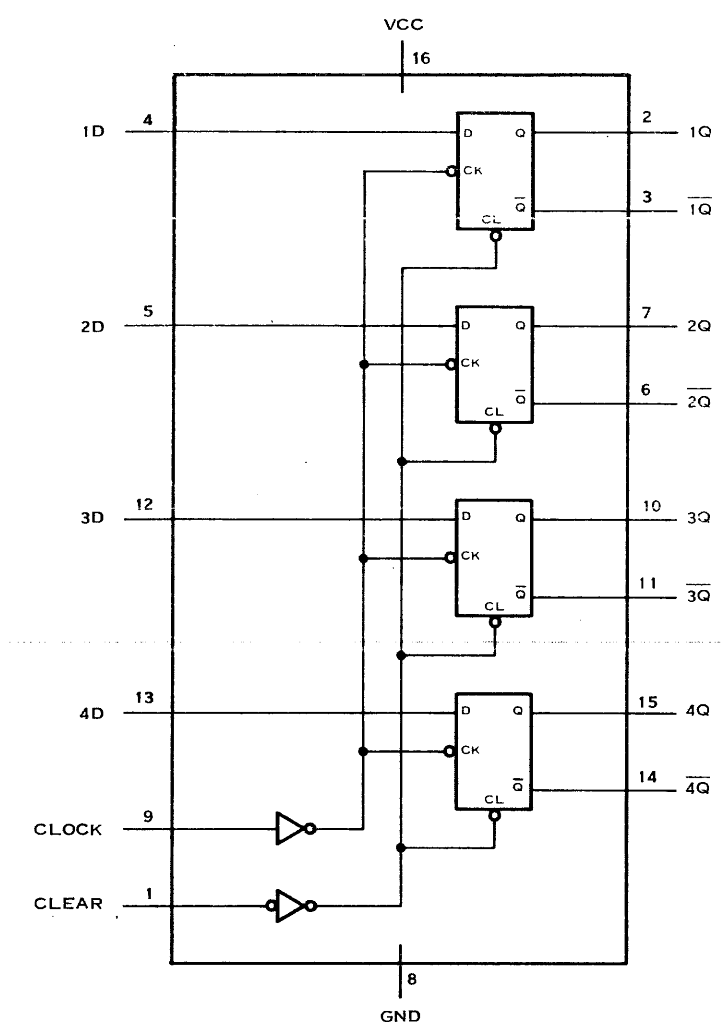
SN74174, SN74LS174, SN74S174

HEX D-TYPE FLIP-FLOPS WITH CLEAR

FUNCTION TABLE SN74175, SN74LS175, SN74S175 (EACH FLIP-FLOP)

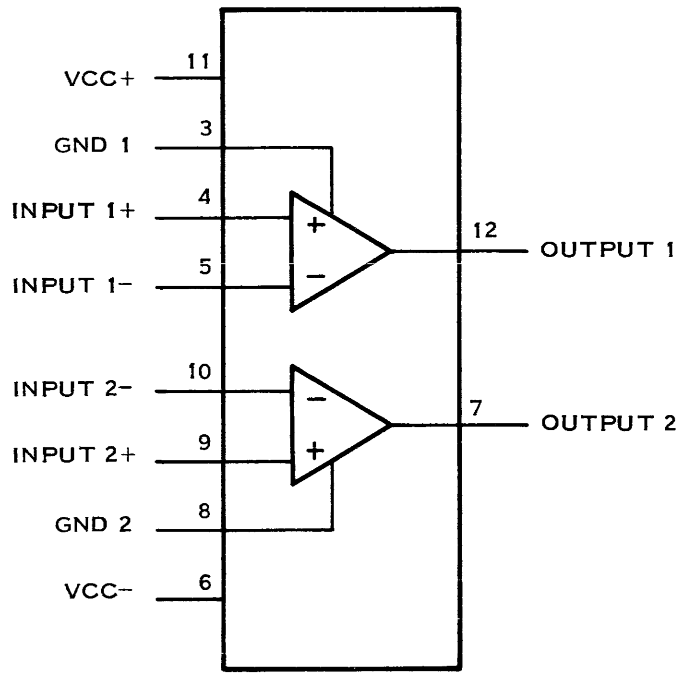
INPUTS			OUTPUTS	
CLEAR	CLOCK	D	Q	$\overline{Q}$
L	X	X	L	H
H	↑	H	H	L
H	↑	L	L	H
H	L	X	Q_0	$\overline{Q}_0$

H = HIGH LEVEL (STEADY STATE)
L = LOW LEVEL (STEADY STATE)
X = IRRELEVANT
↑ = TRANSITION FROM LOW TO HIGH LEVEL
Q_0 = THE LEVEL OF Q BEFORE THE INDICATED STEADY-STATE INPUT CONDITIONS WERE ESTABLISHED.



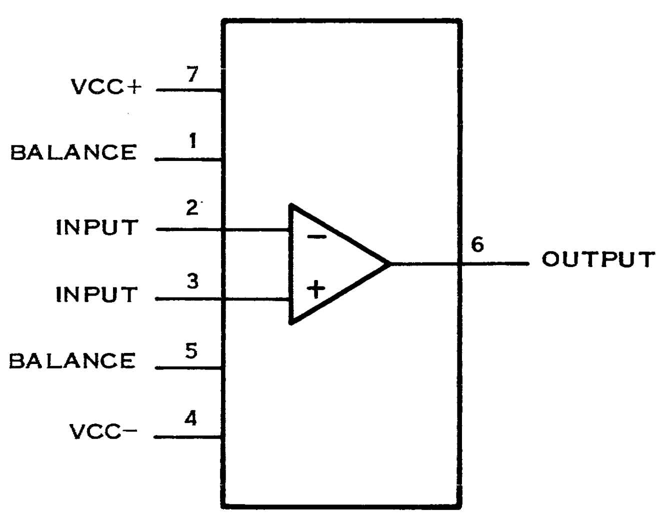
SN74175, SN74LS175, SN74S175

QUADRUPLE D-TYPE FLIP-FLOPS WITH CLEAR



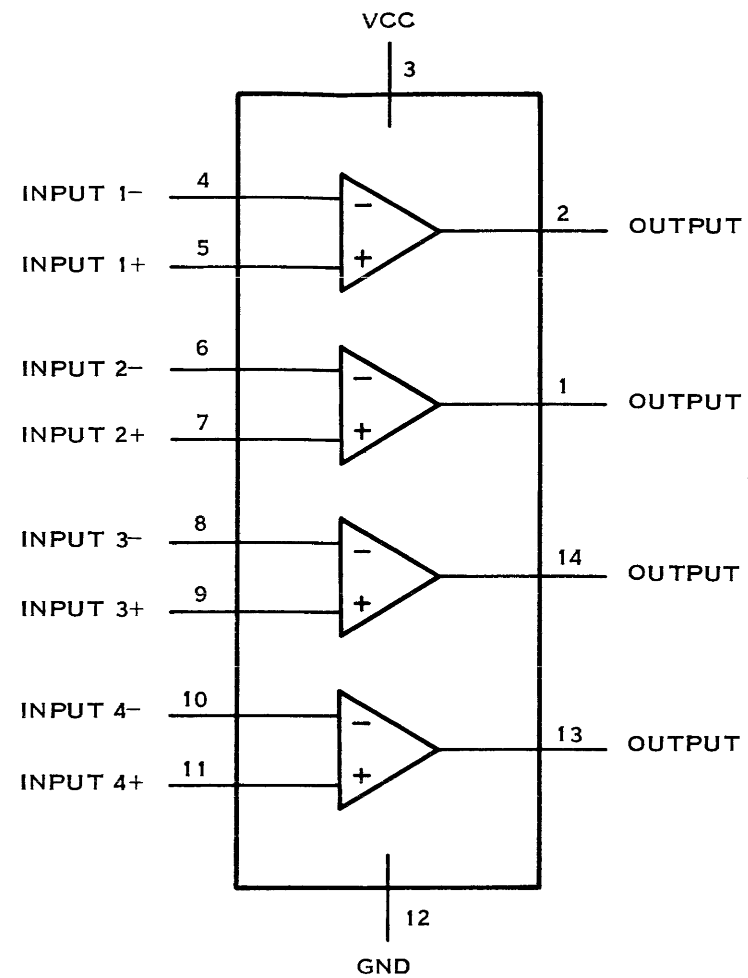
LM319

HIGH SPEED DUAL COMPARATOR



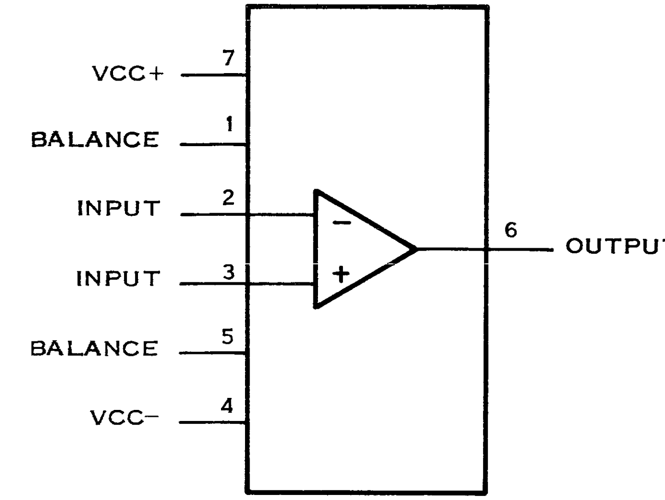
LF357N

WIDE BAND DECOMPENSATED
OPERATIONAL AMPLIFIER/BUFFER



LM 339

QUAD COMPARATOR

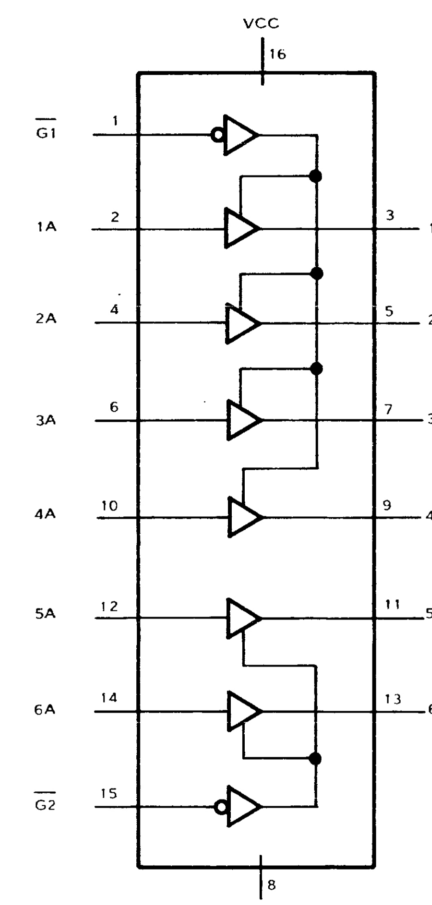


LF356N
WIDE BAND OPERATIONAL
AMPLIFIER/BUFFER

FUNCTION TABLE
(EACH DRIVER)

INPUTS		OUTPUT
$\overline{G}$	A	Y
H	X	Z
L	H	H
L	L	L

H = HIGH LEVEL
L = LOW LEVEL
X = IRRELEVANT
Z = HIGH-IMPEDANCE



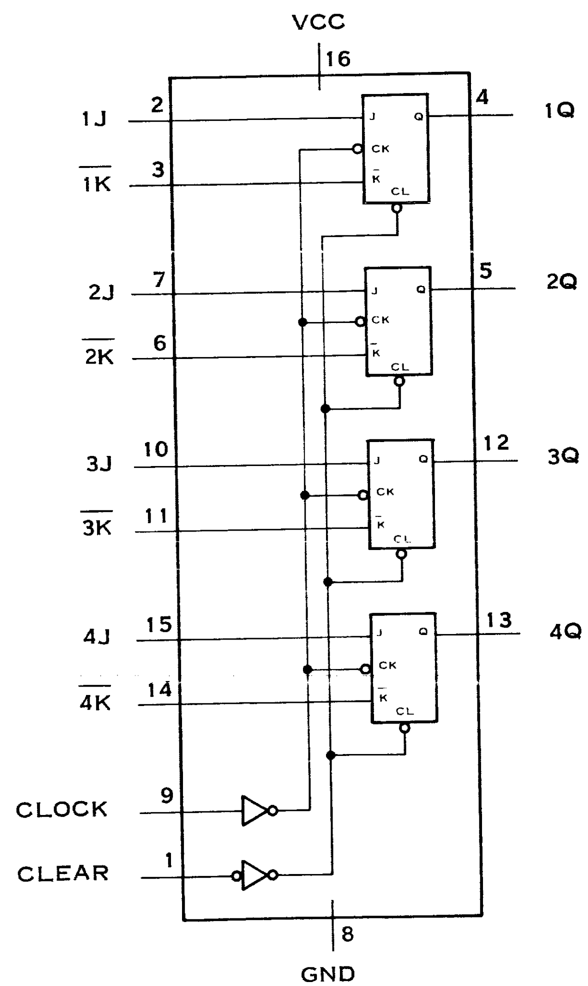
SN74367, SN74LS367
HEX BUS DRIVERS WITH
3-STATE OUTPUTS (TRUE DATA)

FUNCTION TABLE (EACH FLIP-FLOP)

COMMON IN		INPUTS		OUTPUT
CLEAR	CLOCK	J	$\bar{K}$	Q
L	X	X	X	L
H	↑	L	H	Q_0
H	↑	H	H	H
H	↑	L	L	L
H	↑	H	H	TOGGLE
H	L	X	X	Q_0

H HIGH LEVEL (STEADY STATE)
L LOW LEVEL (STEADY STATE)
↑ TRANSITION FROM LOW TO HIGH LEVEL
X IRRELEVANT (ANY INPUT, INCLUDING TRANSITIONS)
Q_0 LEVEL OF Q BEFORE THE INDICATED STEADY-STATE INPUT CONDITIONS WERE ESTABLISHED

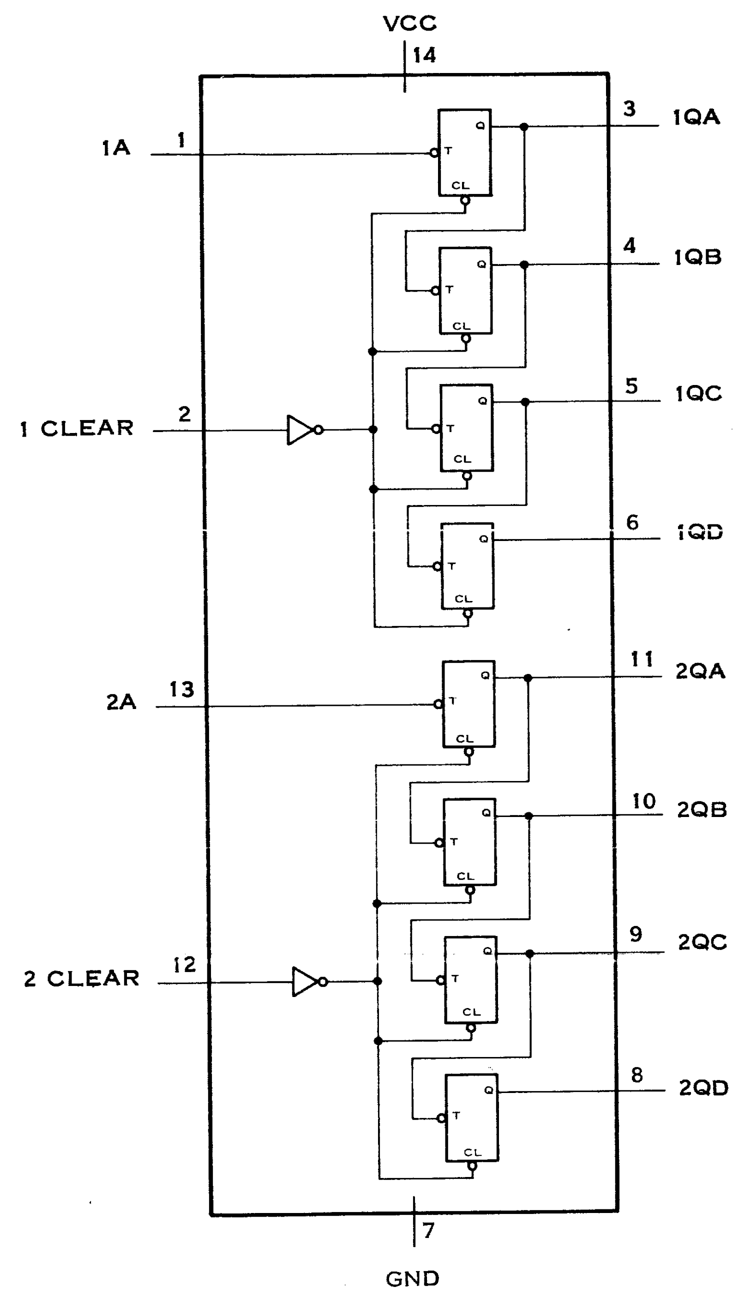
TOGGLE EACH OUTPUT CHANGES TO THE COMPLEMENT OF ITS PREVIOUS LEVEL ON EACH ACTIVE TRANSITION INDICATED BY ↑ OR ↓.



SN74376

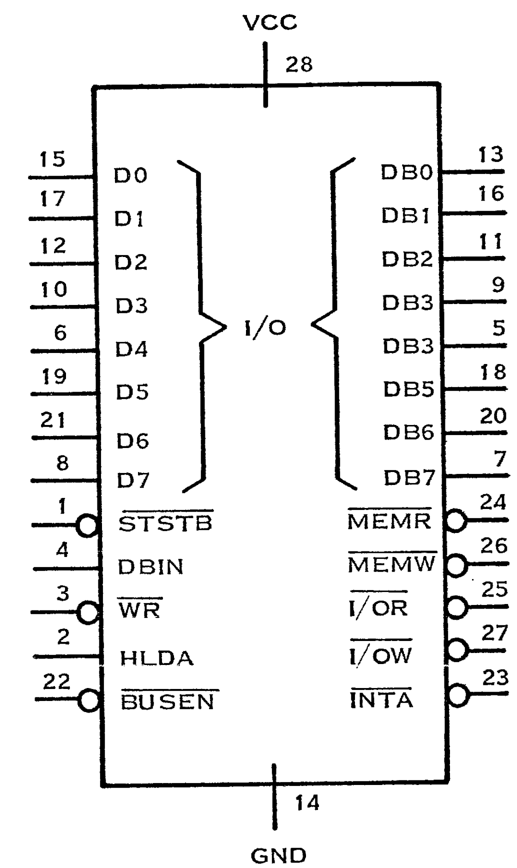
QUADRUPLE J-$\bar{K}$ FLIP-FLOPS

NOTE: SEE PRECEDING PAGE FOR FUNCTION TABLE



SN74393, SN74LS393

DUAL 4-BIT BINARY COUNTER WITH INDIVIDUAL CLOCKS

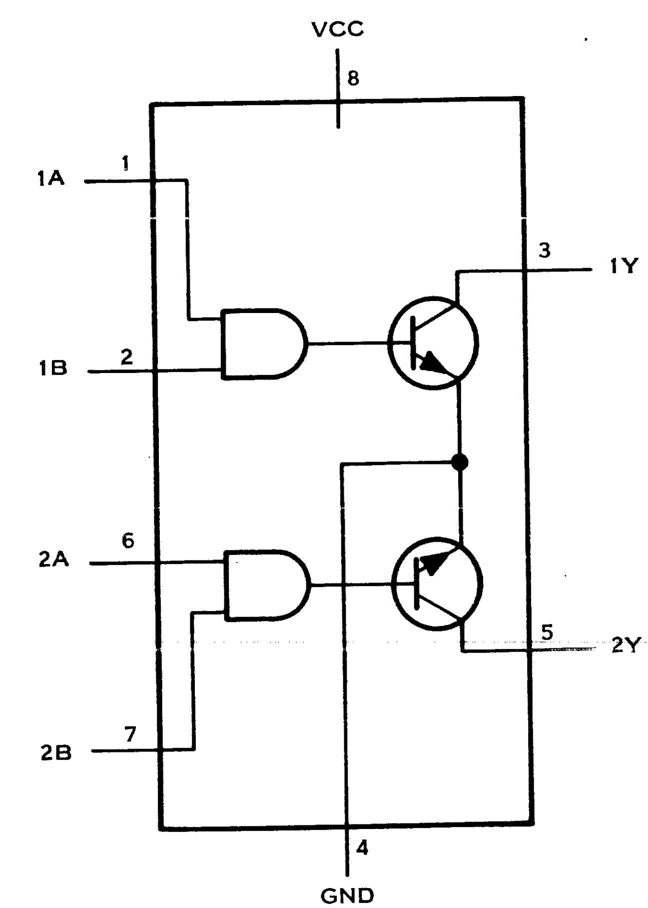


SN745428
(TIM8228)

FUNCTION TABLE

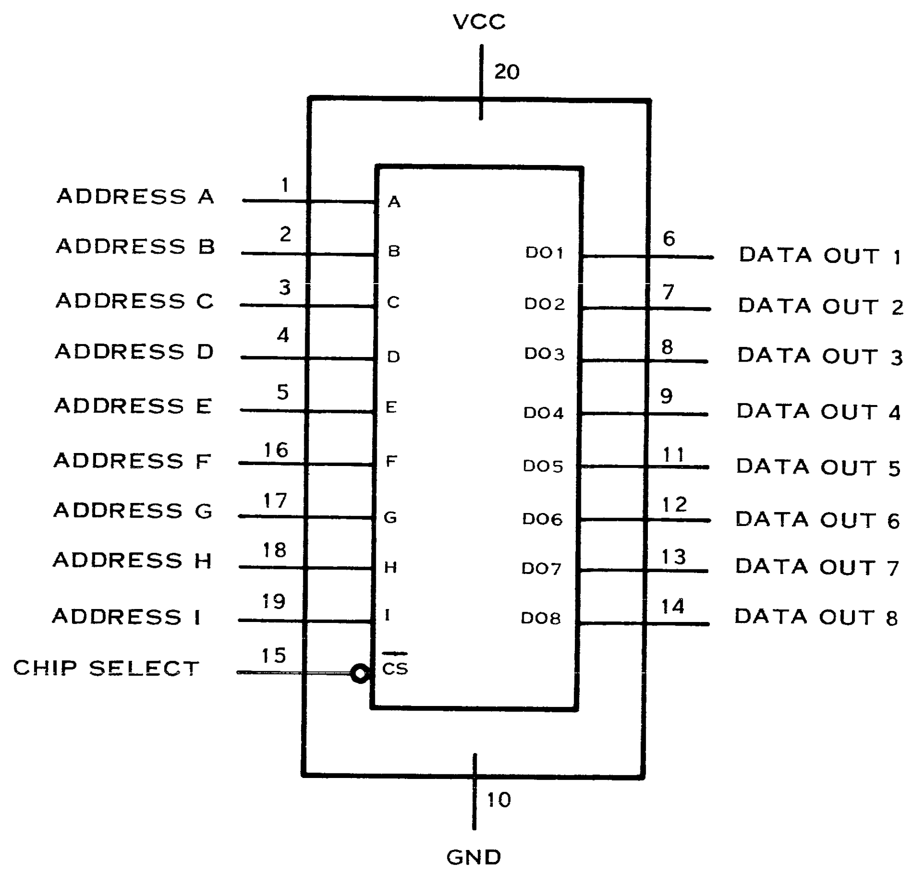
A	B	Y
L	L	H (OFF STATE)
L	H	H (OFF STATE)
H	L	H (OFF STATE)
H	H	L (ON STATE)

H = HIGH LEVEL, L = LOW LEVEL

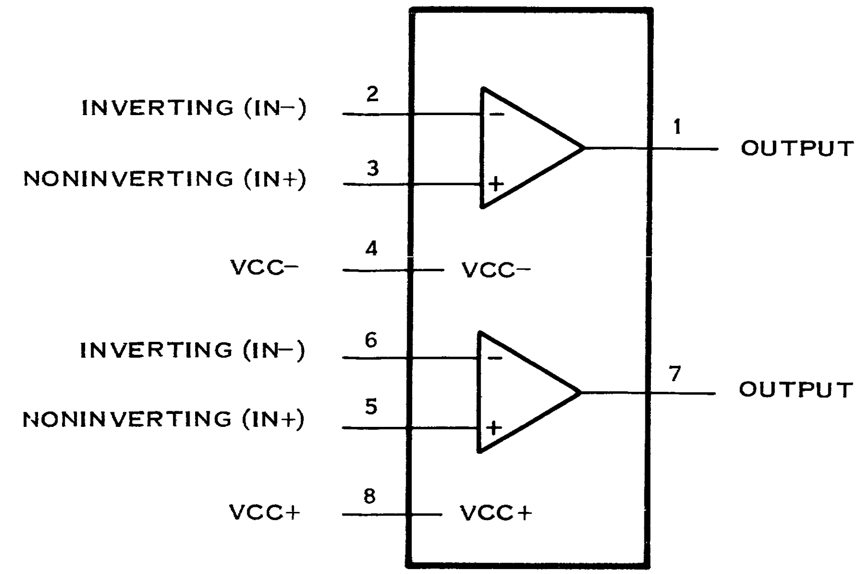


SN75452

DUAL PERIPHERAL POSITIVE-NAND DRIVER

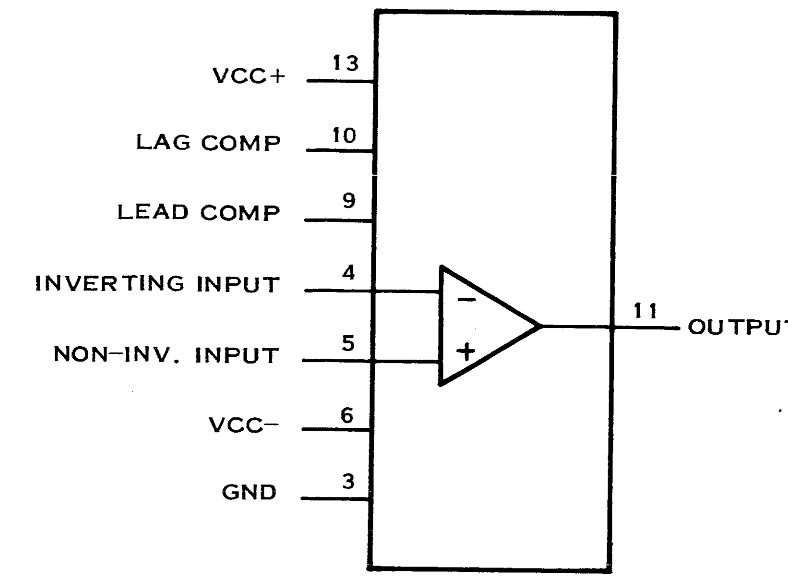


SN74S472
4096 BITS (512 WORDS BY 8 BITS)
PROGRAMMABLE READ-ONLY MEMORY



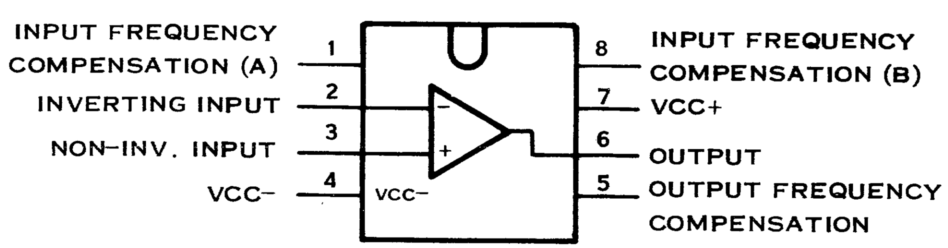
SN72558P

OPERATIONAL AMPLIFIERS

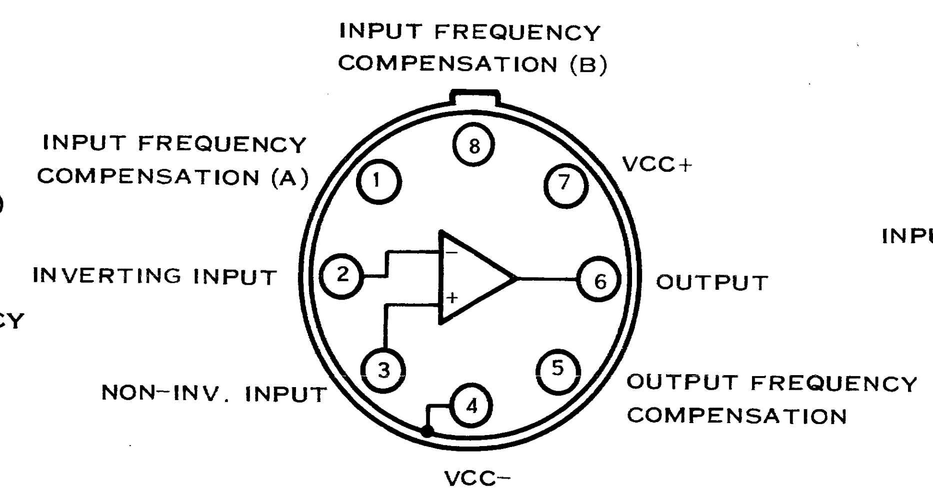


SN72702

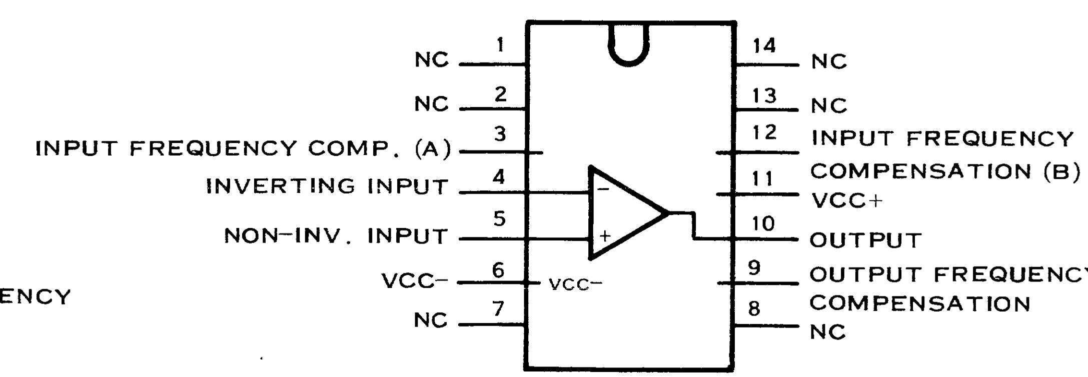
GENERAL-PURPOSE OPERATIONAL AMPLIFIER



LM 709CN-8
SN72709P

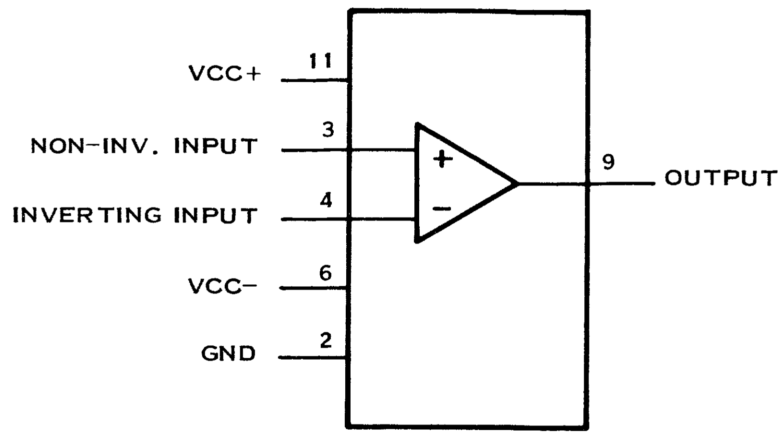


LM 709H, LM 709CH
SN72709L



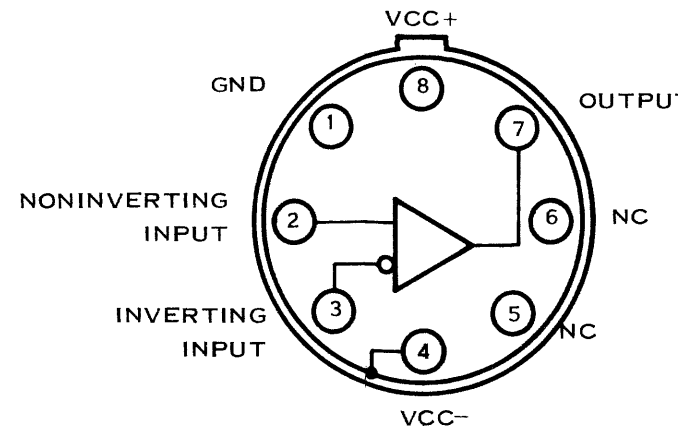
LM 709AJ, LM 709J, LM 709CJ, LM 709CN
SN72709

OPERATIONAL AMPLIFIER

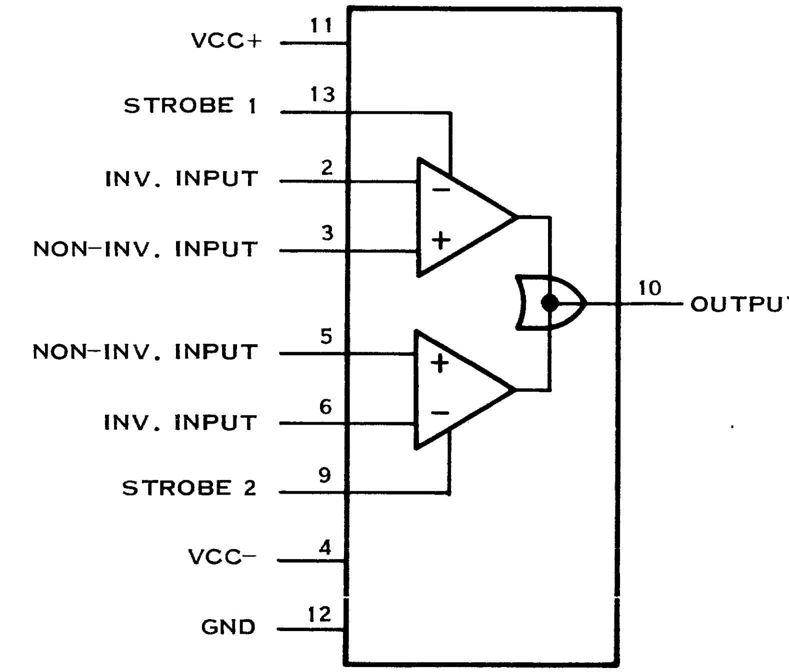


SN72710

DIFFERENTIAL COMPARATOR

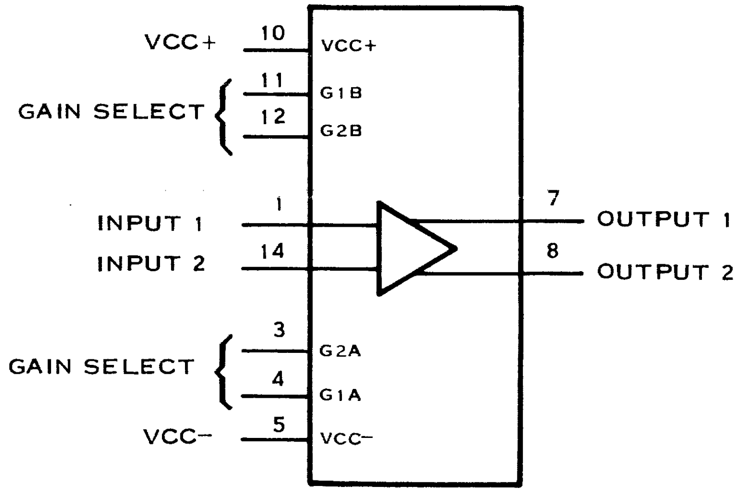


710L

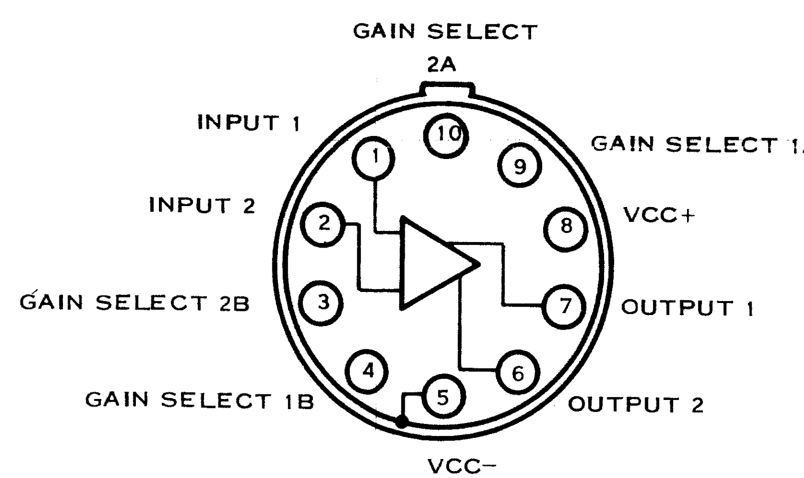


SN72711

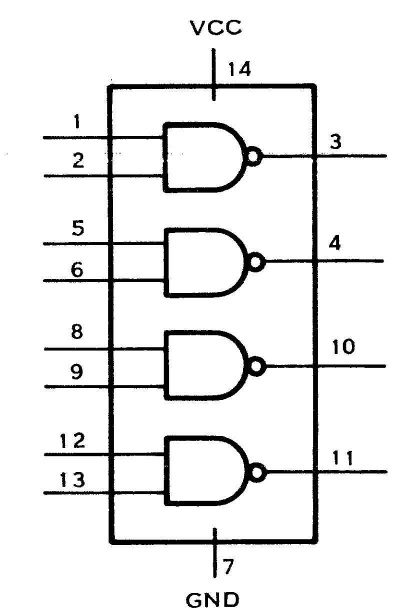
DUAL-CHANNEL DIFFERENTIAL COMPARATOR WITH STROBE



733

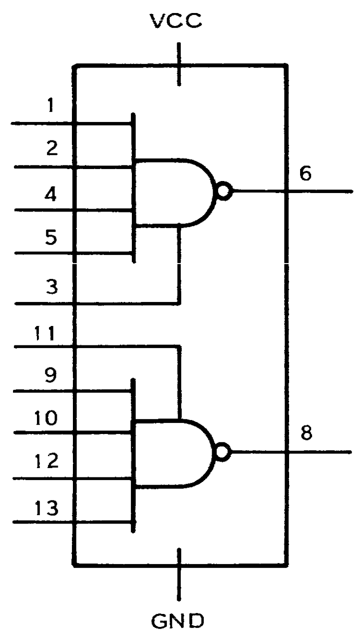


733L



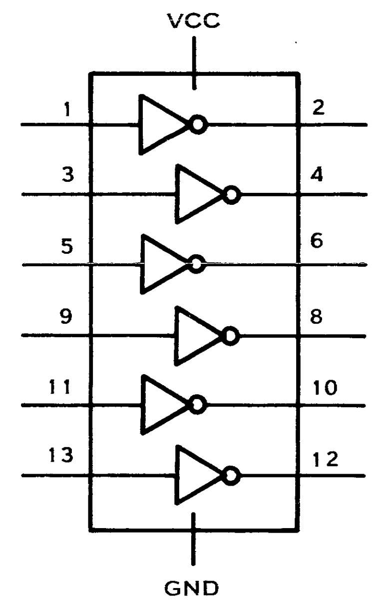
SN15858

DIFFERENTIAL VIDEO AMPLIFIER



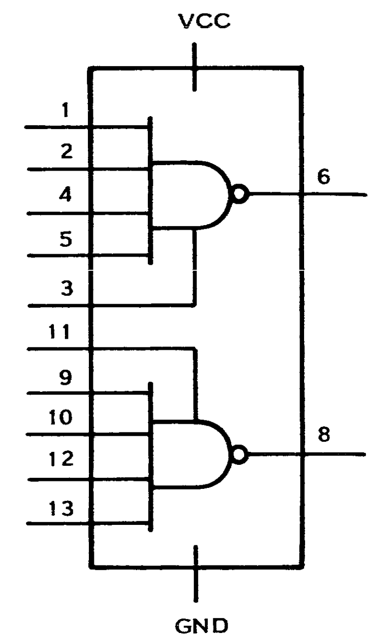
DM 930J, DM 930N

DUAL FOUR INPUT GATES WITH EXPANDERS



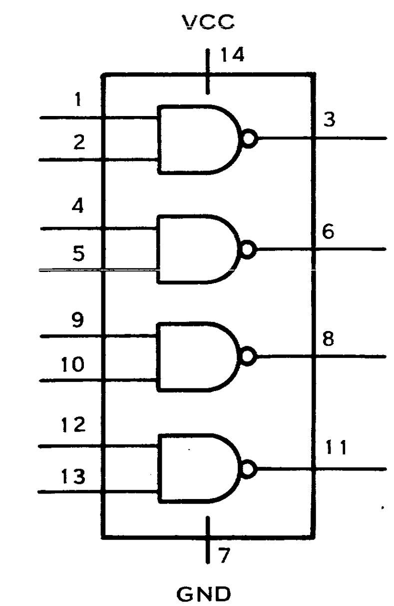
DM 936J, DM 936N

HEX INVERTERS



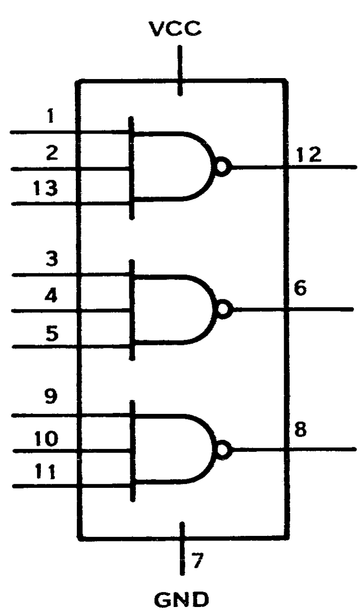
DM 944J, DM 944N

DUAL FOUR INPUT POWER GATES WITH EXPANDERS



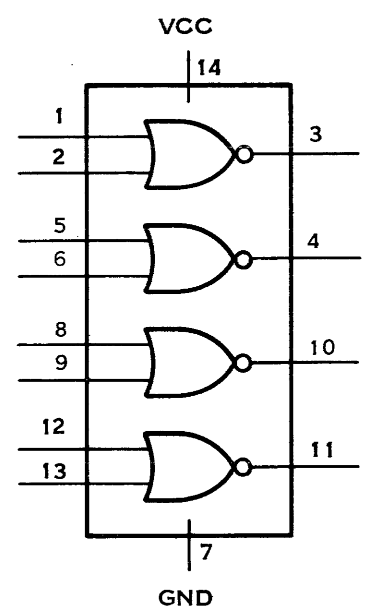
DM 946J, DM 946N

QUAD TWO INPUT GATES

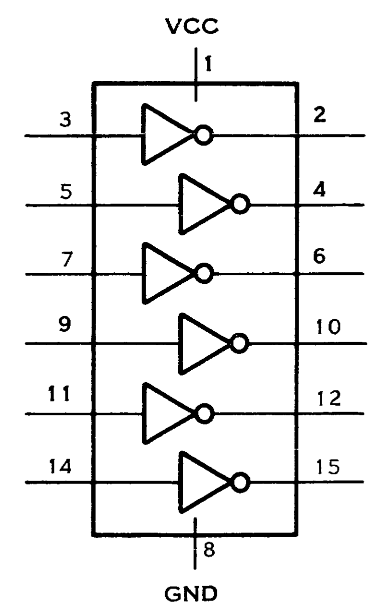


DM 962J, DM 962N

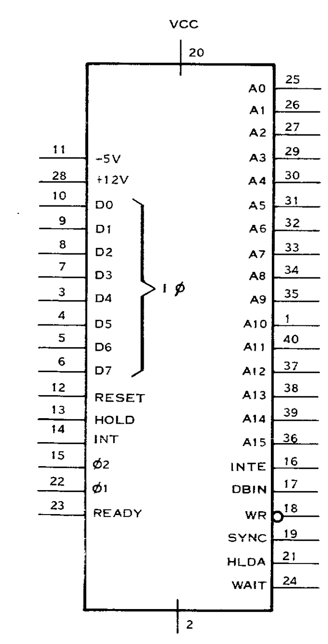
TRIPLE THREE INPUT GATES



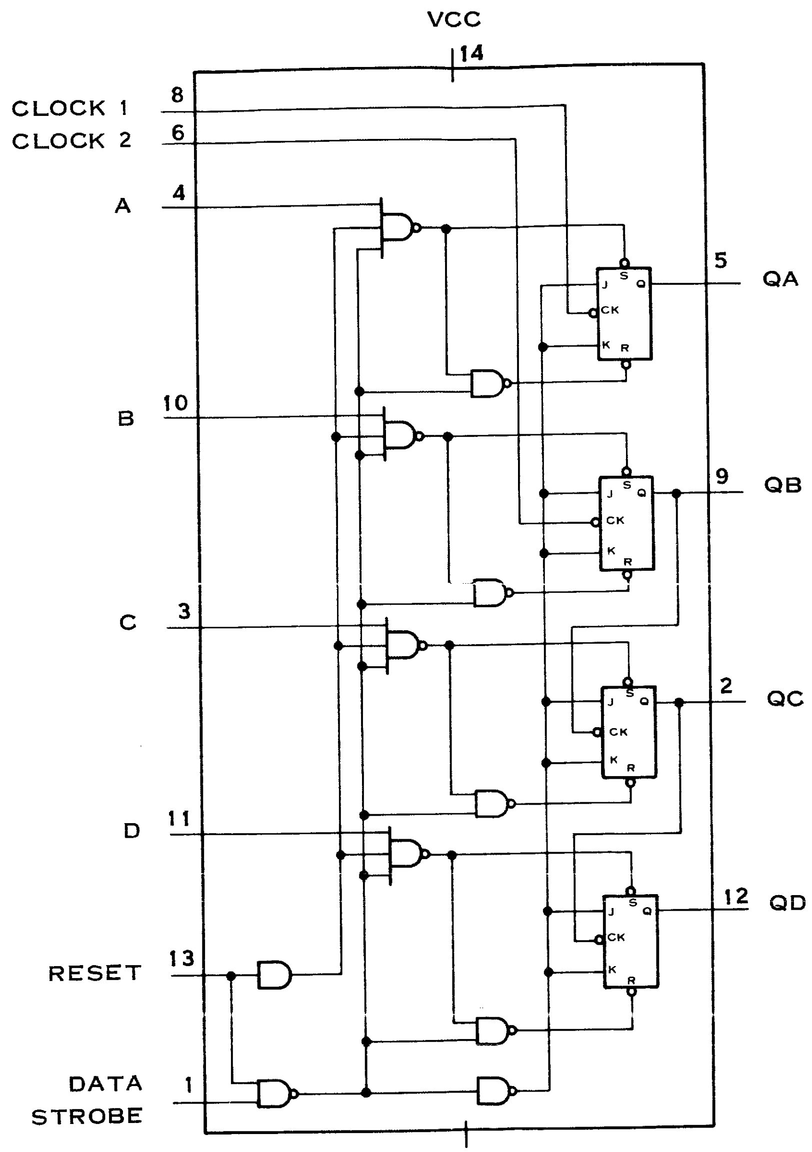
MC14001



MC 4049B



INTEL
8080A



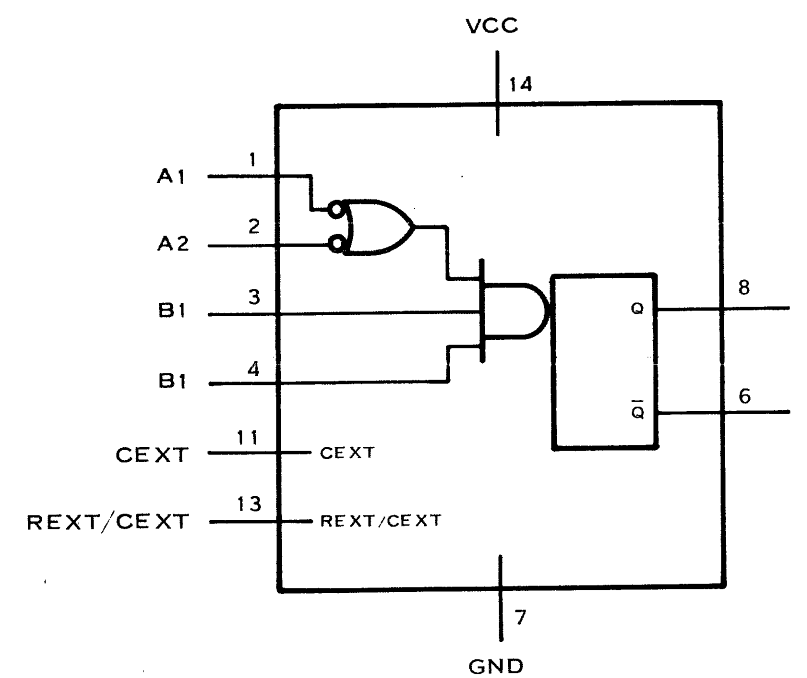
8281

4-BIT BINARY COUNTER

FUNCTION TABLE 9601
(SEE NOTE A)

INPUTS				OUTPUTS	
A1	A2	B1	B2	Q	$\bar{Q}$
H	H	X	X	L	H
X	X	L	X	L	H
X	X	X	L	L	H
L	X	H	H	L	H
L	X	↑	H	⊓	⊔
L	X	H	↑	⊓	⊔
X	L	H	H	L	H
X	L	↑	H	⊓	⊔
X	L	H	↑	⊓	⊔
H	↓	H	H	⊓	⊔
↓	↓	H	H	⊓	⊔
↓	H	H	H	⊓	⊔

NOTES: A. H=HIGH LEVEL (STEADY STATE), L=LOW LEVEL (STEADY STATE), ↑ =TRANSITION FROM LOW TO HIGH LEVEL, ↓ =TRANSITION FROM HIGH TO LOW LEVEL, ⊓=ONE HIGH-LEVEL PULSE, ⊔=ONE LOW-LEVEL PULSE, X=IRRELEVANT (ANY INPUT, INCLUDING TRANSITIONS).



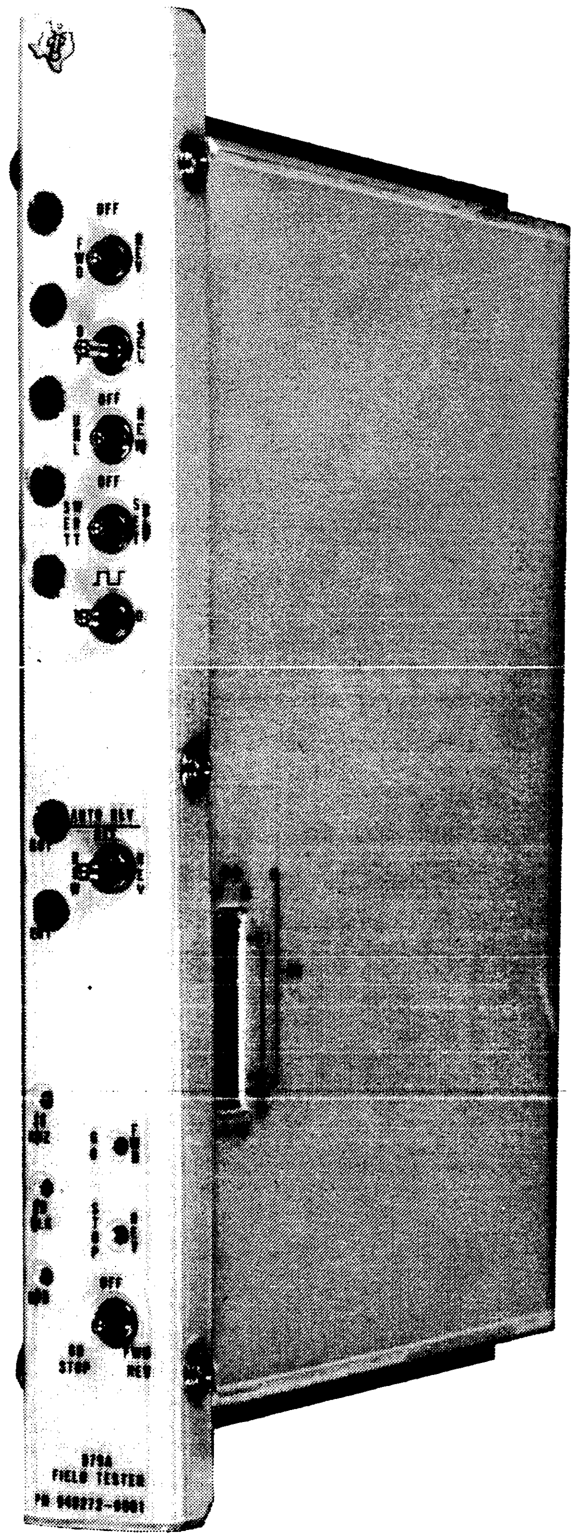
(SN29601)
9601

MONOSTABLE MULTIVIBRATOR

APPENDIX D

979A FIELD TESTER CONTROLS AND INDICATORS

D.1 **979 FIELD TESTER.** The field tester is a portable, logic-card size unit to plug into slot J4 in the tape transport card cage. Figure D-1 and controls and indicators are described in table D-1.



(A)138271 979-178-6-7

Figure D-1. Field Tester Controls and Indicators

Table D-1. 979A Field Tester, Controls and Indicators

Motion Control Switches	Function Performed
FWD/OFF/REV 3-position toggle	Control the direction of tape movement. This switch overrides the GO-STOP/OFF/FWD-REV
OFF/SEL 2 position toggle switch	Setting this switch to SEL selects the transport being tested. When switched to OFF, the transport will not respond to the test and the only status that can be indicated is REWind. (The FWD indicator lamp only indicates that the FWD latch is set.) Before the transport can be selected, the transport must be in the remote mode and not rewinding.
UNL/OFF/REW 3-position momentary toggle center OFF	When transport is selected and ready, momentarily switching to either unload (UNL) or rewind (REW) issues the appropriate command to unload the tape or to rewind the tape. This switch overrides all other motion control switches.
AUTO REV REW/OFF/REV 3-position toggle	This switch when set to rewind (REW), the transport rewinds the tape upon recognizing an EOT. When set to the reverse (REV) position, the transport drives the tape in the reverse direction (at 952.5 mm (37.5 inches) per second) after recognizing an EOT.
PROGRAMMING CONTROLS GO-STOP/OFF/FWD-REV 3-position toggle	This switch is used in conjunction with the FWD/OFF/REV toggle. When set to FWD, the GO-STOP position causes the capstan alternately to start and stop driving the tape in the forward direction. The go start time is adjusted by the GO-FWD potentiometer; stop time by the STOP-REV potentiometer. When the switch is in the FWD-REV position, the tape moves in the forward drive and reverse drive direction alternately. The drive time in this case is adjusted by the GO-FWD potentiometer, and reverse drive time is adjusted by the STOP-REV potentiometer. GO-FWD potentiometer (dual purpose) adjusts the start time and the forward drive time, see above. STOP-REV potentiometer (dual purpose) adjusts for stop time and the reverse drive time, see above.

Table D-1. 979A Field Tester, Controls and Indicators (Continued)

Motion Control Switches	Function Performed
DATA CONTROL SWITCHES SET-WRT/OFF/SET-RD 3-position toggle	In the SET-WRT position, the transport will go to the write mode providing all of the following conditions are met. a. Forward direction is selected. b. Tape is not unloading, i.e., no unload command has been issued. c. Tape is not rewinding. d. Manual reset on the front panel has not been pressed. e. Write enable ring is installed on tape (file not protected). f. Transport is selected. If the set write command is accepted, the read status lamp will be turned off. In the SET RD position, the tape transport is in the read mode.
1/⊓⊔⊓/0 3-position toggle	Selects type data to be written to individual tape channels, all ones, alternate one's and zero's, or all zero's, when transport is in the write mode. Channels are selected by DIP switches on the right side of the tester. When a DATA channel switch is in OFF position, all one's are written to that channel, when in the ON position, the 1/⊓⊔⊓/0 toggle selects type data to be written.
DATA CH1 CH9 9 of 10 switch DIP packages	Enables the 1/⊓⊔⊓ /0 toggle switch to select data type to be written to the channel, see above. In the OFF position, all one's are written to a channel, regardless of the position of 1/ ⊓⊔⊓ /0 switch. In order to maintain proper operation and data density, at least one write DATA channel switch must be left in the OFF position.
PE 1600/NRZI 800 1 of 10 switch DIP packages	Selects recording format type used by tape transport, either 1600 bpi phase-encoded, or 800 bpi nonreturn-to-zero, inverted.

Table D-1. 979A Field Tester, Controls and Indicators (Continued)

Indicators and Test Points

FWD lamp	When lighted, indicates capstan has received a forward drive command.
RDY lamp	Ready is lighted as long as transport is in the remote mode and not performing a rewind operation.
REW	When lighted, tape is in a rewind operation initiated in either the local or remote modes. Neither select or ready is required for this status to be displayed.
RD	When read is lighted, transport is not in write mode. The read indicator does not necessarily mean that the transport is reading from tape.
FP	File protect indicates the reel is write protected; i.e., the write enable ring is not installed.
BOT indicator	Lights when beginning-of-tape marker is located under BOT detector.
EOT indicator	Lights when end-of-tape marker is located under EOT detector.
30 kHz test point	Test point for measuring 30 kHz signal.

APPENDIX E

SDP, PDT979, MAGNETIC TAPE TRANSPORT, 800/1600 BPI-PDT960/980

E.1 INTRODUCTION

E.1.1 SCOPE OF THE USER'S GUIDE. This document contains the program description and operating instructions for the Model 979 Magnetic Tape Transport peripheral demonstration test (PDT979). The PDT runs standalone on either the 960 or the 980 computer. Operating instructions, messages, tests, and error interpretation are identical on both computers and are discussed in this document. For details on program structure, content, and internal methodologies, see the assembly listing (AL) for the particular PDT being used.

E.1.2 GENERAL DESCRIPTION OF THE PDT. PDT979 is a comprehensive program designed to verify with a high degree of reliability the proper performance of the 979 Tape Transport unit (either 800 or 1600 BPI) and its associated control logic (either DMAC, BTC, and TCL for 800 BPI, or DMAC, BTC, TCC, and TIU for 1600 BPI). The PDT is composed of 20 tests which are structured around a building block principal whereby each test introduces a minimum amount of new functions, and, operations proven to work in a previous test are used to verify the new functions being introduced. Although the tests are designed to run in sequential order, each is independent of the others and each is independently selectable by the user. The 20 tests are subdivided into three groups. The first group contains tests 1 though 15. These tests require no operator intervention and are referred to as the automatic tests. The second group contains tests 16 through 18. These tests require user assistance and are referred to as the manual intervention tests. The last group containing tests 19 and 20 is referred to as the optional tests.

E.1.3 RELATED MATERIAL. PDT979, Map Tape XPT Test, 800/1600 BPI-PDT960, part number 948124-9901. PDT979, Mag Tape XPT Test, 800/1600 BPI-PDT980, part number 942944-9901.

E.2 INSTALLATION

E.2.1 EQUIPMENT CONFIGURATION. PDT979 requires a keyboard/display device such as an ASR 733 or 912 CRT for communication with the user. The baud rate of the interface module is calculated by the PDT and can be either 300, 1200, or 9600. On the 960 computer, the interface module is expected in CRU slot EFO. This may be changed by patching relative address 4 and restarting the PDT from relative address 0. On the 980 computer, the interface module is expected to be I/O BUSS ADDRESS 5. A minimum 12K of memory is required. An error free scratch tape with at least 21 metres (70 feet) between BOT and EOT is also required.

E.2.2 LOADING PROCEDURE. To load PDT979, follow standard loading procedures. After the last record of the object media has been read, PDT979 will go into execution and print a title message on the logging device giving part number and revision level. It then prints a request for a user supplied parameter and waits for a keyboard response. At that time verify the scratch tape is loaded, ready, and at the BOT marker.

E.3 OPERATION

E.3.1 GENERAL. After the program title has been printed, a series of questions are output to the user to acquire system parameters and option selections. The user need only type a single character response to these questions. The PDT provides automatic carriage return, line feed, and input validation. An incorrect response results in the following message:

INVALID RESPONSE

The question is then output again for the proper response. In the case where a numerical response is requested, the user should respond with a single decimal digit. When a yes or no answer is required, the user should respond either Y for yes or N for no (any recognized key that is not a Y will be treated as an N). Any key typed is echoed to the printer, but not all keys are recognized. The characters recognized by the PDT are the carriage return, any key that produces an ASCII code between 20 and 5F, and special keys ESCAPE and RUBOUT.

E.3.2 PARAMETER INPUT. This paragraph describes the four parameters required by the PDT.

E.3.2.1 Port Number. The first parameter requested by the PDT is the DMAC port number for the tape transport controller. It appears as follows:

ENTER DMAC PORT NUMBER (0-7)

The user should type a single decimal digit between zero and seven. The port number of the controller can be determined from the BTC #1 board in the DMAC chassis. On that board are five switches of which only switches 1, 2, and 3 are used. These switches are set to represent an octal number zero and seven.

E.3.2.2 Units Under Test. The second parameter requested by the PDT is the unit number of each transport to be tested. Assuming the user responds yes for each transport number possible, the output would appear as follows:

UNITS UNDER TEST - UNIT 1? Y UNIT 2? Y UNIT 3? Y

Should the user respond no to the first two, the output would appear like this:

UNITS UNDER TEST - UNIT 1? N UNIT 2? N UNIT 3? Y

Should the user type carriage return, instead of N, to imply no, the output would appear like this:

```
UNITS UNDER TEST - UNIT 1?
                   UNIT 2?
                   UNIT 3?    Y
```

A minimum of one and a maximum of three units must be selected. When more than one unit is selected the PDT runs to completion on one unit before beginning on the next. The unit number of a particular transport is determined by following the cables from the DMAC chassis to the transport. The transport is connected to the DMAC chassis (or TIU) i.e., transport #1. The first transport on a daisy chain is transport #2, and the last is transport #3.

E.3.2.3 Recording Density. The third parameter requested by the PDT is the recording density. It appears as follows:

1600 BPI?

A response of yes indicates all units under test record at 1600 BPI. A response of no indicates all units under test record at 800 BPI. It is apparent that the recording density is 1600 BPI if the controller interfaces to the transport interface unit (TIU) rather than transport #1.

E.3.2.4 DMAC Chassis. The last parameter required by the PDT is the type of DMAC chassis. The request appears as follows:

DMAC EXPANSION?

A yes response indicates the TCL/TCC and BTC logic boards are contained in a DMAC expander chassis. No indicates these boards are contained either in an internal or external single controller DMAC chassis. The distinction is necessary because of the interrupt status word stored at location 96_{16}. An expander chassis will store at 96_{16} whereas the single controller will not.

E.3.3 OPTIONS. Following parameter input, the PDT requests option selection. This paragraph describes the options provided in the order they are requested by the PDT.

E.3.3.1 Test Headings. The first option provided is whether or not to print test headings. The message appears as follows:

PRINT TEST HEADINGS?

A response of Y will cause each of the 20 tests to print out its title just before executing. If the PDT is going to run for an extended period of time, then to save paper, the user may want to respond N to this option.

E.3.3.2 Error Messages. An option to not print error messages is next. It appears as follows:

PRINT ERROR MESSAGES?

A response of Y will cause errors to be printed. A no response will cause error messages to be suppressed. This may be useful while troubleshooting a known error and the error message is not so much of interest as the trace on an oscilloscope.

E.3.3.3 Stop on Error. The next option is whether or not to stop after an error has been detected. The message appears as follows:

STOP ON ERROR?

A yes response may be useful when running the PDT for extended periods of time while unattended. In the event of a failure, this will prevent page after page of error messages.

E.3.3.4 Loop On Error. The next option is whether or not to loop on the command or sequence of commands that resulted in an error. The message is only printed if the user responds no to stop on error and will appear as follows:

LOOP ON ERROR?

A response of Y may be useful for setting up a scope loop. If an error is detected, the appropriate error message is printed normally followed by the following message:

NOW LOOPING ON ERROR

From that time on, no more messages are printed. If the problem is intermittent or goes away due to the scope probe, the PDT will still remain in the loop. The only way to ABORT is to type the ESCAPE key.

A response of N would mean for the PDT to report errors normally and to continue on through the rest of the test. This would be the normal selection for attended use of the PDT.

E.3.3.5 Test Index and Verb Library. The last option provided allows the user to print the number and title of each test in the PDT, and the abbreviation and definition of each verb in the verb library. The option appears as follows:

LIST TEST INDEX AND VERB LIBRARY?

A yes response may be useful when the user desires a review of the available tests and verbs.

E.3.4 VERBS. The verb library provided with PDT979 contains 7 commands (or verbs) which greatly enhance the versatility of the PDT and its usefulness as a troubleshooting tool. The abbreviation and definition of each verb is shown at the bottom of figure E-1. A sample of program execution under the EM verb is shown in figure E-2. Samples of the CO, ES, LS, and RS verbs are shown in figure E-3.

E.3.5 SPECIAL KEYS. Although PDT979 executes with data bus (or CRU) interrupts disabled, it monitors the interface module for a Read Request with such frequency that it appears interrupt driven. While a test is in execution, typed keys are echoed to the printer, however, only the ESCAPE key and the RUBOUT key have any significance.

E.3.5.1 Escape Key. The primary role of the escape key is to cause the program to abort whatever test it is doing or whatever message it is printing, and return to get a new verb from the user. During parameter input and option selection the escape key has an alternate function as follows: After a request has been printed for a parameter or an option, and the PDT is idle waiting for the user to type a reply, if the escape key is typed, the PDT will backup one message and reoutput the previous parameter or option request. This allows the user to change his mind or correct a mistake without having to restart the entire PDT.

E.3.5.2 Rubout Key. The primary role of the rubout key is to provide the user with a pause capability. Typing the rubout key causes the program to temporarily suspend whatever it is doing until further notice. During that time the user might change a controller board or move the scope probe. To resume execution exactly where it left off, the user must type any key on the keyboard. A second use of the rubout key is to halt and restart the printer. This capability is especially useful if the system console is a 912 CRT. When the CRT screen gets full, the user can type the rubout key to stop the CRT long enough to read the screen and then type any key to start it up again. A third feature of the rubout key is the single step mode. This happens when the rubout key is typed a second time to cause program execution to resume after pausing because the rubout key was typed the first time. When that happens the program will go back into execution, perform one command to the tape drive, and automatically pause again. This single step process will continue each time the rubout key is typed. To resume automatic program execution, type any key other than rubout.

```
PDT979 MODEL 979 800/1600 BPI MAGNETIC TAPE TRANSPORT TEST-SYS980 942944**
ENTER PORT NUMBER (0-7) 2
TYPE Y FOR YES AND ANY OTHER KEY FOR NO:
UNITS UNDER TEST - UNIT 1? Y  UNIT 2? N  UNIT 3? N
1600 BPI? N
DMAC EXPANSION? Y
PRINT TEST HEADINGS? Y
PRINT ERROR MESSAGES? Y
STOP ON ERROR? N
LOOP ON ERROR? N
LIST TEST INDEX AND VERB LIBRARY? Y


     *** TEST INDEX ***

AUTOMATIC TESTS

TEST 01 - DATA INDEPENDENT ATI TESTS
TEST 02 - BASIC WRITE/READ TESTS
TEST 03 - ERASE HEAD POLARITY TEST
TEST 04 - END OF FILE TESTS
TEST 05 - RECORD SKIP TESTS
TEST 06 - CHARACTER COUNTER TESTS
TEST 07 - CHAINING TESTS
TEST 08 - INVALID CHAINING COMMAND TESTS
TEST 09 - SHORT REC EVEN/ODD WRITE/READ TESTS
TEST 10 - LONG REC EVEN/ODD WRITE/READ TESTS
TEST 11 - DATA PATTERN TESTS
TEST 12 - START/STOP WRITE TEST
TEST 13 - RECORD CREEP TEST
TEST 14 - LW1/LW4 TEST
TEST 15 - END OF TAPE TEST

MANUAL INTERVENTION TESTS

TEST 16 - UNLOAD/FILE PROTECT/ OFF LINE TESTS
TEST 17 - CAPSTAN CREEP TEST
TEST 18 - DMAC RESET TEST

OPTIONAL TESTS

TEST 19 - MULTIPLE UNIT TESTS
TEST 20 - ENGINEERING TEST TAPE TEST

     *** VERB LIBRARY ***

EM - EXECUTE AUTOMATIC AND MANUAL INTERVENTION TESTS AND STOP
EA - EXECUTE AUTOMATIC TESTS AND STOP
ES - EXECUTE SELECTED TESTS AND STOP
LA - LOOP ON AUTOMATIC TESTS
LS - LOOP ON SELECTED TESTS
CO - CHANGE PRINT OPTIONS
RS - RESTART PDT
```

Figure E-1. Parameter Input and Option Selection

```
VERB? EM
BEGIN TEST UNIT 1
******** TEST 01 - DATA INDEPENDENT ATI TESTS
******** TEST 02 - BASIC WRITE/READ TESTS
******** TEST 03 - ERASE HEAD POLARITY TEST
******** TEST 04 - END OF FILE TESTS
******** TEST 05 - RECORD SKIP TESTS
******** TEST 06 - CHARACTER COUNTER TESTS
******** TEST 07 - CHAINING TESTS
******** TEST 08 - INVALID CHAINING COMMAND TESTS
******** TEST 09 - SHORT REC EVEN/ODD WRITE/READ TESTS
******** TEST 10 - LONG REC EVEN/ODD WRITE/READ TESTS
******** TEST 11 - DATA PATTERN TESTS
******** TEST 12 - START/STOP WRITE TEST
******** TEST 13 - RECORD CREEP TEST
******** TEST 14 - LW1/LW4 TEST
******** TEST 15 - END OF TAPE TEST

REWIND TIME (IN SEC) = 00071
******** TEST 16 - UNLOAD/FILE PROTECT/ OFF LINE TESTS

RWND/UNLD ATTEMPTED W/ TAPE OFF BOT - DID TAPE UNLOAD (Y OR N)?Y

REMOVE WRITE RING - RELOAD TAPE - PRESS CR TO CONTINUE WHEN XPT READY

RWND/UNLD ATTEMPTED W/ TAPE ON  BOT - DID TAPE UNLOAD (Y OR N)?Y

INSERT WRITE RING - RELOAD TAPE - PRESS CR TO CONTINUE WHEN XPT READY
******** TEST 17 - CAPSTAN CREEP TEST

PRESS CR TO BEGIN 10 SECOND DELAY
******** TEST 18 - DMAC RESET TEST

PRESS CPU RESET - PRESS CPU START

VERB?
```

Figure E-2. Sample Program Execution

```
VERB? XX
INVALID RESPONSE

VERB? CO
PRINT TEST HEADINGS? Y
PRINT ERROR MESSAGES? Y
STOP ON ERROR? Y
LIST TEST INDEX AND VERB LIBRARY? N

VERB? ES 2 4 6 7

BEGIN TEST UNIT 1
******* TEST 02 - BASIC WRITE/READ TESTS
******* TEST 04 - END OF FILE TESTS
******* TEST 06 - CHARACTER COUNTER TESTS
******* TEST 07 - CHAINING TESTS

VERB? LS 12 13

BEGIN TEST UNIT 1
******* TEST 12 - START/STOP WRITE TEST
******* TEST 13 - RECORD CREEP TEST
BEGIN TEST UNIT 1
******* TEST 12 - START/STOP WRITE TEST
******* TEST 13 - RECORD CREEP TEST
BEGIN TEST UNIT 1
******* TEST 12 - START/STOP WRITE TEST
******* TEST 13 - RECORD CR

VERB? RS
PDT979 MODEL 979 800/1600 BPI MAGNETIC TAPE TRANSPORT TEST-SYS980 942944 **
ENTER PORT NUMBER (0-7)
```

Figure E-3. Sample of the VERBS CO, ES, LS and RS

E.4 MESSAGE INTERPRETATION

PDT979 prints very extensive error messages designed for rapid fault isolation and to minimize the need to refer to the assembly listing.

Of the nearly 100 messages the PDT is capable of printing, most are self explanatory. A sample of the less obvious but most likely messages is shown in figure E-4. These messages tend to follow a convention of 4 lines per error message with each error message separated from the others by a double space. Line 1 is a brief description of the type of error detected. Line 2 is a mini memory dump of the DMAC command that caused the error. In the case of a command that causes the BTC to acquire a list, the following information is printed.

AL=XXXX - the assembly listing address of the failing command

AW1=XXXX - word 1 of the Activate DMA Instruction (ATI/ADAC)

AW2=XXXX - word 2 of the Activate DMA Instruction (ATI/ADAC)

LW1=XXXX - word 1 of the list specified by AW2

LW2=XXXX - word 2 of the list specified by AW2

LW3=XXXX - word 3 of the list specified by AW2

LW4=XXXX - word 4 of the list specified by AW2

In the case of a rewind command, Line 2 contains the following alternate information:

AL=XXXX - the assembly listing address of the failing Rewind command

REWIND TYPE - the type will either be with interrupt enabled or without interrupt enabled

BOT - this indicates whether the tape was on or off BOT prior to issuing the Rewind command

INTRPT RCVD - this indicates whether an interrupt was received or not

STATUS RCVD - this indicates whether status word 1 was received or not

Line 3 of the error message is the received status word 1. It is printed in hex and also decoded. Line 4 of the error message is the expected status word 1. Likewise, it is printed in hex and also decoded. In the event of a data compare error the following additional information is printed:

CHARS EXPD=XXXX/XXXXX - number of characters attempted to read in HEX/DECIMAL

CHARS RCVD=XXXX/XXXXX - number of characters actually read in HEX/DECIMAL

CHARS IN ERROR=XXXX/XXXXX - number of characters in the compare buffer that did not match the corresponding character in the read buffer in HEX/DECIMAL.

LOC XXXXL -or- LOC XXXXR - location of character in ERROR XXXX is the word (in HEX) relative to the start of the record that contains the character in error. L or R indicates whether the character is in the left half or right half of the word.

```
INCORRECT STATUS RCVD UNIT 1
AL=0855   AW1=D9CA  AW2=0FFC  LW1=234C  LW2=0100  LW3=A000  LW4=0327
CHAIN LIST SPECIFIED BY LIST WORD 4:  LW1=23CD  LW2=0100  LW3=A000  LW4=0FFC
RCVD STAT WRD1=0600=PE2 CNTRL/XPT + EOR
EXPD STAT WRD1=0001=LIST TAKEN

DATA COMPARE ERROR UNIT 1
AL=0855   AW1=D9CA  AW2=0FFC  LW1=234C  LW2=0100  LW3=A000  LW4=0327
CHAIN LIST SPECIFIED BY LIST WORD 4:  LW1=23CD  LW2=0100  LW3=A000  LW4=0FFC
CHARS EXPD=0100/00256  CHARS RCVD=001A/00026  CHARS IN ERROR=00E7/00231
 LOC     EXPD     RCVD      XOR       BAD TRACK
0000L     FE       --
0000R     FE       --
000CR     FE       FF        01         2
000DL     FE       --
000DR     FE       --
000EL     FE       --
000ER     FE       --
000FL     FE       --
000FR     FE       --
0010L     FE       --
CHAINED RECORD LENGTH ATTEMPTED(IN CHARS)=0800/02048
ATTEMPTED CHAINS=00007  SUCCESSFUL CHAINS=00004


  VERB? ES 1

  BEGIN TEST UNIT 1
  ******* TEST 01 - DATA INDEPENDENT ATI TESTS

  INCORRECT STATUS RCVD UNIT 1
  AL=0173   REWIND TYPE:W/O INTRPT  BOT:ON  INTRPT RCVD:NO  STATUS RCVD:YES
  RCVD STAT WRD1=2000=OFFLINE
  EXPD STAT WRD1=0010=RWND CMPLT 1

  INCORRECT STATUS RCVD UNIT 1
  AL=017C   REWIND TYPE:W/ INTRPT  BOT:ON  INTRPT RCVD:YES  STATUS RCVD:YES
  RCVD STAT WRD1=2000=OFFLINE
  EXPD STAT WRD1=8000=OP COMPLETE

  VERB? ES 2

  BEGIN TEST UNIT 1
  ******* TEST 02 - BASIC WRITE/READ TESTS

  INCORRECT STATUS RCVD UNIT 1
  AL=0246   AW1=D9CA  AW2=0FFC  LW1=22CB  LW2=0100  LW3=1000  LW4=0FFC
  RCVD STAT WRD1=2000=OFFLINE
  EXPD STAT WRD1=8000=OP COMPLETE

  STATUS WORD 2 INCORRECT     RCVD=0100/00256      EXPD=0000/00000
  AL=0246   AW1=D9CA  AW2=0FFC  LW1=22CB  LW2=0100  LW3=1000  LW4=0FFC

  VERB?
```

Figure E-4. Sample Error Messages

EXPD - character expected (in HEX)

XX

RCVD -or- RCVD - character received (in HEX) two dashes
XX — — indicate no character was received.

XOR - exclusive or of the character received with the character expected.

XX

BAD TRACK(s) - 979 XPT TRACK number(s) in error

X, X, X, X, X, X, X, X, X, -

When more than 10 characters are in error, only the first 10 are printed. If the user requested continue on error then testing would resume at that time. If, however, stop on error was selected, then the following message would be printed:

CONTINUE? (Y or N)

If the user types Y for yes, then up to 10 more characters in error are printed followed by CONTINUE? (Y or N). The user can continue to type Y until all errors have been printed or type N for no and cause the program to return to get a new verb.

If an error occurs during a chain write or chain read operation, a two line error message is printed indicating the overall length of the record undertaken and how many levels of chaining occurred before the error occurred.

E.5 DETAILED TEST DESCRIPTIONS

In view of the comprehensive testing of PDT979, and the elaborate error messages it is unlikely that reference to a detailed test description would be necessary except with very obscure failures. In that event, a knowledge of what specifically the test is doing may be desirable in order to patch the PDT on gain insight for a "hand toggle" program to aid in a more rapid isolation of the fault. For this reason the assembly listing of PDT979 is formatted and commented such that the specific actions taken in a particular test stand out and can be seen at a glance. By looking at the title at the top of each page of the listing, the user can flip to the test of interest. Then, by reading the "standalone" comment cards, gain an understanding of what the test does and the steps taken to do it. Programming details are provided in the comment fields of the instructions themselves.

APPENDIX F

GLOSSARY OF MAGNETIC TAPE RECORDING TERMS

Term	Description
BOT	Beginning-of-tape. A reflective BOT marker is placed 3.1 metres (10.0 feet) or more from the beginning of the tape. The BOT status signal is generated when the marker is sensed.
bpi	Bits per inch (25.4 mm). A measure of data packing density on one track of a magnetic tape.
CRCC	Cyclic redundancy check (CRC) character. An error detection character which is written at the end of a record. NRZI format only.
EOF	End-of-file. A special character written on the tape to indicate the end of a file. The EOF status bit is generated when the transport electronics detect an EOF character (while reading). EOF formats differ for NRZI and PE tapes.
EOT	End-of-tape. A reflective EOT marker is placed 4.3 metres (14.0 feet) or more from the end of the tape. The EOT status signal is generated when the marker is sensed.
File	A group of records delimited by file marks.
File Mark	Another name for the end-of-file (EOF).
frpi	Flux reversals per inch of magnetic tape.
IBG	Interblock gap. Synonym for interrecord gap (IRG).
IRG	Interrecord gap. A dc-erased segment of tape which separates successive records. When tape motion stops, the read/write heads should be on an interrecord gap.
LRCC	Longitudinal redundancy check (LRC) character. A character written at the end of a record which contains an even parity bit for each track in the record. The total number of ones in a given track, including the CRCC and the LRCC, must be even. NRZI format only.
NRZI	Nonreturn to zero, inverted. A recording technique in which a logic one is represented by a flux inversion. Pronounced "narzy" in this manual.
PE	Phase-encoding. A recording technique in which a logic one is represented by a positive flux transition, logic zero by a negative flux transition, and successive ones or zeros are separated by an additional transition.
Postamble	A special character grouping which follows a PE record. The postamble consists of an all-ones character followed by 40 all-zeros characters.
Preamble	A special synchronization character grouping which precedes a PE record. The preamble consists of 40 all-zeros characters (3200 frpi) followed by an all-ones character.

Record — A group of characters. A record is the smallest data grouping which can be read from or written onto a tape while maintaining the data integrity checks, such as cyclic and longitudinal redundancy checks.

VRC — Vertical redundancy check. An odd parity check in a single 9-bit character.

USER'S RESPONSE SHEET

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Manual Date: 1 February 1980 **Date of This Letter:** ____________

User's Name: ____________ **Telephone:** ____________

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