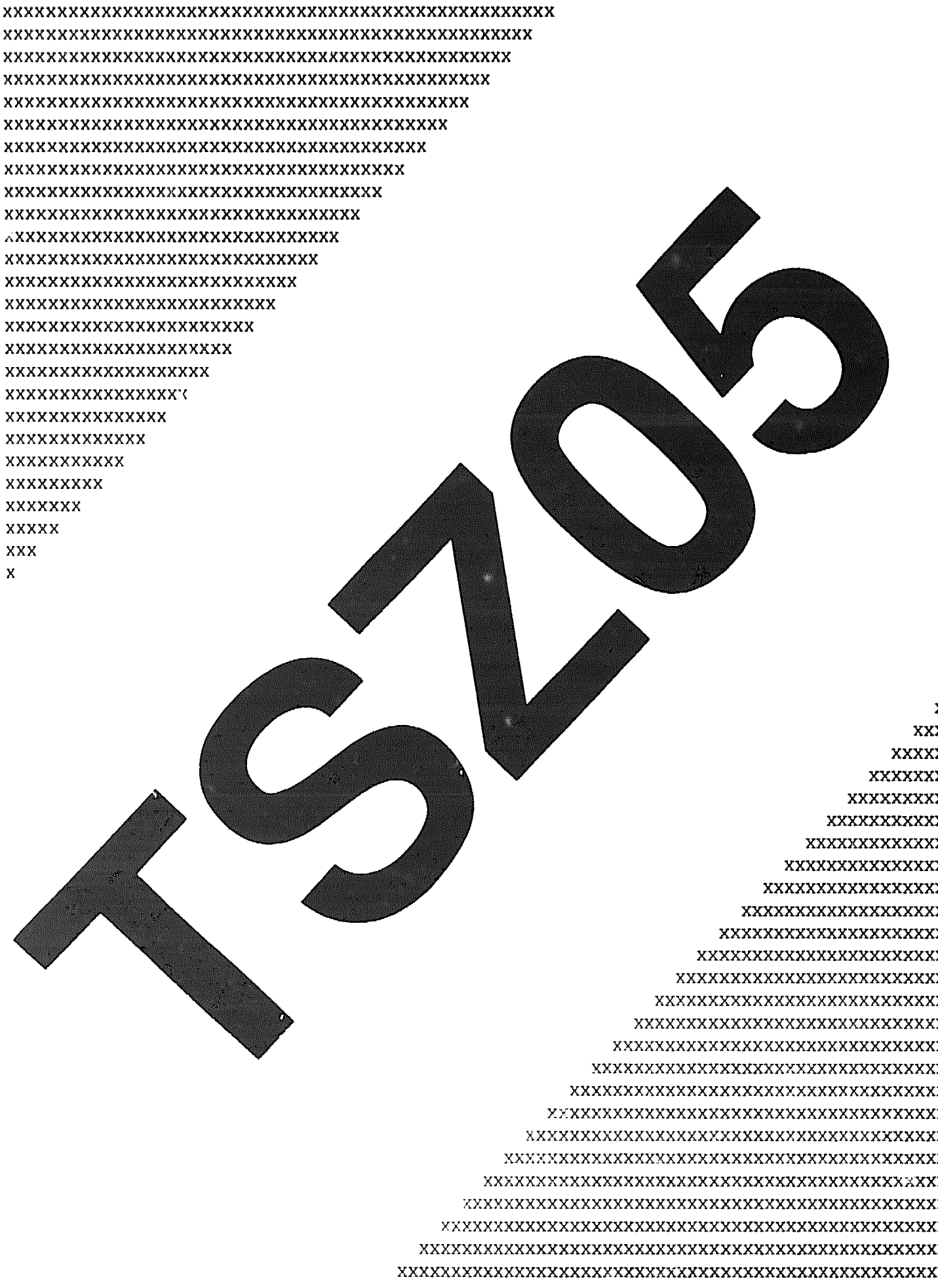
TSZ05

EK-TSZ05-TM-001

# TSZ05 Tape Drive

## Technical Manual

Prepared by Educational Services
of
Digital Equipment Corporation

1st Edition, July 1990



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# About This Manual

## OVERVIEW

This manual provides information necessary for programming, troubleshooting, and repairing the TSZ05 Tape Drive.

The information in this manual is directed toward Digital Customer Services personnel and is intended to address the maintenance needs of the TSZ05 Tape Drive.

- **Chapter 1** contains a general description along with specifications and a description of the switches and indicators.
- **Chapter 2** contains information on the Small Computer System Interface (SCSI). This information includes control signals, pin assignments, messages, status information, and SCSI commands. This information is helpful in understanding how to program or troubleshoot the system.
- **Chapter 3** contains information on the basic maintenance of the TSZ05 Tape Drive. The material covers the procedures involved for 20 hour, 40 hour, and 6 month maintenance.
- **Chapter 4** contains troubleshooting information such as LED error codes, SCSI diagnostic functions, and service aid diagnostics.
- **Chapter 5** contains removal and replacement procedures for all field replaceable units (FRUs)

## RELATED DOCUMENTATION

The following are publications that support the TSZ05 Tape Drive.

### Digital Related Documents

- *TSZ05 Tape Drive Owner's Manual* (EK-TSZ05-OM)
- *TSZ05 Tape Drive Installation Guide* (EK-TSZ05-IM)
- *TSZ05 Tape Drive Pocket Service Guide* (EK-TSZ05-PS)

### CIPHER Related Documents

- *Model F880ES Technical Manual* (799944-001)


CHAPTER 1

# 1
# INTRODUCTION

## 1.1 GENERAL DESCRIPTION

The TSZ05 Tape Drive is a 1600 bpi magnetic tape drive designed to provide backup for high-capacity disk drives and to provide for an interchange of data between systems. The TSZ05 Tape Drive exchanges data with other components of a system and transfers that data to and from half-inch magnetic tape on 7 inch, 8.5 inch, and 10.5 inch reels.

The TSZ05 Tape Drive consists of three functional components: the interface, the drive electronics, and the drive mechanism. These three components interact to accomplish the various functions performed by the tape drive.

Data to be written on the magnetic tape is received from the Small Computer Systems Interface (SCSI) bus, and data read from the magnetic tape is transferred to the SCSI bus. A microprocessor is used to accomplish this transfer of data to and from the magnetic tape. The microprocessor interprets commands from the interface to:

- Accelerate and decelerate the tape
- Position the tape at the read/write head
- Detect tape position
- Control formatting
- Provide status outputs

The interface translates SCSI commands into drive executable commands, and tra' ..ates tape drive data and status signals into the appropriate format for the SCSI bus.

Data is written on the tape in accordance with ANSI Standard X3.39-1986. Nine tracks (eight tracks of data and a parity track) are written simultaneously across the width of the tape.

The TSZ05 Tape Drive is self-loading. Tape is automatically threaded, positioned at beginning-of-tape (BOT), and properly tensioned.

The drive mechanism uses two direct-drive dc torque motors, an optical tachometer assembly that senses tape speed and position, and a servo-drive that eliminates the need for a capstan.

Tape movement is controlled primarily by the take-up servo and the tachometer. The velocity information generated by the tachometer is coupled with the take-up servo to produce a voltage proportional to the angular velocity of the take-up reel. This voltage is compared to the reference voltage from the ramp generator and the difference is used to control the take-up reel. The tape path has five roller guides, a dual-gap head, and a tape cleaner. The roller guides, positioned on each side of the head, are designed to minimize friction, skew, and the effects of tape-width variations.

## 1.2 MODEL VARIATIONS

Table 1–1 lists the model variations of the TSZ05 Tape Drive.

**Table 1–1 Model Variations**

| Model Number | Voltage Rating |
|---|---|
| TSZ05-AA | 120 Volts |
| TSZ05-AB | 240 Volts |
| TSZ05-AC | 100 Volts |
| TSZ05-AD | 220 Volts |

## 1.3 SPECIFICATIONS

Refer to the following sections for the TSZ05 electrical, mechanical, environmental, and performance specifications.

### 1.3.1 Electrical Specifications

The TSZ05 Tape Drive complies with Underwriters' Laboratory (UL) for power cord grounded equipment, VDE/TUV (German standards and testing organizations), and Canadian Standards Association (CSA) requirements. Table 1–2 provides the electrical specifications for the TSZ05 Tape Drive.

**Table 1–2 Electrical Specifications**

| Voltage | Current | Frequency | Voltage Rating |
|---|---|---|---|
| 100 Vac | 1.20 A | 49 to 63 Hz | 100 |
| 120 Vac | 1.00 A | 49 to 63 Hz | 115/120 |
| 220 Vac | 0.53 A | 49 to 63 Hz | 208/220 |
| 240 Vac | 0.47 A | 49 to 63 Hz | 230/240 |

The TSZ05 Tape Drive operates at 220 W maximum with a 750 BTUs per hour maximum heat dissipation.

## 1.3.2 Mechanical Specifications

The following are the mechanical specifications for the TSZ05 Tape Drive.

- Height: 26.9 cm (10.59 in.)
- Width: 50.5 cm (19.88 in.)
- Depth: 68.4 cm (26.94 in.)
- Weight: 43 kg (97 lbs)

## 1.3.3 Environmental Specifications

### Acoustic Noise Emission

55 dBA maximum measured from bystander position

### Operating Temperature

10°C to 40°C (50°F to 104°F)

15°C to 32°C (59°F to 90°F) with tape loaded

### Relative Humidity

20% to 85% noncondensing

20% to 80% noncondensing (with tape loaded)

### Operating Altitude

3 kilometers (10,000 ft) maximum

## 1.3.4 Performance Specifications

### Data Capacity (Unformatted)

46 unformatted megabytes (2400-foot tape)

### Head-to-Tape Data Transfer Rate

40 kilobytes per second at 25 ips

160 kilobytes per second at 100 ips

**NOTE**

**The TSZ05 Tape Drive will stream up to 100 inches per second for data block sizes not exceeding 32 Kbytes.**

### Interface Burst Rate

1.5 megabytes per second maximum, asynchronous

### Recording Speeds

25 and 100 inches per second

### Recording Density

1600 bits per inch (bpi)

### Rewind Speed

175 inches per second (average)

### Operating Times

| Operation | 25 ips | 100 ips † |
|---|---|---|
| Data Access | 40 ms | 260 ms |
| Reposition | 120 ms | 780 ms |
| Write Reinstruct | 10.0 to 11.0 ms | 2.0 to 3.5 ms |
| Read Forward Reinstruct | 16.0 to 18.0 ms | 3.0 to 4.0 ms |

†Actual performance is dependent on system capability. The TSZ05 will stream up to 100 inches per second for data block sizes not exceeding 32 Kbytes

## 1.4 FRONT PANEL

The TSZ05 Tape Drive front panel (Figure 1–1) contains switches and indicators that allow the operator to perform various functions or to determine the status of the tape drive. The switches and indicators are described in Table 1–3.

**NOTE**

**When the tape drive is in test mode, is powering up, or encounters an error, the front panel LEDs provide information for fault isolation. If an error occurs, the LEDs flash a code that indicates the type of error encountered. More information on fault isolation is found in Chapter 4.**

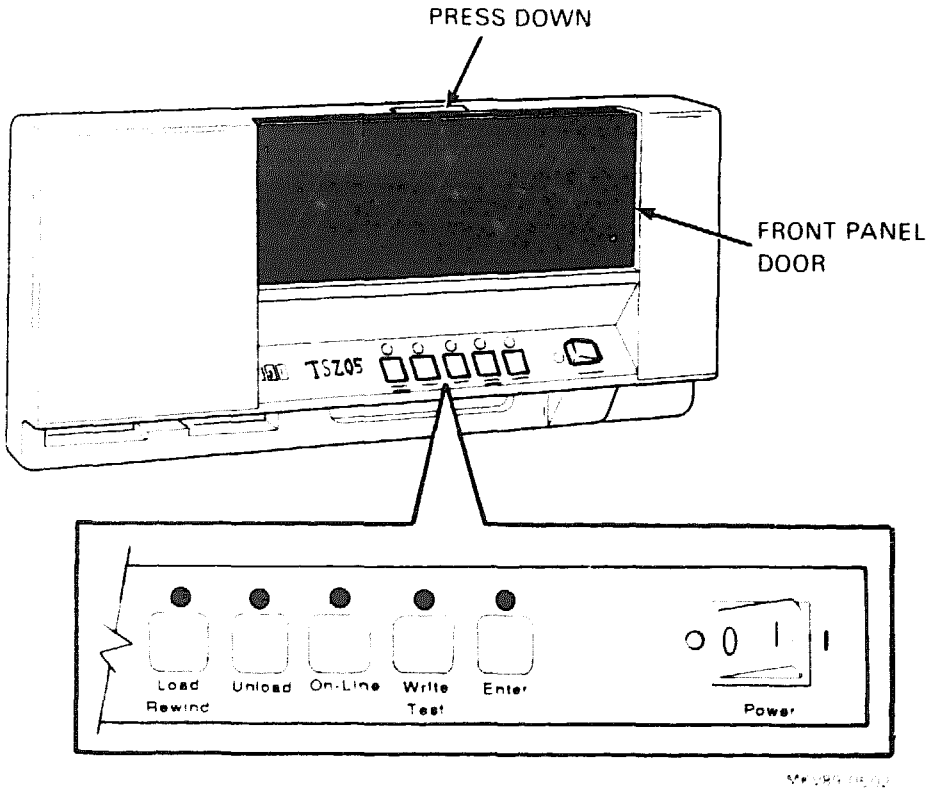
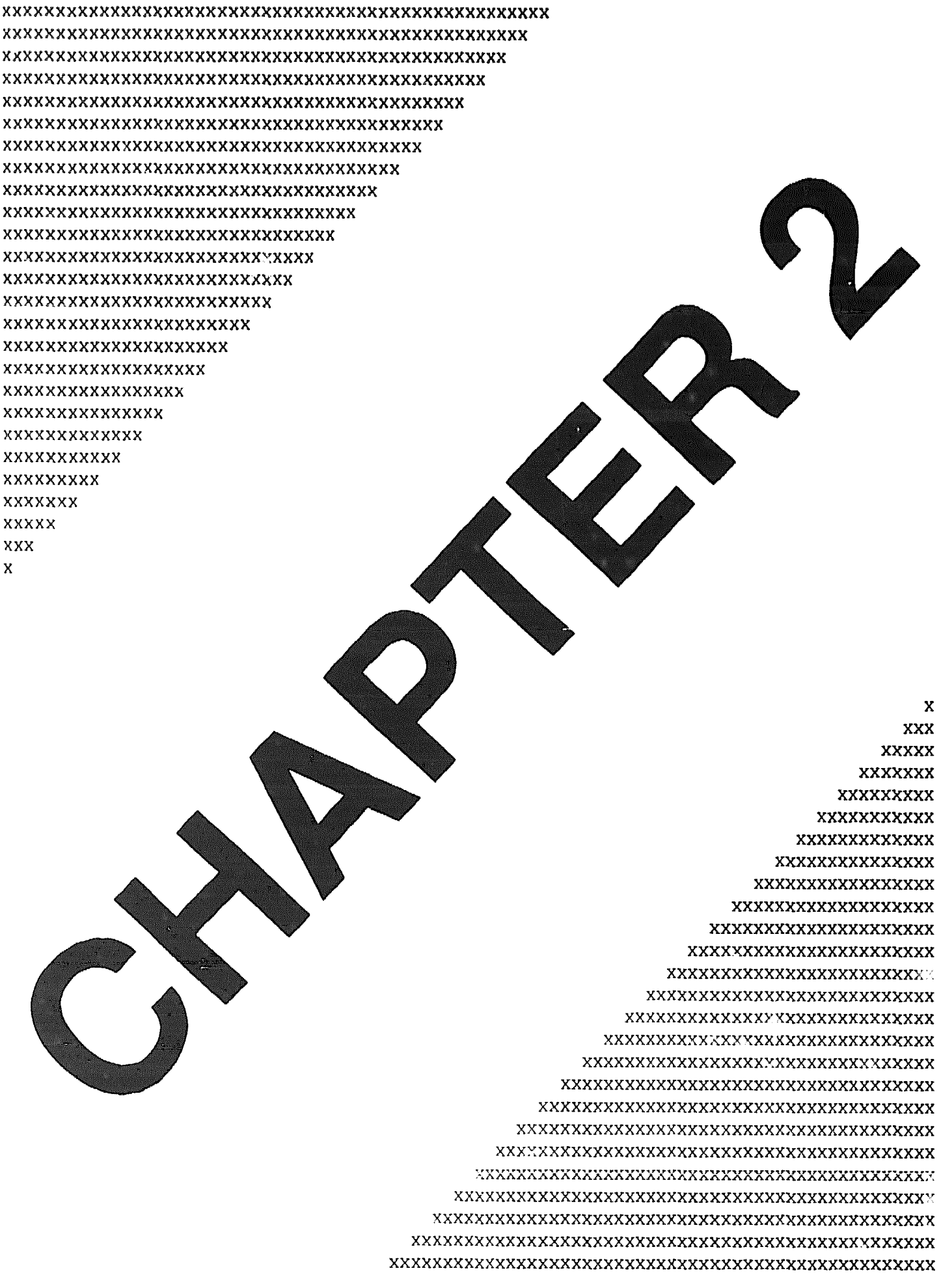



Figure 1–1 TSZ05 Front Panel

**Table 1–3 Switches and Indicators**

| Switch/Indicator | Function |
|---|---|
| Load/Rewind Switch | This switch, when pressed, causes the tape to advance to beginning-of-tape (BOT) during a load sequence or rewind to BOT. This switch is disabled when the unit is on-line or if either the top cover or front door is open. |
| Load/Rewind Indicator | This indicator flashes while tape is loading or rewinding. It then remains ON when either operation is complete to indicate that the tape is positioned with the BOT tab at the BOT photosensor. |
| Unload Switch | This switch, when pressed, causes the tape to unload. When the tape is unloaded, the access door unlocks allowing access to the tape reel. |
| Unload Indicator | This indicator flashes while the tape is unloading and then remains ON to indicate that tape is not loaded. |
| On-Line Switch | This switch places the tape drive either on-line or off-line. When the On-Line switch is pressed the first time, the tape drive is placed on-line (when the tape drive is on-line, all other switches are deactivated). When pressed the second time, the tape drive is placed off-line. |
| On-Line Indicator | This indicator, when ON, indicates that the tape drive is on-line (capable of communicating with the host controller). |
| Write/Test Switch | This switch causes the tape drive to enter or exit the diagnostic mode. The tape drive must be off-line for this switch to function. The first time this switch is pressed, the tape drive enters the diagnostic mode. If the switch is pressed while the tape drive is in the diagnostic mode, the tape drive exits the diagnostic mode. |
| Write/Test Indicator | This indicator, when ON, shows that a write-enable ring is installed in the loaded tape reel. |
| Enter Switch | This switch in conjunction with the Load/Rewind switch allows the operator to bypass the autothreading sequence for manual threading of tapes with damaged leaders. |
| Enter Indicator | This indicator in conjunction with the other indicators is used to indicate tape drive errors to the operator. |


CHAPTER 2

# 2
# SMALL COMPUTER SYSTEM INTERFACE

## 2.1 INTRODUCTION

The Small Computer System Interface (SCSI) consists of circuitry and a bus for handling control signals, messages, status bytes, and commands.

The SCSI generates signals and translates tape drive data and status information into the appropriate format for the SCSI bus. Commands presented to the SCSI bus are translated into drive executable commands by the interface.

## 2.2 CONTROL SIGNALS

The definitions of the SCSI signals are provided in Table 2–1. On single-ended interfaces, signals are active-low. Table 2–2 provides pinout information for the single-ended connectors.

**Table 2–1 SCSI Control Signals**

| Signal Name | Description |
|---|---|
| Acknowledge (ACK) | Set by an initiator to acknowledge a REQ/ACK data transfer handshake. |
| Attention (ATN) | Set by an initiator to indicate the Attention condition. |
| Busy (BSY) | Indicates that the bus is being used. |
| Control/Data (C/D) | Indicates whether control information or data is on the bus. A true signal indicates control. |
| Data Bits (DB0-7, P) | There are eight data bits and a parity bit. DB7 is the most significant bit and has the highest priorty during arbitration. Parity is odd. |
| Input/Output (I/O) | This signal controls the direction of data movement on the bus with respect to an initiator. A true signal indicates input to the initiator. This signal is also used to distinguish between the Selection and Reselection phases. |
| Message (MSG) | This signal is set active during the Message phase. |
| Request (REQ) | This signal is set active to request a REQ/ACK data handshake. |
| Reset (RST) | Indicates the Reset condition. |
| Select (SEL) | Set active to select a target or to reselect an initiator. |

**Table 2–2 Pin Assignments for the Single-Ended Unshielded Connections**

| Signal | Contact Number | Contact Number | Signal† |
|---|---|---|---|
| Ground | 1 | 26 | -DB0 |
| Ground | 2 | 27 | -DB1 |
| Ground | 3 | 28 | -DB2 |
| Ground | 4 | 29 | -DB3 |
| Ground | 5 | 30 | -DB4 |
| Ground | 6 | 31 | -DB5 |
| Ground | 7 | 32 | -DB6 |
| Ground | 8 | 33 | -DB7 |
| Ground | 9 | 34 | -DBP |
| Ground | 10 | 35 | Ground |
| Ground | 11 | 36 | Ground |
| Ground | 12 | 37 | Ground |
| OPEN | 13 | 38 | TERMPWR |
| Ground | 14 | 39 | Ground |
| Ground | 15 | 40 | Ground |
| Ground | 16 | 41 | -ATN |
| Ground | 17 | 42 | Ground |
| Ground | 18 | 43 | -BSY |
| Ground | 19 | 44 | -ACK |
| Ground | 20 | 45 | -RST |
| Ground | 21 | 46 | -MSG |
| Ground | 22 | 47 | -SEL |
| Ground | 23 | 48 | -C/D |
| Ground | 24 | 49 | -REQ |
| Ground | 25 | 50 | -I/O |

†A minus sign indicates an active low signal

## 2.3 MESSAGES

Messages are sent over the SCSI bus to allow the initiator and target to communicate information that helps manage the physical path. The valid messages are listed in Table 2–3.

**Table 2–3 Message Set**

| Message | Description | Direction |
|---|---|---|
| 00h | Command complete | In |
| 02h | Save data pointer | In |
| 03h | Restore pointers | In |
| 04h | Disconnect | In/Out |
| 05h | Initiator detected error | Out |
| 06h | Abort | Out |
| 07h | Message reject | In/Out |
| 08h | No operation | Out |
| 09h | Message parity error | Out |
| 0Ch | Bus device reset | Out |
| 80-FFh | Identify | In/Out |

## 2.4 STATUS

A status byte is sent by the target to the initiator during the status phase of a data transfer, unless the command was cleared by an Abort message, Bus Device Reset message, a Hard Reset condition, or an unexpected Bus Free condition. Table 2–4 lists the status valid bytes.

**Table 2–4 Status Bytes**

| Status Byte | Description |
|---|---|
| 00h | Good |
| 02h | Check Condition |
| 08h | Busy |
| 18h | Reservation Conflict |

## 2.5 COMMANDS

Commands issued to the TSZ05 Tape Drive are sent by way of the Small Computer System Interface (SCSI) bus. The valid commands and their hexadecimal code are listed in Table 2–5. More information on each command is provided in Section 2.5.2. The tape drive is capable of receiving and storing two commands at a time. Additional commands are queued in the form of logical unit number (LUN) and initiator identifier. When the tape drive is ready, it selects the next command from the queue and requests that the initiator send command data. If the command cannot be executed immediately because the tape drive is active, a Busy status byte is returned to the initiator. In general, no other command can execute while the tape drive is busy except the Test Unit Ready, Inquiry, and Read Block Limits commands.

**Table 2–5 TSZ05 SCSI Commands**

| Command | Description | Hex Code |
|---|---|---|
| Copy | Allows the transfer of data to and from the tape drive, without using computer resources. | 18 |
| Erase | Directs the tape drive to erase part or all of the remaining data beginning at the current tape position. | 19 |
| Inquiry | Instructs the tape drive to transfer information that identifies the tape drive to the initiator. | 12 |
| Load/Unload | Rewinds or unloads a tape | 1B |
| Mode Select | Allows the initiator to set parameters for the tape drive, including buffered and unbuffered writes to tape with fixed or variable block sizes | 15 |
| Mode Sense | Allows the tape drive to report the parameters set by the Mode Select command. | 1A |
| Read | Transfers data from the tape drive to the initiator, starting at the current logical position. The amount of data to be transferred is specified in the Command Descriptor Block (CDB) | 08 |
| Read Block Limits | Returns the tape drive's logical block-length limits. | 05 |
| Read Reverse | Functions exactly like the Read command except that the tape is read in reverse. | 0F |
| Receive Diagnostic | Causes the tape drive to return to the initiator the results of specific diagnostic commands sent by the initiator. | 1C |
| Recover Buffered Data | Recovers data that has been transmitted to the buffer, but not yet written to tape. | 14 |
| Release Unit | Releases the tape drive if it was previously reserved by the initiator. | 17 |
| Request Sense | Obtains Sense information from the tape drive, usually when the initiator has received a Check Condition status byte from a previous command. | 03 |
| Reserve Unit | Reserves the tape drive for exclusive use of the requesting initiator. | 16 |
| Rewind | Rewinds the tape to BOT. | 01 |
| Send Diagnostic | Requests that diagnostic tests be performed on the SCSI controller or the peripheral device. | 1D |

**Table 2–5 (Cont.) TSZ05 SCSI Commands**

| Command | Description | Hex Code |
|---|---|---|
| Space | Positions the tape relative to the read/write head. This positioning can move the tape to a specific data block, a data block following a specific file mark, or a data block following a specific series of file marks. | 11 |
| Test Unit Ready | Causes a fast test to determine whether the tape drive is powered ON, ready, and a tape is loaded. This command returns the status of the tape drive. | 00 |
| Verify | Allows one or more data blocks, starting at the current tape position, to be checked without transferring the data to the initiator. | 13 |
| Write | Transfers a specified number of blocks of data from an initiator to the tape drive and writes those blocks to tape. | 0A |
| Write File Mark | Completes any Write or Copy command in process or writes zero or more file marks starting at the current logical tape position. | 10 |

## 2.5.1 Command Descriptor Block

Each command is presented to the SCSI bus in a Command Descriptor Block (CDB). Figure 2–1 is a generic representation of a CDB. The information in each byte of the CDB is explained on the following page.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | Command Group Code | | | Command Code | | | | |
| 01 | Logical Unit Number | | | Command Dependent | | | | |
| 02 | Command Dependent | | | | | | | |
| 03 | Command Dependent | | | | | | | |
| 04 | Command Dependent | | | | | | | |
| 05 | Control Byte | | | | | | | |

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**Figure 2–1 Command Descriptor Block**

### Command Code

This byte contains the hexadecimal number that identifies the command.

### Logical Unit Number

The Logical Unit Number is *always* set to 000. However, if the system implements the Identify mesage (which is part of the Attention-Identify sequence sent by the initiator), the LUN in the message takes precedence over the LUN in the CDB.

### Command Dependent Information

The command dependent information can include the following.

- Logical block address
- Transfer length
- Parameter list length
- Allocation length

**Logical Block Address**—Contains the address of the logical block of data.

**Transfer Length**—Specifies the maximum number of blocks or bytes of data to be transferred. Transfer Length can be several bytes in length. Commands that use two bytes for the transfer length can transfer up to 65,535 blocks of data. If the transfer length is zero, there is no transfer.

**Parameter List Length**—Sets the number of bytes in the parameters sent during the Data Out phase of the command.

**Allocation Length**—Sets the transfer length of the command. This is the number of bytes reserved for returned data during the Data In phase of the command.

### Control Byte

The control byte is the last byte of every CDB. All bits of this byte are set to zero. The Flag bit (bit 1) and the Link bit (bit 0) are not supported.

## 2.5.2 Copy (18h)

The Copy command allows the transfer of data from the tape drive to another device, or from another device to the tape drive. This is accomplished without using computer resources. Third-party transfers are not allowed, so the tape drive must be the source or the destination.

Another SCSI ID must be specified as the source or the destination device. The data is transferred off-line, so the host SCSI controller must support the Disconnect function or else the Copy command terminates with an error.

If the tape drive's buffer has data blocks not yet written to tape, the data blocks are written before the Copy command is performed.

The initiator of the Copy command is responsible for correctly positioning sequential devices (tape position) before sending the command, and for any external device's error recovery. Because the tape drive functions as either the initiator or the target during the Copy command, normal read and write errors can occur.

If end-of-data is encountered during a copy where the drive is the source, the Valid bit is set to one, and the command terminates. The Variable Block Mode also sets the ILI (Incorrect Length Indicator) bit to one. The tape is positioned logically after the last recorded data block or file mark.

The Copy command is always the highest priority relative to other commands.

### The Copy CDB

The contents of the Copy CDB are shown in Figure 2–2.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02 | Parameter List Length (MSB) | | | | | | | |
| 03 | Parameter List Length | | | | | | | |
| 04 | Parameter List Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

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**Figure 2–2 Copy Command Descriptor Block**

The Parameter List Length specifies the number of bytes in the parameters sent during the Data Out phase. This list is sent to the tape drive as data with up to 256 segment descriptors, provided they do not exceed the Parameter List Length. With a length of zero no data is sent; this does not cause an error. The Copy Parameter has a Parameter List Header as shown in Figure 2–3.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | Copy Function Code | | | | | 0 | 0 | 0 |
| 01-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02-N | Segment Descriptors | | | | | | | |

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**Figure 2–3 Copy Command Parameter List Header**

The Copy Function Code defines the type of transfer. The valid codes are:

- 00h = Direct-Access to Sequential-Access
- 01h = Sequential-Access to Direct-Access

The segment descriptors use the Direct-Access Device and Sequential-Access Device format provided in Figure 2–4. This format is required for the Copy command's function codes 00h and 01h. The segment descriptors can be repeated up to 256 times within the parameter list specified in the descriptor block.

**The Source Address**

Specifies the SCSI device sending the data.

**The Source LUN**

Identifies the Logical Unit Number of the SCSI device sending data.

**The Destination Address**

Specifies the SCSI device receiving the data.

**The Destination LUN**

Identifies the Logical Unit Number of the SCSI device receiving the data.

**The Sequential-Access Device Block Length**

Identifies the Copy command's block length for the Sequential-Access Device. If the size is recognized as not supported before or during processing, the command is rejected.

**The Direct-Access Device Number of Blocks**

Specifies the number of blocks in the current segment. A zero value signifies that no blocks are to be transferred in this segment.

**The Direct-Access Device Logical Block Address**

Specifies the starting address of the blocks to be transferred.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | Source Address | | | 0 | 0 | Source LUN | | |
| 01 | Destination Address | | | 0 | 0 | Destination LUN | | |
| 02 | Sequential-Access Device Block Length (MSB) | | | | | | | |
| 03 | Sequential-Access Device Block Length (LSB) | | | | | | | |
| 04 | Direct-Access Device Number of Blocks (MSB) | | | | | | | |
| 05 | Direct-Access Device Number of Blocks | | | | | | | |
| ( ) | Direct-Access Device Number of Blocks | | | | | | | |
| 07 | Direct-Access Device Number of Blocks (LSB) | | | | | | | |
| 08 | Direct-Access Device Logical Block Address (MSB) | | | | | | | |
| 09 | Direct-Access Device Logical Block Address | | | | | | | |
| 10 | Direct-Access Device Logical Block Address | | | | | | | |
| 11 | Direct-Access Device Logical Block Address (LSB) | | | | | | | |

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**Figure 2–4 Segment Descriptor for Copy Function Codes 00h and 01h**

### 2.5.3 Erase (19h)

The Erase command directs the tape drive to erase part or all of the remaining data beginning at the current tape position.

If the buffer contains data from a previous Write command, the drive is synchronized by writing all data in the buffer to tape before the Erase is executed.

The drive can disconnect from the initiator while executing the Erase command.

**The Erase CDB**

The contents of the Erase CDB are shown in Figure 2–5.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | Long |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

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**Figure 2–5 Erase Command Descriptor Block**

With the Long bit set to zero, the drive erases approximately four inches of tape. With the Long bit set to one, the drive erases the remainder of the tape and rewinds to BOT.

## 2.5.4 Inquiry (12h)

The Inquiry command instructs the tape drive to transfer information that identifies the tape drive to the initiator.

If an Inquiry command is received from an initiator with a pending Unit Attention condition (before the drive reports Check Condition status), the drive performs the Inquiry command and does not clear the Unit Attention condition.

### The Inquiry CDB

The contents of the Inquiry CDB are shown in Figure 2–6.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 | Allocation Length | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

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**Figure 2–6 Inquiry Command Descriptor Block**

The Allocation Length byte of the CDB specifies the maximum number of bytes the initiator has allocated for Inquiry data. A zero means no data is to be returned and this is not considered an error. The tape drive terminates the data transfer when the requested amount, or all the data available, has been transferred (whichever is less). The data is listed in Table 2–6.

**Table 2–6 Inquiry Data**

| Byte | Hex Value | Meaning |
|---|---|---|
| 0 | 01 | Sequential-Access device |
| 1 | C5 | Half-inch reel tape |
| 2 | 01 | ANSI SCSI-1 compliance |
| 3 | 00 | Reserved |
| 4 | 27 | Additional valid bytes |
| 5 | C1 | Features SCSI extended commands with ECC and SLI |
| 6-7 | 00 | Reserved |
| 8-10 | XX | DEC |
| 11-15 | 20 | ASCII space character |
| 16-20 | XX | TSZ05 |
| 21-23 | 20 | ASCII space character |
| 24-31 | XX | (C) DEC |
| 33-33 | XX | ROM level in hex |
| 34-35 | XX | RAM level in hex |
| 36-43 | 20 | ASCII space character |

## 2.5.5 Load/Unload (1Bh)

The Load/Unload command rewinds or unloads a tape. After the command is received, the drive disconnects from the SCSI bus. If write data is in the buffer, the drive is synchronized by writing all the data in the buffer to tape before this command is executed.

### The Load/Unload CDB

The contents the Load/Unload CDB are shown in Figure 2–7. If set to one, the Immediate bit causes status to be returned immediately. If set to zero, status is returned after the command is executed.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | Immediate |
| 02-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 | 0 | 0 | 0 | 0 | 0 | 0 | Retension | Load |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS007_90

**Figure 2–7 Load/Unload Command Descriptor Block**

The Retension bit, if set to one, causes the command to rewind the tape to BOT if a reel is loaded and the tape drive is on-line.

The Load bit, if set to one, causes the command to rewind the tape to BOT if a reel is loaded and the tape drive is on-line.

If the Retension and Load bits are zero, the tape is rewound and unthreaded.

## 2.5.6 Mode Select (15h)

The Mode Select command allows the initiator to set parameters for the tape drive, including buffered and unbuffered writes to tape with fixed or variable block sizes. If the command is issued with an incorrect block descriptor, the drive rejects it.

### The Mode Select CDB

The contents of the Mode Select CDB are shown in Figure 2–8.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 | Parameter List Length | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS008_90

**Figure 2–8 Mode Select Command Descriptor Block**

Parameter List Length specifies the number of bytes to be sent to the drive during the Data Out phase. If the drive receives a zero, it does not transfer any data but does not treat the response as an error.

The Mode Select Parameter List contains the header shown in Figure 2–9, followed by the block descriptor shown in Figure 2–10, followed by zero or the Page Zero Descriptor shown in Figure 2–11.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00-01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02 | 0 | 0 | 0 | BUFM | 0 | 0 | Speed | |
| 03 | 0 | 0 | 0 | 0 | BDL | 0 | 0 | 0 |

MKV_VS009_90

**Figure 2–9 Mode Select Parameter List Header**

The BUFM (Buffered Mode) bit is set to one for the Buffered Mode (the default setting) and zero for the Unbuffered Mode. In the Buffered Mode the drive sends a Good status message for write commands as soon as the last data block has been transferred to the buffer. In the Unbuffered Mode the drive does not send a Good status message for write commands until *all* data has been written to tape.

The Speed bits specify the drive's operating speed as follows:

- 00 = 100 inches per second
- 01 = 25 inches per second
- 10 = 100 inches per second (default)
- 11 = Automatic speed control

Automatic speed control allows the tape drive to run at high speed until six tape underruns occur during consecutive read or write commands. The drive then switches to low speed in an attempt to eliminate the underruns. It remains in low speed until a file mark is written or read, or a different command is issued to the drive. It then switches back to high speed.

The BDL (Block Descriptor Length) bit specifies the length in bytes of the block descriptor. If set to zero, there are no block descriptors in the parameter list; this is not an error.

The Density Code is defined as follows:

- 0h = 1600 bits per inch
- 2h = 1600 bits per inch (default)

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | Density Code | | | |
| 01-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | Block Length (MSB) | | | | | | | |
| 06 | Block Length | | | | | | | |
| 07 | Block Length (LSB) | | | | | | | |

MKV_VS010_90

**Figure 2–10 Mode Select Block Descriptor**

The Block Length sets the length in bytes (to a maximum of 64K), of the logical block used for the Fixed Length Block mode. If the Block Length is zero, the length is variable based on the length specified for each command. The default block length is 200h.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 02 | 0 | 0 | 0 | 0 | 0 | 0 | PER | RDEW |

MKV_VS011_90

**Figure 2–11 Mode Select Page Zero Descriptor**

The PER (Post Error) bit set to one indicates the drive is to report corrected errors; set to zero (default), it does not report them.

The RDEW (Report Early-Warning End-of-Medium on Read) bit, if set to one, causes the drive to return Check Condition with the EOM bit in the Extended Sense set to one during a read or a write. If set to zero, the drive reports this only during a write.

## 2.5.7 Mode Sense (1Ah)

The Mode Sense command allows the tape drive to report the parameters set by the Mode Select command.

### The Mode Sense CDB

The contents of the Mode Sense CDB are shown in Figure 2–12.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02-03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 | Allocation Length | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS012_90

**Figure 2–12 Mode Sense Command Descriptor Block**

The Allocation Length specifies the maximum number of bytes of Mode Sense data to be transferred. If set to zero, no data is transferred; this is not an error.

The Mode Sense Parameter List contains the header shown in Figure 2–13. It also has the same block descriptor (Figure 2–10) and Page Zero Descriptor (Figure 2–11) as the Mode Select command.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02 | WP | 0 | 0 | BUFM | 0 | 0 | Speed | |
| 03 | 0 | 0 | 0 | 0 | BDL | 0 | 0 | 0 |

MKV_VS013_90

**Figure 2–13 Mode Sense Parameter List Header**

The WP (Write Protected) bit indicates whether the tape is write-enabled (zero) or write-protected (one).

The BUFM (Buffered Mode) bit is set to one for the Buffered Mode (the default setting) and zero for the Unbuffered Mode. In the Buffered Mode the drive sends a Good status message for write commands as soon as the last data block has been transferred to the buffer. In the Unbuffered Mode the drive does not send a Good status message for write commands until *all* data has been written to tape.

The Speed bits specify the drive's operating speed as follows.

- 00 = 100 inches per second
- 01 = 25 inches per second
- 10 = 100 inches per second (default)
- 11 = Automatic speed adjustment

See the Mode Select command section for an explanation of the automatic speed adjustment.

The BDL (Block Descriptor Length) bit specifies the length in bytes of the block descriptor. If set to zero, there are no block descriptors in the parameter list; this is not an error.

## 2.5.8 Read (08h)

The Read command transfers data from the tape drive to the initiator, starting at the current logical position. The amount of data to be transferred is specified in the CDB.

If a Read command is received with a byte or block count of zero, the command is treated as no operation, with a Complete status returned immediately. No data is transferred and no tape motion is started.

### The Read CDB

The contents of the Read CDB are shown in Figure 2–14.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | FBM |
| 02 | Transfer Length (MSB) | | | | | | | |
| 03 | Transfer Length | | | | | | | |
| 04 | Transfer Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS014_90

**Figure 2–14 Read Command Descriptor Block**

The FBM (Fixed Block Mode) bit, when set to zero, causes a single block to be transferred with the Transfer Length setting the maximum number of bytes that the initiator has allocated for data. If set to one, data blocks are transferred with the Transfer Length setting the number of blocks. The state of this bit must match the block mode specified in the current Mode Sense data.

In the Variable Block Mode, the Transfer Length sets the maximum block length to be transferred. In the Fixed Block Mode, this parameter specifies the number of blocks of the current block length to transfer to the initiator.

## 2.5.9 Read Block Limits (05h)

The Read Block Limits command returns the drive's logical block-length limits.

### The Read Block Limits CDB

The contents of the Read Block Limits CDB are shown in Figure 2–15. The format of the block-length data is shown in Figure 2–16. A value of 0001h is returned for the minimum block length (bytes 04 and 05 of Figure 2–16) and a value of 010000h for the maximum block length (bytes 01 to 03 of Figure 2–16).

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 1 |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS015_90

**Figure 2–15 Read Block Limits Command Descriptor Block**

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

MKV_VS016_90

**Figure 2–16 Read Block Limits Data**

## 2.5.10 Read Reverse (0Fh)

The Read Reverse command functions exactly like the Read command, except that the tape is read in reverse. In this mode blocks are read from the tape in the opposite direction they were written, and are placed in the buffer in the correct character sequence for transfer to the initiator. The amount of data to be transferred is specified in the CDB.

The buffer is checked before the Read Reverse command is executed. If it contains data from a previous Read Forward command, it is cleared and the tape is repositioned before executing the Read Reverse. If it contains data from a previous Write command, the data is written to tape before the Read Reverse is executed.

An End-of-Medium (EOM) status is returned if BOT is encountered and there were not enough blocks or bytes read to satisfy the Read Reverse command. The residue count contains the number of blocks or bytes not read.

### The Read Reverse CDB

The contents of the Read Reverse CDB are shown in Figure 2–17.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | FBM |
| 02 | Transfer Length (MSB) | | | | | | | |
| 03 | Transfer Length | | | | | | | |
| 04 | Transfer Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS017_90

**Figure 2–17 Read Reverse Command Descriptor Block**

The FBM (Fixed Block Mode) bit, when set to zero, causes a single block to be transferred with the Transfer Length setting the maximum number of bytes that the initiator has allocated for data. If set to one, data blocks are transferred with the Transfer Length setting the number of blocks. The state of this bit must match the block mode specified in the current Mode Sense data.

In the Variable Block Mode, the Transfer Length sets the maximum block length to be transferred. In the Fixed Block Mode, this parameter specifies the number of blocks of the current block length to transfer to the initiator.

## 2.5.11 Receive Diagnostic (1Ch)

The Receive Diagnostic command causes the tape drive to return to the initiator the results of specific diagnostic commands sent by the initiator. The command is only executed if a Send Diagnostic command has been processed by the drive. If a Send Diagnostic command was not processed, or another command was received since the Send Diagnostic command, the Receive Diagnostic command is rejected.

Only the Diagnostic Inquiry (D0) and Test Buffer (D1) functions of the Send Diagnostic command are supported.

### The Receive Diagnostic CDB

The contents of the Receive Diagnostic CDB are shown in Figure 2–18. The returned information is shown in Figure 2–19.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03 | Allocation Length (MSB) | | | | | | | |
| 04 | Allocation Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS018_90

**Figure 2–18 Receive Diagnostic Command Descriptor Block**

The Allocation Length specifies the maximum number of bytes the initiator has set for returned diagnostic data. If set to zero, no data is returned. When all the diagnostic data or the maximum specified number of bytes have been transferred, the drive terminates the Data In phase.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | Valid Data Flag | | | | | | | |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02 | Data Field Length (MSB) | | | | | | | |
| 03 | Data Field Length (LSB) | | | | | | | |
| 04 | Data Field | | | | | | | |
| 4 + N | Extended Sense Length | | | | | | | |
| 4 + N + 1 | Extended Sense Data | | | | | | | |

MKV_VS019_90

**Figure 2–19 Receive Diagnostic Results Data**

If set to zero, the Valid Data Flag signals that the data returned by the command is valid. If not zero, the data in the Data Field is invalid.

The Data Field Length specifies the amount of data to be returned in the Data Field. The Diagnostic Inquiry function (D0) returns 64 bytes of data in the Data Field. However, only the first two bytes contain valid data. The value of these bytes is **FFFF**h. The SCSI controller's buffer is tested by the Test Buffer function (D1) of the Send Diagnostic command. The Logical Block Offset value is supported. This value is multiplied by the mode-selected block size to obtain the byte offset into the buffer. On a Send Diagnostic command, the data is transferred into the buffer at this offset. On the Receive Diagnostic command, the data is then transferred from the buffer to the host.

Extended Sense Length specifies the amount of Extended Sense Data to be returned.

## 2.5.12 Recover Buffered Data (14h)

The Recover Buffered Data command recovers data that has been transmitted to the buffer, but not yet written to tape. The order of the recovered blocks is the same as if they were written to tape. This command is normally only used to recover from error or exception conditions that make it impossible to write the buffered data to tape. The command functions similarly to the Read command, except that data is transferred from the buffer.

### The Recover Buffered Data CDB

The contents of the Recover Buffered Data CDB are shown in Figure 2–20.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | FBM |
| 02 | Transfer Length (MSB) | | | | | | | |
| 03 | Transfer Length | | | | | | | |
| 04 | Transfer Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS020_90

**Figure 2–20 Recover Buffered Data Command Descriptor Block**

If set to zero, the FBM (Fixed Block Mode) bit causes a single block to be transferred with the Transfer Length setting the maximum number of bytes. If set to one, the Transfer Length sets the number of blocks to be transferred.

The Transfer Length, in Variable Block Mode, specifies the length of the block to be returned, which is the maximum number of bytes allocated by the initiator for returned data. In Fixed Block Mode, this parameter sets the number of blocks to be transferred from the buffer.

## 2.5.13 Release Unit (17h)

The Release Unit command is issued by an initiator to release a tape drive it had previously reserved. An initiator cannot release a drive reserved by another initiator, but an attempt to release a nonreserved drive does not cause an error. A drive cannot disconnect from an initiator during the execution of the command.

### The Release Unit CDB

The contents of the Release Unit CDB are shown in Figure 2–21.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 01 | Logical Unit Number | | | Third Party Release & ID | | | | |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

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**Figure 2–21 Release Unit Command Descriptor Block**

The Third Party Release and ID bits are not supported.

## 2.5.14 Request Sense (03h)

The Request Sense command obtains Sense information from the tape drive, usually when the initiator has received a Check Condition status byte from a previous command.

When a Check Condition is returned, the Sense data is saved in the drive. It is not cleared until a Request Sense command is received or an initiator issues another command that receives the Check Condition status. A Request Sense command can be issued at any time.

**The Request Sense CDB**

The contents of the Request Sense CDB are shown in Figure 2–22.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02-04 | Allocation Length | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS022_90

**Figure 2–22 Request Sense Command Descriptor Block**

The Allocation Length provides the number of bytes allocated by the initiator for Sense data. The length determines the format of the returned Sense data. If the length is zero, the first four bytes of Extended Sense data are transferred. Any other value represents the maximum defined number of Sense bytes to be transferred.

Data is transferred in the Extended Sense format. The required portion of the Extended Sense data is shown in Figure 2–23. The optional portion is shown in Figure 2–24 for the Copy command and in Figure 2–25 for other commands.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | Valid | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 01 | Segment Number | | | | | | | |
| 02 | File Mark | EOM | ILI | 0 | | Sense Key | | |
| 03 | Information Byte (MSB) | | | | | | | |
| 04 | Information Byte | | | | | | | |
| 05 | Information Byte | | | | | | | |
| 06 | Information Byte (LSB) | | | | | | | |
| 07 | Additional Sense Length | | | | | | | |

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**Figure 2–23 Extended Sense Data for All Commands, Bytes 0-7**

When one, the Valid bit indicates that the Information Bytes contain valid data.

The Segment Number contains the current segment number (0-256) if the Extended Sense is in response to a Copy command. For all other commands this byte is zero.

The File Mark bit, if set to one, indicates that a file mark was detected.

The EOM (End-of-Medium) bit indicates that if the drive is moving tape forward it has reached EOT. If the drive is moving tape in reverse, the command could not be completed because it reached BOT.

The ILI (Incorrect Length Indicator) bit indicates that the requested logical block length did not match the logical block length of the data on the tape.

The Sense Key provides the status of errors found during operation. See Table 2–7.

The Information Bytes, if set to zero, are not defined. If set to one, the bytes contain the residue (difference) in bytes (Variable Block Mode) or blocks (Fixed Block Mode) between the requested and the actual data length transferred, or the difference between the requested number of blocks and the number of blocks copied for the current segment descriptor of a Copy command. Negative values are indicated by twos-complement notation.

The Additional Sense Length specifies the number of additional Extended Sense data bytes to follow. If the allocation length of the CDB is too small to permit the transfer of all the Extended Sense data, the Additional Sense Length is not adjusted to reflect the truncation. The Additional Sense Data further define the Check Condition status, as shown in Figure 2–24 (for the Copy command) and in Figure 2–25 (for all commands other than Copy).

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 08 | Relative Byte Offset to Source's Status | | | | | | | |
| 09 | Relative Byte Offset to Destination's Status | | | | | | | |
| 10 | Completion Status | | | | | | | |
| 11 | Valid | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | File Mark | EOM | ILI | 0 | Sense Key | | | |
| 14 | Information Bytes (MSB) | | | | | | | |
| 15 | Information Bytes | | | | | | | |
| 16 | Information Bytes | | | | | | | |
| 17 | Information Bytes (LSB) | | | | | | | |
| 18 | Additional Sense Bytes | | | | | | | |
| 19-N | Device Specific Sense Data | | | | | | | |
| N+1 - N+6 | Copy CDB | | | | | | | |
| N+7 - N+10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| N+11 - N+14 | Copy Parameter List Header | | | | | | | |
| N+15 - N+26 | Copy Segment Descriptor List | | | | | | | |

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**Figure 2–24 Optional Extended Sense Data for a Copy Command**

The Relative Byte Offset to Source's Status provides the relative byte offset position for the first byte of the Copy command's Sense Data for the source.

The Relative Byte Offset to Destination's Status provides the relative byte offset position for the first byte of the Copy command's Sense Data for the destination.

The Valid bit, if set to one, indicates that bytes 4-17 contain valid Sense Information.

The File Mark bit, if set to one, indicates that a file mark was detected.

The EOM (End-of-Medium) bit indicates that if the drive is moving the tape forward, it has reached EOT. If the drive is moving the tape in reverse, the command could not be completed because it reached BOT.

The ILI (Incorrect Length Indicator) bit indicates the requested logical block length did not match the logical block length of the data on the tape.

Sense Key indicates the status of errors found during operation. See Table 2–7.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 08-11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12-14 | Additional Sense Codes | | | | | | | |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16-19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 0 | 0 | 0 | 0 | 0 | REACT | 0 | 0 |
| 21 | Retry Count | | | | | | | |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | HERR | CERR | FMK | IDENT | EOT | BOT | FBY | DBY |
| 24 | RDY | FPT | SPEED | ONL | 0 | REW | Drive Number | |
| 25 | Tape Status Port | | | | | | | |
| 26 | DMA Status Port | | | | | | | |
| 27-36 | Command Descriptor Block | | | | | | | |
| 37-40 | Parameter List Header | | | | | | | |
| 41-48 | Block Descriptor List | | | | | | | |
| 49-60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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**Figure 2–25 Optional Extended Sense Data for a Non-Copy Command**

The Additional Sense Codes are listed in Table 2–8.

The REACT (Recovery Action) bit indicates that no action is taken if set to zero. If set to one, the specified number of retries is attempted.

The Retry Count indicates the number of retries attempted.

The HERR (Hard Error) bit indicates a hard error.

The CERR (Corrected Error) bit indicates a corrected error.

The FMK (File Mark) bit indicates that a file mark was detected.

The IDENT (Identification) bit indicates that the identification burst was detected.

The EOT bit indicates End-of-Tape.

The BOT bit indicates Beginning-of-Tape.

The FBY (Formatter Busy) bit indicates that the formatter is busy, that is, tape moving.

The DBY (Data Busy) bit indicates that a command is in progress.

The RDY (Ready) bit indicates that the tape is loaded and ready; it is not used during write commands.

The FPT (File Protect) bit indicates that the tape is write-protected.

The SPEED bit indicates 100 inches per second when set to one, and 25 inches per second when set to zero.

The ONL (On-Line) bit indicates whether the drive is on-line (one) or off-line (zero).

The REW (Rewind) bit indicates that the drive is rewinding the tape.

The two Drive Number bits indicate the drive unit number.

The Tape Status Port provides status. See Table 2–9.

The DMA Status Port provides status. See Table 2–10.

The Command Descriptor Block repeats the CDB of the command that caused the error.

The Parameter List Header repeats the header of the command that caused the error when the command is a Mode Select. Not used for other commands (all bytes are zero).

The Block Descriptor List repeats the list for a Mode Select command. Not used for other commands (all bytes are zero).

**Table 2–7 Sense Keys**

| Hex Code | Sense Key | Explanation |
|---|---|---|
| 0 | No Sense | No Sense key data to be reported. |
| 1 | Recovered Error | Command completed successfully with some recovery action. |
| 2 | Not Ready | The tape drive cannot be accessed. |
| 3 | Medium Error | Command terminated with an unrecovered error probably due to the tape. |
| 4 | Hardware Error | The tape drive detected a nonrecoverable hardware fault. |
| 5 | Illegal Request | Illegal parameter in CDB or in additional parameters. |
| 6 | Unit Attention | The tape may have been changed or the tape drive has been reset. |
| 7 | Data Protect | A write was attempted on a tape without a write-enable ring installed. |
| 8 | Blank Check | A read past end-of-data (EOD) was attempted. |
| A | Copy Aborted | Copy command aborted due to an error by the source or destination device. |
| B | Aborted Command | The tape drive aborted a command. |
| D | Volume Overflow | The tape drive reached end-of-tape (EOT) and unwritten data remains in the buffer. |

**Table 2–8 Additional Sense Codes**

| Hex Code | Additional Sense Code |
|---|---|
| 00 00 | No additional sense information |
| 00 04 | At BOT |
| 00 85 | Write File Mark Immediate bit error |
| 04 01 | Not ready; rewinding |
| 20 00 | Illegal command |
| 29 00 | Power-on occurred |
| 43 00 | Data buffer parity error |
| 4B 00 | Power-up failure |
| 50 00 | No data detected |
| 51 00 | Function timeout |
| 52 00 | Tape position error |
| 53 00 | Error occurred before command completion |
| 54 00 | Data buffer not empty |
| 55 00 | Fixed mode bit incorrectly set |
| 56 00 | Data transfer error: host to controller |
| 57 00 | Data transfer error: controller to host |
| 58 00 | Verify command with byte compare not supported |
| 59 00 | Space to EOD not supported |
| 5A 00 | Self-test not supported |
| 5B 00 | Command sequence error |
| 5C 00 | Unit select error |
| 5D 00 | Variable block length greater than 64K |
| 5E 00 | Unable to obtain buffer |
| 5F 00 | Command parameter error |
| 60 00 | Status error from target |
| 61 00 | Copy failed: host cannot disconnect |
| 62 00 | Controller detected retries; buffer parity |
| 63 00 | Controller detected retries; SCSI parity |
| 64 00 | Controller detected tape retries |
| 65 00 | Density change request not at BOT |
| 66 00 | Physical end of medium detected |
| 84 00 | Medium changed |

**Table 2–9 Tape Status Port Byte**

| Bit | Description |
|---|---|
| 7 | Tape TC (for level 0 diagnostics) |
| 6 | SCSI TC (for level 0 diagnostics) |
| 5 | Block underrun |
| 4 | SCSI DMA-generated parity (used for level 0 diagnostics) |
| 3 | Tape overrun |
| 2 | Parity in (used for level 0 diagnostics) |
| 1 | Tape DMA parity error |
| 0 | SCSI DMA parity error |

**Table 2–10 DMA Status Port Byte**

| Bit | Description |
|---|---|
| 7 | Tape DMA length terminal count (active low) |
| 6 | SCSI DMA length terminal count (active low) |
| 5 | Manual SCSI DMA request (for level 0 diagnostics) |
| 4 | Manual tape DMA request |
| 3 | Dynamic RAM refresh enable (active low) |
| 2 | SCSI to tape |
| 1 | Tape DMA enable |
| 0 | SCSI DMA enable |

## 2.5.15 Reserve Unit (16h)

The Reserve Unit command reserves the tape drive for the exclusive use of the requesting initiator. Once in force, any attempt by another initiator to reserve the same drive returns a Reservation Conflict status message. The command stays in effect until the drive is released by the requesting initiator, a Bus Device Reset message is received, or a Hard Reset occurs.

### The Reserve Unit CDB

The contents of the Reserve Unit CDB are shown in Figure 2–26.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 01 | Logical Unit Number | | | Third Party Reserve & ID | | | | |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_SV026_90

**Figure 2–26 Reserve Unit Command Descriptor Block**

The Third Party Reserve and ID bits are not supported.

## 2.5.16 Rewind (01h)

The Rewind command rewinds the tape to BOT. If the Disconnect function is enabled, the drive disconnects from the initiator during the operation. If the buffer contains write data, the drive synchronizes the buffer by writing the data to tape before rewinding. If the buffer contains read data from a previous read command to the same initiator, the buffer is cleared; if it contains read data from another initiator, the data is preserved.

### The Rewind CDB

The contents of the Rewind CDB are shown in Figure 2–27.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | Immediate |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS027_90

**Figure 2–27 Rewind Command Descriptor Block**

The Immediate bit, if zero, causes a status message to be returned after the rewind is completed. If the bit is one, status is returned as soon as the rewind is initiated.

## 2.5.17 Send Diagnostic (1Dh)

The Send Diagnostic command causes the drive to execute a diagnostic test. The results of the diagnostic are stored by the drive. The initiator requests the results with the Receive Diagnostic command.

### The Send Diagnostic CDB

The contents of the Send Diagnostic CDB are shown in Figure 2–28.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | Self Test | DevOfL | UnitOfL |
| 02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03 | Parameter List Length (MSB) | | | | | | | |
| 04 | Parameter List Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS028_90

**Figure 2–28 Send Diagnostic Command Descriptor Block**

If the Self Test bit is set to one and the parameter list is zero, the drive returns a Good status message.

A DevOfL (Device Off-Line) bit of one enables diagnostic operations that may adversely affect operations to other logical units on the same target.

A UnitOfL (Unit Off-Line) bit of one enables diagnostic operations that may adversely affect operations to other logical units on the same target.

Parameter List Length specifies the length in bytes of the parameter list to be transferred. A length of zero indicates that no data will be transferred; this is not considered an error.

The format for the Send Diagnostic Data sent by the initiator as part of the Send Diagnostic command is shown in Figure 2–29.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | Diagnostic File Length (MSB) | | | | | | | |
| 01 | Diagnostic File Length (LSB) | | | | | | | |
| 02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03 | Diagnostic Function Code | | | | | | | |
| 04-05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 06 | Block Offset Value (MSB) | | | | | | | |
| 07 | Block Offset Value (LSB) | | | | | | | |
| 08 | Data Field Length (MSB) | | | | | | | |
| 09 | Data Field Length (LSB) | | | | | | | |
| 10+ N | Data Field | | | | | | | |

MKV_VS029_90

**Figure 2–29 Send Diagnostic Data**

Diagnostic File Length specifies the number of bytes belonging to the diagnostic parameter.

Diagnostic Function Code sets the diagnostic function to be executed. Diagnostic Inquiry function (D0h) returns information about the SCSI controller. Test Buffer function (D1h) tests the SCSI controller's buffer when it is empty. The Test Buffer function can only be issued when the buffer is empty unless the Device or the Unit Off-Line bit is set. If either of these bits are set to one and data remains in the buffer, the data is destroyed.

The Block Offset Value sets the offset value for the Test Data Buffer function (D1h). This value is multiplied by the current Mode Sense block size to find the offset in bytes. On a Send Diagnostic command, data is transferred to the buffer, starting at this offset. On the subsequent Receive Diagnostic command, the data is returned, starting at this offset.

The Data Field Length specifies the amount of data to be transferred to the buffer. The Data Field contains the actual data transferred to this buffer.

## 2.5.18 Space (11h)

The Space command positions the head and tape relative to a specific data block, a data block following a specific file mark, or a data block following a specific series of file marks. The Space command can change the current logical position by moving the tape forward or reverse from the current tape position. Movement is logically restricted to the current tape.

If there is write data in the buffer, the drive synchronizes the buffer by writing all blocks in the buffer to tape before performing the space operation.

### The Space CDB

The contents of the Space CDB are shown in Figure 2–30. If the command is received with a count of zero in the Count Bytes, the command is treated as no operation.

| Byte | Bits 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | Code | |
| 02 | Sign | Count (MSB) | | | | | | |
| 03 | Count | | | | | | | |
| 04 | Count (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS030_90

**Figure 2–30 Space Command Descriptor Block**

The Code bits specify the space operation as follows:

- 00 = Data blocks
- 01 = File marks
- 10 = Sequential file marks
- 11 = Not supported

When the Sign bit is positive, motion is logically forward. When it is negative, motion is logically reverse.

The Count bytes specify the number of file marks or data blocks to space over. A count of zero does not cause motion.

## 2.5.19 Test Unit Ready (00h)

The Test Unit Ready command returns the status of the drive. It causes a fast test to determine whether the drive is powered ON, ready, and tape is loaded.

### The Test Unit Ready CDB

The contents of the Test Unit Ready CDB are shown in Figure 2–31.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | 0 |
| 02-04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS031_90

**Figure 2–31 Test Unit Ready Command Descriptor Block**

## 2.5.20 Verify (13h)

The Verify command allows one or more data blocks, starting at the current tape position, to be checked without transferring the data to the initiator. The data to be verified is located in bytes two through four of the CDB.

If the buffer contains write data, the drive synchronizes the buffer by writing the blocks to tape before beginning the verify.

### The Verify CDB

The contents of the Verify CDB are shown in Figure 2–32.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | BytCmp | FBM |
| 02 | Verification Length (MSB) | | | | | | | |
| 03 | Verification Length | | | | | | | |
| 04 | Verification Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS032_90

**Figure 2–32 Verify Command Descriptor Block**

The BytCmp (Byte Compare) bit is not supported.

The FBM (Fixed Block Mode) bit verifies the next block if set to zero. If set to one, it requests that the number in the Verification Length be verified starting with the next logical block.

The Verification Length specifies the number of bytes to verify in the Variable Block Mode. In the Fixed Block Mode, it specifies the number of blocks to verify.

## 2.5.21 Write (0Ah)

The Write command transfers a specified number of blocks of data from an initiator to the tape drive and writes those blocks to tape. Data blocks can be fixed or variable length as specified in the Mode Select command. Writing can be buffered or unbuffered, which is also specified by the Mode Select command. If buffered, a status message is returned when the data for the last block is placed in the buffer. If unbuffered, a status message is not returned until the last block has been written to the tape. Unbuffered writes prevent the drive from streaming. A Write command following EOT is always written in the unbuffered mode.

### The Write CDB

The contents of the Write CDB are shown in Figure 2–33.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | FBM |
| 02 | Transfer Length (MSB) | | | | | | | |
| 03 | Transfer Length | | | | | | | |
| 04 | Transfer Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS033_90

**Figure 2–33 Write Command Descriptor Block**

If set to zero, the FBM (Fixed Block Mode) bit causes a single block to be written with the Transfer Length specifying the maximum number of bytes. If set to one, the Transfer Length specifies number of blocks.

The Transfer Length specifies the length of the blocks to be written in Variable Block Mode. In Fixed Block Mode it specifies the number of blocks of the current length to be written.

## 2.5.22 Write File Mark (10h)

The Write File Mark command completes any Write or Copy command in process or writes zero or more file marks starting at the current logical tape position.

The drive rejects the Write File Mark command if the tape is write-protected or if the logical tape position is at EOT and the End-of-Medium and Valid bits are set to one.

When zero file marks are specified and the drive is in the buffered mode, the command forces any buffered data to be written, which is known as Synchronization. The logical tape position after completing the operation is after the last data block written.

If there is write data in the buffer when this command is received, the drive is synchronized by writing all blocks to tape before executing the Write File Mark command. The drive does not return a Good status message for this command until all buffered data blocks and file marks are correctly written.

### The Write File Mark CDB

The contents of the Write File Mark CDB are shown in Figure 2–34.

| Byte | Bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 01 | Logical Unit Number | | | 0 | 0 | 0 | 0 | Immediate |
| 02 | Transfer Length (MSB) | | | | | | | |
| 03 | Transfer Length | | | | | | | |
| 04 | Transfer Length (LSB) | | | | | | | |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | Flag | Link |

MKV_VS034_90

**Figure 2–34 Write File Mark Command Descriptor Block**

If set to one, the Immediate bit causes status to be returned immediately. If set to zero, status is returned after the command is executed.

The Transfer Length specifies the number of file marks to be written to tape.

# 2.6 ERROR PROCESSING

This section explains error processing for all SCSI commands. Error processing for the following error types is included.

- Common Errors
- Copy Error
- Erase Error
- Read Error
- Read Reverse Error
- Space Error
- Verify Error
- Write Error
- Write File Mark Error

## 2.6.1 Common Error Processing

This error processing is common to all commands. There are three types of Common errors:

- Command Descriptor Block Error
- Parity Error
- Data Transmission Error

**Command Descriptor Block Error**

If the command descriptor is not the correct length or has any illegal parameters, the command is rejected. If the Parameters List (if any) is not the correct length or has any illegal parameters, the command is rejected.

**Parity Error**

If parity is enabled and a parity error is detected, the drive changes the phase to Message In, sends the initiator a Restore Pointer message to reset the data pointer to the first byte, then changes the phase to Data Out to receive the data again. If a parity error continues after one retry, the command is rejected.

**Data Transmission Error**

If an Initiator Detected Error message is received while transmitting a data block, the drive retransmits the data block by changing the phase to Message In. The drive also sends the initiator a Restore Pointers message to reset the data pointer. If an Initiator Detected Error message is received again, the command is rejected.

## 2.6.2 Copy Error Processing

There are two types of Copy errors:

- End-of-Data Error
- Read and Write Errors

**End-of-Data Error**

If 25 feet of tape is read without encountering data, a Blank Check Sense Key results.

**Read and Write Errors**

When executing a Copy command, the drive is either the source device or the destination device; therefore, Read or Write command errors may occur, with Read or Write command error processing occurring.

## 2.6.3 Erase Error Processing

There are two types of Erase errors:

- Completion Error
- Synchronization Error

**Completion Error**

If an error occurs that prevents the Erase operation from completing, the command terminates with a Hardware Error Sense Key.

**Synchronization Error**

During a Synchronization, any of the Write command errors may occur; therefore, Write command error processing may result.

## 2.6.4 Read Error Processing

For all Read errors, unless otherwise stated, the information bytes of the Extended Sense (Figure 2–23) are set in the Variable Block Mode equal to the difference between the requested Transfer Length and the actual block length. In the Fixed Block Mode, the information bytes are set equal to the difference between the requested Transfer Length and the actual number of blocks read, not including the block in error.

There are seven types of Read errors:

- End-of-Data Error
- Block Length Error
- Buffer Parity Error
- End-of-Medium Error
- File Mark Error
- Recovered Data Error
- Unrecovered Data Error

**End-of-Data Error**

If 25 feet of tape is read without encountering data, a Blank Check Sense Key results.

**Block Length Error**

In the Variable Block Mode, if the actual block length exceeds the specified Transfer Length, no more than the Transfer Length is transmitted to the initiator. If the actual block length is less than the specified Transfer Length, no more than the actual block length is transferred. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is after the block with the incorrect length.

In the Variable Block Mode, if the transfer length exceeds the maximum allowable value specified in the Read Block Limits data, the command is rejected with an Illegal Request Sense Key.

In the Fixed Block Mode, if the actual block length encountered is different than the specified length, no additional blocks are transferred. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is after the block with the incorrect length.

In the Fixed Block Mode, if the actual number of blocks available is less than the specified transfer length, no more than the actual number of blocks is transferred. A File Mark Error, End-of-Data Error, or an End-of-Medium Error is reported.

**Buffer Parity Error**

If an unrecoverable buffer parity error occurs, a Hardware Error Sense Key results.

**End-of-Medium Error**

If the Report Early-Warning End-of-Medium on Read (RDEW) bit is set to one, and the end-of-medium (EOT reflector) is encountered, the command terminates with the End-of-Medium bit set to one.

If the physical end of medium [5.49 m (18 ft) past EOT] is encountered, the command terminates with the End-of-Medium bit set to one and a Medium Error Sense Key.

### File Mark Error

If a file mark is read, the Valid and File Mark bits are set to one, and the command terminates. At termination, the logical tape position is after the file mark.

### Recovered Data Error

If the drive detects and recovers one or more data errors, the command terminates successfully. If the Post Error bit is set to one, a Recovered Error Sense Key results; if set to zero, recovered error reporting is suppressed.

### Unrecovered Data Error

If an unrecovered error occurs, the drive backspaces and attempts to re-read the data up to eight times. If the data cannot be recovered, the command terminates with a Check Condition Status and a Medium Error Sense Key.

## 2.6.5 Read Reverse Error Processing

For all Read errors, unless otherwise stated, the information bytes of the Extended Sense (Figure 2–23) are set in the Variable Block Mode equal to the difference between the requested Transfer Length and the actual block length. In the Fixed Block Mode, the information bytes are set equal to the difference between the requested Transfer Length and the actual number of blocks read, not including the block in error.

There are six types of Read Reverse errors:

- Beginning-of-Tape Error
- Block Length Error
- Buffer Parity Error
- File Mark Error
- Recovered Data Error
- Unrecovered Data Error

**Beginning-of-Tape Error**

If BOT is encountered, the command terminates with the Valid and End-of-Medium bits set to one. The logical position of the tape at termination is at BOT.

**Block Length Error**

In the Variable Block Mode, if the actual block length exceeds the specified Transfer Length, no more than the Transfer Length is transmitted to the initiator. If the actual block length is less than the specified Transfer Length, no more than the actual block length is transferred. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is before the block with the incorrect length.

In the Variable Block Mode, if the transfer length exceeds the maximum allowable value specified in the Read Block Limits data, the command is rejected with an Illegal Request Sense Key.

In the Fixed Block Mode, if the actual block length encountered is different than the specified length, no additional blocks are transferred. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is before the block with the incorrect length.

In the Fixed Block Mode, if the actual number of blocks available is less than the specified transfer length, no more than the actual number of blocks is transferred. A File Mark Error or an End-of-Medium Error is reported.

**Buffer Parity Error**

If an unrecoverable buffer parity error occurs, a Hardware Error Sense Key results.

**File Mark Error**

If a file mark is read, the Valid and File Mark bits are set to one, and the command terminates. At termination, the logical tape position is before the file mark.

**Recovered Data Error**

If the drive detects and recovers one or more data errors, the command terminates successfully. If the Post Error bit is set to one, a Recovered Error Sense Key results; if set to zero, recovered error reporting is suppressed.

### Unrecovered Data Error

If an unrecovered error occurs, the drive spaces forward and attempts to re-read the data up to eight times. If the data cannot be recovered, the command terminates with a Check Condition Status and a Medium Error Sense Key.

## 2.6.6 Space Error Processing

For all errors, unless otherwise stated, the information bytes of the Extended Sense (Figure 2–23) are set equal to the difference between the requested count and the actual number of blocks or file marks spaced over.

There are six types of Space errors:

- End-of-Data Error
- End-of-Medium Error
- File Mark Error
- Unrecovered Data Error
- Beginning-of-Tape Error
- Synchronization Error

**End-of-Data Error**

If 25 feet of tape is read without encountering data, a Blank Check Sense Key results.

**End-of-Medium Error**

If the Report Early-Warning End-of-Medium on Read (RDEW) bit is set to one, and the end-of-medium (EOT reflector) is encountered, the command terminates with the End-of-Medium and Valid bits set to one. At termination, the logical tape position is after the last data block or file mark read.

If the physical end of medium [5.49 m (18 ft) past EOT] is encountered, the command terminates with the End-of-Medium bit set to one and a Medium Error Sense Key.

**File Mark Error**

If a file mark is read, the Valid and File Mark bits are set to one, and the command terminates. The information bytes of the Extended Sense (Figure 2–23) are set equal to the difference between the requested count and the actual number of blocks spaced over, not including the file mark. At termination, the logical tape position is on the EOT-side of the file mark if the tape movement was *forward*, or on the BOT-side of the file mark if the tape movement was *reverse*.

**Unrecovered Data Error**

Data and block length errors are not reported during a Space command.

**Beginning-of-Tape Error**

If BOT is encountered while spacing in reverse, the command terminates with the Valid and End-of-Medium bits set to one. The logical tape position at termination is at BOT.

**Synchronization Error**

During a Synchronization, any of the Write command errors may occur; therefore, Write command error processing may result.

## 2.6.7 Verify Error Processing

For all Verify errors, unless otherwise stated, the information bytes of the Extended Sense (Figure 2–23) are set in the Variable Block Mode equal to the difference between the requested Verification Length and the actual block length. In the Fixed Block Mode, the information bytes are set equal to the difference between the requested Verification Length and the actual number of blocks verified, not including the block in error.

There are six types of Verify errors:

- Block Length Error
- End-of-Data Error
- End-of-Medium Error
- File Mark Error
- Recovered Data Error
- Unrecovered Data Error

**Block Length Error**

In the Variable Block Mode, if the actual block length exceeds the specified verification length, no more than the verification length is verified. If the actual block length is less than the specified verification length, no more than the actual block length is verified. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is after the block with the incorrect length.

In the Variable Block Mode, if the verification length exceeds the maximum allowable value specified in the Read Block Limits data, the command is rejected with an Illegal Request Sense key.

In the Fixed Block Mode, if an actual block length is encountered that is different than the specified length, no additional blocks are verified. The Valid and Incorrect Length Indicator bits are set to one, and the command terminates. At termination, the logical tape position is after the block with the incorrect length.

In the Fixed Block Mode, if the actual number of blocks available is less than the specified verification length, no more than the actual number of blocks is verified. A File Mark Error, End-of-Data Error, or an End-of-Medium error is reported.

**End-of-Data Error**

If 25 feet of tape is encountered, the command terminates with the Valid bit set to one and a Blank Check Sense Key. In the Variable Block Mode the Incorrect Length Indicator bit is also set to one. At termination, the logical tape position is after the last data block verified.

**End-of-Medium Error**

If the Report Early-Warning End-of-Medium on Read (RDEW) bit is set to one and the end-of-medium (EOT reflector) is encountered, the command terminates with the End-of-Medium bit set to one. At termination, the logical tape position is after the last data block verified.

If the physical end of medium [5.49 m (18 ft) past EOT] is encountered, the command terminates with the End-of-Medium bit set to one and a Medium Error Sense Key.

### File Mark Error

If a file mark is read, the Valid and File Mark bits are set to one, and the command terminates. At termination, the logical tape position is after the file mark.

### Recovered Data Error

If the drive detects and recovers one or more data errors, the command terminates successfully. If the Post Error bit is set to one, a Recovered Error Sense Key results; if set to zero, recovered error reporting is suppressed.

### Unrecovered Data Error

If an unrecovered error occurs, the drive backspaces and attempts to re-read the data up to eight times. If the data cannot be recovered, the command terminates with a Check Status and a Medium Error Sense Key. At terminiation, the logical tape position is after the data block with the error.

## 2.6.8 Write Error Processing

For all write errors, unless otherwise stated, the information bytes of the Extended Sense (Figure 2–23) are set in the Buffered Variable Block Mode equal to the number of bytes and file marks not written. This is the number of bytes not transferred from the initiator, plus the number of bytes and file marks remaining in the buffer. The value in the information bytes may exceed the transfer length.

In the Unbuffered Variable Block Mode, the information bytes are set to the requested transfer length.

In the Buffered Fixed Block Mode, the information bytes are set equal to the number of blocks and file marks not written. This is the number of blocks not transferred from the initiator, plus the number of blocks and file marks remaining in the buffer. The value in the information bytes may exceed the transfer length.

In the Unbuffered Fixed Block Mode, the information bytes are set equal to the difference between the requested transfer length and the actual number of blocks written.

There are four types of Write errors:

- Block Length Error
- End-of-Medium Error
- Recovered Data Error
- Unrecovered Data Error

**Block Length Error**

In the Variable Block Mode, if the actual block length exceeds the maximum block length specified in the Read Block Limits data, the command is rejected with an Illegal Request Sense Key.

**End-of-Medium Error**

When the Early-Warning End-of-Medium (EOT reflector) is detected, all data in the buffer is written to the medium. The End-of-Medium bit is set to one with a No Sense Sense Key.

If the physical end of medium [5.49 m (18 ft) past EOT] is encountered, the command terminates with the Valid and End-of-Medium bits set to one and the Volume Overflow Sense Key. The value in the information bytes equals the number of blocks remaining in the buffer, plus those not yet transferred from the initiator.

**Recovered Data Error**

If the drive detects and recovers one or more data errors, the command terminates successfully. If the Post Error bit is set to one, a Recovered Error Sense Key results; if set to zero, recovered error reporting is suppressed. Recoverable write errors are not reported until a file mark is written.

**Unrecovered Data Error**

A Medium Error Sense Key is issued for any unrecoverable errors. The tape drive tries rewriting the data before this error is reported. Before each retry, the tape is repositioned so the read/write head is over the bad block, then one foot of tape is erased.

### 2.6.9 Write File Mark Error Processing

There are three types of Write File Mark errors:

- End-of-Medium Error
- Recovered File Mark Error
- Synchronization Error

**End-of-Medium Error**

When the Early-Warning End-of-Medium (EOT reflector) is detected, the command terminates with the Valid and End-of-Medium bits set to one. At termination, the logical tape position is after the last file mark written.

When the physical end of medium is [5.39 m (18 ft) past EOT] is encountered, the command terminates with the Valid and End-of-Medium bits set to one and the Volume Overflow Sense Key.

In the Buffered Variable Block Mode, the information bytes of the Extended Sense (Figure 2–23) are set equal to the total number of unwritten bytes and file marks. This is the number of file marks not transferred from the initiator, plus the number of bytes and file marks remaining in the buffer.

In the Buffered Fixed Block Mode, the information bytes are set equal to the total number of unwritten blocks and file marks. This is the number of file marks not transferred from the initiator, plus the number of blocks and file marks remaining in the buffer.

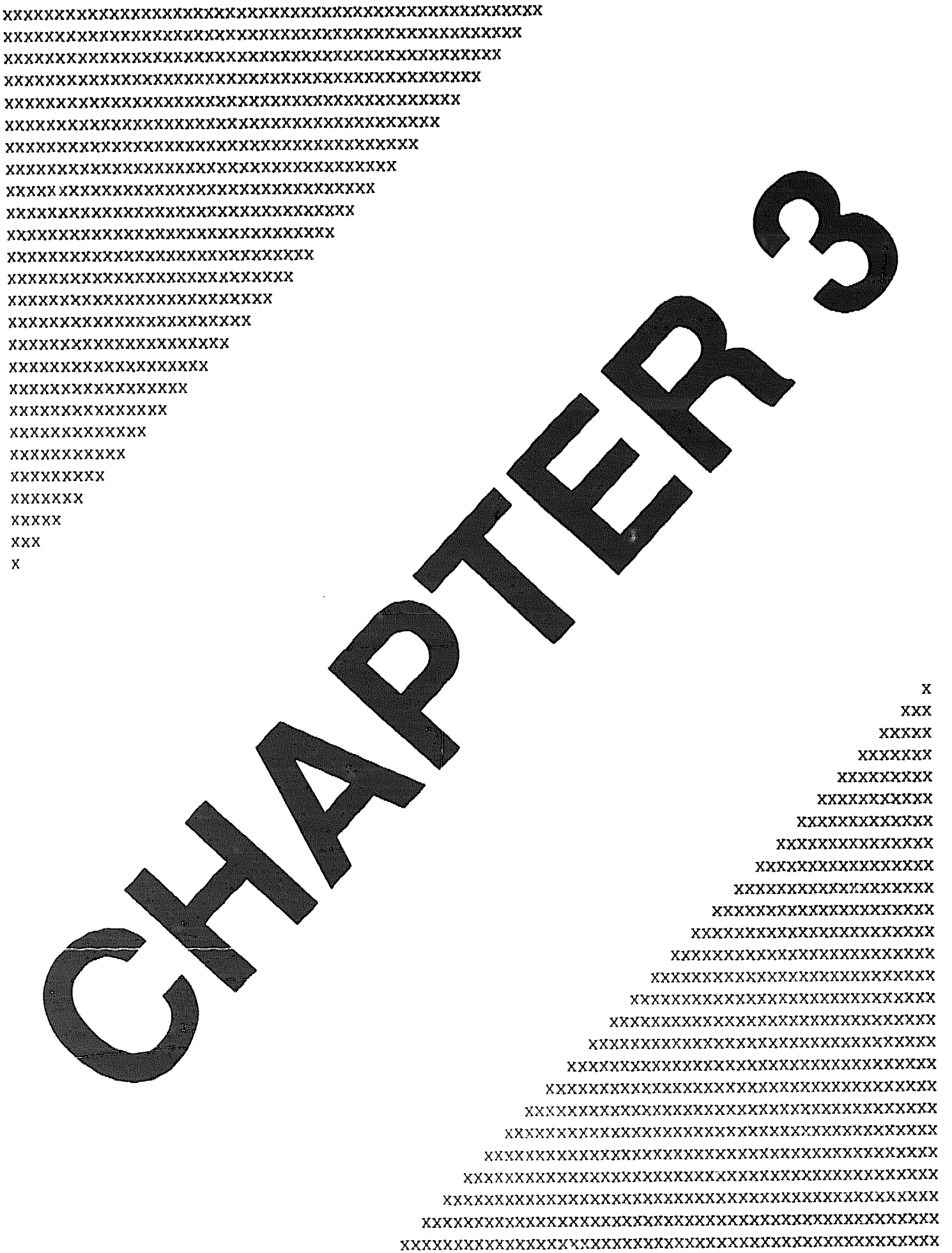
In the Unbuffered Fixed Block Mode, the information bytes are set equal to the difference between the requested transfer length and the actual number of file marks written.

**Recovered File Mark Error**

If the drive detects and recovers one or more file mark errors, the command terminates successfully. If the Post Error bit is set to one, a Recovered Error Sense Key results; if set to zero, recovered error reporting is suppressed.

**Synchronization Error**

During a Synchronization, any of the write command errors may occur; therefore, Write command error processing may result.


CHAPTER 3

# 3
# MAINTENANCE

## 3.1 INTRODUCTION

This chapter discusses basic maintenance for the TSZ05 Tape Drive.

## 3.2 BASIC MAINTENANCE

The only user maintenance for the TSZ05 Tape Drive is the cleaning of the tape read/write head, tape path, sensors, and cleaning or replacement of the air filter.

The following are needed for maintenence on the TSZ05 Tape Drive:

- Tape Drive Cleaning Kit, P/N: TCU01 (for 20 hour, 40 hour, and 6 month service).
- Air Filter, P/N: 29-25065-00 (6 month service, if desired).

**NOTE**

**All components of the tape path should be cleaned after every 40 hours of operation or once per week, whichever occurs first. The read/write head should be cleaned after every 20 hours of operation. Only Freon TF™ should be used as a cleaning agent, and it should be applied with a lint-free swab or wipe.**

**CAUTION**

**Do not apply a cleaning agent directly to the item to be cleaned, even if the instructions on the cleaning agent state to do so. Always apply the cleaner to a lint-free swab or wipe first. Cleaning agents can dissolve the lubricants in precision bearings.**

**Table 3–1 Maintenance Matrix**

| Service Assembly | 20 Hour | 40 Hour | 6 Month |
|---|---|---|---|
| Read/Write Head | X | X | X |
| Tape Cleaner | | X | X |
| Tachometer Roller | | X | X |
| Take-up Hub | | X | X |
| Roller Guides | | X | X |
| Sensors | | X | X |
| Air Filter | | | X |

## NOTES

### 3.2.1 20 Hour Maintenance

After every 20 hours of operation, clean the read/write head as follows.

**CAUTION**

**Switching off the tape drive while the system is operating could cause data on the SCSI bus to be corrupted. Halt the system before performing the maintenance procedure. Raising the cover operates a safety interlock that disconnects the power.**

1. Place the Power switch to the OFF (O) position.
2. Open the outer enclosure lid by pressing down on both front corners of the lid until the latch unlocks (a distinct click should be heard).
3. Raise the outer lid until the yellow safety latch on the right rear corner locks into place.
4. Grasp the inner cover on both sides, raise the inner cover, and place the cover retaining arm in its hole (Figure 3–1).

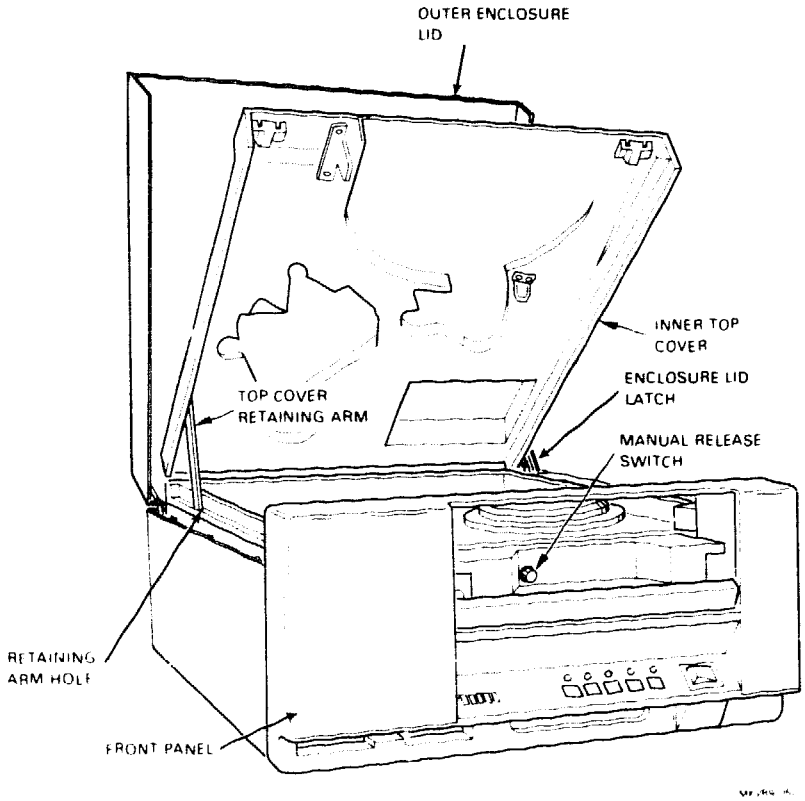



**Figure 3–1 Gaining Access to the Tape Path (20 Hour Maintenance)**

5. Apply Freon TF to a lint-free swab or wipe and clean the tape contact surface of the read/write head (Figure 3–2).
6. Wipe any residue from the head with the dry lint-free wipes provided in the kit.

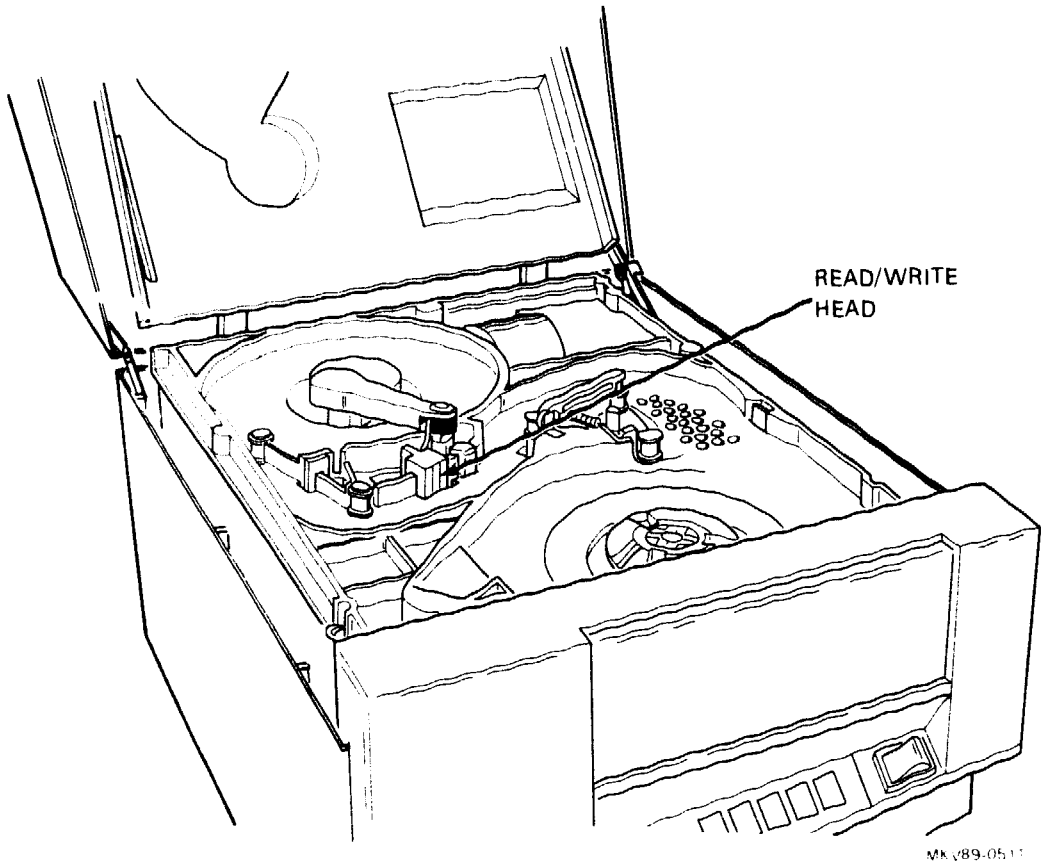



**Figure 3–2 Cleaning the Read/Write Head (20 Hour Maintenance)**

7. Close the inner cover by releasing the cover retaining arm and lowering the cover.
8. Press down on the front corners until the inner cover snaps closed.
9. Release the latch and lower the outer lid of the enclosure.
10. Press gently on the front of the lid to latch it in place.

## 3.2.2 40 Hour Maintenance

After every 40 hours of operation or once per week, whichever occurs first, clean the read/write head, tape path, and BOT/EOT sensors.

**CAUTION**

**Switching off the tape drive while the system is operating could cause data on the SCSI bus to be corrupted. Halt the system before performing the maintenance procedure. Raising the cover operates a safety interlock that disconnects the power.**

### Cleaning the Read/Write Head

1. Place the Power switch to the OFF (O) position.
2. Open the outer enclosure lid by pressing down on both front corners of the lid until the latch unlocks (a distinct click should be heard).
3. Raise the outer lid until the yellow safety latch on the right rear corner locks into place.
4. Grasp the inner cover on both sides, raise the inner cover, and place the cover retaining arm in its hole (Figure 3–3).

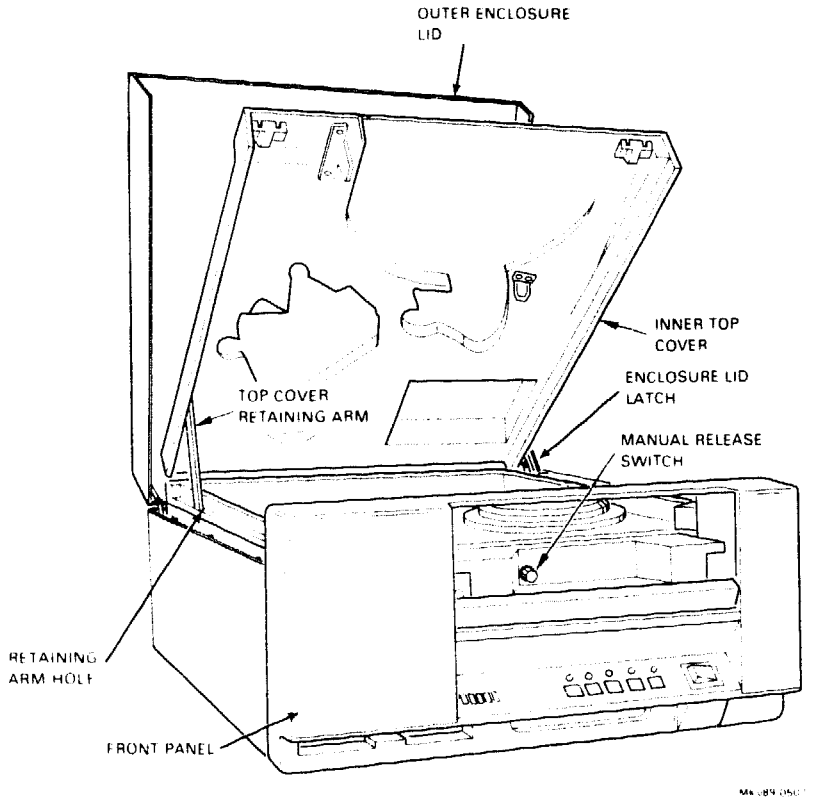



**Figure 3–3 Gaining Access to the Tape Path (40 Hour Maintenance)**

5. Apply Freon TF to a lint-free swab or wipe and clean the tape contact surface of the read/write head (Figure 3–4).
6. Wipe any residue from the head with the dry lint-free wipes provided in the kit.

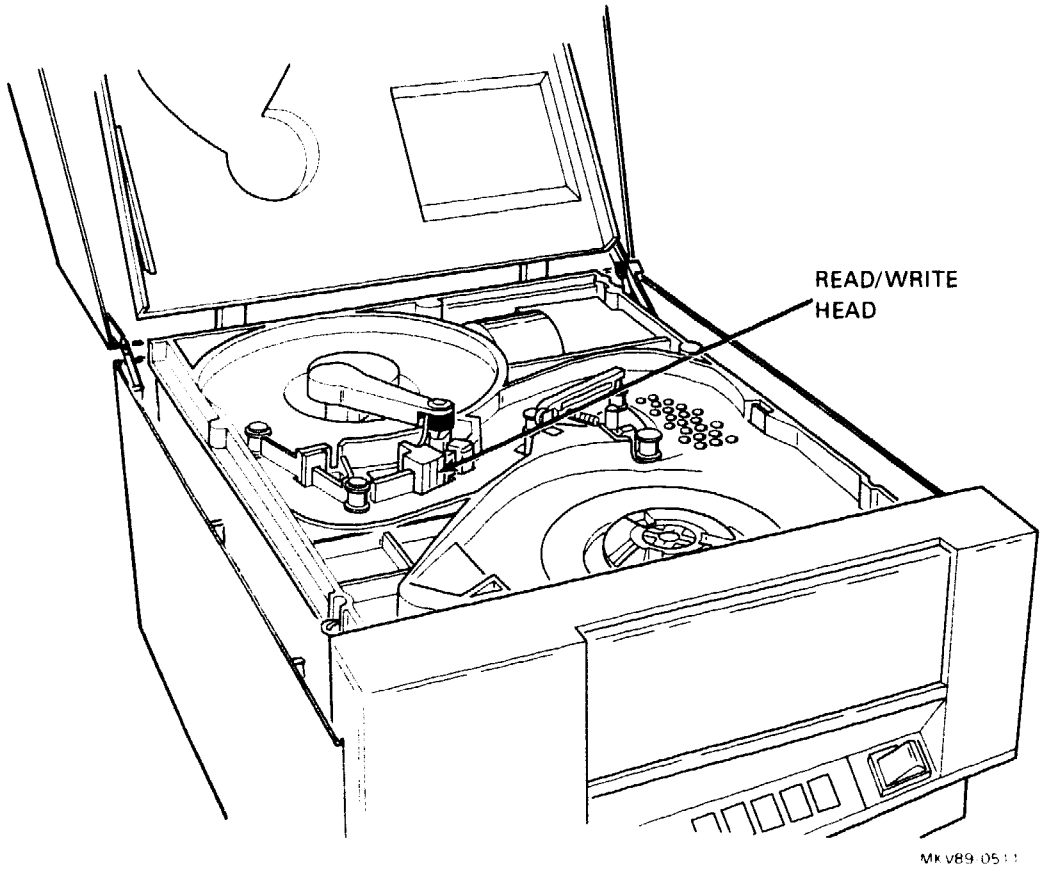



**Figure 3–4 Cleaning the Read/Write Head (40 Hour Maintenance)**

### Cleaning the Tape Path

1. Apply Freon TF to a lint-free swab or wipe and clean the following components of the tape path:
   a. Tape cleaner (Figure 3–5)
   b. Tachometer roller (Figure 3–6)
   c. Take-up hub (Figure 3–7)
   d. Roller guides (Figure 3–8)
2. Wipe any residue from the components with the dry lint-free wipes provided in the kit.

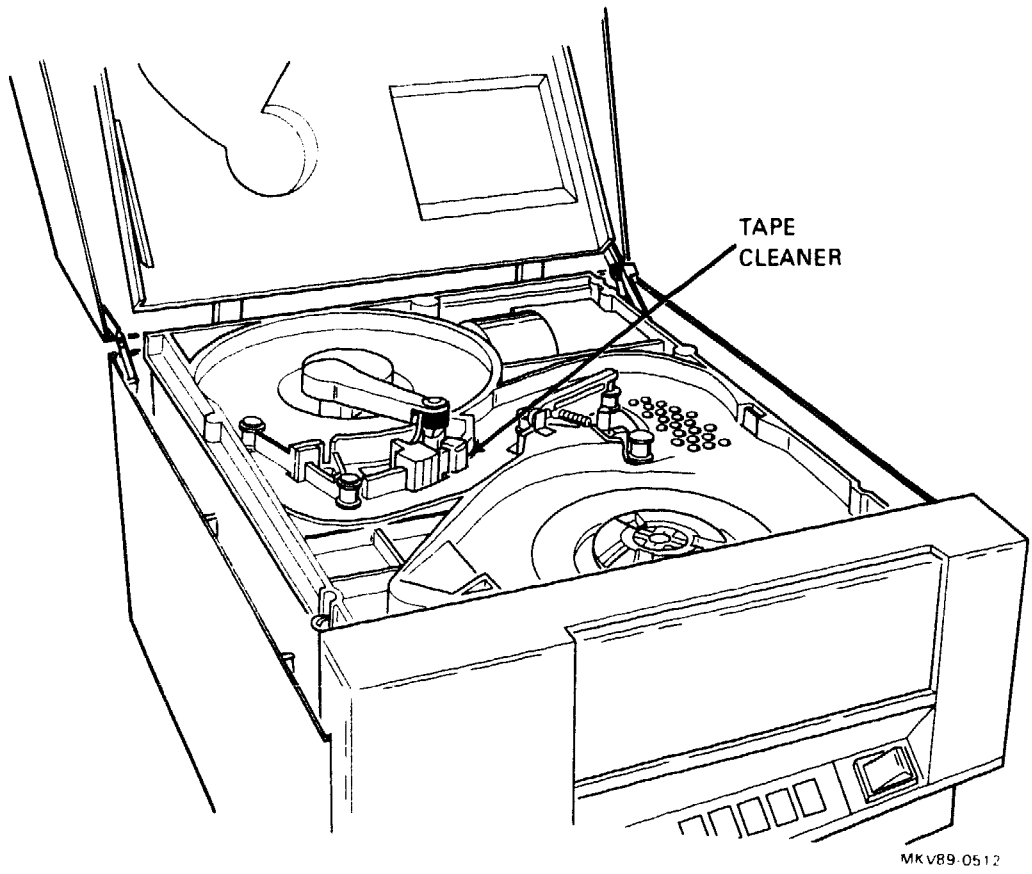



**Figure 3–5 Cleaning the Tape Cleaner**

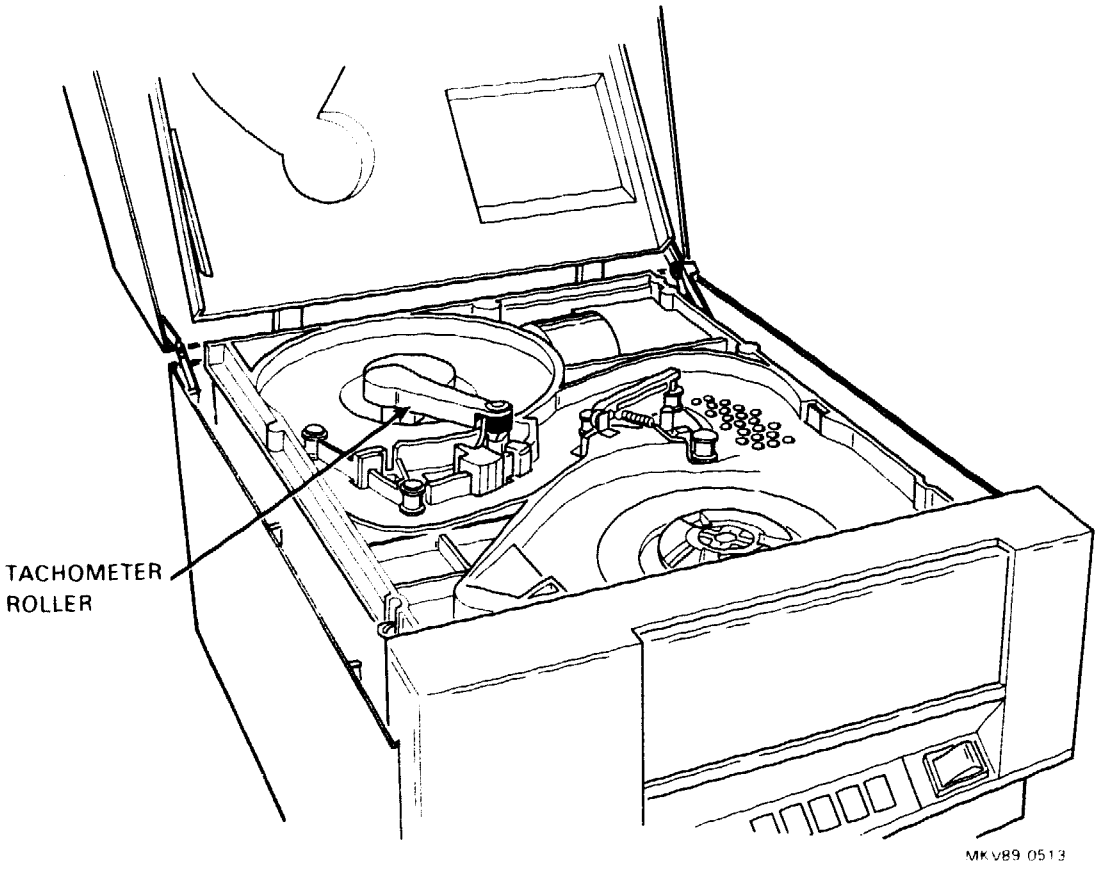



**Figure 3–6 Cleaning the Tachometer Roller**

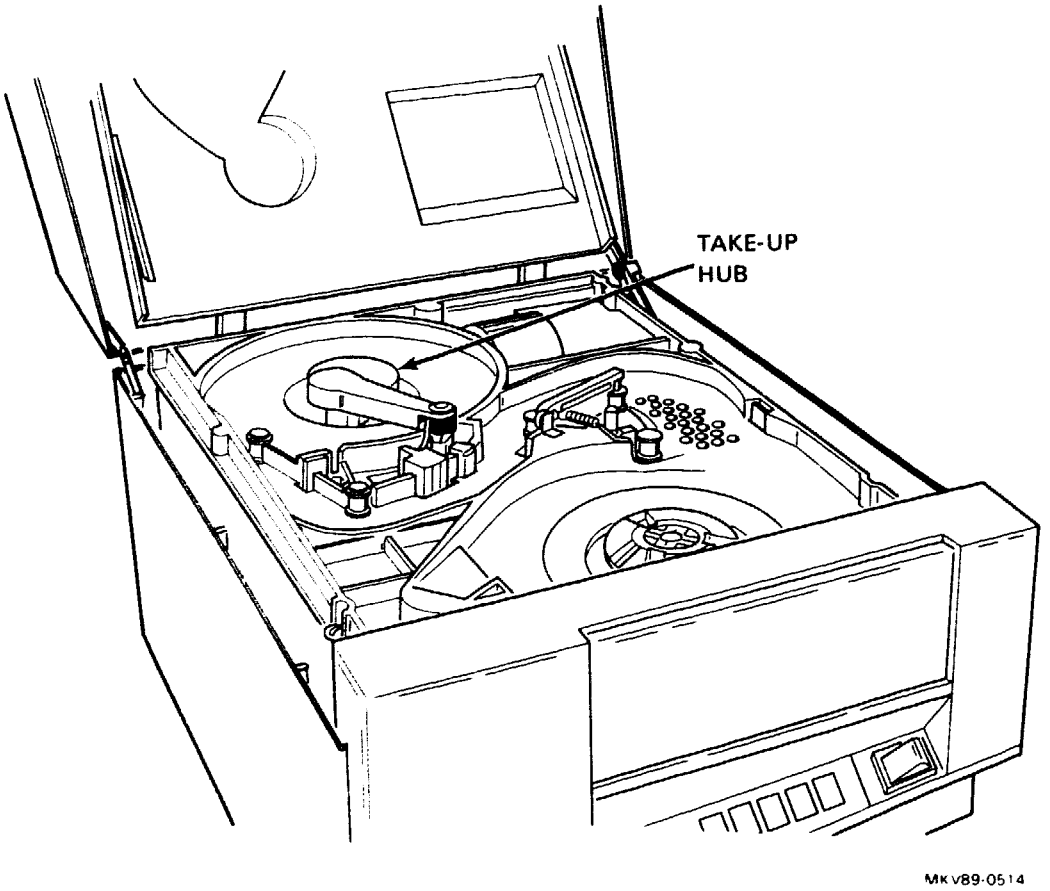



**Figure 3–7 Cleaning the Take-up Hub**

Note that it will be necessary to hold the tachometer arm away from the hub during cleaning.

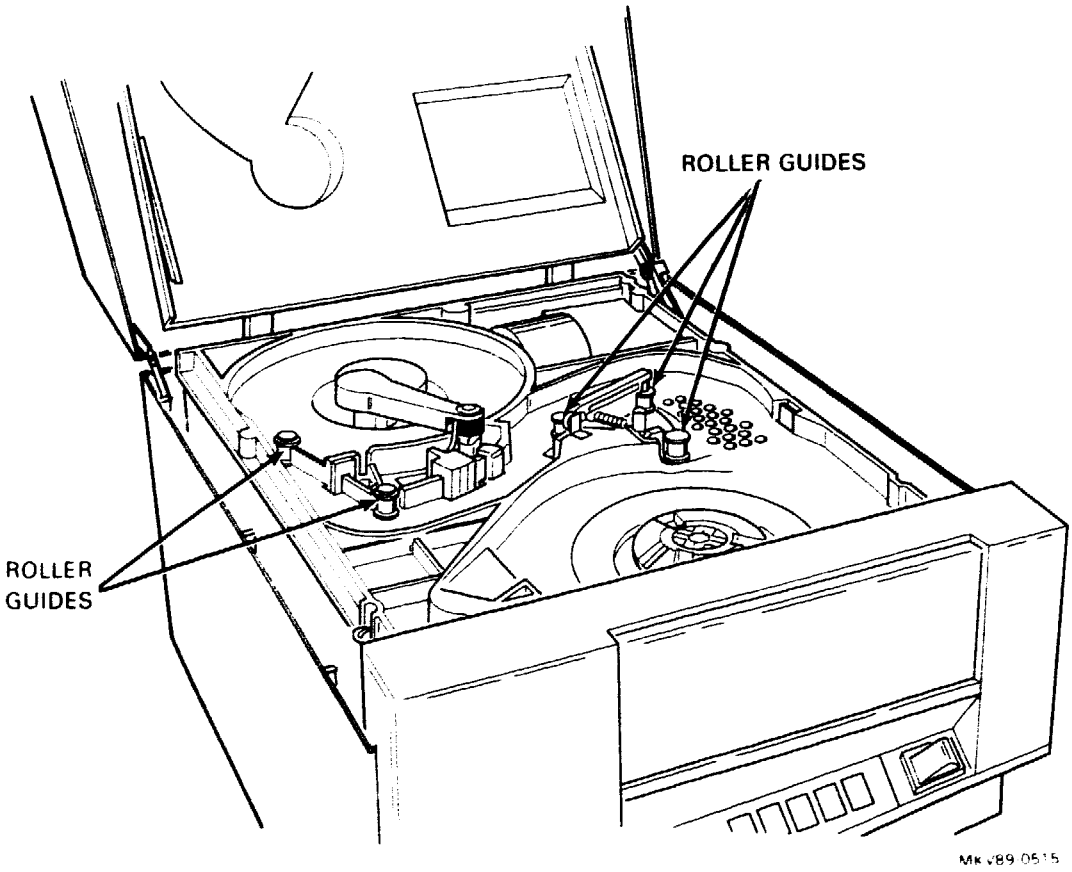



**Figure 3–8 Cleaning the Roller Guides**

### Cleaning the Sensors

**CAUTION**

**When cleaning the sensors, be as gentle as possible. The alignment of the LEDs is critical.**

1. Using a dry cotton swab, gently wipe any dust off each sensor transmitter and receiver lens and the EOT/BOT reflector (Figure 3–9).

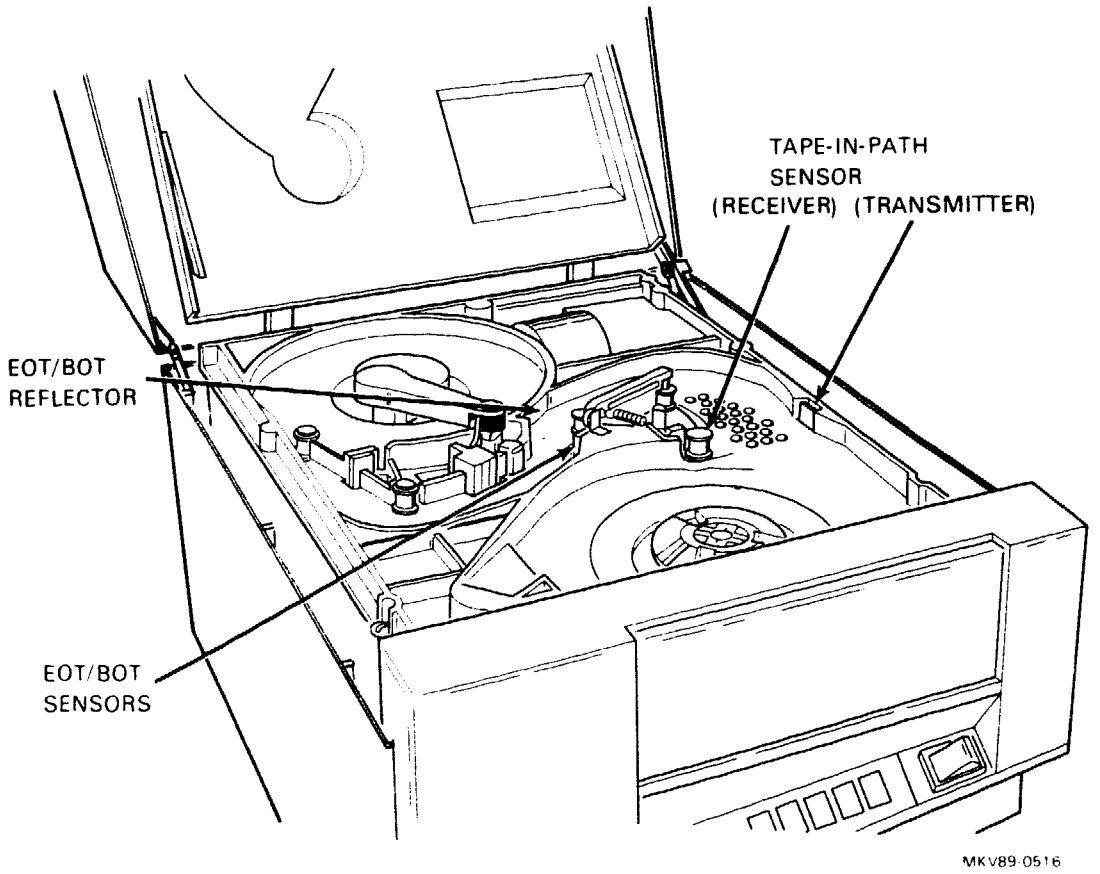



**Figure 3–9 Cleaning the Sensors**

2. Close the inner cover by releasing the cover retaining arm and lowering the cover.
3. Press down on the front corners until the inner cover snaps closed.
4. Release the latch and lower the outer lid of the enclosure.
5. Press gently on the front of the lid to latch it in place.

### 3.2.3 6 Month Maintenance

Every six months, in addition to the 40 hour maintenance, clean or replace the air filter as follows. The filter is located in the lower left front of the enclosure (Figure 3–10).

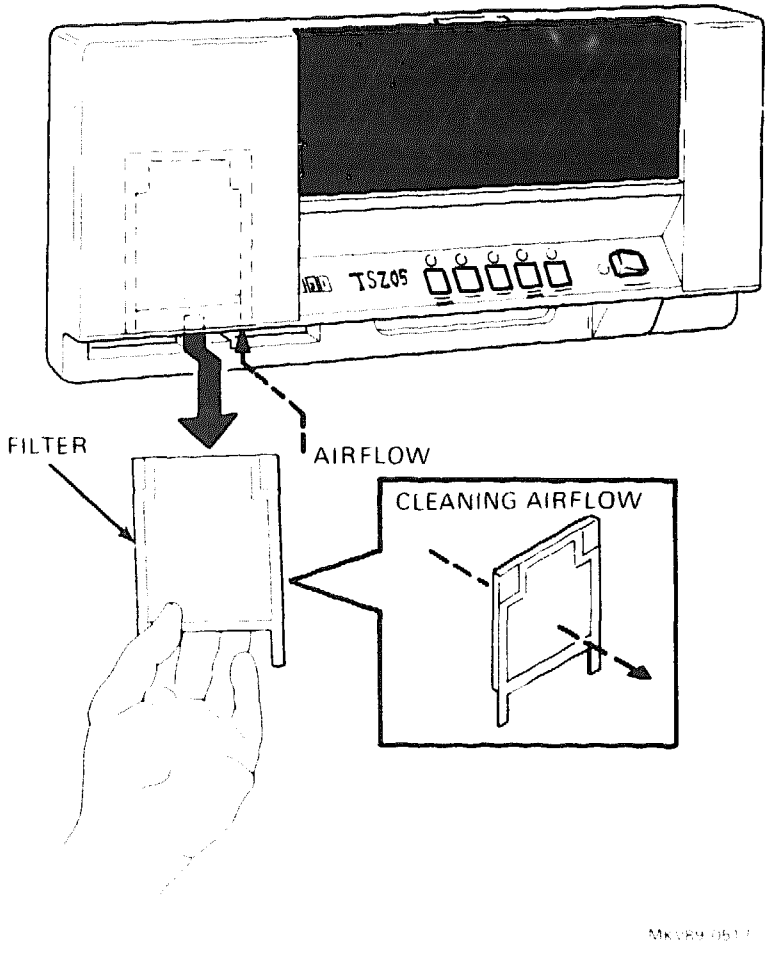



**Figure 3–10 Removing the Air Filter**

1. Remove the filter by pulling the bottom of the filter forward to free the two fingers at the bottom (Figure 3–10).
2. Pull the filter down and out.
3. Note that the direction of airflow is from the outside to the inside of the cabinet.
4. Vacuum or blow compressed air through the filter in the opposite direction of the airflow.
5. Reinstall the filter or replace it with a new unit (P/N: 29-25065-00) by sliding it up and under the top hold-down fingers (the plastic frame to the outside). See Figure 3–10 for position.
6. Snap the two bottom fingers under the opening.


CHAPTER 4

# 4
# TROUBLESHOOTING

## 4.1 INTRODUCTION

Troubleshooting the TSZ05 Tape Drive consists of interpreting the results of error codes on the front panel LEDs, using SCSI Power-up Diagnostics, using SCSI Diagnostic Functions, using SCSI Diagnostic Commands, or using Service Aid Diagnostics.

The tape drive reports errors by way of LEDs on the front panel, power-up LEDs in the rear of the unit, and by messages on the host system.

## 4.2 FRONT PANEL ERROR CODES

The front panel error codes are transmitted as flashing binary numbers with the Load/Rewind indicator as the *least* significant bit and the Enter indicator as the *most* significant bit (Figure 4–1). Table 4–1 identifies all possible error codes for the front panel LEDs. These error codes can help to troubleshoot problems with the tape drive by indicating what test failed or what condition was detected.

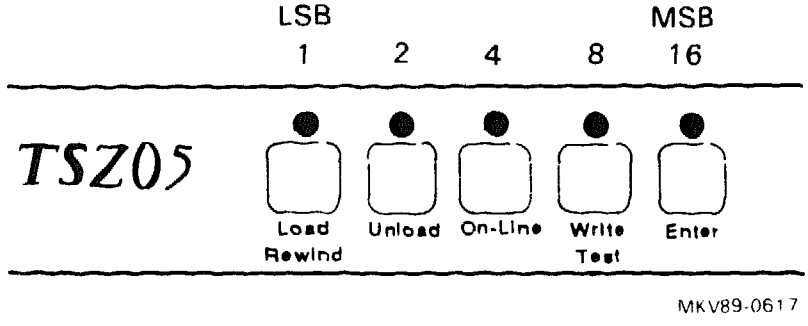



**Figure 4–1 Bit Significance of the Front Panel Indicators**

**Table 4–1 Front Panel LED Error Codes**

| LED Pattern | Error Code Decimal Number | Description or Meaning of Error Code |
|---|---|---|
| 11000 | 3 | More than 1128 m (3700 ft) of tape beyond beginning-of-tape (BOT). |
| 00100 | 4 | Tension arm swing exceeded normal range during load or unload. |
| 10100 | 5 | Command received before previous command completed. |
| 01100 | 6 | Write command received for write-protected tape. |
| 11100 | 7 | Illegal command. |
| 00010 | 8 | Supply hub locking mechanism failed. |
| 01010 | 10 | Auto-zero of digital-to-analog converter (DAC) failed during power-up. |
| 11010 | 11 | Servo circuit output test failed. |
| 00110 | 12 | Reel not seated on supply hub or file-protect circuit failed. |
| 10110 | 13 | Supply reel did not remain locked during unload, or tape-in-path failed during load, or too much slack in the tape to allow tensioning. |
| 01110 | 14 | Tape travel beyond end-of-tape (EOT) exceeded 5.5 m (18 ft). |
| 11110 | 15 | Reel seat/file protect sensor failed. |
| 10001 | 17 | Tension arm swing exceeded normal range. |
| 01001 | 18 | Tape speed variation exceeded ± 10% or the tachometer has failed. |
| 11101 | 23 | Load attempted without tape reel. |
| 11011 | 27 | Load attempted with front panel door open. |
| 10111 | 29 | Tape reel upside down or tape-in-path sensor failed. |
| 01111 | 30 | BOT not detected after 10.7 m (35 ft) of tape. |
| 11111 | 31 | Load failure. |

## 4.3 SCSI POWER-UP DIAGNOSTICS

Level 0 diagnostics are power-up routines that test the SCSI controller before allowing any SCSI function to be executed. Toggling the Reset switch, switch 1 of U2C, resets the SCSI controller causing the Level 0 diagnostics to execute. Normally switch 1 is Open/Off.

Eight LEDs at the rear of the main circuit board provide the status of the Level 0 diagnostics the last time they were executed (Figure 4–2). The LEDs are labeled 7 to 0, with 7 being the most significant bit. The LEDs indicate the SCSI status as a coded hexadecimal byte. Successful completion of the Level 0 diagnostics is indicated by the code 90. Table 4–2 lists the codes and their meaning. The error codes identify the point in the power-up sequence where a failure occurred. If power-up fails, the clear-power-up flag remains set and the first SCSI function results in an error status.

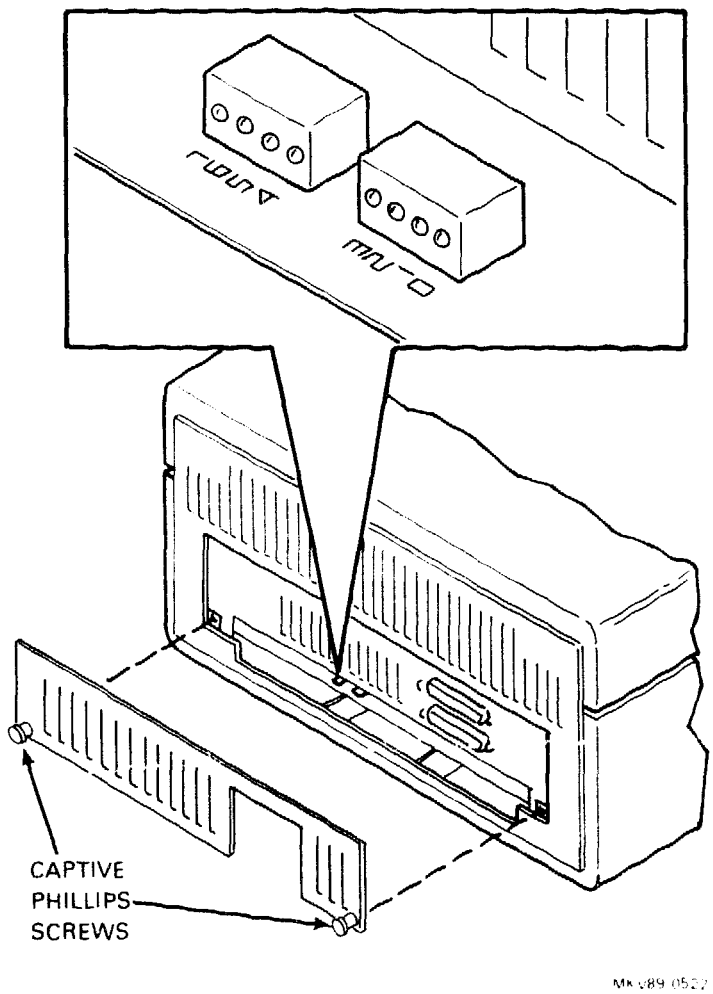



**Figure 4–2 Location of the Rear Diagnostic LEDs**

**Table 4–2 Level 0 Diagnostic Error Codes**

| 7,6,5,4 | 3,2,1,0 | Hex Code | Function |
|---|---|---|---|
| 1001 | 0000 | 90 | No failures |
| 1001 | 0001 | 91 | PROM1 sum check |
| 1001 | 0010 | 92 | PROM2 sum check |
| 1001 | 0011 | 93 | PROM3 sum check |
| 1001 | 0100 | 94 | 8085, register and memory commands |
| 1001 | 0101 | 95 | RAM, set stack pointer |
| 1001 | 0110 | 96 | (Not defined at this time) |
| 1001 | 0111 | 97 | Timer |
| 1001 | 1000 | 98 | SCSI chip |
| 1001 | 1001 | 99 | 8085, jump and initial command |
| 1001 | 1010 | 9A | (Not defined at this time) |
| 1001 | 1011 | 9B | DMA registers |
| 1001 | 1100 | 9C | DMA data paths |
| 1001 | 1101 | 9D | (Not defined at this time) |
| 1001 | 1110 | 9E | (Not defined at this time) |
| 1001 | 1111 | 9F | Data buffer |

## 4.4 SCSI DIAGNOSTIC FUNCTIONS

The SCSI Diagnostic Functions consist of accessing error or exception data (outlined in this section) and using SCSI diagnostic commands (Section 4.5).

The SCSI generates error and exception data that can be accessed by a host system with the Request Sense command. The Request Sense command obtains sense information from the tape drive in what is known as the Extended Sense Format. One byte of this extended sense information contains sense keys, and another byte may contain additional sense codes. The sense keys are listed in Table 4–3 and the additional sense codes are listed in Table 4–4. This information can be useful when troubleshooting the tape drive. Additional information on the Request Sense command is available in Section 2.5.14.

**Table 4–3 Sense Keys**

| Hex Code | Sense Key | Meaning |
|---|---|---|
| 0 | No Sense | No sense key data to be reported. |
| 1 | Recovered Error | Command completed successfully with some recovery action. |
| 2 | Not Ready | The tape drive cannot be accessed. |
| 3 | Medium Error | Command terminated with an unrecovered error probably due to the tape. |
| 4 | Hardware Error | The tape drive detected a nonrecoverable hardware fault. |
| 5 | Illegal Request | Illegal parameter. |
| 6 | Unit Attention | The tape may have been changed or the tape drive has been reset. |
| 7 | Data Protect | A write was attempted on a tape without a write-enable ring installed. |
| 8 | Blank Check | A read past end-of-data (EOD) was attempted. |
| A | Copy Aborted | Copy command aborted due to an error by the source or destination device. |
| B | Aborted Command | The tape drive aborted a command. |
| D | Volume Overflow | The tape drive reached end-of-tape (EOT) and unwritten data remains in the buffer. |

**Table 4–4 Additional Sense Codes**

| Hex Code | Additional Sense Code |
|---|---|
| 00 00 | No additional sense information |
| 00 04 | At BOT |
| 00 85 | Write File Mark Immediate bit error |
| 04 01 | Not ready; rewinding |
| 20 00 | Illegal command |
| 29 00 | Power-on occurred |
| 43 00 | Data buffer parity error |
| 4B 00 | Power-up failure |
| 50 00 | No data detected |
| 51 00 | Function timeout |
| 52 00 | Tape position error |
| 53 00 | Error occurred before command completion |
| 54 00 | Data buffer not empty |
| 55 00 | Fixed mode bit incorrectly set |
| 56 00 | Data transfer error: host to controller |
| 57 00 | Data transfer error: controller to host |
| 58 00 | Verify command with byte compare not supported |
| 59 00 | Space to EOD not supported |
| 5A 00 | Self-test not supported |
| 5B 00 | Command sequence error |
| 5C 00 | Unit select error |
| 5D 00 | Variable block length greater than 64K |
| 5E 00 | Unable to obtain buffer |
| 5F 00 | Command parameter error |
| 60 00 | Status error from target |
| 61 00 | Copy failed: host cannot disconnect |
| 62 00 | Controller detected retries; buffer parity |
| 63 00 | Controller detected retries; SCSI parity |
| 64 00 | Controller detected tape retries |
| 65 00 | Density change request not at BOT |
| 66 00 | Physical end of medium detected |
| 84 00 | Medium changed |

## 4.5 USING SCSI DIAGNOSTIC COMMANDS

There are two SCSI diagnostic commands:

Send Diagnostic Command
Receive Diagnostic Command

**Send Diagnostic Command**

The Send Diagnostic command requests that diagnostic tests be performed on the SCSI controller or the tape drive. The diagnostic tests performed are determined by the Diagnostic Function Code sent as part of the Send Diagnostic command. There are two valid Diagnostic Function Codes:

Diagnostic Inquiry
Test Buffer

**Diagnostic Inquiry** – This diagnostic function reports the SCSI data buffer size (FFFF hex or 64 Kbytes) in the data field of the Receive Diagnostic command.

**Test Buffer** – This diagnostic function tests the SCSI data buffer. The test buffer function can only be issued when the data buffer is empty, unless the Device Off-line bit (bit 0) or the Unit Off-line bit (bit 1) of the command descripter block for the Send Diagnostic command is set to 1. Data can be written to or read from any byte in the data buffer.

**Receive Diagnostic Command**

The Receive Diagnostic command causes the tape drive to return the results indicated by the Send Diagnostic command.

## 4.6 SERVICE AID DIAGNOSTICS

There are two categories of service aid diagnostics: those that run *with* a tape loaded and those that run *without* a tape. All service aid diagnostics are started by entering a five-digit numeric sequence (45XX5) in the front panel switches. The numeric sequence is based on the numeric value assigned to each switch as shown in Figure 4–3. The "XX" in the sequence represents the test code number. For example, entering 45115 starts test 11. Some of the test code numbers are the same for both categories of service aid diagnostics, but the test run depends on whether there is a tape installed or not.

**NOTE**

**The sequence must be entered within three seconds or it will be rejected.**

Table 4–5 lists the tests that are run *without* a tape, and Table 4–6 lists the tests that are run *with* a tape loaded on the tape drive.

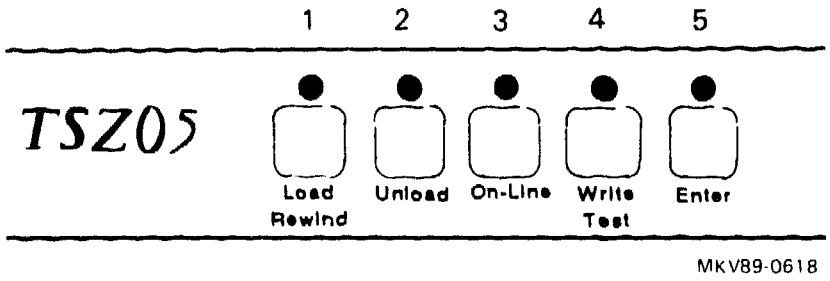



**Figure 4–3 Decimal Value of Front Panel Switches**

**Table 4–5 Tape Unloaded Diagnostics**

| Test Number | Test Name | Switch Sequence |
|---|---|---|
| 11 | Servo Motor Test | 45115 |
| 14 | Tachometer Test | 45145 |
| 22 | BOT Sensor Test | 45225 |
| 23 | EOT Sensor Test | 45235 |
| 24 | Tension Arm Test | 45245 |
| 31 | Sensors Test | 45315 |
| 32 | Hub Lock Test | 45325 |
| 33 | Door Lock Disable Test | 45335 |
| 34 | Blower Motor Test | 45345 |

**Table 4–6 Tape Loaded Diagnostics**

| Test Number | Test Name | Switch Sequence |
|---|---|---|
| 21 | Read Threshold Adjustment Test | 45215 |
| 22 | Tension Arm Motion Test | 45225 |
| 23 | Write Data Test | 45235 |

### 4.6.1 Starting a Service Aid Diagnostic Test

To start any service aid diagnostic test, do the following.

**NOTE**

**If a mistake is made while entering the service aid test sequence, or if it takes more than three seconds, wait five seconds and then try again.**

1. Power ON the tape drive.
2. Select the test by entering the sequence number (45XX5) for the test to be run. "XX" is the test number for the specific test (see Table 4–5 or Table 4–6).
3. Observe the test for proper results.
4. Press switch 4 to exit the test.
5. Perform any indicated corrective action.

### 4.6.2 Tape Unloaded Test Descriptions

This section provides the following for each test that runs *without* a tape loaded.

- Detailed description of the test
- Instructions for analyzing the test results
- Recommended corrective action

**TEST 11 (SERVO MOTOR TEST)**

**Test 11 Description** – This test checks the supply and take-up motors and their servo circuits. Both servo motors are caused to rotate, alternating clockwise and counterclockwise. Pressing switch 1 (the Load switch) while the test is running enables the high-voltage drivers and limits the maximum current to one ampere. Pressing switch 2 (the Unload switch) disables the high-voltage drivers.

**Analyzing Test 11 Results** – Observe that both the supply and take-up hubs rotate alternately clockwise and counterclockwise. No difference in speed should be seen when the Load and Unload switches are pressed.

**Recommended Corrective Action** – Follow these steps.

1. Replace the main circuit board (Section 5.4.13).
2. Replace the defective motor (Section 5.4.24 or Section 5.4.27).

## TEST 14 (TACHOMETER TEST)

**Test 14 Description** – This test samples the phase relationship for each quadrature of operation of the tachometer (see Figure 4–4). When the test begins, all front panel LEDs are ON; then the percentage of phase shift for quadrature 00 is displayed in the front panel LEDs. This phase shift is displayed as a binary number where the LSB is the Load switch and the MSB is the Enter switch. A phase shift of approximately 90 degrees is represented by a 00010 pattern in the LEDs. The minimum acceptable phase shift is 30 degrees represented by a 11000 pattern in the LEDs.

To advance the test through the four quadratures of operation in the forward direction, press the Load switch once for each quadrature. Each time the Load switch is pressed, observe the display to determine the amount of phase shift. After the fourth quadrature is tested, press the Load switch again to reverse the direction and display quadrature zero. Advance through all quadratures in the reverse direction, observing the amount of phase shift for each phase.

**Analyzing Test 14 Results** – If a phase shift of less than 30 degrees is indicated (Decimal 3 or less in the LED pattern), or if all the front panel LEDs are flashing, the test failed. All other conditions are good.

**Recommended Corrective Action** – Follow these steps.

1. Replace the tachometer (Section 5.4.25).
2. Replace the main circuit board (Section 5.4.13).

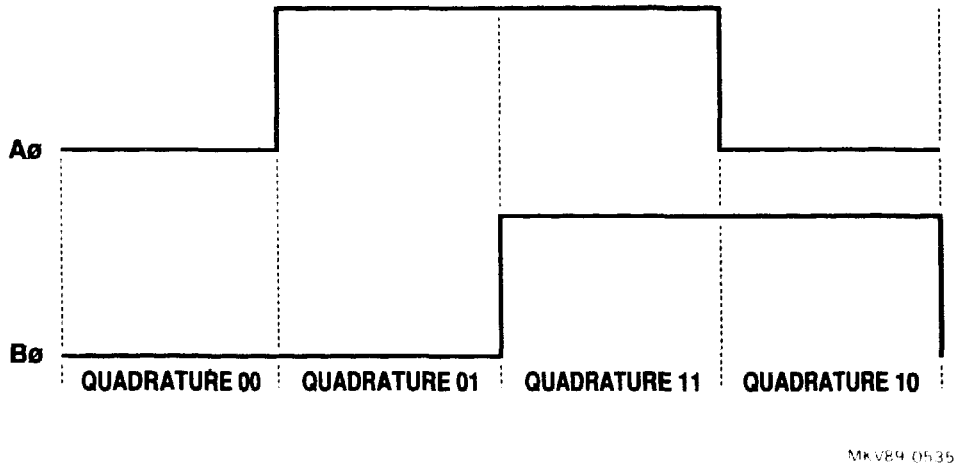



**Figure 4–4 Tachometer Phase Quadrature**

### TEST 22 (BOT SENSOR TEST)

**Test 22 Description** – This test measures the output voltage of the BOT sensor and displays it at the LEDs as a binary number. Table 4–7 provides the decimal voltage equivalent for each binary LED pattern.

**NOTE**

**Ensure that the BOT sensor is shielded from the ambient light.**

**Table 4–7 BOT/EOT Sensor Voltage Conversion Chart**

| LOAD | UNLOAD | ON-LINE | WRT EN | ENTER | Voltage |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0.00 |
| 0 | 0 | 0 | 0 | 1 | 2.56 |
| 0 | 0 | 0 | 1 | 0 | 1.28 |
| 0 | 0 | 0 | 1 | 1 | 3.84 |
| 0 | 0 | 1 | 0 | 0 | 0.64 |
| 0 | 0 | 1 | 0 | 1 | 3.20 |
| 0 | 0 | 1 | 1 | 0 | 1.92 |
| 0 | 0 | 1 | 1 | 1 | 4.48 |
| 0 | 1 | 0 | 0 | 0 | 0.32 |
| 0 | 1 | 0 | 0 | 1 | 2.88 |
| 0 | 1 | 0 | 1 | 0 | 1.60 |
| 0 | 1 | 0 | 1 | 1 | 4.16 |
| 0 | 1 | 1 | 0 | 0 | 0.96 |
| 0 | 1 | 1 | 0 | 1 | 3.52 |
| 0 | 1 | 1 | 1 | 0 | 2.24 |
| 0 | 1 | 1 | 1 | 1 | 4.80 |
| 1 | 0 | 0 | 0 | 0 | 0.16 |
| 1 | 0 | 0 | 0 | 1 | 2.72 |
| 1 | 0 | 0 | 1 | 0 | 1.44 |
| 1 | 0 | 0 | 1 | 1 | 4.00 |
| 1 | 0 | 1 | 0 | 0 | 0.80 |
| 1 | 0 | 1 | 0 | 1 | 3.36 |
| 1 | 0 | 1 | 1 | 0 | 2.08 |
| 1 | 0 | 1 | 1 | 1 | 4.64 |
| 1 | 1 | 0 | 0 | 0 | 0.48 |
| 1 | 1 | 0 | 0 | 1 | 3.04 |
| 1 | 1 | 0 | 1 | 0 | 1.76 |
| 1 | 1 | 0 | 1 | 1 | 4.32 |

**Table 4–7 (Cont.) BOT/EOT Sensor Voltage Conversion Chart**

| LOAD | UNLOAD | ON-LINE | WRT EN | ENTER | Voltage |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 | 1.12 |
| 1 | 1 | 1 | 0 | 1 | 3.68 |
| 1 | 1 | 1 | 1 | 0 | 2.40 |
| 1 | 1 | 1 | 1 | 1 | 4.96 |

**Analyzing Test 22 Results** – A tape with no BOT marker placed in the sensor path should cause a reading of less than 0.5 volts. With a BOT marker, the reading should be more than 2 volts.

**Recommended Corrective Action** – Follow these steps.

1. Replace the EOT/BOT assembly (Section 5.4.5).
2. Replace the main circuit board (Section 5.4.13).

### TEST 23 (EOT SENSOR TEST)

**Test 23 Description** – This test measures the output voltage of the EOT sensor and displays it at the LEDs as a binary number. Table 4–7 provides the decimal voltage equivalent for each binary LED pattern.

**NOTE**

**Ensure that the EOT sensor is shielded from the ambient light.**

**Analyzing Test 23 Results** – A tape with no EOT marker placed in the sensor path should cause a reading of less than 0.5 volts. With an EOT marker, the reading should be more than 2 volts.

**Recommended Corrective Action** – Follow these steps.

1. Replace the EOT/BOT assembly (Section 5.4.5).
2. Replace the main circuit board (Section 5.4.13).

## TEST 24 (TENSION ARM TEST)

**Test 24 Description** – This test measures the tension arm output voltage and displays it as a binary number at the LEDs, four bits at a time. The high-order bits (4-7) are displayed when the Enter LED is ON. The low-order bits (0-3) are displayed when the Enter LED is OFF. Pressing the Load switch cycles between the high-order and low-order bits. Table 4–8 provides voltage conversions for the high-order bits and Table 4–9 provides voltage conversions for the low-order bits. The values from each table are added to obtain the tension arm's output voltage. For example, if a 10101 is displayed in the high-order bits, and a 10010 is displayed in the low-order bits, the tension arm output voltage is 3.56 volts.

Test 24 can also measure the voltage difference between the output of the tension arm at rest and the output of the tension arm when it is against the forward bumper. This measurement is obtained by manually moving the tension arm to the forward bumper and then pressing the Unload switch. The binary values obtained in this procedure can be converted to voltage equivalents using Table 4–8 and Table 4–9.

When the voltage obtained from the high-order pattern is positive, the voltage obtained from the low-order pattern can only be positive. In the same way, when the high-order voltage is negative, the low-order voltage must also be negative.

**Analyzing Test 24 Results** – Perform the following steps.

1. Record the high-order LED pattern.
2. Press the Load switch to select the low-order LED pattern.
3. Record the low-order LED pattern.
4. Use Table 4–8 and Table 4–9 to determine the voltage equivalents for the high-order and low-order LED patterns.
5. Add the voltage values to determine the total tension arm output voltage.

When the tension arm is held against the *forward* bumper, the voltage reading should be -3.0 volts or less. When the tension arm is against the *rear* bumper, the voltage reading should be +1.0 volt or less. The voltage difference obtained by pressing the Unload switch must be between 2.4 and 3.6 volts.

**Table 4–8 High-Order Bits Conversion Chart**

| LOAD | UNLOAD | ON-LINE | WRT EN | ENTER | Voltage |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 0.00 |
| 0 | 0 | 0 | 1 | 1 | -4.48 |
| 0 | 0 | 1 | 0 | 1 | 2.56 |
| 0 | 0 | 1 | 1 | 1 | -1.92 |
| 0 | 1 | 0 | 0 | 1 | 1.28 |
| 0 | 1 | 0 | 1 | 1 | -3.20 |
| 0 | 1 | 1 | 0 | 1 | 3.84 |
| 0 | 1 | 1 | 1 | 1 | -0.64 |
| 1 | 0 | 0 | 0 | 1 | 0.64 |
| 1 | 0 | 0 | 1 | 1 | -3.84 |
| 1 | 0 | 1 | 0 | 1 | 3.20 |
| 1 | 0 | 1 | 1 | 1 | -1.28 |
| 1 | 1 | 0 | 0 | 1 | 1.92 |
| 1 | 1 | 0 | 1 | 1 | -2.56 |
| 1 | 1 | 1 | 0 | 1 | 4.48 |
| 1 | 1 | 1 | 1 | 1 | 0.00 |

**Table 4–9 Low-Order Bits Conversion Chart**

| LOAD | UNLOAD | ON-LINE | WRT EN | ENTER | Voltage |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | +0.00 or -0.64 |
| 0 | 0 | 0 | 1 | 0 | +0.32 or -0.32 |
| 0 | 0 | 1 | 0 | 0 | +0.16 or -0.48 |
| 0 | 0 | 1 | 1 | 0 | +0.48 or -0.16 |
| 0 | 1 | 0 | 0 | 0 | +0.08 or -0.56 |
| 0 | 1 | 0 | 1 | 0 | +0.40 or -0.24 |
| 0 | 1 | 1 | 0 | 0 | +0.24 or -0.40 |
| 0 | 1 | 1 | 1 | 0 | +0.56 or -0.08 |
| 1 | 0 | 0 | 0 | 0 | +0.04 or -0.60 |
| 1 | 0 | 0 | 1 | 0 | +0.36 or -0.28 |
| 1 | 0 | 1 | 0 | 0 | +0.20 or -0.44 |
| 1 | 0 | 1 | 1 | 0 | +0.52 or -0.12 |
| 1 | 1 | 0 | 0 | 0 | +0.12 or -0.52 |
| 1 | 1 | 0 | 1 | 0 | +0.44 or -0.20 |
| 1 | 1 | 1 | 0 | 0 | +0.28 or -0.36 |
| 1 | 1 | 1 | 1 | 0 | +0.60 or -0.04 |

**Recommended Corrective Action** – Follow these steps.

1. Ensure that the nonmetallic dielectric of the capacitor plate assembly moves when the tension arm is moved.
2. Perform the tension arm output adjustment procedure (Section 5.5.7).
3. Replace the main circuit board (Section 5.4.13).
4. Replace the tension arm assembly (Section 5.4.30).

### TEST 31 (SENSORS TEST)

**Test 31 Description** – This test checks the file-protect/reel-seated sensor and the tape-in-path sensor.

The file-protect/reel-seated sensor is checked by placing a tape reel without a write-enable ring on the supply hub and running the test. As the supply hub rotates, a quick double-pulse of the Unload LED occurs, indicating that the tape is write protected. The double-pulsing can only be observed by grasping and manually rotating the supply hub until the reel-seated reflector moves past the sensor; otherwise, the double-pulse blurs into a single-pulse. Installing a write-enable ring in the reel causes the Unload LED to produce both a double-pulse and a single-pulse. This indicates that the tape is write-enabled.

The tape-in-path sensor is checked when tape blocks the light from entering the tape-in-path sensor. When tape is loaded properly, the Load LED is ON; when no tape is loaded, the Load LED is OFF.

**Analyzing Test 31 Results** – Perform the following steps.

1. Observe that the supply hub rotates counterclockwise. If it does not, run test 11.
2. Observe that the Unload LED flashes twice per revolution when a write-enable ring is installed, and once per revolution when the write-enable ring is not installed.
3. Slow down the tape reel with your hand and observe that the single-pulse per revolution with no write-enable ring installed is actually two closely spaced pulses.
4. Observe that the Load LED flashes once per revolution when the loose end of the tape passes in front of the tape-in-path sensor.

**Recommended Corrective Action** – Follow these steps.

1. Replace the file-protect sensor (Section 5.4.6).
2. Replace the tape-in-path transmitter (Section 5.4.29).
3. Replace the tape-in-path receiver (Section 5.4.28).
4. Replace the main circuit board (Section 5.4.13).

### TEST 32 (HUB LOCK TEST)

**Test 32 Description** – This test rotates the supply hub while enabling the hub lock solenoid. The hub should stop when the hub tab engages the bell crank. The reel servo is momentarily reversed, and the hub lock solenoid is disengaged. The hub is then positioned past the solenoid latch and the cycle is repeated If the front panel door is not closed, the On-Line LED lights.

**CAUTION**

**Running this test repeatedly can damage the hub lock.**

**Analyzing Test 32 Results** – Observe the test for proper operation of the supply hub and to ensure that the On-Line LED does not light.

**Recommended Corrective Action** – Follow these steps.

1. Check that the doors are properly closed.
2. Replace the faulty solenoid (Section 5.4.9).

### TEST 33 (DOOR LOCK DISABLE TEST)

**Test 33 Description** – This test disables the front panel door interlock to allow observation of the tape during operation. The door interlock is reenabled when a tape is unloaded following a load, or when the tape drive is powered OFF and back ON.

**Analyzing Test 33 Results** – Observe that the tape drive can operate with the doors open.

**Recommended Corrective Action** – Replace the defective interlock switch (Section 5.4.11).

### TEST 34 (BLOWER MOTOR TEST)

**Test 34 Description** – This test provides manual control of the blower motor via the Load switch. Pressing the Load switch to ON starts the blower motor; pressing the Load switch to OFF stops the blower motor.

**Analyzing Test 34 Results** – Observe that the Load switch starts and stops the blower motor.

**Recommended Corrective Action** – Follow these steps.

1. Replace the blower motor (Section 5.4.1).
2. Replace the main circuit board (Section 5.4.13).

### 4.6.3 Tape Loaded Test Descriptions

The test procedures for the tape loaded diagnostics are the same as that for the tape unloaded diagnostics (Section 4.6.1).

This section provides the following for each test that runs *with* a tape loaded.

- Detailed description of the test
- Instructions for analyzing the test results
- Recommended corrective action

**NOTE**

**Ensure that the tape drive is Off-Line before starting any diagnostics.**

#### TEST 21 (READ THRESHOLD ADJUSTMENT TEST)

**Test 21 Description** – This test provides a means to adjust the read threshold circuit using the Load and Unload LEDs. No analysis or recommended corrective action is required. Details on this test are provided in Section 5.5.2.

#### TEST 22 (TENSION ARM MOTION TEST)

**Test 22 Description** – This test cycles the tape forward and reverse while changing speed between 25 ips and 100 ips. The front panel LEDs display a binary number that indicates how close the tension arm came to hitting one of its stops during the time this test is running. The binary code should be 5 (10100) or more. The display holds the minimum value, so it is not necessary to watch the LEDs constantly. When EOT is reached, the tape is rewound and the test is repeated.

**Analyzing Test 22 Results** – Observe that a binary code of five (10100) or greater is displayed.

**Recommended Corrective Action** – Follow these steps.

1. Run tape unloaded test 24 (Tension Arm Test).
2. Perform the tension arm output adjustment procedure (Section 5.5.7).
3. Perform the tension arm spring adjustment procedure (Section 5.5.8).

### TEST 23 (WRITE DATA TEST)

**Test 23 Description** – This test writes and reads data blocks at 25 ips (Load switch pressed) or 100 ips (Unload switch pressed). The test is started when the switch (Load or Unload) is pressed the first time. The test is stopped when the switch is pressed the second time.

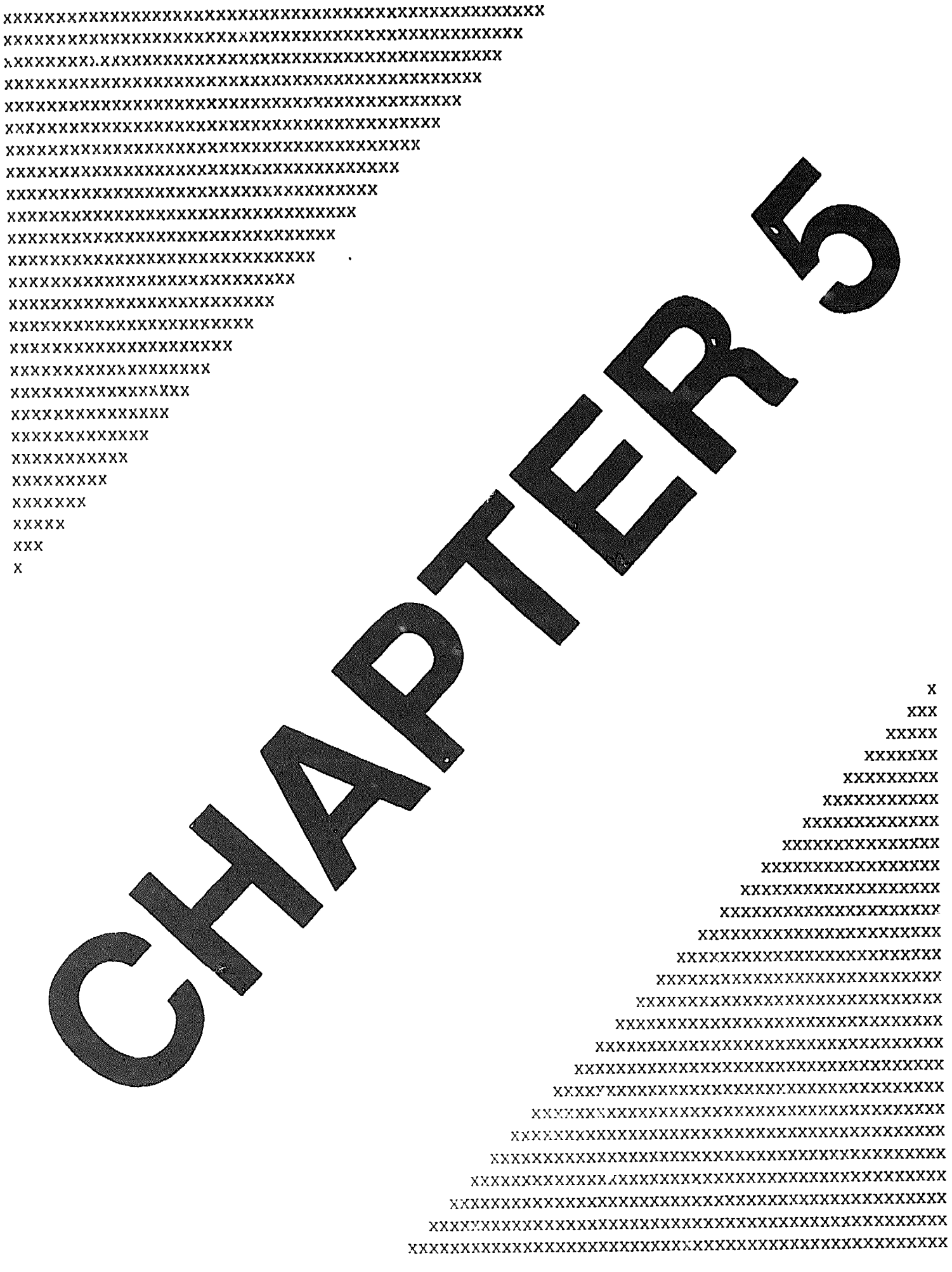
If the tape reel is not write-enabled, only data already written to the tape can be read. A read reverse is performed if the Enter switch is pressed while the Load or Unload switches are pressed to select the desired speed.

The Load LED flashes approximately once every five seconds if data is being read from the tape at the same speed it was written. The Load LED flashes rapidly if data written at 25 ips is being read at 100 ips.

**Analyzing Test 23 Results** – Perform the following steps.

1. Observe that the data is written and read at both 25 and 100 ips and that no errors are reported through the front panel LEDs.
2. Observe that a read reverse is performed with no error when the Enter switch is pressed while selecting the speed.

**Recommended Corrective Action** – Run the test indicated by the failure symptoms.


CHAPTER 5

# 5
# REMOVAL AND REPLACEMENT PROCEDURES

## 5.1 INTRODUCTION

This chapter provides removal and replacement procedures for most field replaceable units (FRUs). The FRUs included in this manual are based on the recommended spares list and are listed in Table 5–1. Adjustment procedures are included at the end of this chapter.

**WARNING**

**Before performing any removal or replacement procedures, ensure that the tape drive is powered OFF and that the power cord is disconnected from the wall outlet.**

**Table 5–1 TSZ05 FRUs**

| Part Number | Description |
|---|---|
| 29-25065-00 | Air Filter |
| 29-28150-01 | Air Pump Assembly |
| 29-28151-01 | Bell Crank Assembly |
| 29-24099-00 | Capacitor Plate Assembly |
| 29-28084-01 | Control Switches |
| 29-28221-01 | Digital Front Facia TSZ05 |
| 29-28080-01 | Door Assembly (dark smoke) |
| 29-28222-01 | Front Panel Assembly (complete) |
| 29-28085-01 | Front Panel Lock Assembly |
| 90-07213-00 | Fuse, 3AG Slo-Blo 1.5 A 250 V |
| 90-07218-00 | Fuse, 3AG Slo-Blo 3 A 250 V |
| 29-28081-01 | Head Cable Assembly-Read |
| 29-28079-01 | Head Cable Assembly-Write |
| 29-28077-01 | Hub Lock Solenoid Coil |
| 29-28149-01 | Interlock Switch, Top Cover |

**Table 5–1 (Cont.) TSZ05 FRUs**

| Part Number | Description |
|---|---|
| FD-12674-01 | Manual Release Switch |
| 29-24082-00 | PCB, EOT/BOT Assembly |
| 29-24084-00 | PCB, File-Protect Sensor Assembly |
| 29-28082-01 | PCB, Motor Noise Filter Assembly |
| 29-24085-00 | PCB, Power Supply Assembly |
| 29-28086-01 | PCB, SCSI, Single Ended |
| 29-24083-00 | PCB, Tape-In-Path Sensor |
| 29-28083-01 | Power Switch (green) |
| 29-24081-00 | Roller Guide #1 |
| FD-13578-01 | Roller Guide #2 |
| 29-24101-00 | Roller Guide #3, 4, and 5 |
| 29-28078-01 | Safety Pin |
| 29-24077-00 | Supply Hub |
| 29-24095-00 | Supply Motor/Insulator/Bell Crank |
| 29-28147-01 | Tachometer Assembly |
| 29-24094-00 | Take-Up Motor |
| 29-24093-00 | Tape Sensor Assembly, Receiver |
| 29-24079-00 | Tension Arm Assembly |
| 12-30552-01 | Terminator, SCSI |
| 29-28148-01 | Top Cover |
| 29-28146-01 | Transformer Assembly |
| 29-24080-00 | Universal Head with Cables |

## 5.2 TOOLS AND MATERIALS

Table 5–2 lists the special tools and materials necessary to service the TSZ05 Tape Drive.

**Table 5–2 Special Tools and Materials**

| Part Number | Item |
|---|---|
| FD-13588-01 | Hub-Height Adjustment Tool |
| FD-11319-01 | Tape, Master Skew |
| 29-11696-00 | Tape, Reference Level |
| 29-80681-00 | Tape, Cleaning Kit |
| 29-12522-00 | Scale, 36 oz Chatillon™ |

™Chatillon is a trademark of John Chatillon & Sons, Inc.

# 5.3 OPENING THE TAPE DRIVE TO THE SERVICE ACCESS POSITION

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the enclosure lid by pressing gently on the front of the lid and raising until the latch locks.
4. Raise the top cover and place the cover retaining arm in its slot (Figure 5–1).

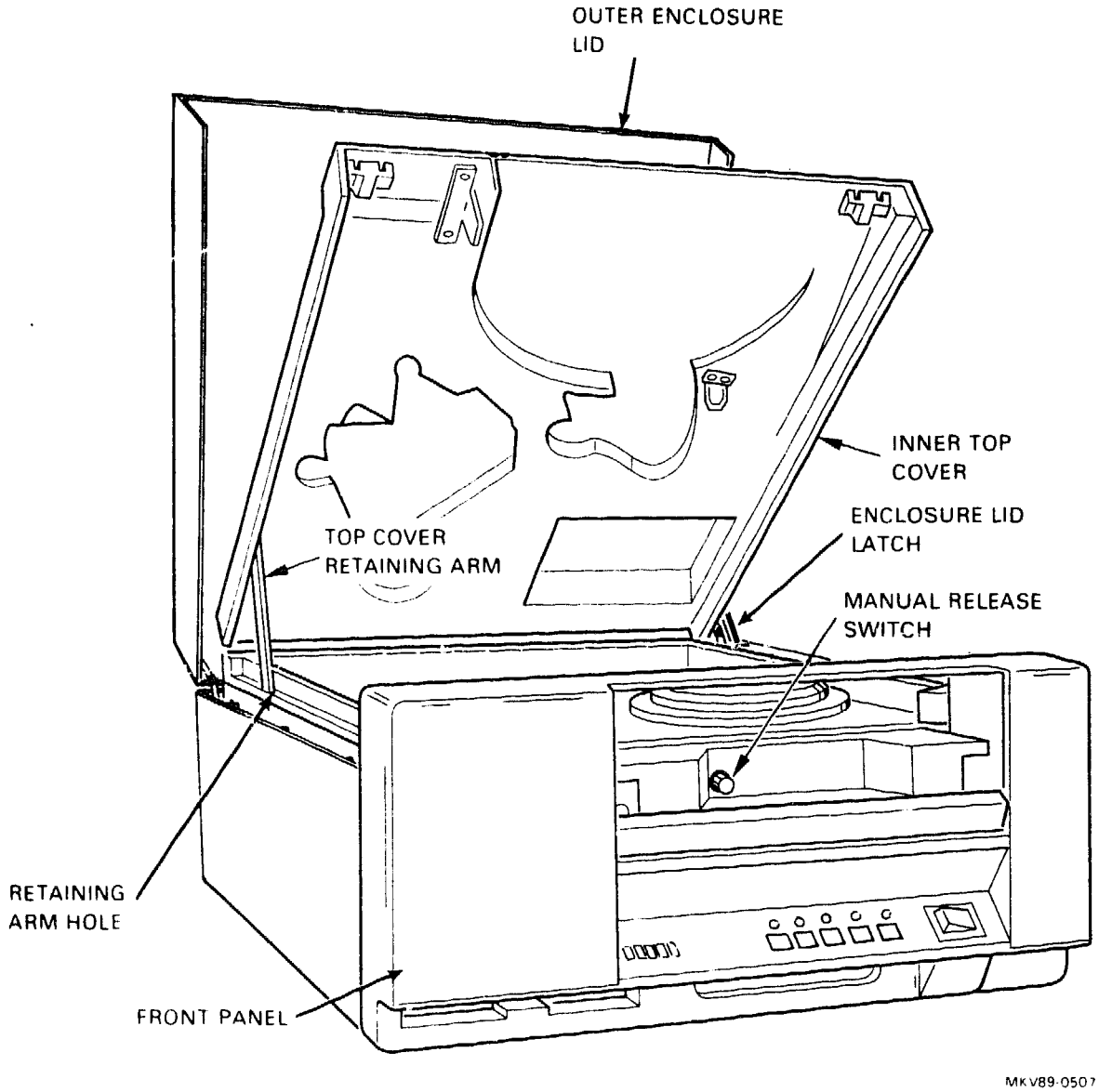



**Figure 5–1 Raising the Top Cover**

5. Use a screwdriver to loosen (do not remove) the two retainer screws (one on each side of the deck plate) until they pop up under spring pressure (Figure 5–2).
6. Grasp the bottom center of the front panel with both hands and lift it upward as far as it goes, then lower it slowly until the latch in the support arm locks.

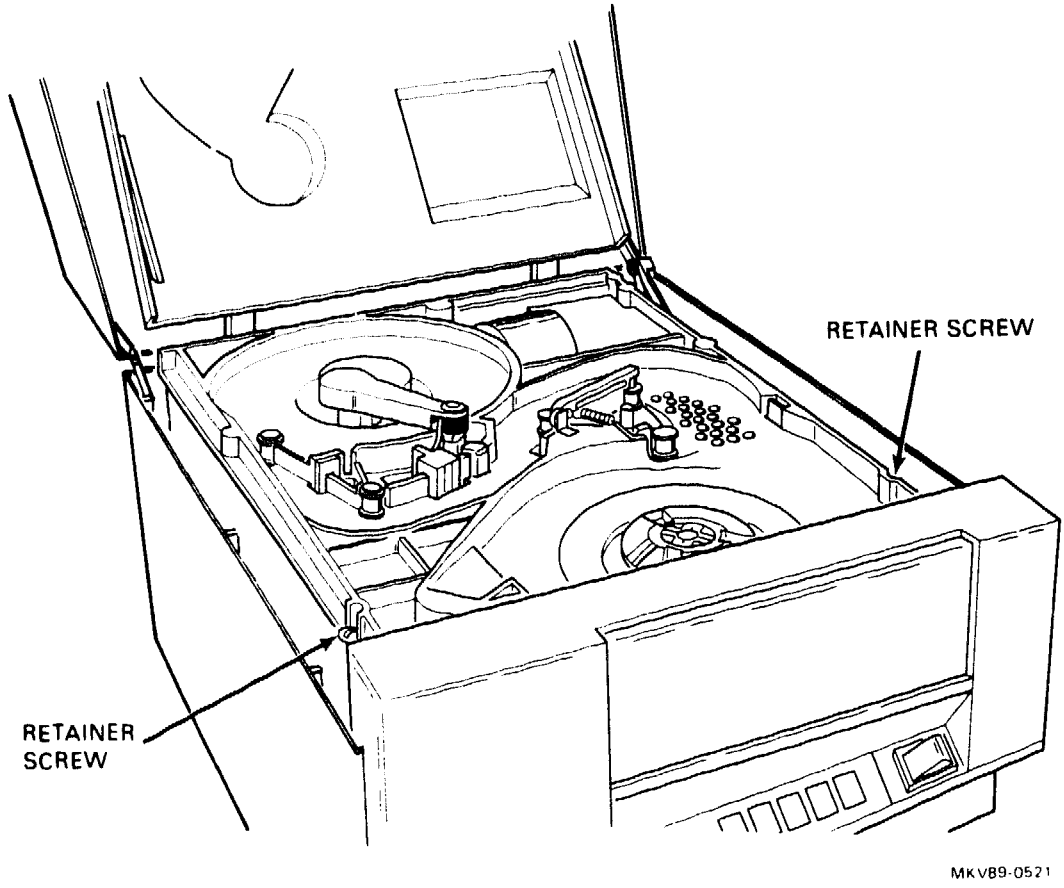



**Figure 5–2 Loosening the Deck Plate Retainer Screws**

7. Insert the safety pin into the hole in the support arm (Figure 5–3).

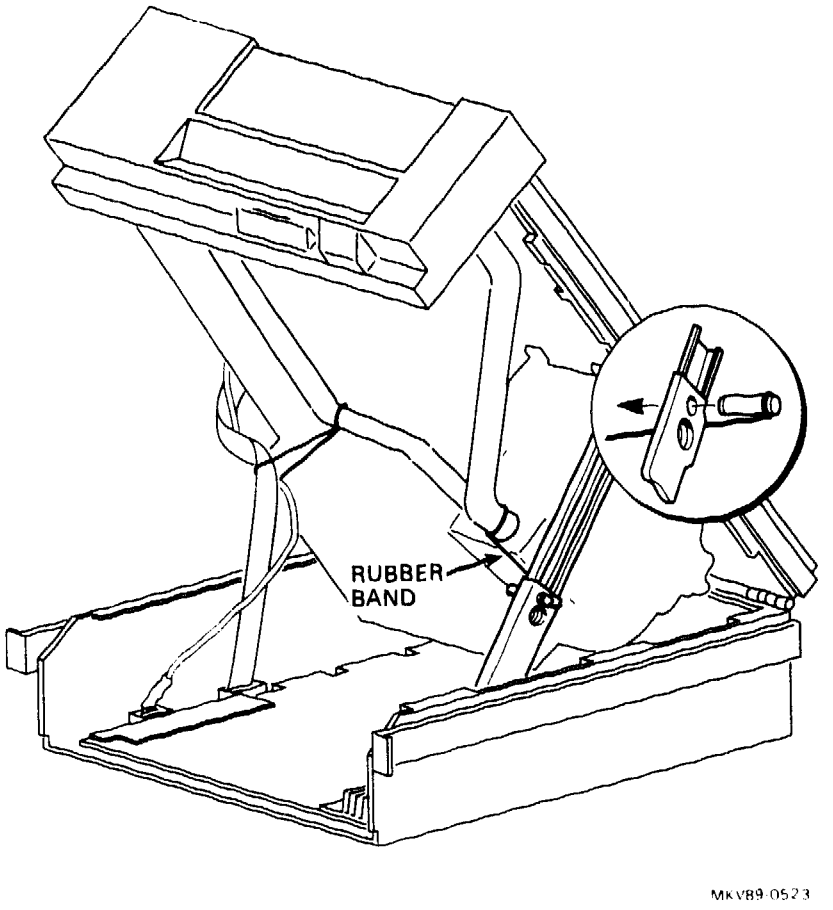



**Figure 5–3 Inserting the Safety Pin**

# 5.4 REMOVAL AND REPLACEMENT PROCEDURES

Refer to the following sections for specific removal and replacement procedures.

## 5.4.1 Blower Motor

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the main circuit board (Section 5.4.13).
5. Perform steps one through ten of the Power Supply Circuit Board Removal procedure (Section 5.4.15).
6. Remove the three nuts (1) securing the blower (2) to the power supply housing, then remove the blower (Figure 5–4).

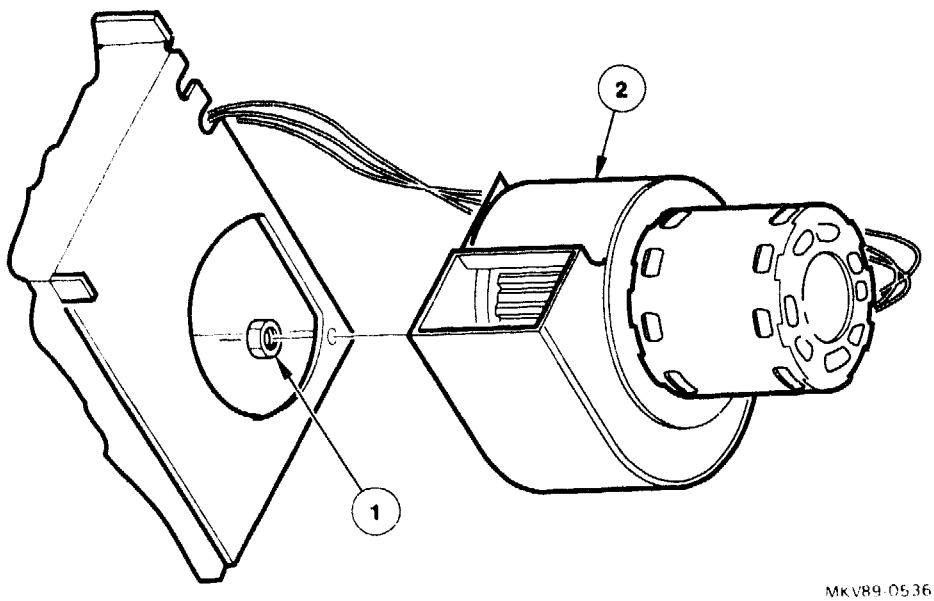



**Figure 5–4 Removing the Blower Motor**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.2 Control Switches

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Disconnect the electrical connector (1). See Figure 5–5.
4. Remove the switch panel overlay.
5. Push the switch assembly (2) out of the front panel. (It is held to the front panel with adhesive.)

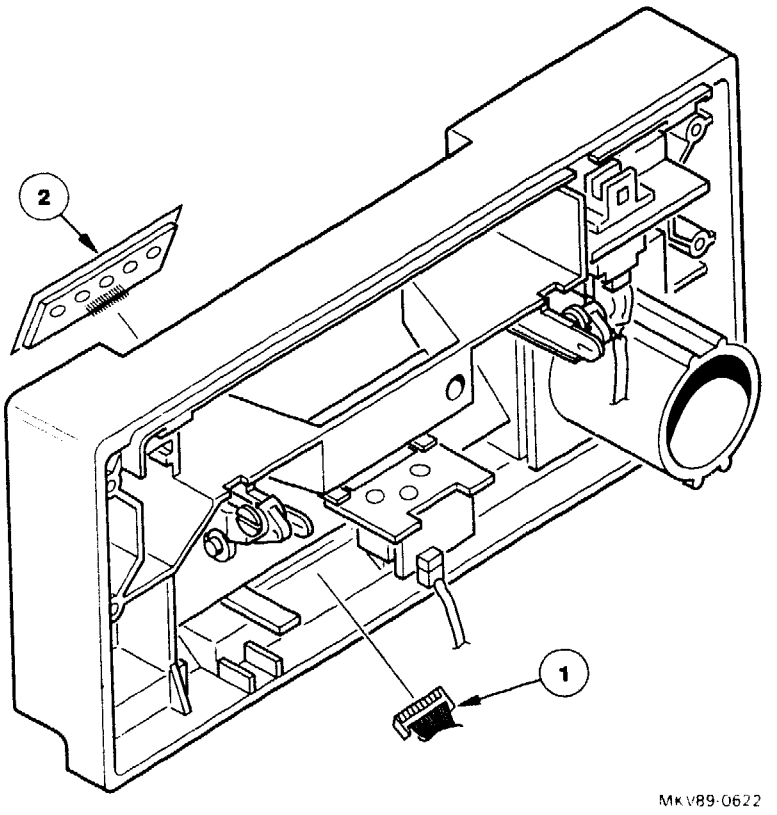



**Figure 5–5 Removing the Control Switches**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. New control switches must have the adhesive backing removed to install them.

## 5.4.3 Front Panel Door Lock

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the cables (1) from the door lock circuit board (2). See Figure 5–6.
5. Remove the two clips (3) securing the door lock (4) to the front panel, then remove the door lock.

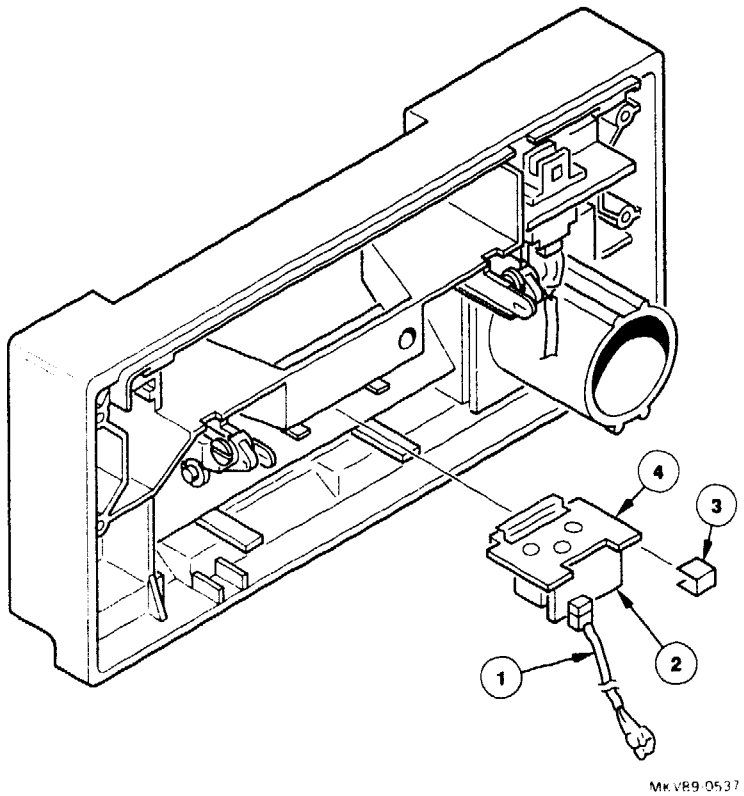



**Figure 5–6 Removing the Front Panel Door Lock**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. The tab at the front of the door lock mounting plate slides into a groove in the front panel. The tab on the clips (3) goes downward.
2. Use Service Aid Diagnostic Test 33 to check that the door lock functions properly.

## 5.4.4 Front Door

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the front panel (Section 5.4.7).
4. With the door opened fully, remove each spring (1). See Figure 5–7.
5. Push the door inward to separate the arms (2) from the pivots (3).
6. Remove the door through the opening in the front panel.

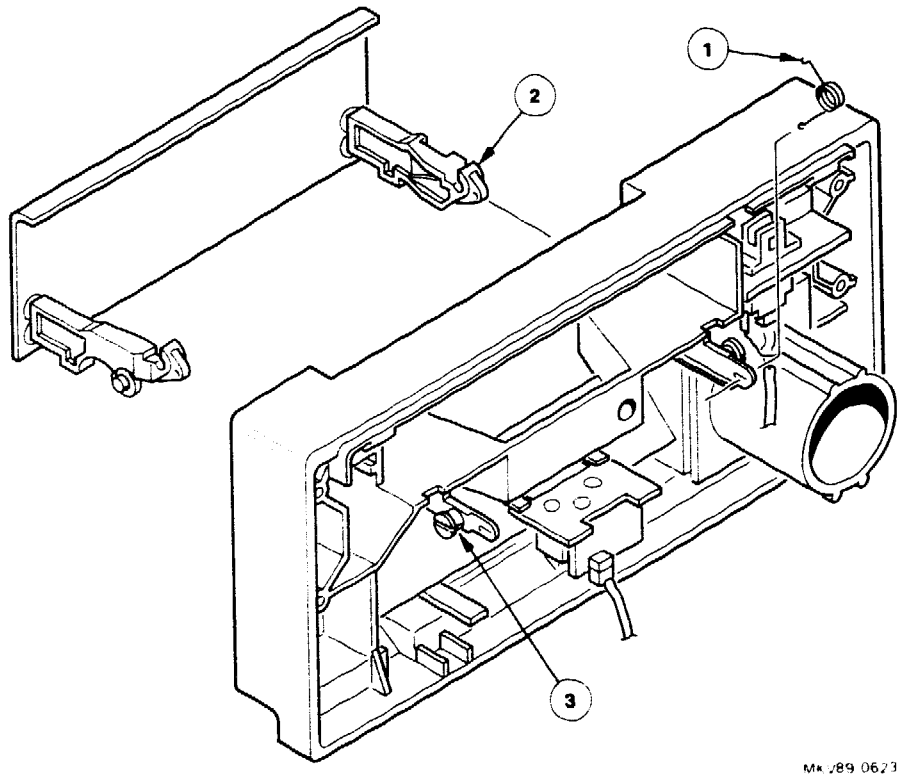



**Figure 5–7 Removing the Front Door**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. Put a small amount of Lubriplate® on each pivot (3) before snapping the door arms (2) onto the pivots and reinstalling the springs (1).

® Lubriplate is a registered trademark of Lubriplate Corporation

## 5.4.5 EOT/BOT Sensors

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the cable (1) from the EOT/BOT sensors (2). See Figure 5–8.
5. Remove the two screws (3) and washers securing the sensors to the deck plate, then remove the sensors.

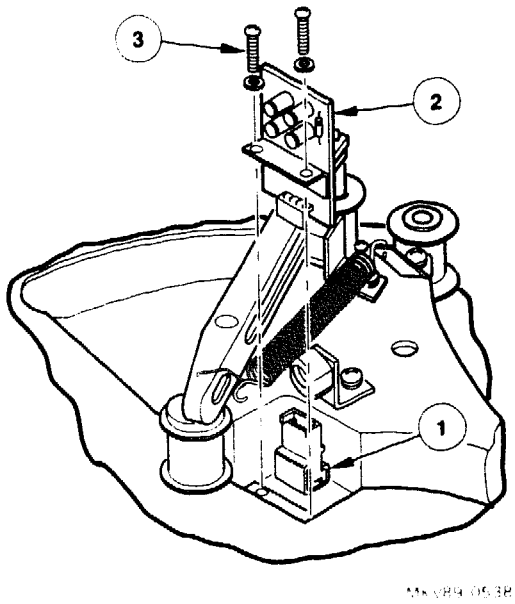



**Figure 5–8 Removing the EOT/BOT Sensors**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Use Service Aid Diagnostic Tests 22 and 23 to check that both sensors function properly.

## 5.4.6 File-Protect Sensor

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the cable (1) from the file-protect sensor (2). See Figure 5–9.
5. Remove the two screws (3) and washers securing the sensor to the deck plate.

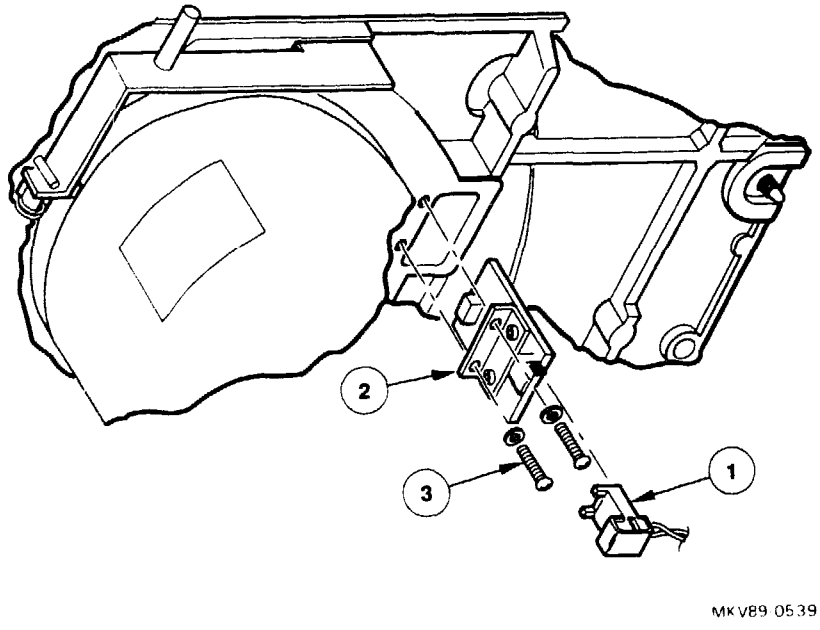



**Figure 5–9 Removing the File-Protect Sensor**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Use Service Aid Diagnostic Test 31 to check that the sensor functions properly.

## 5.4.7 Front Panel

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Open the front door.
5. Disconnect the electrical connectors (1, 2, and 3). See Figure 5–10.
6. Remove the four screws (4) and washers securing the front panel (5) to the deck plate.
7. Remove the front panel.

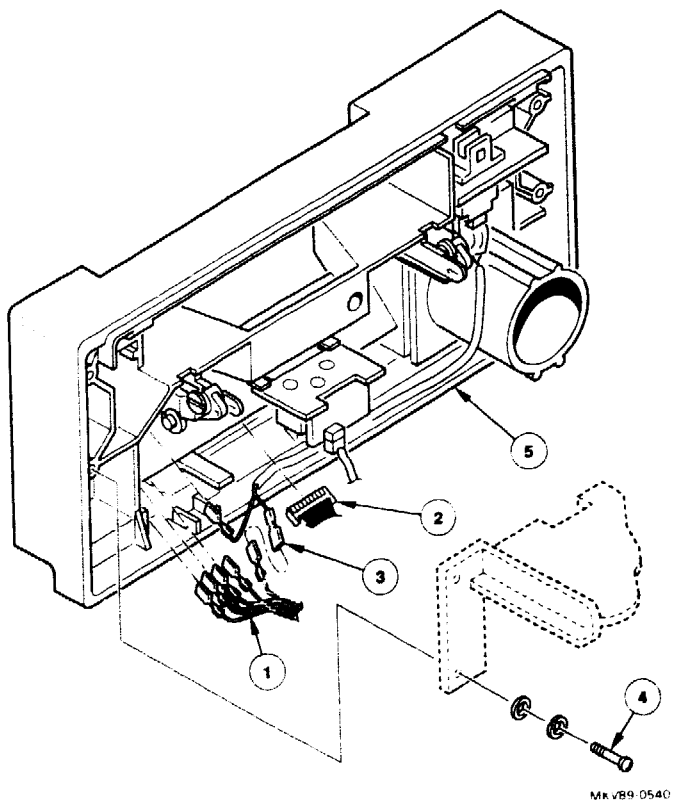



**Figure 5–10 Removing the Front Panel**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Ensure that both air ducts fit correctly to the front panel.
3. Use Service Aid Diagnostic Test 33 to check that the door lock functions properly.

## 5.4.8 Fuse

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the fuse cap (1). See Figure 5–11.
4. Remove the fuse from the fuse cap.

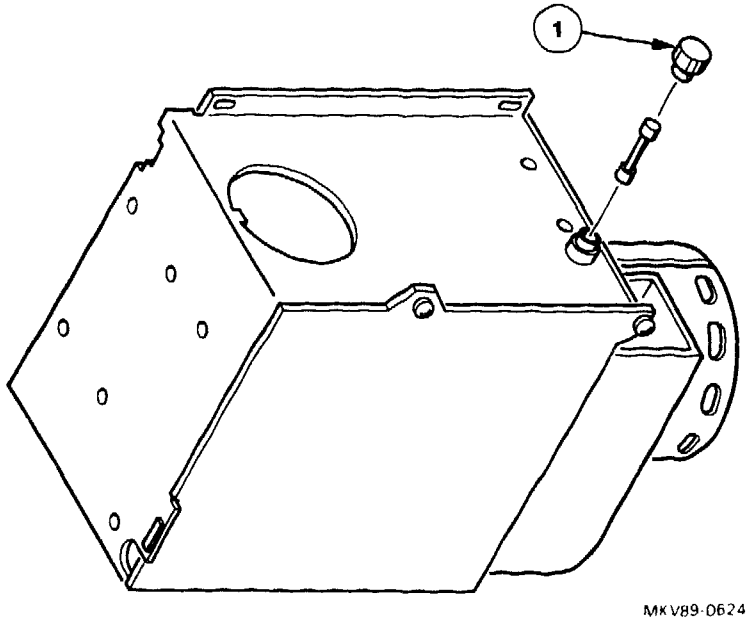



**Figure 5–11 Removing the Fuse**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. Be sure to use the correct fuse: for 100 to 120 Vac operation, use a 3 ampere, 250 volt, Slo-Blo fuse; for 208 to 240 Vac operation, use a 1.5 ampere, 250 volt, Slo-Blo fuse.

## 5.4.9 Hub Lock Solenoid

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the cables (1) from the hub lock solenoid (2). See Figure 5–12.
5. Remove the two screws (3) and washers securing the solenoid to the deck plate, then remove the solenoid.

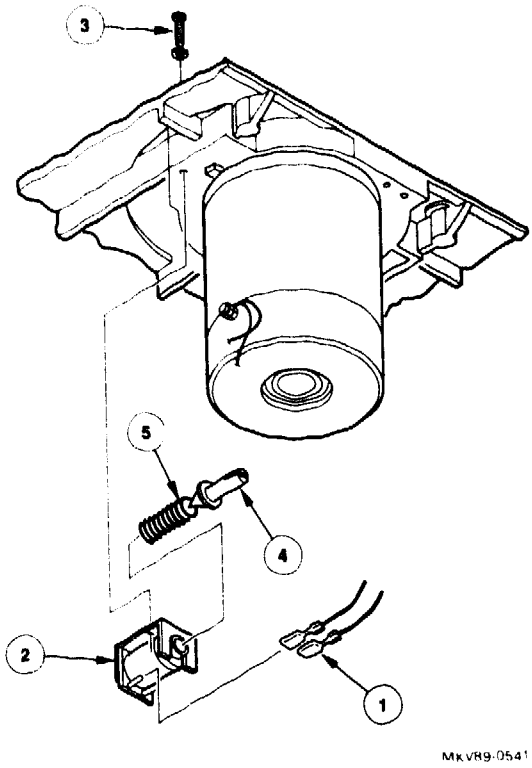



**Figure 5–12 Removing the Hub Lock Solenoid**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. Be sure that the bell crank plunger (4) is inserted through the spring (5) and into the solenoid (2), and that the bell crank is connected to the hub lock.
2. Use Service Aid Diagnostic Test 32 to check that the hub lock functions properly.

## 5.4.10 Input Air Duct

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the front panel (Section 5.4.7).
4. Remove the input air duct (1) by squeezing the left side of the duct where it enters the power supply housing to disengage the duct from the tooth (2). See Figure 5–13.

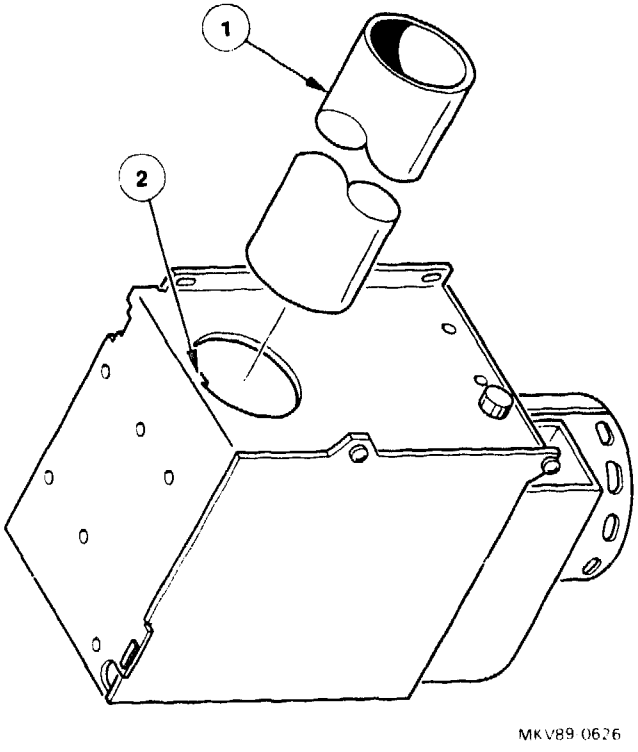



**Figure 5–13 Removing the Input Air Duct**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. Ensure that the tooth in the power supply housing fits in the hole of the duct.

## 5.4.11 Interlock Switch

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the two wires (1) from the interlock switch (2). See Figure 5–14.
5. Press inward on the sides of the switch and move it upward to remove it.

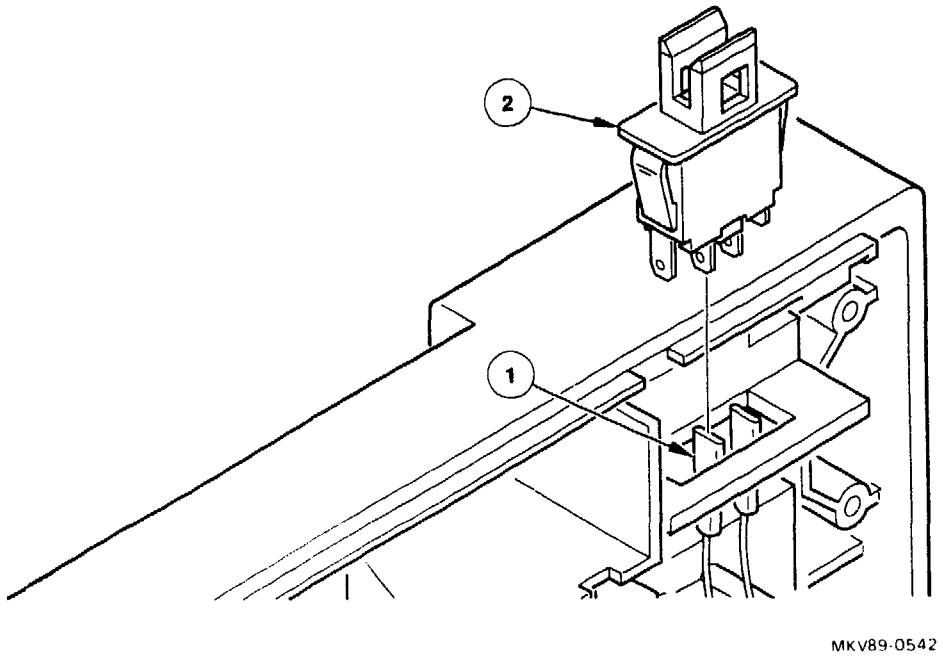



**Figure 5–14 Removing the Interlock Switch**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Power up the drive and check that the interlock functions properly by lifting the top cover. The drive should shut down.

## 5.4.12 Left Output Air Duct

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Disconnect connectors J4 (1) and J5 (2). See Figure 5–15.
4. Pull the cables through the cable holder (3).
5. Remove the screw (4) and washers attaching the air duct (5) to the deck plate.
6. Disconnect the air duct from the adapter (6).

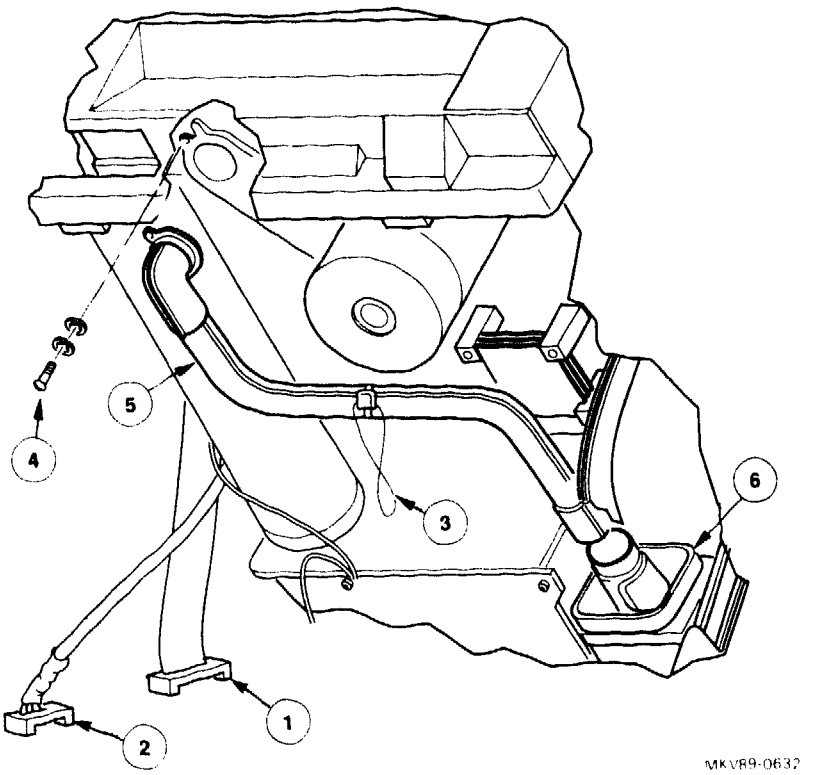



**Figure 5–15 Removing the Left Output Air Duct**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.13 Main Circuit Board

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the SCSI connector (1). See Figure 5–16.
5. Disconnect connectors J1 (2), J2 (3), J3 (4), J4 (5), and J5 (6).
6. Remove the screw (7) and washers securing the main circuit board (8) to the chassis, then remove the board.

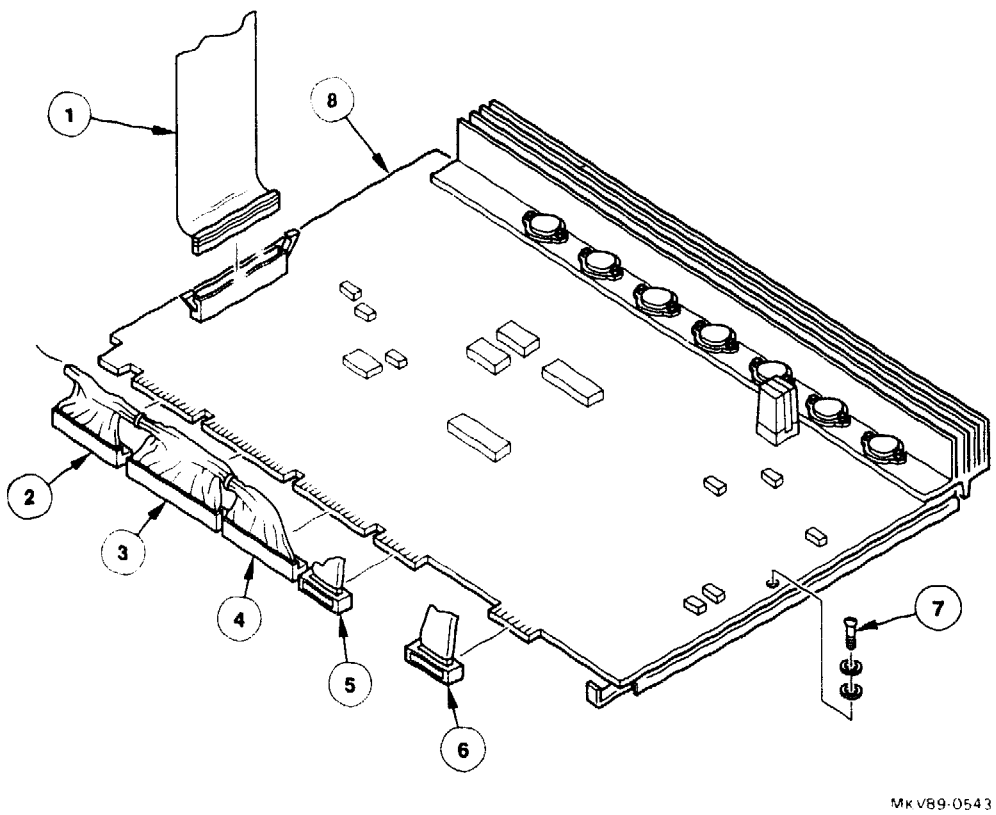



**Figure 5–16 Removing the Main Circuit Board**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Perform the Read Threshold Adjustment Procedure (Section 5.5.2).

## 5.4.14 Manual Release Switch

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the two screws (1) and washers securing the manual release switch (2) to the deck plate, then remove the release switch (Figure 5–17).

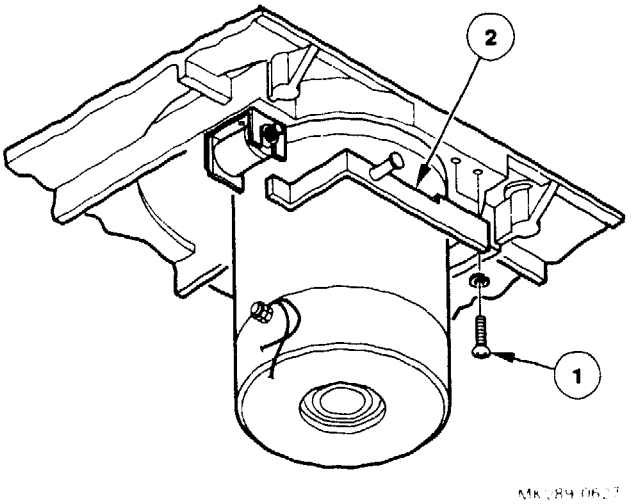



**Figure 5–17 Removing the Manual Release Switch**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.15 Power Supply Circuit Board

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the main circuit board (Section 5.4.13).
5. Remove the front panel (Section 5.4.7).
6. Remove the input air duct (Section 5.4.10).
7. Remove the right output air duct (Section 5.4.18).
8. Remove the left output air duct (Section 5.4.12).
9. Remove the two screws (1) and washers securing the power supply housing cover (2). See Figure 5–18.
10. Remove the cables from the cable holder (3).
11. Disconnect the take-up motor wires (4) from the motor filter (5).
12. Disconnect connector J7 (6) from the power supply circuit board.
13. Disconnect the line filter output wires (7) from the power supply circuit board.
14. Disconnect the blower motor wires (8) from the power supply circuit board.
15. Remove the screw (9) and washers securing the blower bracket to the deck plate.
16. Remove the two screws (10) and washers securing the power supply housing to its brackets.
17. Remove the two screws (11) and washers securing the front of the power supply housing to the deck plate, then remove the housing.
18. Disconnect connectors J5 (12), J6 (13), and J8 (14) from the power supply circuit board.
19. Remove the four screws (15) and washers securing the power supply circuit board, then remove the power supply circuit board. Feed the harness through the hole in the circuit board while removing the circuit board.

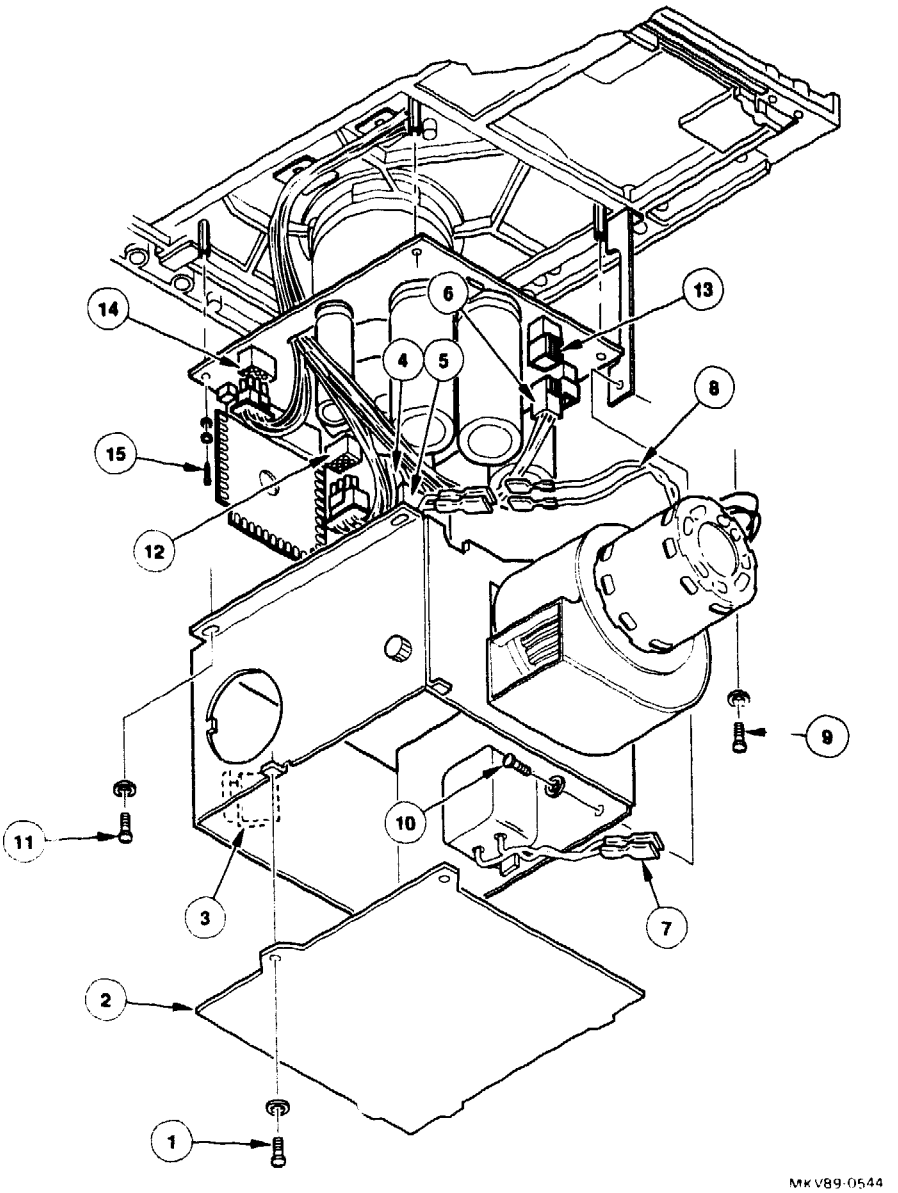



**Figure 5–18 Removing the Power Supply Circuit Board**

## REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.16 Power Switch

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Disconnect the wires (1) connected to the power switch (2). See Figure 5–19.
4. Compress the side tabs securing the power switch in the front panel, then push the switch from the back out the front of the panel.

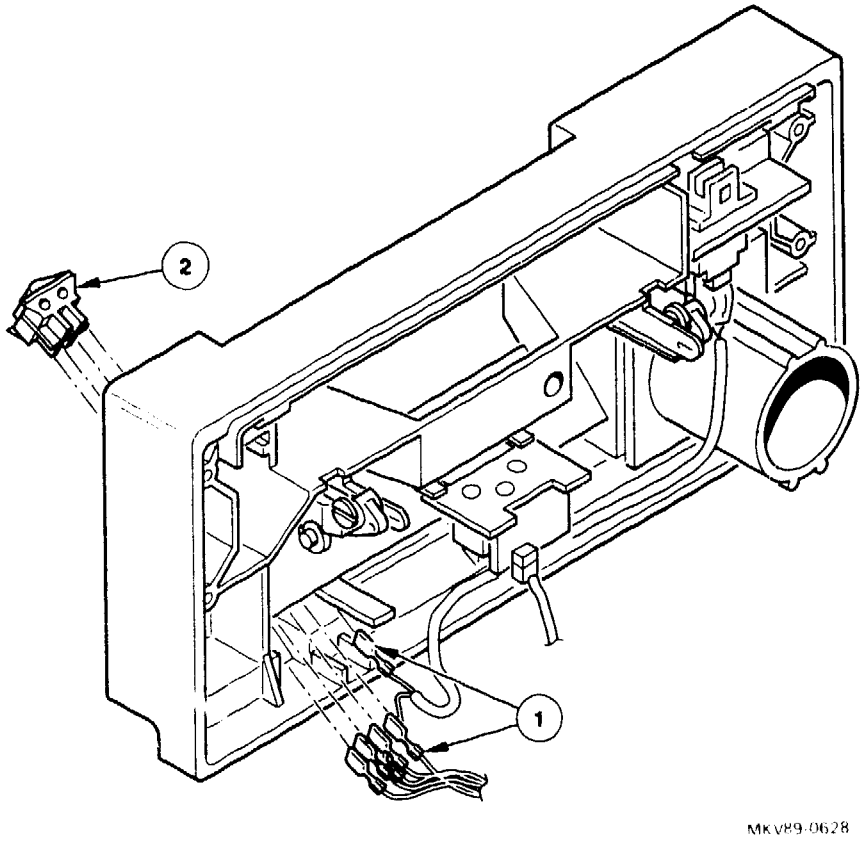



**Figure 5–19 Removing the Power Switch**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. Insert the power switch from the front of the front panel.

## 5.4.17 Read/Write Head

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect connectors J4 (1) and J5 (2). See Figure 5–20.
5. Remove the adjustment screw (1) and washers (Figure 5–21).
6. Remove the four screws (2) and washers that secure the read/write head (3) to the deck plate. Hold the head while removing the last screw.
7. Remove the head.
8. Remove the cables (4, 5, and 6) from the read/write head.

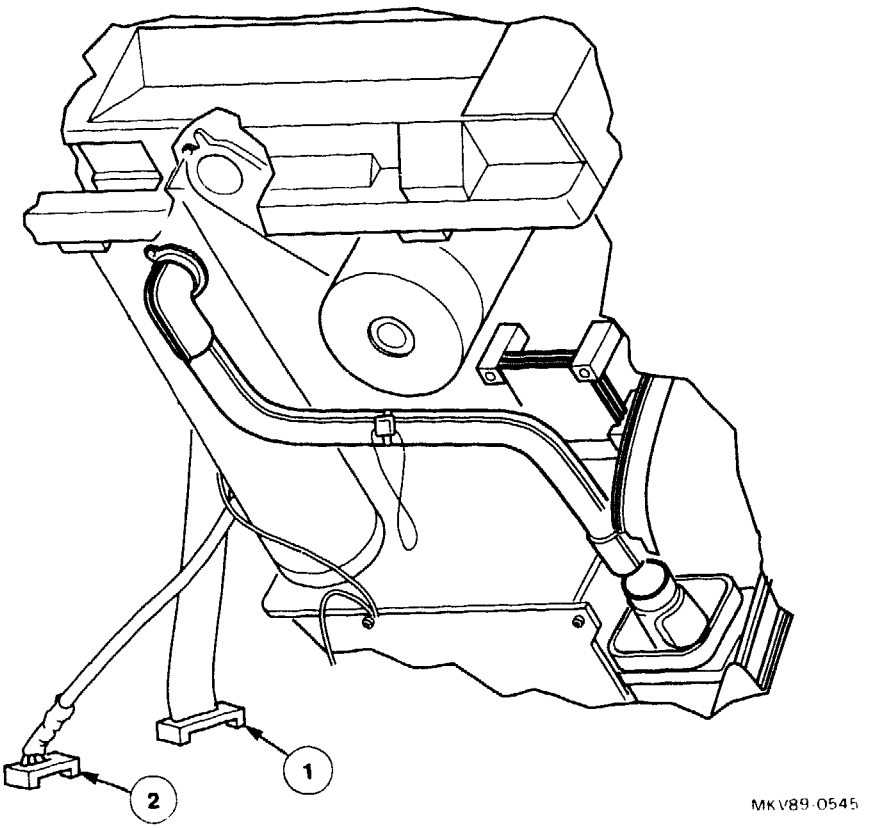



**Figure 5–20 Disconnecting the Read/Write Head**

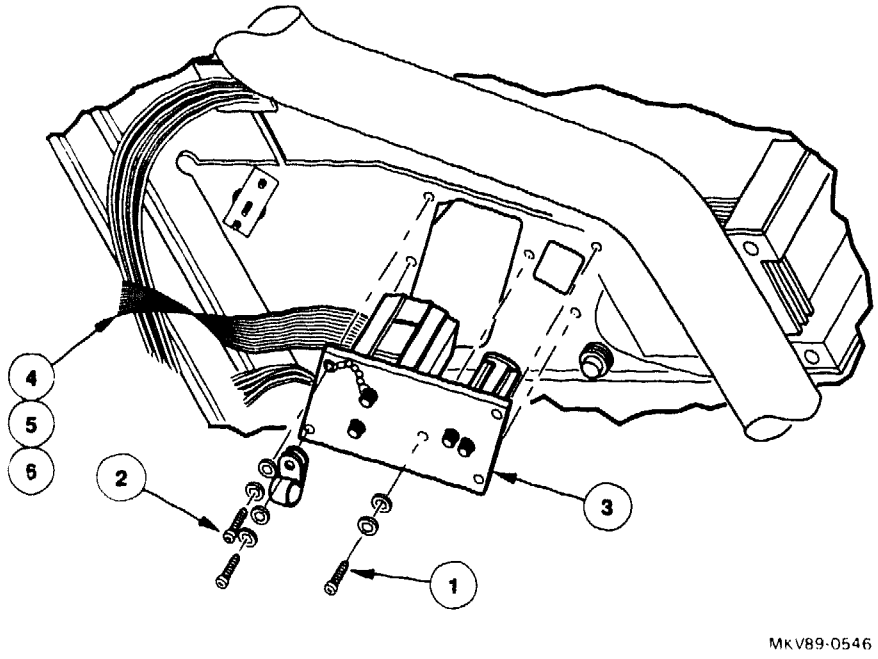



**Figure 5–21 Removing the Read/Write Head**

## REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. Leave the cover on the head until the installation is completed. Two wires from the write cable connect to the erase head. When connecting these wires, connect the black connector above the red connector.
2. Perform the Tape Alignment Adjustment (Section 5.5.6).
3. Perform the Skew Adjustment (Section 5.5.3).
4. Perform the Read Threshold Adjustment (Section 5.5.2).

## 5.4.18 Right Output Air Duct

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the front panel (Section 5.4.7).
4. Remove the tie-wraps (1 and 2) securing the power switch cable (3) and the right output air duct (4). See Figure 5–22.
5. Disconnect the air duct from the adapter (5).

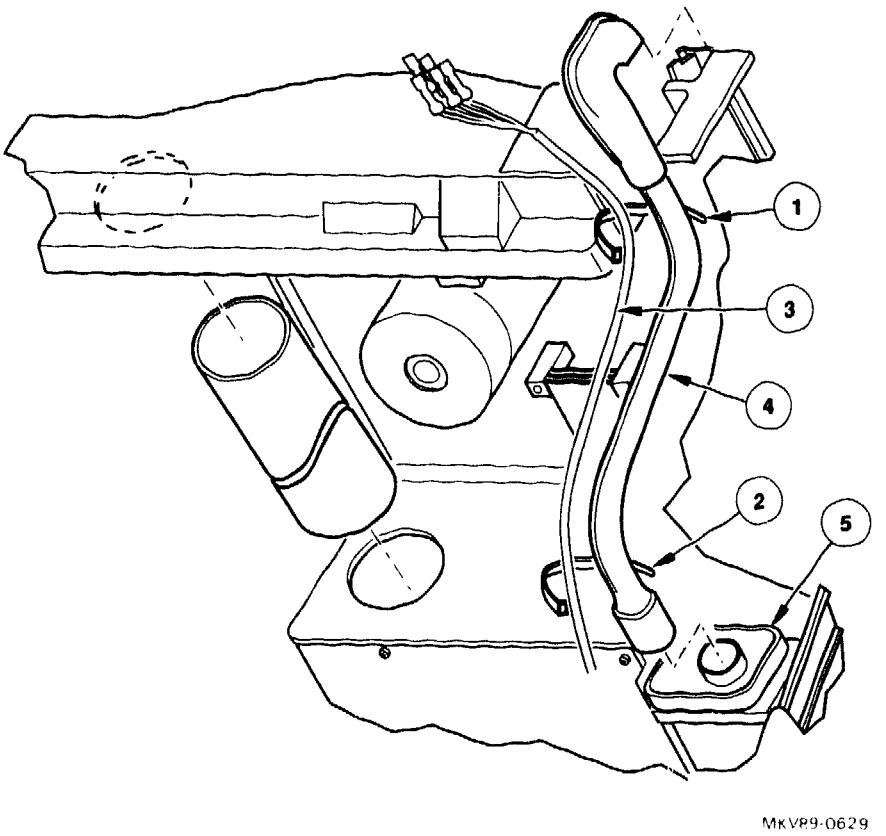



**Figure 5–22 Removing the Right Output Air Duct**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.19 Roller Guide 1

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the screw (1) and washers securing the roller guide (2), then remove the roller guide (Figure 5–23).
5. If there are any shims (3) between the roller guide and the mounting bracket (4), save them.

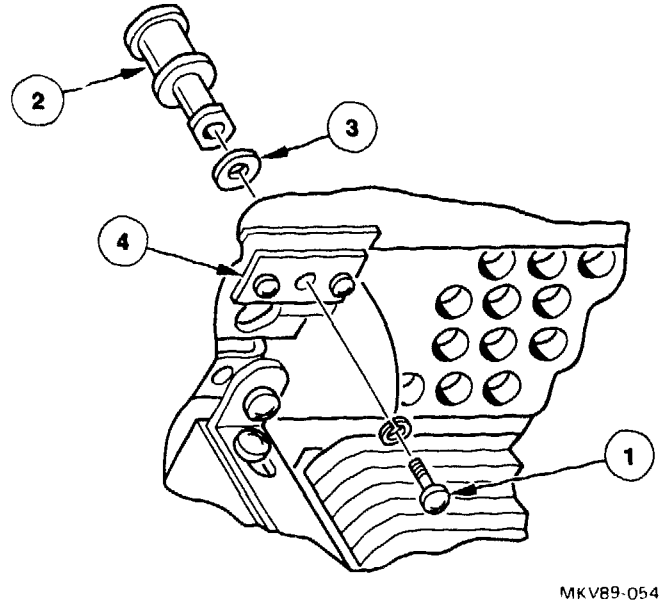



**Figure 5–23 Removing Roller Guide 1**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. If any shims (3) were saved when the roller guide was removed, place them between the roller guide (2) and the mounting bracket (4).
2. Perform the Tape Alignment Adjustment (Section 5.5.6).

## 5.4.20 Roller Guide 2

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the screw (1) and washers securing the roller guide (2), then remove the roller guide (Figure 5–24).
5. If there are any shims (3), save them.

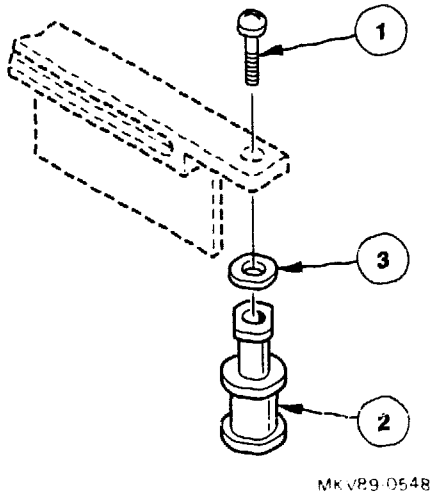



**Figure 5–24 Removing Roller Guide 2**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. If any shims (3) were saved when the roller guide was removed, replace them.
2. Perform the Tape Alignment Adjustment (Section 5.5.6).

## 5.4.21 Roller Guides 3, 4, and 5

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the screw (1) and washers securing the roller guide (2), then remove the roller guide (Figure 5–25).
5. If there are any shims (3) between the spring (4) and the mounting bracket (5), save them.

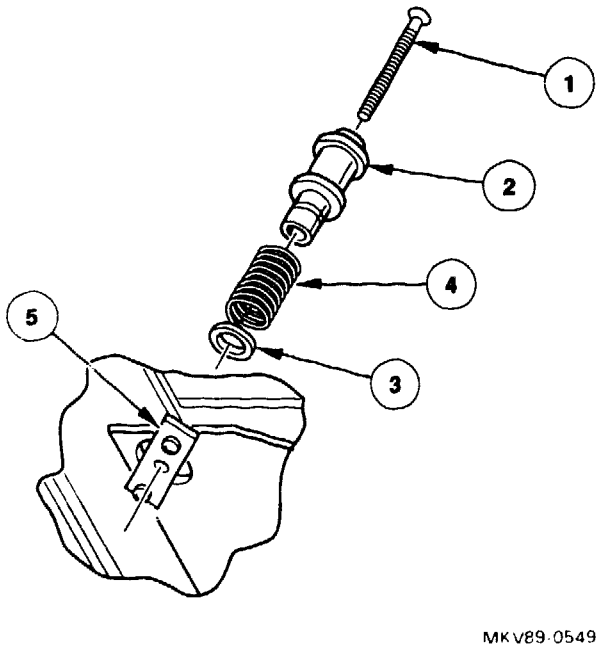



**Figure 5–25 Removing Roller Guides 3, 4, and 5**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. If any shims (3) were saved when the roller guide was removed, place them between the spring (4) and the mounting bracket (5).
2. Perform the Tape Alignment Adjustment (Section 5.5.6).

## 5.4.22 Supply Hub

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Rotate the supply hub (1) until the two screws (2) that secure the supply hub to the motor shaft are toward the front door (Figure 5–26).
5. Loosen the two screws (2), then remove the supply hub.

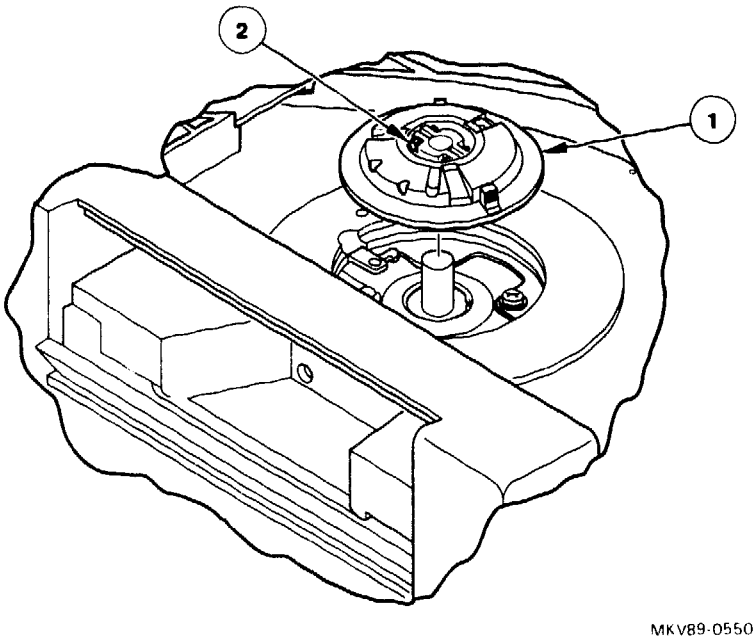



**Figure 5–26 Removing the Supply Hub**

### REPLACEMENT

1. Install the supply hub (1) on the motor shaft. Do not tighten the two screws.
2. Perform the Supply Hub Adjustment (Section 5.5.4).

## 5.4.23 Supply Hub Bell Crank

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the supply hub (Section 5.4.22).
5. Remove the hub lock solenoid (Section 5.4.9).
6. Remove the clip (1) securing the supply hub bell crank (2) to the supply motor, then remove the bell crank (Figure 5–27).

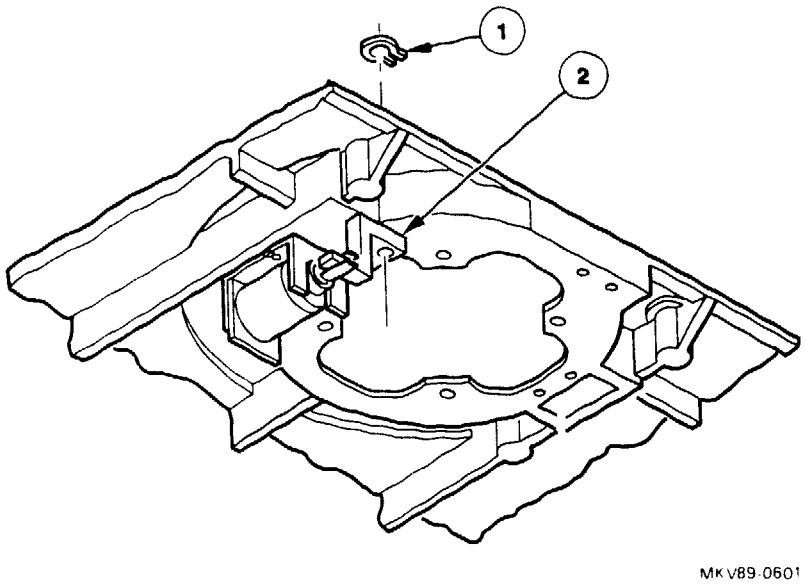



**Figure 5–27 Removing the Supply Hub Bell Crank**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order. Use Service Aid Diagnostic Test 32 to check the operation of the hub lock after the supply hub is installed.

## 5.4.24 Supply Motor

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the supply hub (Section 5.4.22).
5. Remove the clip (1) securing the supply hub bell crank (2) to the supply motor (3). See Figure 5–28.
6. Disconnect the two wires (4) from the motor filter (5).
7. Loosen the four screws (6) securing the supply motor to the deck plate.
8. Hold the motor (3) while removing the four screws (6) and washers.
9. When removing the motor from the deck plate, slide the supply hub bell crank (2) off the stud (7) on the motor.
10. Remove the motor insulator (8) from the motor.

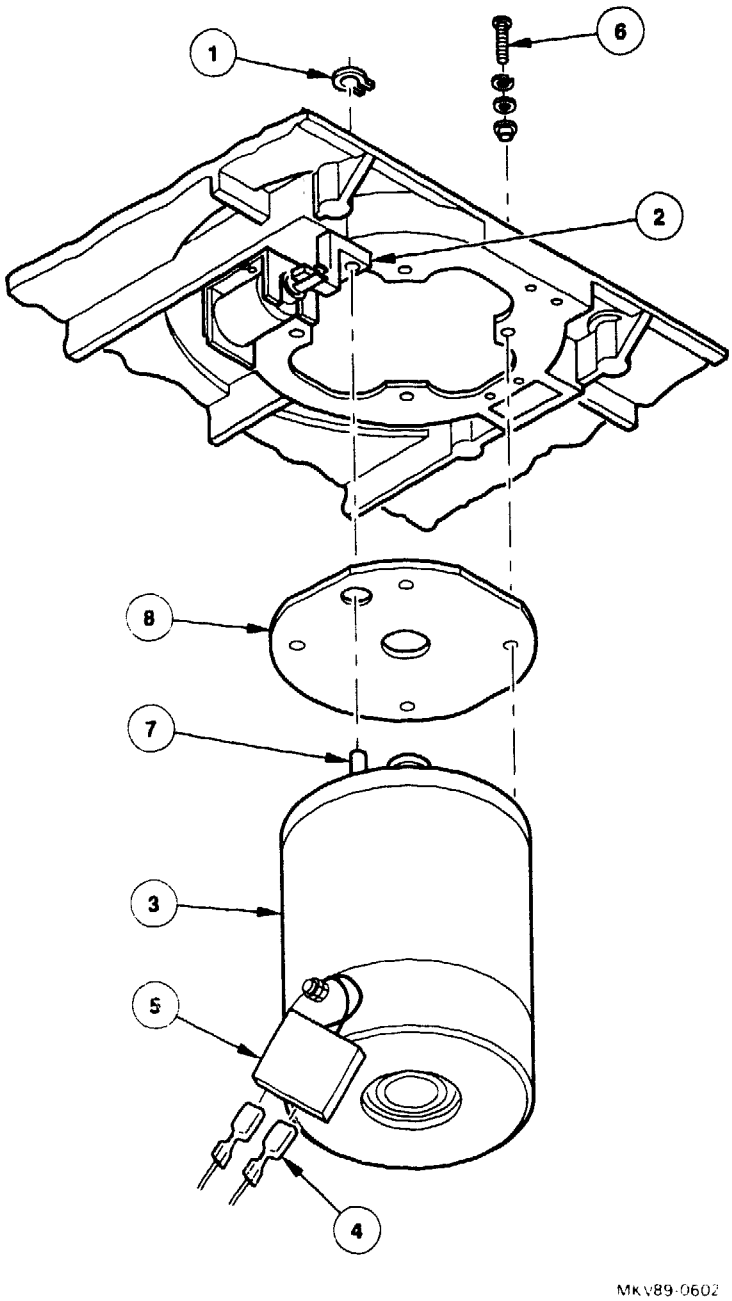



**Figure 5–28 Removing the Supply Motor**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.25 Tachometer

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the tachometer cable (1). See Figure 5–29.
5. Remove the snap ring (2), wavewasher (3), and shims (4).
6. Remove the tachometer (5) from the deck plate.
7. Check whether the upper bearing (6) and lower bearing (7) are damaged. Remove if necessary.

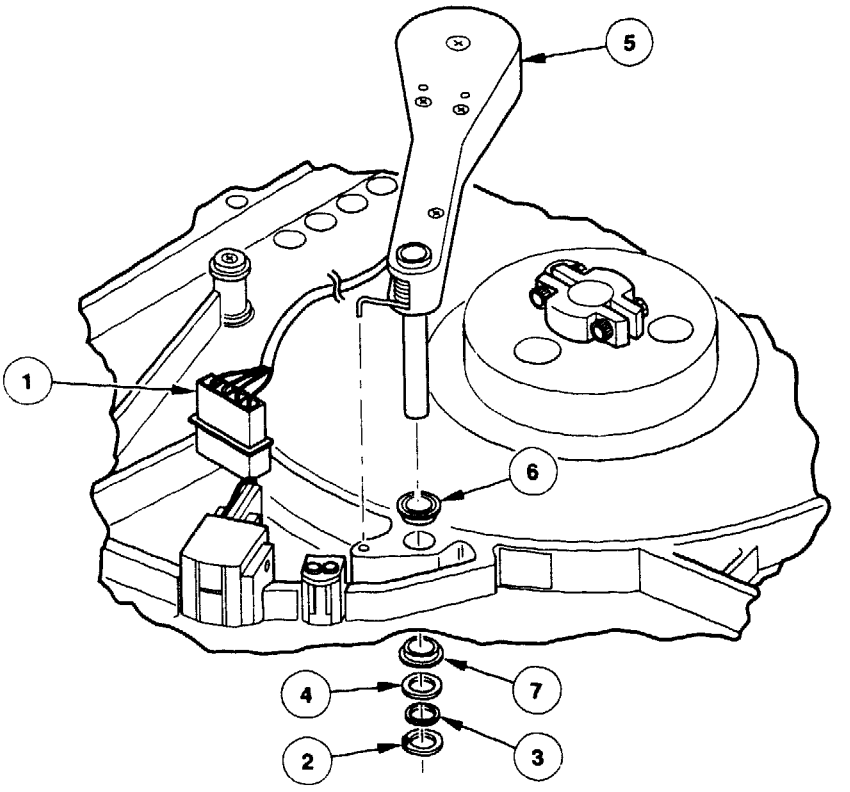



**Figure 5–29 Removing the Tachometer**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. If either bearing is replaced (6 and 7), apply Loctite® 601 to the outside surface of the bearing that contacts the deck plate before installing it. The purpose of the shims is to allow the snap ring to compress the wavewasher. Add or subtract shims so that the wavewasher is compressed approximately 50% when the snap ring is installed.
2. Use Service Aid Diagnostic Test 14 to check that the tachometer functions properly.

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## 5.4.26 Take-Up Hub

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Secure the tachometer (1) away from the take-up hub (2) using tape or string (Figure 5–30).
5. Loosen the two screws (3) that secure the take-up hub (2) to the take-up motor shaft, then remove the take-up hub.

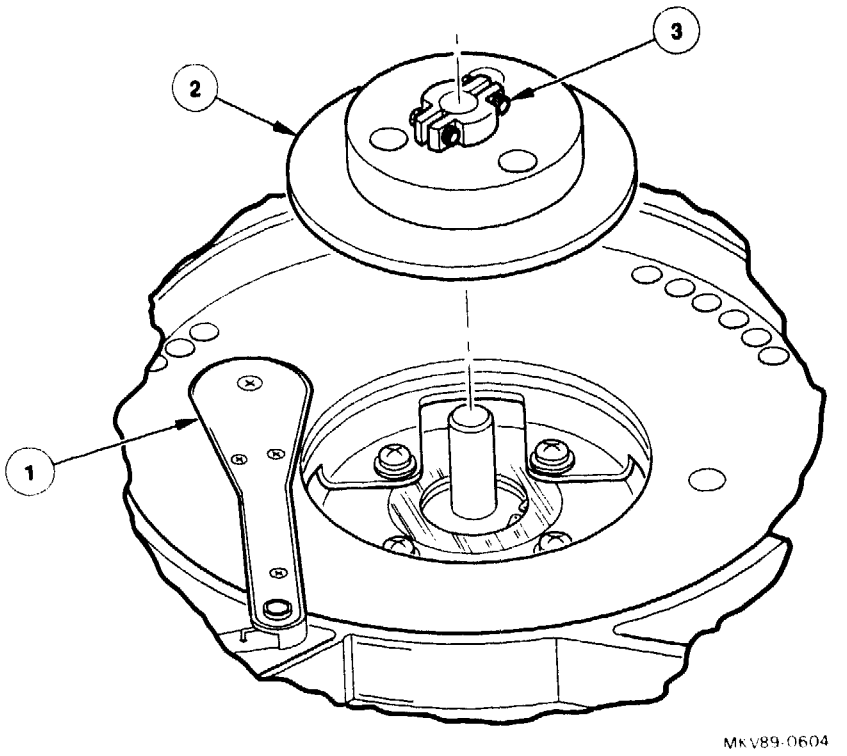


**Figure 5–30 Removing the Take-Up Hub**

### REPLACEMENT

1. Install the take-up hub (2) on the take-up motor shaft. Do not tighten the two screws (3).
2. Perform the Take-Up Hub Adjustment (Section 5.5.5).

## 5.4.27 Take-Up Motor

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the main circuit board (Section 5.4.13).
5. Remove the take-up hub (Section 5.4.26).
6. Remove the two screws (1) and washers securing the power supply housing cover (2) and remove the cover (Figure 5–31).
7. Disconnect the take-up motor wires (3) from the motor filter (4).
8. Loosen the four screws (5) securing the take-up motor (6) to the deck plate.
9. Hold the motor (6) while removing the four screws (5) and washers, then remove the motor.
10. Remove the motor insulator (7).

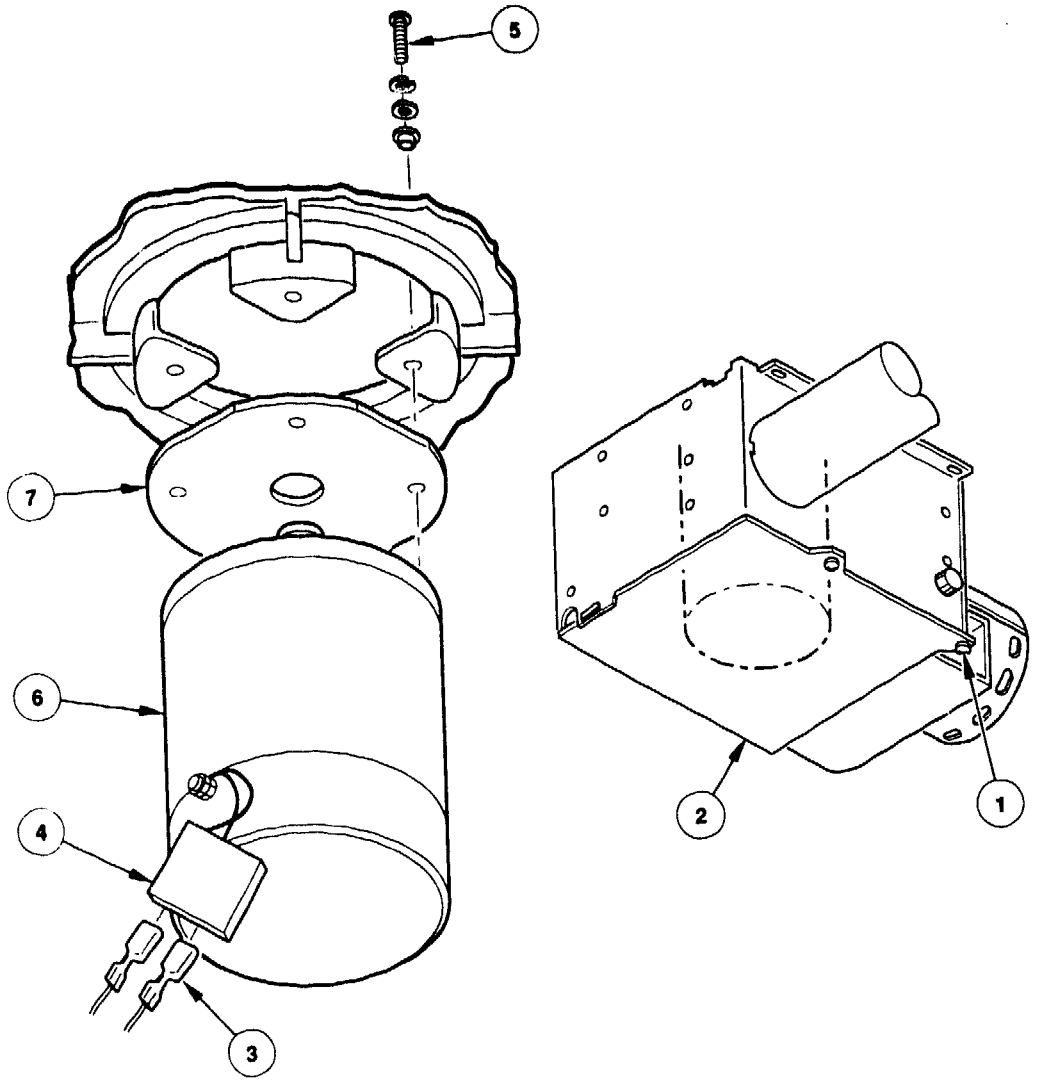


**Figure 5–31 Removing the Take-Up Motor**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.4.28 Tape-In-Path Receiver

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the connector (1) to the tape-in-path receiver (2). See Figure 5–32.
5. Remove the screw (3) and washers securing the tape-in-path receiver (2) to the deck plate, then remove the receiver.

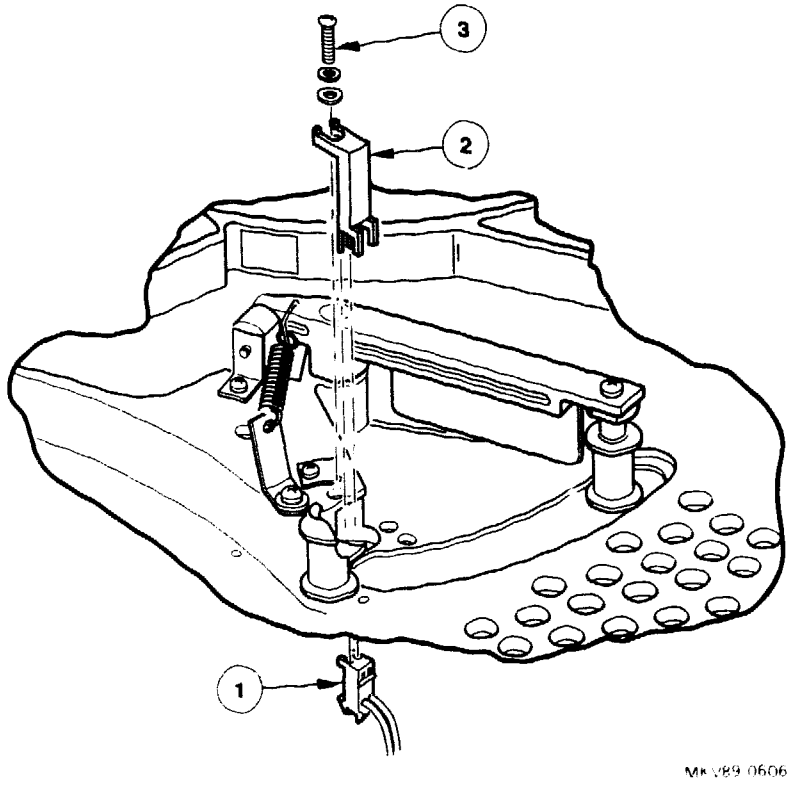


**Figure 5–32 Removing the Tape-In-Path Receiver**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Use Service Aid Diagnostic Test 31 to check that the sensor functions properly.

## 5.4.29 Tape-In-Path Transmitter

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Disconnect the connector (1) to the tape-in-path transmitter (2). See Figure 5–33.
5. Remove the two screws (3) and washers securing the tape-in-path transmitter (2) to the deck plate, then remove the transmitter.

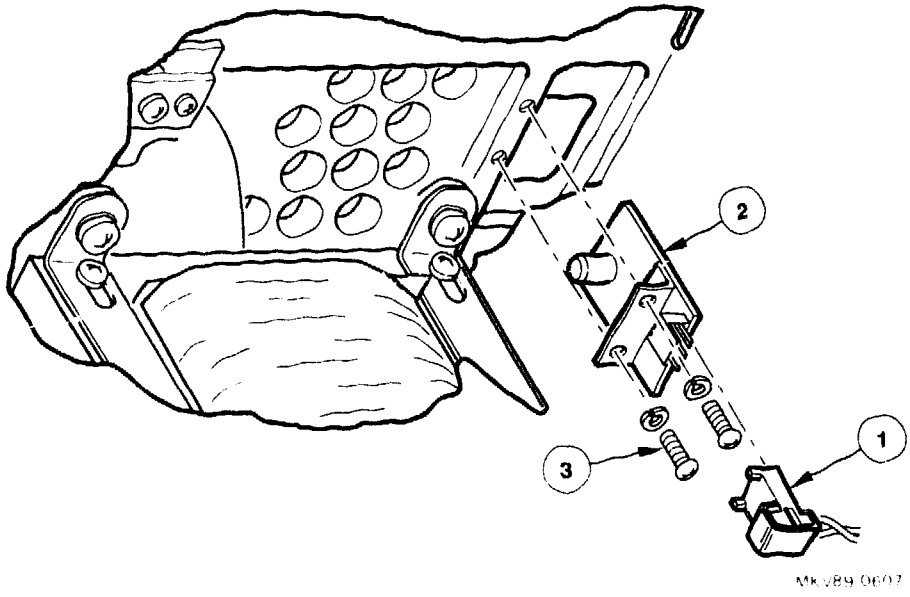


**Figure 5–33 Removing the Tape-In-Path Transmitter**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order.
2. Use Service Aid Diagnostic Test 31 to check that the sensor functions properly.

## 5.4.30 Tension Arm, Stator, and Rotor

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Open the tape drive to the service access position (Section 5.3).
4. Remove the left output air duct (Section 5.4.12).
5. Remove the three wires (1) clipped to the tension arm stator (2). See Figure 5–34.
6. Loosen the screw (3) securing the hub (4) to the shaft of the tension arm (5).
7. Remove the three screws (6) securing the tension arm stator (2) to the deck plate, then remove the stator (2), rotor (7), and hub (4) from the shaft.
8. Disconnect the tension arm spring (8) from the bracket (9).
9. Remove the snap ring (10) securing the tension arm shaft.
10. Remove the tension arm (5).
11. Check whether the upper bearing (11) and lower bearing (12) are damaged. Remove if necessary.

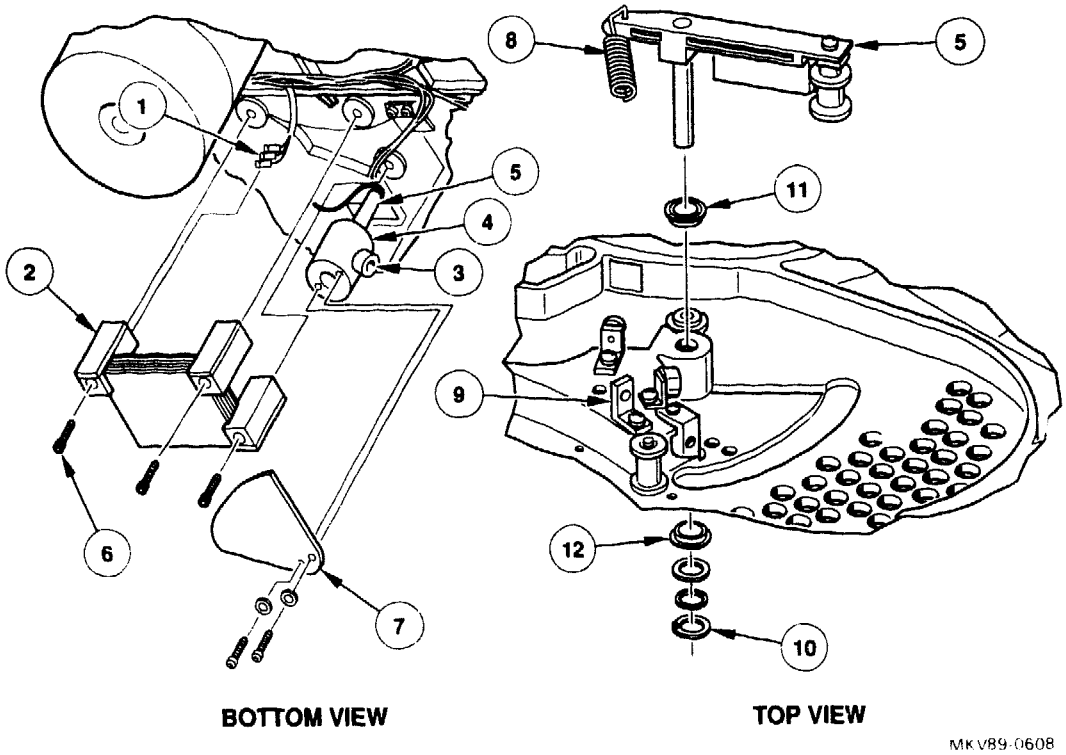


**Figure 5–34 Removing the Tension Arm, Stator, and Rotor**

## REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. Do not tighten the screw (3) securing the hub (4) to the shaft of the tension arm, do not install the tension arm spring (8) to the bracket (9), and do not install the left output air duct.

   If either bearing is replaced (11 and 12), apply Loctite® 601 to the outside surface of the bearing that contacts the deck plate before installing it. The purpose of the shims is to allow the snap ring to compress the wavewasher. Add or subtract shims so that the wavewasher is compressed approximately 50% when the snap ring is installed.

   The rotor (7) goes between the two plates of the stator (2) that are closest together.

2. Apply Loctite® 242 to the three screws (6) that secure the tension arm stator (2) to the deck plate.
3. Secure the tension arm (5) against the bumper next to roller guide 1.
4. Adjust the hub (4) on the tension arm shaft (5) so the edge of the rotor (7) is approximately 0.1 to 0.2 inches from the power supply housing. Adjust the hub (4) vertically until the rotor (7) is approximately centered between each plate of the stator (2).
5. Tighten the screw (3) to secure the hub (4) on the shaft.
6. Move the tension arm (5) several times between each bumper to check that it moves freely and that the rotor (7) does not rub against either plate of the stator (2); adjust if necessary.
7. Connect the tension arm spring (8) to the bracket (9).
8. Install the left output air duct.
9. Perform the Tension Arm Output Adjustment (Section 5.5.7).
10. Perform the Tape Alignment Adjustment (Section 5.5.6).

## 5.4.31 Top Cover

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the four screws (1) and washers attaching the top cover (2) to its hinges, then remove the top cover (Figure 5–35).

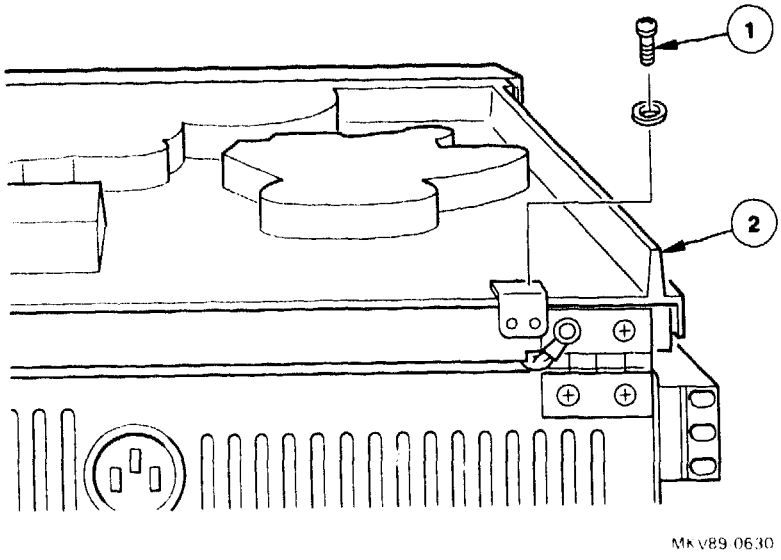


**Figure 5–35 Removing the Top Cover**

### REPLACEMENT

1. Follow the REMOVAL procedure in reverse order. Be sure the top cover lies flat on the deck plate. The top cover should close with light pressure; if it does not, adjust the two latches at the bottom front of the top cover.
2. Check that the interlock switch is closed when the top cover is down.

## 5.4.32 Transformer

### REMOVAL

1. Ensure that the tape drive is powered down.
2. Disconnect the power cord from the wall outlet.
3. Remove the power supply circuit board.
4. Open any tie-wraps securing the transformer (1) cables to the deck plate (Figure 5–36).
5. Remove the four screws (2) and washers securing the transformer (1) to the deck plate, then remove the transformer.

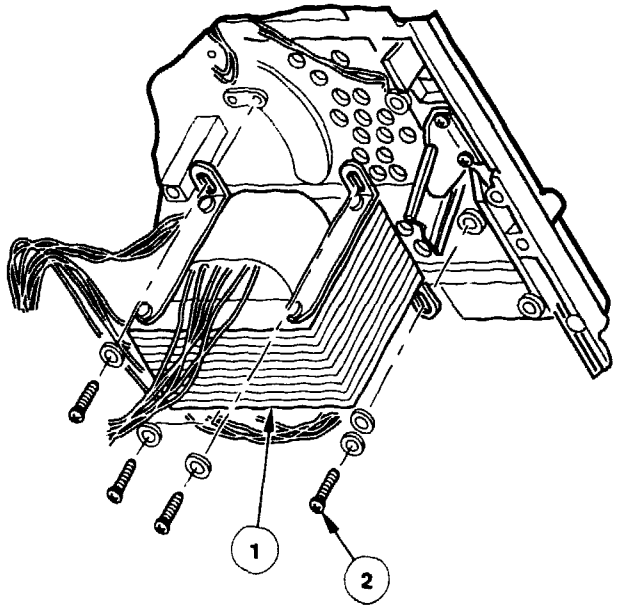


**Figure 5–36 Removing the Transformer**

### REPLACEMENT

Follow the REMOVAL procedure in reverse order.

## 5.5 ADJUSTMENT PROCEDURES

Adjustments may be required on certain components:

- To correct improper operation as a result of aging and/or wear.
- To ensure that the component is properly adjusted after replacement.

The following sections contain all necessary adjustment procedures.

### 5.5.1 Interlock Disable Procedure

Most of the adjustments require that the tape drive be opened while the adjustments are being made. This means that the interlock switch must be disabled. To disable the interlock switch proceed as follows:

1. Power OFF the tape drive.
2. Open the top cover and place the cover retaining arm in its slot.
3. Insert the interlock disable tool into the interlock switch and turn the tool ninety degrees clockwise.
4. To reenable the interlock, turn the interlock disable tool ninety degrees counterclockwise and remove it.

## 5.5.2 Read Threshold Adjustment

1. Switch ON the drive, then load a reference level tape with a write-enable ring.
2. Start Service Aid Diagnostic Test 21.
3. If the Load and Unload LEDs are flashing, or if Load stays ON and Unload flashes, no adjustment is necessary; go to step 5.
4. If the LEDs are not lighting as required in step 3, turn potentiometer R136, the Read Threshold Potentiometer (Figure 5–37), clockwise until the Load and Unload LEDs are OFF. Then turn the potentiometer counterclockwise until the requirements of step 3 are met.
5. Exit the service aid and unload the tape.

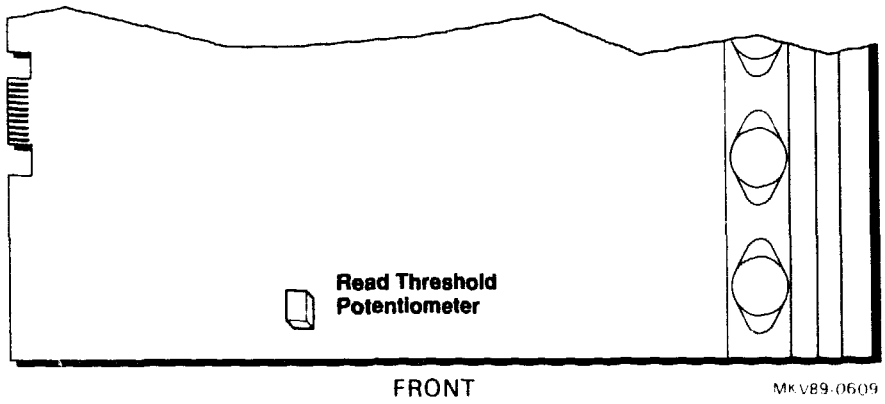


**Figure 5–37 Locating the Read Threshold Potentiometer**

## 5.5.3 Skew Adjustment

1. Switch ON the drive and load a master skew tape without a write-enable ring.
2. Connect an oscilloscope to Test Point 14 and to ground (Test Point 18 or 19) on the main circuit board. Set the oscilloscope at 1 volt per division and 2 microseconds.
3. Start Service Aid Diagnostic Test 23 and run the tape at 100 inches per second.
4. Turn the skew adjustment screw (1 in Figure 5–38) until the outputs of all tracks fall within 27 percent or less of the byte space, while the tape runs forward then in reverse. See Figure 5–39.

   Optimize the forward skew. If, when the forward skew is optimized, the reverse skew exceeds 27 percent of the byte space, either roller guide 5 is improperly shimmed or there is excessive tape shift on roller guide 2 when the tape direction is changed.
5. Apply torque seal to the skew adjustment screw (1 in Figure 5–38).
6. Check that the skew adjustment is still within specification. If not, go back to step 5.
7. Use Service Aid Diagnostic Test 23 to unload the master skew tape, then exit the service aid.

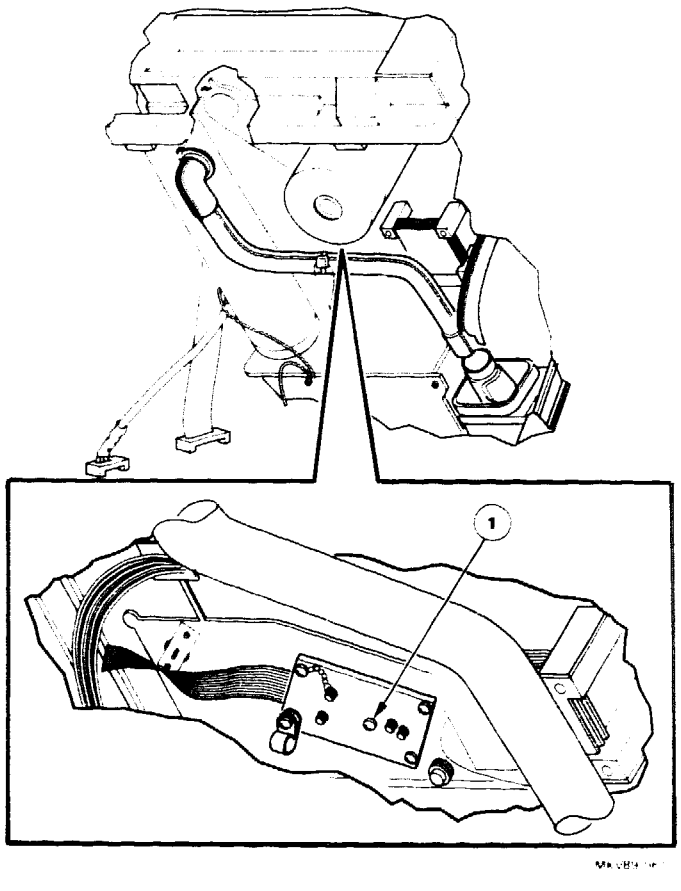


**Figure 5–38 Skew Adjustment**

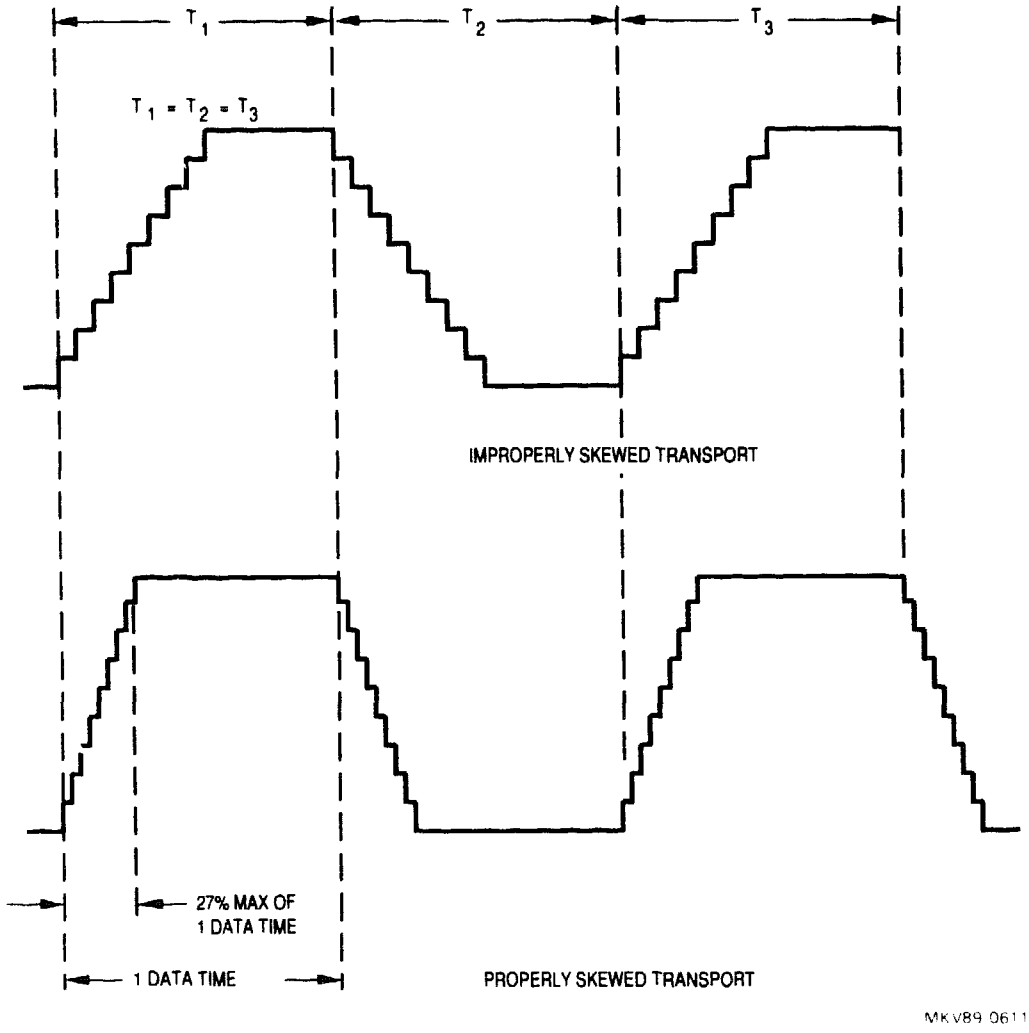


**Figure 5–39 Skew Adjustment Waveform**

## 5.5.4 Supply Hub Adjustment

1. Loosen the two screws (1) securing the supply hub (2) to the motor shaft (Figure 5–40).
2. Position a hub-height adjustment tool (3) so that it lies on the deck plate as shown in Figure 5–40.
3. Raise the supply hub (2) until it contacts the tool, then tighten the two screws (1). This is a coarse reference setting that is 0.672 inches below the raised surface of the top plate. (If a ruler or scale is used instead of a hub-height adjustment tool, adjust the hub so there is 1.0 inches between the supply motor case and the top of the hub.)
4. Remove the hub-height adjustment tool.
5. Load a scratch tape, then run the tape to EOT then back to BOT using Service Aid Diagnostic Test 23.
6. Check the tape while it is rewinding onto the supply reel. If the tape is approximately centered between the reel's flanges, no further adjustment is required. If the tape is rewinding high or low onto the reel (not centering), unload and remove the tape, and adjust the hub up or down to center the tape. This is a fine adjustment with the tape-to-reel clearance being only 0.005 to 0.047 inches. If this fine adjustment is required, run Service Aid Diagnostic Test 23 again to ensure that the tape centers on the reel.

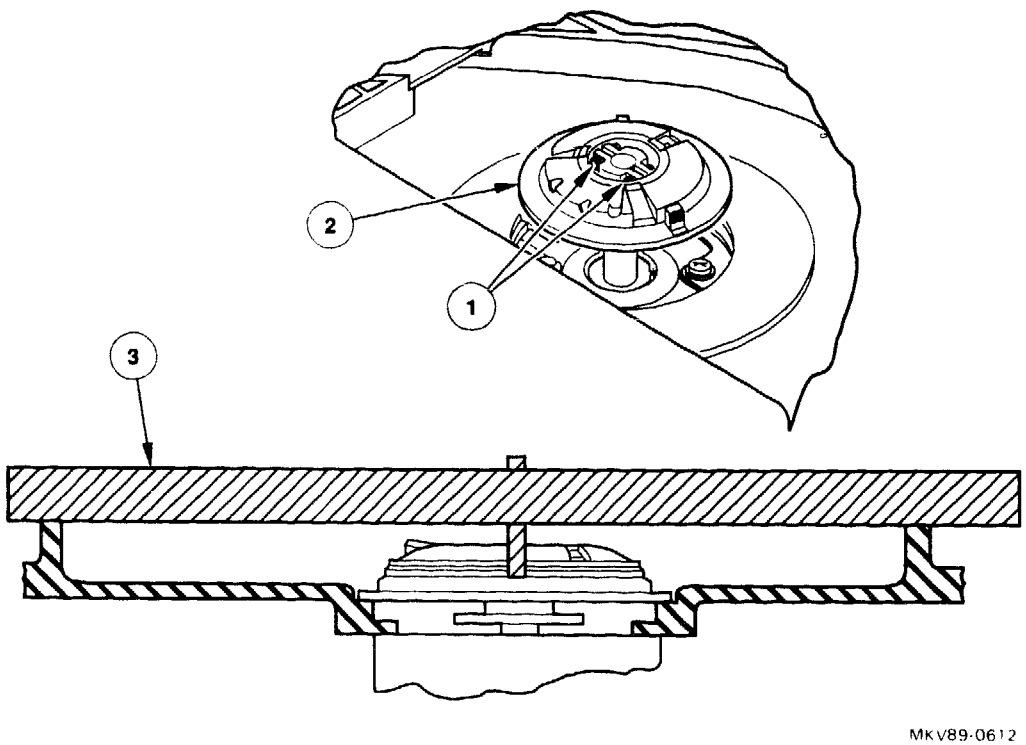


**Figure 5–40 Adjusting the Supply Hub**

## 5.5.5 Take-Up Hub Adjustment

1. Secure the tachometer away from the take-up hub (1) using tape or string (Figure 5–41).
2. Loosen the two screws (2) securing the take-up hub (1) to the motor shaft.
3. Position a hub-height adjustment tool (3) so that it lies on the deck plate as shown in Figure 5–41.
4. Raise the take-up hub (1) until it contacts the tool, then tighten the two screws (2). This is a coarse reference setting that is 0.045 inches below the raised surface of the top plate. (If a ruler or scale is used instead of a hub-height adjustment tool, adjust the hub so there is 1.5 inches between the take-up motor case and the top of the hub.)
5. Remove the hub-height adjustment tool.
6. Place the tachometer against the hub.
7. Load a scratch tape, then run the tape to EOT using Service Aid Diagnostic Test 23.
8. Check the tape while it is winding onto the take-up hub. If the tape is approximately centered on the hub, no further adjustment is required. If the tape is winding high or low onto the hub (not centering), unload and remove the tape, and adjust the hub up or down to center the tape. If this fine adjustment is required, run Service Aid Diagnostic Test 23 again to ensure that the tape centers on the hub.

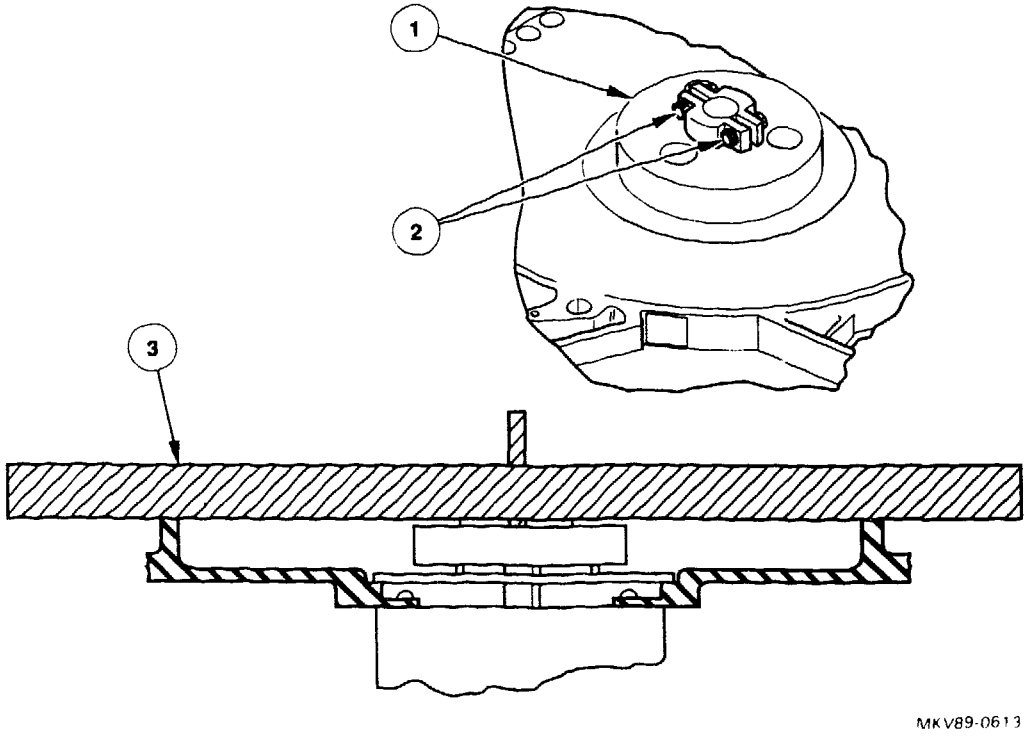


**Figure 5–41 Adjusting the Take-Up Hub**

## 5.5.6 Tape Alignment Adjustment

1. Power ON the drive.
2. Load a scratch tape.
3. Start Service Aid Diagnostic Test 23.
4. Observe the tape tracking on roller guide 3. See Figure 5–42 for the locations of each roller guide. Check for curling at the bottom and top edges of the roller guide. The tape tracks bes when it runs against the lower part of roller guide 3 without curling. To check for this, press on the lower washer of tape guide 3; the tape should drop from 0.001 to 0.005 inches. If there is no curl on roller guide 3, go to step 5. If there is curl on roller guide 3, rewind the tape, switch OFF the drive, remove roller guide 1, and either *add* shims to roller guide 1 (to remove bottom curl on roller guide 3) or *remove* shims from roller guide 1 (to remove top curl on roller guide 3). Then go back to step 1.
5. Observe the tape tracking on roller guide 2. The tape should be approximately centered on the roller guide. If the tape is properly centered, go to step 6. If the tape is not properly centered, rewind the tape, switch OFF the drive, remove roller guide 2, and either *add* shims to lower the roller guide or *remove* shims to raise it. Then go back to step 1.
6. Observe the tape tracking on roller guide 1. Check for curling at the bottom and top edges of the roller guide. If there is no curling, go to step 7. If there is curling, rewind the tape, switch OFF the drive, and perform the Supply Hub Adjustment (Section 5.5.4). Then go back to step 1.
7. Observe the tape tracking on roller guide 4. Check for curling at the bottom and top edges of the roller guide. The tape tracks best when it runs against the lower part of roller guide 4 without curling. To check for this, press on the lower washer of tape guide 4; the tape should drop from 0.001 to 0.005 inches. If there is no curl on roller guide 4, go to step 8. If there is curl on roller guide 4, rewind the tape, switch OFF the drive, remove roller guide 5, and either *add* shims to roller guide 5 (to remove bottom curl on roller guide 4) or *remove* shims from roller guide 5 (to remove top curl on roller guide 4). Then go back to step 1.
8. Observe the tape tracking on roller guide 5. Check for curling at the bottom and top edges of the roller guide. If there is no curling, go to step 9. If there is curling, rewind the tape, switch OFF the drive, and perform the Take-Up Hub Adjustment (Section 5.5.5). Then go back to step 1.
9. If any roller guides or either hub were adjusted, perform the Skew Adjustment (Section 5.5.3).

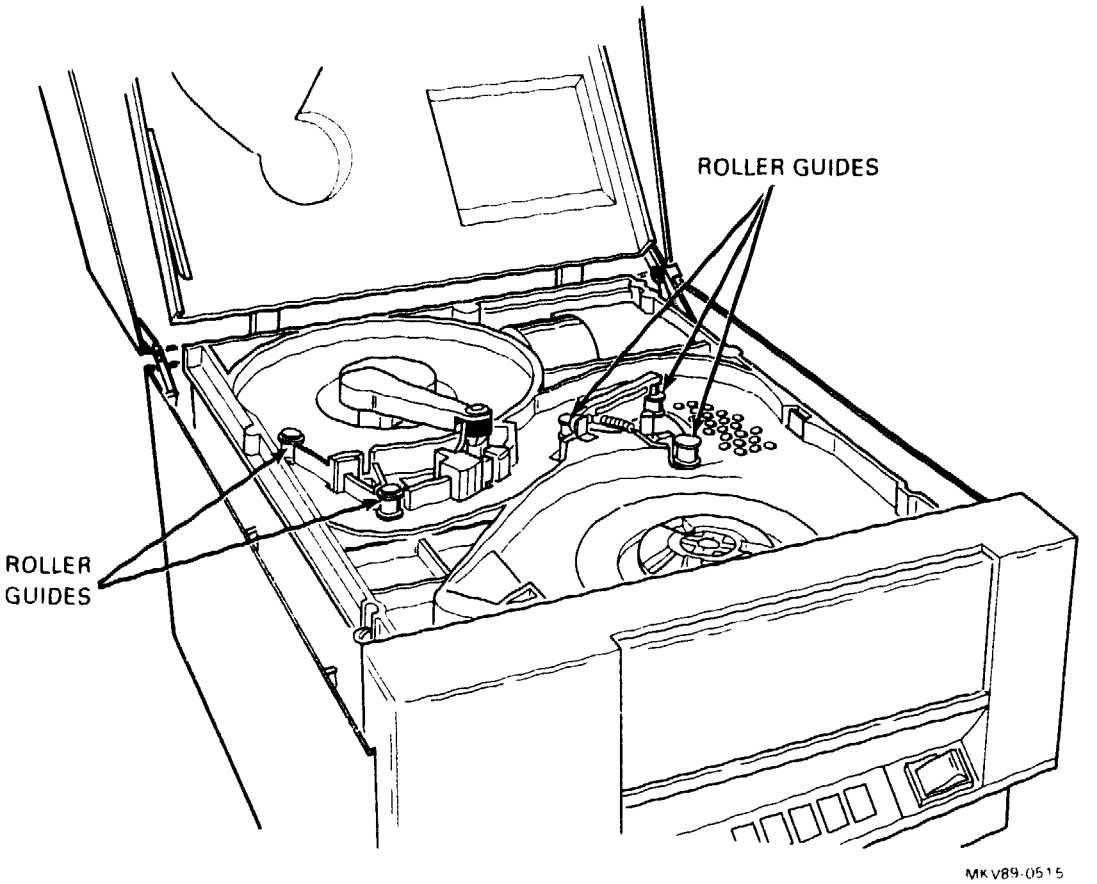


**Figure 5–42 Locating the Roller Guides**

## 5.5.7 Tension Arm Output Adjustment

1. Disable the interlock switch with an interlock disable tool. Start Service Aid Diagnostic Test 24.
2. Move the tension arm against the front bumper. Check which LEDs are ON and convert that pattern to a voltage using Table 4–8 and Table 4–9. If the voltage is -3.00 V or less, go to step 4. If the voltage is greater than -3.00 V, go to step 3.
3. Loosen the screw (1) securing the hub to the shaft of the tension arm (Figure 5–43). Adjust the rotor (2) to decrease the output voltage, then tighten the screw. Go to step 2.

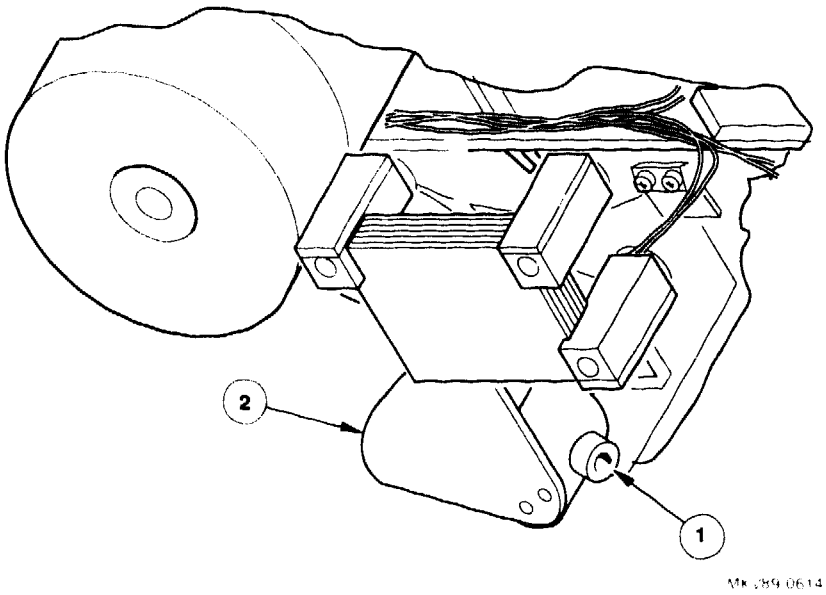


**Figure 5–43 Adjusting the Tension Arm Output**

4. Allow the tension arm to swing back gently to the rear bumper. Check which LEDs are ON and convert that pattern to a voltage using Table 4–8 and Table 4–9. If the voltage is +1.00 V or less, go to step 6. If the voltage is greater than +1.00 V, go to step 5.
5. Loosen the screw (1) securing the hub to the shaft of the tension arm. Adjust the rotor (2) to decrease the output voltage, then tighten the screw. Go to step 2.
6. Subtract the voltage found in step 2 from the voltage found in step 4. If the voltage difference is between 2.4 V and 3.6 V, go to step 8. If the voltage is less than or greater than that range, go to step 7.
7. Loosen the screw (1) securing the hub to the shaft of the tension arm. Adjust the rotor (2) to shift the high or low end of the range, then tighten the screw. Go to step 2.
8. Exit Service Aid Diagnostic Test 24.

## 5.5.8 Tension Arm Spring Adjustment

The position of the tension arm spring bracket is set at the factory and should not be changed unless necessary. If the bracket is replaced or the setting is changed, the following tension arm spring adjustment *must* be performed.

1. Attach a spring scale to the tension arm (1) by inserting the hook-end of the scale into the notch in the top of the tension arm near the pivot point (Figure 5–44).
2. Pull the spring scale forward (toward the front panel) until the tension arm roller is between the fourth and fifth rows of holes (from the front panel) in the top plate. The scale must be perpendicular to the tension arm. The scale should indicate 23.5 ounces ±4.25 ounces. If it *does*, go to step 4; if it *does not*, remove the scale and go to step 3.
3. Loosen the screw (2) securing the bracket (3) to the top plate and move the bracket to stretch (increase tension) or shorten (decrease tension) the spring. Tighten the screw, then go to step 1.
4. Remove the spring scale and apply torque seal to the screw (2).
5. Perform the Tension Arm Output Adjustment (Section 5.5.7).
6. Run Service Aid Diagnostic Test 24.

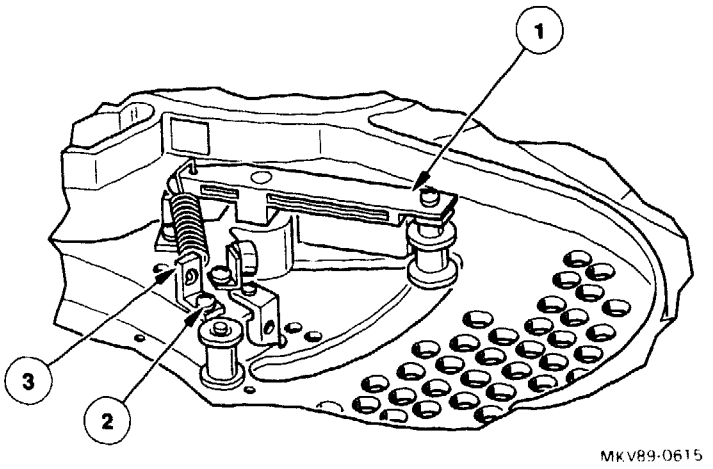


**Figure 5–44 Adjusting the Tension Arm Spring**


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