GENERAL DESCRIPTION

WD900/MT3200

Part No. 2234398-9701 *D
August 1986

TEXAS INSTRUMENTS

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WD900/MT3200 General Description (2234398-9701)

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WD900/MT3200 General Description (2234398-9701)

Continued:

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, can cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computer device pursuant to Subpart J of Part 15 of FCC Rules, which are designated to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference; in which case, the user at his own expense will be required to take whatever measures necessary to correct the interference.

WARNING: Lethal high voltages are present inside the chassis of this equipment. Only qualified service personnel who are familiar with the dangers of high voltages are permitted to open the chassis of this equipment to the service access position.

WARNING: Use extreme care when opening this equipment to the service access position as the equipment is very heavy and an accident or improper lifting techniques could cause personal injury.

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

This Document: 2540205-0001

Preface

This manual covers the theory of operation, installation and operation instructions, programming instructions, a description of the diagnostics, a status code list, and a list of field replaceable parts for the Texas Instruments WD/MT controller, the WD900 disk drive, and the MT3200 tape unit. The manual is organized into four sections as follows:

Section

1 General Information -- This section describes the components, the specifications, and the theory of operation for the WD/MT controller, the WD900 disk drive, and the MT3200 tape unit.

2 Installation -- This section provides detailed instructions for unpacking and installing the WD/MT controller, the WD900 disk drive, and the MT3200 tape unit.

3 Programming -- This section provides general operational programming information for the WD/MT controller.

4 Operation -- This section provides detailed operating instructions, operator maintenance, and status codes for the the WD/MT controller, the WD900 disk drive, and the MT3200 tape unit.

Appendix

A Field Replaceable Parts -- This appendix lists all parts with their associated part numbers, that can be replaced at the customer's site.

The following related publications are available as reference material for support of this manual:

Title	Part Number
<u>Control Data Company, 138M-Byte Documentation Master Kit</u> (Includes volumes 1, 2, and 3)	2246129-0001
<u>Control Data Company, 138M-Byte Drive, Volume 1</u>	2246125-0001

Control Data Company, 138M-Byte Drive, Volume 2	2246125-0002
Control Data Company, 138M-Byte Drive, Volume 3	2246125-0003
Control Data Company, 425M-Byte Documentation Master Kit (Includes volumes 1, 2, and 3)	2246129-0002
Control Data Company, 425M-Byte Drive, Volume 1	2246125-0004
Control Data Company, 425M-Byte Drive, Volume 2	2246125-0005
Control Data Company, 425M-Byte Drive, Volume 3	2246125-0006
Cipher Data Products Master Kit (Includes volumes 1 and 2)	2246130-0001
Cipher Data Products Operation and Maintenance	2246126-0001
Cipher Data Products Theory of Operation	2246126-0002
Spectra Logic Documentation Master Kit (Includes the Product Reference manual, the schematics, and the microcode volumes)	2246131-0001
Spectra Logic, Spectra 126 Product Reference	2246127-0001
Spectra Logic, Spectra 126 Schematics	2246127-0002
Spectra Logic, Spectra 126 Microcode	2246127-0003
Model 990A13 Chassis, General Description	2308774-9701
Model 990/12 Computer Assembly Language Programmer's Guide	2270509-9701
Model 990 TMS9900 Microprocessor Assembly Language Programmer's Guide	943441-9701

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Section 1

General Information

1.1 INTRODUCTION

The major components of the Texas Instruments WD900/MT3200 Mass Storage System are the Winchester Disk/Magnetic Tape (WD/MT) controller, the WD900 fixed storage disk drive(s), and a MT3200 streamer-cache tape unit. The WD/MT TILINE(TM) controller contains dual microprocessors. The first processor controls the TILINE interface and the Pertec(TM)-compatible 9-track half-inch tape interface, and the second processor controls the storage module drive (SMD) interface to the disk or disks. The WD900 disk units are available with either 138- megabytes or 425- megabytes of formatted data storage capacity. The mass storage unit can be configured with two disk units by daisy-chaining a secondary disk unit to the primary disk unit. The MT3200 is a streaming magnetic tape unit with a 64K-byte cache memory.

The WD900 Mass Storage System configuration is modular. The maximum configuration is a WD/MT controller, any combination of two 138-megabyte or 425-megabyte disk units, and a MT3200 streaming-cache tape unit.

1.2 SYSTEM COMPONENTS

This section describes the components of the WD/MT controller, the WD900 disk drive, and MT3200 streamer-cache tape.

1.2.1 WD/MT Controller

The WD/MT TILINE controller, TI part number 2244780-0001, uses a unique dual microprocessor architecture that provides the high performance and flexibility required to support the MT3200 half-inch magnetic cache tape drive and up to two WD900 disk drives.

The WD/MT TILINE controller employs a dual microprocessor architecture that provides the high performance and flexibility required to support the MT3200 half-inch magnetic tape drive and two WD900 disk drives.

TILINE is a trademark of Texas Instruments Incorporated.
Pertec is a trademark of Pertec Computer Corporation.

Built on a single, full size 990 circuit board (10.8 inches by 14.2 inches, 27.43 centimeters by 36.2 centimeters), the dual microprocessor implementation provides for simultaneous control of the TILINE, tape, and disk interfaces. Concurrent disk and tape data transfer is provided with an aggregate throughput equal to two separate controllers. High performance is achieved by buffering each type of drive. The tape interface has a 64-byte, first-in first-out (FIFO) buffer, and the disk interface is capable of queueing 28 sectors or 7168 bytes of data. The two disk drives are interconnected in a daisy-chain fashion by a single cable.

1.2.2 WD900 Description

The following paragraphs provide a physical description of the WD900 drive. The components are identified in Figure 1-1.

NOTE

> Unless described otherwise, WD900 refers to both the 138-megabyte and the 425-megabyte drives.

The drive package includes a deck, front and rear panels, and a top cover. A fan mounted on the rear panel circulates cooling air around the electronic assemblies.

The front panel of the drive contains the operator controls and a fault display board. The fault display board is located behind the front panel on the 425-megabyte drive and on the left side of the 138-megabyte drive. The operator controls consist of the logic plug and all switches and indicators used by the operator to control normal operation of the drive.

The internal components of the drive include a set of circuit boards and a module. The circuit boards are interconnected through a motherboard that contains the electronics required for drive operation. The module is the sealed fixed disk unit.

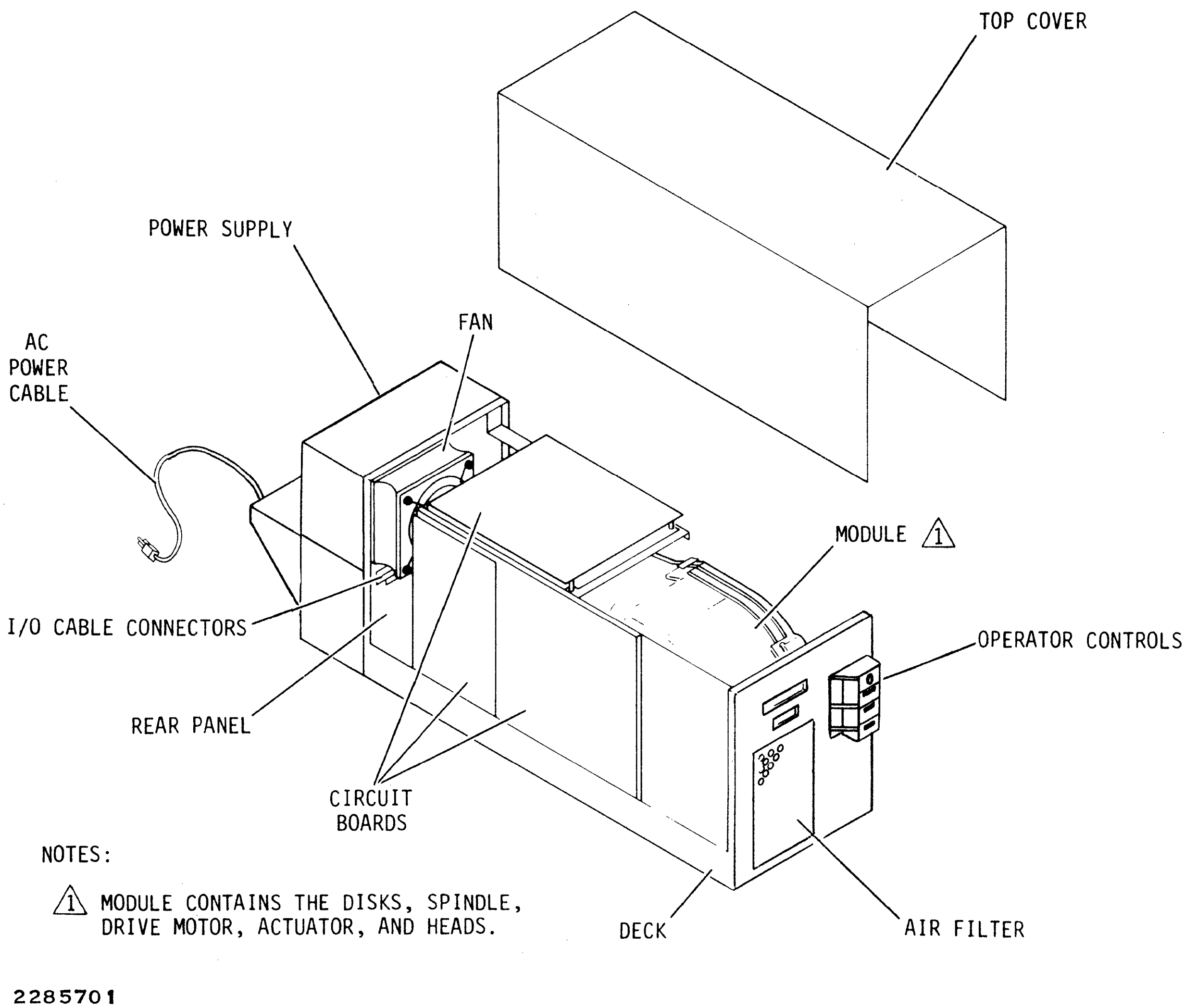

Figure 1-1 WD900 Major Assemblies

1.2.3 MT3200 Components

The MT3200 can be functionally divided into a logical tape unit and a physical tape unit, both controlled by the microprocessor. The logical unit consists of the following:

* 64K-byte cache memory
* Read/write latches and strobes
* Read/write formatter
* Read/write circuits
* Command and status latches
* Microprocessor
* 16K words of control-storage read only memory (ROM)
* 2K words of random access memory (RAM)
* Direct Memory Access (DMA) controller

The physical unit consists of the following:

* Take-up and supply reel motor servos
* Compliance-arm position sensor
* Tachometer
* Digital-to-analog/analog-to-digital converter
* End-of-tape/beginning-of-tape sensors
* Supply hub lock
* Tape-in-path sensor
* File-protect/reel-seat sensor
* Blower motor control
* Door/cover lock
* Front panel controls and indicators

The MT3200 controls and indicators are shown in Figure 1-2 and explained in detail in paragraph 4.2.2.

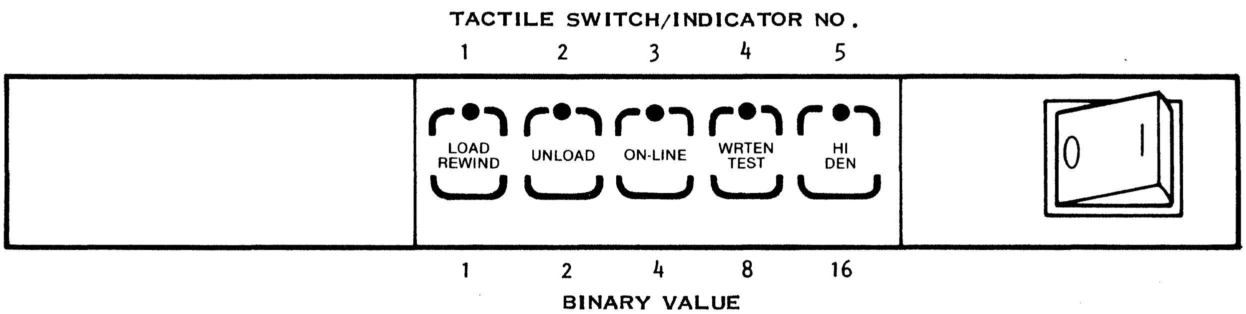

Figure 1-2 MT3200 Control Panel

1.3 SYSTEM FUNCTIONAL DESCRIPTION

The following is a functional description of the WD/MT controller, the WD900 drive, and the MT3200 tape unit.

1.3.1 WD/MT

The WD/MT controller has a dual processor design, and performs many operations. The following paragraphs describe some of the major operations of the controller. Refer to Figure 1-3 for a block diagram of the WD/MT controller.

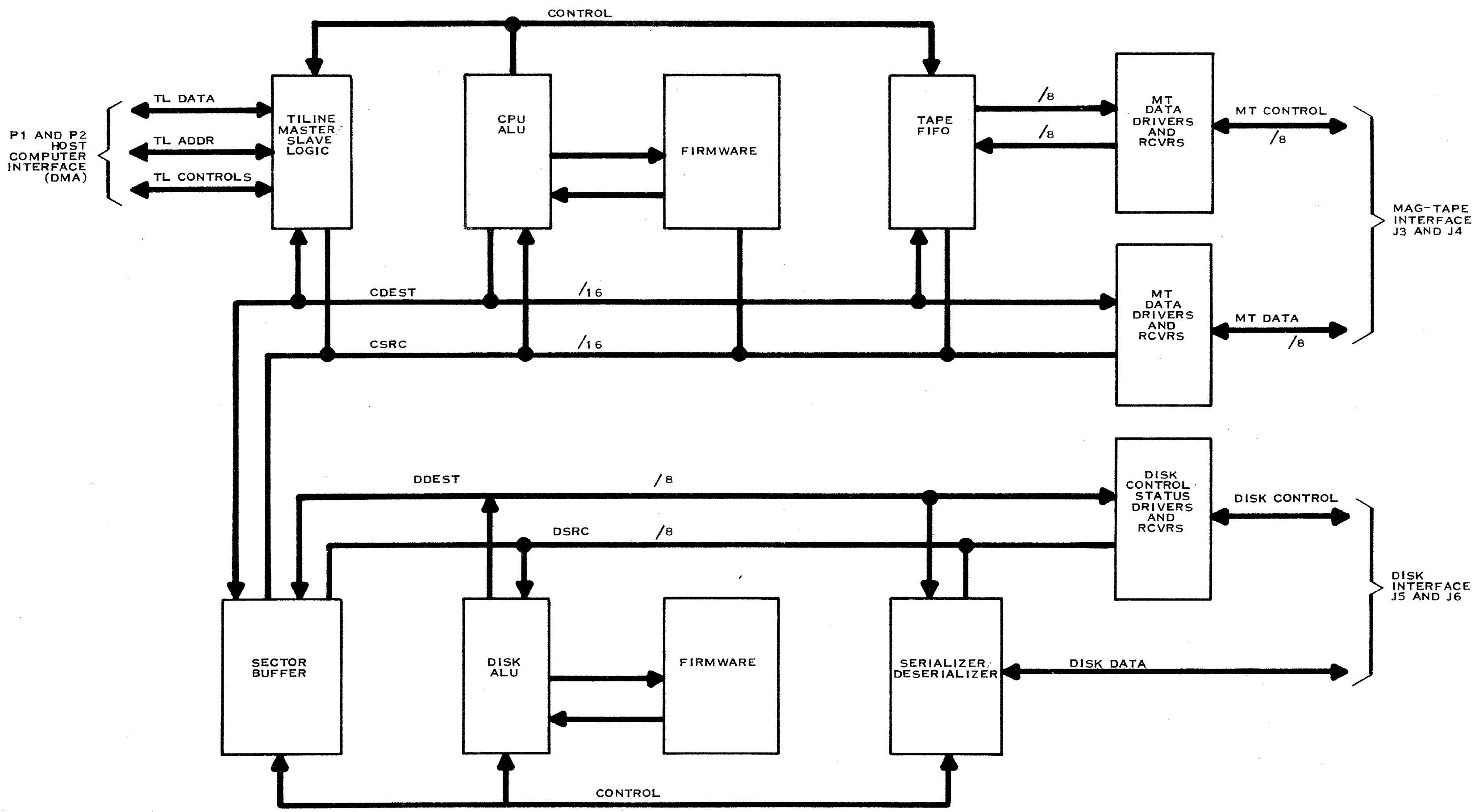

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Figure 1-3 WD/MT Controller Block Diagram

1.3.1.1 WD/MT Drivers and Receivers. The SMD portion of the WD/MT controller has compatible, balanced line drivers and receivers (MC3450 and MC3453) that ensure reliable operation of the disk drives at up to 15.33 meters, or 50 feet, from the TI system (30.68 meters, or 100 feet, for a daisy-chain cable).

The tape portion of the WD/MT controller uses 7416 drivers that ensure reliable operation at up to approximately 8 meters (26 feet).

1.3.1.2 Cable Connector Ports. Marked on the top edge of the circuit board are the input/output (I/O) port designators (refer to Figure 1-4). The I/O ports are as follows:

* Port J3 (Tape A) -- 40-pin connector
* Port J4 (Tape B) -- 40-pin connector
* Port J5 (Disk B) -- 26-pin connector
* Port J6 (Disk A) -- 60-pin connector

1.3.1.3 Power. The power requirements for the WD/MT controller are +5 volts dc at 10 amperes and -12 volts dc at 0.55 amperes.

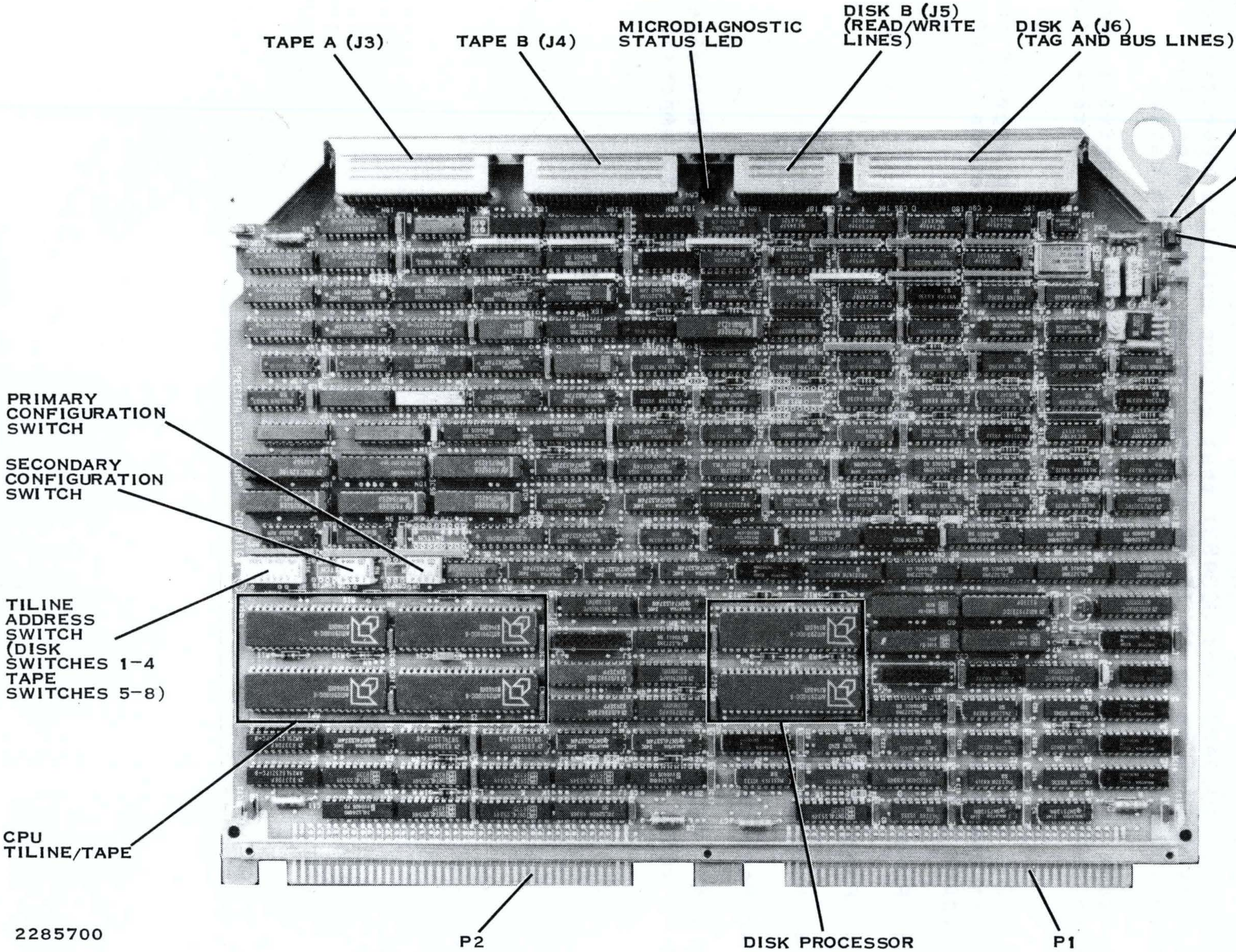

Figure 1-4 WD/MT Controller

1.3.1.4 WD/MT CPU Processor. The central processor unit (CPU) of the WD/MT controller is a bit-slice design using four 2901 integrated circuit (IC) chips. The four 2901 chips form a 16-bit arithmetic logic unit (ALU) that performs arithmetic, logical, and shift operations. A 2902 chip is connected to the four 2901 chips to perform the high-speed carry look-ahead during arithmetic operations. The two major buses in the processor section are CSRC and CSDEST.

CSRC is a 16-bit data bus providing the 16-bit source to the four 2901 chips. Data on the CSRC can be selected from a variety of sources such as TILINE data, constants from the control store-literal field, dual in-line pin (DIP) switches, tape input data, and the RAM data buffer.

CSDEST is a 16-bit bus that provides a 16-bit path for output information. A variety of destinations can be selected, such as TILINE data, TILINE address, bits from the next address of the processor, tape data, RAM data-buffer address, and RAM data-buffer data.

The sequencer for the CPU processor consists of an octal latch and a programmable array logic (PAL(TM)) that provides the ability to perform jumps, conditional jumps, subroutine jumps, and subroutine returns. Up to four levels of subroutines can be nested. An interrupt capability is provided, with interrupts occurring (when enabled) on memory error or TILINE address comparison. The CPU bus provides the control store address from the outputs of the 2911 chip. The CPU bus provides a 16-bit path for the 2911 data inputs.

The control store for the CPU processor is formed by six 2K by 8-bit programmable ROM (PROM) chips that provide an instruction-word width of 48 bits. The firmware instructions are contained in this control store for the processor.

1.3.1.5 Disk Processor. The disk processor is a bit-slice design using two 2901 chips. These two chips form an 8-bit ALU to perform arithmetic, logical, and shift operations. The DSRC bus is the major bus in the disk processor section. It provides an 8-bit source of data inputs to the 2901 chips. Several input sources can be selected, such as serializer/deserializer data, drive configuration PROM, drive status, data buffer, and DIP switches.

PAL is a trademark of Monolithic Memories, Inc.

A variety of destinations can be selected, including the data buffer address, data buffer data, branch condition input, serializer/deserializer data, serializer/deserializer control register, and SMD interface control registers.

The sequencer for the disk processor is similar to the CPU sequencer. The disk processor sequencer does not have an interrupt capability. This sequencer provides control store addressing and has the ability to continue, conditional jump, subroutine jump, and return from subroutine.

1.3.1.6 Disk Interface. The SMD disk interface is controlled by the disk processor. The firmware can write directly into registers feeding the SMD bus and TAG lines. Disk unit selection, cylinder addressing, head addressing, and read/write control information is sent to the drive via balanced line drivers.

The serializer/deserializer contained in this logical section uses two 74S299 chips to form a 16-bit serial-parallel/parallel-serial shift register. The firmware is synchronized to the serializer/deserializer by a bit counter that sets a flip-flop each time the counter overflows. A control register synchronizes firmware control information previously stored in a 74LS273 register. This register synchronizes switching of error-checking and correction (ECC) logic enable, ECC reset, and ECC clock enable.

1.3.1.7 Disk Interface Cables. The following are the disk interface cables:

* 26-pin Wye cable (connects from J2 on disk drives to J5 (Disk B) on controller), TI part number 2244845-0001, and an optional 15.4-meter (50.58 foot) cable, TI part number 2244845-0002.

* 60-pin cable (connects from J3 on primary drive to J6 (Disk A) on controller), TI part number 2244787-0001, and an optional 8.5-meter (28 foot) cable, TI part number 2244787-0002.

* 60-pin daisy-chain cable (connects from J4 on the primary drive to J3 on the secondary drive), TI part number 2244787-0003.

These cables provide adequate cable shielding termination and reroute the interface signals to the proper interface pins.

1.3.1.8 Tape Interface. The Pertec-compatible formatted tape interface is controlled by the CPU processor. This 16-bit bus is clocked into two 74LS273 octal latches that drive the tape control lines and initiate the micro sequencer. The micro sequencer issues clocks and other internal control signals to the MT3200 tape control circuitry.

All input and output data goes through two 67402 chips that create a 64 byte buffer. A 74S280 chip generates parity for the write operations. Write data is clocked through 74LS374 latches into the FIFO buffers. Read data is clocked out of the FIFO buffers through latches and back to the CPU processor.

1.3.1.9 Tape Interface Cables. The tape interface cables consist of two ribbon cables and two twisted-pair cables. The two ribbon cables are 50-pin connectors, TI part number 2244831-0001, that connect from P1 to J1 and P2 to J2. The two 25 twisted-pair cables (TI part number 2244802-0001, or an optional 8.1-meter (26.6 feet) cable, TI part number 2244802-0002) use a 50-pin connector (per cable) on the drive end and a 40-pin connector on the controller end. The interface cables plug into a special cable transition board (TI part number 2244779-0001) on the MT3200 tape transport. This transition board provides adequate cable shield termination and reroutes cable signals to the proper interface pins. Refer to paragraph 1.3.3.12 for more information.

1.3.1.10 Microdiagnostics. Microdiagnostics are performed each time the controller powers up. The microdiagnostics can be performed by the 990 system through either the tape or disk TILINE peripheral control space (TPCS) registers. The built-in self-test can detect most board failures. During the power-up self-test, the red fault light emitting diode (LED) is lit and then extinguished upon successful completion of the microdiagnostics. The red LED is visible from the top edge of the circuit board when the board is mounted in the system. Additional board failure information can be obtained visually or by reading the TPCS registers. Additional information on system failures that are not reported by the self-test LED can be found by reading the extended status of the tape only (the WD900 does not support extended status).

Three LEDs on the WD/MT controller show the status of the controller. When lit, the red LED indicates that the microdiagnostics have failed on power-up. The two green LEDs indicate that the disk controller and the tape controller are idle. Table 1-1 gives a list of possible combinations of these LEDs after power-up.

Table 1-1 WD/MT Controller LED Combinations

Green LED (Tape)	Green LED (Disk)	Red LED	Meaning
ON	ON	OFF	Microdiagnostics successful
OFF	ON	ON	Disk microdiagnostics successful
ON	OFF	ON	Tape microdiagnostics successful
OFF	OFF	OFF	No power; LED failure
OFF	OFF	ON	Microdiagnostics failure
OFF	ON	ON	Microdiagnostics failure, refer to the TILINE register*

NOTE:

* A fault on the tape interface cable can cause this failure. If in doubt, switch the machine off, unplug the cable, and switch it on again.

Refer to Table 4-2 for further information concerning controller microdiagnostic failures.

1.3.2 WD900 Functional Description
The WD900 drive contains all the circuits and mechanical devices necessary to record data on and recover data from the disks (refer to Figure 1-5). The necessary power for the drive is provided by the power supply, which receives its input power from the site main power source.

All functions performed by the drive are accomplished under the direction of the controller. The controller communicates with the drive via the interface, which consists of a number of I/O lines carrying the necessary signals to and from the drive.

Some interface lines, including those that carry commands to the drive, are not enabled unless the drive is selected by the controller. The WD/MT controller, which can be connected to more than one drive, selects the unit to initiate and direct operations on a specific drive.

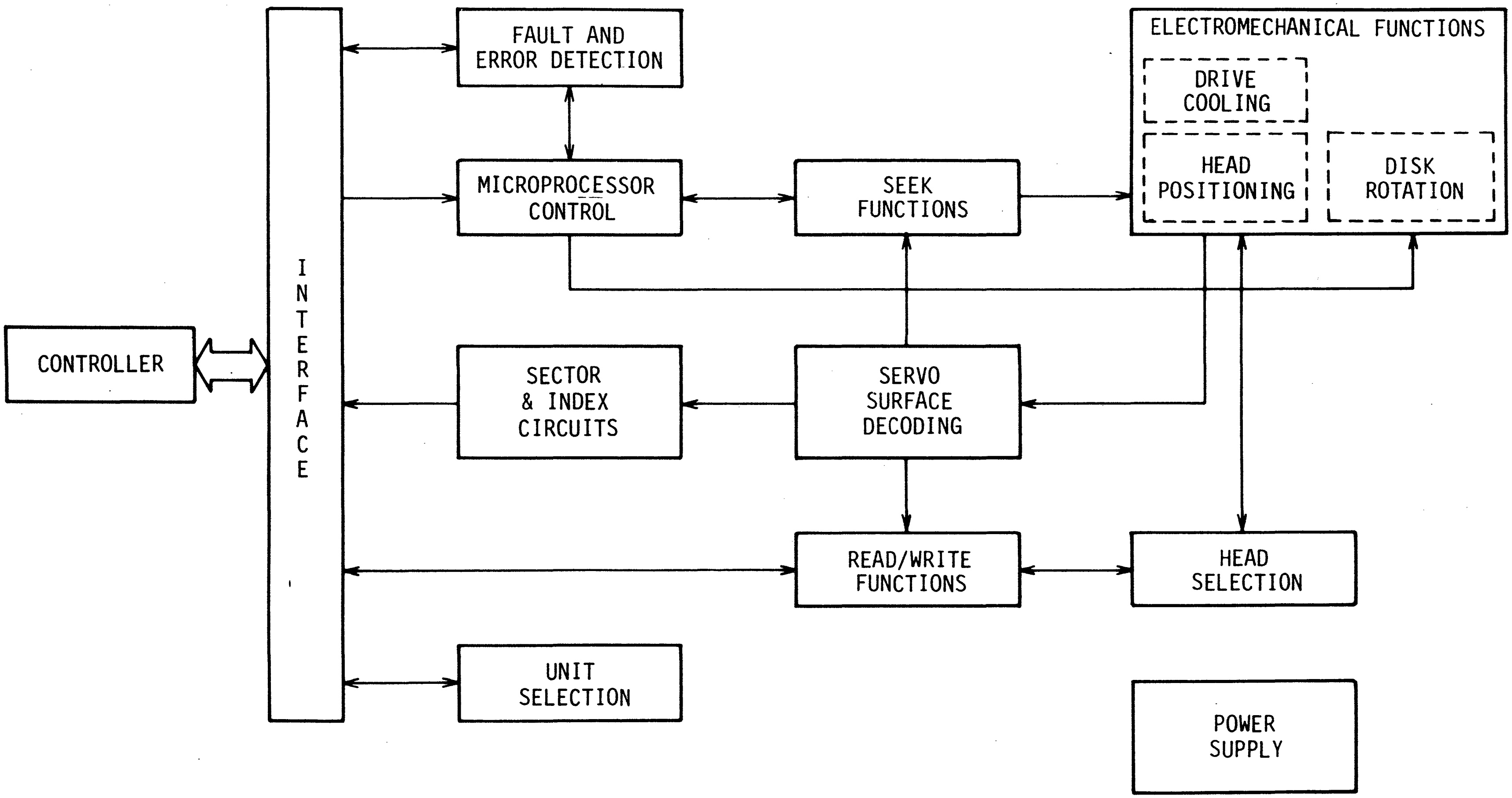

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Figure 1-5 WD900 Functional Block Diagram

All operations performed by the drive are related to data storage and recovery. Storage and recovery are referred to as writing and reading. The actual writing and reading are performed by electromagnetic devices called heads. The heads are positioned over the recording surfaces of the rotating disks. There are two heads for each disk surface (one head per disk surface on the 138-megabyte drive). The heads are positioned so that data is written in concentric tracks around the disk surfaces. Tracks are narrow concentric bands that cover the entire circumference of the circle. The tracks are then further subdivided into equal areas called sectors.

The WD/MT controller instructs the drive to position the heads over the desired cylinder (called seeking) and select the proper head (head selection). The controller then locates the portion of the track (sector) where the data is to be written or read. This is called track orientation and uses the index and sector signals generated by the drive. The index signal indicates the logical beginning of each track, and the sector signals are used by the controller to determine the position of the head on the track with respect to the index signal.

The controller commands the drive to actually read or write the data when the desired location is reached. During a read operation, the drive recovers data from the disks and transmits it to the controller. During a write operation, the drive receives data from the controller, processes it, and writes it on the disks.

The drive is also capable of recognizing certain errors that can occur during this operation. When an error is detected, it is indicated either by a signal to the controller or by a maintenance indicator on the drive itself.

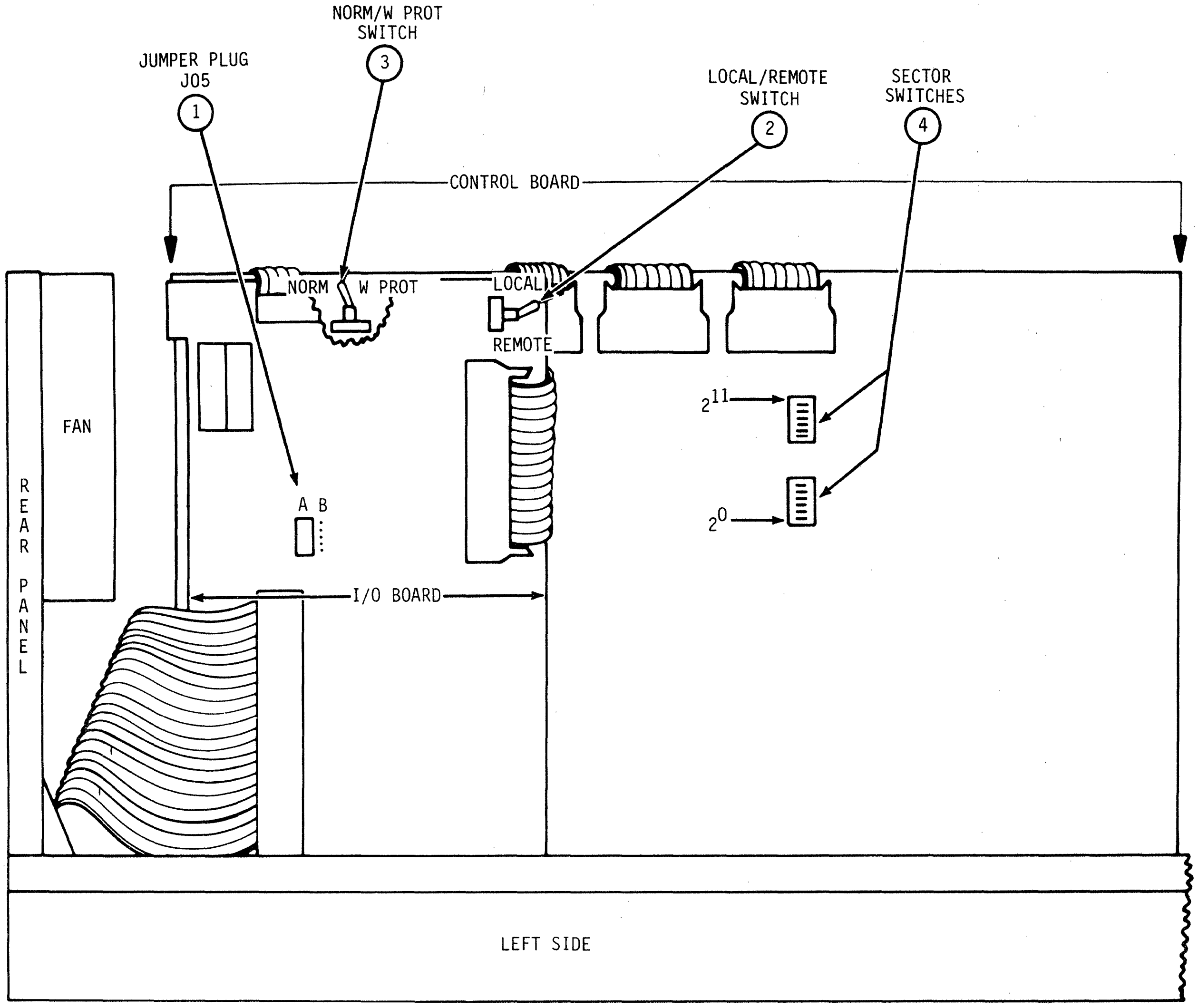
1.3.2.1 Module. The module is a sealed unit containing the electromechanical components used for data storage and retrieval. These components include the disks, spindle, drive motor, actuator, and heads.

The disks provide the recording medium for the drive. These disks are center-mounted on a spindle. The spindle is coupled directly to the drive motor. When activated, the drive motor rotates the disks at 3600 revolutions per minute (rpm). The rotation of the disk produces air circulation within the sealed module.

The actuator is an assembly that holds or moves the heads to control actuator positioning. The actuator also controls the 24 data heads on the 425-megabyte drive and 10 data heads on the 138-megabyte drive used for data transfers to and from the disks. The actuator has a voice coil that moves in and out of a permanent magnetic field in response to signals from the servo-positioning circuitry. The voice coil forces the actuator carriage to roll on parallel rails. When the actuator carriage rolls, the heads move accurately across the disk surfaces. When the drive is not in use, the heads rest on the disk surface in the preassigned landing zone (beyond the data zone in the outer area of the disk surface). The actuator is automatically latched in this position at shutdown to protect it from movement or shipment damage. When the drive is activated to bring the disks up to speed, the heads fly on a cushion of air close to the disk surface.

1.3.2.2 I/O Board. The I/O board (refer to Figure 1-6 and Figure 1-7) has a toggle switch and jumper plug. These are the LOCAL/REMOTE toggle switch and the index/sector jumper plug. The LOCAL/REMOTE switch determines whether the WD900 can be powered up from the drive (LOCAL) or the controller (REMOTE). In both switch positions, power-up requires turning CB1 to the ON position and pressing the START switch. However, in the REMOTE position, a power-sequence signal must come from the controller (that is, the I/O board must be cabled to the controller). The index/sector jumper plug J5 determines which cable receives the index/sector signals. The J5 jumper plug is normally put in the A position (refer to Figure 1-6 and Figure 1-7).

1.3.2.3 Control Board. The control board (refer to Figure 1-6 and Figure 1-7) has two switches: the W PROT/NORM toggle switch and the sector select switch (the 425-megabyte drive has a jumper plug for W PROT/NORM). Move the W PROT/NORM switch to the W PROT (write-protect) position to prevent the drive from performing write operations. You must return the toggle to the NORM position to enable write operations. The sector select switch is either a rocker-type or slide-type switch. It has 12 selections, which are used to specify the division of the disk into distinct segments or sectors. The switch settings determine the number of sectors per track. Refer to paragraph 2.4.1 for the proper switch settings for the 138-megabyte and 425-megabyte drives.



INDEX	SWITCH	SETTING
ON I/O BOARD:		
(1)	INDEX/SECTOR JUMPER PLUG	LEAVE J05 IN "A" POSITION FOR INDEX/SECTOR IN "A" CABLE OR PLACE IN "B" POSITION FOR INDEX/SECTOR IN "B" CABLE.
(2) ⚠1	LOCAL/REMOTE	LOCAL: DRIVE POWER UP INDEPENDENT OF CONTROLLER. REMOTE: DRIVE POWER UP DEPENDENT ON CONTROLLER.
ON CONTROL BOARD:		
(3)	NORM/W PROT	NORM
(4) ⚠1	SECTOR SWITCHES	SEE DISCUSSION ON SETTING SECTOR SELECT SWITCHES.

NOTES:

⚠1 THESE SWITCHES CAN BE SET THROUGH LABELLED OPENINGS IN TOP COVER.

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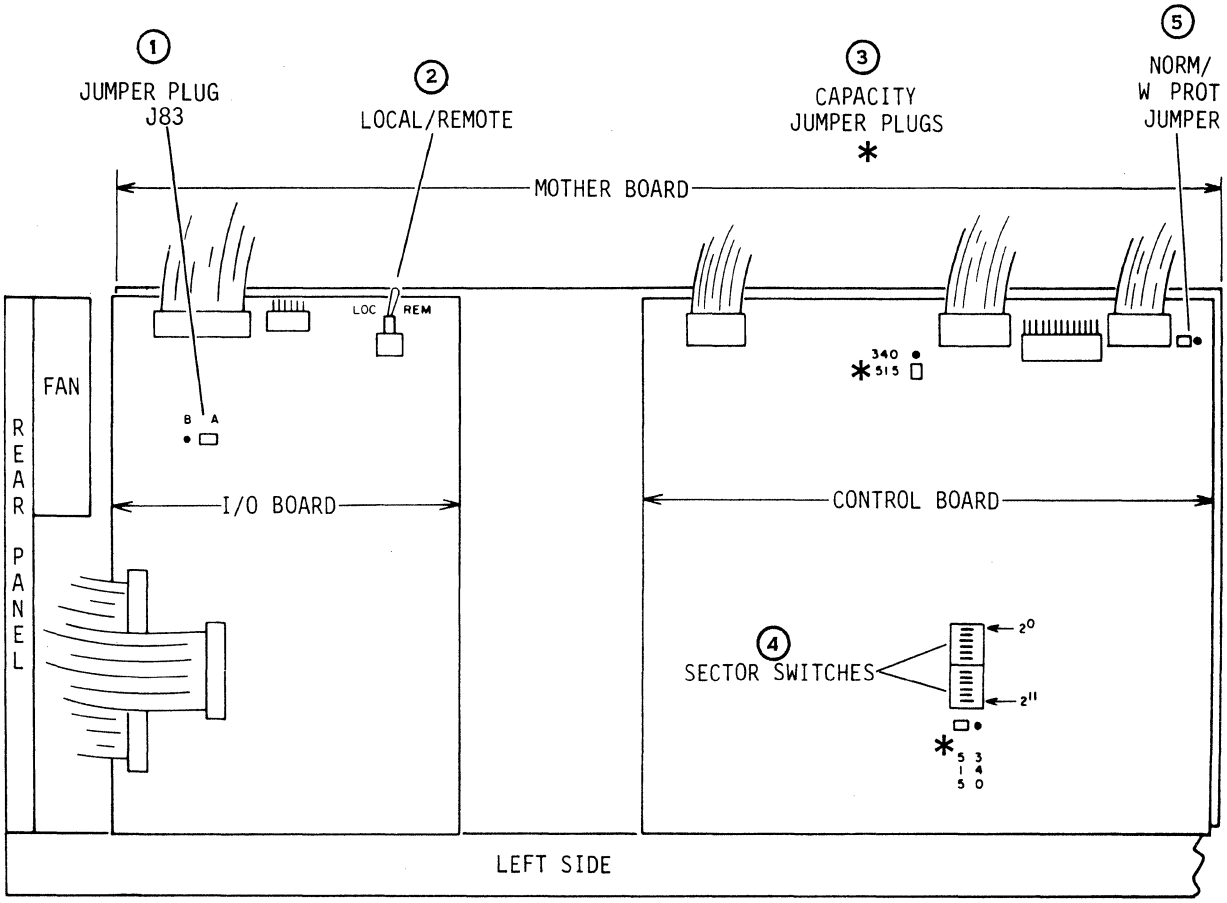
Figure 1-6 138-Megabyte Drive Circuit Board Switches



INDEX	SWITCH	SETTING
ON I/O BOARD:		
1	INDEX/SECTOR JUMPER PLUGS	LEAVE J05 IN "A" POSITION FOR INDEX/SECTOR IN "A" CABLE.
2	LOCAL/REMOTE	LOCAL: DRIVE POWER UP INDEPENDENT OF CONTROLLER. REMOTE: DRIVE POWER UP DEPENDENT OF CONTROLLER.
ON CONTROL BOARD:		
3	DRIVE CAPACITY JUMPER PLUGS 340/515	PRESET IN FACTORY ACCORDING TO 515M-BYTE CONFIGURATION.
4	SECTOR SWITCHES	SEE DISCUSSION ON SETTING CIRCUIT BOARD SWITCHES.
5	NORM/W PROT JUMPER PLUG	NORM

2286029

Figure 1-7 425-Megabyte Drive Circuit Board Switches

1.3.2.4 Power Supply. The ac power is controlled by the CB1 breaker on the power supply. Normally, CB1 is left ON. The site ac power generates all operating voltages for the drive to the power supply, which in turn supplies the dc operating voltages to the drive electronics.

1.3.2.5 Air Flow System. Fans provide air flow to the WD900. The air flow system is divided into two parts, one for the drive unit and the other for the sealed module.

The drive air flow system (Figure 1-8) provides continuous air replacement and circulation to dissipate the heat generated by drive operation. The main component of the drive air flow system is the fan that is mounted on the rear panel. The fan motor is driven by the -24 volts from the power supply. The fan pulls ambient air through the front panel filter and forces air over the electronics, cooling these assemblies before exiting the drive through the back panel. The system intake port is located on the front panel. This port is covered by the filter, which keeps large particles from being drawn into the system and causing damage to the drive.

The air flow system for the module is a self-contained closed loop system. The system consists of a fan, circulation filter, and breather filter. The fan blades are located at the top of the hub assembly. The motion of the blades above the cutout pulls air through the circulation filter into the disk area.

If the pressure within the module becomes less than the surrounding atmosphere, air enters through the breather filter to equalize the pressures. If the module pressure exceeds atmospheric pressure, air exits the module through the breather filter.

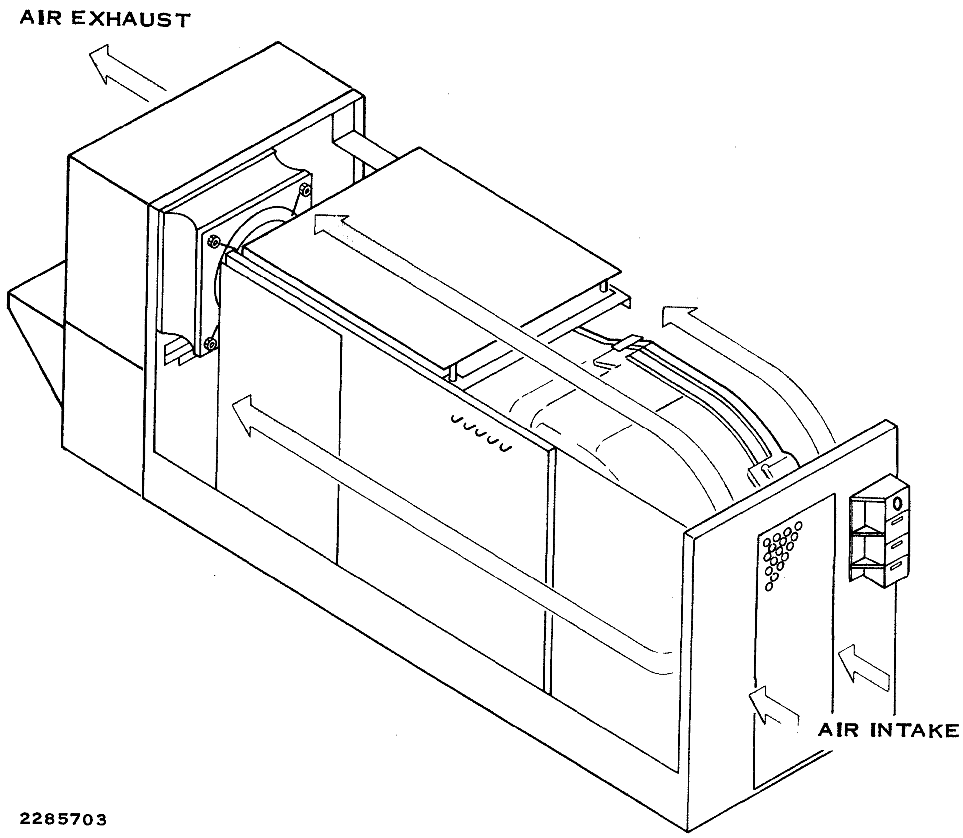


Figure 1-8 Drive Air Flow System

1.3.2.6 Front Panel. The front panel contains all the switches and indicators required to control and monitor the basic operation of the WD900 drive (refer to Figure 1-9). Refer to paragraph 2.3.1.1, subparagraph Installing the Front Panel Filter and Trim Kit, for removal and replacement instructions.

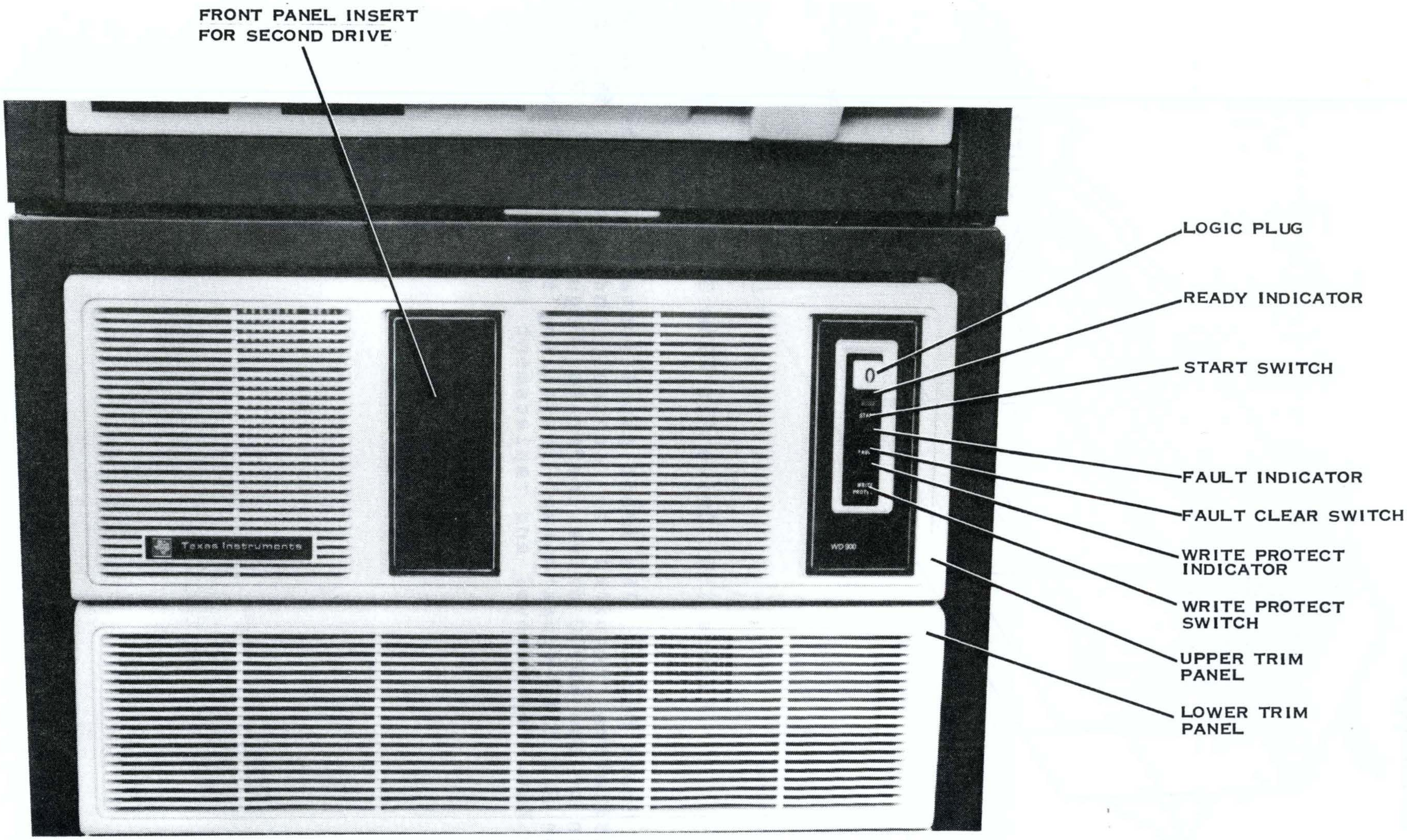


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Figure 1-9 WD900 Front Panel Switches and Indicators

1.3.2.7 Maintenance Indicators. The WD900 has special fault indicators. The 138-megabyte drive fault indicators are located on the control board. The 425-megabyte drive fault/maintenance indicators are located on the status/fault board. The fault indicators on the 138-megabyte drive can be viewed without removing the drive cover. The fault/maintenance indicators for the 425-megabyte drive are located behind the front panel insert on the status/fault board.

The following are the fault indicators and their functions for both the 138-megabyte and 425-megabyte drives (refer to Figure 1-10 and Figure 1-11):

* First Seek Indicator -- Indicates that the drive failed the first seek/load attempt

* Read/Write Off Cylinder Indicator -- Indicates that a write or read condition existed during a seek operation (an off cylinder condition)

* Write Indicator -- Indicates that a write fault has occurred

* Read/Write Indicator -- Indicates that a write and a read command exist simultaneously

* VOLT Indicator -- Indicates that a below normal voltage exists

* Head Select Indicator (425-megabyte only) -- Indicates that more than one head was selected at the same time

In addition, the 425-megabyte drive can perform diagnostics via four switches and indicators on the status/fault board. The switches and indicators consist of the following:

* Diagnostic Mode Switch -- Located in the lower left corner, this switch places the drive in the diagnostic mode and disables the drive I/O.

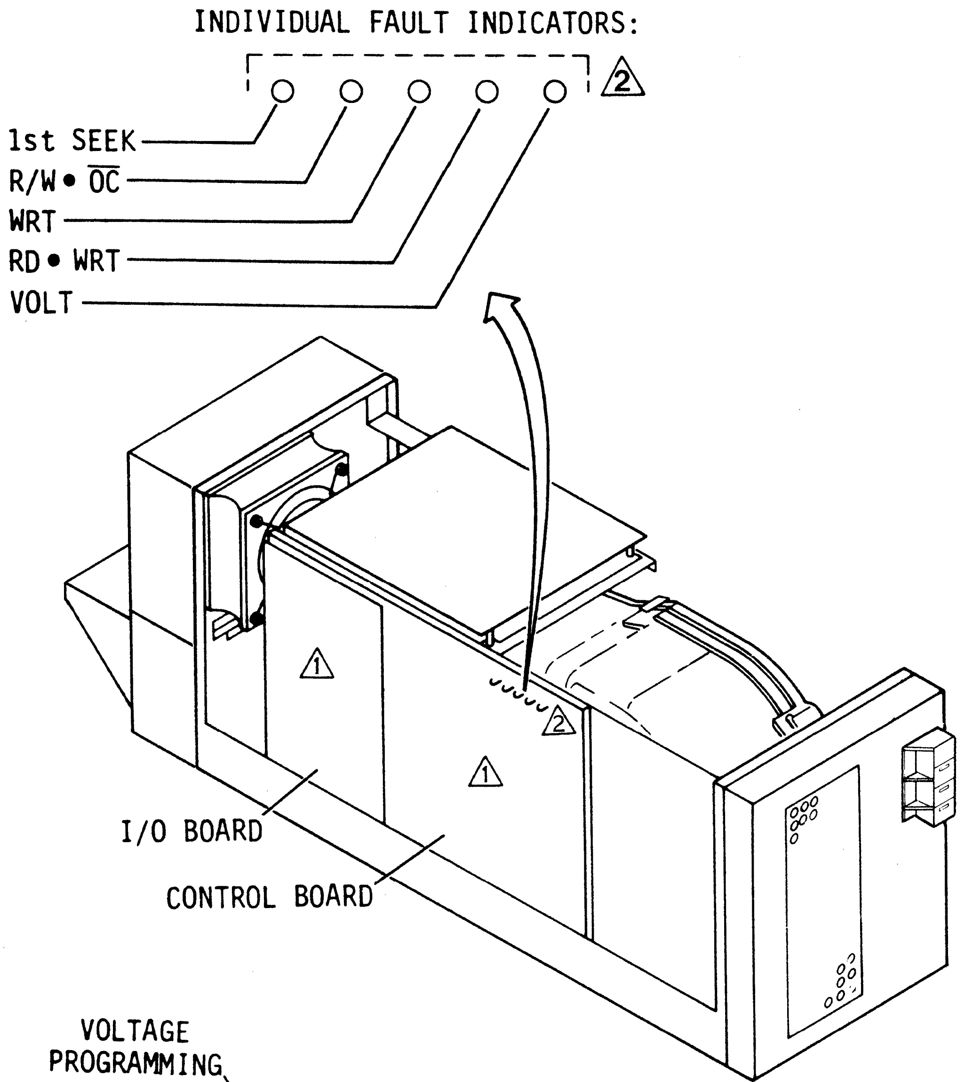
* Diagnostic Mode Indicator -- This indicates that the drive is in the diagnostic mode.

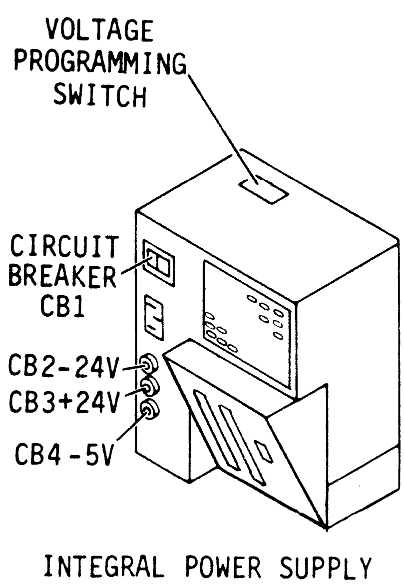
* Diagnostic Execute Switch -- This starts and stops the diagnostic tests.

* Diagnostic Step Switch -- This selects individual diagnostic tests.

* Diagnostic/Servo Fault Display Indicator -- When the drive is in the diagnostic mode, this display indicates which diagnostic test is running. If a failure occurs, the display indicates which major assembly needs replacing to correct the failure. When the drive is not in the diagnostic mode, the display indicates an error code.

Refer to paragraph 4.3.2.7 for more information on the individual diagnostic tests.





NOTES:

1. SWITCHES LOCATED ON CIRCUIT BOARDS ARE ILLUSTRATED IN FIGURE 1-6

2. INDIVIDUAL FAULT INDICATORS ARE VISIBLE THROUGH OPENINGS IN TOP COVER.

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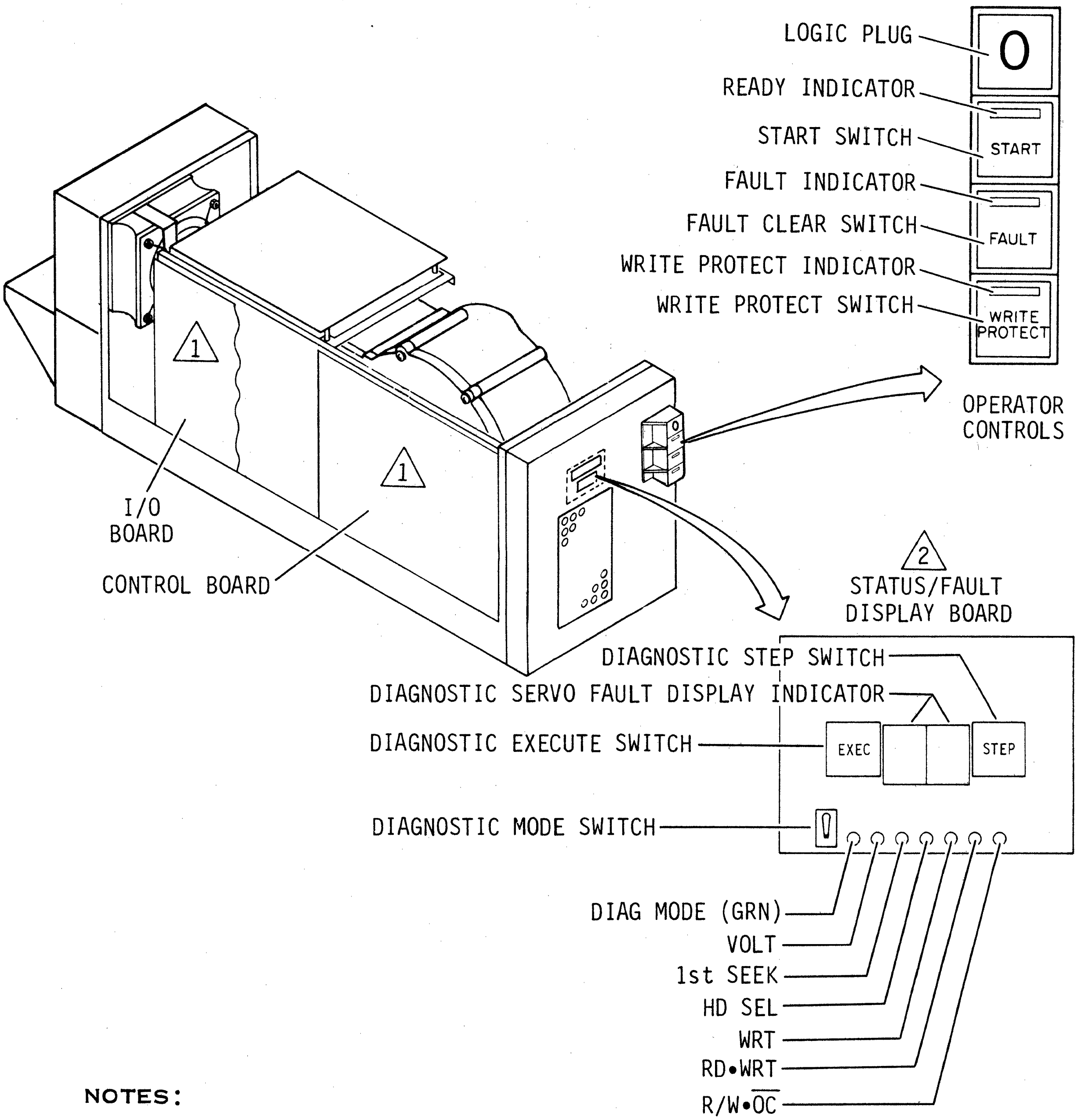
Figure 1-10 138-Megabyte Disk Drive Fault Indicators



NOTES:

1. SWITCHES LOCATED ON CIRCUIT BOARDS ARE ILLUSTRATED IN FIGURE 1-7

2. STATUS/FAULT DISPLAY BOARD IS LOCATED BEHIND FRONT PANEL.

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Figure 1-11 425-Megabyte Disk Drive Fault/Maintenance Indicators

1.3.2.8 Air Filter. The air filter prevents contaminants from affecting the performance of or possibly damaging the drive. The air filter must be clean to ensure proper air circulation through the drive. This filter is located behind the front panel. Figure 1-12 shows the air filter. Inspect the filter periodically and either replace or clean it when dirty. Clean the filter only if replacement filters are not available. The interval for filter maintenance depends on the operating environment. In computer room conditions, a six-month interval is suggested. In other conditions, the interval should be varied accordingly.

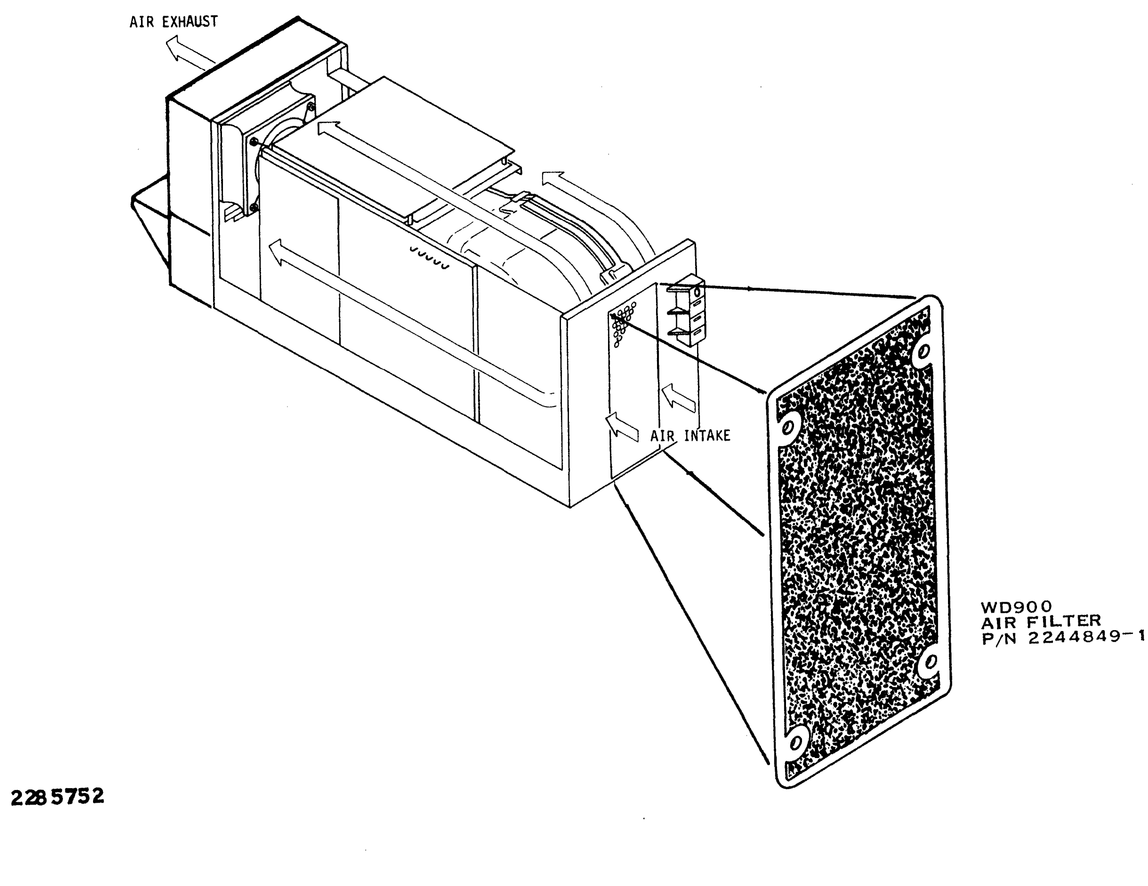

Figure 1-12 WD900 Air Filter

1.3.2.9 I/O Cable Connectors. All communications between the drive and the controller must pass through the interface. This communication includes status, control signals, all commands, and read/write data transfers.

The interface consists of the I/O cables and the logic required to process the signals sent between the drive and the controller. All input and output signals are digital and utilize industry-standard transmitters and receivers. When used with properly shielded cables, this interface provides a terminated, balanced transmission system for long distances and/or noisy electrical environments.

The WD900 has two I/O cables: the A cable and the B cable. These cables contain all the lines between the drive and the controller. Both the A and B cables are shielded to minimize cross-talk, reduce inductive coupling due to static discharge, and control impedance variations due to cable lengths and environments.

The A cable, TI part number 2244787-0001, is a 30 twisted-pair, (refer to Figure 1-13) shielded cable that carries commands and control information to the drive and status information to the controller.

The B cable (or Wye cable), TI part number 2244845-0001, is a 13 twisted-pair, shielded cable that carries read/write data, clock, and status information between the drive and the controller. The Wye cable has a second connector (refer to Figure 1-13) that can attach to J2 of a second drive.

The daisy chain cable, TI part number 2244787-0003, connects the secondary drive to the primary drive. Figure 1-14 shows all the lines (except those not used) in the A and B cables.

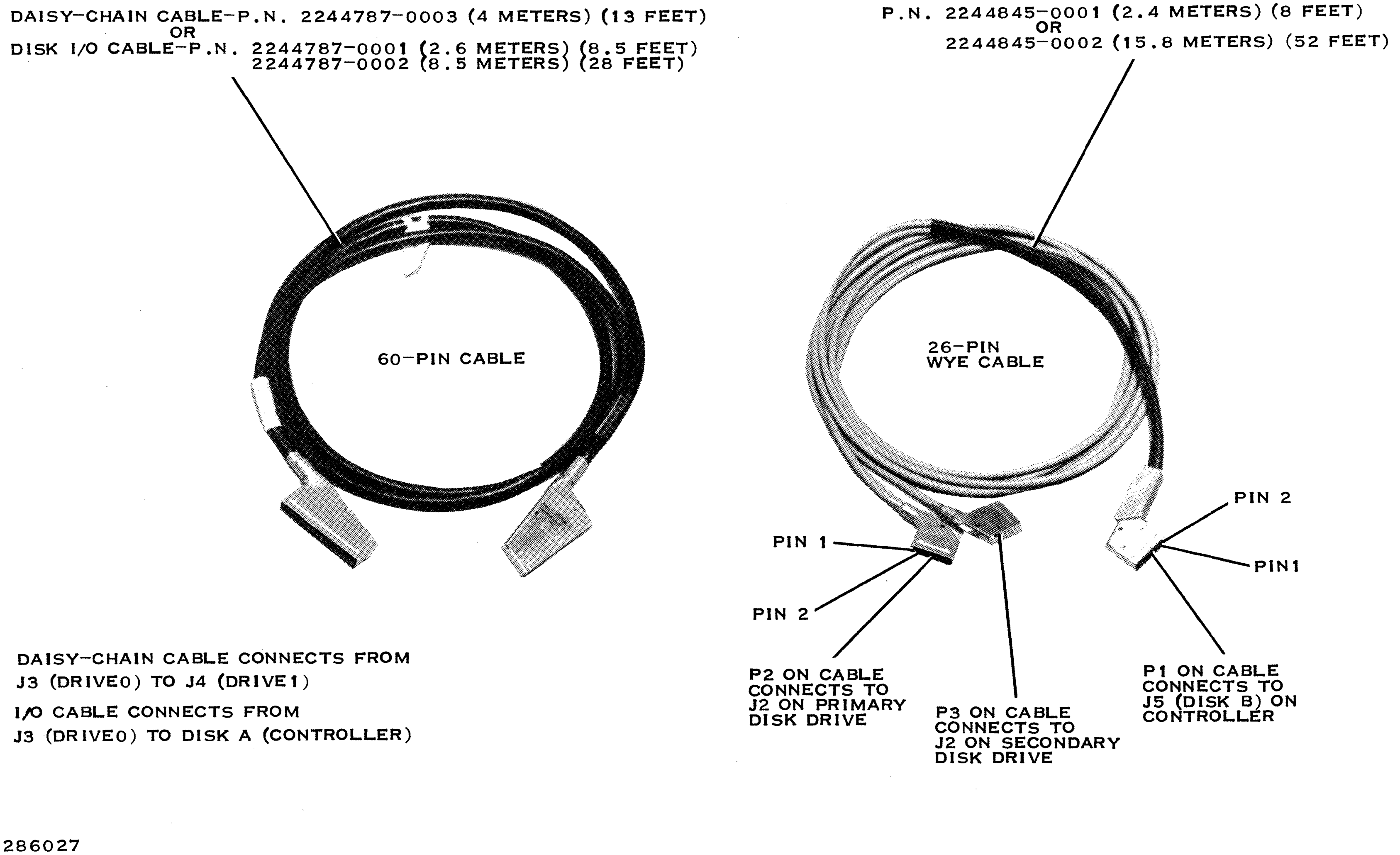

Figure 1-13 WD900 Cables

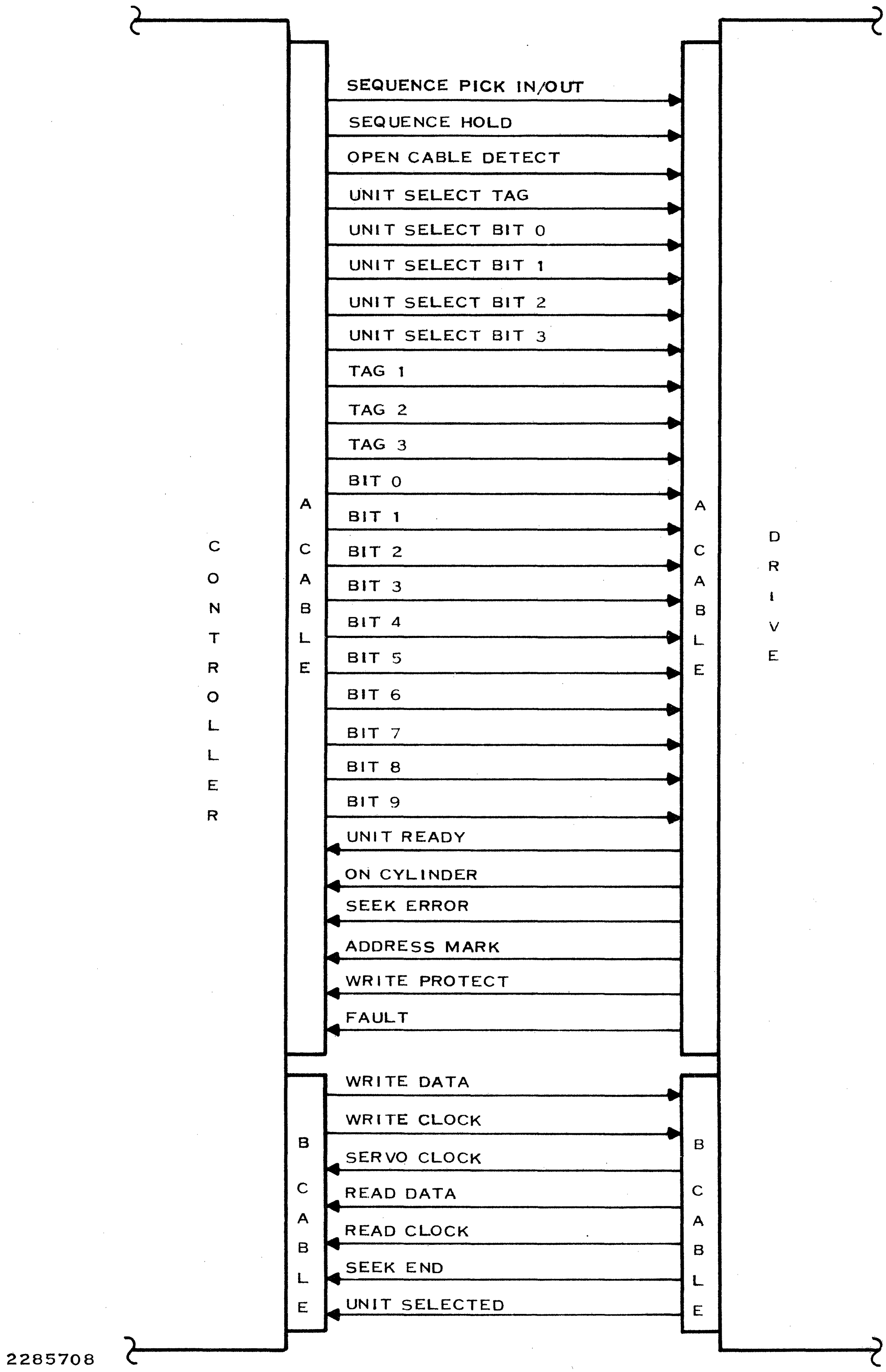

Figure 1-14 WD900 Interface Signals

1.3.2.10 Interface Board. The interface board is connected to the rear of the drive. This board mates the cable pinouts from the drive to the controller and from drive to drive.

1.3.2.11 Power. Power functions are processes that take place within the power supply and the drive when the drive is powered up and powered down. These processes depend on whether the drive is set up for local or remote operation. In all cases, the power-up and power-down sequences are controlled through microprocessing unit (MPU) programming. The MPU monitors start conditions and certain interlock and operating conditions.

The power supply provides the drive with basic dc supply voltages when circuit breaker CB1 is placed in the ON position. The drive itself has no ac power requirements. All the drive circuits (including the electronics, cooling fan, and drive motor) are operated with the dc supply voltages. The ac power cable connects the power supply through CB1 to site ac power. The power supply can be configured for operation with any standard ac input voltage. Refer to paragragh 2.2.1.1 for more information on power supply configurations.

The dc power cable connects the power supply to the drive. When CB1 is ON, this cable transmits four basic dc supply voltages to the drive electronics. These voltages are +5 volts, -5 volts, +24 volts, and -24 volts. The -5 volt, -24 volt, and +24 volt supplies are protected against overload by pop-out circuit breakers on the power supply. The dc power cable also contains signal lines, which are enabled by control circuitry in the drive. The control circuitry switches on the drive motor's 40 volt dc power to produce disk rotation.

Secondary power supplies on the WD900 control board develop additional bias voltages for certain integrated circuits. One supply steps down the +24 volt input and develops a regulated +15 volt source. Another supply steps down the -24 volt input and develops a regulated -15 volt source. A third supply steps down the -15 volt supply to develop a regulated bias of -8.3 volts for the servo preamp chip.

The drive circuitry monitors the various supply voltages and disables write and/or servo functions when dc power is unreliable. For more information about voltage faults, refer to the discussion of fault and error conditions in paragraph 4.3.2.7, subparagraph Voltage or Actuator Current Fault.

1.3.2.12 Local/Remote Power Sequencing. The local/remote feature selects whether the controller controls the starting and stopping of the drive motor. Part of drive installation is setting the LOCAL/REMOTE switch (on the drive I/O board) for either the local or remote operation. The LOCAL/REMOTE switch setting determines the start conditions for the drive motor during power-up. With the LOCAL/REMOTE switch in the LOCAL position, the start conditions require only that the START switch be in the ON position. With the LOCAL/REMOTE switch in the REMOTE position, the start conditions require that the START switch be in the ON position and that the controller activate the SEQUENCE HOLD and SEQUENCE PICK signals.

NOTE

> The SEQUENCE PICK and SEQUENCE HOLD signals are grounded at the controller. This means that when the A cable is connected, the drive will start spinning up after the logic plug delay.

In a system of several drives that are set up for remote operation, all drives receive the sequence signals at the same time. A delay circuit in the I/O circuitry activates each drive after a predetermined interval. Thus, each drive in the system has a unique start-up interval. However, when the hold signal deactivates, it causes all drive motors to stop at the same time.

1.3.2.13 Disk Rotation. Certain drive functions are a result of the electromechanical devices using the drive motor and working under the control of drive logic circuitry.

Disk rotation is accomplished by an electromechanical system that accelerates the disks to 3600 rpm during power-up and stops disk rotation with friction braking during power-down. The mechanical components used for disk rotation are the spindle, the drive motor, and the brake.

1.3.2.14 Spindle. The disks are mounted on the spindle assembly. The spindle, like the disks, is part of the module. When the spindle is rotated by the drive motor, the disks rotate with the spindle.

1.3.2.15 Drive Motor. The WD900 has a direct drive system for disk rotation with the drive motor mounted concentrically on the spindle. The motor has a three-phase stator surrounded by a four-pole rotor. The motor speed control (described in paragraph 1.3.2.16) provides a pulsed current to the three stator windings. To keep the stator pulses in phase with rotor position, the speed control uses feedback from sensors located in the motor. These sensors check flux reversals from the rotor magnets. As the rotor magnets pass each sensor, the output line toggles.

1.3.2.16 Motor Speed Control. The motor speed control regulates operation of the drive motor. Subject to interlocks, the microprocessor issues a command to start the drive motor during the power-up sequence (refer to paragraph 4.3.2.3). The motor speed control activates the 40-volt dc output of the power supply and uses this power source to start the drive motor.

The motor speed control regulates motor speed by modulating the width of the pulses applied to the stator coils. The motor speed is kept within the following range: 3528 rpm (17.01 milliseconds per revolution or mspr) to 3672 rpm (16.34 mspr). The pulses have maximum width until the rotation time decreases to 17.01 mspr. Then the pulse width decreases linearly to a zero value corresponding to a rotation time of 16.34 mspr.

Three status outputs are generated by the motor speed control and are used as follows:

* +Motor Fault -- Indicates to the MPU that the drive motor has a bad magnetic sensor.

* -Speed OK -- Indicates to the MPU that the drive motor speed is between 3528 and 3672 rpm and that no motor fault is present.

* -Disk Stopped -- Indicates to the interlock circuitry that the last disk rotation exceeded two seconds.

1.3.2.17 Friction Motor Braking. The drive motor decelerates during the power-down sequence under control of the friction brake. A transistor switch in the motor speed control board energizes the brake during drive motor operation to release the brake and allow the motor to turn. When the motor is powered down, the brake loses power and contacts the rotor in the drive motor. The motor speed control signal then activates to indicate that braking is complete. This output to the interlock circuitry turns off the flasher circuit for the ready indicator to show that power-down is complete.

1.3.2.18 WD900 Heads. Data is written on and read from the disk by the heads. The drive must position the heads over a specific data track before a read or write operation can be performed. Head positioning is performed by the actuator mechanism, which is an integral part of the drive (refer to Figure 1-15). Inputs received from the servo circuits control the actuator.

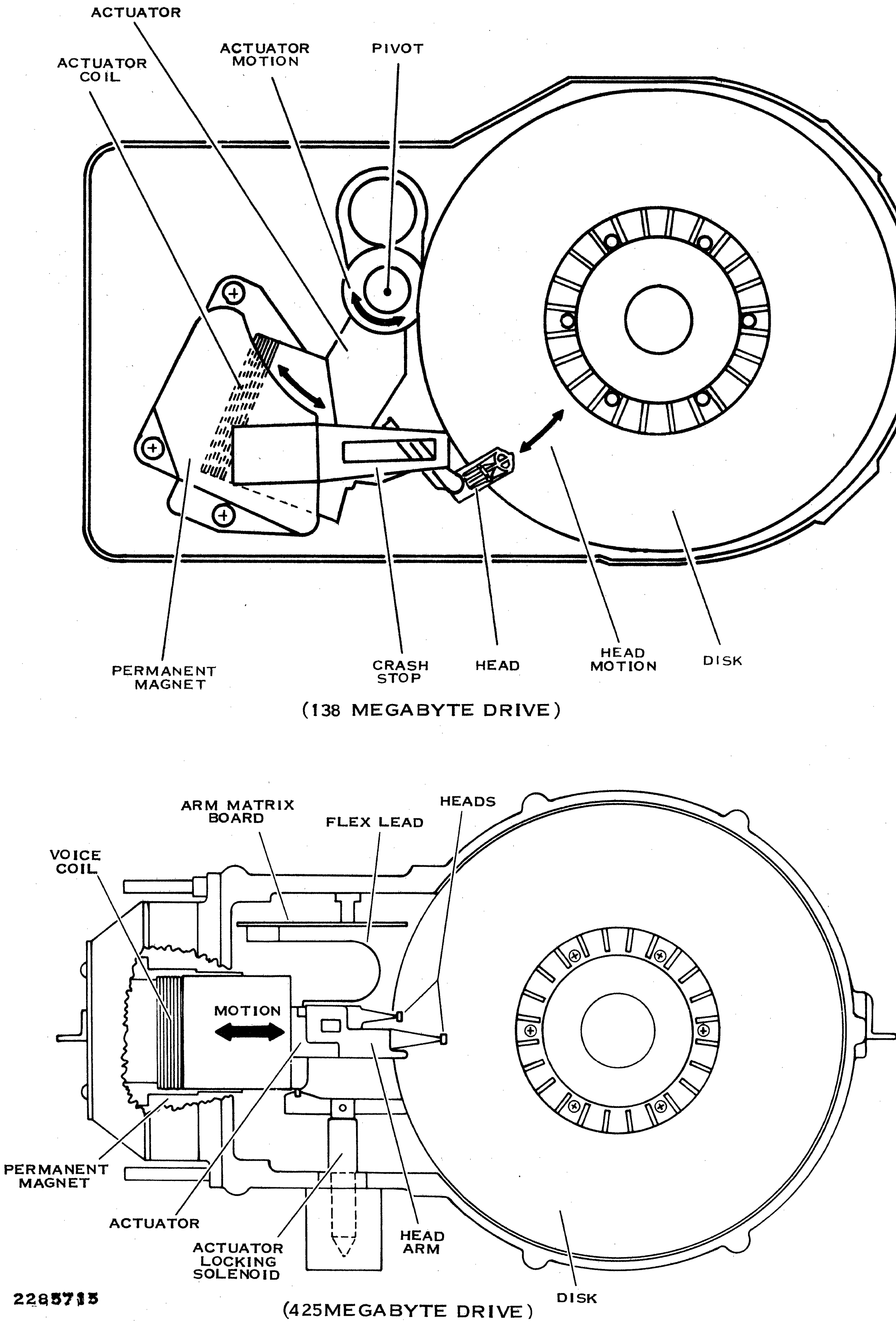

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Figure 1-15 Actuator and Magnet Assembly

Whenever the drive is powered down, the actuator is latched in the unloaded position with the heads over the landing zone. The actuator remains locked until the next power-up sequence when the MPU releases the actuator-locking solenoid. The automatic actuator-locking feature eliminates the need to manually lock the actuator when transporting the drive.

The voice coil is mounted at the opposite end of the assembly and moves in and out of the magnet as the servo signals change. The magnet is mounted on the housing in a position that allows the voice coil to move as the field in the coil changes. This small in and out motion of the voice coil in the magnet provides the motion for the heads over the disk surface. The movement of the carriage and voice coil (and, therefore, the heads) is controlled by positioning signals from the servo logic.

The heads record data on and read data from the disk surface. The servo head, however, reads prerecorded data but cannot write. Up to four heads are attached to each supporting arm. The heads and arm together are called a head-arm assembly. The head-arm assemblies are attached to the front of the actuator assembly (Figure 1-16 and Figure 1-17).

The drive has 24 data heads (10 on the 138-megabyte drive) and one servo head. The data (or read/write) heads record data on and read data from the disk data surfaces. The servo head reads prerecorded data from the servo disk surface for use by the drive analog-servo circuits.

1.3.2.19 Drive Servo System. The drive writes data on and reads data from the disk data recording areas under the directions of the controller. Data cannot be randomly placed on the recording surface because when the controller retrieves data, it must be able to find the exact location where that data has been stored. This problem is resolved by mapping the disks into discrete sections or tracks, which are further subdivided into equal sectors.

After the controller selects a unit, it must then direct the drive to the specific location on the data recording surface where it wants the operation performed. The operation of positioning the heads over the desired track is called a seek operation. The drive servo system, under the direction of the MPU, performs the seek operation to position the heads by using information read from the servo surface by the servo head.

The data recording areas of each of the disks (two areas on each of 12 disk surfaces) are divided into 711 cylinders (6 disk surfaces and 823 cylinders on the 138-megabyte drive). These cylinders are assigned sequential number addresses starting at 0. Cylinder 0 is located on the outer edge of the recording area, and the last cylinder (cylinder 692 for the 425-megabyte drive and cylinder 804 for the 138-megabyte drive) is on the inner edge closest to the hub. The 425-megabyte drive has 24 data recording areas (refer to Figure 1-16), each with 711 tracks with addresses 0 through 710. The 138-megabyte drive has 10 surfaces (refer to Figure 1-17), each with 823 cylinders with addresses 0 through 822.

NOTE

> Although the 425-megabyte drive has 823 cylinders and the 138-megabyte drive has 711 cylinders, fewer user cylinders are accessible because of diagnostic tracks and spare tracks.

The controller must select 1 of 24 possible heads (1 of 10 on the 138-megabyte drive) with the same cylinder address. This further selection is accomplished by assigning numbers to the data recording areas (and the heads associated with the data areas) from 0 through 23 (0 through 9 for the 138-megabyte drive).

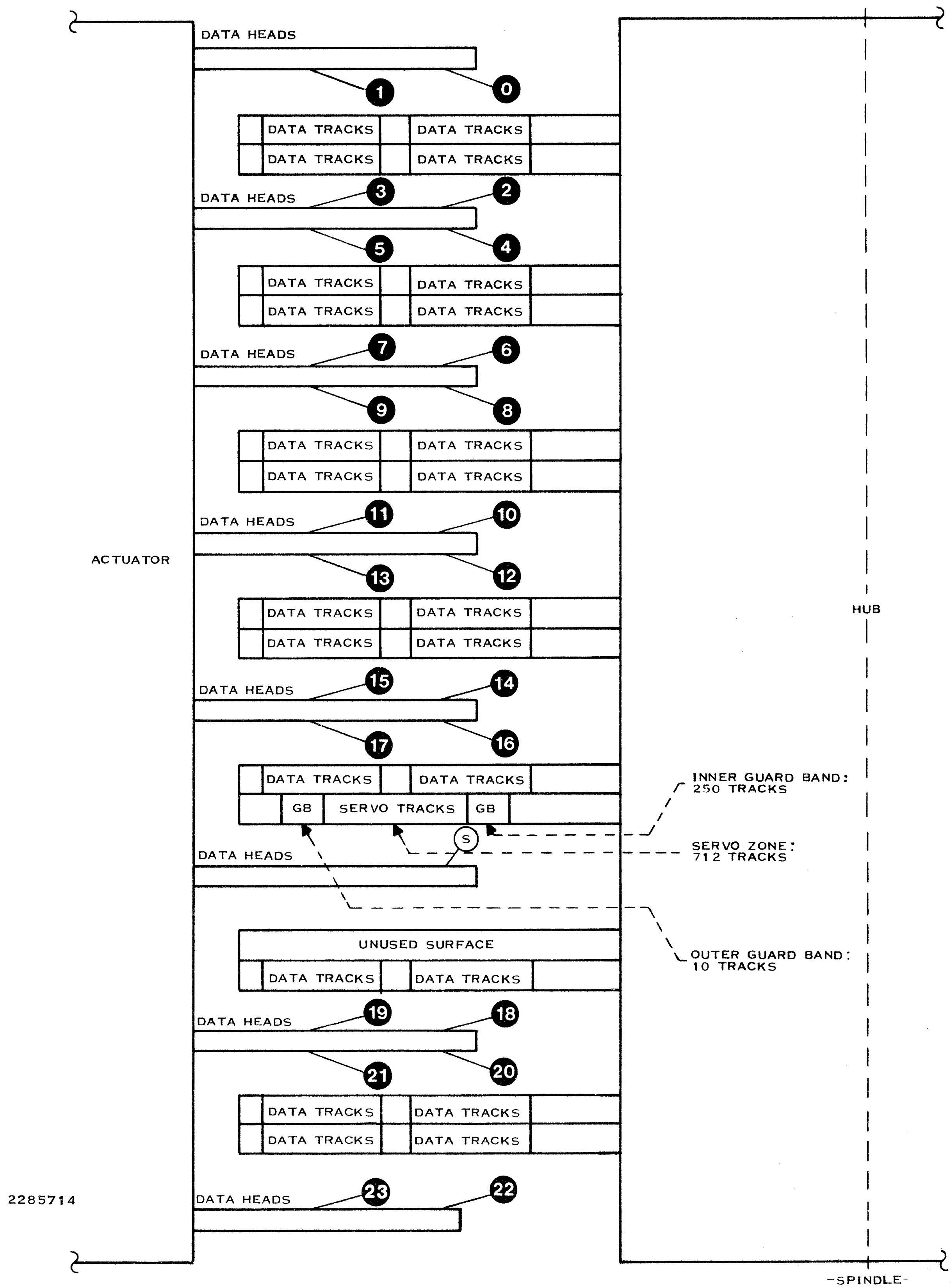


Figure 1-16 425-Megabyte Head Positions

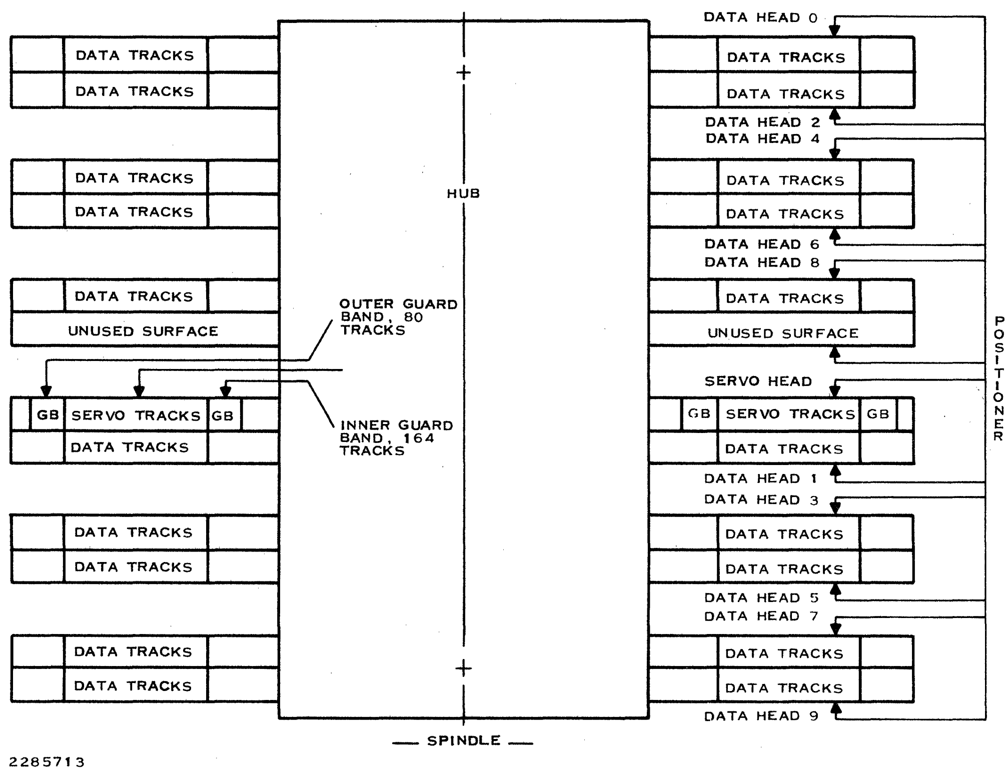


Figure 1-17 138-Megabyte Head Positions

Once a particular track is selected, the controller then further narrows down the location by addressing one of five heads located at the selected track. The division of each track into sectors is accomplished by setting a group of switches called the sector switch. After the controller has selected the unit, the track, and the head, it waits for the particular sector(s) to come around on the rotating disk. The controller then performs the selected write (store) or read (retrieve) operation. You can also locate an area on a track by writing an address mark at a specific location on the track, and then looking for the mark at the beginning of a read operation.

The drive servo system, directed by the MPU, performs a positioning (seek) operation when the controller commands the drive to go to a track, head, or sector for a read or write operation. The MPU uses information read from the servo surface by the servo head to do the seek operation.

1.3.2.20 Servo Surface Decoding. The servo surface is a prerecorded disk surface in the module that provides three basic types of information to the drive electronics. The three types of information available from the servo surface are as follows:

* Radial movement of the heads, indicated by the position signal

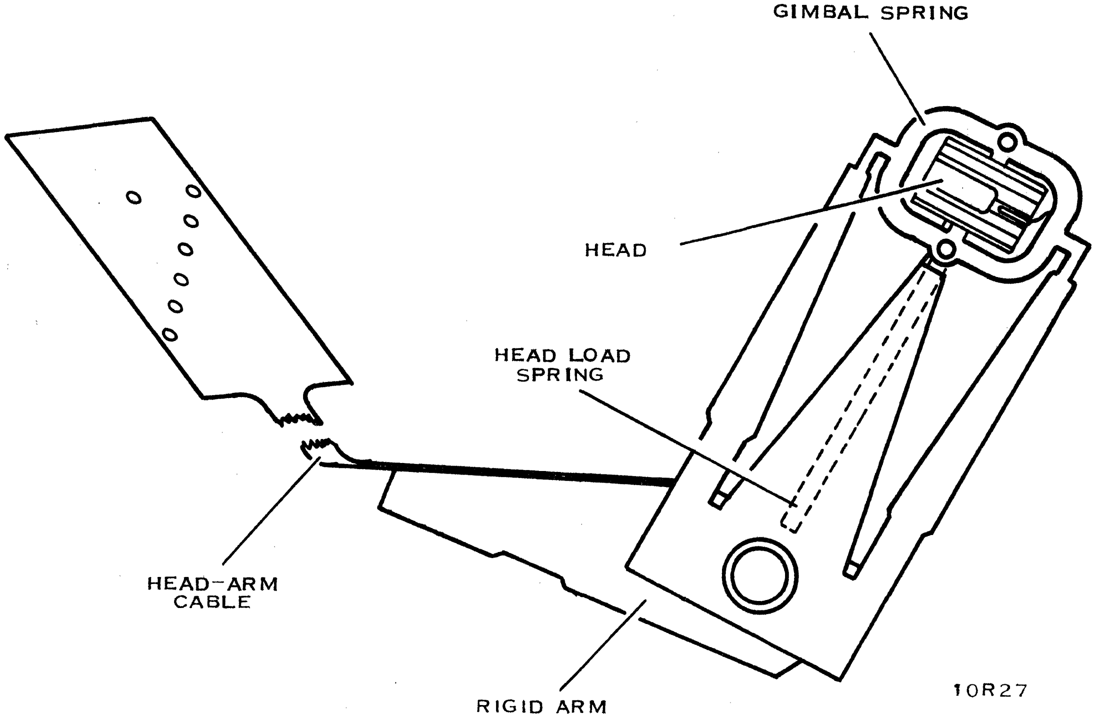
* Rotational position of the disks, indicated by the index signal

* Exact speed of the disks, indicated by the clock signal from the servo

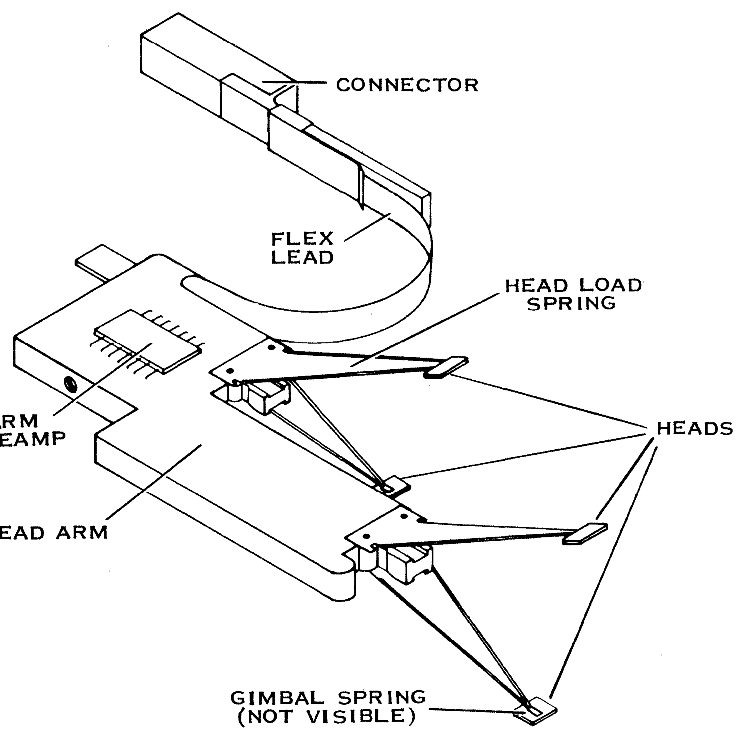
Information from the servo surface is read by the servo head. The servo head is mounted on the same positioner as the data heads. Thus, movements of the servo heads across the servo surface correspond exactly to movements of the data heads across the data surfaces.

1.3.2.21 Head-Arm Assembly. Each head-arm assembly consists of a rigid arm that supports either two or four heads on load springs and gimbal springs (Figure 1-18). The head-arm assemblies are mounted at the front of the actuator carriage. These assemblies follow the in and out carriage motion, which is created by the reaction of the voice-coil magnetic field to the permanent magnet field. The rigid arm alone does not provide the action necessary for the heads to load or unload. The head-load spring forces the associated head toward the disk surface. The gimbal spring allows free axial movement of the head along its vertical and horizontal axes independent from the rigid arm.

Read and write information is transferred to and from the heads through cables connected to a preamp mounted on the arm. The preamp interface connects to the read and write circuitry via the arm matrix board, which is located inside the sealed module.



(138 MEGABYTE DRIVE)



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(425 MEGABYTE DRIVE)

Figure 1-18 WD900 Data Heads

1.3.2.22 Head Loading. In the retract condition, the head-load springs force their respective heads against the disk surface in the landing zone. The landing zone is located in the outward section of the disks. When the system powers up, the program turns on the drive motor. When the drive motor rotates the disks at an acceptable speed, the heads move away from the disk surfaces and fly on the cushion of air created by disk rotation. At this point in the power-up sequence, the actuator is unlocked and the heads are moved inward to track 0. Until the power-down sequence begins, the heads float on a cushion of air.

The head-load spring forces the head toward the disk surface while the cushion of air pushes against the head to resist its closer approach. The air cushion pressure varies directly with disk speed. When the proper speed is reached, the force of the head-load spring (pressing the head towards the disk surface) and the opposing force of the air cushion (resisting the closer approach of the head) are balanced so that the heads fly at the correct height above the disk.

If the disk drops below the critical speed, the air cushion pressure decreases and the head-load springs force the heads closer to the disk surface. Sufficient loss of speed causes the heads to stop flying and contact the disk. This is called head landing. Because insufficient disk speed causes head landing, heads are not moved into the data areas until the disks have come up to speed. For the same reason, the heads are retracted from the data areas and locked over the landing zone when the disk speed drops below a safe operating level.

1.3.2.23 Unit Selection. The following paragraphs describe how the drive is initially selected and also how a selected, reserved, or disabled drive responds to a unit select TAG line.

If the drive is available (not selected, reserved, or disabled), it receives a unit select TAG and a logical address from the controller. The drive then compares the address received from the controller with that indicated by its logical address plug (located on the front panel). If the two addresses are the same, the drive enables the select compare signal.

The select compare signal causes the Selected FF gate to set. When the gate is set, it enables the receivers and drivers to the controller. The output pulse from this sets the Reserved FF gate. When both these gates are set, the drive is ready to accept further commands.

The drive remains selected until the controller deactivates the unit select TAG or switches the logical address to another drive. At this time, the drive's Selected FF gate clears and disables the WD900 drivers and receivers. When the gate clears, it also disables the unit select signal and informs the controller that the drive will no longer respond to commands.

If the controller tries to select the drive while the drive is disabled (either by a priority-select function or maintenance-disable function), the attempt is unsuccessful and no response is sent to the controller.

1.3.2.24 Release Function. The release function releases the drive from either a reserve or priority-select condition. There are two types of release functions:

* Time-out release pulse

* Release command

The time-out release pulse is capable of releasing the drive from only the reserved condition. This pulse is generated by the time-out release signal. The time-out release pulse releases the drive by clearing the Reserve FF gate.

A Release command releases the drive from both the reserve and priority-select conditions. This command is initiated by reserving and/or priority-selecting the controller when the controller issues a TAG 3 (control select signal) with bus bit 9 active. This clears the Reserve and Disable FF gates.

1.3.2.25 Interface. The interface consists of the I/O cables and the logic required to process the signals sent between the drive and the controller. Table 1-2, Table 1-3, Table 1-4, Table 1-5, and Table 1-6 describe the functions of each of these lines.

Table 1-2 WD900 Interface Lines

Signal	Description
Sequence pick	A ground from the controller on this line starts the power-up cycle when the LOCAL/REMOTE switch is in the REMOTE position provided that the START switch is in the start position. Sequence pick triggers a delay circuit that delays the power-up sequence for an interval based on the drive address.
Sequence hold	A ground from the controller on this line holds the drive in a power-on condition when the LOCAL/REMOTE switch is in the REMOTE position provided that the START switch is left in the start position. Removing the ground from this line and from the sequence pick line powers down all operating drives in the system.

Table 1-3 Interface Lines -- Controller Drive Selection

Signal	Description
Unit-select TAG	This signal enables the unit-select lines and the logical number-compare circuit. Unit-select TAG is selected after a 600-nanosecond (maximum) internal time lapse. The drive does not process commands until it is selected.
Unit-select bits 0, 1, 2, and 3	A binary code is placed on these four lines to select a drive. The binary code must match the logical address of the drive. The logical address is determined by the logical address plug, which is inserted in the operator panel. Drives can be numbered 0 and 1. Bit 3 must be inactive for a unit selection to occur.
Unit selected	This signal indicates that the drive has accepted a unit-select request. Unit selected must be active before the drive can respond to any command from the controller.
Open cable detect	The controller supplies the voltage to override the bias voltage at the drive receiver. If the A cable is disconnected or if controller power is lost, the unit selection and/or controller commands are inhibited.

Table 1-4 Interface Lines -- Drive Operational Status

Signal	Description
Unit ready	Unit ready indicates that the drive is up to speed, the servo head is positioned on the cylinder, and no fault condition exists.
Index	This signal is derived from the servo tracks. It occurs once per revolution of the disk, and its leading edge is the leading edge of sector 0.
Sector	This signal is derived from the servo tracks. The number of sector signals that occur for each revolution of the disk is controlled by switches on the control board.
Write protected	This signal indicates that the drive write circuits are disabled. The write-protect mode is enabled by either a jumper on the control board, a switch on the operator panel, or a fault condition. Attempting to write while the write-protect mode is active results in a fault condition.
On cylinder	This signal indicates that the servo head is positioned at a track. This line goes inactive if the positioner drifts off cylinder.
Seek end	This signal indicates either an on-cylinder status or seek error status, resulting from a seek operation that has terminated.
Seek error	This signal indicates that either the drive was unable to complete a seek within 250 milliseconds, the positioner has moved outside the recording field, or a command was issued to seek beyond cylinder 710 (823 on the 138-megabyte drive). The seek error can be cleared by a return-to-zero (RTZ) command or by a power-up operation.

Table 1-4 Interface Lines -- Drive Operational Status (Continued)

Signal	Description
Fault	When the fault line is active, it indicates that one or more of the faults listed below exist. * First-seek fault * Head-select fault * DC voltage fault * Write fault * Write or read attempted while off cylinder * Write-gate fault during a read operation
Address mark	When an address mark has been found, this line goes high.

Table 1-5 Interface Lines -- Controller Drive Commands

Signal	Description
Bits 0 through 9 (bus lines)	These ten lines carry data to the drive. The meaning of the data is a function of the active tag line.
Tag 1 (cylinder select)	This tag line gates the data on the bus lines to the drive cylinder address register. The bus bits have the significance listed below. Bus bits 0-9, with the values in the following list, encode the cylinder address for the seek operation. Cylinder addresses above 710 (822 on the 138-megabyte drive) are illegal and result in seek errors.

Bus Bit	Function
0	Cylinder address 2^0
1	Cylinder address 2^1
2	Cylinder address 2^2
3	Cylinder address 2^3
4	Cylinder address 2^4
5	Cylinder address 2^5
6	Cylinder address 2^6
7	Cylinder address 2^7
8	Cylinder address 2^8
9	Cylinder address 2^9

Signal	Description
TAG 2 (head select)	This TAG line sends the data on the bus lines to the drive head address register. The bus bit functions are listed below.

Bus Bit	Function
0	Head address 2^0
1	Head address 2^1
2	Head address 2^2
3	Head address 2^3

Table 1-5 Interface Lines -- Controller Drive Commands (Continued)

Signal	Description
TAG 3 (control select)	This tag line gates the data on the bus lines to the logic circuits of the drive for commanding various operations. The operation performed depends on which of the bus lines is active. The bus bit functions are listed below.

Bus Bit	Name	Function Performed
0	Write gate	Enables write driver. Not accepted if there is a seek error or fault status.
1	Read gate	Enables read circuitry. The leading edge triggers the read chain circuit to synchronize on an all zero patterns. Not accepted if there is a seek error or fault status.
2	Servo offset plus	Offsets the positioner 190 microns (75 micro-inches) towards the spindle from the on-cylinder position. Disables the ON CYLINDER signal for 2.75 milliseconds.
3	Servo offset minus	Offsets the positioner 190 microns (75 micro-inches) away from the spindle from the on-cylinder position. Disables the ON CYLINDER signal for 2.75 milliseconds.
4	Fault clear	A pulse sent to the drive that clears the fault flip-flop, provided that the fault condition no longer exists.

Table 1-5 Interface Lines -- Controller Drive Commands (Continued)

Signal	Description		
	Bit	**Bus Name**	**Function Performed**
	5	Address mark enable	When this signal occurs with a write gate, an address mark is written. When this signal occurs with a read gate, an address mark search is initiated.
	6	RTZ	A pulse sent to the drive to move the positioner to track 0. This bit also resets the head address register, the cylinder address register, and the seek error flip-flop.
	7	Data strobe early	Enables the read comparator to strobe the data at a time earlier than usual.
	8	Data strobe late	Enables the read comparator to strobe the data at a time later than usual.
	9	Release	Used with dual-channel option only. This bit clears channel-reserved and channel priority-select reserve status.

Table 1-6 Interface Lines -- Read, Write, and Clocks

Signal	Description
Read data	This line transmits data recovered from the disk. This data is transmitted in nonreturn-to-zero (NRZ) form to the controller.
Read clock	This clock is derived from and is synchronous with the detected data. Read clock defines the beginning of a data cell and is transmitted continuously.
Write data	This line transmits NRZ data from the controller to the drive for recording on the disk surface.
Write clock	This clock is the servo clock retransmitted to the drive during a write operation. Write clock must be synchronized to the NRZ data and must be transmitted 250 nanoseconds prior to write enable.
Servo clock	Servo clock is a phase-locked signal generated from the servo track tribits. The servo clock frequency is 14.52 MHz in 425-megabyte drives and 9.67 MHz in 138-megabyte drives. The servo clock signal is continuously transmitted.

1.3.2.26 Seek Operations. The drive has four basic types of seeks: the load operation, normal seek, RTZ seek, and the unload operation. The load operation and RTZ seek operation use both the outward and inward movements to move the actuator to track 0. The unload operation is an outward movement that moves the heads to the landing zone beyond the outer guard band. Normal seek operations can be either inward or outward movements, depending upon where the new address is located relative to the present address. The four basic seek operations are briefly discussed in the following text.

Load Operation. The load operation is an MPU-controlled sequence that starts the drive motor, moves the heads from the retracted position to track 0, and calibrates the velocity measurement circuitry. A load operation cannot take place until power-up initialization has successfully completed.

If the load operation is unsuccessful, the MPU performs a normal retract, provides a servo status code on the fault display board, sets the first-seek fault latch, and lights the front panel fault indicator. This fault can be cleared only by pressing the fault clear switch. Pressing the fault clear switch initiates another load attempt; the MPU allows a maximum of three tries.

Normal Seek. Normal seeks are initiated by controller command and implemented by the drive servo circuitry. The normal seek is the operation used to move the heads from one location to another on the disk surface. The same track can also be selected, but a zero track seek requires no actuator movement and the operation is handled by the I/O gate array.

The normal seek occurs in two directions: reverse (from the center towards the outer edge) and forward (from the outer edge towards the center). Going from a higher-numbered track to a lower-numbered track involves an out-direction movement of the actuator, while going from a lower-numbered track to a higher-numbered one involves an in-direction movement of the actuator.

With the drive in the unit-ready and on-cylinder conditions, the controller initiates a normal seek by raising the TAG 1 (cylinder select) signal and placing the desired cylinder address on bus bits 0 through 9. The address is moved into the cylinder address register (in the I/O gate array) by the cylinder select TAG.

If the seek operation is unsuccessful, the MPU sets the seek error FF gate in the I/O gate array by using control lines 1 and 2. With the FF gate set, the seek error and seek end status appear on the interface. As a maintenance aid, the MPU displays a servo status code on the fault display board. Refer to Volume 2, Section 3 of your drive type manual (TI part number 2246129-0002 for the 425-megabyte drive, and TI part number 2246129-0001 for the 138-megabyte drive) for more information on status codes.

After providing seek end status, the MPU waits for further commands from the controller.

Return to Zero Seek. The RTZ seek is the operation that moves the heads from any location on the disk to track 0. Although the MPU uses an RTZ seek as part of the load operation, the controller can also command RTZ seeks. Both types of RTZ seeks are identical, except for the status presented if they fail. If the RTZ seek in a load operation is unsuccessful, the MPU lights the first seek fault indicator, and a reattempt occurs only if the fault clear switch is pressed. If a controller-initiated RTZ seek is unsuccessful, the MPU sets the seek error FF gate, and seek error is active on the I/O gate array. In this case, the drive waits for another RTZ command from the controller.

If the RTZ operation was unsuccessful, the MPU sets the seek error FF gate in the I/O gate array by using control lines 1 and 2. With the FF gate set, seek error and seek end status appear on the interface. As a maintenance aid, the MPU displays a servo status code on the fault display board. Refer to Volume 2, Section 3 of your drive type manual.

After providing seek end status, the MPU waits for further commands from the controller.

Unload Operation. The MPU uses the unload operation during the power-down sequence to move the heads outward until they are located over the landing zone. When the MPU detects a loss of start conditions, it initiates the unload sequence. A loss of start conditions occurs when the START switch is pressed so that the switch is released from the start position (in remote operation), or when the controller deactivates sequence hold or sequence pick.

Sensing a loss of start conditions, the MPU deactivates the ready signal, drops all commands to the servo circuitry, and then issues the Retract command. The retract operation moves the heads slowly outward into the landing zone and holds them in contact with the soft actuator stop. After a delay, the MPU deactivates the Unlock Actuator command to lock the actuator in this position.

The MPU then deactivates the Motor Run command. The MPU monitors motor sensor pulses with a programmable timer. When the motor has stopped rotating, the MPU waits two seconds and deactivates the Retract command. The MPU allows a 30-second delay (during which the ready indicator flashes) before it recognizes new start conditions and initiates another load operation.

1.3.3 MT3200 Functional Description

The recording of data on a magnetic tape originates with the input device. The input device has nine channels of digital signals that are transmitted to the corresponding data channels of the transport. The information is transmitted in parallel bytes composed of nine bits (eight bits of data and one bit for parity detection) that are aligned across the width of the magnetic tape. These signals produce corresponding electrical currents in the write head of the transport. The transport then produces positive and negative magnetic polarities that correspond to the original data and parity signals. In phase-encoded (PE) writing, a binary 1 signal produces a transition toward the erase polarity on the tape when the tape moves forward. A binary 0 produces a transition away from the erase polarity.

As written tape passes across the magnetic read head of a transport, the head responds to each change of flux and produces a read voltage waveform.

1.3.3.1 Phase-Encoded Operation. PE recording is used for the 1600 bits per inch (bpi) format in the nine-track mode only. A major advantage offered by the PE format is the fact that the data is self-clocking, which allows each channel to be synchronized using a preamble.

Refer to Figure 1-19 for details of the PE format. Channels 0 through 7 contain data bits. The bit in channel 0 is the most significant bit (MSB). Channel P contains the parity bit, which is always odd in the PE format. Each PE data block is preceded by a preamble consisting of 40 bytes of all zeros, followed by one byte of all ones. This is used to establish synchronization for the data block. The all-ones byte identifies the end of the preamble and the start of the data bytes in the block. Following each PE data block is a postamble, which is one byte of all ones and 40 bytes of all zeros.

A 1600 bpi PE tape requires an identification (ID) burst of 1600 flux reversals per inch (frpi) in the P channel and erasure in all other channels at the beginning of the tape. The burst must begin at least 43.2 millimeters (1.7 inches) ahead of the trailing edge of the beginning of tape (BOT) marker, extend beyond the trailing edge of the marker, and end at least 12.7 millimeters (0.5 inch) before the block of data. The typical distance for a gap is 95.25 millimeters (3.75 inches).

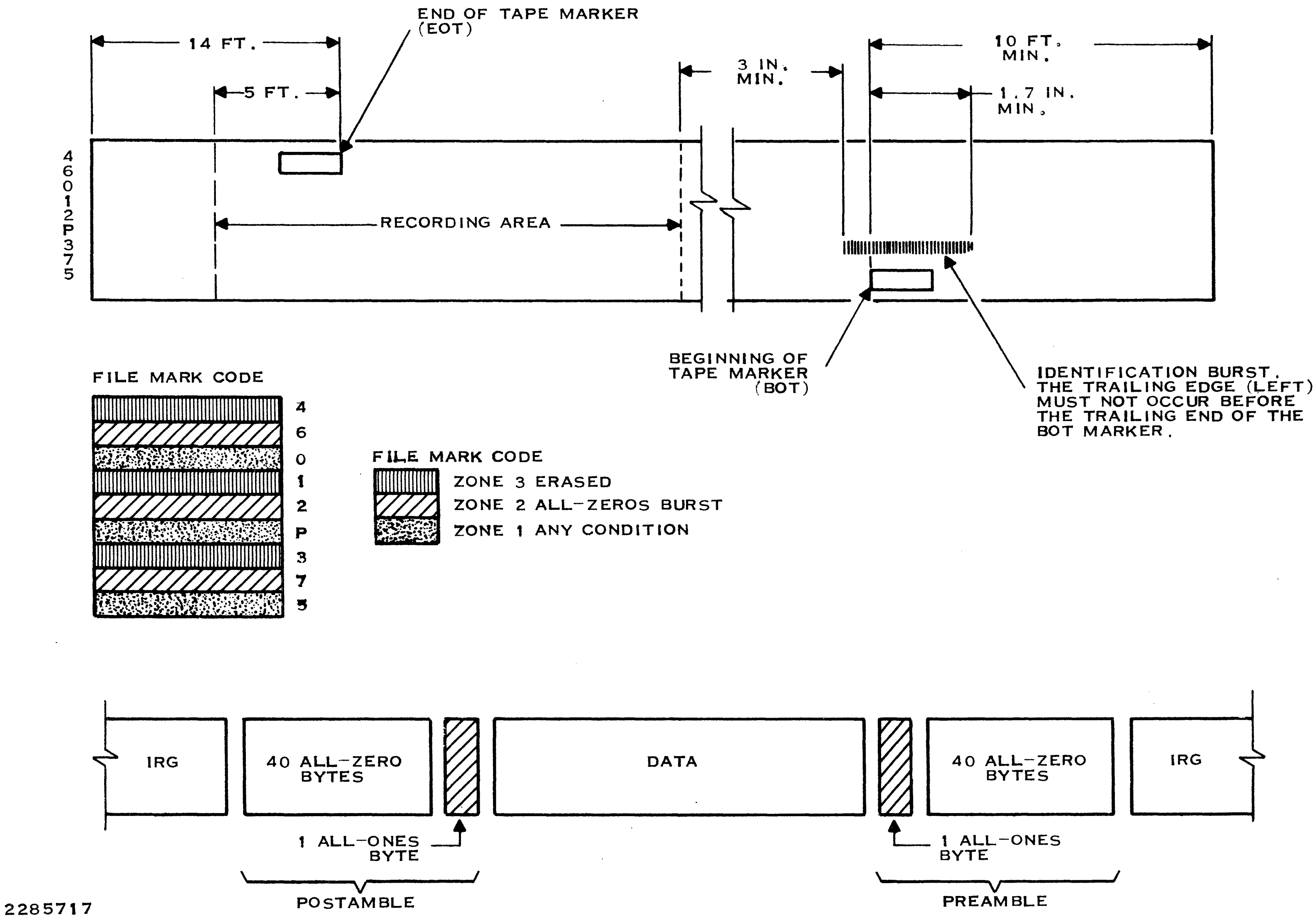

Figure 1-19 Nine-Track PE Data Format

1.3.3.2 Cache Tape Operation. Cache tape operation consists of the MT3200 receiving data from the host computer, placing the data in cache memory, and then writing the data on tape when the physical write head is available. This permits faster write speeds when viewed from the host system because when the write data is available, it is transferred to the cache tape unit and stored in cache memory. The MT3200 then writes the data on tape in a time frame that is independent of the host transfer rate. The cache memory allows the MT3200 to perform most of the functions normally assigned to the host, thus freeing the host for other system activities. In this way, the cache memory acts as a logical drive by interfacing with the host.

1.3.3.3 Streaming Tape Operation. Streaming tape operation is simply writing data to tape without stopping and starting between each record block. Interblock gaps (IBGs) are inserted automatically. Figure 1-20 illustrates in the simplest form what a streaming drive automatically performs if for any reason the unit must start and stop after each block. The period called Command Reinstruct Time is the time after the tape reads or writes the last character of the last block in which the system must instruct the tape drive to continue. This period can also be that time after reaching point B that the tape drive enters the repositioning cycle. If the command to continue reading or writing is not received by the time the normal forward velocity reaches point B, the drive automatically accelerates and stops at point E. This sequence is called repositioning. After stopping at point E, the unit waits for the next command to read or write.

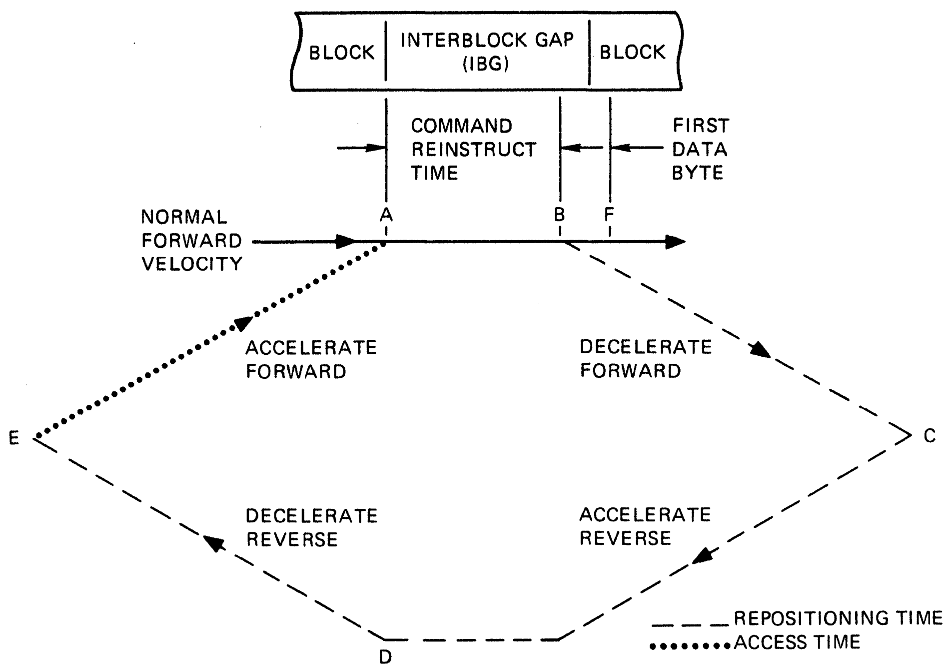

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Figure 1-20 Repositioning Cycle

1.3.3.4 Power-Up Self Test. The power-up self test (PUST) consists of a series of tests that are executed each time power is applied to the unit. These tests verify the proper operation of the unit prior to loading the tape (refer to Figure 1-21). In case of a failure, PUST can help the operator isolate the fault and report it to a certified technician for repair. If the PUST is successful, the unload indicator remains lit, and the transport is ready to be loaded. If the PUST is unsuccessful, a unique pattern is displayed on the front panel LEDs that indicates the areas that failed. This is referred to as level 1 failure information. For certain tests, level 2, 3, 4, and 5 failure information is available to provide a more specific cause for the failure (refer to paragraph 4.3.3.7).

The failure display is a binary number that results from the on (1) and off (0) states of the LEDs. The least significant bit (LSB) is the load indicator on the left and the MSB is the HI DEN indicator on the right (refer to Figure 1-2). For the first six tests, the display is the number of the test that failed. The drive halts and no further interaction can take place. Refer to Section 4 for PUST failure codes.

If all MT3200 LEDs light continuously for more than one second after power-up and the LED display does not match the level 1 displays in Table 4-6 through Table 4-8, a failure of the Z8002 is indicated and no further failure information is available.

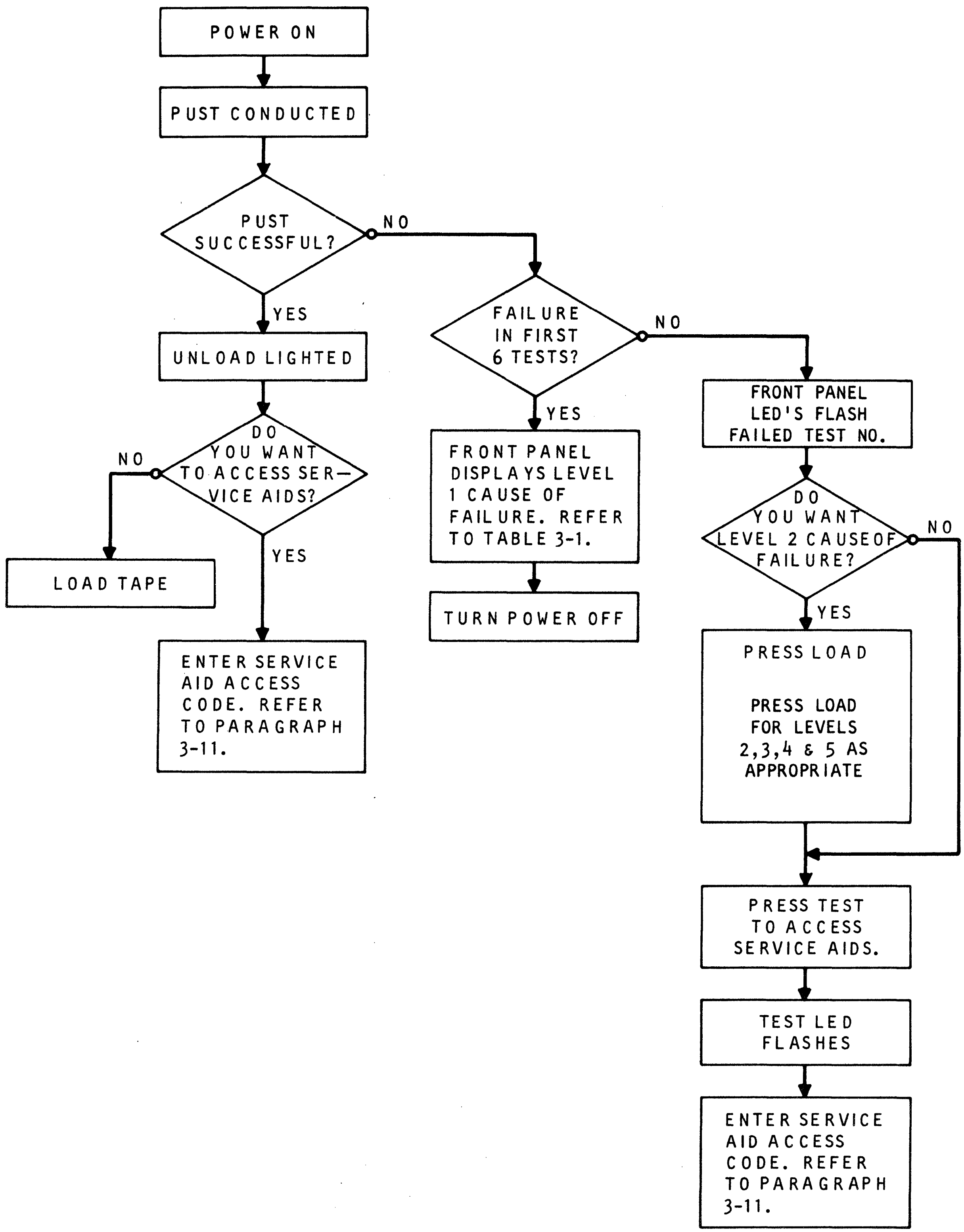

Figure 1-21 Power-Up Self-Test Process

Refer to the simplified block diagram (Figure 1-22) while reading the following discussion.

1.3.3.5 Microprocessor. The Z8002 microprocessor is supported by 16K words of control storage ROM and 2K words of RAM. The microprocessor has analog I/O ports for diagnostic purposes, control of the motor drivers, and read-threshold selection. The interface logic in the MT3200 consists of both the read/write latches and strobes and the command and status latches. The read/write latches and strobe logic are connected to the DMA controller and cache memory through device-request logic. The microprocessor determines the rate of access from the read/write latch and strobe to the direct memory access (DMA) controller and cache memory. The command and status latches interface directly with the microprocessor logic. The host interface communicates only with the logical tape drive.

1.3.3.6 Cache Memory. The cache memory, which consists of 64K of 9 bit (one byte plus one parity bit) memory, has independent pointers for the logical and physical transports. The logical port is connected to the system interface, and the physical port is connected to the read/write logic of the physical transport. Separate DMA channels allow simultaneous cache loading and unloading under microprocessor control. The DMA controller accesses the following in the order listed:

1. The physical tape drive

2. The logical tape drive

3. Communications between the microprocessor and cache memory

4. Dynamic RAM (DRAM) refresh

1.3.3.7 Write Circuits. The write formatter is under the direct control of the microprocessor. The ID burst, preamble, postamble, and file mark are generated internally by the write formatter. The formatter output is sent to the write circuits. The write circuits force the head of the physical tape drive to write the data on the tape.

1.3.3.8 Read Circuits. During a read operation, the read circuits recover the low voltage from the read head, condition the signals, and route the signals to the read formatter. The read-formatter detects the polarity of the data transitions. It sends input requests to the serial-processing and skew buffers in the read-formatter logic. When a full data character is assembled by the skew buffer, the buffer requests that the DMA controller recover the character and place it in cache memory.

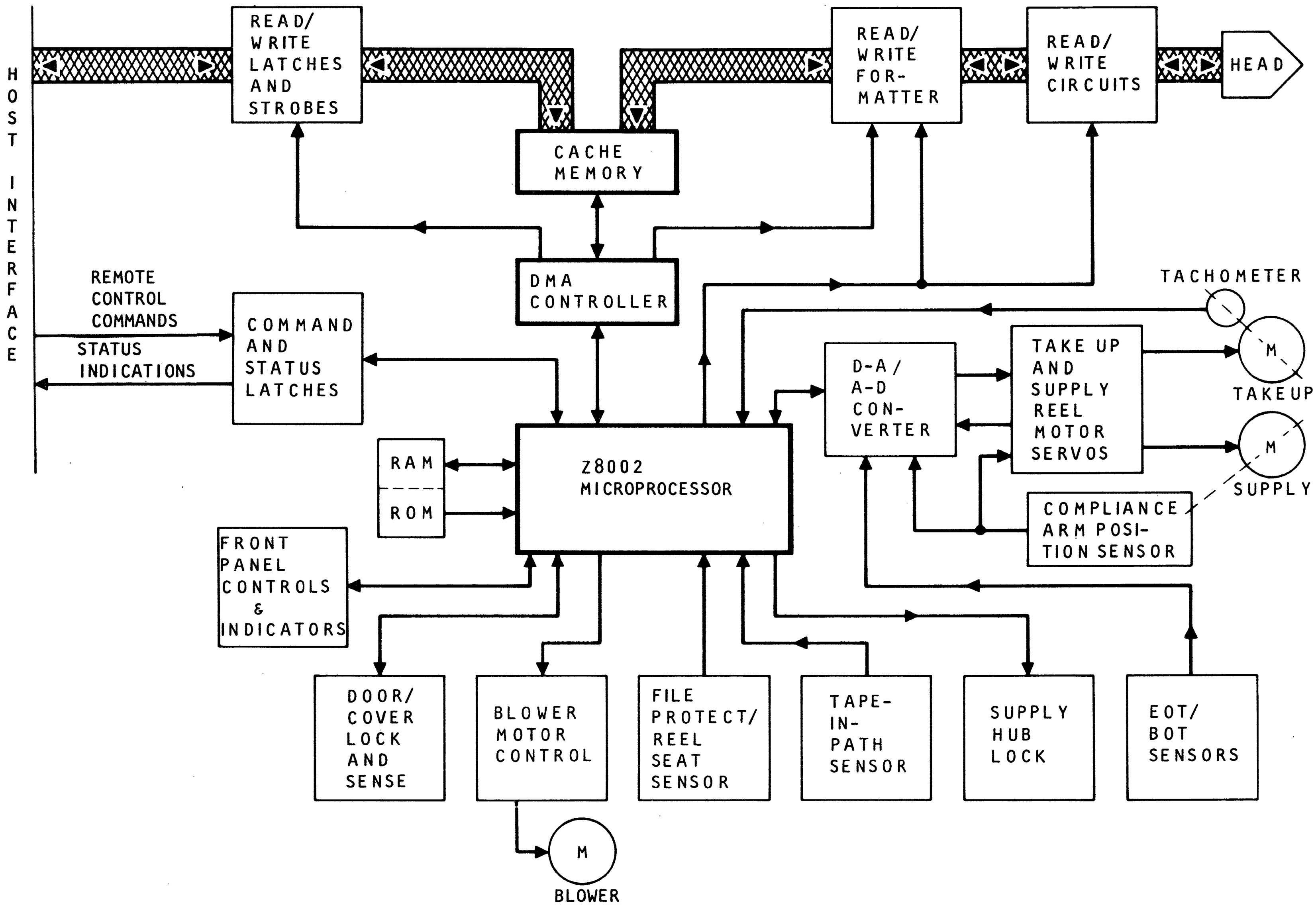

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Figure 1-22 MT3200 Simplified Block Diagram

1.3.3.9 Tachometer. Tape movement in the physical tape drive is controlled primarily by the take-up servo and tachometer assembly. The information on velocity generated by the tachometer assembly is used to develop the drive voltage for the take-up motor. The tachometer is also used to derive position displacement information between the beginning and end of the consecutive tape records.

1.3.3.10 Supply Motor. The supply motor is the driving mechanism of a position servo loop. Together they maintain the tape at the proper tension. The compliance arm is held at a position between its two limit stops. Any tape movement causes a change in position of the compliance arm resulting in a feedback signal from the compliance-arm position sensor to the supply reel servo. The servo adjusts the supply reel motor speed and direction to correct the compliance-arm position.

1.3.3.11 EOT/BOT Sensor. The end-of-tape (EOT) and BOT sensors consist of two-channel infrared detectors. These detectors operate on reflections from American National Standards Institute (ANSI) metallized markers that are applied to standard tape reels.

The EOT marker on the tape signifies that there are only 3.05 meters (10 feet) of certified tape remaining on the reel. When the EOT marker is reached, the logical data transfer comes to an orderly halt. Any additional data is limited to whatever fits into the remaining 3.05 meters (10 feet) past the EOT marker. A full cache represents 4.88 meters (16 feet) of tape (in 256-byte blocks), so the microprocessor must not allow a full cache to be transferred. When the microprocessor detects that approximately 7.62 meters (25 feet) of tape remains on the supply reel, the effective cache is reduced so that only 26.03 centimeters (10.25 inches) of written data is held. This cache reduction is limited to the final one to two percent of a 731.5-meter (2400-foot) reel of tape and does not significantly reduce the overall transfer rate.

For more information, refer to the Cipher Data Products <u>Theory of Operation</u> manual, TI part number 2246126-0002.

1.3.3.12 Interface Description. Figure 1-23 and Figure 1-24 show the interface signals for cable A and cable B, respectively. Table 1-7 describes the MT3200 interface signals. Table 1-8 defines the transition board signals for cable A, and Table 1-9 defines the transition board signals

CONTROLLER | ADAPTER BOARD

PIN	SIGNAL	SIGNAL NAME	PIN
01	GROUND	GND	1
02	FORMATTER BUSY –	FBY –	2
03	GROUND	GND	3
04	WRITE DATA 4 –	IW4 –	4
05	GROUND	GND	5
06	WRITE DATA 0 –	IW0 –	6
07	GROUND	GND	7
08	WRITE DATA 1 –	IW1 –	8
09	GROUND	GND	9
10	REVERSE –	IREV –	10
11	GROUND	GND	11
12	WRITE DATA PARITY –	IWP –	12
13	GROUND	GND	13
14	WRITE DATA 7 –	IW7 –	14
15	GROUND	GND	15
16	WRITE DATA 3 –	IW3 –	16
17	GROUND	GND	17
18	WRITE DATA 6 –	IW6 –	18
19	GROUND	GND	19
20	WRITE DATA 2 –	IW2 –	20
21	GROUND	GND	21
22	WRITE DATA 5 –	IW5 –	22
23	GROUND	GND	23
24	WRITE –	IWRT –	24
25	GROUND	GND	25
26	ERASE –	IERA –	26
27	GROUND	GND	27
28	WRITE FILEMARK –	IWEM –	28
29	GROUND	GND	29
30	READ DATA 2 –	R2 –	30
31	GROUND	GND	31
32	READ DATA 3 –	R3 –	32
33	GROUND	GND	33
34	LAST WORD –	ILWD –	34
35	GROUND	GND	35
36	INITIATE COMMAND –	IGO –	36
37	GROUND	GND	41
38	REWIND –	IREW –	38
39	EDIT –	EDIT –	42
40	TRANSPORT ADDRESS 0 –	ITAD0 –	40

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Figure 1-23 MT3200 Interface Lines -- Cable A

CONTROLLER — ADAPTER BOARD

PIN	SIGNAL	SIGNAL NAME	PIN
01	GROUND	GND	1
02	READ DATA PARITY—	RP —	2
03	GROUND	GND	3
04	READ DATA 0 —	R0 —	4
05	GROUND	GND	5
06	READ DATA 1 —	R1 —	6
07	GROUND	GND	7
08	LOAD POINT—	LDP—	8
09	GROUND	GND	9
10	READ DATA 4 —	R4 —	10
11	GROUND	GND	11
12	READ DATA 7—	R7—	12
13	GROUND	GND	13
14	READ DATA 6—	R6—	14
15	GROUND	GND	15
16	HARD ERROR—	HER —	16
17	GROUND	GND	17
18	FILEMARK—	FMK—	18
19	GROUND	GND	19
20	FORMATTER ENABLE—	IFEN —	20
21	GROUND	GND	21
22	READ DATA 5 —	R5 —	22
23	GROUND	GND	23
24	REWINDING—	RWD —	24
25	GROUND	GND	25
26	READ STROBE —	RSTR —	26
27	GROUND	GND	27
28	WRITE STROBE—	WSTR—	28
29	GROUND	GND	29
30	DATA BUSY—	DBY—	30
31	GROUND	GND	31
32	CORRECTED ERROR—	CER—	32
33	GROUND	GND	33
34	FILE PROTECT—	FPT—	34
35	GROUND	GND	39
36	READY—	RDY—	36
37	GROUND	GND	41
38	REWIND/UNLOAD—	IRWU—	38
39	DENSITY—	DEN—	42
40	END OF TAPE—	EOT—	40

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Figure 1-24 MT3200 Interface Lines -- Cable B

Table 1-7 MT3200 Interface Signal Definitions

Signal	Description
Transport address 0 (ITADO-)	This signal is used to select the tape transport for an operation. The ITADO- signal enables a given transport to send and receive signals to the controller. This signal must be set high a minimum of one microsecond before a command is issued or status is polled.
Go (IGO-)	The trailing edge of this line initiates tape motion and latches the command into the transport control status unit. Once the command is accepted by the transport, it is acknowledged by the busy signal (IFBY-). IGO- is a pulse of 500 nanoseconds minimum.
Rewind (IREW-)	When not at load point, a one-microsecond minimum pulse on this line initiates a rewind in the selected drive. If the drive is at load point, the command is ignored. This command does not use IFBY- or the data busy signal (IDBY-). The rewind with unload (RWD-) status goes true within one microsecond, while ready signal (RDY-) goes false. Any new command (except unload) should be delayed until the RDY- status is true and the RWD- status is false.
Rewind with unload (IRWU-)	This signal has a one microsecond minimum (active low), which causes the selected ready tape drive to clear its online status, set RWD- true until BOT, rewind to load point, and unload the tape The transport indicates that RDY- and online (IONL-) are false within one microsecond of the command.
Last word (ILWD-)	This flag is appended to the last data character by the host in a write-record operation. ILWD- is also used to terminate the Write command and variable-length erase operation, and it goes true with the last data character to signal termination for the record.

Table 1-7 MT3200 Interface Signal Definitions (Continued)

Signal	Description
Formatter enable (IFEN-)	This signal is asserted to enable operation of the unit. IFEN can be pulsed high (two microseconds minimum) to reset the transport. When IDBY- is false, IFEN- is ignored. Command termination occurs within 50 milliseconds of IDBY- going low, followed by IFBY- going low.
Busy (IFBY-)	This is a low-level signal that goes true within one microsecond after the trailing edge of IGO-. IFBY- goes false approximately 100 microseconds after IDBY- goes false. New commands of a different type or direction can be issued while IFBY- is true as long as IDBY- is false.
Data busy (IDBY-)	This signal goes active low both after the simulated ramp delay stays true and during all commands initiated by IGO-, including the transfer of error status. Any command or direction can be given on the trailing edge of this signal. IDBY- goes true at least 100 microseconds before any data transfer is required.
Hard error (IHER-)	This signal is used to indicate two types of hard-error conditions, catastrophic and noncatastrophic. Catastrophic hard errors result in IHER- being latched while IDBY- is inactive. The tape motion is stopped and a hard-error code is reported to the front panel. This error code is numbered according to an established binary weight for each switch. Refer to paragraph 4.3.3.7 for more information. The physical tape is considered offline, even though the logical transport is still online. This allows a reading of extended status. This type of hard error results from the following situations:

Table 1-7 MT3200 Interface Signal Definitions (Continued)

Signal	Description
Hard error (IHER-) (Continued)	* A hard-write error occurring during a true write operation that persists beyond 16 automatic write retries. This error results in a front panel error code of 11. * Attempting to write records greater than 32K bytes in length. This error results in a front panel error code of 15. * A transmission error that occurs when the cache transfer rate exceeds the rate that the controller can handle. This error results in a front panel error code of 24. * Attempting to write a new block greater than the original block during a write edit. This error results in a front panel error code of 10. During noncatastrophic hard errors, the tape remains loaded with both the logical and physical drives online. Situations that result in this type of error are listed below. * A record-length error (record length greater than the maximum block size set) during a read or write operation. * A write-parity error only if external parity is selected. All media write errors are automatically corrected by the MT3200 recovery logic.

Table 1-7 MT3200 Interface Signal Definitions (Continued)

Signal	Description
Hard error (IHER-) (Continued)	* A write-data error that occurs during a write-edit operation. * The record being read containing an uncorrectable read-data error. * Invalid software commands being issued.
Correctable error (ICER-)	This line is pulsed during a write edit or read operation when a single-track correctable error occurs.
File mark (IFMK-)	This line is pulsed while IDBY- is true for a write verification or for a read operation when a file mark is detected. This line is also pulsed by the logical tape drive before the file mark is written on tape during a write file mark.
Ready (IRDY-)	This line indicates that the tape is taut and is either not rewinding, loading, unloading, or is offline. The drive goes offline and not ready if a hard-fault shutdown occurs. This line is used to precondition any tape drive command other than unload.
Rewind (IRWD-)	This signal indicates that the tape drive is in either a rewind or BOT sequence. The status goes true within one microsecond of the rewind command and stays true until the tape returns to BOT. IRDY- goes false while the drive is rewinding.
File protect (IFPT-)	This signal indicates that the loaded reel does not have a write-protect ring. This causes the electronics to become disabled and the write commands prohibited. This status goes true during the tape load sequence before the drive is ready. The status remains valid once the tape is loaded.

Table 1-7 MT3200 Interface Signal Definitions (Continued)

Signal	Description
Load point (ILDP-)	This signal is true when the load-point reflective marker is logically at the sensor. A command reset occurs with ILDP- set if a reverse command conflicts with BOT. ILDP- remains true if an illegal reverse command occurs at BOT. IFBY- and IDBY- occur quickly (10 milliseconds) in order to retain compatibility with other commands.
End of tape (IEOT-)	This level indicates the EOT marker is past the logical recording head. This signal goes false either on a rewind or by backing up over the EOT marker.
Write data 0 - 7 (WRITEDATA0- to WRITEDATA7-)	These data lines carry the information to be written on tracks 1 through 9. When write data lines are true (low), the head current changes to the proper state. The head current does this on the active edge of the write-clock pulse to magnetize the tape in the direction opposite the interrecord gap (IRG-) polarity. When the lines are false, the direction reverses. The lines must be held steady for 5 microseconds before and 5 microseconds after the write-clock pulse.
Write strobe (IWSTR-)	This pulse is associated with each write-data character. The drive asserts this line to sample the write-data lines.
Read data 0 - 7, parity (R0- through R7-, P)	The signals on these nine lines are the outputs of the nine peak detectors that are individually gated with the outputs of their envelope detectors. The threshold level is set to 10 percent of the base-to-peak amplitude of the read-after-write mode. The threshold remains at 10 percent in the read-only mode. These signals resemble the PE waveforms on the write-data lines. A low level on these lines represents the level opposite the IRG level when the tape is moving forward.

Table 1-7 MT3200 Interface Signal Definitions (Continued)

Signal	Description
Read strobe (IRSTR-)	This signal indicates that a read character is present on the controller side of the tape interface.

Table 1-8 Tape Adapter Board -- Cable A Interface Signals

Interface Cable		Adapter Edge Connector	
Signal	Connector (P4)	Connector (J1)	Signal
IFBYG	01	01	IFBYG
IFBY	02	02	IFBY
IW4G	03	05	IW4G
IW4	04	06	IW4
IWOG	05	09	IWOG
IWO	06	10	IWO
IW1G	07	11	IW1G
IW1	08	12	IW1
IREVG	09	17	IREVG
IREV	10	18	IREV
IWPG	11	21	IWPG
IWP	12	22	IWP
IW7G	13	23	IW7G
IW7	14	24	IW7
IW3G	15	25	IW3G
IW3	16	26	IW3
IW6G	17	27	IW6G
IW6	18	28	IW6
IW2G	19	29	IW2G
IW2	20	30	IW2
IW5G	21	31	IW5G
IW5	22	32	IW5
IWRTG	23	33	IWRTG
IWRT	24	34	IWRT
IERASEG	25	39	IERASEG
IERASE	26	40	IERASE
IWFMG	27	41	IWFMG
IWFM	28	42	IWFM
R2G	29	47	R2G
R2	30	48	R2
R3G	31	49	R3G
R3	32	50	R3
ILWDG	33	03	ILWDG
ILWD	34	04	ILWD
IGOG	35	07	IGOG
IGO	36	08	IGO
IREWG	37	19	IREWG
IREW	38	20	IREW
ITADOG	39	45	ITADOG
ITADO	40	46	ITADO
IEDITG	41	37	IEDITG
IEDIT	42	38	IEDIT
	43 through 50	Not called	

Table 1-9 Tape Adapter Board -- Cable B Interface Signals

Interface Cable		Adapter Edge Connector	
Signal	Connector (P3)	Connector (J2)	Signal
IRPG	01	45	IRPG
IRP	02	01	IRP
IR0G	03	25	IR0G
IR0	04	02	IR0
IR1G	05	39	IR1G
IR1	06	03	IR1
ILDPG	07	15	ILDPG
ILDP	08	04	ILDP
IR4G	09	05	IR4G
IR4	10	06	IR4
IR7G	11	07	IR7G
IR7	12	08	IR7
IR6G	13	09	IR6G
IR6	14	10	IR6
IHERG	15	11	IHERG
IHER	16	12	IHER
IFMKG	17	13	IFMKG
IFMK	18	14	IFMK
IFENG	19	17	IFENG
IFEN	20	18	IFEN
IR5G	21	19	IR5G
IR5	22	20	IR5
IRWDG	23	29	IRWDG
IRWDZ	24	30	IRWD
IRSTRG	25	33	IRSTRG
IRSTR	26	34	IRSTR
IWSTRG	27	35	IWSTRG
IWSTR	28	36	IWSTR
IDBYG	29	37	IDBYG
IDBY	30	38	IDBY
ICERG	31	41	ICERG
ICER	32	42	ICER
IFPTG	33	31	IFPTG
IFPT	34	32	IFPT
IRDYG	35	27	IRDYG
IRDY	36	28	IRDY
IRWUG	37	23	IRWUG
IRWU	38	24	IRWU
IEOTG	39	21	IEOTG
IEOT	40	22	IEOT
IDENG	41	39	ISPEEDG
IDEN	42	40	ISPEED
	43 through 50	Not called	

1.3.3.13 Commands. The basic transport commands are derived by decoding the reverse, write, write file mark, edit, and erase interface lines. When the controller issues a command to the transport, the MT3200 asserts the IFBY- line (true state) and performs all timing and control functions necessary for the execution of the command.

The command lines are transferred to the command registers on the trailing edge of the IGO- pulse. Any errors occurring during the execution of the command are reported to the controller via the IHER- or ICER- interface lines. When the IGO- command completes, the IDBY- interface line goes false. When the IDBY- signal goes false, it indicates to the controller that another command can follow. All acceptable combinations of the interface lines are listed in Table 1-8 and Table 1-9. The interface lines used for command decoding are defined as follows:

* Reverse (IREV-). When this level is true, it specifies reverse tape motion. When false, the IREV- line specifies forward tape motion.

* Write (IWRT-). When this level is true, it specifies the write mode of operation. When false, the IWRT- line specifies the read mode of operation.

* Write File Mark (IWFM-). When this level is true and IWRT is also true, a file mark is written on the tape.

* Edit (IEDIT-). When this level is true and IWRT is true, the transport operates in the edit mode.

* Erase (IERASE-). When this level is true and IWRT is true, the transport executes an Erase Variable Length command. The transport is conditioned to execute a normal Write command but no data is recorded. A length of tape, defined by ILWD-, is erased. Alternately, if IERASE-, IWRT-, and IWFM- lines are true, the transport is conditioned to perform a Fixed Length Erase command. A fixed length of tape of approximately 101.6 millimeters (4 inches) is erased. When IWRT-, IWFM-, IEDIT-, and IERASE- are true, the transport is conditioned to perform a security erase operation. A length of tape, from the point where the command was issued to 1.52 meters (5 feet) beyond EOT, is erased.

The following commands can be executed by the MT3200. These commands are strobed by IGO-.

<u>Read</u>. The MT3200 reads data records or file marks in either a forward or reverse direction and generates output data (eight data lines plus parity) and read data strobes to the controller. A read forward operation is terminated if it occurs more than 4.57 meters (15 feet) beyond EOT. This prevents further transport operation, which could cause the tape to run off the supply reel.

A read reverse operation into loadpoint clears the formatter. The recovery threshold is automatically lowered during a read operation to provide additional reliability. The write threshold is nominally 25 percent, while the read threshold is set at an approximate 10 percent level for normal operation. If a read error is detected, a read-retry sequence is automatically initiated, transparent to the host. During the resulting retry sequence, the read threshold is lowered further (approximately an additional 2 percent for each successive retry) until a maximum of four retries have been attempted. IHER- is issued to the interface after four unsuccessful retry attempts.

Space (Forward and Reverse). This operation is identical to a standard Read command, except that read strobe and error flags are not generated. This command moves one record either in the forward or the reverse direction.

File Search. This command initiates a space operation in either the forward or the reverse direction. The read data lines can be deactivated during a file search operation, thereby ignoring any data that is written on the tape. The File Search command is terminated when:

* A file mark is encountered

* Load point is encountered in a reverse direction

* The formatter is externally cleared

* The tape is past EOT by 4.57 meters (15 feet) or more

Write (Forward Only). The MT3200 starts the tape and generates the proper delay before transferring the data character, which ensures the generation of ANSI-compatible IRGs and ID bursts for PE. When writing in 1600 bpi mode from load point, the tape drive always generates the required PE ID burst. When IDBY- goes true, it indicates that the first write strobe (IWSTR) occurs no sooner than 40 character intervals later. The write operation continues until last word (ILWD) is received by the transport, which indicates the last character in the data block.

True write operations (not erase) generate an automatic read verification with the signals activated as in read commands, except that signal thresholds are higher (25 percent). If the read-after-write verification operation detects a write error on the tape, an automatic write-retry sequence is initiated. The block in error plus an additional 5.08 millimeters (0.2 inches) of tape is erased and the record is rewritten. This procedure is repeated for 16 retries (transparent to the host) until the record is successfully written without error. At this time IHER- is issued, tape motion stops, and error code 11 or 21 is displayed on the front panel. Refer to paragraph 4.3.3.10 for more information.

The following are two variations of the basic write operation:

* Edit. This signal is identical to the basic write operation except that erase and write head currents are sequenced to overlap the record being rewritten. Precede this operation with a Read Reverse or Read Reverse Edit command to position the head in front of the block being edited. To ensure proper gap spacing, do not edit a block more than three times.

* Write File Mark. This signal generates the compatible file mark and produces a 101.6-millimeter (4-inch) IRG. The read file mark circuitry is activated. If a file mark status is not returned, the file mark must be backspaced and rewritten. File mark identification is reliable since it is recovered by means of majority gating. All required and optional tracks are written with 80 transitions (40 characters) of zeroes. Channels 1, 3, and 4 are dc erased.

<u>Erase</u>. This signal produces an erase field at the head with no data flux transitions. There are three variations to this command, as follows:

* Erase Fixed Length. Erases a fixed length of tape -- 101.6 millimeters (4 inches).

* Erase Variable Length. Erases continuously until terminated by the controller. Length is determined by the last character flag used in a normal write operation.

* Security Erase. Erases forward to EOT and 1.52 meters (five feet) beyond. No status lines are activated; other transports can be selected while a Security Erase occurs. It is not necessary to wait for IFBY- to deactivate before selection of another transport, but it is preferable to wait for IDBY- to deactivate. You can instruct the transport to rewind after completion of a Security Erase by issuing a Rewind. The transport indicates an immediate rewind status, dropping the IDBY-, IRDY-, and IFBY-, but completes Security Erase and a Rewind automatically. Other transports can be selected and used during execution of these commands.

<u>Write Sychronize</u>. This command is used to ensure that all pending writes are complete. Following issuance of this command, IDBY- remains set until the entire contents of the cache are written on tape.

<u>3200 BPI</u>. This command specifies the 3200 bpi mode of operation, if invoked while the tape is at the BOT marker (3200 bpi model only).

<u>1600 BPI</u>. This command specifies the 1600 bpi mode of operation, if invoked while the tape is at the BOT marker.

<u>Read Extended Drive Status</u>. Extended drive status is available to the host in the form of four independently-accessible records containing up to 16 bytes each. Extended status can only be read when the drive is online. To access one of the 16-byte records the host must first issue the Read Extended Status command, which is 00010 = EDIT. The command is accompanied by the usual IGO- pulse. This command places the drive in the extended status mode whereby the drive waits for a second Access command, accompanied by IGO-. This second command, or block access code, selects the appropriate 16-byte block to be transferred to the host as a normal read operation on the R0- through R7- data lines, complete with read strobes. Should you desire more than one record, the Read Extended Status command and IGO- pulse can be reissued and the appropriate block access code asserted on the five command lines, accompanied by the IGO- pulse. The new status block then moves to the interface.

The error history block can be reset to zero if the block access code is 10011.

<u>Write Edit</u>. This command can be used to rewrite an existing data block on tape. The command is 01010 = EDIT, WRITE. The use of this command has certain restrictions. The tape must be positioned at the start of a valid data block via a space reverse or read reverse operation. If this condition is not met, then an illegal command code 7 results. In addition, the block size transferred to replace the old block must not exceed the original block byte count. The block size can be less if the user can ensure that the post-block gap erases any old data. If the newly written block is greater than the old block, fault code 10 results (refer to Table 4-9).

1.4 SYSTEM SPECIFICATIONS

The following paragraphs define the environmental, physical, and power specifications of the WD/MT controller, the WD900 disk drive, and the MT3200 tape unit.

1.4.1 WD/MT TILINE Controller Specifications

Table 1-10 describes the environmental specifications for the WD/MT controller. Table 1-11 describes the power specifications for the WD/MT controller.

Table 1-10. WD/MT Environmental Specifications

Characteristics	Specifications
Temperature:	
Storage	– 40° C to 65° C (– 40° F to 149° F)
Operating	0° C to 50° C (32° F to 122° F) (maximum change of 10° C (50° F) per hour). A minimum of 100 feet-per-minute exhaust velocity, uniformly distributed from 5° C to 65° C (41° F to 149° F) measured at the exhaust.
Humidity:	
Storage	5% to 95% relative
Operating	8% to 80% relative, noncondensing
Altitude:	
Storage	– 305 m to 3048 m (– 1000 ft to 10 000 ft)
Operating	– 305 m to 1982 m (– 1000 ft to 6500 ft)
Shock:	
Operating	5.0 g for 11 milliseconds at a half-sine wave shock impulse on three orthogonal axes
Vibration:	0.5 g from 5 Hz to 250 Hz sine wave

Table 1-11. WD/MT Controller Power Specifications and Heat Dissipation

Operating Voltage	Current
+ 5 volts dc	10 amperes
– 12 volts dc	0.55 amperes

Heat Dissipation
+ 3.22 Btu output/minute

1.4.2 WD900 Specifications

Table 1-12 lists the environmental specifications of the WD900 drive and Table 1-13 lists the physical specifications of the WD900 drive. Table 1-14 lists the ac power specifications of the WD900 drive.

Table 1-12. WD900 Environmental Specifications

Characteristics	Specifications
Temperature:	
Storage	– 40° C to 65° C (– 40° F to 150° F) (maximum change 20° C (68° F) per hour)
Operating	10° C to 40° C (50° F to 104° F) (maximum change 10° C (50° F) per hour)
Humidity:	
Storage	5% to 95% relative humidity (noncondensing)
Operating	15% to 85% relative humidity (maximum change 10% per hour)
Barometric pressure:	105 kilopascal (kPa) to 69 kPa (15.225 psi to 10.005 psi) – 300 m to 3000 m (– 983 ft to 10 000 ft)

Table 1-13. WD900 Physical Specifications

Characteristics	Specifications
Size (drive only):	
Height	26.0 cm (10.2 in)
Width	21.5 cm (8.5 in)
Length	138M-byte — 76.96 cm (30.3 in) 425M-byte — 76.96 cm (30.3 in)
Weight	138M-byte — 34.5 kg (76.0 lbs) 425M-byte — 39.5 kg (87 lbs)
Recording:	
Total capacity (formatted)	138 megabytes or 425 megabytes
Number of platters	6 (138M-byte) 7 (425M-byte)
Number of recording surfaces	10 (138M-byte) 12 (425M-byte)
Moveable data heads	10 (138M-byte) 24 (425M-byte)
Servo heads	1
Bytes per sector	256
Tracks per inch	551 (138M-byte) 960 (425M-byte)
Physical heads per surface	1 (138M-byte) 2 (425M-byte)
Logical cylinders per head/disk	823 (138M-byte) 711 × 2 (425M-byte)
Latency:*	
Average	8.33 milliseconds at 3600 rpm disk rotation
Maximum	16.83 milliseconds at 3564 rpm disk rotation
Recording:	
Mode	2-7 run length limited (RLL) code
Density (inner track)	9492 bpi (138M-byte) 15 159 bpi (425M-byte)

Note:

* Latency is the time it takes to reach a particular track address after positioning is complete.

Table 1-13. WD900 Physical Specifications (Continued)

Characteristics	Specifications
Seek Time:	
Full	55 milliseconds maximum (138M-byte) 45 milliseconds maximum (425M-byte)
Average	30 milliseconds (138M-byte) 20 milliseconds (425M-byte)
Single track	7 milliseconds maximum (138M-byte) 5 milliseconds maximum (425M-byte)
Reliability:	
Recoverable read errors	1 in 10 E10 bits read
Nonrecoverable read errors	1 in 10 E12 bits read
Positioning error rate	1 in 10 E6 seeks
Transfer Rate:	
Disk speed (3600 rpm)	9.677 MHz (138M-byte) (1 209 625 bytes per second) 14.52 MHz (425M-byte) (1 814 438 bytes per second)
Start time	30 seconds maximum
Stop time	15 seconds maximum (138M-byte) 45 seconds maximum (425M-byte)

Table 1-14. WD900 AC Power Specifications

Drive Type	Volts	Frequency	Amperes Operating	Startup Amperes	Power	Heat Disspation
425M-byte	87-128	48-62 Hz	3.4 A max.	8 A max. for 16 s	260 W	14.8 Btu/hr
425M-byte	179-256	48-62 Hz	2.1 A max.	6 A max. for 16 s	252 W	14.3 Btu/hr
138M-byte	87-128	48-62 Hz	2.8 A max.	5 A max. for 9 s	244 W	13.9 Btu/hr
138M-byte	179-256	48-62 Hz	1.6 A max.	3 A max. for 9 s	236 W	13.4 Btu/hr

1.4.3 MT3200 Specifications

Table 1-15, Table 1-16, and Table 1-17 contain the environmental and physical specifications for the MT3200.

Table 1-15. MT3200 Environmental Specifications

Characteristics	Specifications
Temperature:	
Storage	– 40° C to 65°C (– 40°F to 149°F) (maximum change 15°C (59°F) per hour)
Operating	10°C to 40°C (50° F to 104°F) (maximum change 10°C (50°F) per hour)
Humidity:	
Storage	5% to 95% relative humidity (noncondensing)
Operating	15% to 85% relative humidity (maximum change 10% per hour)
Altitude:	
Storage	– 300 m to 10 000 m (– 983 ft to 32 800 ft)
Operating	– 300 m to 3 000 m (– 983 ft to 10 000 ft)

Table 1-15. MT3200 Environmental Specifications (Continued)

Characteristics	Specifications
Vibration (Storage):	
Frequency	20 Hz to 500 Hz
Peak Acceleration	2.0 g to 3.5 g
Application	Each direction on three orthogonal axes
Vibration (Operating):	
Frequency	Sine wave from 5 Hz to 250 Hz
Peak Acceleration	1.0 g
Application	Each direction on three orthogonal axes
Shock (Storage):	
Peak Acceleration	25.0 g
Duration	11 milliseconds
Waveshape	One-half sine wave
Application	Each direction on three orthogonal axes
Shock (Operating):	
Peak Acceleration	5.0 g
Duration	11 milliseconds
Waveshape	One-half sine wave
Application	Each direction on three orthogonal axes
Pollutants	
Dust	60 milligrams per 1000 cu ft of air by weight of particles (5 micron diameter)

Table 1-16. MT3200 Physical Specifications

Characteristics	Specifications
Size:	
Height	22.2 cm (8.75 in)
Width	48.26 cm (19.0 in)
Length	62.23 cm (24.5 in)
Weight	37.65 kg (82 lbs)
Recording:	
Method	PE
Tracks	8 data and 1 parity
Density	1600 bpi 3200 bpi (optional)
Velocity	100 inches per second (1600 bpi) 50 inches per second (3200 bpi)
Rewind velocity	225 inches per second (10.5-inch reel)
Character rate	72 kilobytes per second (kps) to 384 kps (switch selectable)
Reel size	Maximum diameter of 26.7 cm (10.5 in)
Tape	Tape width of 12.7 mm (0.5 in); constraints as per ANSI X3.40 — 1976 Tape length of 73 m (2400 ft)
Tape tension	7 ounces nominal

Table 1-17. MT3200 Power Requirements

Voltage	Frequency	Startup Current	Operating Current	Operating Surge Current	Watts	Heat Dissipation
120 +10% −15%	49-61 Hz	< 40 A	1.7 A	< 5 A	220 W	12.52 Btu/hr
220v/240v ±10%	49-61 Hz	< 20 A	0.85 A	< 5 A	220 W	12.52 Btu/hr

Section 2

Installation

2.1 INTRODUCTION

This section supplies preparation, unpacking, mounting, and cabling information needed to install a WD900 disk drive and MT3200 tape unit at your site. If your units are part of a complete Texas Instruments computing system, refer to the system installation instructions. Much of the work described in this manual is already done for you in a standard TI system.

2.2 SITE REQUIREMENTS

A computer site must provide the electrical power, environmental control, and mounting space the units require for proper operation.

2.2.1 WD900 Site Requirements

Refer to the WD900 specifications in Section 1 for a summary of the site requirements. If the WD900 is installed with other TI equipment, more stringent environmental limits may be required as described in your system's site preparation manual.

2.2.1.1 Electrical Power Connectors and Cord Sets. A low-voltage version of the WD900 disk drive can operate on any ac voltage in the range from 87 to 128 volts (48 to 62 Hz) without adjustment. A high-voltage version (nominal 220-240 volts) operates on any ac voltage between 179 and 254 volts (48 to 62 Hz), also without adjustment.

2.2.1.2 Electrical Power Distribution and Grounding. Voltage irregularities and noise on ac power lines can cause errors in computer operation. In order to minimize line noise pickup, provide a dedicated ac power circuit for your WD900 disk drive and any related computer equipment. This power circuit must be routed away from large switching devices, motors, welders, and other sources of induction fields. Copiers, electric typewriters, and other office machines can also generate electrical noise.

If you are installing the WD900 disk drive as part of a standard Texas Instruments computing system, the accompanying site preparation manual describes any special power distribution or grounding requirements. Any power circuit must meet the safety and good practice standards of the regulatory agencies having jurisdiction at your site.

2.2.1.3 Environmental Requirements. WD900 environmental requirements include limits or minimums for air temperature, air flow, humidity, and airborne dust.

Although the WD900 drive is rated for a wide range of operating temperatures and humidities, longest life and best reliability are obtained at about 22 degrees centigrade (72 degrees Fahrenheit) and 50 percent relative humidity. This operating point coincides with the comfort range setting of most office air-conditioning systems.

The WD900 drive does not require conditioned air for cooling. Room-temperature air is pulled in through the front panel (refer to Section 1 for air flow direction) and warmed air is forced out the rear by the exhaust fan. However, if the computer is installed in a restricted space or unventilated cabinet, the internal temperature can build up, reducing component life and leading to increased maintenance costs.

Low humidity promotes static charge and dust build-up. Static charges can cause operating faults or destroy some semiconductor devices. Refer to Section 1 to determine the minimum and maximum humidity for reliable operation.

Excessive dust can clog the intake air filters and reduce cooling efficiency. You must clean or change the intake air filter regularly to prevent clogging and overheating.

2.2.1.4 Space Requirements. Space requirements include the mounting space for the drive and the access space needed to operate and maintain the drive.

The WD900 disk drive mounts in a standard 483-millimeter (19-inch) wide Electronic Industries Association (EIA) cabinet, often called a rack or pedestal. Cabinets are available commercially or from Texas Instruments. The WD900 138-megabyte drive occupies 311 millimeters (12.25 inches) of front panel height and 752 millimeters (29.7 inches) of depth behind the front panel. The WD900 425-megabyte drive occupies 311 millimeters (12.25 inches) of front panel height and 780 millimeters (30.6 inches) of depth behind the front panel.

CAUTION

> Failure to provide adequate cabinet ventilation or exhaust air clearance can lead to overheating, reduced equipment life, and unnecessary service calls.

Allow a 25-millimeter (approximately 1-inch) minimum clearance behind the chassis for exhaust air escape. This is an absolute minimum figure; cooling efficiency and reliability are increased with larger exhaust air clearances.

Your cabinet must have enough natural or forced air ventilation for all equipment in the cabinet. Drive exhaust fans are not rated to blow into a sealed cabinet or into high back pressure.

NOTE

> Allow approximately 850 millimeters (33.5 inches) in front of the cabinet for full slide extension and for removing the drive from the slides.

2.2.2 MT3200 Site Requirements

Refer to the MT3200 specifications in Section 1 for a summary of the site requirements. If the MT3200 is installed with other TI equipment, more stringent environmental specifications may be required as described in your system's site preparation manual.

2.2.2.1 Electrical Power Connectors and Cord Sets. A low-voltage version of the MT3200 tape drive can operate on any ac voltage in the range 102 to 132 volts (49 to 61 Hz) without adjustment. A high-voltage version (nominal 220-240 volts) operates on any ac voltage between 179 and 254 volts (49 to 61 Hz), also without adjustment.

2.2.2.2 Electrical Power Distribution and Grounding. Voltage irregularities and noise on ac power lines can cause errors in computer operation. In order to minimize line noise pickup, provide a dedicated ac power circuit for your MT3200 tape unit and any related computer equipment. This power circuit must be routed away from large switching devices, motors, welders, and other sources of induction fields. Copiers, electric typewriters, and other office machines can also generate electrical noise.

If you are installing the MT3200 tape as part of a standard Texas Instruments computing system, the accompanying site preparation manual describes any special power distribution or grounding requirements. These requirements come from the additional computing equipment, not from the MT3200 unit. Any power circuit must meet the safety and good practice standards of the regulatory agencies having jurisdiction at your site.

2.2.2.3 Environmental Requirements. The MT3200 environmental requirements include limits or minimums for air temperature, humidity, and shock and vibration.

NOTE

Environmental specifications represent worst-case conditions as determined by the most sensitive component in the storage system.

Although the MT3200 unit is rated for a wide range of operating temperatures and humidities, longest life and best reliability are obtained at about 22 degrees centigrade (72 degrees Fahrenheit) and 50 percent relative humidity. This operating point coincides with the comfort range setting of most office air-conditioning systems.

The MT3200 tape unit does not require conditioned air for cooling. Room temperature air is pulled in through the front panel and warmed air is forced out the rear. However, if the computer is installed in a restricted space or unventilated cabinet, the internal temperature can build up, reducing component life and leading to increased maintenance costs.

CAUTION

Failure to provide adequate cabinet ventilation or exhaust air clearance can lead to overheating, reduced equipment life, and unnecessary service calls.

Low humidity promotes static charge and dust build-up. Static charges can cause operating faults, or tape loading failures, or destroy some semiconductor devices.

Excessive dust can clog the intake air filters and reduce cooling efficiency. You must clean or change the intake air filter regularly to prevent clogging and overheating. Section 4 includes a sample schedule for these preventive maintenance operations.

2.2.2.4 Space Requirements. Space requirements include the mounting space for the tape and the access space needed to operate and maintain the unit.

An MT3200 tape unit mounts on a 1.07-meter (42-inch) pedestal or in a 1.52-meter (60-inch) rack, 483-millimeter (19-inch) standard EIA cabinet. An MT3200 tape unit occupies 262 millimeters (10.32 inches) of front panel height and 698.5 millimeters (27.5 inches) of depth including the cable interface board.

NOTE

> To mount the tape on slides, allow approximately 750 millimeters (29.5 inches) in front of the cabinet for full slide extension and for removing the chassis from the slides.

2.3 UNPACKING

The WD900 drive is shipped in one of three ways: as an individual unit (for instance, as a replacement chassis), as part of a complete computer system, or as part of a subsystem (computer not supplied).

The MT3200 chassis is always shipped in an separate container even when ordered as part of a system. The mounting hardware is the only difference.

The following paragraphs describe unpacking procedures for units that are shipped in separate containers.

2.3.1 Unpacking the WD900

Figure 2-1 illustrates the individual unit container. When the unit is shipped as part of a complete system, the container can differ. The interconnecting cables and mounting hardware are packed either with the unit or with the computer. The shipping configurations differ in certain other respects; for example, the top of the container is indicated either by a label or by arrows on the sides that point to the top.

Inspect the shipping container for evidence of damage. If the container looks damaged, do not start the unpacking procedure. Get in touch with the carrier and report the damage. If the container passes preliminary inspection, then perform the following procedure.

WARNING

Have all personnel stand clear while steel straps are being cut to avoid injury from the flying loose ends of the straps.

1. Open the package (save all packaging materials).

2. Make a visual inspection and a parts inventory. If the unit appears damaged or if parts are missing, get in touch with the TI sales and service office.

3. Remove the packages containing the two slide mounts and the slide mount hardware kit.

4. Remove the package containing the ac power cable.

5. Remove the plastic dust cover from around the drive and power supply.

2.3.1.1 WD900 Installation in an EIA Cabinet. The following paragraphs supply the mounting and cabling information needed to install a WD900 drive in a 1.52-meter (60-inch) rack. If your drive is part of a complete Texas Instruments computing system, refer to the system installation instructions. Much of the work described in this section is already done for you in a standard TI system.

Use the supplied slide kit to install the drive. This kit includes left and right telescoping slides. Small mounting hardware items (screws and washers) are also included.

Drive installation consists of five operations:

1. Installing the drive shelf

2. Installing the slide assembly

3. Attaching the chassis-mount plate to the bottom of the drive

4. Attaching the cable clamp

5. Installing the front panel trim kit

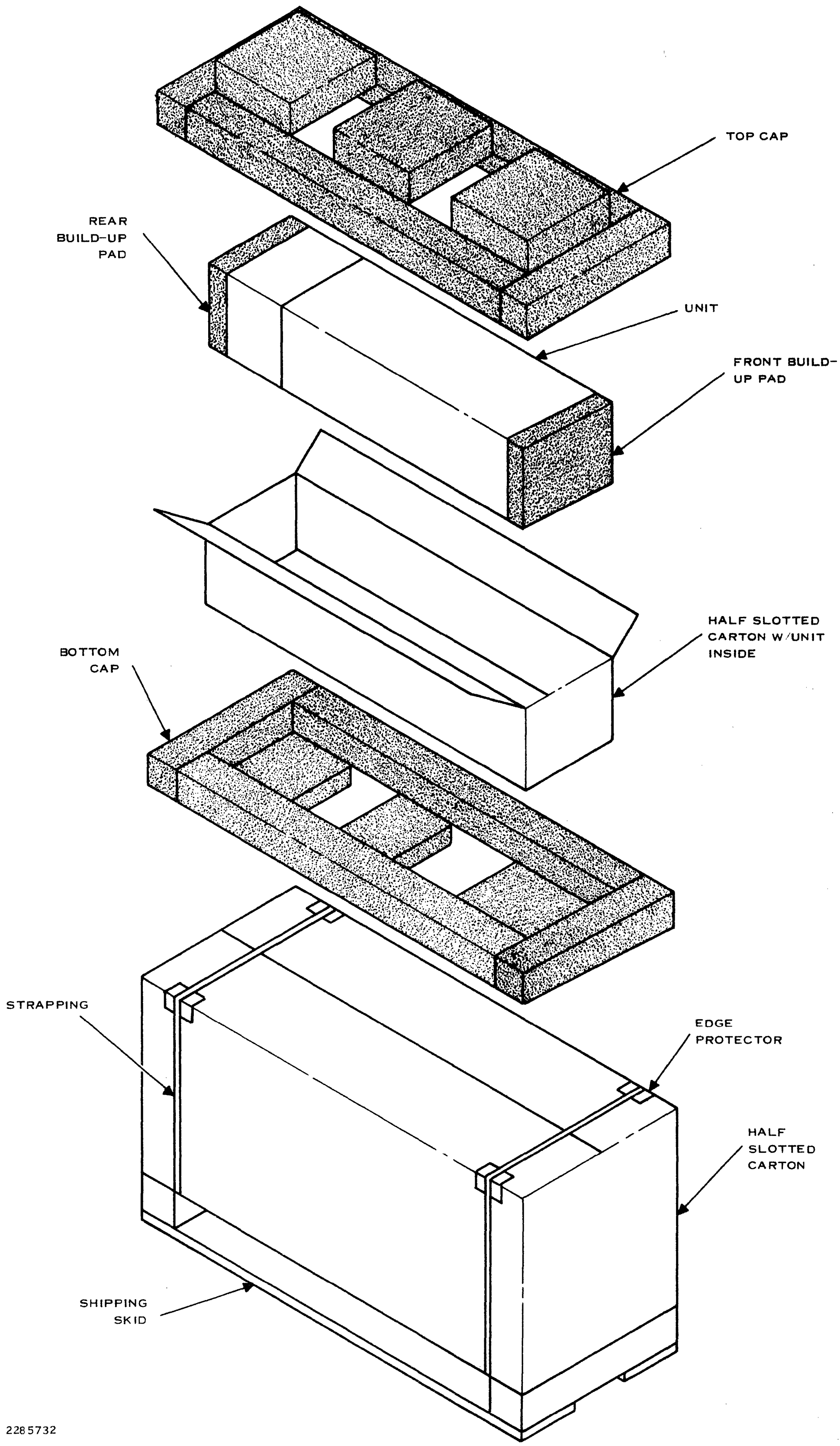

Figure 2-1 WD900 Chassis -- Individual Container

Using standard hand tools, prepare the drive for installation as follows:

<u>WD900 Shelf Installation in an EIA Standard Cabinet</u>.

1. The center shelf (Figure 2-2) is 711 millimeters (28 inches) in length and is designed to fit on the inside of the EIA cabinet rails. Move the cabinet rear rails if the spacing is not the required 711 millimeters.

   The drive cables are part of the drive shelf kit and are installed at the factory.

2. Determine where you want to locate the bottom edge of the lower trim panel, as shown in Figure 2-3.

   Make a reference mark between a set of holes with narrow spacing. By EIA standards, this mark is not centered but is 6.86 millimeters (0.27 inches) below the centerline of the upper hole. After installation, the drive and trim panels will occupy the next 311 millimeters (12.25 inches) above the reference mark.

   Use a level or straight edge to locate the corresponding points on the rear rails.

3. Locate the shelf mounting holes in the cabinet rails. Count the first hole above your reference mark as hole 1, with holes 2 and 3 as the mounting holes.

4. Attach the shelf flanges to the mounting holes on the rails with twelve 10-32, 5/16-inch Phillips-head screws.

NOTE

The Phillips-head screws enter the rails from inside the cabinet so the shelf flanges are properly anchored.

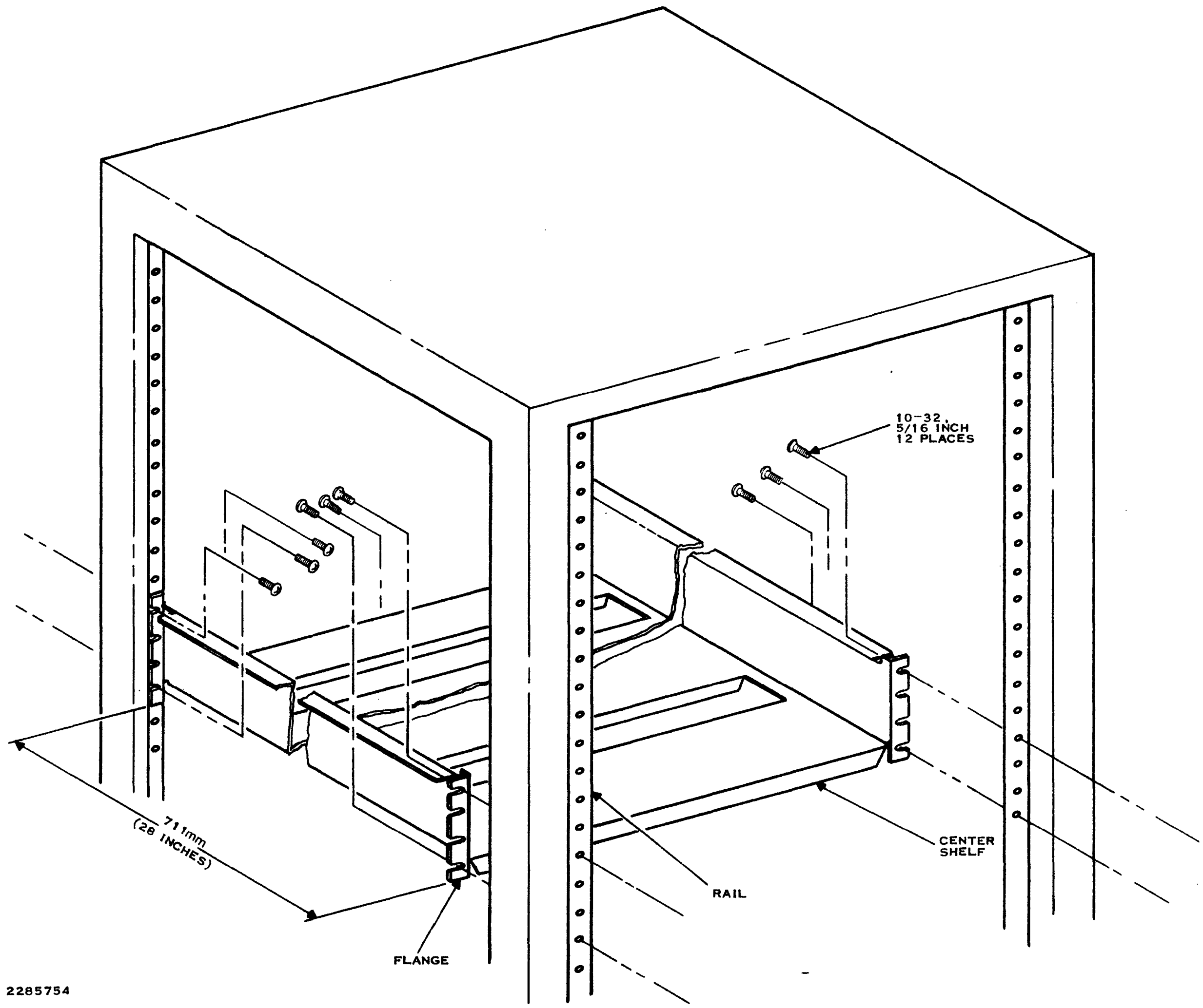

Figure 2-2 WD900 Center Shelf

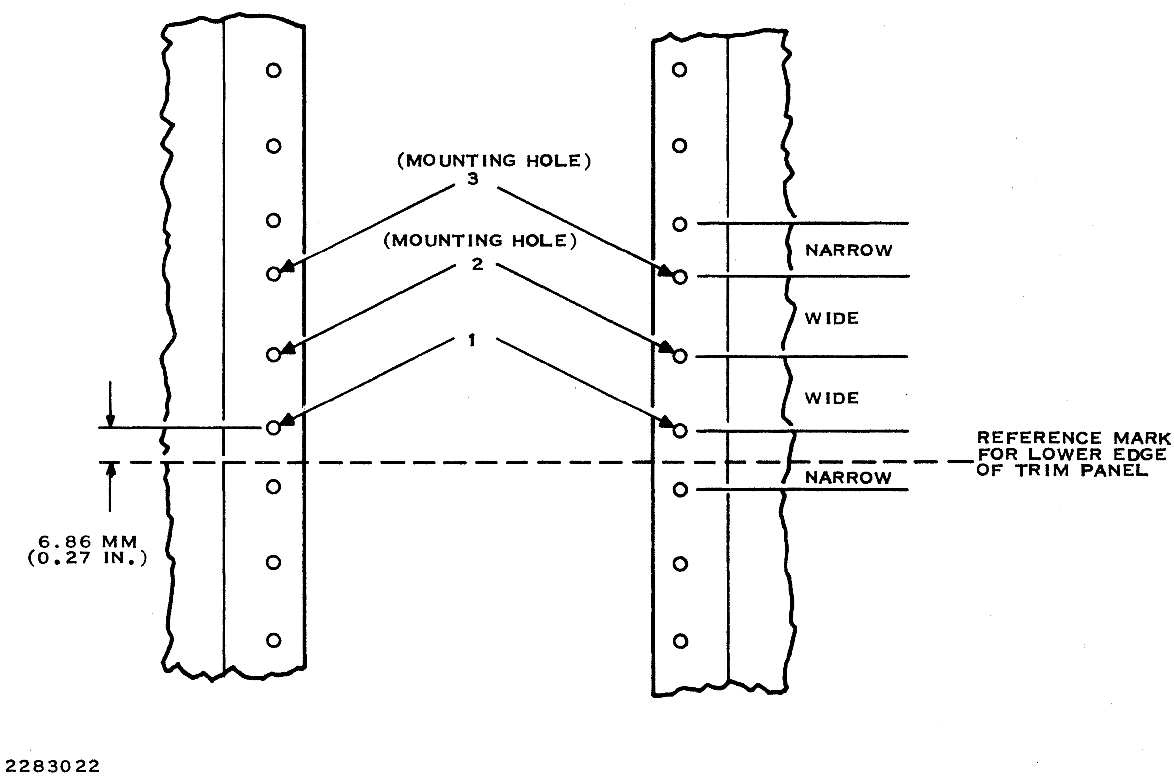

Figure 2-3 EIA Mounting Rails

CAUTION

Make sure that each flange is secured to the inside of the mounting rail. If you assemble the parts in the wrong order the shelf may fail under load.

Refer to Figure 2-4 and mount the slides inside the front and rear mounting rails. The screws enter the rails from inside the chassis.

NOTE

If you do not install the shelf as shown in the detailed view, the chassis front trim panels may not fit properly.

Installing the Slide Kit. The following procedure is already done for the TI Business System 600/800, and the WD900 master kit. Use these instructions if you have a WD900 secondary or add-on kit. Refer to Figure 2-5 for the following installation.

1. Attach both outer slide assemblies to the rear, predrilled holes on the shelf, with four 8-32, 1/8-inch flathead screws.

2. Attach both outer slide assemblies to the front, predrilled holes on the shelf.

   a. Pull the slide forward until the slide predrilled hole aligns with the bracket predrilled hole. Attach the slide assembly to the front of the support bracket (center bracket) with one 8-32, 1/8-inch flathead screw.

   b. Attach the assembly to the front of the outside shelf bracket with two 8-32, 1/8-inch flathead screws.

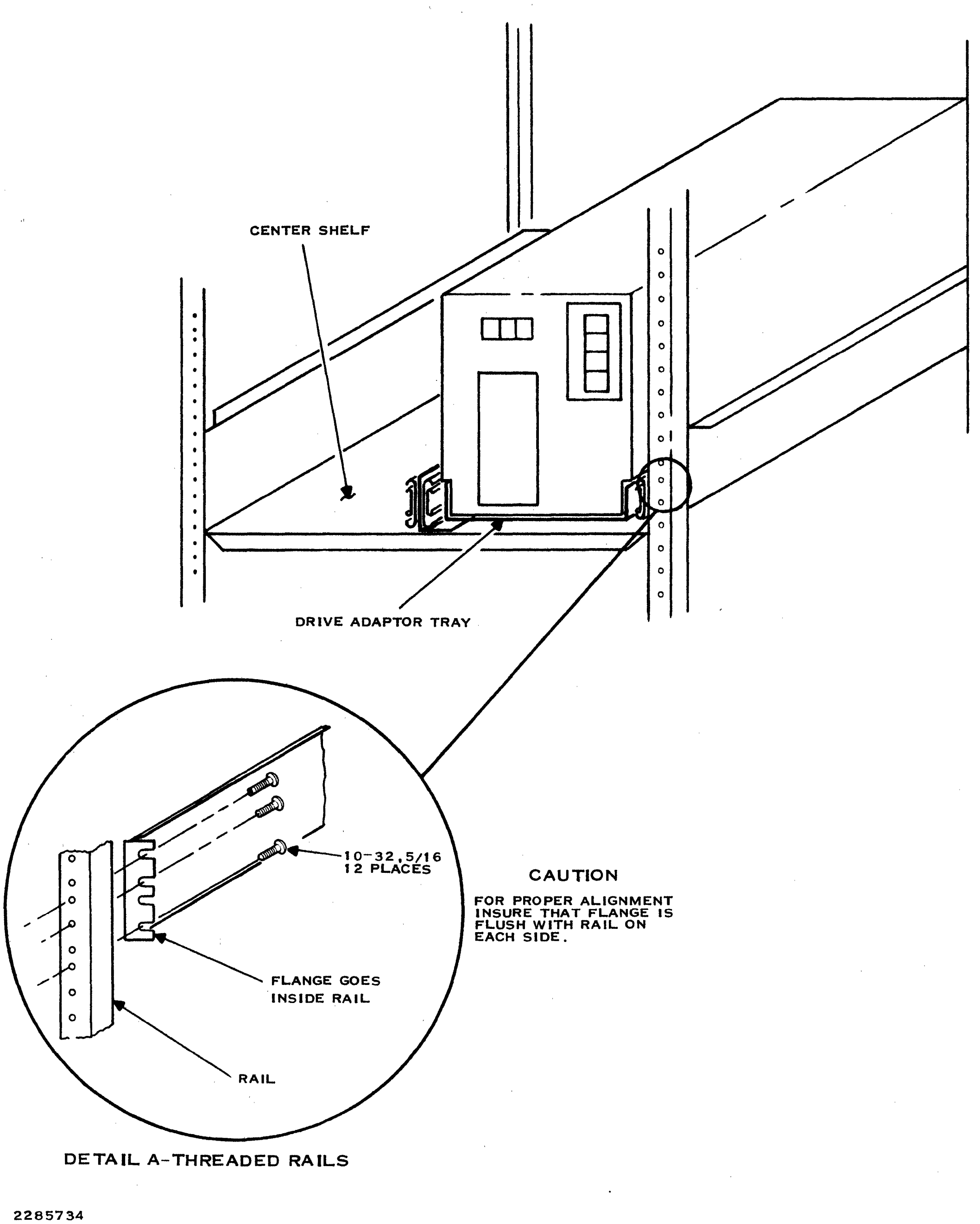

Figure 2-4 Perspective View of Inner Slides and Drive Tray

<u>Drive Tray Installation</u>. Refer to Figure 2-5 for the following procedures.

1. Remove the drive brackets, and save all the hardware except the brackets.

2. Remove the inner slides from the slide kit.

   a. Extend the slides by slightly raising the front of each slide while pulling forward. Release the inner slides by lifting the quick disconnect latches. The quick disconnect latches are on the outside of the slides, about 65 millimeters (2.5 inches) from the junction of the inner slides and the middle slides.

CAUTION

The WD900 weighs as much as 41 kilograms (90 pounds). Use two people to mount the unit in the slides. Be careful when lifting the drive to avoid backstrain or other injury.

3. Turn the drive upside down to attach the drive tray.

4. Position the drive tray over the square plastic inserts on the sides of the drive.

5. Position the inner slide over the holes of the drive tray and drive.

6. Mount the right and left inner slides on the drive. Do this by installing nine 10-16 x 1/2-inch PlasTite(R) (screws for plastic threading) screws through the holes in the inner slide into the plastic inserts previously installed. Figure 2-5 shows the slide and drive tray positioned on the drive.

PlasTite is a registered trademark of the Research Engineering and Manufacturing Company.

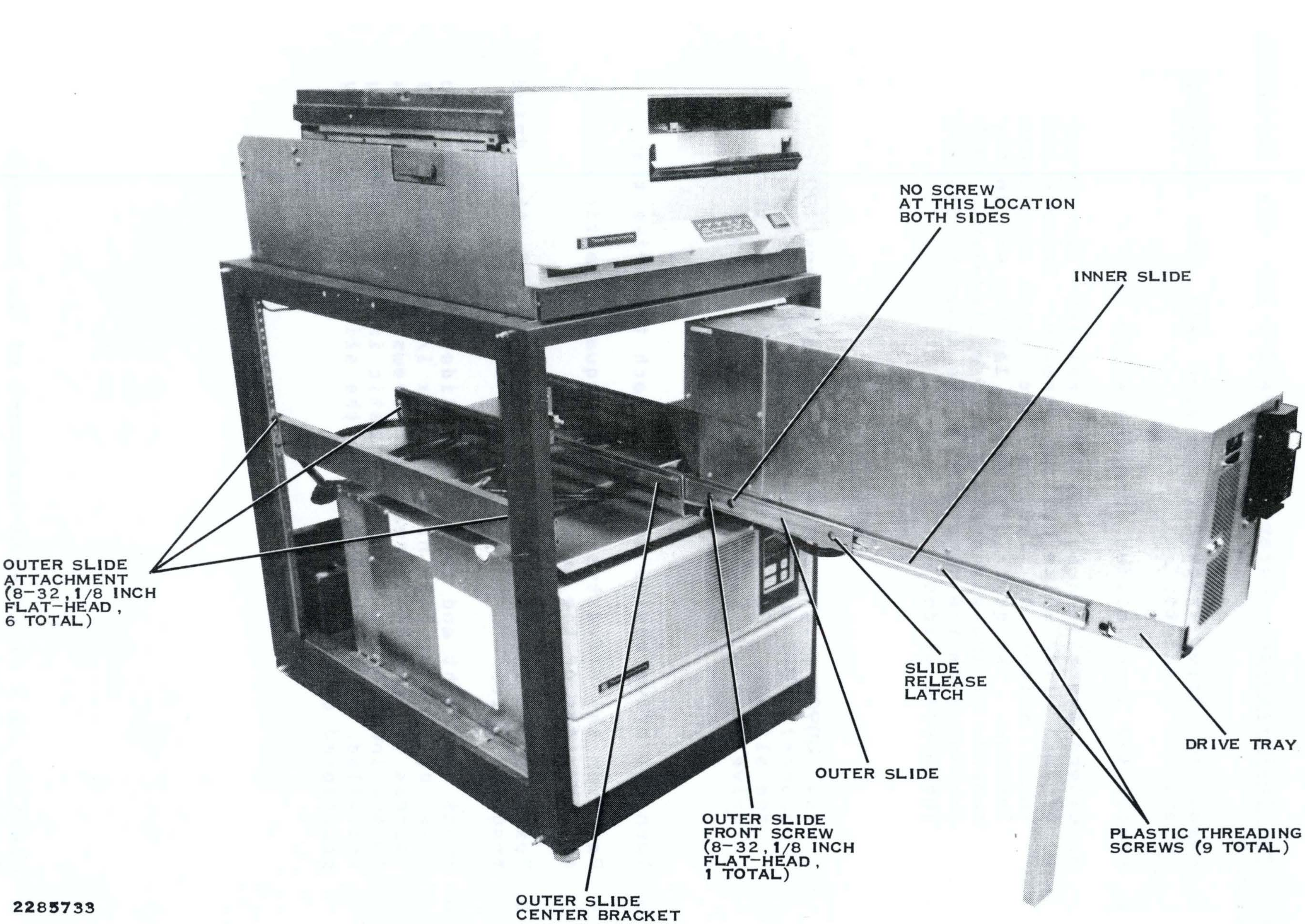

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Figure 2-5 Slide Kit Installation

7. Insert the drive into the extended slides. Work the slides several times to be sure that they operate smoothly, without binding.

NOTE

Do not push the drive into the rack until you install the cable clamp. The cable clamp is installed in the next procedure.

8. Recheck all mounting hardware to ensure that all screws are tight.

<u>Installing the Cable Clamp</u>. Refer to Figure 2-6 when installing the cable clamp.

1. Extend the drive completely (if you have not already done so) and ensure that the support strut is squarely on the floor.

2. Position the cable clamp on the two stand-offs on the bottom of the drive tray and connect with two 10-32, 1/4-inch panhead screws.

CAUTION

Be careful not to pinch the cables between the cable clamp and the drive tray.

3. Attach the I/O cables to the rear of the drive and then attach the strain relief brackets to the 60-pin cables and 26-pin cables.

NOTE

Ensure that the support strut is flush with the underside of the drive tray before pushing the drive into the cabinet (pedestal-mount drives only). Push up the locking strut before folding the strut under the drive.

NOTE

A one-quarter turn, internal wrenching, Turnlok(R) fastener is located on the bottom edge of the drive. You can unlock/lock the drive with a 4-millimeter (5/32-inch) hexagonal key by turning one-quarter turn clockwise to lock or one-quarter turn counter-clockwise to unlock the mechanism. The drive can now be pulled out on its slides until the support strut drops down (pedestal-mount drives only).

4. Lift the quick disconnect latches on the sides of the slides and push the chassis into the cabinet. Work the slides several times to be sure that they operate smoothly without binding or crimping the cables.

Turnlok is a registered trademark of Southco Incorporated.

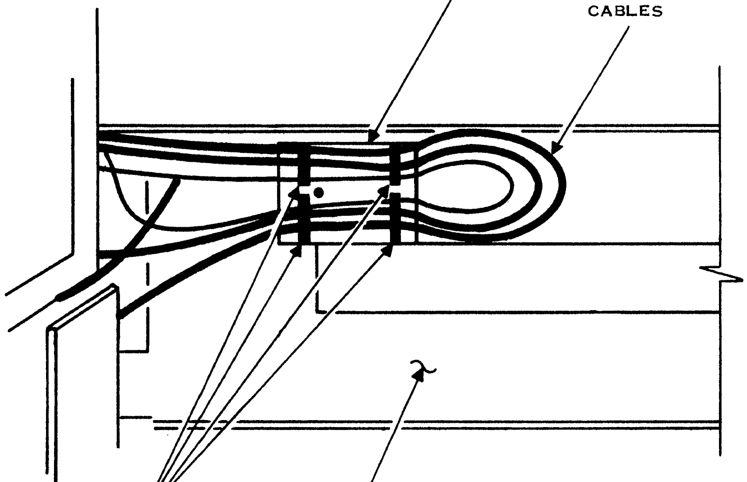

Figure 2-6 Cable Clamp Installation

Installing the Daisy-Chain Cable. If you have a second WD900 drive you must install a 60-pin daisy-chain cable, TI part number 2244787-0003, from J4 of drive 0 to J3 of drive 1 (the terminator connects to J4 of the last drive).

CAUTION

> Always pull the drive out on its slides so that the support brace drops down and is positioned squarely on the floor.

1. Install the WD900 add-on kit slides. Refer to Figure 2-8. Attach both outer slide assemblies to the rear, predrilled holes on the shelf, with four 8-32, 1/8-inch flathead screws.

2. Attach both outer slide assemblies to the front, predrilled holes on the shelf.

   a. Pull the slide forward until the slide predrilled hole aligns with the bracket predrilled hole. Attach the slide assembly to the front of the support bracket (center bracket) with one 8-32, 1/8-inch flathead screw.

   b. Attach the assembly to the front of the outside shelf bracket with two 8-32, 1/8-inch flathead screws.

3. When installing the WD900 add-on kit tray, refer to Figure 2-7. Remove the drive brackets, and save all the hardware except the brackets.

4. Remove the inner slides from the slide kit.

   a. Extend the slides by slightly raising the front of each slide while pulling forward. Release the inner slides by lifting the quick disconnect latches. The quick disconnect latches are on the outside of the slides, about 65 millimeters (2.5 inches) from the junction of the inner slides and the middle slides.

CAUTION

The WD900 weighs as much as 41 kilograms (90 pounds). Use two people to mount the unit in the slides. Be careful when lifting the drive to avoid backstrain or other injury.

5. Turn the drive upside down to attach the drive tray.

6. Position the drive tray over the square plastic inserts on the sides of the drive.

7. Position the inner slide over the holes of the drive tray and drive.

8. Mount the right and left inner slides on the drive. Do this by installing nine 10-16 x 1/2-inch PlasTite (screws for plastic threading) screws through the holes in the inner slide into the plastic inserts previously installed. Figure 2-7 shows the slide and drive tray positioned on the drive.

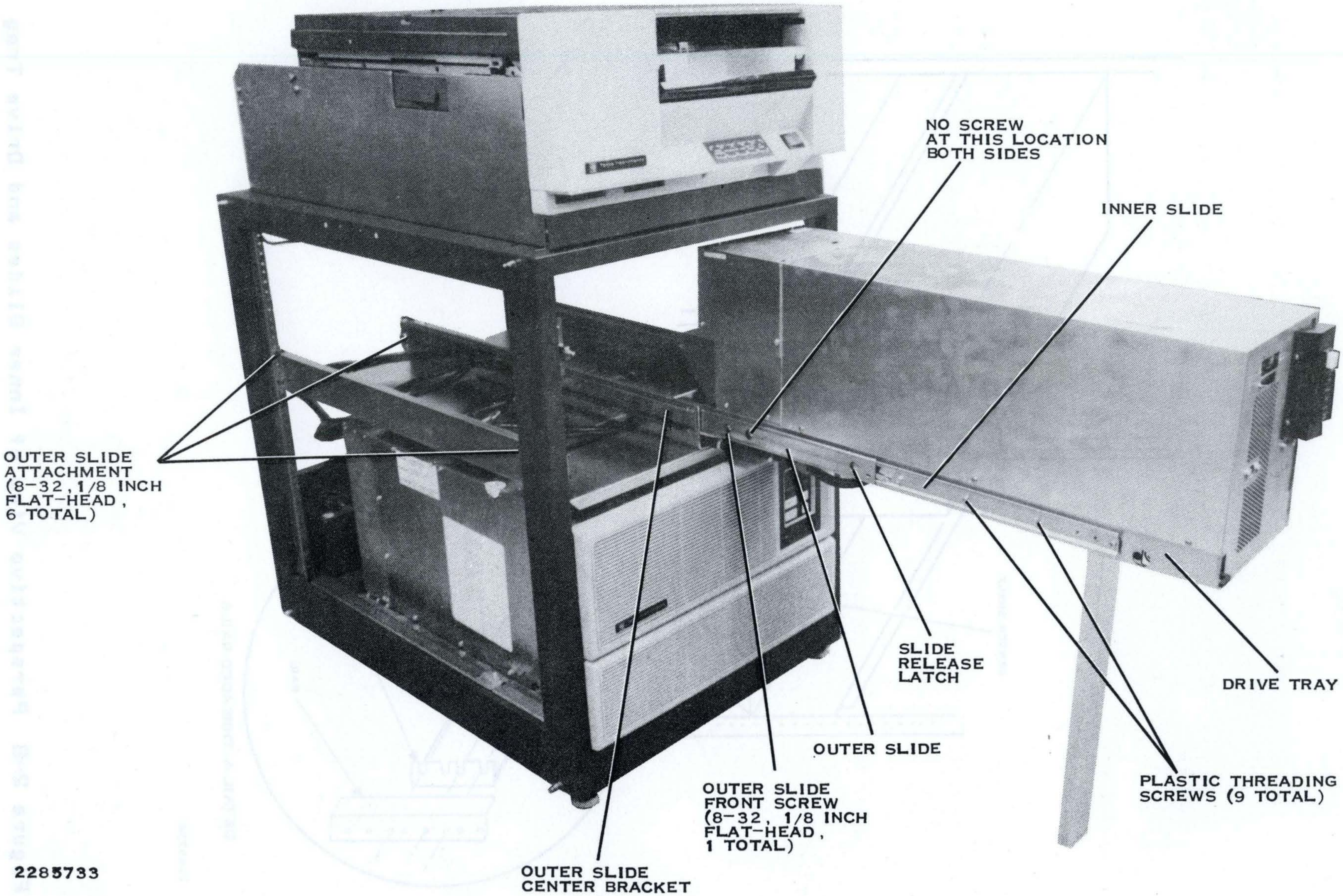

Figure 2-7 Slide Kit Installation

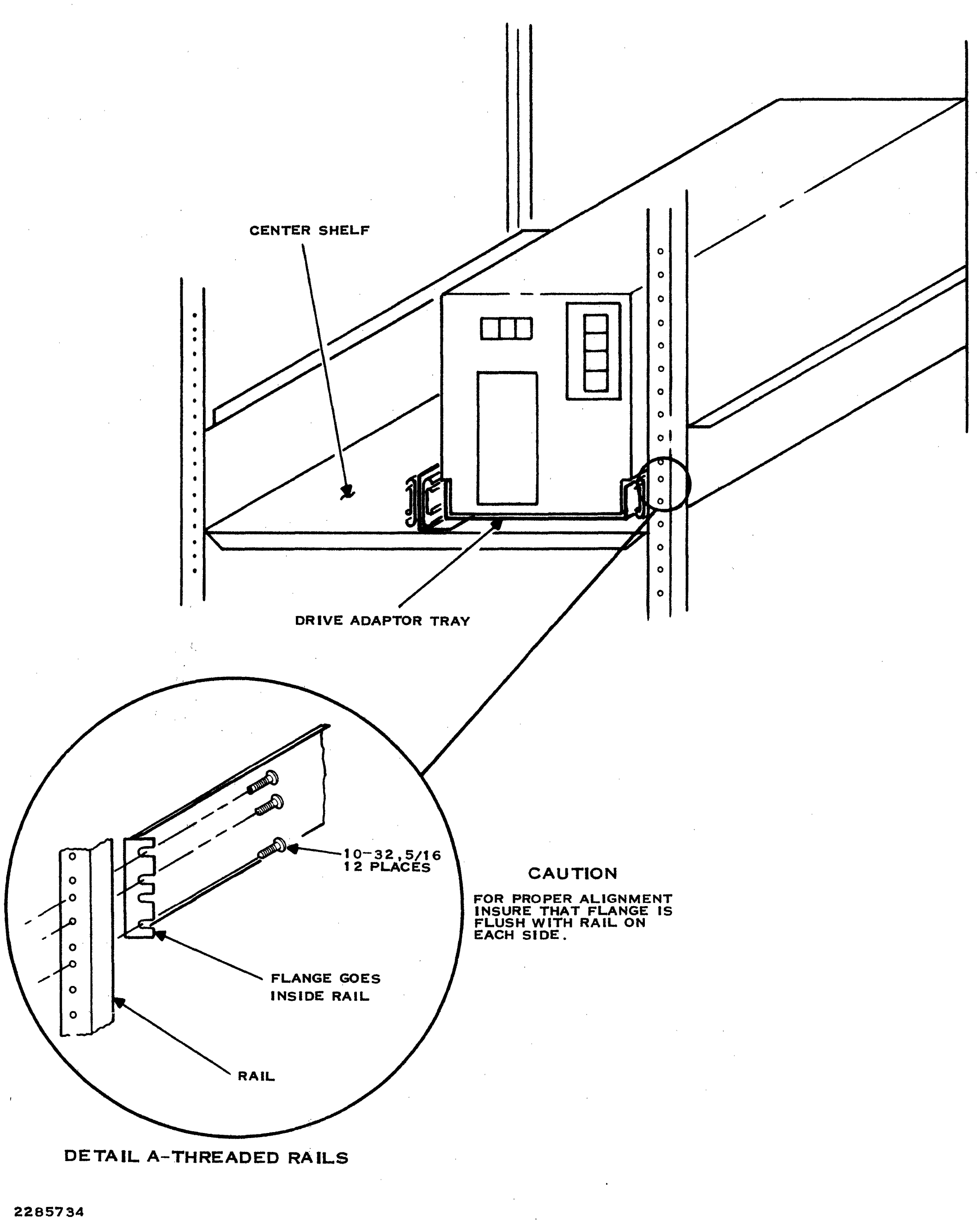

Figure 2-8 Perspective View of Inner Slides and Drive Tray

9. Insert the drive into the extended slides. Work the slides several times to be sure that they operate smoothly, without binding.

NOTE

Do not push the drive into the rack until you install the cable clamp. The cable clamp is installed in the next procedure.

10. Recheck all mounting hardware to ensure that all screws are tight.

11. After completing the installation of the add-on drive, completely extend both drives on their slides.

12. Route the daisy-chain cable along the same path as the cables for the primary drive as shown in Figure 2-9, except that, at the point where the cables are routed through the sheet metal chassis, route the daisy-chain cable into the secondary bay of the chassis along with the secondary branch of the Wye cable.

13. Connect the daisy-chain cable to J3, and the 26-pin Wye cable to J4, and secure with the strain relief clamp (refer to Figure 2-9). Connect the power cord to the add-on drive.

14. The power cable is routed from the secondary bay along the same path as the daisy-chain and Wye cables, then the power cable is routed to the far side of the primary chassis and then to the rear of the chassis along the same path as the primary drive cables.

15. All tie wraps holding the primary unit's cabling in place must be cut and replaced when installing the secondary kit. To ensure proper spacing and to maintain lengths in the cable loop and clamp location, replace the tie wraps one at a time.

16. Tie wraps for attaching the secondary kit cabling in the secondary bay are located like the tie wraps in the primary bay.

17. Ensure that all tie wraps are properly located and that the power cord lies to the inside of the loop prior to tightening the tie wraps.

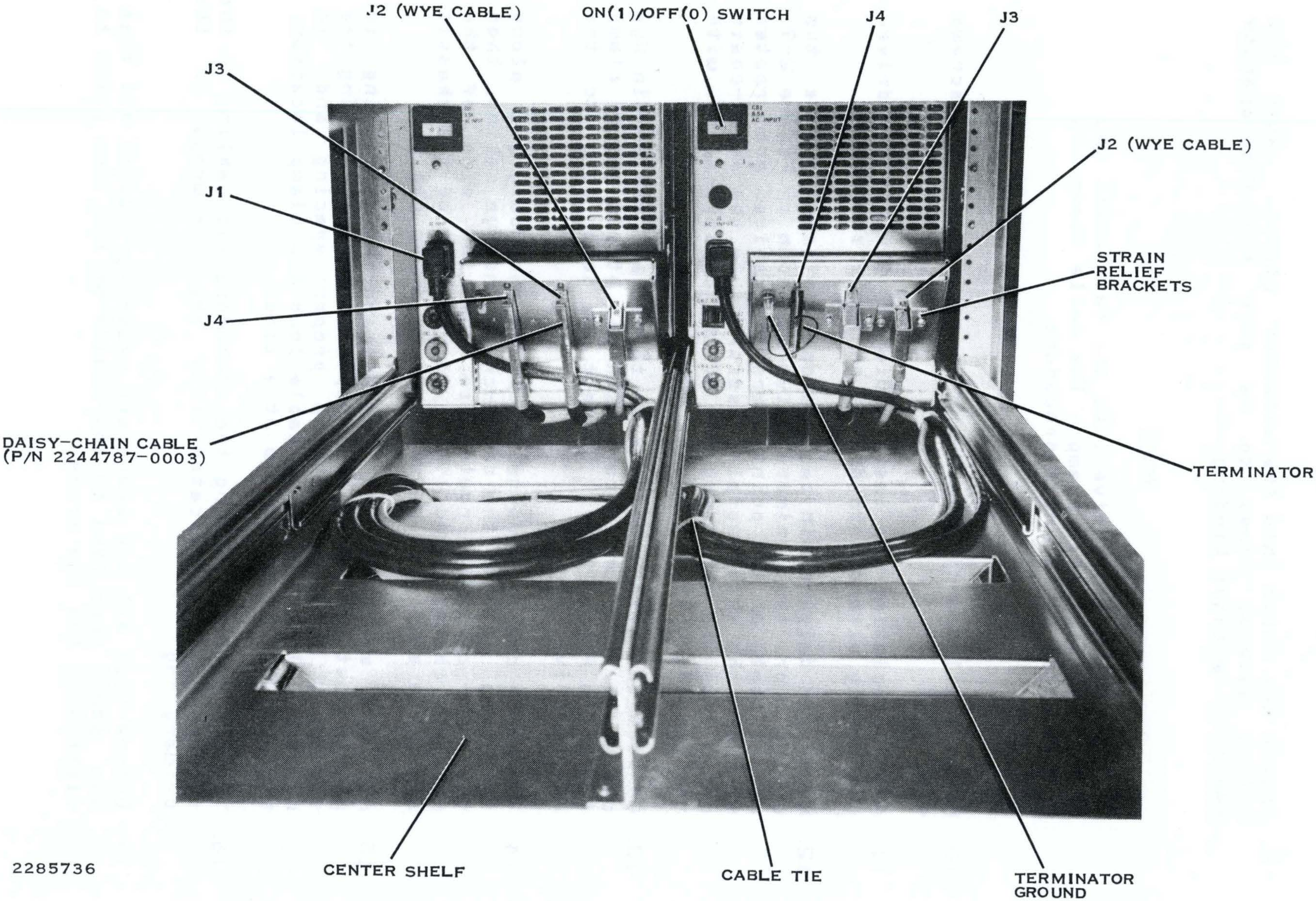

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Figure 2-9 Daisy-Chain Cable

Installing the Front Panel Filter and Trim Kit. To install the front panel trim kit, you must first mount the brackets on the cabinet rails along with the ball stud and receptacle. Refer to Figure 2-10 to install the trim kit and filter.

1. Attach the air filter to the disk drive (refer to Figure 1-10). Use an air filter, TI part number 2244849-0001.

2. Attach the front panel trim kit to coincide with the reference mark on the rails. If they do not coincide, there may be interference with other units installed in the cabinet.

3. You need four types of brackets (a total of six are used) to install the front panel. Refer to Figure 2-10 when installing the brackets. Mount each of the brackets to the cabinet rail with two screws. The screws enter the rail from the front.

   Readjust the vertical position of the slides if necessary to obtain the correct trim panel position.

NOTE

If the switches on the disk drive do not align with the cutout in the front panel, loosen the screws holding the switch unit in position and move the switch unit to align with the cutout in the front panel.

4. Recheck all mounting hardware to ensure that all screws are tight.

5. Attach the air filter with four 8-32 x 1/4-inch screws.

6. Position the receptacles on the underside of the trim panel over the ball studs on the rack, and push firmly into place.

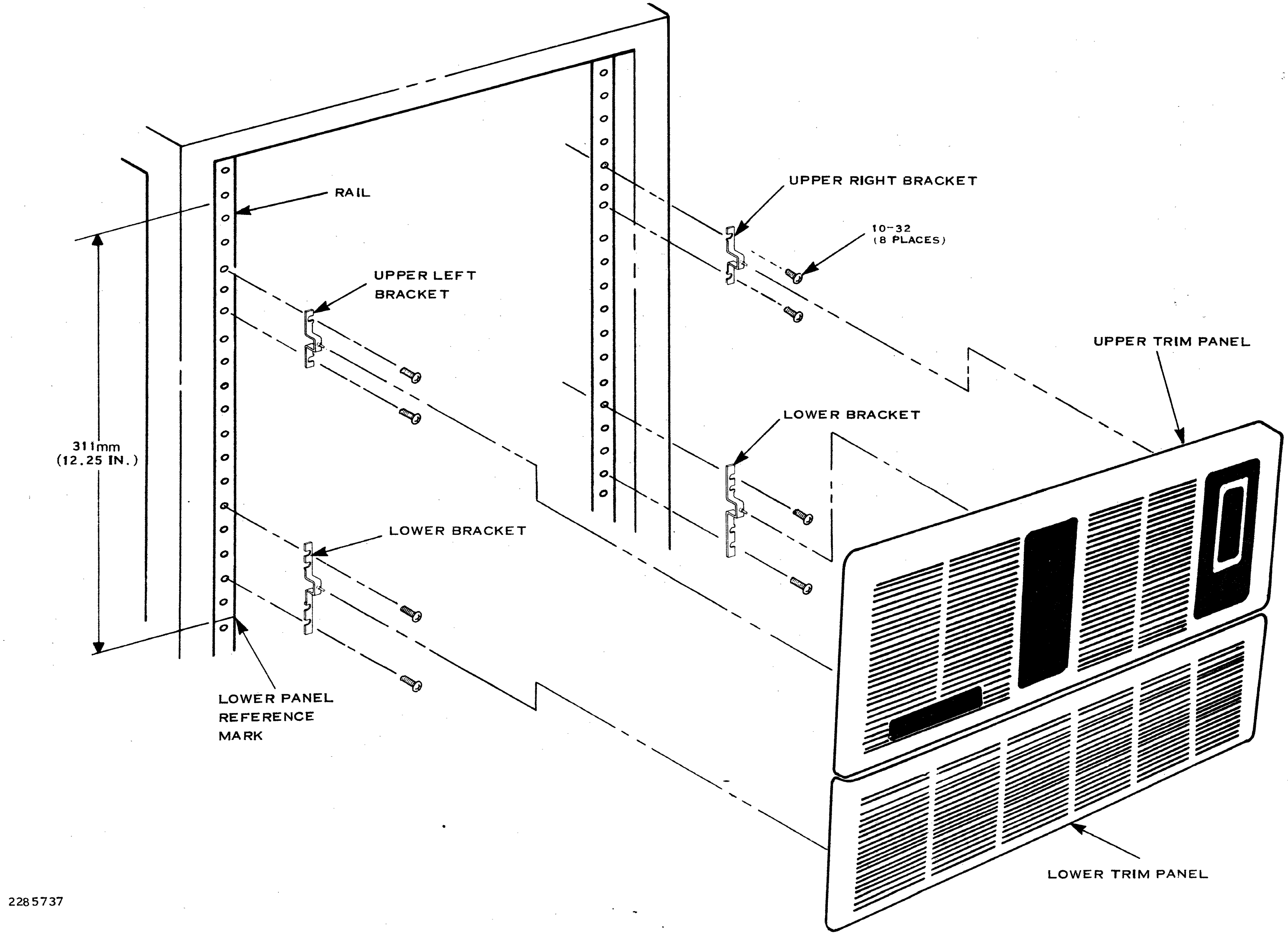

Figure 2-10 Front Panel Trim Kit Installation

2.3.1.2 WD900 Power Cord Installation. The WD900 is available with three types of ac power cords. Refer to Figure 2-11 for the different power cord types and part numbers. The following list describes how to install the WD900 ac power cord.

1. Connect the female end of the ac power cord to the ac cord receptacle on the rear of the WD900 chassis. Route the power cord loosely along the same path as the existing disk interface cables.

NOTE

> There are four partially installed bow tie tie wraps located on the disk interface cables. Use these tie wraps when installing the power cord.

2. Loop the tail of each bow tie tie wrap loosely around the power cord and into the center retainer. Do not tighten the tie wraps at this time.

3. Adjust the length of the power cord coming from the disk drive to conform with the contours of the existing interface cable loop. Ensure that there is enough slack to prevent binding the power cord.

4. Tighten the first bow tie tie wrap.

5. Move around the interface cable loop, adjusting the power cord to conform to the loop, and tighten each bow tie tie wrap in succession.

6. Clip off the excess tail of each tie wrap after tightening to prevent snagging on the sheet metal of the chassis.

7. Plug the other end of the cord into an available ac outlet on the rail.

The chassis is now ready to be powered up.

2.3.1.3 WD900 Voltage Conversion. The WD900 power supply is configured before shipment to operate in one of two ranges of ac input voltages. The equipment label on the power supply indicates the voltage range selected prior to shipment. The voltage range is determined by setting the voltage programming switch, located at the top of the power supply, to the desired range. The ac power cord must also be replaced. Refer to Figure 2-11 for the part numbers of the different ac power cords.

Perform the following to convert the WD900 ac power voltage:

1. Ensure that the ac power cable is disconnected from the power supply.

2. Change the voltage programming switch (located at the top of the power supply) to the new setting.

3. Modify the equipment label to reflect the new ac operating voltage range for the power supply.

4. Replace the existing ac power cable with the ac power cable specified for the new operating voltage.

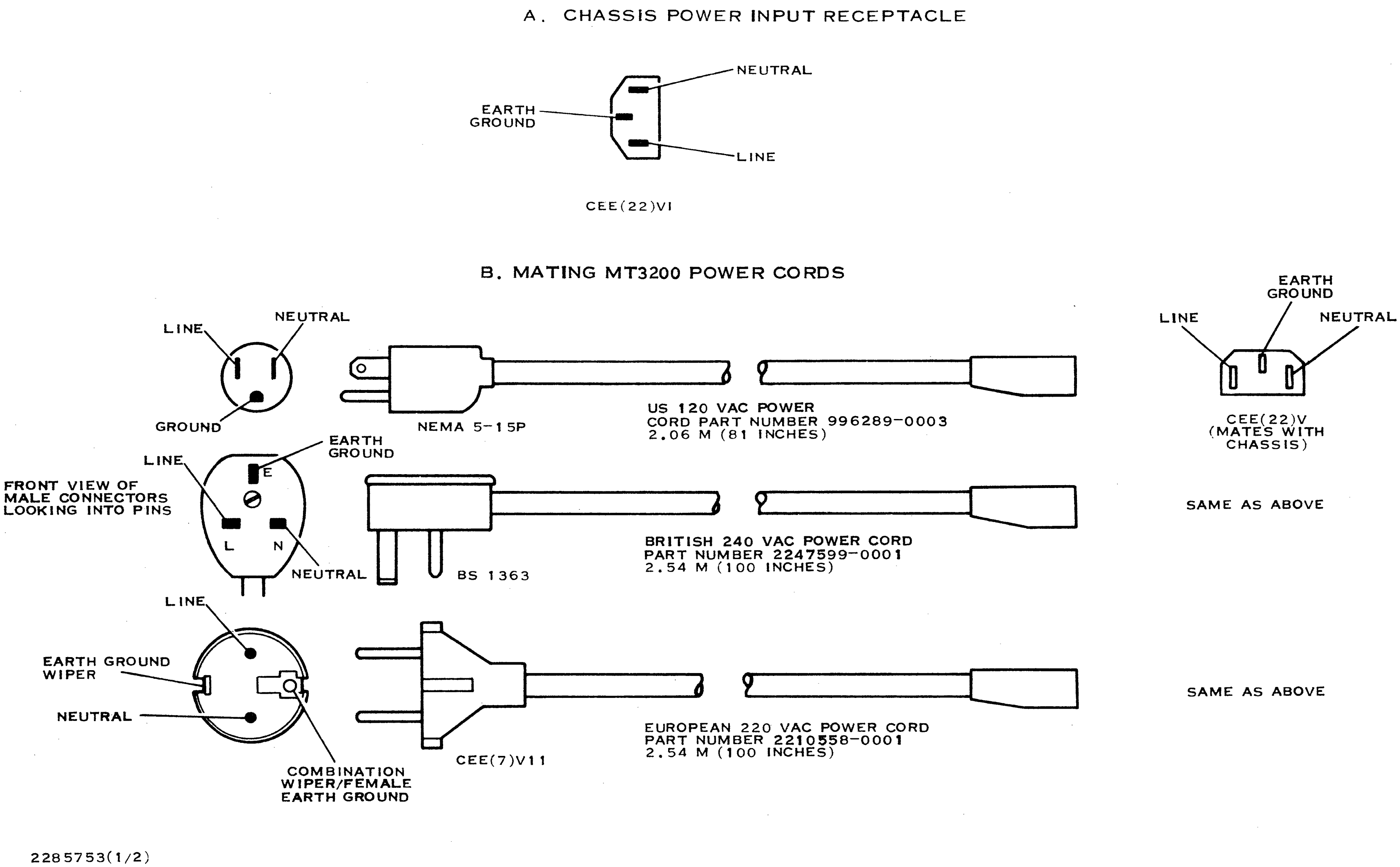

Figure 2-11 AC Power Cables (Sheet 1 of 2)

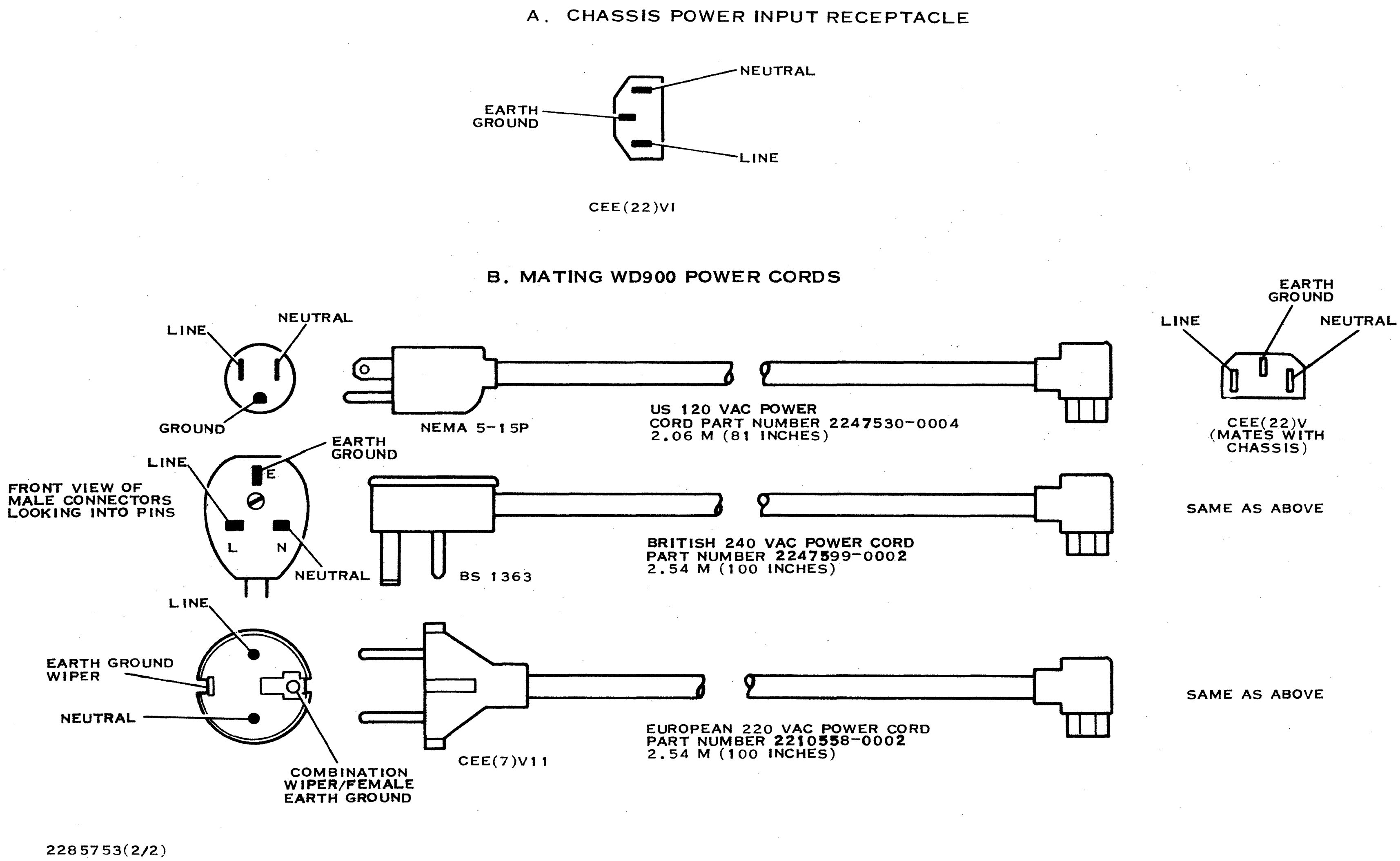

Figure 2-11 AC Power Cables (Sheet 2 of 2)

2.3.2 Unpacking the MT3200

Figure 2-12 illustrates the individual unit container. When the unit is shipped as part of a complete system, the container can differ. The interconnecting cables and mounting hardware are packed either with the unit or with the computer. The shipping configurations differ in certain other respects; for example, the top of the container is indicated either by a label or by arrows on the sides that point to the top. The MT3200 is shipped in a single carton reinforced to minimize the possibility of damage during shipment. Unpack the MT3200 using the following procedure.

WARNING

> Have all personnel stand clear while steel straps are being cut to avoid injury from the flying loose ends of the straps.

1. With the shipping container on the floor or workbench, cut the side and center tapes, securing the top of the box.

2. Pull the top flaps down along the sides of the box. Remove the upper foam blocks and place the MT3200 on a workbench or table. Remove the installation hardware from the shipping carton.

3. Check the contents of the shipping container against the packing slip and inspect for possible damage. If damage exists, notify the carrier.

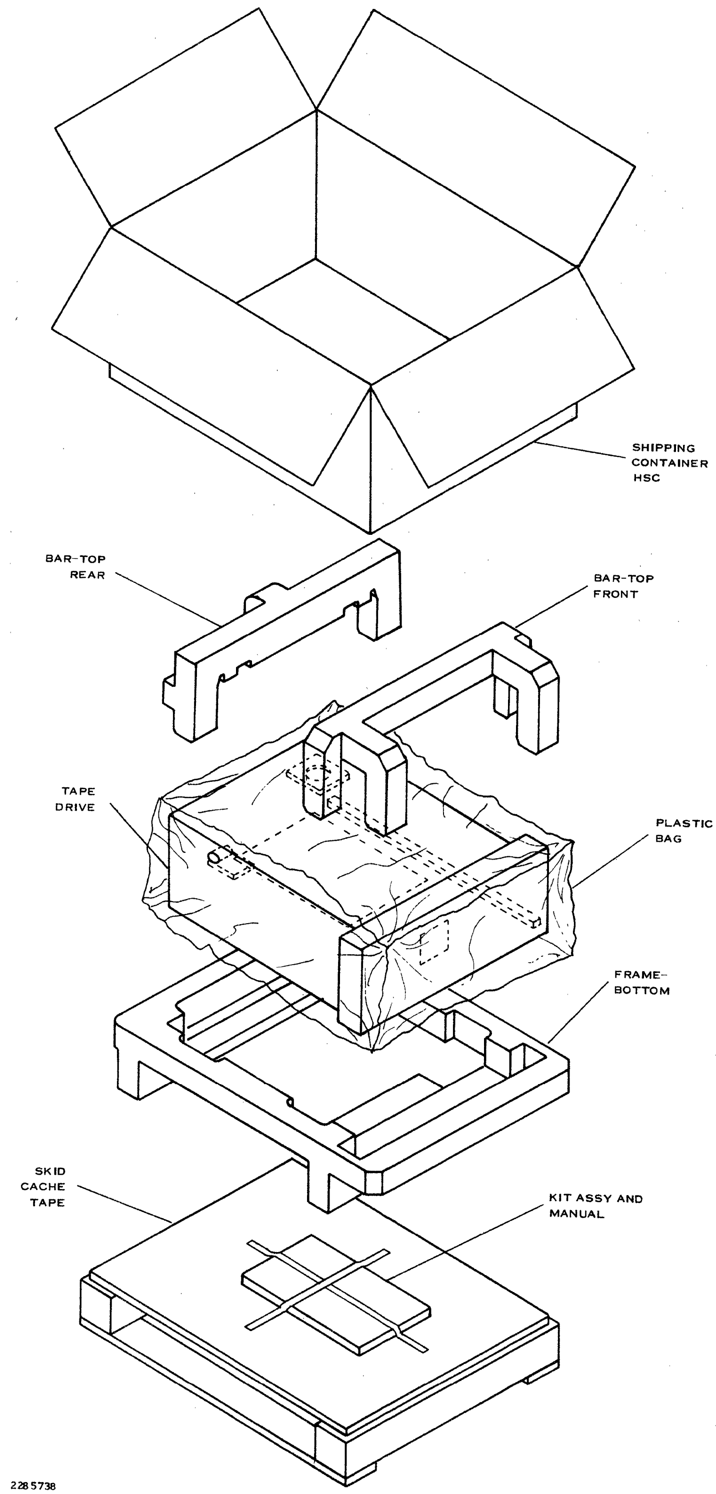

Figure 2-12 MT3200 Unit -- Individual Container

4. Refer to the packing illustration taped to the front door. Remove the tape holding the top cover and the front door in place. Open the top cover by lifting the sides directly behind the front panel. Place the cover stay (left-rear of top cover) in the slot provided. This is the maintenance access position. Pull the tachometer (spring-loaded arm at left-rear of unit) away from the hub and discard the foam cushion. Carefully replace tachometer assembly against the hub.

5. Examine the hubs, tachometer, and other components in the tape path area for foreign matter.

6. Using a screwdriver, loosen the two captive screws at the front sides of the top plate casting. Close the top cover.

   a. Lift the front panel (and top plate casting) by grasping the two lower corners. Lift the unit to its maximum upright position. The latch mechanism will automatically engage when the unit is lowered approximately one inch.

   b. Insert the safety pin provided through both holes in the top plate support from outside inward (Figure 2-13). This is the maintenance access position.

7. Remove the three pieces of foam packing material from the printed circuit board (PCB). Check the PCB and all connectors for correct installation.

8. Remove the safety pin to release the latch mechanism, and lift the front panel slightly and then lower it.

   a. Open the top cover and tighten the captive screws.

   b. Close the top cover.

9. Do not replace the packing tape or foam cushion materials.

10. Verify that the operating voltage indicated on the manufacturers label (rear of chassis) matches the power outlet voltage for the unit. If not, refer to paragraph 2.3.2.3 for instructions to change the operating voltage.

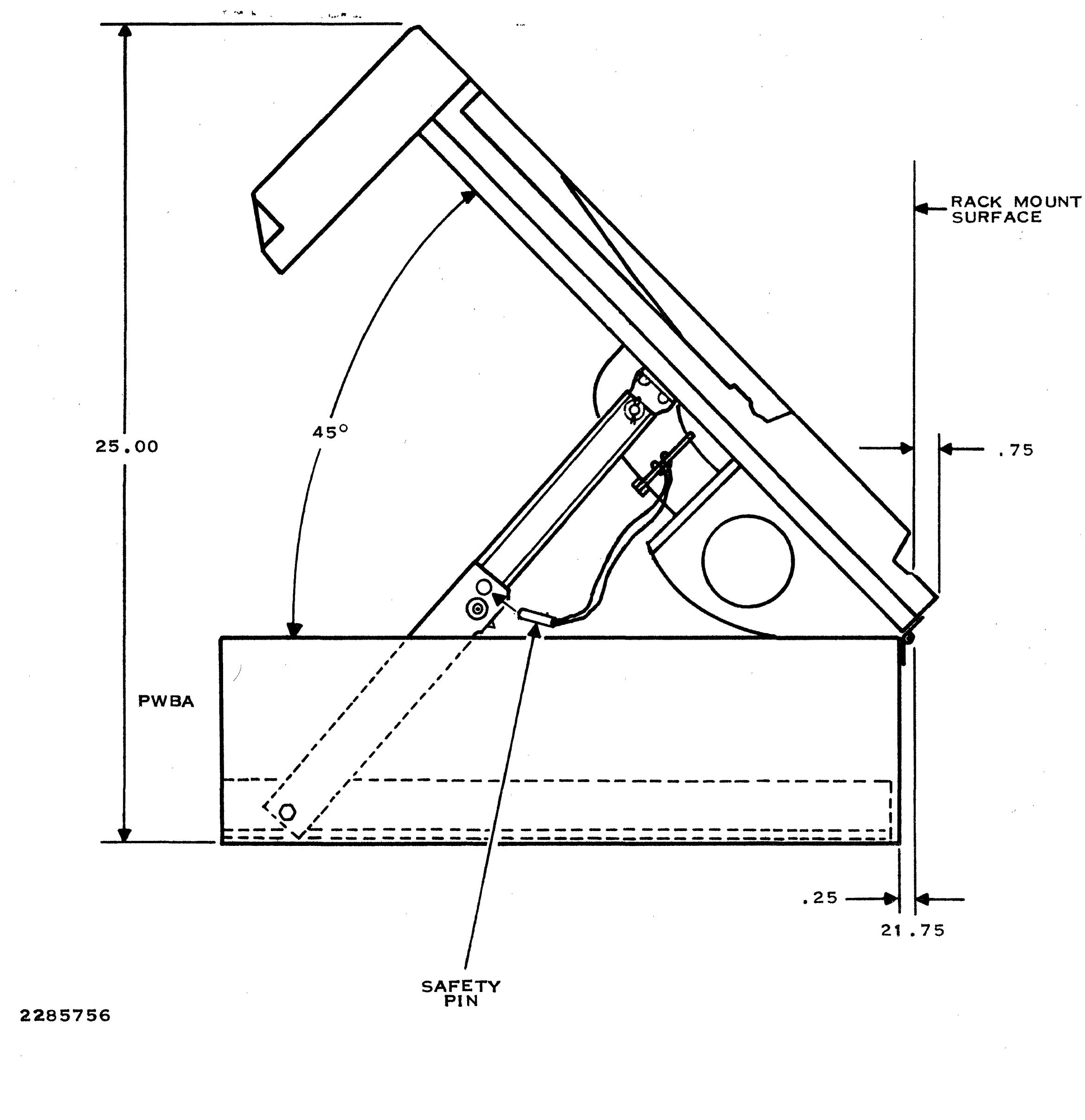

Figure 2-13 Maintenance Access Position

2.3.2.1 MT3200 Pedestal Installation. The following procedure describes how to mount an MT3200 tape drive in a 1.07-meter (42-inch) pedestal. Included are procedures for installing the slides, cabling, support brackets, and the transition board.

After unpacking is complete, the tape drive must be prepared for installation. A pedestal mounting kit, TI part number 2244799-0001, is supplied for mounting the tape drive on a 1.07-meter (42-inch) pedestal. The inner slides are preinstalled on the tape drive, and the outer slides are provided with the MT3200 and must be installed (refer to the slide installation procedure that follows).

<u>MT3200 Pedestal Installation</u>. Pedestal mounting for the tape consists of five operations:

1. Attaching the brackets to the top of the pedestal
2. Mounting the slide set to the brackets
3. Installing the transition board to the tape drive
4. Installing the I/O cables
5. Mounting the pedestal cover

NOTE

The tape path and heads must be cleaned prior to the initial operation of the MT3200 unit.

<u>MT3200 Bracket Installation</u>. Install the side brackets to the top of the 1.07-meter (42-inch) pedestal as follows (refer to Figure 2-14):

1. Position the side brackets over the predrilled holes located at each corner of the pedestal.
2. Insert four 10-32 x 3/8-inch screws from the underside of the predrilled holes to the Pem(TM)-nuts of the side brackets.
3. Position the center bracket over the predrilled holes at the rear and between the side brackets.

Pem is a trademark of the Penn Engineering and Manufacturing.

4. Insert four 10-32 x 3/8-inch screws from the outside edge of the side bracket through the predrilled holes of the center bracket. Tighten a sem-nut to each of the screws.

5. Locate the predrilled holes at the lower front lip of the side brackets.

   a. Push the 1.5-inch x 18-inch blank front panel riveted screws through the side bracket predrilled holes (refer to Figure 2-14).

   b. Attach with 2 sem-nuts.

6. Locate the predrilled holes on the upper left front, side bracket.

   a. Position the catch plate over the predrilled threaded holes.

   b. Attach the catch plate with two 10-32 x 3/8-inch flathead screws.

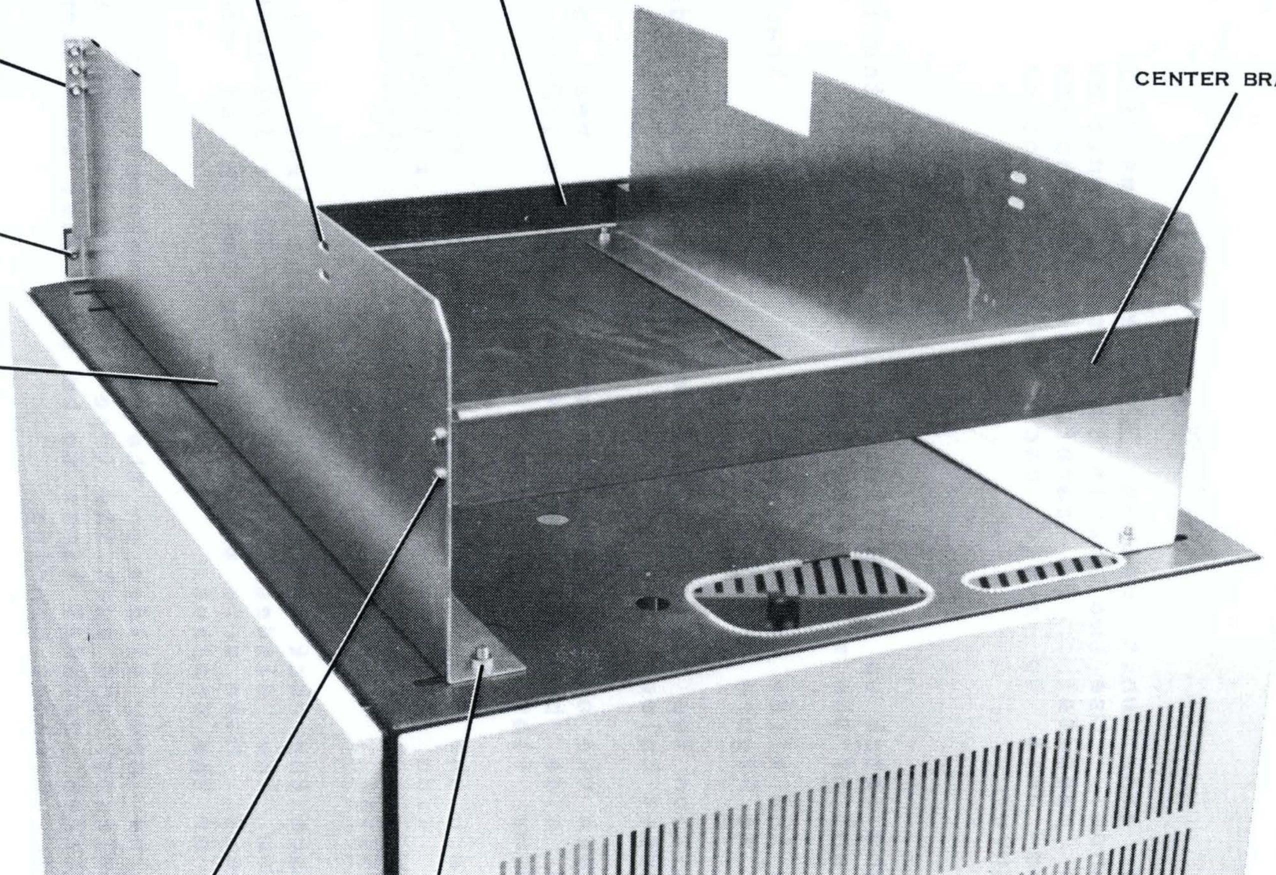

Figure 2-14 MT3200 Pedestal Bracket Installation

<u>MT3200 Slide Installation</u>. Mount the tape unit on a pedestal according to the following procedure:

CAUTION

> The tape unit weighs 32.6 kilograms (72 pounds). Use two people to mount the unit on the pedestal. Be careful when lifting the tape unit to avoid backstrain or other injury.

1. Lift the latch up on the inner slide and pull the inner slide out of the slide assembly.
2. Locate the slide mounting holes in the side brackets (refer to Figure 2-15).
   a. Position the outer slide assembly over the side bracket holes.
   b. Attach the outer slide assembly to the rear of the side brackets with four 10-32 x 1/2-inch screws, flat washers, and sem-nuts.
   c. Attach the outer slide assembly to the front of the side brackets with six 10-32 x 1/2-inch screws, flat washers, and lock washers (Pem-nuts installed).
   d. Attach the rack latch bracket on the left rail, below the slides, using two 6-32 x 1/2 inch screws. Make sure the protruding tab is at the top of the bracket.
3. Align the inner slides on the tape transport with the outer slides, and push the tape into the cabinet. Work the slides several times to be sure that they operate smoothly, without binding.
4. Recheck all mounting hardware to ensure that all screws are tight.

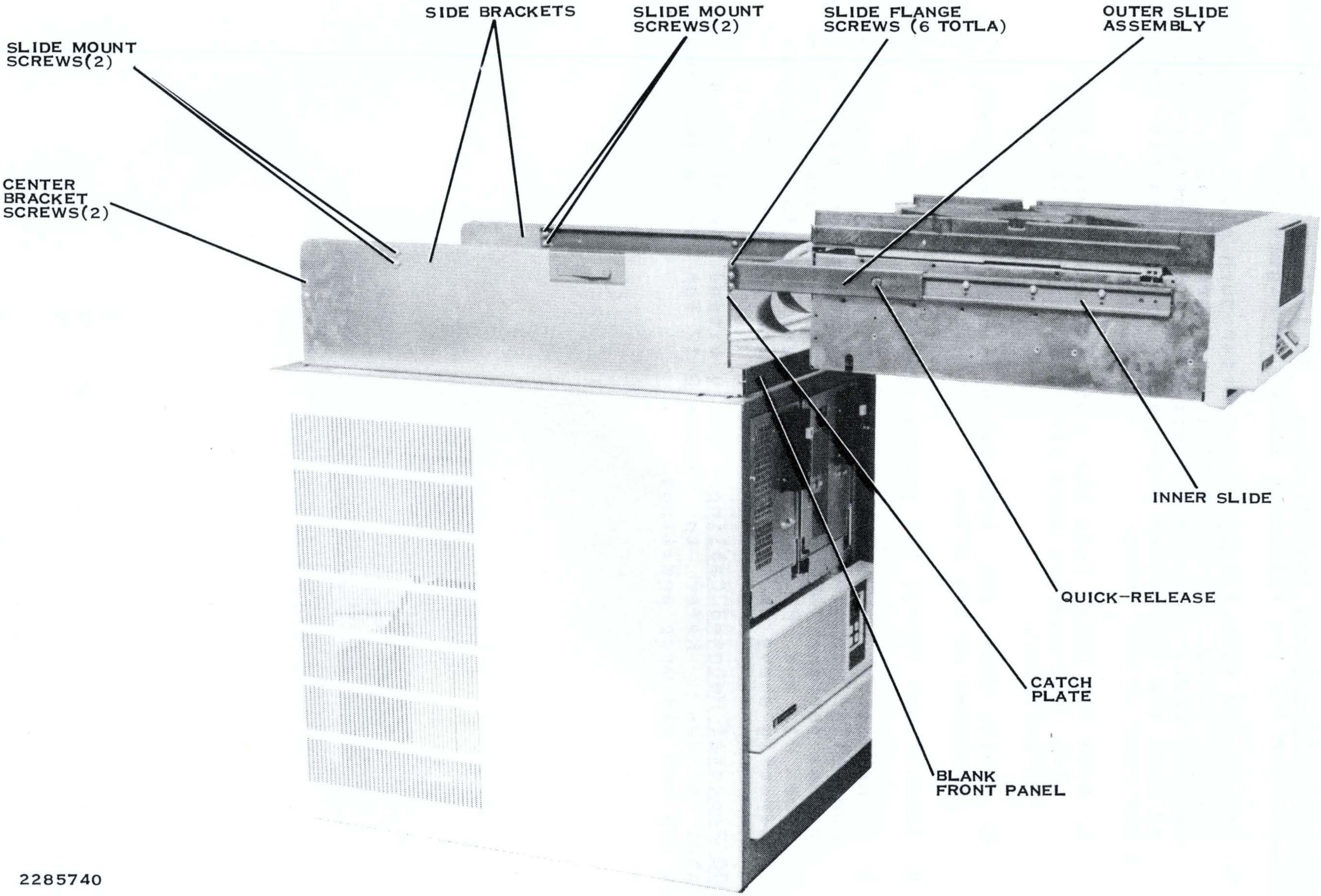

Figure 2-15 Perspective View of MT3200 Pedestal Slides

<u>MT3200 Transition Board Installation</u>. To install the transition board, perform the the following (refer to Figure 2-16):

1. Orient the four plastic one-quarter-turn plugs and the ground screw on the transition board (TI part number 2244779-0001) over the cutouts on the rear of the drive so that the transition board ports are accessible from the rear of the drive.

   a. Push the plugs into the cutouts and turn each plug one-quarter turn clockwise with a flatblade screwdriver.

   b. Verify that the transition board is securely fastened to the drive.

2. Install and fasten the ground screw.

3. Connect the I/O cable that attached to TAPE A on the controller to TAPE A on the transition board, and repeat for the TAPE B cable. Connect the ribbon cable from P1 and P2 on the tape drive to the connector directly above on the transition board (J1 and J2).

<u>MT3200 Pedestal Mounted Cabling</u>. Fully extend the MT3200 on the pedestal slides. Refer to Figure 2-17 for a detailed view of cable lay and tie wrap positions.

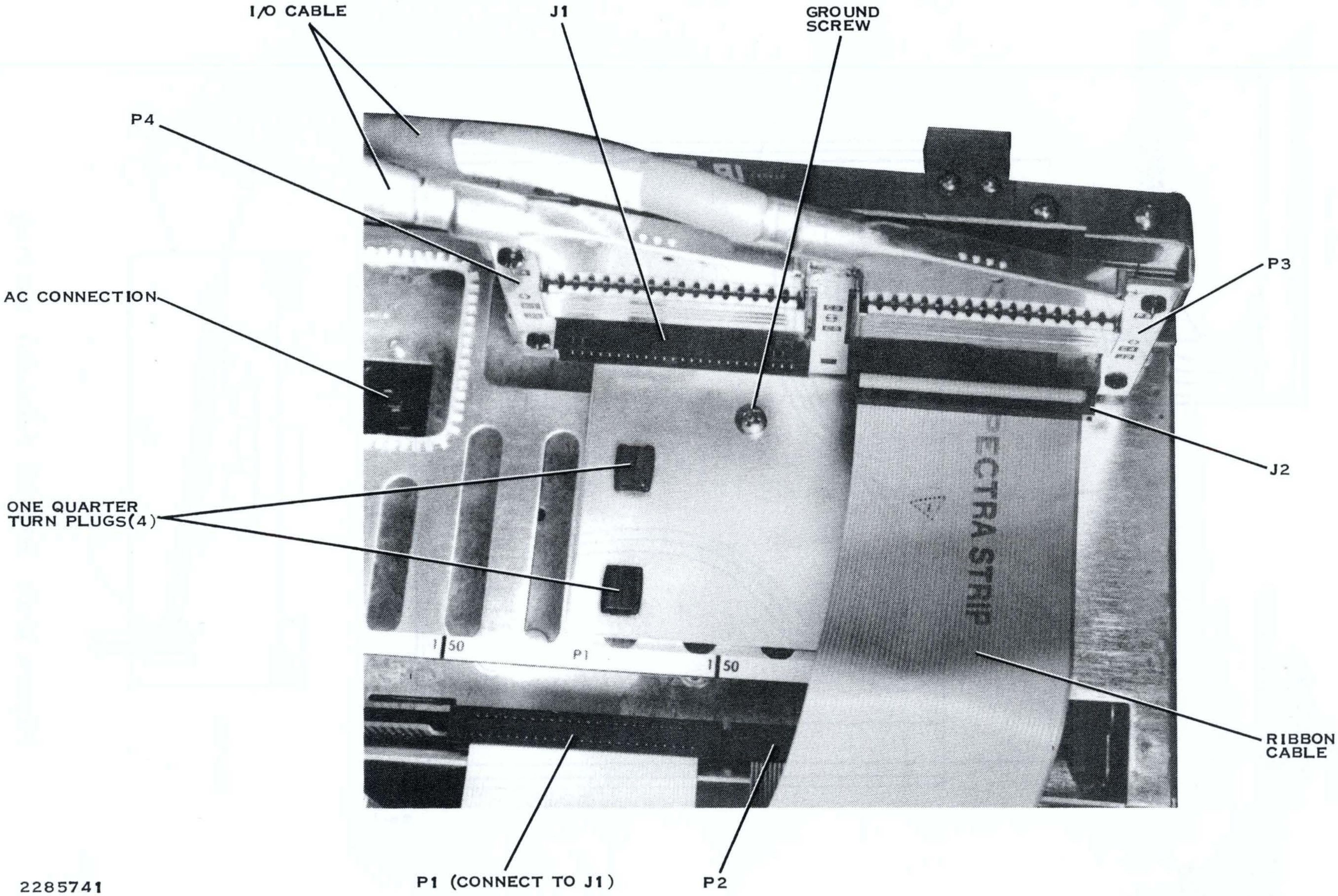

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Figure 2-16 MT3200 Transition Board

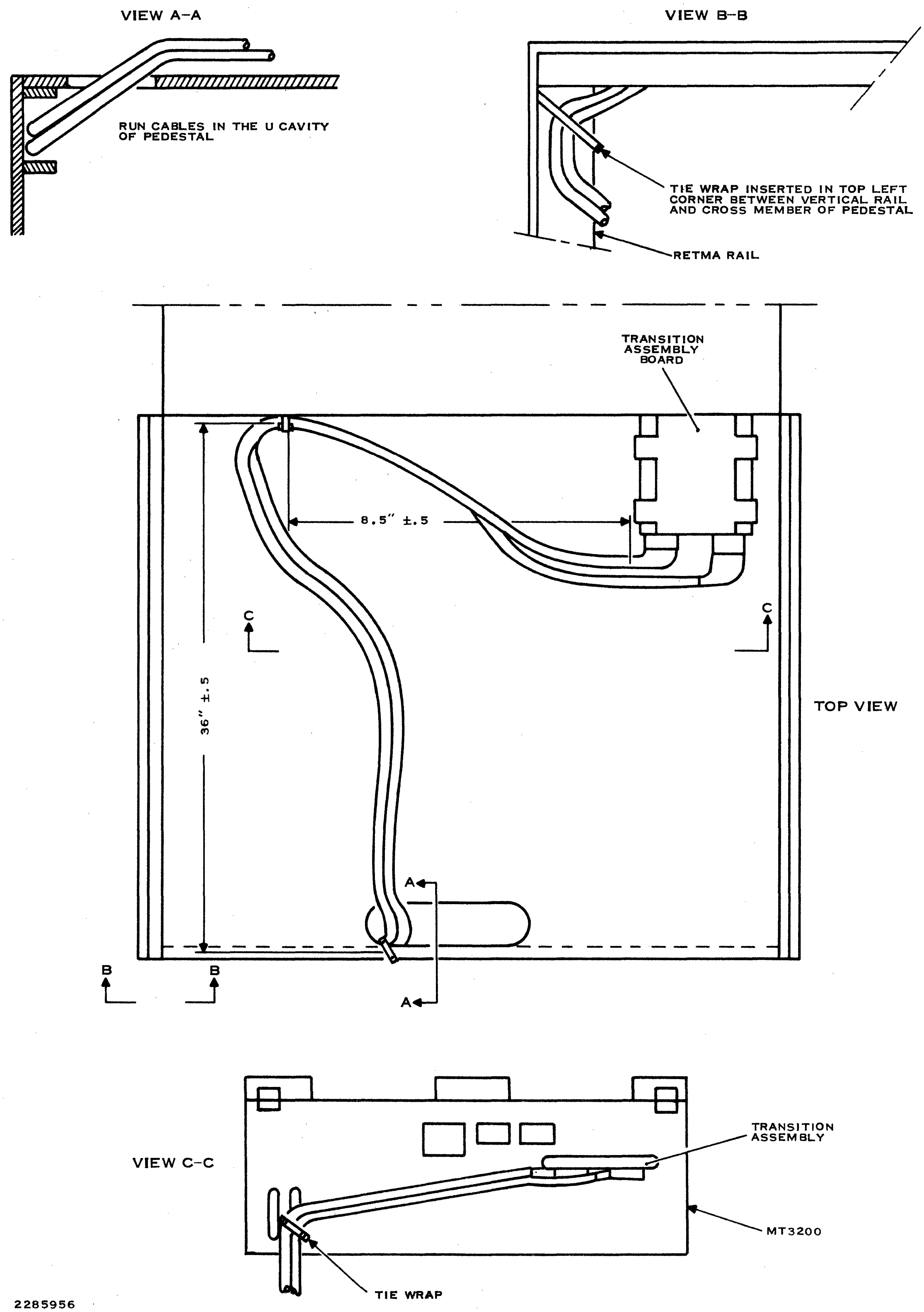

Figure 2-17 MT3200 Pedestal Cabling

MT3200 Cable Installation. Connections for the MT3200 and the system equipment are completed with a 40-pin flat ribbon cable, TI part number 2244831-0001, and a twisted-pair I/O cable, TI part number 2244802-0001.

It is important that the alternate conductor in the ribbon cable and the ground wires of the twisted-pair be grounded at each end of the cable. The MT3200 is shipped so that it is grounded when connected. Tables 1-7, 1-8, and 1-9 identify the connector pin assignments for each signal line. The signals indicated Not Used are properly terminated by the MT3200 for bus compatibility.

1. Connect the transition cables (ribbon cables), TI part number 2244831-0001, from P1 to J1 and P2 to J2.

NOTE

Assemble the ribbon cable to the connector so that the arrow on the cable connects to the arrow (pin 1) on the drive connector.

2. Connect the two 40-pin I/O cables, TI part number 2244802-0001, one to the TAPE A connector and one to the TAPE B connector on the transition board.
3. Secure the cables together with a plastic cable fastener.
   a. Position the cable fastener over the threaded predrilled hole.
   b. Connect the cable fastener to the rear of the drive with one 8-32 x 3/8-inch screw.
4. Dress the cable down and back under the transition board and down through the cable opening in the pedestal.
   a. Attach the cables to the right rear brace.
   b. Dress the cables to the chassis cable clamps and attach cable A from the tape to TAPE A on the controller. Repeat for the TAPE B cable.
5. Connect the female end of the ac power cord to the rear of the tape drive.
6. Dress the power cord down through the pedestal opening and connect the male end to the power strip.

Mounting the Pedestal Cover. Mount the MT3200 pedestal cover as follows (refer to Figure 2-18):

1. If not already done, remove the pedestal rear panel, and locate the ground strap that is bolted and taped to the rear rail of the pedestal.
2. Untape the strap and bolt the lug end of the strap to the pedestal top cover.
3. Place the pedestal top cover over the tape drive allowing the locating studs to protrude through the holes in the pedestal mounting deck. Route the ground strap through the cable slot in the pedestal.
4. Connect the spade lug of the ground strap to the machine screw on the rear rail of the pedestal.
5. Replace the pedestal rear panel.

NOTE

The tape path and heads must be cleaned prior to the initial operation of the MT3200 unit.

The tape drive is now ready to be powered up.

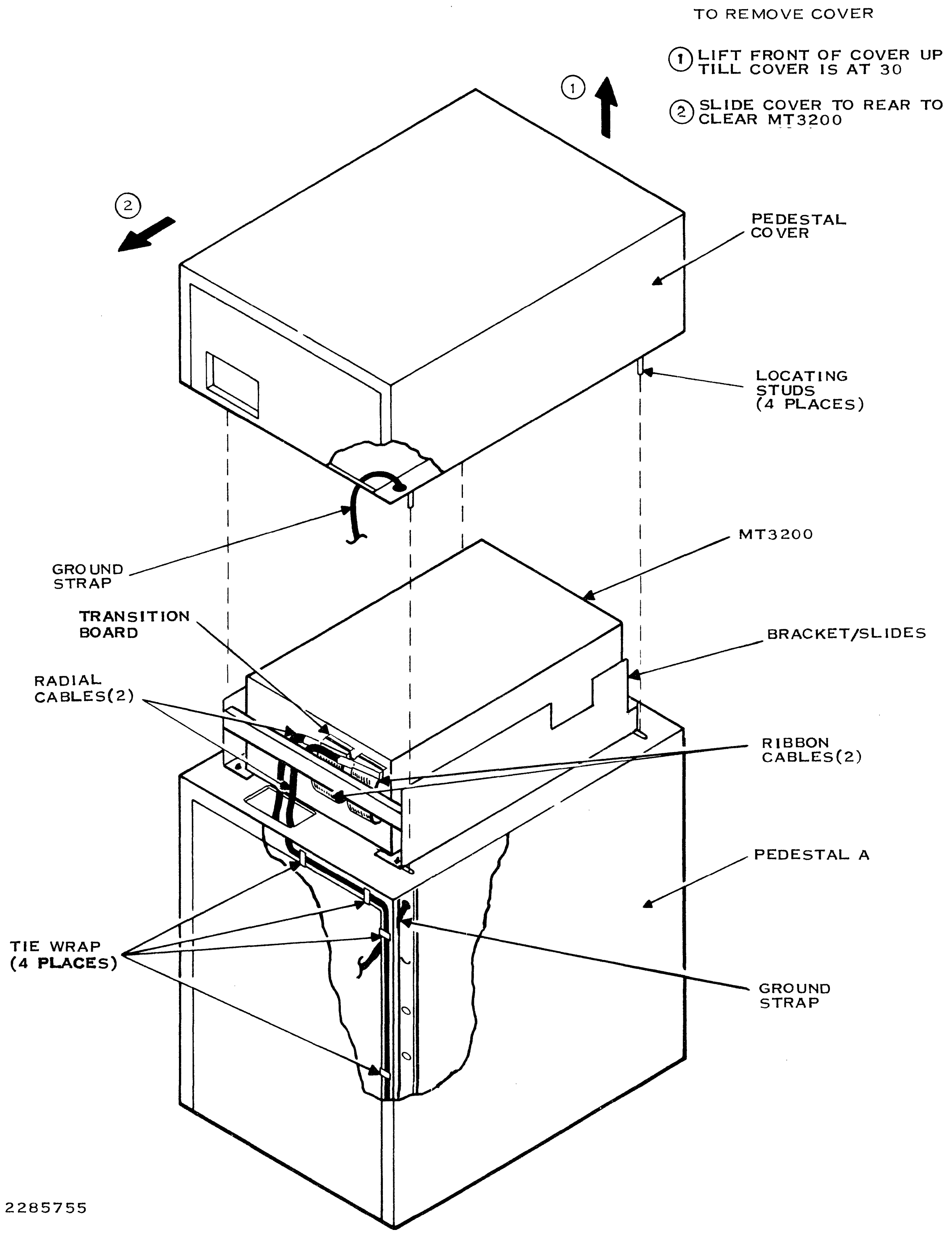

Figure 2-18 MT3200 Pedestal Cover Installation

2.3.2.2 MT3200 Installation in a 1.52-Meter (60-Inch) Rack. The MT3200 is designed to be mounted in a standard, 19-inch wide EIA equipment rack using the slides and mounting hardware provided with each unit. A slide mounting kit, TI part number 2244803-0001, is supplied for mounting the tape in the 19-inch wide, 1.52-meter (60-inch) high cabinet. The following procedure describes how to mount an MT3200 tape drive with the provided slides. These slides include a left and right telescoping slide, two adjustable-length rear mounting brackets, and four clamp or nut plates. Nut plates are threaded for use with unthreaded EIA rails; clamp plates are unthreaded for use with threaded EIA rails. Small mounting hardware items (screws and washers) are also included.

Slide mounting consists of four operations:

1. Selecting the mounting location in the cabinet

2. Mounting the slide set in the cabinet

3. Installing the inner slides (and tape drive) in the cabinet as shown in Figure 2-19

4. Connecting the tape drive transition board

NOTE

The tape path and heads must be cleaned prior to the initial operation of the MT3200 unit.

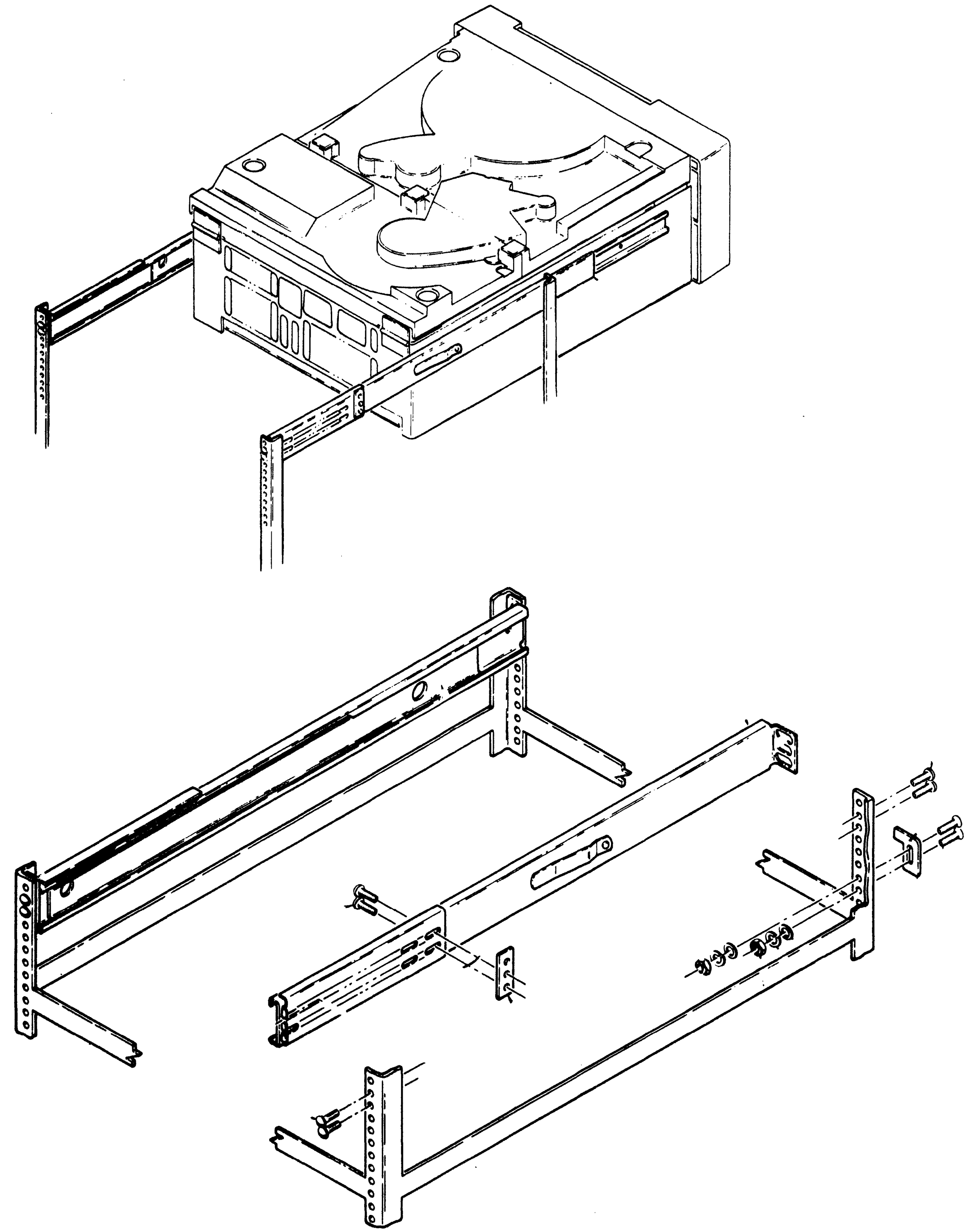

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Figure 2-19 Perspective View of Slide Mounts

To mount an MT3200 tape drive in an EIA standard cabinet:

1. The allowable spacing between the front and rear cabinet rails ranges from 616 to 717 millimeters (24.25 to 28.25 inches). The slide set is adjustable over this range, so spacing is not critical. Move the cabinet rear rails if the spacing is outside the allowable range.

2. Determine where you want to locate the bottom edge of the lower trim panel, as shown in Figure 2-3. Typically the tape drive is installed above the disk drive and computer chassis.

   Make a reference mark between a set of holes with narrow spacing. By EIA standards, this mark is not centered but is 6.86 millimeters (0.27 inches) below the centerline of the upper hole. After installation, the front panel will occupy the next 273 millimeters (10.75 inches) above the reference mark.

   Count the holes or use a tape measure to locate the corresponding points on the rear rails.

3. Locate the slide mounting holes in the cabinet rails. Count the first hole above your reference mark as hole 1, with holes 2 and 3 as the mounting holes.

4. Each slide rear extension has a number of adjustment slots. Select a set of slots for a rough adjustment. The final length adjustment and tightening come later in the procedure.

   Loosely assemble the rear extensions to the slides so the front and rear mounting flanges fit between the cabinet front and rear rails.

5. Mount the slides in the cabinet, following the appropriate mounting details in Figure 2-3.

   Mount the slides inside the front and rear mounting rails with two 10-32 x 1/2-inch screws, a flat washer, and a lock washer for each mounting bracket. The screws enter the rails from inside the cabinet.

WARNING

> Make sure that each flange is firmly seated on the inside of the mounting rail. If you assemble the parts in the wrong order, the slides may fail under load.

6. Install the rack latch bracket on the left rail below the slide, with the protruding tab on top. Use two 6-32 screws, flat washers, lock washers, and nuts.

7. Tighten the rear extensions to the slides.

8. Insert the tape transport into the extended slides, lift the quick disconnect latches, and push the tape transport into the cabinet. Work the slides several times to be sure that they operate smoothly, without binding.

9. Recheck all mounting hardware to ensure that all screws are tight.

10. Check that the lower edge of the front panel coincides with the reference mark on the rails. If not, there may be interference with other units installed in the cabinet.

    Readjust the vertical position of the slides if necessary to obtain the correct trim panel position.

Refer to paragraph 2.3.2.1 for example information on cable lay, tie wrap positioning, and transition board installation for the 1.52 meter (60-inch) rack.

2.3.2.3 MT3200 Voltage Conversion. The MT3200 power supply is configured before shipment for the proper voltage supply. The equipment label on the power supply indicates the voltage range selected prior to shipment. A power cord (refer to Figure 2-9) is supplied only for the voltage range indicated on the label.

CAUTION

To prevent damage to the MT3200 and to ensure proper operation, be sure the outlet voltage and drive voltage are the same before applying power to the MT3200.

The MT3200 can be operated over a wide range of line voltages by selection of the appropriate power supply voltage option. To change the power supply option, proceed as follows:

CAUTION

Ensure that the rack is mounted securely when the MT3200 is extended on slides. The weight of the MT3200 in the extended position can upset an inadequately mounted equipment rack.

1. Switch the unit power to OFF and remove the power cord from the outlet.

2. Open the unit to the service access position.

3. Place an antistatic cloth of some type (the original packing will suffice) over the printed wire board (PWB) in the area of the power supply assembly.

WARNING

> Lethal voltages can be encountered in the next two steps if the unit has not been disconnected from the ac power source for at least two minutes.

4. Remove the two Phillips-head screws securing the power supply cover. Note the position of the chassis ground cable. Pivot the cover to the right and slide it forward to remove.

5. Remove the voltage selection card from J9 on the power supply PWB. Note the position of the key slot on the voltage selection card. Reinstall the card in J9 to correspond to the desired voltage. Refer to Table 2-1.

6. Replace the fuse, if required, with one for the correct current rating for the voltage selected. Refer to Table 2-1. Use a Slo-Blo(R) 250-volt type of fuse. The fuse holder is located on the right front of the power supply assembly. Replace the power cord if required.

7. Note the new operating voltage in a prominent location on the unit.

Table 2-1 Operating Voltage Selection

Nominal Line Voltage (Tolerance)		Selection Card	Fuse (Amps)	Frequency (Hz)
100	(85-100)	100	3.0	49-61
120	(102-132)	120	3.0	49-61
208	(187-228)	220	1.5	49-61
220	(187-242)	220	1.5	49-61
230	(207-253)	240	1.5	49-61
240	(204-264)	240	1.5	49-61

Slo-Blo is a registered trademark of Littelfuse Incorporated.

2.3.2.4 Separating Chassis Ground and Logic Ground. The MT3200 comes configured with a common chassis and logic ground. The MT3200 chassis ground and logic ground can be separated in the field to avoid ground loops caused by other logic ground points in the WD900/MT3200 system. To separate chassis and logic ground, proceed as follows:

WARNING

Chassis ground and logic ground must be connected together at a minimum of one point in the WD900/MT3200 systems for safety reasons and for compliance with Underwriter's Laboratory regulations.

1. Switch the unit power to OFF and remove the power cord from the outlet.

2. Open the unit to the service access position.

3. Place an antistatic cloth of some type (the original packing will suffice) over the printed wire board (PWB) in the area of the power supply assembly.

CAUTION

The screw that you remove in the next step holds the roller guide assembly in place. Make sure that the roller guide is not damaged or misplaced.

4. Remove the Phillips-head screw securing the logic ground to the chassis top plate. Figure 2-19A shows the location of the connection of logic ground to the chassis top plate.

CAUTION

Ensure that the tape path alignment is still correct when replacing the roller guide assembly.

5. Dress the wire back along the wire bundle, ensuring that the lug does not contact any other metal of the chassis. Reinstall the screw.

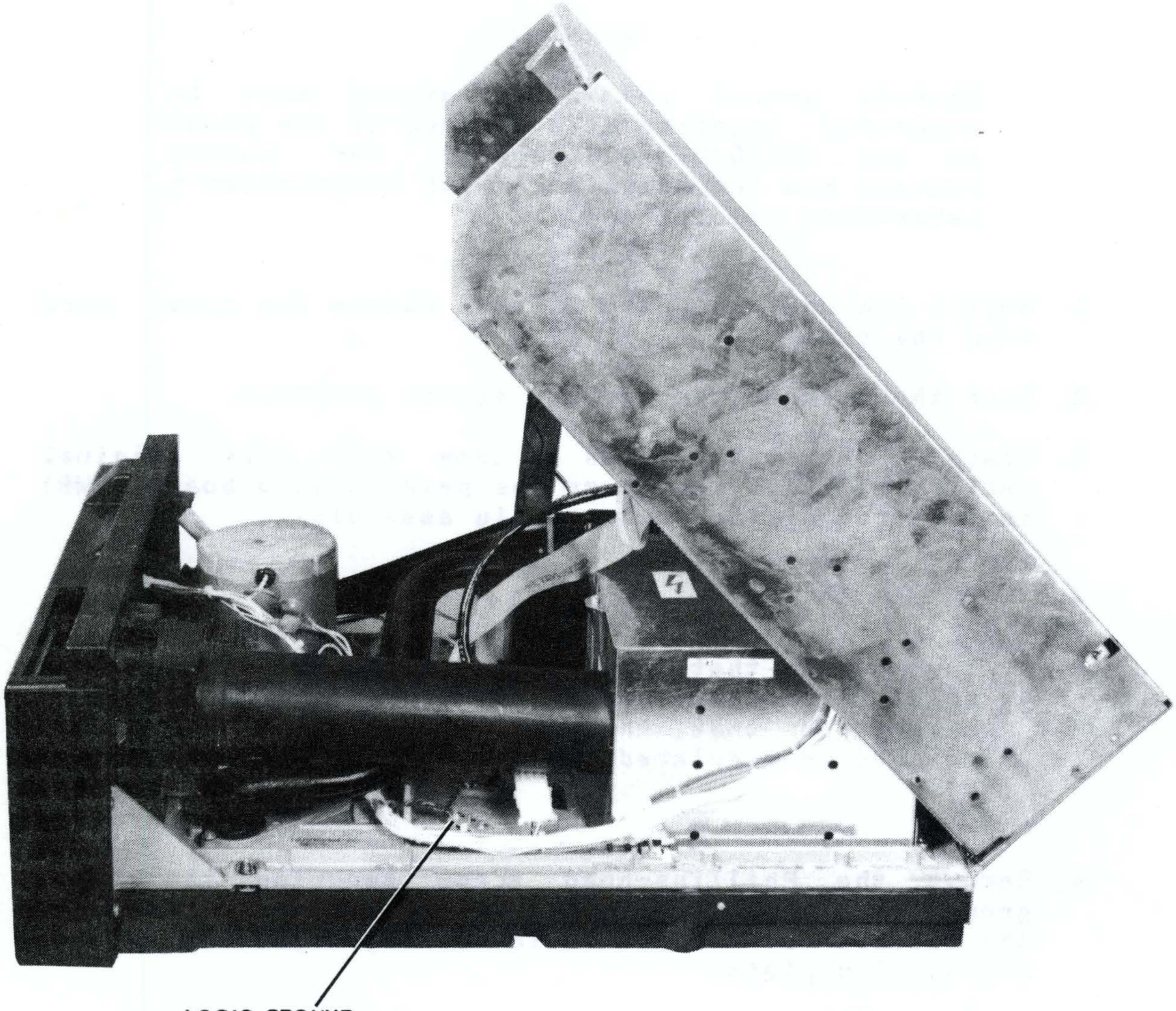

Figure 2-19A Location of the Logic Ground Connection

2.3.3 System Grounding Connections
The WD900 is grounded when the power supply is connected and does not require any additional grounding.

The MT3200 is grounded internally through the power supply and requires no additional external grounding.

2.4 HARDWARE PREPARATIONS

The following paragraphs describe the PCBs and how to prepare them for unit operation.

2.4.1 WD900 Preparations
The WD900 drive is shipped with all circuit board switches preset. Use the following paragraphs to verify and/or set the switches and jumpers.

2.4.1.1 Circuit Board Preparations. The circuit boards inside the drive contain a number of switches that must be set correctly for normal operation of the drive. Figure 1-3 and Figure 1-4 identify these switches and give their locations on the circuit boards. They also give the correct settings for normal drive operation for all switches except the sector select switches. Setting the sector select switches is discussed in the following paragraph.

Figure 1-3 and Figure 1-4 show the location of the sector select switch assembly. The sector select switch assembly has twelve independent switches used for selecting sectors. The number of sectors per revolution generated by the drive logic must be matched to that required by the controller. Therefore, sector select switches are provided in the drive logic to allow selection of different sector counts.

The recommended switch settings for the WD900 drives are the following:

* 138-megabyte drive -- 67 sectors; switches 0, 1, 2, 6, and 7 -- ON

* 425-megabyte drive -- 100 sectors; switches 0, 2, and 7, -- ON

Refer to Section 1, paragraphs 1.2.2.2 and 1.2.2.3, for more information.

2.4.2 MT3200 Preparations

The following describes how to set the switches for the MT3200 tape unit. Figure 2-20 shows the location of the switches on the MT3200 formatter board.

2.4.2.1 Unit Address Select/Option Switches. The following paragraphs and tables indicate the unit address select switches and the option switches.

Table 2-2 Unit Address Select/Option Switch -- Switch U5W

Switch 1	Switch 2	Switch 3	Function: Unit address select
Position			
ON	ON	ON	0
ON	OFF	ON	1
OFF	ON	ON	2
OFF	OFF	ON	3
ON	ON	OFF	4
ON	OFF	OFF	5
OFF	ON	OFF	6
OFF	OFF	OFF	7

Switch	Position	Function
4	ON	Post-EOT streaming enabled
4	OFF	Post-EOT streaming disabled, and double filemark disabled
5	ON	3200 bpi IDENT enabled
5	OFF	3200 bpi IDENT disabled
6	--	Not used
7	--	Not used
8	--	Not used

The recommended switch settings for switch U5W are the following:

Switch	1	2	3	4	5	6	7	8
Position	ON	ON	ON	OFF	OFF	N/A	N/A	N/A

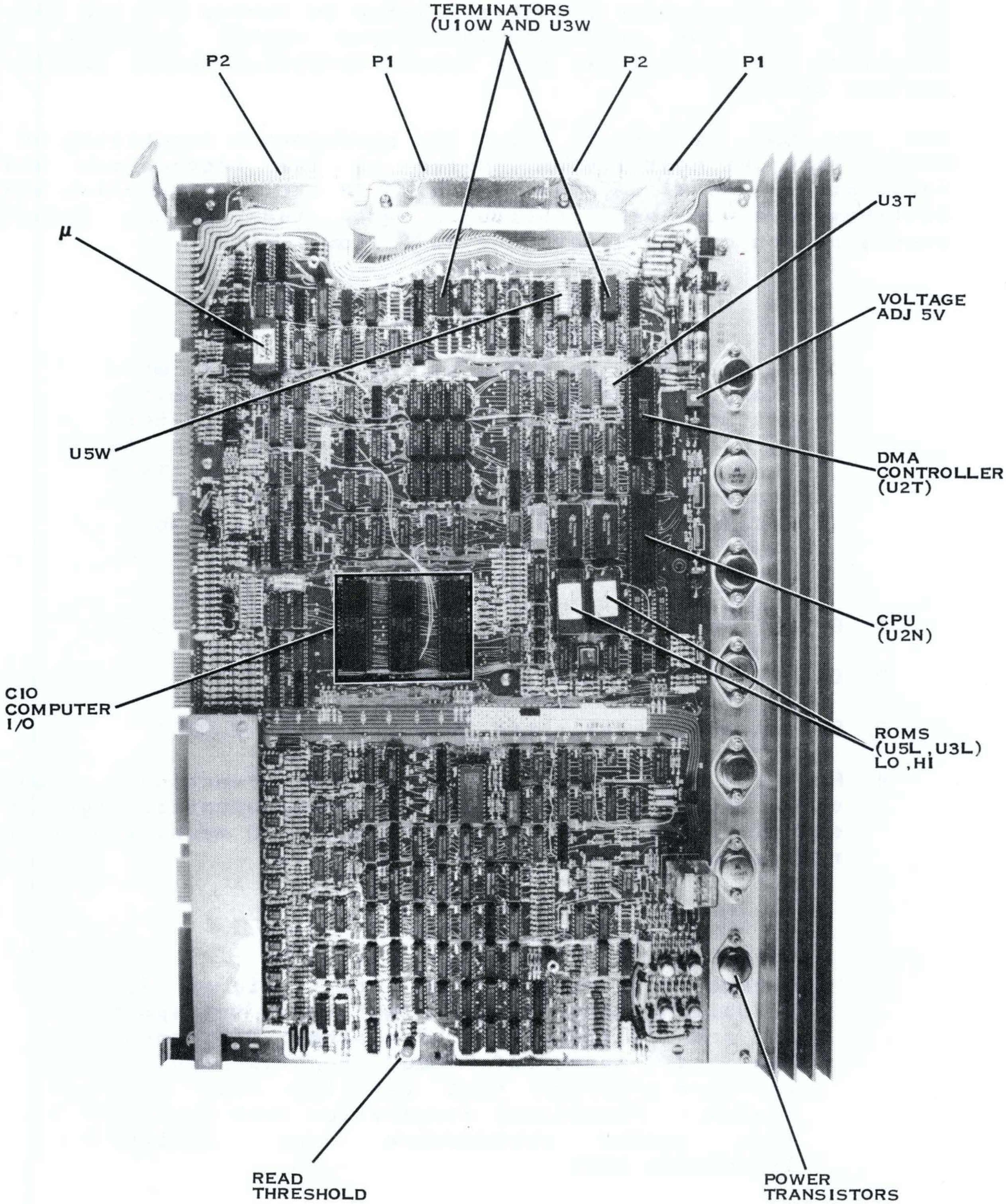

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Figure 2-20 MT3200 Formatter Board

2.4.2.2 Configuration Switches. Refer to Tables 2-2 and 2-3 for the U3T and U5W configuration/option switch settings that establish the block size, ramp delay, simulated speed, parity and various options.

Set the U3T switch to match the performance capability of the MT3200 with the host system (refer to the recommended switch settings that follow this list). If the configuration switch settings have not been previously set, the optimum operating configuration can be determined as follows:

CAUTION

A Power-Up Reset must be performed when changing any U3T configuration switch setting, and prior to loading tape. Do this by cycling the front panel power switch to the OFF position, and then back to ON. This procedure allows the MT3200 processor to update the new U3T switch settings to memory.

1. Set the block size to 9K bytes (U3T-3 and 4 OFF).

2. Disable the ramp delay (U3T-5 ON).

3. Select the lowest speed (U3T-6, 7, and 8 OFF).

4. Run an actual tape program or functional tape diagnostic test to establish basic compatibility; for example, measure the time to back up 10 megabytes as a reference.

NOTE

Parametric diagnostics are designed for troubleshooting a particular tape transport and are not indicative of system performance. The best tests of MT3200 compatibility are the live programs that use the tape subsystem. Functional diagnostics that measure tape system performance are another legitimate tool.

5. Set the next lower or higher block size (U3T-3 and 4), as appropriate, and repeat step 4.

6. Select the next highest speed for increased throughput (U3T-6, 7, and 8).

7. Repeat steps 4 through 6 until the data rate of the MT3200 exceeds the data rate capability of the system. This is evident when there are data late flags in the host system or a substantial increase in repositioning activity in the MT3200 (caused by write retries due to incomplete data transfers).

8. Select the next lowest speed (U3T-6, 7, and 8).

9. Switch U3T-2 is used to select internal parity generation (U3T-2 OFF) or external parity generation (U3T-2 ON). In the external mode, the external parity is compared to the actual internal parity of the data character. If external and internal parity do not agree, a hard error is issued. The MT3200 does not drop tape tension for this hard write error condition.

Table 2-3 Configuration Switches -- U3T

Switch	Position	Function
1	ON	EOT location enabled
1	OFF	EOT location disabled
2	ON	External parity
2	OFF	Internal parity
Switch/Position		
3	4	Maximum block size
OFF	OFF	9K-byte
ON	OFF	16K-byte
OFF	ON	24K-byte
ON	ON	32K-byte
Switch	Position	
5	OFF	Enable ramp delay
5	ON	Disable ramp delay

Table 2-3 Configuration Switches (Continued)

Simulated Speed Select -IPS- 6	7	8	Data Transfer -KBS- (Avg & Min/Max)	Burst Rate (Avg & Min/Max)	Delay -msec- (Enabled)
OFF	OFF	OFF	45	72	8.3
ON	OFF	OFF	75	120	5.0
OFF	ON	OFF	100	160	3.7
ON	ON	OFF	112 (103/120)	180 (165/192)	3.0
OFF	OFF	ON	125 (108/140)	200 (172/225)	2.6
ON	OFF	OFF	155 (138/170)	250 (220/272)	2.2
OFF	ON	ON	185 (160/206)	295 (256/330)	1.5
ON	ON	ON	250 (200/300)	400 (320/480)	1.0

The maximum throughput can be determined by running a tape diagnostic test and looking for data lates (buffer was empty when request for more data occurred) as the throughput is stepped up (increased in simulated speed). If the configuration is not matched to the system capability during a backup, the MT3200 does a reposition. These are incomplete data transfers that cause repositioning when the host cannot output data as fast as the requests of the cache. The tape stops after 16 repositions on write retries with an error code of 11010 or 11001, excessive write retries. An excessively long backup time compared to a previous run or compared to a start/stop drive is an indication of too high a transfer rate switch setting (or media with excessive faults).

Set the lowest possible maximum block size so the throughput is not limited by the cache buffer size. For example, if during a read the maximum block size is set to 32K-bytes for a 9K-byte actual block size, the throughput can be degraded by up to 50 percent compared to reading the same data at the 9K-byte setting. Performance is maximized by setting the configuration switches to the lowest maximum block size setting that contains the actual recorded block size.

A performance enhancement feature is incorporated to prevent a dropped tape condition in the drive when an attempt is made to write a larger block of data than the maximum block size settings of unit configuration switches U3T-3 and U3T-4. When writing a block of data that exceeds the maximum block size setting, an IHER- flag is issued to the host and the drive automatically increments to the next higher maximum block size (from 9K-byte to 16K-byte or 16K-byte to 24K-byte, and so on).

CAUTION

IHER- is pulsed prior to termination of the data transfer. It is the responsibility of the host to issue a normal write retry sequence after recognizing the hard write error condition.

The drive continues to increment to the next higher block size with each write retry operation. This happens if the data block is greater than the expanded block size during the write retry operation, or until one of the following events occurs:

* The data block is successfully written within the limits of the newly expanded maximum block size.

* The block size expansion exceeds the 32K-byte limit. In this event the drive latches IHER- to the host and reports hard error code 15 to the front panel.

The expanded final increment of the maximum block size remains fixed for the remainder of the tape or until a system reset is initiated. It is important that the operating system maintains reasonable block sizes based on the initial switch settings of U3T-3 and U3T-4 to maintain optimum throughput performance. Refer to Table 2-3 for configuration switch settings and to Figure 2-20 for switch locations.

Note that in many cases the maximum throughput capability of the MT3200 is attained at one or more speed settings below the maximum attainable throughput setting. For example, if the backup time for 10.4 megabytes is 3 minutes at the 100, 120, 140, 170, and 200 ips settings, then the ideal setting would be 100 or 120 ips. This eliminates the risk of data transfer problems at the higher speeds. This example is generally an indication of the limits of system throughput (bus activity-speed) and not controller/coupler limitations.

The recommended switch settings for switch U3T are the following:

Switch	1	2	3	4	5	6	7	8
Position	OFF	ON	OFF	OFF	ON	OFF	ON	ON

2.4.3 Controller Preparations

The following paragraphs describe the preparations needed for the proper functioning of the WD/MT controller.

2.4.3.1 TILINE Address Switch. The WD/MT board contains one eight-section, dual in-line pack (DIP) switch. This DIP switch comprises both the tape and disk TILINE peripheral control space (TPCS) registers. Switches 1 through 4 are used to set the TPCS for the WD900 and switches 5 through 8 for the MT3200. A switch set to ON corresponds to a logical 1. Verify switch positions according to the following paragraphs.

The CPU incorporates addressable memory space for access via the TILINE. Switches on the WD/MT board determine the TILINE base memory addresses and must be correctly set prior to use. If the WD/MT is shipped as part of a complete system, these switches are already set, but you should verify settings prior to operation. The following paragraphs describe this procedure.

Figure 1-1 shows the WD/MT board and switch locations. Table 2-4 lists the CPU byte addresses and corresponding switch positions for each of these addresses. The standard main 990 computer chassis slot assignment for a system disk controller is slot 7 for the 13-slot chassis. The CPU byte address for the WD900 is >F800 (all switches in the off position). Throughout this manual the symbol > is used in front of an address to indicate a hexadecimal address or value. The CPU byte address for the MT3200 controller is >F880 (all switches in the off position except switch number 8).

If these switches need setting, determine the proper TILINE address according to the operating system software, and set the switches (Table 2-4).

Table 2-4 TILINE Address Switch Configurations

DISK TAPE	1 5	2 6	3 7	4 8	CPU Address (Hexadecimal)
	OFF	OFF	OFF	OFF	F800 (Disk address)
	ON	OFF	OFF	OFF	F810
	OFF	ON	OFF	OFF	F820
	ON	ON	OFF	OFF	F830
	OFF	OFF	ON	OFF	F840
	ON	OFF	ON	OFF	F850
	OFF	ON	ON	OFF	F860
	ON	ON	ON	OFF	F870
	OFF	OFF	OFF	ON	F880 (Tape address)
	ON	OFF	OFF	ON	F890
	OFF	ON	OFF	ON	F8A0
	ON	ON	OFF	ON	F8B0
	OFF	OFF	ON	ON	F8C0
	ON	OFF	ON	ON	F8D0
	OFF	ON	ON	ON	F8E0
	ON	ON	ON	ON	F8F0

2.4.3.2 Configuration Switches. Two four-section DIP switches, one for each WD900 physical drive, are used to determine the type and logical division of the drives attached. This configuration also depends on the contents of the drive configuration programmable read-only memory (PROM) installed. The primary drive is controlled by the switch at board location 8M and the secondary drive is controlled by the switch at location 8N. Table 2-5 shows the switch settings for both the WD900 138-megabyte and 425-megabyte drives.

Table 2-5 WD900 Configuration Switches

Switches				Disk Type	Logical Units
4	3	2	1		
X	OFF	OFF	OFF	138M-byte	1
X	OFF	OFF	ON	425M-byte	1
X	OFF	ON	OFF	138M-byte	2
X	OFF	ON	ON	425M-byte	2
X	ON	OFF	OFF	Reserved	
X	ON	OFF	ON	Reserved	
X	ON	ON	OFF	Reserved	
X	ON	ON	ON	Reserved	

NOTE:

If you have two drives and are using one logical unit per drive, set each primary and secondary configuration switch for one logical unit. For example, if you have two 425-megabyte drives and you want one logical unit for each, set both configuration switches to: X, OFF, OFF, ON, where X is a do not care situation.

2.4.3.3 WD900 Logical Unit Selection. The WD900 physical unit can be used as single logical unit or as two logical units. When the physical unit is used as two logical units, the drive operates as though it were two separate storage devices (except when performing independent seeks). Dividing the drive into two separate logical units can lead to confusion unless you clearly understand how the controller manages the attached units.

The WD/MT controller can control two WD900 physical units, and each drive can be divided into two logical units, giving a total of four addressable logical units. The units are addressed on the TPCS interface by indicating the proper select bits (0 through 3). How the configuration switches are set on the controller determines the assignment of the select bits. The primary drive is always assigned to TPCS unit-select zero. The primary drive is also assigned unit-select one if the drive is divided into two logical units. This means that the unit select assignments of the second physical drive depend upon the configuration of the first drive. Refer to Table 2-6 for the unit-select assignments for the different configurations.

Table 2-6 WD900 Logical Drive Assignments

Physical Unit	Divided	Drive Select Assignment
Zero	No	0
One	No	1
Zero	Yes	0 and 1
One	No	2
Zero	No	0
One	Yes	1 and 2
Zero	Yes	0 and 1
One	Yes	2 and 3

The controller splits the disk by assigning half the heads to one unit and the other half to the other unit. When the drive is divided into two logical units, the controller assigns the lower heads to the even unit-select number (zero is considered an even number) and the upper heads to the odd unit-select number.

<u>System Installation</u>. The WD900 drive is shipped from the factory configured and formatted as one logical unit. If site requirements are for one or more divided physical units, then the drive configuration switches on the controller must be set, and a surface analysis must be done on each logical unit to reformat the drive for the new head address assignments. (Bad track maps are recorded such that they can be used for either one or two logical units per drive.) Follow the flowchart in Figure 2-21 for installation procedures of the drive. Refer to the recommended switch settings in this section to verify the drive and controller switch settings.

CAUTION

It is essential that you follow the installation procedure any time you make a configuration change in unit assignment. Changing the logical unit division of physical drive zero changes the logical unit-select numbers assigned to physical drive one. This not only changes the logical unit-select numbers used in running the diagnostics, it also changes the disk assignments made by the operating system.

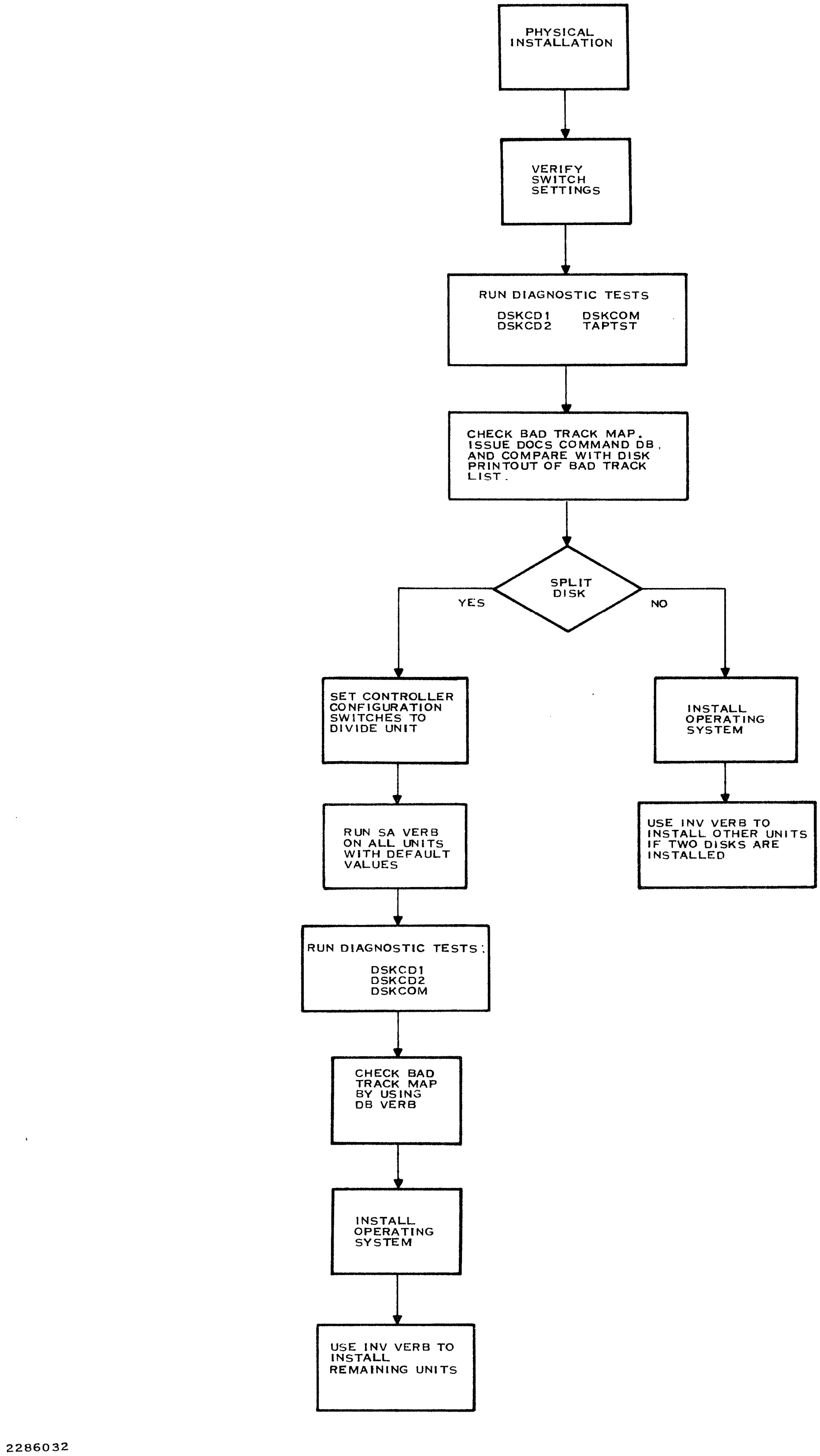

Figure 2-21 WD900 Logical Unit Installation Flowchart

2.4.4 Preparing the 990A13 Chassis for the Controller
The following paragraphs describe 990 computer preparations for the WD/MT controller. This material is abstracted from the Model 990A13 Chassis, General Description, TI part number 2308774-9701. Refer to this manual for more detailed information.

If the WD/MT controller is shipped as part of a 990 computer system, computer chassis preparation is done at the factory. The controller is assigned a slot location, the interrupt card is installed, and the TILINE access-granted (TLAG) jumpers/switches are correctly set. In this case, after the controller switch settings are verified, the hardware is compatible with the supplied software.

2.4.4.1 Selecting a Chassis Slot for the Controller. Chassis slot selection is based upon interrupt level and TILINE priority considerations. Each of the 990 packaged systems already incorporates a planned growth path that specifies preferred slot locations, interrupt levels, and TILINE base addresses for standard peripheral controllers.

Coordinate interrupt assignments and TILINE address switch settings with the operating system software by system generation (sysgen) procedures. Refer to sysgen instructions in operating system documentation upon completion of hardware installation.

2.4.4.2 TILINE Philosophy. The TILINE is a common data path that connects to all slot positions in the 990 chassis. Devices that use this bus fall into two major types: masters and slaves. Master devices address slave devices and command them to accept or transmit data. Some TILINE peripherals, including the WD/MT controller, have both master and slave logic.

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

The TLAG signal from a higher priority master enters each master on P2, pin 6. The signal leaves the master on P2, pin 5. Logic on the master allows it to block the output to lower priority masters. Jumpers are installed on the back panel to assure line continuity across slots not occupied by masters. Additional masters can be inserted at slot positions of higher or lower priority by removing the jumper between P2, pin 5 and P2, pin 6 (TLAG) for the selected slot location. Installing a board with TILINE master logic requires the following:

* The TLAG jumper (P2, pin 5 to P2, pin 6) must be opened for the chosen slot. Opening a TLAG jumper consists of physically pulling out a jumper.

* Continuity of the TLAG lines between the highest priority master and the central processor board must be preserved. This means that if an intermediate slot is assigned to a TILINE master, that master must be installed to preserve continuity and to allow the priority system to function. This also means that the jumpers must be in place for all slots not occupied by TILINE couplers or TILINE device controllers.

By convention, slot 7 is usually chosen for the system disk controller, and the TLAG jumper is removed from that location.

2.4.4.3 Slot Preparation -- 990A13 Chassis. The 990A13 unit has the TLAG jumpers accessible from the connector side of the motherboard, as shown in Figure 2-22. For this unit, perform the following steps:

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

2. Remove any circuit boards that are necessary for access by rocking the plastic ejector tabs firmly. Note the locations and orientation of the boards to reinstall them properly.

3. Remove the access-granted jumper plug for the selected location.

4. Reinstall the circuit boards in the proper locations. Check the configuration label on the chassis to ensure that the boards are installed in the correct slots.

5. Record the new slot assignment on the configuration chart affixed to the chassis.

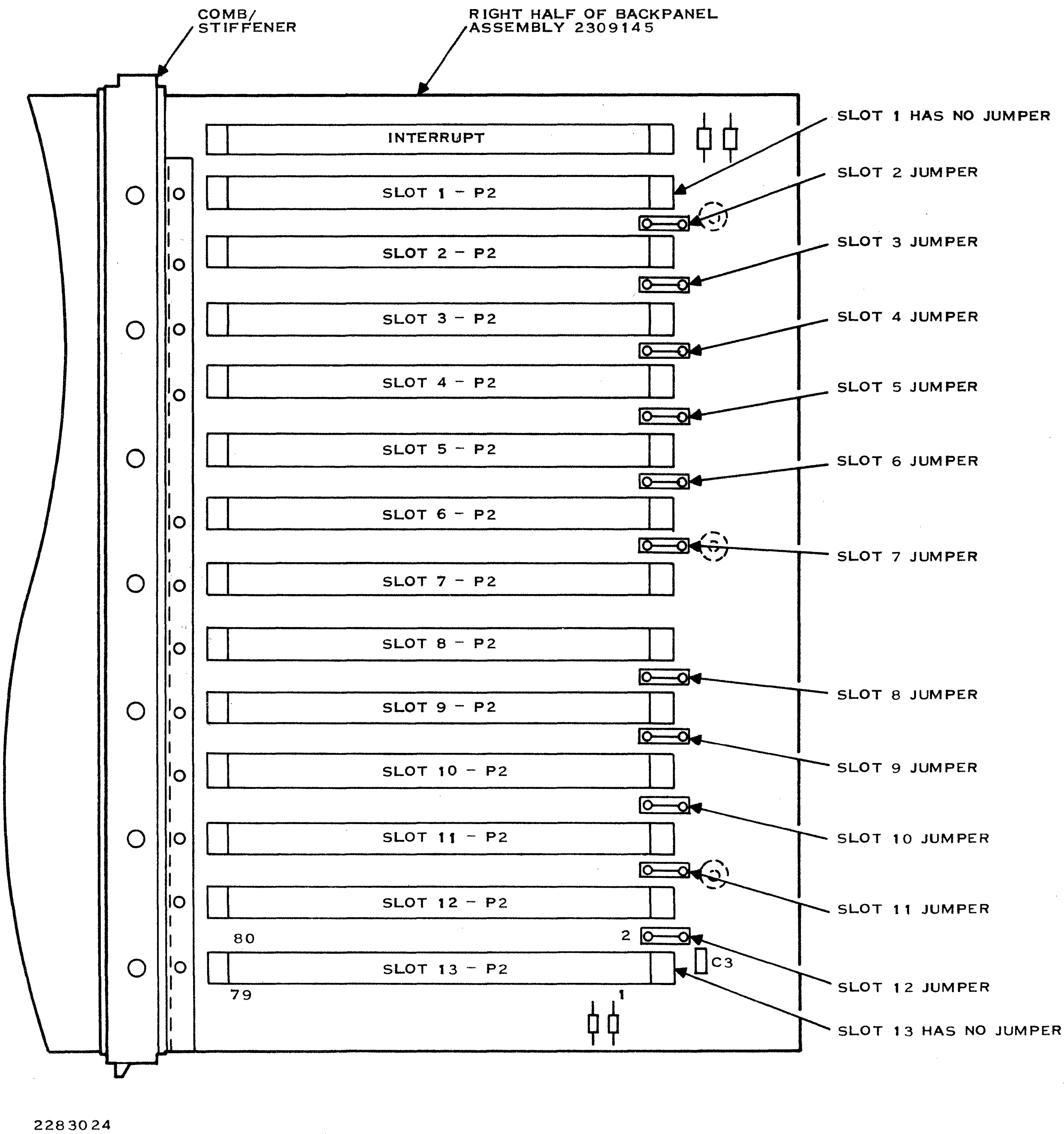

Figure 2-22 TLAG Jumper Locations for the 990A13 Chassis

2.4.4.4 Interrupt Connections. Interrupt connections to interface peripheral equipment to the 990 processor are usually made before the system is delivered to the customer. The planned growth path for the 990 systems avoids the necessity for the customer to modify interrupt levels. Preassigned slot assignments do not require modification of the plug-in interrupt board levels. Note, however, that adding a controller to a previously existing installation requires a sysgen operation to coordinate hardware and software operation.

The information in the following paragraphs is for users who must modify existing interrupt assignments.

Two versions of the interrupt board are currently available:

Interrupt Board	TI Part Number
Type 13-1	2310380-0001
Programmable interrupt kit	2309085-0001

2.4.4.5 Programmable Interrupt Kit. You can set up the interrupts to meet your own special requirements with a programmable interrupt kit, TI part number 2309085-0001, as shown in Figure 2-23.

NOTE

TILINE interrupt 13 is the standard interrupt for a disk designated as the system disk. Use TILINE interrupt 9 for a tape unit if it is used for system initializing via the loader ROM.

A programmable interrupt kit includes an interrupt circuit board with cold-contact terminals, a length of Teflon(TM)-insulated #26 AWG solid wire, and a small plastic adapter tool for inserting wires into the terminals. Refer to the Model 990A13 Chassis, General Description, TI part number 2308774-9701, for more information about the interrupt card

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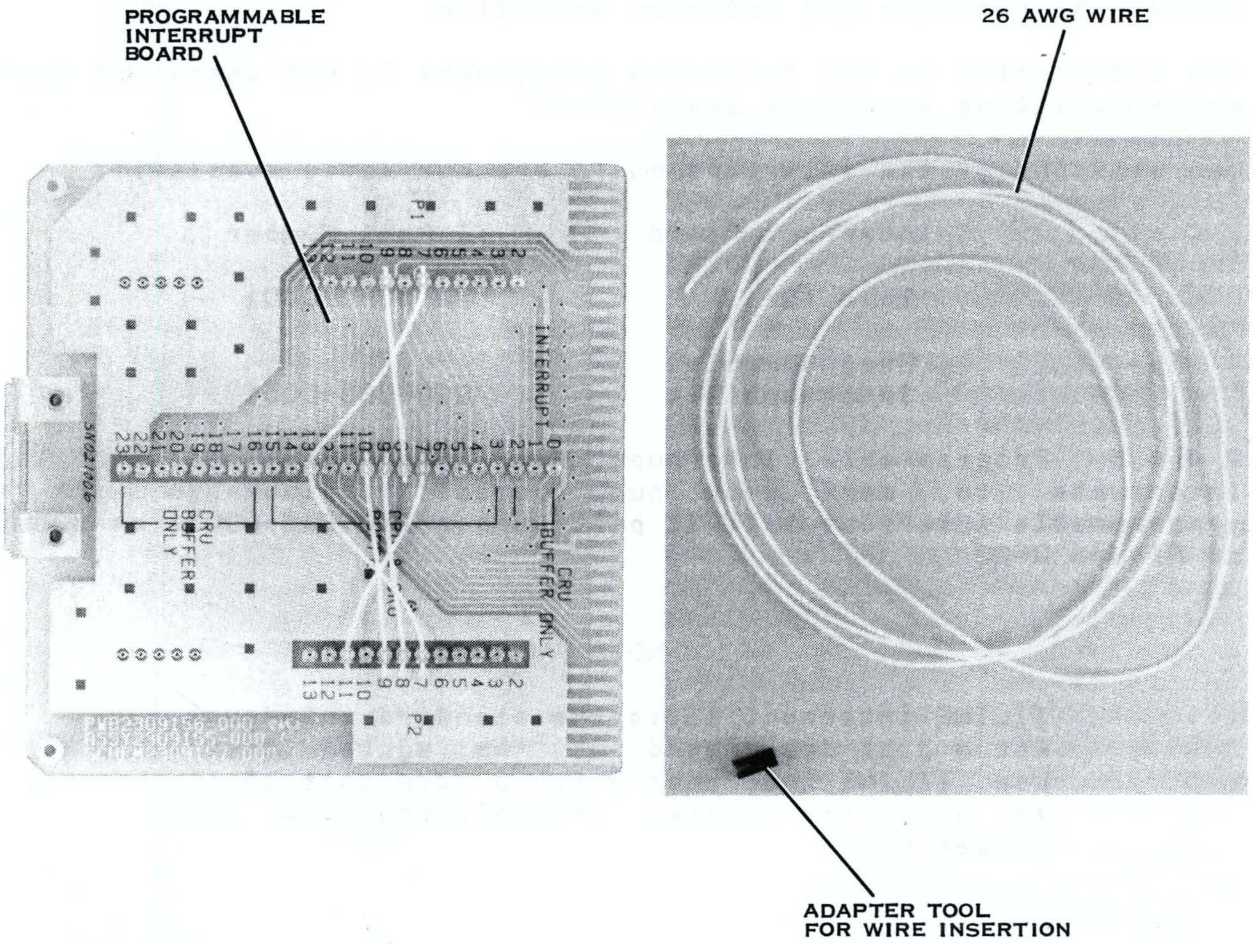

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Figure 2-23 Programmable Interrupt Kit

2.4.5 System Cabling Configurations
The following paragraphs describe the cabling information for the WD/MT controller, the WD900 drive, and the MT3200 tape unit. Figure 2-24 shows a cable block diagram for a system with two WD900 drives, one MT3200 tape drive, and one WD/MT controller.

2.4.5.1 WD900 Cabling. The I/O cables for the WD900 are designated as A and B cables. The I/O A cables can connect in a daisy-chained configuration as shown in Figure 2-8 for two drives. The daisy chain requires a terminator resistor pack on the second drive in the chain.

The following discussion of the I/O configurations describes the interface of more than one drive to the controller.

The daisy-chained configuration has individual B cables going from the controller to each drive. However, a single A cable connects the controller to the first drive. Another A cable goes from the first drive to the second drive, and the second drive has a terminator installed.

The length of the cable can influence system layout. The maximum length for each B cable is 15.3 meters (50 feet). The cumulative A cabling in a daisy-chained system cannot exceed 30.6 meters (100 feet) in length. Refer to the parts list in Appendix A for part numbers.

2.4.5.2 MT3200 Cabling. Refer to paragraph 1.3.1.9 for information on the cabling for the MT3200. The MT3200 does not support a daisy-chained configuration.

2.4.5.3 Grounding. Safety ground, system ground, and connecting the drive power cord to a grounded outlet establish a common ground between the WD900 drives, the MT3200 tape, power supplies, and the controller.

A safety ground must be provided by the site ac power system. The green (or green and yellow striped) wire in the power cord from the drive provides the safety ground connection between the power supply and the site power system. In turn, the site ac power system must tie the safety ground to earth ground. All site ac power connection points, including convenience outlets for test equipment, must be maintained at the same safety ground potential.

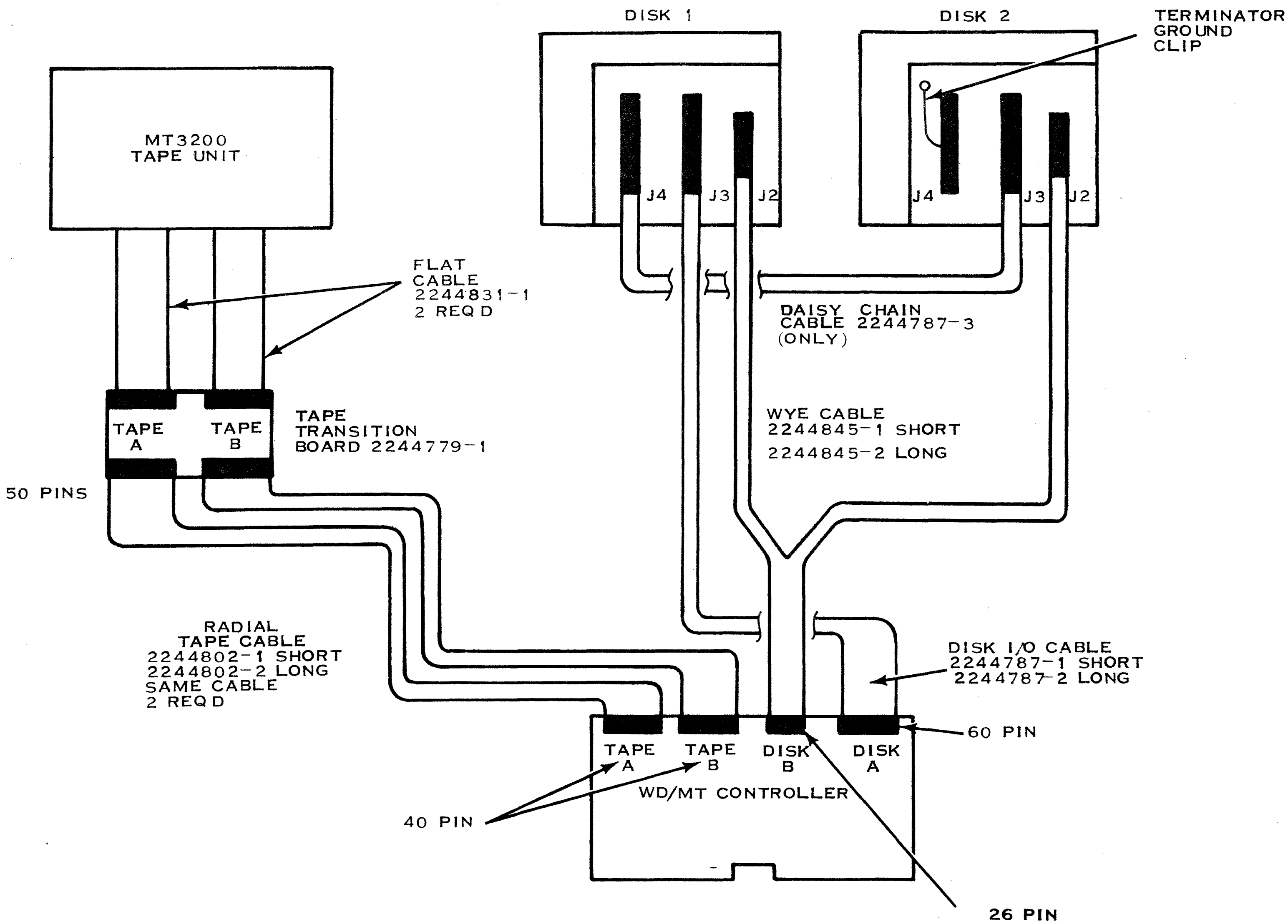

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Figure 2-24 System Cabling Block Diagram

2.4.6 Power-Up Procedure

The following paragraphs and procedures demonstrate how to power up the WD900 disk drive and the MT3200 tape drive.

2.4.6.1 WD900 Power-Up Procedure. The following procedure describes how to power up the drive. It is assumed that dc power is available to the drive because power supply circuit breaker CB1 is normally left in the ON position.

1. Press the START switch to engage the drive. If the LOCAL/REMOTE switch is set in the LOCAL position, the power-up sequence begins immediately. If it is set in the REMOTE position, the power-up sequence continues when the power sequence ground is available from the controller. In the REMOTE position, the power-up sequence to each drive is delayed. The length of delay is determined by the number of the unit logic plug used, in increments of five seconds. For example:

   Logic Plug 0 = 0-second delay
   Logic Plug 1 = 5-second delay

2. After the delay is completed, the ready indicator (located in the START switch) flashes. This indicates that a power-up is in progress.

3. Observe that the ready indicator lights steadily within 30 seconds, indicating that the disk is up to speed and the heads are loaded.

4. Ensure that the fault indicator is off.

The power-up sequence is now complete, and the drive is ready to read or write data.

2.4.6.2 MT3200 Power-Up Procedure. Section 1 contains a detailed description of all the controls. To check for proper operation before installation, proceed as follows:

1. Connect the power cord.

2. Clean the tape path as directed in paragraph 4.3.3.6.

3. Apply power to the unit and verify that the unload indicator is illuminated. (Allow for normal delay of 5 seconds.) For other indications refer to paragraph 4.3.3.3 and paragraph 4.3.3.5.

4. Ensure that the tape is wound completely onto the reel.

CAUTION

The top cover and front panel door are locked during tape-loading functions. Any attempt to open either the top cover or front panel door before the tape is unloaded results in mechanical damage to the locking mechanism.

5. Open the front panel door by pressing down gently on the top (center) of the door.

6. Insert the tape into the front panel of the unit with the write-enable ring side down.

7. Close the front panel door.

8. Actuate the LOAD switch. The access doors are now locked. When the load sequence is completed, the load indicator remains illuminated.

9. Allow the transport to cycle tape for a sufficient length of time to ensure proper servo operation. The unit requires about 30 minutes to make a full pass on a 10.5-inch reel and complete a rewind sequence.

NOTE

Refer to Service Aid 22 (Tape Installed) in the Cipher Data Products Operation and Maintenance manual for more information on steps 9 and 10.

10. Check that the load indicator remains illuminated following a rewind sequence.

11. Check the ONLINE switch and indicator by pressing repeatedly, and observing that the online indicator is alternately illuminated and extingushed. Leave the drive in the offline state (indicator extinguished).

12. Press the UNLOAD switch. When the tape is unloaded (unload indicator illuminated), open the front panel door and remove the tape reel. Close the front panel door.

13. Switch the power off and remove the power cord from the outlet.

The power-up sequence is now complete, and the tape is ready for use.

Section 3

Programming

3.1 INTRODUCTION

This section contains information necessary for an assembly language programmer to write device service routines (DSRs) that communicate with the WD900 disk drive and the MT3200 tape unit. The programmer must be familiar with assembly language as described in the Model 990 TMS9900 Microprocessor Assembly Language Programmer's Guide or the Model 990/12 Computer Assembly Language Programmer's Guide.

Most users prefer the Texas Instruments standard operating system software that includes DSRs and features standardized file manipulation schemes that are essentially independent of I/O device type. These users should refer to the applicable operating system reference manual. Users who want to perform direct disk I/O operations without a standard operating system DSR can initiate disk commands and receive disk status as described in this section.

This section is organized as follows:

* Communication between the disk and the CPU using the TILINE

* Communication between the tape and the CPU using the TILINE

* Basic programming of the controller, including command descriptions, disk operation, tape operations, and command completion

* Control and status word formats and descriptions

* Detailed command descriptions with example command formats and status word formats

3.2 TILINE COMMUNICATION

The TILINE is an asynchronous 16-bit parallel data bus that transfers data between high-speed system elements such as the 990 main memory, 990 CPU, and the WD/MT controller. There are two classes of controllers that interface to the TILINE: the TILINE master controllers, which initiate data transfers, and TILINE slave controllers, which transmit or receive data in response to a master controller's request. A system with masters and slaves is configured so that only one master controller has control of the TILINE input/output (I/O) lines and only one slave controller recognizes a particular address. The WD/MT controller has both master and slave controllers. The controller is assigned two blocks (one for the disk and one for the tape) of four TILINE memory addresses, and these memory locations reside on the controller board. The 990 processor communicates with the controller by writing 16-bit command words into the eight disk or tape TILINE addresses. After a disk or tape operation is completed, the controller replaces the control words with status words, and the 990 processor can read the words in these same memory locations to determine disk or tape status. Controller operations are initiated when control words containing initialization parameters, operation parameters, and command codes are written into the memory locations assigned to the controller. After initialization, the controller acts independently of the 990 processor and transfers data between specified TILINE memory locations and the disk as required by the command. Any computer instruction that reads or modifies general memory can be used to communicate with the controller.

3.2.1 TILINE Addresses

Standard conventions built into the hardware and software of the Model 990 computer reserve CPU byte addresses >F800 to >FBFF for control and status communication with TILINE peripheral controllers, such as the WD/MT controller. This range is called the TILINE peripheral control space (TPCS). Addresses in this range can be mapped by the processor hardware to TILINE addresses in the range >FFC00 to >FFDFF. This mapping requires the 990 processor to operate either unmapped or in map file 0. The TPCS also can be addressed through alternate map files if the mapping bias value is chosen to yield the correct TILINE address. This programmable mapping feature is standard on some 990 CPUs and optional on others. This feature allows effective use of the entire TILINE address space rather than just the lower 32K words. Depending on the values in the map file registers, memory can be addressed anywhere in the TILINE address space (assuming a memory board exists at that address).

The physical TILINE bus includes 20 address lines; however, each CPU byte address consists of 16 bits. When a CPU byte address falls within the TPCS, all 1s are loaded automatically into the upper five bits of the TILINE address, and the least significant bit (LSB) is dropped. This LSB is a byte selector that is used only within the CPU. The remaining 15 bits form the lower 15 bits of the TILINE address. Figure 3-1 shows the conversion of a 16-bit CPU byte address to a 21-bit TILINE word address. One way to visualize this conversion is to think of a 21-bit TILINE byte address of >1FF800 that loses its LSB to become TILINE word address >FFC00. The 1F comes from the five 1s, and the >F800 comes from the original CPU byte address. The only part of this address accessible to the programmer is the CPU byte address, >F800.

The eight addresses of each controller interface are assigned to the controller from a base address to a base address plus 7 word address. The base address is dedicated to control and status word 0 (W0). Base address plus 1 is dedicated to word 1 (W1) continuing through base address plus 7, dedicated to word 7 (W7).

The base address for each interface is selected by one eight-section switch on the controller board (refer to Table 2-4), allowing multiple controllers in one system. Base address selection must be coordinated with the operating system software. Refer to Section 2 of this manual for instructions on setting the base address switches.

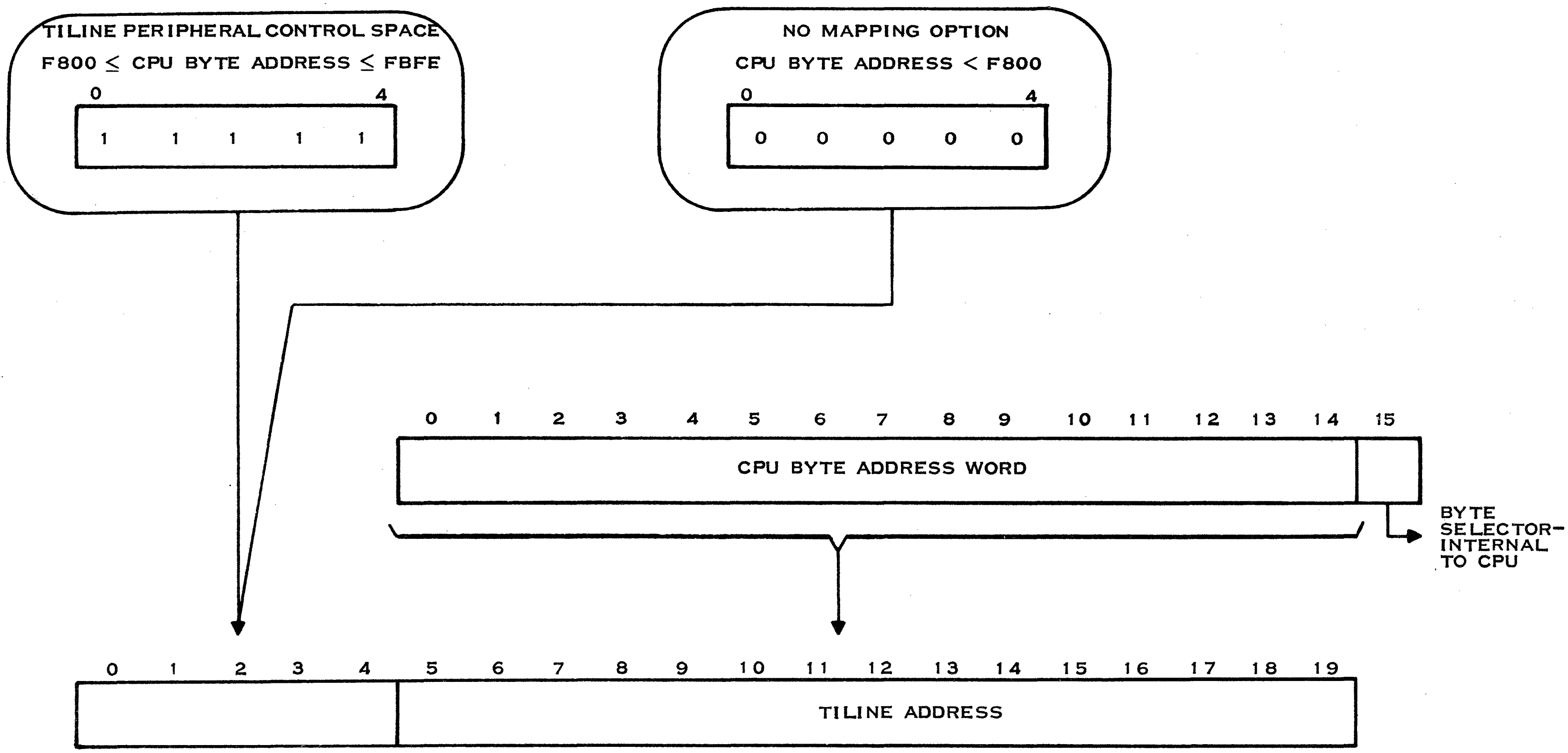

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Figure 3-1 Relationship Between TILINE Address and CPU Byte Address

3.3 CONTROLLER COMMAND DESCRIPTIONS (DISK SECTION)

Commands sent to the WD/MT controller from the CPU cause the controller to perform any of the following nine basic disk system operations.

* Store Registers. A Store Registers command causes the controller to return certain critical drive parameters, such as words per track and cylinders available per drive unit, to the CPU.

* Write Format. The Write Format command formats a new disk (or reformats a disk previously in operation) with identification (ID) words (which make up the header), fixed data in the data field, an error-checking character (ECC), and the required gaps. The write format operation must be performed before using any unformatted disk media. One complete track is formatted per command.

* Read Data. The Read Data command transfers data from a specified disk location to a specified location in TILINE memory.

* Write Data. The Write Data command reads data at a specified TILINE memory location and records this data at a specified location on a previously formatted disk.

* Unformatted Read. There are two Unformatted Read command operations. The Unextended Unformatted Read command returns certain disk drive parameters to the software, which ensures compatibility with some existing operating systems that obtain these parameters by reading header information. The Extended Unformatted Read command, on the other hand, reads a specified number of words from the disk without regard to formatting, and is used primarily for diagnostic purposes.

* Unformatted Write. The Unformatted Write command writes data from TILINE memory onto the disk without regard for existing record boundaries and is used primarily for diagnostic purposes.

* Restore. The Restore command reinitializes the cylinder counter and repositions the heads of the selected drive over cylinder zero. This operation clears certain disk error conditions.

* Seek. A Seek command is used to position the read/write head over a track that is to be read or recorded. Since the seek operation is a relatively slow mechanical operation, the CPU can issue a Seek command to a particular drive to prepare it for a later data transfer without having to wait for the seek operation to complete. In addition, data transfers that use other drive units in a daisy chain can occur while this seek operation is executing. When the seek operation is completed, the controller can generate an interrupt to signal the CPU that a drive is ready for data transfer. However, since mapped drives contain two (or more) logical units that share a common read/write head, preseek operations are not supported. Overlapping seek operations can be used effectively on direct (unmapped) drives in the expanded emulation mode.

* Self-Test. The controller incorporates extensive self-test routines that can be used to locate many controller faults.

3.4 PROGRAMMING THE CONTROLLER (DISK SECTION)

The eight control and status words that the CPU uses to communicate with the controller contain the following information:

* Word 0 (W0), Disk Status -- Contains disk status codes for the selected drive, and attention bits and attention mask bits for generating interrupts

* Word 1 (W1), Command and Surface Address -- Contains command codes, head address, and several control bits used during certain data recovery operations

* Word 2 (W2), Record Format and Sector Address -- Determines the number of sectors per record and the address of each sector

* Word 3 (W3), Cylinder Address -- Contains the cylinder address

* Word 4 (W4), Byte Count -- Specifies the number of bytes to be transferred between the disk and CPU memory

* Word 5 (W5), LSB Memory Address -- Contains the 15 LSBs of the 20-bit TILINE memory address

* Word 6 (W6), Select and MSB Memory Address -- Contains drive select codes and the five MSBs of the twenty-bit TILINE memory address

* Word 7 (W7), Controller Status -- Contains controller status codes, the interrupt enable bit, and the idle/busy bit

To initiate a controller operation, the program loads the control words into the on-board memory addresses assigned to the controller. W7 must be the last control word; otherwise, the order in which the control words are transmitted is not important. This is because the controller immediately begins to perform the operation specified by the control words as soon as controller location W7 is loaded with a word that has bit 0 set to zero.

Transmitting a new set of control words to the controller destroys the status words from the previous operation, except for the disk status fields of W0. Word 0 disk status fields are set by the disk drive and cannot be modified by overwriting with a new control word. If overwriting is attempted, the controller ignores the bits placed in the W0 disk status fields.

If the CPU attempts to send a control word to the controller after an operation is initiated, the attempt is completed normally, but the controller ignores the control word.

Any status word read from a busy controller is a simulated W7 word in which bit 0 is a zero (busy) and bits 1 through 15 are meaningless. This word is returned regardless of the status word requested. This feature allows the controller to be polled for idle/busy status without interfering with any on-going controller operations.

Before writing a command to the controller registers, verify that W7, bit 0 of the controller (controller idle) is set. If W7, bit 0 is set, the command can write to the controller registers. Note that the controller is not busy until it receives a command.

3.4.1 Command Completion

An interrupt enable bit in W7 allows the programmer to specify if the controller will generate an interrupt to the CPU upon completion of an operation. The disk controller can be used with either an interrupt-driven or a polled DSR. The following paragraphs discuss these options.

3.4.1.1 Command Completion Without Interrupts. To check command completion or controller availability in a polled system, you must read status W7, bit 0 for an idle status. The controller is idle and available for commands if W7, bit 0 is equal to 1. In a normally completed operation, W7, bit 1 is set to 1. If an error occurs during operation, W7, bit 2 is set to 1. Read other status words to obtain more detailed status information.

Usually, the program initiates a timing loop when controller operation begins, and checks the idle bit at timer expiration. If the idle bit is still zero, the timer can be restarted and the sequence repeated a preselected number of times. This method requires more program overhead than the interrupt-driven approach.

If a Restore or Independent Seek command is initiated, the disk may not be ready after the controller reports a completion. To determine if the disk completed a Restore or Independent Seek command, the program checks the drive status bits of W0. If the disk drive completes its operation and the correct drive is selected, either the seek incomplete line is set, or the not ready bit is inactive. If the attention line of the selected drive is set, the drive has completed its operation.

3.4.1.2 Command Completion With Interrupts. The controller can issue two types of interrupts to the computer. One type of interrupt is issued when the controller completes a command, and the other type is issued when the disk drive completes a seek or restore operation.

3.4.2 Command Completion Interrupts

The interrupt enable bit (W7, bit 3) must be set when an operation is initiated. This bit is set in order to have the controller issue an interrupt to the 990 processor upon command completion. When the controller returns to idle, the interrupt is issued to the CPU. This interrupt is cleared by resetting the interrupt enable bit (W7, bit 3) or the appropriate completion bit (complete W7, bit 1, or error W7, bit 2).

3.4.2.1 Seek and Restore Complete Interrupts. Control word 0 contains four attention lines (one for each of the four disk drive unit addresses) and four attention mask lines. The attention line for each drive is set when the seek operation is complete for that drive. When the attention bit and mask bit for any drive are both set, the interrupt line to the computer is also set.

The programmer can set or reset the mask bits by using any of the computer memory instructions. However, the computer cannot set or reset the attention bits directly. The attention bits are set by the controller to indicate current disk status.

To use the seek and complete interrupts, first issue a Seek or Restore command to the controller. When the controller reports the command completion (by a controller idle or command completion interrupt), set the mask bit that corresponds to the desired drive. When the drive finishes the seek operation, an interrupt is issued to the CPU. This interrupt can be cleared by resetting the mask bit corresponding to the drive that requested the interrupt. All disk controller interrupts are reset when the controller switches from an idle to a busy condition.

3.5 WD900 CONTROL AND STATUS WORDS

The control and status words described in this section are used for both operating the controller and reporting disk system status. As described earlier, the CPU can write control words into device control registers (DCRs) to initiate operation, and can read status words in those registers to determine disk status after an operation has completed. Some bits in the registers are used only for disk operation control, some only for status reporting, and some for both control and status. Table 3-1 gives an overview of the TPCS registers and Table 3-2 through Table 3-9 describe each of these registers in more detail.

Table 3-1 WD900 TPCS Registers (Device Control Registers)

Bit:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
REG. 0	Off Line	Not Rdy	WRT PRT	UN-SAF	End Cyl	SK Inc	SP	PC	Attn Lines 0	1	2	3	Attn Mask 0	1	2	3
REG. 1	Ext A	Ext B	STB EAR	STB LAT	TIH	Command			OFF SET	OFS FWD	Head Address					
REG. 2	Sectors/Record								Starting Sector Address							
REG. 3	Cylinder Address Self-Test/Extended Status Cmd.								Return Extended Status							
REG. 4	Transfer Byte Count															0
REG. 5	TILINE Address (LSB)															0
REG. 6	Spare 0	0	0	0	Drive Select 0	1	2	3	Spare 0	0	0	TILINE Address (MSB)				
REG. 7	IDLE	OP CMP	ERR	INT ENB	LOK OUT	RET	ECC	ABN CMP	MEM ERR	DAT ERR	TL TO	ID ERR	RT ERR	CMD TMR	SER ERR	UT ERR
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

3.5.1 WO -- Disk Status

Control word WO is used to enable/inhibit the attention interrupts, to determine which drive initiated an attention interrupt, and to determine the status of the selected drive. Table 3-2 defines the bit assignments for WO on the WD900 drive. Bits 0 through 6 contain the individual status indicators for the selected drive.

Table 3-2 WO -- Disk Status

Bit	Description
0	Offline -- The selected drive is either not powered up or is not at the proper speed.
1	Not Ready -- The selected drive is either offline or performing a seek or restore operation.
2	Write Protect -- The selected drive is write-protected and no format information or data can be written on the disk.
3	Unsafe -- The selected drive is in an unsafe condition, indicating a fault that prevents normal disk operation. A Store and Restore command clears unsafe status if the unsafe condition no longer exists.
4	End of Cylinder -- This bit indicates that the head address exceeds the maximum allowable head number for the specific drive.
5	Seek Incomplete -- The head carriage failed to locate the specified cylinder. A restore operation and a retry is required to recover.
6	Not used -- This bit is not used and is set to 0.
7	An unsafe condition exists because of the following: * The drive lost power * The drive sequencing finished * The cable to the host CPU is disconnected This bit is reset by a Restore command.

Table 3-2 W0 -- Disk Status (Continued)

Bit	Description
8-11	Attention Lines (0-3) -- The attention line for a drive is set unless the drive is performing a seek or restore operation. The attention lines notify the 990 processor when seek and restore operations are complete.
12-15	Attention Interrupt Mask (0-3) -- An interrupt to the 990 is generated if the attention mask bit and its corresponding attention bit are both set and the controller is idle. Set the mask bits corresponding to the drive unit (after the command is issued and the controller is idle) to detect completion of a seek or restore operation.

3.5.2 W1 -- Format and Command

Control word W1 contains command codes, head addresses, and control bits that are used during certain data operations. Table 3-3 defines the bit assignments for W1 of the WD900 drive.

Table 3-3 W1 -- Command Code and Surface Address

Bit	Definition
0-1	Extended Commands A and B -- The three command code bits (5-7) allow up to eight unique commands. The extended mode bits (bits 0 and 1) are interpreted as additional command code bits.
2	Strobe Early -- Enables a strobe early condition.
3	Strobe Late -- Enables a strobe late condition.
4	Transfer Inhibit -- Inhibits transfer of data to the TILINE interface during read operations. This function allows a check on the integrity of a record without providing a memory buffer area to hold the data. When data is read by the controller, ECC verifies the data written to the disk.

Table 3-3 W1 -- Command Code and Surface Address (Continued)

Bit	Definition
5-7	Command -- The normal and extended command codes are:

Extended Mode Bits 0	Extended Mode Bits 1	Command Code Bits 5	Command Code Bits 6	Command Code Bits 7	Command
0	0	0	0	0	Store Registers
0	0	0	0	1	Write Format
0	0	0	1	0	Read Data
0	0	0	1	1	Write Data
0	0	1	0	0	Unformatted Read(1)
0	0	1	0	1	Unformatted Write
0	0	1	1	0	Seek(2)
0	0	1	1	1	Restore
1	0	0	0	0	Store Registers(3)
1	0	0	0	1	Write Format(3)
1	0	0	1	0	Read Data(3)
1	0	0	1	1	Write Data(3)
1	0	1	0	0	Unformatted Read
1	0	1	0	1	Unformatted Write(3)
1	0	1	1	0	Seek(2,3)
1	0	1	1	1	Self-Test(4)
1	1	0	0	1	Absolute Write
0	1	0	0	1	Relocate
0	1	1	0	0	Surface Analysis Assist

Bit	Definition
8	Head Offset -- This bit is set when data is read from the disk with the head offset (forward or reverse).

NOTES:

1. This command does not actually do an unformatted read. Refer to paragraph 3.6.1.5 for details.

2. Seek commands are ignored in some instances. Refer to paragraph 3.6.1.7.

3. For compatibility with other drives, do not use these particular extended commands. Use the normal commands that perform identical operations.

4. The controller contains self-test microdiagnostics. Refer to paragraph 3.6.2.2.

Table 3-3 W1 -- Command Code and Surface Address (Continued)

Bit	Definition
9	Head Offset Forward -- This bit is set if bit 8 is set and if data is read from the disk with the head offset forward. Bit 9 is not set if data is read with the head offset reverse.
10-15	Head Address -- This selects the read/write head and the associated cylinder surface. The head selection codes are as follows:

	Head Select Bits					
Head	10	11	12	13	14	15
0	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
5	0	0	0	1	0	1
6	0	0	0	1	1	0
7	0	0	0	1	1	1
8	0	0	1	0	0	0
9	0	0	1	0	0	1
10	0	0	1	0	1	0
11	0	0	1	0	1	1
12	0	0	1	1	0	0
13	0	0	1	1	0	1
14	0	0	1	1	1	0
15	0	0	1	1	1	1
16	0	1	0	0	0	0
17	0	1	0	0	0	1
18	0	1	0	0	1	0
19	0	1	0	0	1	1
20	0	1	0	1	0	0
21	0	1	0	1	0	1
22	0	1	0	1	1	0
23	0	1	0	1	1	1

3.5.3 W2 -- Record Format and Sector Address

Control word W2 determines the number of sectors per record and the address of each sector. Table 3-4 defines the bit functions of W2.

Table 3-4 W2 -- Record Format and Sector Address

Bit	Definition
0-7	Sectors per Record -- These bits are ignored by the controller since the recording format is always one sector per record.
8-15	Starting Sector Address -- These bits select the starting sector address for all reads and writes except for a write format. Write format does not require a starting sector address. A starting sector address larger than the maximum sector address causes a command time-out, because the controller cannot locate the address at which to start executing the operation.

3.5.4 W3

Control word 3 is used to specify maintenance commands and to select the cylinder address for read and write operations.

3.5.4.1 W3 -- Cylinder Address. W3 selects the cylinder address that the disk seeks for a read or write operation. The valid range of addresses is 0 through maximum number of cylinders less 1 in hexadecimal. The number of cylinders on a 425-megabyte drive is 693. The number of cylinders on a 138-megabyte drive is 805. An invalid cylinder address terminates the current operation, and the unit error (UE) controller status (control W7) is set. The disk status (control W0) indicates a seek incomplete (SI) status. This field is also used during self-test. The most significant byte specifies test numbers, and the least significant byte returns the current revision level of the ROMs used in the disk section of the controller.

The combination of the head address in W1, the sector address in W2, and the cylinder address in W3 forms a complete address that locates a record on the disk. Table 3-5 shows the bits of a cylinder address.

Table 3-5 W3 -- Cylinder Address

Bit	Definition
0-15	Cylinder Address -- Bit 15 is the least significant and bit 0 is the most significant.

3.5.4.2 W3 -- Maintenance Commands. When the extended mode bit 0 of W1 is set to one and the primary command field of W1 (bits 5-7) is set to FF hexadecimal, W3 bits 0 through 7 are a maintenance command field. In this mode the W3 bits are defined as follows:

Table 3-6 W3 -- Maintenance Commands

Bit	Definition
0	Loop bit -- When this bit is set to one, the specified self-test command is repeated until a reset is received. This function gives the system a scope loop capability.
1	Controller bit -- When this bit is set to one, the controller intercepts the command.
2-7	Maintenance command bits -- These bits specify the individual maintenance commands. Refer to the <u>TILINE Peripheral Bus Interface Depot Maintenance Manual</u> for a complete list and explanation of the maintenance commands and error codes.

3.5.5 W4 -- Transfer Byte Count

W4 sets the number of 8-bit data bytes to be transferred between the disk and the TILINE. The specified number of bytes for transfer must be even (bit 15 is always set to 0). The byte count range is limited by the available TILINE memory and the 64K byte maximum specified in the control word. An attempt to transfer to or from nonexistent TILINE memory results in a TILINE time-out (TT) controller status. Table 3-7 shows the bits of the transfer byte count.

Table 3-7 W4 -- Transfer Byte Count

Bit	Definition
0-15	Transfer Byte Count -- The byte count must be an even number (bit 15 set to 0). If a read with transfer inhibit is selected, the transfer byte count specifies the number of logically sequential bytes on the disk that must be checked.

3.5.6 W5 -- LSB Memory Address

The TILINE starting address is 20 bits in length. The 15 LSBs occupy bits 0 through 14 of control W5. The five MSBs are located in control W6. The 20 bit TILINE address specifies the start of the buffer address space. The controller accesses memory starting at the specified TILINE address and increments for the specified word count (byte count/2). For a read operation, the software must allocate a contiguous area in TILINE memory that is large enough to accept the data transfer without overwriting other regions of memory. The byte count and starting address must be specified in the control words. Table 3-8 shows the bits for W5.

Table 3-8 W5 -- LSBs Memory Address

Bit	Definition
0-15	Starting Memory Address, LSBs -- The TILINE starting memory address is 20 bits in length with the 15 LSBs contained in bits 0-14 of W5. Bit 15 is always held at 0. The 5 MSBs are in W6.

3.5.7 W6 -- Unit Select and MSB Memory Address

W6 contains the unit select bits and the MSBs of the TILINE buffer memory. Bits 0 through 3 and 8 through 10 are reserved and should be set to 0. Table 3-9 defines the bits of W6.

Table 3-9 W6 -- Unit Select and MSB Memory Address

Bit	Definition
0-3	Not used.
4-7	Position-coded unit select field. Only one bit position in this field can be set to 1. Any code with two or more positions set to 1 causes an offline status to be reported and no drive operations are performed. A 100 microsecond time delay is required after the unit select field is changed before the status information in W0 in updated for the newly selected unit. The valid unit select codes are listed below.

W6 Bits 4	5	6	7	Unit Selected
1	0	0	0	0
0	1	0	0	1
0	0	1	0	2
0	0	0	1	3

Bit	Definition
8-10	Not used.
11-15	Starting TILINE memory address MSB. These are the five MSBs of the 20-bit TILINE starting memory address. Refer to the W5 description for more information.

The controller supports up to two physical drives. Each drive can be divided into two logical units, making it possible to have a maximum of four addressable units. Units are numbered consecutively with no holes in the numbering scheme. For example, if three units are supported, the units are numbered unit 0, unit 1, and unit 2. A unit would not be numbered unit 3 because one of the lower numbers would be skipped.

3.5.8 W7 -- Controller Status

W7 contains control bits from the 990 processor at the beginning of an operation and contains controller status data at the completion of an operation.

NOTE

W7 is the last word loaded during operation setup. This is because the idle/busy bit (W7, bit 0) initiates controller operation when forced low by the processor. W7 must be the first status word checked after an operation.

Table 3-10 defines the functions of the W7 bits.

Table 3-10 W7 -- Controller Status

Bit	Definition
0	Idle -- The controller is idle when this bit is 1. The host can read and write into the registers only when bit 0 is set to 1. The host sets this bit to zero to activate any command. The command activated is contained in W1, bits 5 through 7. The TPBI sets this bit to 1 when command execution is complete, either normally or as a result of an error condition. The TILINE interrupt for each slave set is active only when bit 0 is set to 1.
1	Complete -- This bit is set when the controller completes a command without error. Setting this bit to zero clears the command complete interrupt, if enabled by bit 3.
2	Error -- This bit is set if an error is detected. W7 bits 7-15 and W0 bits 0-7 provide more detailed error information.

Table 3-10 W7 -- Controller Status (Continued)

Bit	Definition
3	Interrupt Enable -- This bit must be set to enable the controller to generate an interrupt when a command completes either idle and complete or error. Note that if the interrupt enable bit is set while the controller is idle and the complete or error bit is set, an interrupt is generated immediately. Attention interrupts in W0 are independent of this interrupt enable bit.
4	Always 0.
5	Retry -- This bit is set when the controller performs a re-read operation because of a data error.
6	ECC Corrected -- This bit is set when the controller corrects data within its buffer during a read operation.
7	Abnormal Completion -- This bit is set if a disk operation is terminated due to either an I/O reset, a TILINE power-failure warning, a TILINE power reset, or a Write Format or an Unformatted Write command that is issued with the format enable switch set to disable.
8	Memory Error -- This bit is set if a TILINE memory error is detected during a disk write. Data transfer is terminated when a memory error is detected.
9	Data Error -- This bit is set if an uncorrectable ECC error is detected during a read operation.

Table 3-10 W7 -- Controller Status (Continued)

Bit	Definition
10	TILINE Time-Out -- This bit is set if the 50-microsecond timer on the controller expires before the completion of any TILINE cycle. A common cause of time-out is an attempt to read or write to a nonexistent memory.
11	Header Error -- This bit is set if an ID word comparison error occurs during an ID verification of ID words 1, 2, 3, and ECC checking. If bit 9 is also set, it indicates an ECC data error in the sector read. This error causes command termination.
12	Rate Error -- This bit is set if the TILINE is not able to keep up with the disk. The data buffer prevents this error from occurring.
13	Command Time-Out -- This bit is set if the controller fails to complete an operation before the command timer expires. The timer is started at the following times: when a seek operation is performed, when a head address is set or incremented, when the controller is at the beginning of the idle routine, after each successful sector read or write, and during execution of the disk drive power-up sequence.
14	Search Error -- This bit is set if the controller does not detect a synchronization character within one physical sector during a read operation. If either the internal or external ECC inhibit flag is set, a search error status is reported and the command is aborted.

Table 3-10 W7 -- Controller Status (Continued)

Bit	Definition	
15	Unit Error -- This bit is set if an operation is terminated due to a disk drive error. The causes of a unit error depend on the command being performed when the error occurs. Listed below are the commands and the causes of the command termination.	
	Terminated Command	Possible Causes
	Restore	Unit offline
	Unextended Unformatted Read	Unit offline, not ready, unsafe, seek incomplete, or offset active
	Write Data, Write Formatted, Unformatted Write, Absolute Write Format, Relocate	Unit offline, not ready, unsafe, seek incomplete, offset active, or write protected
	Read Data, Extended Read Unformatted	Unit offline, unsafe, seek incomplete, offset active, or not ready
	Seek (performed by the selected drive), as well as operations performed as part of other read or write commands	Unit offline, unsafe, seek incomplete, or offset active

3.6 DETAILED WD900 CONTROLLER COMMAND DESCRIPTIONS

The following are the normal and extended disk controller command descriptions.

3.6.1 Normal Commands

Store Registers, Write Format, Read Data, Write Data, Unformatted Read, Unformatted Write, Seek, and Restore are the normal commands of the controller.

3.6.1.1 Store Registers Command. The Store Registers command allows the operating system software to determine critical disk parameters such as words per track and cylinders available per drive unit. This command causes the controller to send one, two, or three words to the 990 memory from the disk system. The Store Registers command starts at the memory address specified in W5 and W6, and is specified by the word count in W4. The three words contain the following information:

* W1 -- W1 contains the total number of unformatted words that can be recorded on a disk track.
* W2 -- Bits 0 through 7 of W2 specify the number of sectors per track, and bits 8 through 15 specify the number of bytes of overhead per sector.
* W3 -- Bits 0 through 4 of W3 specify the number of tracks per cylinder, and bits 5 through 15 specify the number of cylinders per drive.

3.6.1.2 Write Format Command. The Write Format command formats a new disk or reformats existing media. One complete track is formatted per command. After receiving all command words, the controller verifies correct disk status (offline, not ready, unsafe, write protect, offset active, or seek incomplete), seeks the specified cylinder, and sets the specified head address. A verify ID and an ECC are performed after the seek. Relocation from a bad track to a spare track is allowed when the spare track is formatted. The track is formatted if the verify ID fails due to a data error or search error. The verify ID error or search error is retried up to three times before formatting. The Write Format command returns an ID error status if the ID is incorrect and an ECC error does not exist. Any retries are returned if either a data error or search error is encountered during the verify ID. The controller assembles the ID words from its internal registers and counters, and records the word(s) on the specified disk track address. The controller then records the entire data field following the ID words with the data word in the specified TILINE address. This is repeated for all data word positions and the ECC. The controller formats each sector on the track with ID words, data, ECC, and the required gaps. All sectors contain ID words and the ECC field.

3.6.1.3 Read Data Command. The Read Data command identifies a record location, specifies the number of bytes to be transferred from this record, and gives the starting address to the TILINE memory address buffer area that receives data from the disk. After firmware initialization, the controller performs the following operations:

1. Checks for unit errors by examining the disk status bits (offline, offset active, not ready, unsafe, and seek incomplete).

2. Seeks the specified cylinder.

3. Sets the specified head address.

4. Searches for the right ID as the data passes under the head. If the ID is not found before the next index mark, sector pulses are counted from the index mark to locate the correct sector to be transferred.

5. Performs the read after the correct sector is located.

6. Terminates the read operation with an ID status error (W7, bit 11), if the sector count fails to find the correct ID.

Normal controller operation for the WD/MT controller allows a maximum number of six retries to find two consecutive reads to yield the same error syndrome. If two consecutive syndromes are found to be equal, error correction is attempted, otherwise data error status is set. If the error is not correctable, data error status is set. Note that when retries are attempted, the retry status is set; and when ECC correction takes place, the ECC corrected status is set.

3.6.1.4 Write Data Command. The Write Data command causes the controller to record data on a previously formatted track or to write over a previously recorded sector. After firmware initialization, the disk controller performs the following operations:

1. Checks for unit errors by examining disk status (offline, not ready, unsafe, write protect, offset active, or seek incomplete).

2. Seeks the specified cylinder.

3. Selects the specified head address.

4. Locates the desired starting sector by reading the ID words of each sector and comparing its contents to the desired sector address. If the words contain the defective track bit and no ECC error exists, a re-seek is issued to the head and the cylinder address specified in the data field, and the operation continues on this alternate track. When the controller detects the sector immediately before the desired sector, it arms the interface so that the write operation is started when the next sector mark occurs.

5. Waits for the correct sector and performs the write.

If the ID words in step 4 do not compare, the write operation is terminated with an ID status error.

Unless a terminate condition is encountered, data is written on the disk, sector by sector, until the specified number of words have been transferred. When the transfer word count is less that the sector word count, the controller fills the remainder of the sector with zeros until the sector word count has been decremented to zero. When the number of words is greater than the words per sector, the controller continues to the next sequential sector.

When the controller encounters the end of a track and the remaining transfer word count is nonzero, the controller automatically increments the head address to the next track and selects sector 0 as the next sector to be written. The controller then repeats steps 4 and 5 in the preceding list.

When the controller encounters the end of a cylinder and the remaining transfer word count is nonzero, the controller automatically seeks to the next cylinder, selects head address 0 for the new cylinder, and selects sector 0 as the next sector to be written. The controller then repeats steps 4 and 5 in the preceding list.

3.6.1.5 Unformatted Read Command. To ensure compatibility with the DSRs, the Unformatted Read command (nonextended) does not actually read any data from the disk. Instead, three words are returned to the TILINE memory after this command is performed. W1 contains the head and cylinder addresses. The second word contains the sectors-per-record number (>01) and the sector address. The third word contains the record word count (>80).

If a genuine unformatted read operation is desired, the Extended Unformatted Read command words can be used.

3.6.1.6 Unformatted Write Command. An Unformatted Write command transfers up to 510 bytes of data from a specified TILINE address to a specified disk address. The controller seeks the specified cylinder (after the firmware is initialized), sets the head address, detects the beginning of the sector, generates the correct lead gap, writes a synchronization character, and writes data on the disk. All data is written consecutively regardless of sector boundaries until a termination condition is encountered. The controller adds an ECC character and a trailing gap at the end of the data.

3.6.1.7 Seek Command. If a physical drive is configured as two logical drives, independent seek operations can cause head thrashing. Head thrashing is when the head assembly moves all the heads from one read/write location to the next specified read/write location, only to return to finish the first operation on the original track. Head thrashing is eliminated by ignoring any pre-seek command from the software to the drives that are logically divided. This command is performed on drives that are not divided logically. The Seek command causes the drive to orient the heads to the cylinder specified in the command words. An interrupt can be generated via the attention bits in WO to alert the CPU that this operation has completed.

3.6.1.8 Restore Command. The Restore command reinitializes the cylinder counter and repositions the heads of the selected drive over cylinder zero. The Restore command also issues a Fault Clear command to the drive. The Restore command is used to clear an unsafe condition or seek error at the drive. This command is required if a seek incomplete or unsafe status is detected. Before initiating the restore operation, the controller determines if a unit error exists by examining the offline bit. If the controller finds a disk status error before it initiates the Restore command, it sets the unit error bit in W7.

Completion of the restore operation can be determined by enabling a disk drive completion interrupt (attention bit interrupt, WO) or by monitoring the attention bit for the selected drive unit.

3.6.2 Extended Mode Commands

The extended mode commands set the extended mode bits (W1, bits 0 and 1). The extended mode bits allow the command code field (W1, bits 5 through 7) to select from an additional set of commands. These commands are less commonly used during the course of data storage and retrieval operations.

Except for the extended Read Unformatted, Write Format Flagged, and extended Self-Test commands, extended mode commands perform functions identical to the unextended mode commands.

3.6.2.1 Read Unformatted (100 -- Extended). The extended Unformatted Read command allows the programmer to read a sector and to examine a specified number of words starting immediately after the synchronization (sync) character without regard to ECC errors or standard sector formatting. This is primarily a diagnostic feature.

The programmer specifies a sector of the selected track to start the read process. When the sector is located, the controller transfers the specified number of words to TILINE memory, starting with the first word after the sync character.

The ID words, data fields, ECC words, and trailing gap are read and transferred to memory as data words. There are normally glitches in the trailing gap due to write-head turn-on and turn-off transients and differing write-clock phases that are recorded during formatting and write operations. These glitches can cause shifting of word boundaries. This shifting occurs when the word count is large enough to require data to be written beyond the normal position of the ECC characters.

An ECC check is performed at the end of the operation, and data error status is reported if the ECC check shows an error. However, no ECC correction is attempted. A data error occurs unless the byte count is the correct value to allow comparing the calculated ECC checkbits against the read checkbits.

The word transfer count is limited to 510 bytes. Command time-out occurs if too many bytes are requested. The extended Read Unformatted command can also be used to read the information.

3.6.2.2 Self-Test Commands (111 -- Extended). The WD/MT controller automatically performs a sequence of self-tests on power-up. Self-tests can also be initiated by self-test commands (see Table 3-11). In either case, self-test failures cause all 1s (>FF) to be reported to the controller in the right byte of W7. Two 16-bit failure codes, one in W2 and the other in W4, are also reported.

You can access the extended command field for the controller self-test by entering >8700 in slave W1 and >0000 in slave W3. W3, bit 0 is a loop bit for self-test. To loop on all self-tests, enter >8000 in W3. An IORESET is the only method to exit the looping self-test. Note that the Execute Self-Tests command (W3, >0000) is the same one used for power-up conditions. Self-test results for both the Execute Self-Test command and the power-up self-test are returned to register 2 and register 4 (refer to paragraph 1.3.10) but the self-test LED only lights during the power-up self-test. The FAULT LED cannot be reset unless the self-test passes. W2 and W4 contain error status information.

The disk controller ROM revision level is available through the extended self-test mode. You can obtain this information by setting the most significant byte of W3 to 7C hexadecimal. The revision level of the ROMs used in the disk section of the WD/MT controller is reported in the least significant byte of W3.

Table 3-11 Extended Commands

Command	Device Register 3 Bits 0	1	2	3	4	5	6	7
Controller:								
Report ROM Revision Level	0	1	1	1	1	1	0	0
Execute Self-Test	0	0	0	0	0	0	0	0
Loop on Self-Test	1	0	0	0	0	0	0	0

3.6.2.3 Absolute Write Format Command. This is a nonrelocatable Write Format command. The controller performs the following functions:

1. Checks for unit errors by examining disk status (off-line, not ready, unsafe, write protect, offset active, or seek incomplete)

2. Seeks the specified cylinder

3. Sets the specified head address

4. Waits for the correct starting sector

5. Formats the track with the fill word specified by the TILINE address

The format of this command is:

W0: 0
W1: MSB = #C1, LSB = Head Address of Track
W2: 0100
W3: Cylinder Address of Track
W4: TILINE Byte Count=0002
W5: TILINE Address
W6: Unit Address and TILINE Address
W7: 0

The TILINE address contains the fill word to format the track.

3.6.2.4 Relocate Command. This command relocates a bad track to a spare track. The format of the command is as follows:

W0: 0
W1: MSB = #41 LSB = Head Address of Bad Track
W2: 0
W3: Cylinder Address of Bad Track
W4: TILINE Byte Count = 0004
W5: TILINE Address
W6: Unit Address and TILINE Address
W7: 0

The spare track address and format word should be on the following TILINE address:

TILINE ADR=SPARE TRK ADR; HDADR=BITS 0-4, CYLADR=BIT 5-15.

TILINE ADR+2=WORD TO FORMAT SPARE TRACK WITH.

The disk controller performs the following operations:

1. Verifies the ID of the bad track.

2. Formats the bad track so that header words 1 and 2 contain the cylinder, head, and sector addresses of the bad track. W3 contains the bad track flag (>8000). The data field contains the spare track address where SPARE TRACK ADR: HD ADR=BITS 0-4, CYL ADR=BITS 5-15.

3. Seeks the spare track address.

4. Verifies the spare track ID.

5. Formats the spare track address with the header of the bad track, and fills the word specified by the Relocate command at TILINE ADR and TILINE ADR+2. Command statuses that apply to this command are UE, SE, CT, RE, ID (the track may already be relocated), TT, DF, ME, AC, and RETRY.

3.7 CONTROLLER COMMAND DESCRIPTIONS (TAPE SECTION)

Tape commands sent to the WD/MT controller from the CPU cause the controller to perform any of eleven basic tape operations. The command code that selects the operation to be performed by the controller is formed by bits 4 through 7 of word 6 (W6). The command code assignments are shown in the description of W6, and the tape commands are described in the following:

* No-Operation (NOP) Command -- Any NOP command results in an idle and complete status. The controller recognizes all NOP commands and returns the system to idle after setting the idle and complete bits.

* Buffer Sync (Write Sync) -- Use this command to ensure that all pending writes complete. The controller remains busy until the entire contents of the controller and transport buffers are written on tape.

* Write End Of File (EOF) -- This command causes the file mark record to be written on tape preceded by a 101.6-millimeter (4-inch) gap. For a phase encoded (PE) tape transport, the controller verifies that the file mark was properly written on the tape. A PE hard error status is reported if the file mark was not properly written on the tape.

The end of tape (EOT) and offline status are reported in the same manner as the write binary operation.

When EOF completes, either operation complete or error status is reported and an interrupt is issued if the interrupt enable bit (W7, bit 3) is set.

* Record Skip Reverse -- This command is performed after the skip forward operation except in the following instances:

  - The tape is moving in the reverse direction.

  - The operation terminates when beginning of tape (BOT) (instead of EOT) is detected. In this case, the BOT status is reported and the tape is positioned in the same place as during a rewind command.

* Read Binary Forward -- Data from the tape is transferred to the main memory via the TILINE in a read binary operation. The controller accesses the TILINE as needed and transfers the tape characters, assembled in 16-bit words, and transmits the words into successive memory locations.

* Record Skip Forward -- In the skip forward operation, the read head passes over the records in a forward direction with no transfer of data to TILINE memory. The number of records to skip is indicated in W4, which is decremented each time a record is skipped. If the initial record number is zero, the controller attempts to skip 65 536 records and stops on EOT or EOF.

* Write Binary Forward -- The controller fetches data from main memory via TILINE and records it on the tape in a write binary operation. The 20-bit starting address of the memory buffer is specified in W6 (bits 11 through 15) and W5 (bits 0 through 14). The number of 8-bit characters to be recorded is specified in W4.

* Erase -- A portion of tape is deleted when this command is performed. The maximum length of tape that can be erased with one command is 1082.0 millimeters (42.6 inches). During an erase operation, an EOT or offline error can occur.

* Read Transport Status -- The Read Status command selects a transport and returns transport status information without performing any transport functions. The controller responds to the command by returning a transport status word (W0) and a controller status word (W7).

* Rewind -- The controller tests the unit to determine if it is already rewinding. If the unit is not rewinding, the controller issues the Rewind command and reports an idle and operation complete status in W7. If the unit is rewinding, the controller reports tape rewind status in W0, and idle, error, and tape status in W7.

* Rewind and Offline -- The Rewind and Offline command causes the tape to rewind and unload from the transport and also causes the offline bit to be set.

3.8 MT3200 CONTROL AND STATUS WORDS

The control and status words described in this section are used to operate the tape and report tape status. Table 3-12 gives an overview of the MT3200 TPCS registers. A more detailed explanation of the bits follows in Table 3-13 through Table 3-19.

Table 3-12 MT3200 TPCS Registers (Device Control Registers)

Bit:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
REG. 0	Off Line	BOT	EOR	EOF	EOT	WR RNG	RW	CMD TO	Rewind Bits 0	1	2	3	Rewind Mask 0	1	2	3
REG. 1	Read Overflow Status Count (16 LSBs)															
REG. 2	Read Overflow Status (8 MSBs)								Error Classification							
REG. 3	Read Offset															
	Extended Command															
	Track in Error								Retry Count							
REG. 4	R/W Character Count, Skip Record Count, or Erase Length															
REG. 5	TILINE Memory Buffer Starting Address (15 LSBs)															0
REG. 6	Unit Select 0	1			Command				WR DIAG			TILINE Address (5 MSBs)				
REG. 7	IDLE	OP CMP	ERR	INT ENB	1	0	PE FMT	ABN CMP	IP ERR	COR ERR	HRD ERR	MEM ERR	TIM ERR	TL TO	FMT ERR	TAP ERR
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

3.8.1 W0 -- Tape Transport Status

Word 0 (W0), bits 0 through 7 contain individual status indicators for the tape drive. Bits 8 through 11 contain the rewind status for the tape unit. The rewind status bits generate interrupts when enabled by the corresponding rewind mask bits located in bits 12 through 15. Table 3-13 shows the tape transport status for W0.

Table 3-13 WO -- Tape Transport Status

Bit	Definition
0	Offline -- This bit indicates that the transport is not ready and is not rewinding. The error and tape error bits are also set when this bit is set.
1	Beginning of Tape (BOT) -- This bit is set when the BOT marker is detected while performing a Skip Reverse command. The error and tape error status bits are set when this bit is set. It is not considered an error when a Read Transport Status command is performed.
2	End of Record (EOR) -- The EOR status bit is set when a Read Binary Forward command specifies more characters to be read than actually exist in the tape record. The error and tape error status bits are also set when this bit is set.
3	End of File (EOF) -- This is set when an EOF mark is encountered during a Read Binary Forward, Record Skip Forward, or Skip Reverse command. The tape error and error bits are also set when this bit is set.
4	End of Tape (EOT) -- This bit is set when the EOT marker is detected during a forward tape movement. The EOT does not abort a write operation but reports when an ongoing operation completes. It is not considered an error condition when a Read Tape Status command is performed.
5	Write Ring -- This is set if a Write Binary, Write EOF, or Erase command is specified when the tape does not have a write ring inserted in the tape file reel. Setting this bit causes the operation to abort. The error and tape error status bits set when this bit is set. It is not considered an error when a Read Tape command is performed.
6	Tape Rewinding -- This bit is set whenever a command is performed and the drive is in the rewind mode. The error and tape error status bits are set when this condition exists.

Table 3-13 W0 -- Tape Transport Status (Continued)

Bit	Definition
7	Command Time-Out -- This bit indicates that the drive failed to respond within a controller-selected time interval. The error and tape error bits are set when this bit is set. If during a Read Binary or Skip Forward command, a nonzero value is in device register 4, then an EOR is also reported.
8-11	Rewind Status -- This bit indicates the rewind status of the transport and is set whenever the transport is rewinding.
12-15	Rewind Mask -- These bits enable the assigned unit to generate a rewind complete interrupt. The rewind complete interrupt is set when the rewind mask bit is on and the rewind status bit is off. Software can disable the interrupt by resetting the rewind mask bit. The interrupt is reported only when the controller is not performing a previously initiated command.

3.8.2 W1 -- Read Overflow Status Count (LSB)
The 16 bits of W1 are normally meaningful only when a Read Binary Forward command is performed. These 16 bits plus the eight MSBs of W2 form a 24-bit read overflow status count. The read overflow status count contains a count of the number of characters that were contained in the record, minus the initial read offset character count and the initial read buffer character count. Table 3-14 defines the bit assignments for W1.

Table 3-14 W1 -- Read Overflow Status Count

Bit	Definition
0-15	Contains the upper 16 bits of the 24-bit read overflow status count.

3.8.3 W2 -- Read Overflow Status Count (MSB)

The eight MSBs of W2 contain the eight MSBs of the 24-bit read overflow status count. The eight LSBs of W2 return an error classification status from the transport when a hard error occurs. Table 3-15 defines the functions of these bits.

Table 3-15 W2 -- Read Overflow Status Count MSB

Bit	Definition
0-7	Contains the lower 8 bits of the 24-bit read overflow status count
8-15	Used to return the status on a hard error (refer to W7, bit 10 for more information)

3.8.4 W3 -- Read Offset

During normal operation, this register is used for read offset and is used by the controller to provide a means of reading large records when only small memory buffer areas are available. Read offset is normally used by the controller when a Read Binary Forward command is performed. The controller decrements the read offset count each time a character is read and inhibits transfer of characters into the memory buffer until the read offset count reaches zero. The largest read offset value that can be specified is 65,535. No characters are transferred into TILINE memory if the record contains a character count less than or equal to the read offset value. This register is also used to return special transport status when a hard error condition is encountered. Table 3-16 defines the bit assignments for W3.

Table 3-16 W3 -- Read Offset

Bit	Definition
0-15	Read Offset -- These bits define the number of characters to read before starting a transfer to memory.

3.8.5 W4 -- Character Count

W4 serves several functions, depending on which command is performed. The commands that use W4 are Read Binary Forward, Write Binary, Record Skip Forward, Record Skip Reverse, and Erase. Table 3-17 defines the bit assignmentsfor W4.

Table 3-17 W4 -- Character Count

Bit	Definition
0-15	The count supplied in W4 is used with Read commands and is counted down as each character is read. W4 contains the remaining number of bytes not read if an error occurs. The Write command uses the count just like the Read commands but it indicates the number of bytes not written.

W4 for the Read Binary Forward command corresponds to the size of the TILINE memory buffer available to the controller. At the end of the operation, W4 contains the decremented character count. The controller writes the exact number of characters specified by the CPU and the write binary operation unless an abortive condition occurs. W4 is decremented each time a character is written on tape. W4 contains 0 when a normal operation reaches completion.

The Erase command uses W4 to control the length of tape erased, which is increased by one character length for each count in W4. The count is decremented and is normally 0 for a successful erase operation.

The Record Skip Forward and Record Skip Reverse commands use W4 to count the number of records to skip. The count is decremented each time a record is skipped. If an EOF mark is detected before the count is decremented to 0, the operation is aborted and W4 contains the decremented skip count. W4 is normally 0, if an EOF mark is not encountered when the Skip command completes.

3.8.6 W5 -- Buffer Address (LSBs)

Bits 0 through 14 of W5 are loaded by the CPU via the TILINE with the 15 LSBs of the 20-bit TILINE memory buffer starting word address. The LSB of this register is forced to 0 by the controller. At the end of an operation, W5 contains the incremented memory buffer address, shifted right one place. This word is used only by the Write Binary and Read Binary Forward commands.

3.8.7 W6 -- Command and Transport Select

W6 contains the unit select, command buffer, and data buffer memory address information. Table 3-18 defines the bit assignments for W6.

Table 3-18 W6 -- Command and Transport Select

Bit	Definition
0-1	Unit Select -- Bit 0 set to one to select unit 0. Bit 1 set to one to select unit 1. If more than one bit is set, the controller selects only one unit with priority to the MSB.
2-3	Not used, always set to 0.
4-7	Command Codes -- Specify which command the controller performs. The following list summarizes the command assignments. Refer to the following paragraphs for a description of the commands.

Bit 4	Bit 5	Bit 6	Bit 7	Command
0	0	0	0	No operation (NOP)
0	0	0	1	Buffer Sync
0	0	1	0	Write EOF
0	0	1	1	Record Skip Reverse
0	1	0	0	Read Binary Forward
0	1	0	1	Record Skip Forward
0	1	1	0	Write Binary Forward
0	1	1	1	Erase
1	0	0	0	Read Transport Status
1	0	0	1	Read Transport Status
1	0	1	0	Rewind
1	0	1	1	Rewind and Offline
1	1	0	0	NOP
1	1	0	1	NOP
1	1	1	0	NOP
1	1	1	1	Extended Control and Status

Refer to the extended mode commands in paragraph 3.9 for more information.

3.8.7.1 W6, Bit 8 -- Write Diagnostic. The Write Diagnostic command bit is used to to verify the error detection features of the tape transport.

3.8.7.2 W6, Bits 9 and 10. These bits are not used and are normally set to zero.

3.8.7.3 W6, Bits 11 Through 15. Bits 11 through 15 are the five MSBs of the TILINE starting memory address. These bits are used by the controller during the Read Binary and the Write Binary commands.

3.8.8 W7 -- Status and Control

W7 contains both control and status information. The control information is entered into W7 by the CPU. The status information is entered by the controller as described in Table 3-19 and Table 3-20.

Table 3-19 W7 -- Status and Control

Bit	Definition
0	Idle -- This bit is set to 0 by the software to activate the controller and begin performing the commands in bits 4 through 7 of W6. When a command finishes successfully or terminates due to an error, the controller sets bit 0, 1, or 2. If a command is used when the idle bit is 0, the controller ignores the command.
1	Operation Complete -- This bit is set when a command completes without an error.
2	Error -- This bit is set when an operation is terminated due to an error. This bit is reset by the software.
3	Interrupt Enable -- This bit enables the controller to generate an interrupt when the operation completes or error bit is set. Note that W0 interrupts (rewind complete) are independent of W7.
4	Not used.
5	Not used.
6	PE Format -- This bit is always set for the MT3200.
7	Abnormal Completion -- This is set if a tape operation is terminated due to an I/O reset or a power-fail warning that is detected by the TILINE.

Table 3-19 W7 -- Status and Control (Continued)

Bit	Definition
8	Interface Parity error -- This is set if the controller detects parity errors on the transport read data lines.
9	Error Correction Enabled -- This bit is set when a read binary operation is performed on a PE tape and a single bit dropout is corrected by the vertical parity information recorded on the tape. The error status bit is also set.
10	Hard Error -- There are two types of hard errors, one is recoverable and the other is not recoverable. The unrecoverable hard error results when the tape drive exhausts all retry capabilities and fails to correct the error. This error causes the TILINE hard error status and offline status bits to set. If the hard error status is true after command completion, an offline status is issued in W0, bit 0. This type of hard error results from the situations listed below. * A hard error occurring in a true write operation that goes beyond 16 automatic retries. * An attempt to write records greater than 32K bytes in length. * A transport transmission error when the cache transfer rate exceeds the rate the controller can handle. * An attempt to write a new block during a write edit operation that is greater than the original block.

Table 3-19 W7 -- Status and Control (Continued)

Bit	Definition
10 (cont.)	The recoverable hard error condition is returned to the controller prior to command completion. This causes the hard error status and online status in W0, bit 0 to set. This type of hard error results from the situations listed below. * A transport record length error during a a read or write operation. This happens when the record is greater than the maximum block size setting but less than 32K bytes. * A write parity error. All media write errors are automatically corrected by the MT3200 unit recovery logic. * The record that was read contains an uncorrectable read data error. * An invalid software command was issued. For either type of hard error, the three bytes of transport status are returned to the TILINE interface in W2, bits 8 through 15, and W3. Refer to Table 3-20 for the TPCS status of the MT3200.
11	TILINE Memory Read Parity Error -- This bit sets after a Write Binary command completes and a memory read error occurs during a data transfer. The error status bit is also set.

Table 3-19 W7 -- Status and Control (Continued)

Bit	Definition
12	TILINE Timing Error -- This bit is set when there is a data transfer timing error. During a read operation, the TILINE did not transfer a word before the next word was assembled. During a write operation, the TILINE did not have a new word available when it was required by the controller. The TILINE timing error does not abort operations. The error status bit is set.
13	TILINE Time-Out Error -- This bit is set if a transfer cycle is not completed within 10 microseconds after the controller gains TILINE access. Time-out is reported only during a Read Binary or Write Binary command. Tape operation is not stopped to assure proper interrecord gap (IRG) positioning. The error status bit is set.
14	Format Error -- Always set to zero.
15	Tape Error -- This bit is set if one of the Transport errors listed belows occurs. * Offline * BOT * EOR * EOF * Write Ring * Tape Rewinding * EOT * Command Time-Out

Table 3-20 MT3200 TPCS Status

TPCS Reg.	Bit	Contents
2		Error Classification
	8	Density Found/Operating Density (bpi)
		000 = 800
	9	010 = 3200
		100 = 1600
	10	110 = 6250
	11	Write from host to cache overrun
	12	Read from tape to cache overrun
	13	Cache automatically expanded block size:
	14	000 = 9K bytes 110 = 32K bytes
	15	100 = 16K bytes 011 = 64K bytes
		010 = 24K bytes
3		Track in Error
	0	Track 0 in error
	1	Track 1 in error
	2	Track 2 in error
	3	Track 3 in error
	4	Track 4 in error
	5	Track 5 in error
	6	Track 6 in error
	7	Track 7 in error
	15	Track P in error
	Read/Write Retry Count in Current Host Record	
	8	MSB
	Through	
	14	LSB

3.9 DETAILED MT3200 CONTROLLER COMMAND DESCRIPTIONS

The following paragraphs describe the detailed tape controller command descriptions and the extended mode self-test status commands.

3.9.1 Buffer Sync (Write Sync)

Use this command to ensure that all pending writes complete. The controller remains busy until the entire contents of the controller and transport buffers are written on tape.

3.9.2 Write EOF

This command causes the file mark record to be written on tape preceded by a 101.6-millimeter (4-inch) gap. For a PE transport, the controller verifies that the file mark was properly written on the tape. A PE hard error status is reported if the file mark is not properly written on the tape.

The EOT and offline status are reported in the same manner as the write binary operation.

When EOF completes, either operation complete or error status is reported and an interrupt is issued if the interrupt enable bit (W7, bit 3) is set.

3.9.3 Record Skip Reverse

This command is performed after the skip forward operation except in the following instances:

* The tape is moving in the reverse direction.

* The operation terminates when BOT (instead of EOT) is detected. In this case, the BOT status is reported and the tape is positioned in the same place as during a Rewind command.

3.9.4 Read Binary Forward

Data from the tape is transferred to the main memory via the TILINE in a read binary operation. The controller accesses the TILINE as needed and transfers the tape characters, assembled in 16-bit words. The characters (bytes) are read sequentially from tape and deposited into successive memory locations. The characters are read starting at the address specified by W6, bits 11 through 15 (MSBs), and W5, bits 0 through 14 (LSBs). The controller transfers the number of characters specified by W4.

The transfer stops when the last character of the record has been assembled and transferred to main memory, provided that the character count specifies more characters than actually exist in the record. Instead of an operation complete at the end of the operation, the end of record (EOR) tape error and error status are set. In this situation, when the record contains an odd number of characters, the right half of the last assembled and transferred word contains ones (FF).

W3 (read offset) specifies the number of characters read from tape before the start of transfer to the main memory. Use this feature to read data out of long records when only small buffers are available. The controller continues to read the record (until it detects the postamble) after the specified number of characters are assembled and transferred to main memory. W1 (LSBs) and the left half of W2 (MSBs) contain the number of characters read from the record and not transferred after W4 reaches zero. This forms the 24-bit count of the remaining characters on the record.

3.9.5 Record Skip Forward

In the skip forward operation, the read head passes over the records in a forward direction with no transfer of data to TILINE memory. The number of records to skip is indicated in W4. The controller decrements W4 each time a record is terminated in one of the following ways:

* W4 reaches 0 and the head is properly positioned on the IRG following the last record skipped. EOF status is reported if the last record was a file mark record.

* W4 did not reach 0 but a file mark record was detected. The tape stops with the head positioned on the IRG following the file mark record. This record is counted as a normal record. In this case EOF status is reported.

* W4 did not reach 0 but EOT was detected during the last record skipped. This causes EOT status to be reported. The EOT status is also reported when the last record skipped is a file mark record.

3.9.6 Write Binary Forward

The controller fetches data from main memory via TILINE and records it on the tape in a write binary operation. The 16-bit words fetched from main memory are specified by the starting address of W5 and W6. The number of characters specified by W4 are written by the controller. If the initial contents of this register are 0, the controller starts the tape motion and reports the operation complete status. This is done after the controller erases the same length of tape that is indicated by the Erase command.

During a write binary operation, the read circuitry of the controller is active. Checks are performed on the written data as it passes across the read head. The read portion of the controller checks for vertical parity and any type of PE hard error. The following errors can also occur during a write binary operation.

* Timing Error -- Some of the characters are written twice on the tape.

* TILINE Time-Out Error -- The controller fetched at least one defective word. This causes at least two defective characters to be written on the tape.

* Offline -- Offline condition occurred on the transport during a write binary operation. When this happens, the length of the written record is random and the preamble and postamble may not be written on the tape.

* EOT -- The EOT marker passed across the EOT sensor during a write binary operation. The EOT status does not report again once the reflective strip passes the EOT sensor and a new forward operation is active for the same transport.

The write binary operation also has special diagnostic provisions that are described in W6, bit 8.

3.9.7 Erase

A portion of tape is deleted when this command is performed. The maximum length of tape that can be erased with one command is 1082.0 millimeters (42.6 inches). During an erase operation, an EOT or offline error can occur.

3.9.8 Read Transport Status

The Read Transport Status command reads W7, bit 6 to identify the transport type selected. This bit is always set. The controller then checks if the unit is offline. An idle, error, and tape error status are reported to W7, and an offline status is reported to W0 if the unit is offline. The controller then checks for a rewinding unit if it is not offline. If the unit is not rewinding, the controller reports an idle, error, and a tape error status in W7 and tape rewinding status in W0. If the unit is not offline and not rewinding, the controller reports an idle and operation complete status in W7 and the proper condition for BOT, EOT, and write ring in W0.

3.9.9 Rewind

The controller tests the unit to determine if it is already rewinding. If the unit is not rewinding, the controller issues the Rewind command and reports an idle and operation complete status in W7. If the unit is rewinding, the controller reports tape rewind status in W0 and idle, error, and tape status in W7.

3.9.10 Rewind and Offline

The Rewind and Offline command is processed the same as the Rewind command except that the controller issues a Rewind and Offline command.

3.9.11 No-Operation (NOP) Commands

Any NOP command results in an idle and complete status. The controller recognizes all NOP commands and returns the system to idle after setting the idle and complete bits.

3.9.12 Self-Test, Extended Command Status

The controller is capable of operating in the extended mode for maintenance. The extended commands initiate self-test routines, read the controller ROM revision, obtain status from the drive, and issue commands to the drive. To operate in the extended command mode for either control or status, enter an >F in the command block of W6. Then enter the appropriate command code in W3, bits 0 through 7. Table 3-21 defines the codes that must be placed in W3 for extended control and status. Table 3-22 lists the transport status that is available via the extended status. Read extended status bits retain information about the control status, configuration status, error history status, machine status, and the error history reset status.

Use the following two commands for each block of data transferred to get the status from the transport:

* Enter the Read Extended Status command by placing >F in the command block and by placing >22 (from Table 3-21) in the MSB of W3.

* Issue the command for the desired transport status by entering >F in the command block and the appropriate code from Table 3-21 in the MSB of W3. At the same time, the second command must include a transfer character count (up to 16 bytes) in W4 and a TILINE memory address for up to 16 bytes of status in W5.

The controller self-test can be called from the extended command field by entering >0000 in W3. A loop bit (bit 0) is provided in W3 to allow for scope loops on self-test. Placing >8000 in W3, bit 0 allows a loop on all self-tests. An IORESET is then the only exit method. It is a good practice to place zeroes in all other slave words, with W7 always being the last word entered to the controller.

If >7C is entered in the most significant byte of W3 during self-test, the revision level of the ROMs used in the tape/TILINE section of the board is reported in the least significant byte of W3.

After the controller issues the command code from W3 to the MT3200 drive, the controller enters a read transfer mode and transfers the number of bytes specified to the TILINE memory. If a write command is issued, a command time-out status occurs and the controller terminates with a normal completion status for those commands that do not result in a read (RSTR-) or write (WSTR-) strobe issued from the tape drive.

Table 3-21. Extended Commands

Command	Device Register 3 Bits 0	1	2	3	4	5	6	7
Controller:								
Report ROM Revision Level	0	1	1	1	1	1	0	0
Execute Self-Test	0	0	0	0	0	0	0	0
Loop on Self-Test	1	0	0	0	0	0	0	0
Tape Transport:								
Read Forward	0	0	1	0	0	0	0	0
Read Reverse	0	0	1	1	0	0	0	0
Read Reverse Edit	0	0	1	1	0	0	1	0
Write*	0	0	1	0	1	0	0	0
Write Edit*	0	0	1	0	1	0	1	0
Write File Mark	0	0	1	0	1	1	0	0
Erase Variable Length	0	0	1	0	1	0	0	1
Erase Fixed Length	0	0	1	0	1	1	0	1
Security Erase	0	0	1	0	1	1	1	1
Space Forward	0	0	1	0	0	0	0	1
Space Reverse	0	0	1	1	0	0	0	1
File Search Forward	0	0	1	0	0	1	0	0
File Search Forward (Ignore Data)	0	0	1	0	0	1	0	1
File Search Reverse	0	0	1	1	0	1	0	0
File Search Reverse (Ignore Data)	0	0	1	1	0	1	0	1
Write Sync	0	0	1	0	0	0	1	1
3200 bpi	0	0	1	1	0	1	1	1
1600 bpi (PE)	0	0	1	0	0	1	1	1
Read Extended Status	0	0	1	0	0	0	1	0
Read Current Status	0	0	1	0	0	0	0	0
Read Configuration Status	0	0	1	1	0	0	0	0
Read Error History Status	0	0	1	0	0	0	1	0
Read Machine Status	0	0	1	1	0	0	1	0
Read Error History Reset	0	0	1	1	0	0	1	1

Note:

* Results in command TILINE timing error because data transfer to the drive is not supported in this mode. Using these commands may result in lost data at the specified TILINE address as well as erasing a portion of tape.

Table 3-22. Read Extended Tape Status (Current Status)

Byte No.	Bit*	Contents	
		Current Status Block — Access Code 00100000	
0		Tape Status Byte #1:	
	0	IDENT-	Note — For all blocks:
	1	HER-	1 = True/Yes
	2	ICER-	0 = False/No
	3	FMK-	(Unless otherwise specified)
	4	RDY-	
	5	IONL-	
	6	RWD-	
	7	FPT-	
1		Tape Status Byte #2:	
	0	LDP-	
	1	EOT-	
	2	Read Retries Exceeded	
	3	Write Parity Error at Interface	
	4	Write Hard Error	
	5	Illegal Command	
	6		
	7		
2		Error Classification:	
	0, 1, 2	Cache Auto-Expanded Block Size	000 = 9K, 001 = 16K, 010 = 24K, 011 = 32K, 100 = 64K
	3	Read From Tape to Cache Overrun	
	4	Write From Host to Cache Overrun	
	5		
	6		
	7		
3		Track in Error:	
	0	Track 7	
	1	Track 6	
	2	Track 5	
	3	Track 4	
	4	Track 3	
	5	Track 2	
	6	Track 1	
	7	Track 0	

Note

* Bit 0 = LSB; Bit 7 = MSB, unless otherwise specified.

Table 3-22. Read Extended Tape Status (Current Status) (Continued)

Byte No.	Bit*	Contents
4	0	Track P in error
	1 Through 7	LSB through MSB: Read/Write Retry Count on Current Host Record
5	0 Through 4	LSB through MSB: Front Panel Error Code
6		Density Code
	0–2	Density Found/Operating Density (bpi): 000 = 800 001 = 1600 010 = 3200 011 = 6250
	3–5	Density Requested: 000 = 800 001 = 1600 010 = 3200 011 = 6250
	6	Read Density Conflict
	7	Write Density Conflict
7		Unfixed Block Count (includes file marks):
	0 Through 7	Block Detachable Structures Remaining in Cache
		Fixed Block Count From BOT (includes file marks):
8		Low Order Byte
9		Mid Order Byte
10		High Order Byte
		Sequence Number of Record in Hard Error:
11		Low Order Byte
12		Mid Order Byte
13		High Order Byte

Note

* Bit 0 = LSB; Bit 7 = MSB, unless otherwise specified.

Table 3-22. Read Extended Tape Status (Current Status) (Continued)

Byte No.	Bit*	Contents			
		Configuration Status Block — Access Code 00110000			
0		Capability:			
	0	800 bpi			
	1	1600 bpi	0 = Do Not Have Capability		
	2	3200 bpi	1 = Do Have Capability		
	3	6250 bpi			
	4	Other			
1		Vendor Code:			
2		Model Code:			
	0, 1, 2 Through 7	000 = Other	011 = M891-1	110 = M990-1	
		001 = M890-1	100 = M891-11	111 = M991-HPGCR	
		010 = M890-11	101 = M990-1		
3		Configuration State:			
	0	EOT Location	1 = EOT Search	0 = STD	(U3T-1)
	1	Parity	1 = External	0 = Internal	(U3T-2)
	2, 3	Maximum Block Size	00 = 9K	10 = 24K	(U3T-3)
			01 = 16K	11 = 32K	(U3T-4)
	4	Ramps	1 = Disabled	0 = Enabled	(U3T-5)
	5	LSB	Simulated Speed Setting		(U3T-6)
	6				(U3T-7)
	7	MSB			(U3T-8)
4		Software Configuration:			
	0				
	1				
	2				
	3	Post-EOT Streaming			(U5W-4)
	4	3200 bpi IDENT			(U5W-5)
	5				
	6				
	7				

Note

* Bit 0 = LSB; Bit 7 = MSB, unless otherwise specified.

Table 3-22. Read Extended Tape Status (Current Status) (Continued)

Byte No.	Bit*	Contents		
		Error History Block — Access Code 00100010		
0		Read Retry Count — Since Unload (255 MAX):		
1		Write Retry Count — Since Unload (255 MAX):		
		Track History — Error Counts Per Track (255 MAX):		
2		Track 0		
3		Track 1		
4		Track 2		
5		Track 3		
6		Track 4		
7		Track 5		
8		Track 6		
9		Track 7		
10		Track P		
		Machine Status Block — Access Code 00110010		
		Head Position and Tachometer Count in Multiples of 1.28 inches:		
0		Low Order Byte of Tach Count		
1		High Order Byte of Tach Count		
		Logical Command History:		
2		Previous Host Command		
3		2nd Previous Host Command		
4		3rd Previous Host Command		
5		4th Previous Host Command		
6		5th Previous Host Command		
7		Operating Status:		
	0, 1	Reel Size:	00 = Unknown 10 = 8½ Inch	01 = 7 Inch 11 = 10½ Inch
	2	Door Lock Status: 0 = Unlocked, 1 = Locked		

Note

* Bit 0 = LSB; Bit 7 = MSB, unless otherwise specified.

Section 4

Operation

4.1 INTRODUCTION

This section explains the operating procedures for the WD900 drive and the MT3200 tape unit. The following paragraphs discuss the controls and indicators, operating procedures, error codes, and preventive maintenance.

4.2 CONTROLS AND INDICATORS

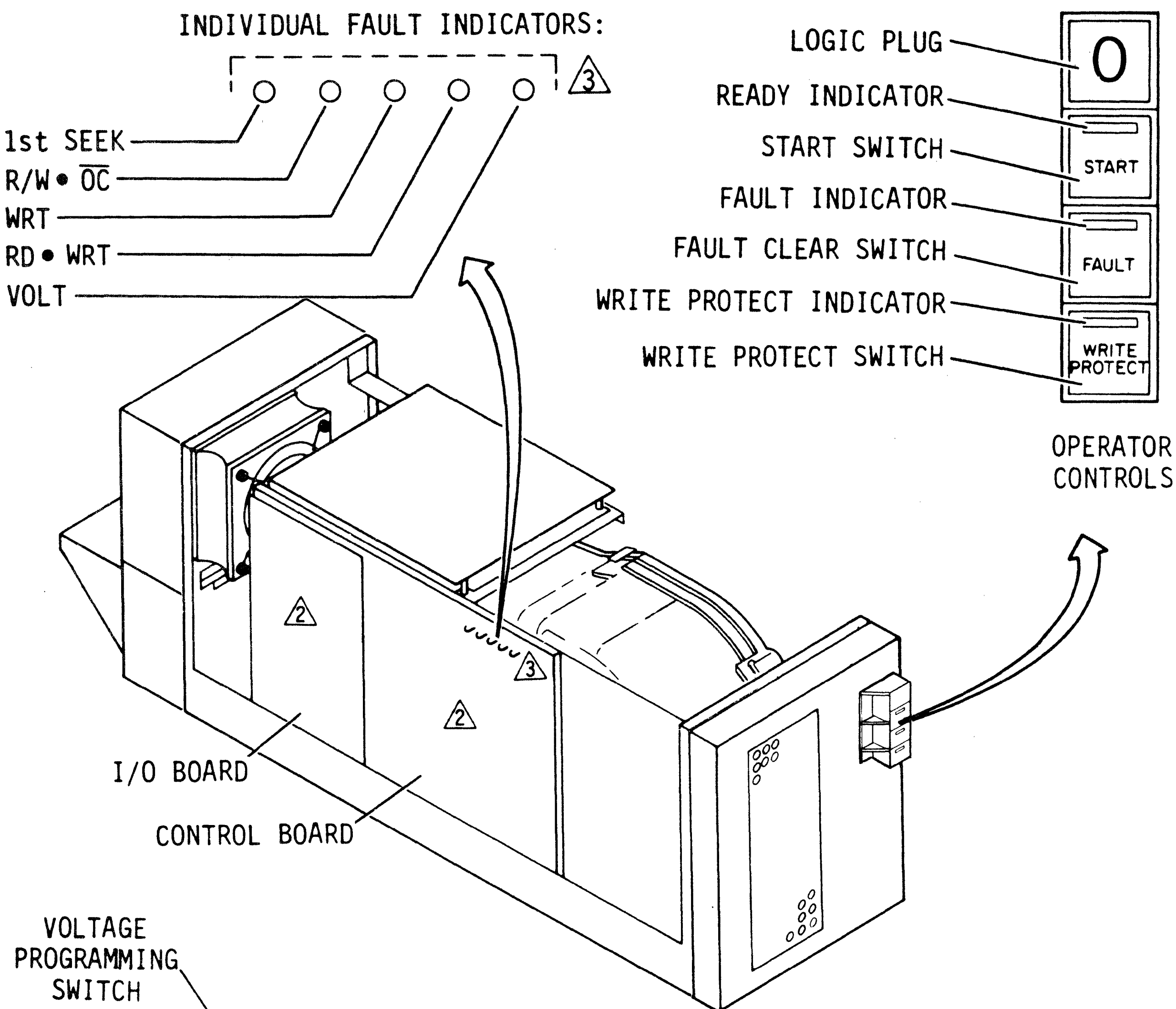
The following paragraphs describe the controls and indicators for the WD900 disk drive and the MT3200 tape unit.

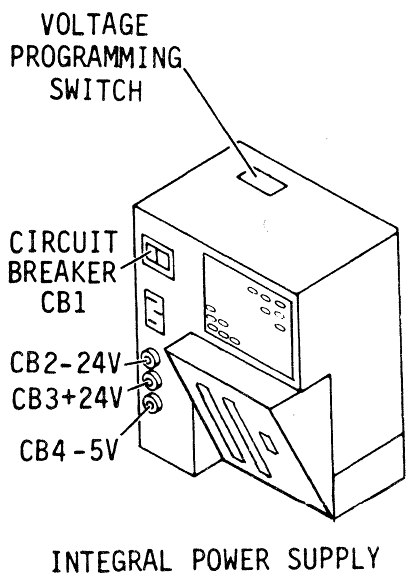
4.2.1 WD900 Controls and Indicators

The WD900 controls and indicators provide you with a simple means of monitoring and controlling the disk drive. All the controls and indicators are located on the front panel and the I/O and control boards (refer to Figure 4-1 and Figure 4-2).

* Logic Plug -- The logic plug activates switches that establish the logical address of the device. Two logic plugs, numbered 0 or 1, are included with each unit. The logic plugs have amber indicators that indicate, when lit, that the drive is selected.

* START Switch -- The START switch is an alternate action switch with a ready indicator on the top portion of the switch. Pressing the START switch activates the power-up sequence and causes the ready indicator to flash until the disks are up to speed, the heads are loaded, and there are no fault conditions. The ready indicator stays on when power-up completes. Pressing the START switch again releases it from the start position and causes the ready indicator to flash until the disk stops rotating.





NOTES:

1 POWER SUPPLY IS SHOWN WITH REAR SURFACE UP.

2 SWITCHES LOCATED ON CIRCUIT BOARDS ARE ILLUSTRATED IN FIGURE 1-6

3 INDIVIDUAL FAULT INDICATORS ARE VISIBLE THROUGH OPENINGS IN TOP COVER.

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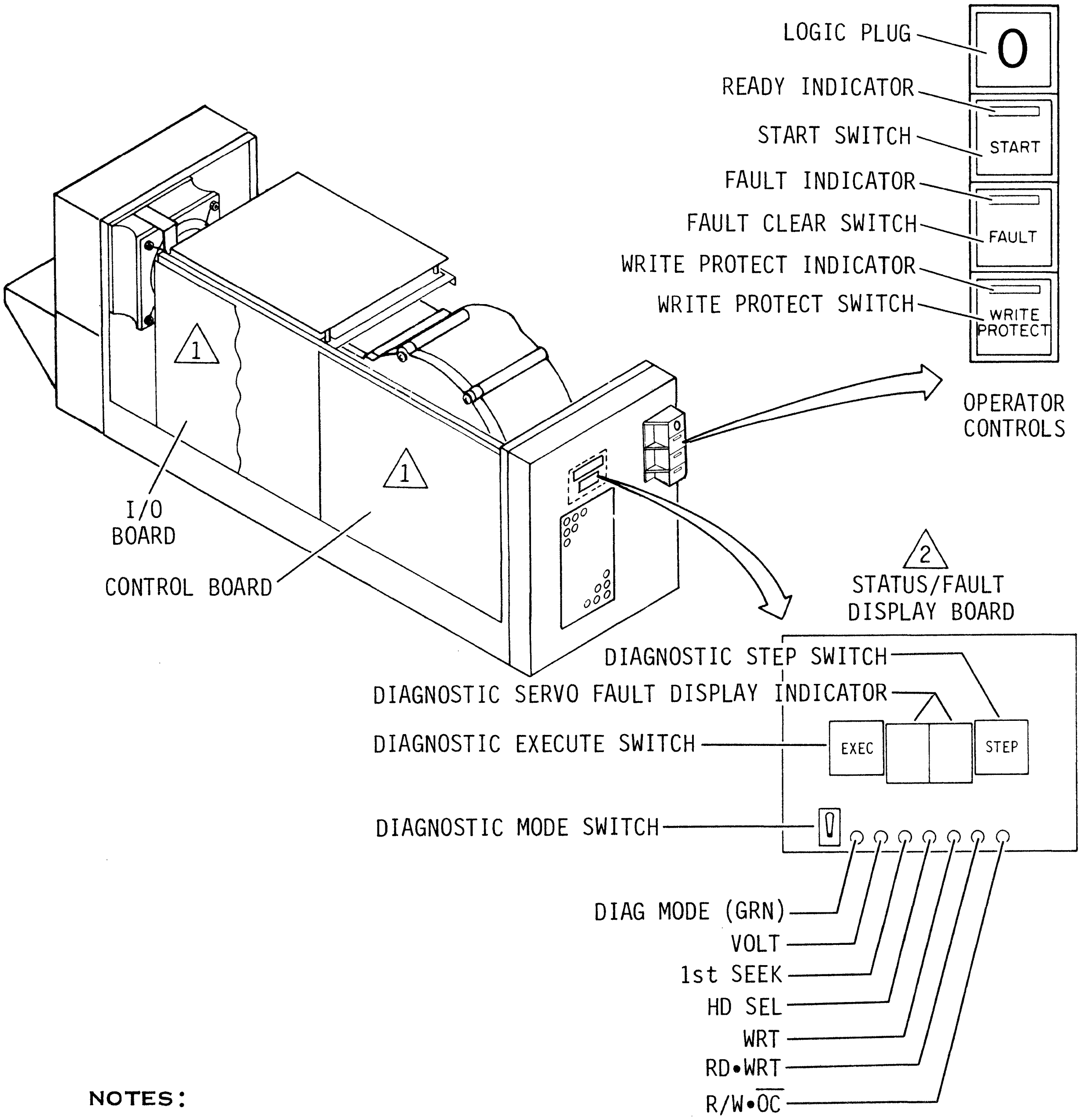
Figure 4-1 138-Megabyte Drive Controls and Indicators



NOTES:

1. SWITCHES LOCATED ON CIRCUIT BOARDS ARE ILLUSTRATED IN FIGURE 1-7

2. STATUS/FAULT DISPLAY BOARD IS LOCATED BEHIND FRONT PANEL.

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Figure 4-2 425-Megabyte Drive Controls and Indicators

* Fault Indicator -- The fault indicator is located on the top portion of the FAULT/Clear switch. The indicator lights if a fault exists within the drive and is turned off by any of the following (provided that the error condition no longer exists):

  - Pressing the FAULT/Clear switch

  - Fault Clear command from the controller

  - A drive power-up operation

* WRITE PROTECT -- Either the WRITE PROTECT switch on the front panel or the W PROT toggle switch on the control board places the drive in the write-protect mode. This prevents write operations and lights the write-protect indicator (located on the top portion of the WRITE-PROTECT switch).

4.2.2 MT3200 Controls and Indicators

The MT3200 controls and indicators are described in Table 4-1.

Table 4-1 MT3200 Controls and Indicators

Control/ Indicator	Function	Conditions
POWER	Switches line power on and off.	Fuse installed. Power cord connected.
LOAD REWIND	Loads tape to BOT marker.	Tape inserted in front panel door. Top cover and front panel door closed.
	Rewinds tape to BOT marker. Illuminates to indicate BOT tab is logically positioned at photosensor. When flashing, transport is executing a load or a rewind sequence.	Transport in offline mode (online indicator extinguished).
UNLOAD	Unloads tape from any point. Unload indicator flashes during unload sequence, then remains illuminated.	Transport in offline mode (online indicator extinguished).

Table 4-1 MT3200 Controls and Indicators (Continued)

Control/ Indicator	Function	Conditions
ONLINE	Transport switches to online mode, and online indicator illuminates to indicate the transport is online.	Transport is in online mode (online indicator illuminated).
	Press a second time to return the transport offline. (The indicator is extinguished to indicate the transport is offline.)	Tape loaded and transport online indicator extinguished.
TEST	Selects the test mode switches.	Refer to paragraph 4.3.2.3.
WRT EN (Write Enable)	Illuminates to indicate a write function can be performed.	Write-enable ring installed, mounted on supply hub, and tape loaded.
HI DEN (High Density)	When illuminated, this indicates the high density mode (3200 characters-per-inch (cpi)).	3200 cpi transport must be in offline mode (online indicator is extinguished) and loaded tape must be at BOT.
	When extinguished, this indicates the lower density mode (1600 cpi).	

4.3 OPERATING PROCEDURES

The following paragraphs describe the operating procedures for the WD900 disk drive and the MT3200 tape transport, as well as status codes for the WD/MT controller, WD900 disk drive, and the MT3200 tape transport.

4.3.1 WD/MT Controller TILINE Register Status Codes

Refer to Table 4-2 for a partial list of microdiagnostics failure status codes indicating certain types of controller failures.

Table 4-2 Words 2 and 4 -- WD/MT Controller TILINE Registers

Word 2	Word 4	Meaning
0000	0000	Diagnostics OK
00XX	0000	Self-test command OK
XX1X	XXXX	MRC or CDEST bus failed
F121	XXXX	Arithmetic logic unit (ALU) on central processor unit (CPU) failed logical test
F222	XXXX	ALU failed CPU arithmetic test
F323	XXXX	ALU failed CPU shift test
F333	XXXX	CPU failed register-address test
F434	XXXX	CPU count failed
F242	XXXX	CPU failed sector buffer-pattern test
F141	XXXX	CPU failed JSR/RTS test
F343	XXXX	CPU failed sector buffer-address test
F444	XXXX	CPU INH CLK signal failed
F151	XXXX	CPU MDAC signal failed
F252	XXXX	CPU TIGO signal failed
F353	XXXX	CPU WRN signal failed
F454	XXXX	CPU NMTO signal failed
F555	XXXX	CPU NMPE signal failed
F181	XXXX	CPU/magnetic tape (MT) sequencer handshake failed
F282	XXXX	MT first-in, first-out (FIFO) full/empty not properly detected
F383	XXXX	MT FIFO data failed
F484	XXXX	MT data late or parity error detection failed
F585	XXXX	MT timer test failed
FF14	XXXX	CPU and disk processor handshake failed
FF15	XXXX	CPU INH CLK signal failed
0000	1XXX	DSRC or DDEST bus failed
0000	XX1X	DSRC or DDEST bus failed

Table 4-2 Words 2 and 4 -- WD/MT Controller TILINE Registers (Continued)

Word 2	Word 4	Meaning
0000	2121	Disk processor ALU failed logical test
0000	2222	Disk processor ALU failed arithmetic test
0000	2323	Disk processor ALU failed shift test
0000	3333	Disk processor ALU failed register address test
0000	4141	Disk processor failed JSR/RTS test
0000	4242	Disk processor failed serializer/ deserializer data test
0000	4343	Disk processor detected word-available signal too early
0000	4444	Disk processor did not detect any word-available signal
0000	4545	Disk processor failed sync-word detection test
0000	5151	Disk processor ECC test failed
0000	5252	Disk processor ECC error not detected
0000	5353	Disk processor ECC error could not be reset
0000	5454	Disk processor error-correcting circuitry (ECC) test failed to detect any word-available signal
0000	6161	Disk processor failed sector buffer upper-byte test
0000	5262	Disk processor failed sector buffer lower-byte test
0000	AAAA	Disk processor did not set ATTN at the end of its microdiagnostics

4.3.2 WD900 Operation

The paragraphs that follow describe the power-up and power-down procedures. Self-test diagnostics, error conditions, and error codes are also discussed.

4.3.2.1 WD900 Power. Power functions are processes that take place within the power supply and the drive when the drive is powered up and powered off. These processes depend on whether the drive is set up for local or remote operation. In all cases, the power-up and power-down sequences are controlled through microprocessing unit (MPU) programming. The MPU monitors start conditions and certain interlock and operating conditions.

The power supply provides the drive with basic dc supply voltages when circuit breaker CB1 is placed in the ON position. The drive itself has no ac power requirements. All the drive circuits (including the electronics, cooling fan, and drive motor) are operated with the dc supply voltages. The ac power cable connects the power supply through CB1 to site ac power. The power supply can be configured for operation with any standard ac input voltage. Refer to paragraph 2.2.1.1 for more information on power supply configurations.

The dc power cable connects the power supply to the drive. When CB1 is ON, this cable transmits four basic dc supply voltages to the drive electronics. These voltages are +5 volts, -5 volts, +24 volts, and -24 volts. The -5 volt, -24 volt, and +24 volt supplies are protected against overload by pop-out circuit breakers on the power supply. The dc power cable also contains signal lines, which are enabled by control circuitry in the drive. The control circuitry switches on the drive motor's 40 volt dc power to produce disk rotation.

Secondary power supplies on the WD900 control board develop additional bias voltages for certain integrated circuits. One supply steps down the +24 volt input and develops a regulated +15 volt source. Another supply steps down the -24 volt input and develops a regulated -15 volt source. A third supply steps down the -15 volt supply to develop a regulated bias of -8.3 volts for the servo preamp chip.

The drive circuitry monitors the various supply voltages and disables write and/or servo functions when dc power is unreliable. For more information about voltage faults, refer to the discussion of fault and error conditions in paragraph 4.3.2.9, subparagraph Voltage or Actuator Current Fault.

4.3.2.2 Local/Remote Power Sequencing. The local/remote feature selects whether the controller controls the starting and stopping of the drive motor. Part of drive installation is setting the LOCAL/REMOTE switch (on the drive I/O board) for either the local or remote operation. The LOCAL/REMOTE switch setting determines the start conditions for the drive motor during power-up. With the LOCAL/REMOTE switch in the LOCAL position, the start conditions require only that the START switch be in the ON position. With the LOCAL/REMOTE switch in the REMOTE position, the start conditions require that the START switch be in the ON position and that the controller activate the SEQUENCE HOLD and SEQUENCE PICK signals.

NOTE

The SEQUENCE PICK and SEQUENCE HOLD signals are grounded at the controller. This means that when the A cable is plugged in, the drive will start spinning up after the logic plug delay.

In a system of several drives that are set up for remote operation, all drives receive the sequence signals at the same time. A delay circuit in the I/O circuitry activates each drive after a predetermined interval. Thus, each drive in the system has a unique start-up interval. However, when the hold signal deactivates, it causes all drive motors to stop at the same time.

4.3.2.3 Power-Up Sequence. The power-up sequence takes place in two steps. Power-up initialization occurs when dc power is applied to the drive. Following successful initialization, a load operation occurs each time that start conditions become available. Figure 4-3 is a flowchart of the power-up sequence. The following paragraphs describe power-up initialization in detail and summarize the load operation. For more information about load operations refer to paragraph 1.3.2.26.

Placing CB1 (power supply circuit breaker) to ON enables dc power to the drive. A level detector on the control board monitors the input from the power supply and sets the low-voltage line when the input attains a critical voltage.

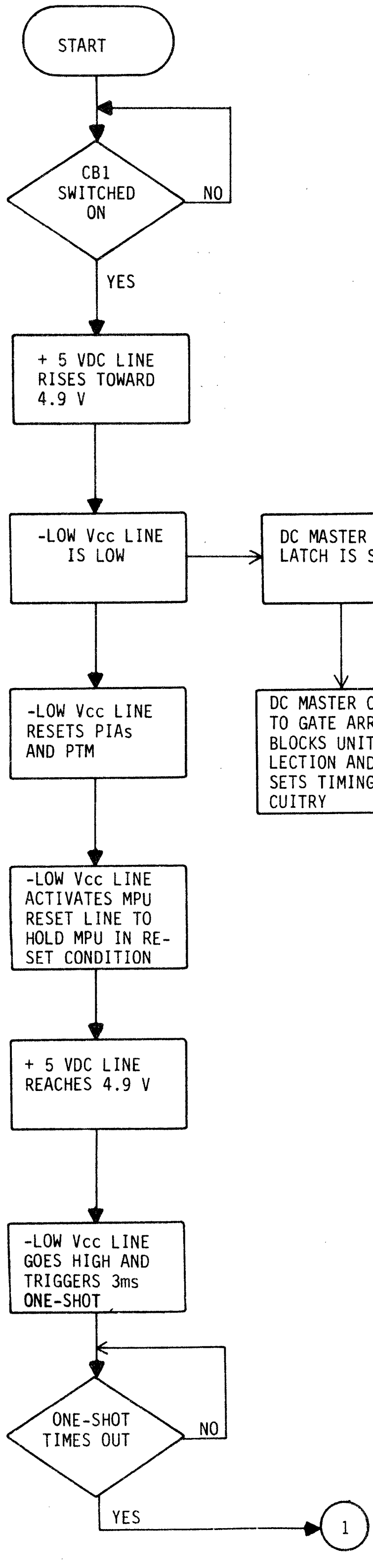
When the power-up test passes, the MPU performs three self-test operations to initialize itself. These tests are as follows:

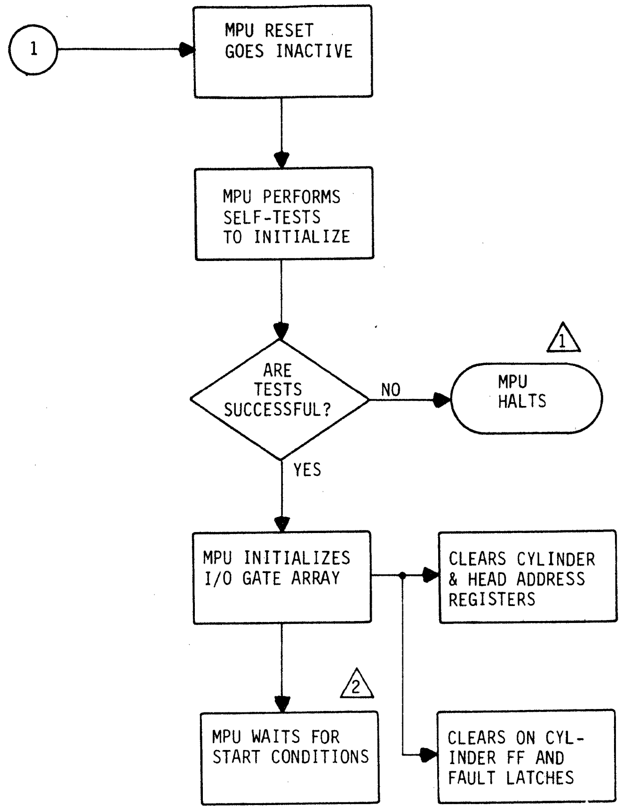
* The MPU performs a checksum calculation on the ROM contents. This test verifies that the MPU firmware instructions are readable.

* The MPU tests its internal RAM by writing information into the RAM and reading the information back.

* The MPU initializes the peripheral interface adapters (PIAs) by sending data to them and reading it back.

If the first two tests fail, the MPU halts and all the individual fault LEDs on the control board remain lit. If the third test fails, the MPU tries to light the first seek LED and halts.





NOTES:

1. INDICATIONS OF MPU HALT ARE GIVEN IN TEXT. DRIVE MUST BE POWERED OFF AND ON AGAIN IN EVENT OF MPU HALT.
2. REFER TO PARAGRAPH 1.3.2.18, SUB-PARAGRAPH LOAD OPERATIONS, FOR EVENTS THAT FOLLOW START CONDITIONS.

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Figure 4-3 WD900 Power-Up Sequence Flowchart

The only way to clear these individual faults is to turn CB1 to OFF.

NOTE

> None of these tests can produce a fault indication on the 990 chassis operating panel.

When the self-tests are completed, the MPU initializes the circuitry within the I/O gate array. At this point, power-up initialization is complete. This process is not repeated until dc power is removed and reapplied to the drive (via CB1).

When start conditions are present, the MPU directs the load operation. The load operation energizes the drive motor to bring the disks up to speed and loads the heads to position them at cylinder 0 on the disk. When the load operation is complete, the drive waits for commands from the controller.

4.3.2.4 Power-Down Sequence. The power-down sequence unloads the heads and stops the drive motor. Two conditions initiate a power-down sequence: a loss of start conditions and a loss of dc power to the drive.

A loss of start conditions occurs when either the START switch is pressed to release it from the start position or (in remote operation) when the controller deactivates the sequence signals. The MPU monitors the start conditions and directs an unload operation when the conditions are removed. The unload operation uses servo control to move the heads completely outward over the landing zone. The heads are held in this position by a Retract command until the actuator is locked by the actuator-locking solenoid. The MPU disables the motor speed control, and the friction brake stops the drive motor. The drive remains in this condition until start conditions reappear.

A loss of dc power results when CB1 is switched to OFF or when a loss of site ac power occurs. When a loss of dc voltages occurs, an emergency retract of the heads takes place under hardware control. The emergency retract operation does not require MPU intervention. It uses voltage generated by the decelerating drive motor to drive the heads inward to the landing zone. When the heads have moved outward to the landing zone, the actuator-locking solenoid automatically holds them in this position. With a loss of dc power, the drive motor is stopped by the friction brake.

4.3.2.5 WD900 Power-Up Procedure. The following procedure describes how to power up the drive. These instructions assume that dc power is available to the drive because power supply circuit breaker CB1 is normally left in the ON position.

1. Press the START switch to engage the drive. If the LOCAL/REMOTE switch is set in the LOCAL position, the power-up sequence begins immediately. If the switch is set in the REMOTE position, the power-up sequence continues when power-sequence ground is available from the controller. In the REMOTE position, the power-up sequence to each drive is delayed. The length of delay is determined by the number of the unit logic plug used, in increments of five seconds. For example:

   Logic Plug 0 = Zero-second delay
   Logic Plug 1 = Five-second delay

2. After the delay, the ready indicator (located in the START switch) flashes, indicating that the power-up is in progress. Observe that the ready indicator lights steadily within 30 seconds, indicating that the disks are up to speed and the heads are loaded.

3. Ensure that the fault indicator is off.

The power-up sequence is now complete, and the drive is ready to read or write data.

4.3.2.6 WD900 Power-Down Procedure. The following procedure describes how to power down the drive.

1. Press the START switch to release it from the start position.

2. Observe that the ready indicator (located on the START switch) flashes, indicating that power-down is in progress.

3. Observe that the ready indicator goes off within 45 seconds, indicating that power-down is complete.

With power-down completed, the heads are positioned in the landing zone and the disks are not rotating. Normally, power supply circuit breaker CB1 is left on to continue supplying dc power to the drive.

4.3.2.7 WD900 Self-Test Diagnostics (425-Megabyte Drive). The following is required to perform the diagnostic tests for the 425-megabyte drive. Table 4-3 defines the functions of the switches and indicators on the fault/display panel.

Table 4-3 Diagnostic Switch/Indicator Description

Description	Function
Diagnostic mode switch	Placing this switch in the up position puts the unit in the diagnostic mode, lights the diagnostic mode indicator, and drops the READY signal.
Diagnostic STEP switch	This switch steps the numerical pattern from 0 to F. Holding the switch down causes the numbers to increment continuously and wrap around from F to 0. Refer to the description of the diagnostic execute switch.
Diagnostic execute switch	This switch enters numerical display values into memory. The entries permit test selection, entry of test parameters, and test deselection.
Numerical display	These indicators display the current status either when the drive is in the normal mode or in the diagnostic mode (displaying either the diagnostic options or error codes).

Test Selection Procedures. Place the diagnostic mode switch to the ON position, causing a 00 to be displayed in the numerical display. Press the STEP switch after pressing the mode selection to increment the least significant character (display on the right side). Press the EXEC (execute) switch when the desired character is displayed to enter the character into memory. Press the STEP switch a second time to increment the most significant character (left side display), and press the EXEC switch after the desired character is displayed to enter the character into memory. Press the EXEC switch again to initiate the test. Tests that require additional parameters are defined in the test descriptions. When a test completes, the display returns to 00. At this point, place the diagnostic mode switch in the OFF (down) position, and observe the display to determine if an error has occurred. You can also perform diagnostic test 00 to display any errors.

Test 00 -- Display Status/Error Code Log. This test displays the sixteen most recently generated status/error codes. This test displays a pointer to a memory location in the range from >20 to >2F. Press the STEP switch to display the contents of memory locations >20 through >2F. After displaying location >2F, the display returns to the original pointer. Press the EXEC switch to end the test.

Test 01 -- Display Fault Log. This test displays the eight most recently generated fault conditions and provides a display that points to a memory location in the range from 31 through 39. Press the STEP switch to display the contents of these memory locations. After displaying location 39, the display returns to the original pointer. The current fault is in the location preceding the original pointer. Press the EXEC switch to end the test. The following are definitions of each bit within the fault byte:

Bit	Defintion
0	Not used
1	Voltage fault
2	Write fault
3	Read/write fault
4	Read/write and off cylinder fault
5	Head select fault
6	First seek fault
7	Not used

Test 2 -- Restart Power-Up. This test performs the drive power-up routine. It performs a complete check of the MPU and power control logic if the spindle motor stops. This test does not cause the spindle motor to recycle if the motor is operating. This test is performed once and then returns to test 00.

The pointer is set to >25 if the complete power-up routine is performed. Continuously press the STEP switch to display the contents of the status/error log. The expected contents of the status/error log are 70, 71, 00, 02, 03, and 00 in all the remaining locations.

The pointer is set to >24 if the spindle is turning during the power-up routine. Press the STEP switch to display the contents of the status/error log. The expected contents of the status/error log are 70, 18, 01, 51 and 00 in all the remaining locations.

Test 03 -- Switch Display Test. Immediately after this test is selected, all the fault indicators are lit, and the display alternates ten times between EE and 11. You can press the switches in the following list to cause the associated LED to light.

Switch	LED
Local/Remote	Write fault.
Start	Read/Write fault (LOCAL/REMOTE must be in the LOCAL position).
FAULT/clear	Voltage fault (may be erratic).
Servo test	Read/Write fault and not on cylinder fault.
Diagnostic Mode	Head select fault. Turn this switch off then on, and leave in the on position at the conclusion of the test.

These subtests can be performed any number of times. Press the EXEC switch to exit the subtests. Pressing the EXEC switch again displays >80. Press the STEP switch eight times to cause the display to change as follows: 80, 40, 20, 10, 08, 04, 02, 01, 00. Turn the diagnostic mode switch off and press the EXEC switch to exit. To continue testing, turn the diagnostic mode switch to on.

Test 4. To be supplied in a future revision.

Test 5 -- Servo Test. This test automatically performs several types of seek operations. The following lists the seek operations in the order they are performed.

Operation	Number of Times Performed
RTZ	1
One-track seek	16
Servo recalibrate	8
Full stroke seek	16

The status and error code information is displayed after each operation. The test stops when an error is detected or the test completes.

Test 6 -- Clear Status/Error Log. This test clears the status/error log. At the conclusion of the test, the log pointer is set to >20 but is not displayed.

Test 7 -- Clear Fault Log. This test clears the fault log. At the conclusion of the test, the log pointer is set to >31 but is not displayed.

Test 8 -- Direct Seek. This test performs a continuous seek between cylinder 0 and the cylinder address loaded by test >0D. Status is displayed at the end of each seek. The operation is terminated if a bad status error is reported or if the EXEC switch is pressed.

Test 9 -- Random Seek. This test performs a continuous random seek between cylinder >0 and cylinder >710. The operation is terminated if a bad status error is reported or if the EXEC switch is pressed.

Test A -- Load Delay. This test displays a count corresponding to the amount of delay between seeks during a power-up seek scan operation. Each increment represents 10 milliseconds. An 08 count represents a default.

Test B -- Display/Alter Memory. This test displays the contents of a memory address previously loaded by Test D. You can alter the contents of this address by pressing the STEP switch the required number of times to increment the display to the desired low order digit. Then press the EXEC switch to enter the digit into memory. Repeat this operation to alter the high order digit. The display then automatically advances to the next memory address. You can alter the contents of this address by repeating the previous procedure. To bypass an address, press the EXEC switch twice. Exit this test by turning the diagnostic switch to OFF and then turning the switch to ON.

<u>Test C -- Display EPROM Part Number</u>. This test displays the eight-digit part number of the erasable programmable read-only memory (EPROM) located on the control board. The display is broken into four two-digit bytes starting with the most significant byte. You can display the remaining bytes by pressing the STEP switch three times. Exit the test by turning the diagnostic switch to OFF and then turning the switch to ON.

<u>Test D -- Load Cylinder or Memory Address</u>. This test allows you to load a four digit hexadecimal cylinder or memory address for use when performing Test 8 (Direct Seek), or Test B (Display/Alter Memory). Load the LSB of the upper memory byte by pressing the STEP switch until the desired character is displayed and then by pressing the EXEC switch. Enter the MSB of the upper memory byte by repeating the above procedure. Use the same procedures to load the lower memory byte. The test concludes when the EXEC switch has been pressed four times.

<u>Test E -- Return-to-Zero</u>. This test performs the return-to-zero (RTZ) seek.

4.3.2.8 Error Display. When the power is initially turned on, the controller performs a self-test microdiagnostic. While the diagnostic is running, the red light-emitting diode (LED) located on the top edge of the board (refer to Figure 1-1) remains lit and extinguishes upon successful completion of the microdiagnostic. Additional board failure information can be obtained by reading the TILINE peripheral control space (TPCS) registers and the extended status of the individual units. For more information on the extended mode self-test, refer to paragraphs 3.9.12 (tape extended commands) and 3.6.2.2 (disk extended commands). If no errors are found, the red LED turns off. Below the right ejector tab are two green LEDs that indicate, when lit, that the disk and tape sections of the controller are idle and ready to accept commands.

NOTE

The fault LED does not light during a self-test initiated by the operator.

4.3.2.9 WD900 Fault and Error Conditions. The following paragraphs describe those conditions that are interpreted by the drive as errors. These errors are divided into those that generate the fault signal and those that do not.

The following descriptions include a list of conditions that produce each error status, the effect of that status on drive operation, and actions that clear the status indication to return the drive to normal operation.

Errors Indicated by the Fault Signal. The drive has monitoring circuitry that recognizes six types of error conditions. When any of these error conditions occur, the respective fault LED on the control board is illuminated. The LED remains lit until the fault is cleared.

When the fault line goes active, it lights the fault indicator on the operator panel, disables write operations, and issues fault and write-protected status to the controller. The ready indicator on the operator panel then flashes until the fault is cleared.

Provided the error condition or conditions no longer exist, the fault signal is cleared by the following:

* Using the controller Fault Clear command (TAG 3 with bus bit 4)

* Pressing the FAULT/Clear switch on operator panel

* Powering down the drive

The controller Fault Clear command is decoded inside the I/O circuitry to develop a reset input for the six fault LEDs. When the FAULT/Clear switch is pressed, it interrupts the MPU. The MPU responds by resetting the fault LEDs if the error condition no longer exists. The process of removing and reapplying power (cycling power) to the drive clears the fault circuitry, and any preexisting fault status is lost.

The following paragraphs describe the individual fault conditions that light the fault LEDs.

Voltage or Actuator Current Fault. This fault is generated whenever either the +15 or +5 voltages are below satisfactory operating levels or whenever the actuator current exceeds an allowable level. Threshold detectors on the control board activate the overcurrent line if the actuator current reaches 5.9 amperes. The detectors light the volt indicator if any of the following voltages drop:

* The +15-volt supply drops to 14.35 volts.

* The +5-volt supply drops to 4.83 volts.

* The -5-volt supply drops to -4.90 volts.

* The -15-volt supply drops to -14.46 volts.

If an overcurrent and voltage fault occurs, the power LED is illuminated. When the power LED is illuminated, the current data is write-protected and no write operations can be performed until the fault is cleared.

Read or Write and Off Cylinder. This fault is generated if the drive is in an off-cylinder condition and it receives a Read or Write command from the controller. The I/O gate array decodes both gates from TAG 3 commands and contains the on cylinder FF signal. When the on cylinder FF signal is cleared and either gate of TAG 3 goes active, logic in the gate array lights the read/write indicator.

Write Fault. A write fault lights the WRT indicator (on the control board of the 138-megabyte drive and on the status/fault display board on the 425-megabyte drive) if the following conditions exist:

* Write attempt received while the drive is in write-protected mode

* No write current signaled to the write driver when write enable is active

* No write data transitions when attempting to write data (except when the address mark enable signal is active)

* Bad head detected

* An invalid head address received

When the controller selects an illegal head, an error is not detected until the controller attempts to write with that head. Since no head was selected, there is no write current to the write driver and the WRT fault indicator lights.

Head Select Fault. This fault is generated when more than one head is selected during a write operation. When this condition is detected, the fault LED lights.

Read and Write Fault. This fault is generated whenever the drive receives a Read command and a Write command simultaneously. This condition lights the fault LED.

First Seek Fault. A first seek fault, as opposed to a seek error, results from error conditions that occur during power-up initialization and the load operation. A seek error, on the other hand, indicates error conditions that occur during normal seeks and return-to-zero (RTZ) seeks. First seek faults light the first seek indicator while seek errors activate the seek error and seek end lines to the controller.

The drive aborts the load operation when a first seek fault is indicated. Although a controller Fault Clear command resets the fault signal, the drive waits until the FAULT/Clear switch is pressed before attempting another load.

Errors Not Indicated by Fault Signal. Two types of errors do not generate the fault status -- seek errors and motor speed errors. The seek error has an associated status FF, while the motor speed error does not.

Motor Speed Error. A motor speed error is caused when the spindle speed falls below 3528 revolutions per minute.

Seek Error. Seek error is a status signal that is sent to the controller and indicates error conditions that occur during normal seeks and RTZ seeks. If any seek error condition fails, the MPU sets the fault LED on the controller. These seek error conditions include the following:

* An invalid cylinder address, which is specified by the controller for a normal seek
* The demodulator active signal, which is active at the start and end of normal seeks and throughout RTZ seeks
* A fault staying inactive throughout all seeks

4.3.2.10 WD900 Status Codes. Whenever the drive is in a power-up condition (dc power active), the MPU periodically checks operation of the servo status system and generates appropriate status codes. The codes can be visually monitored (the 425-megabyte drive only) by removing the drive front panel insert. Table 4-4 is a summary of all the status codes.

When interpreting the status codes, be aware that not all codes appearing on the display indicate errors. Some codes indicate that the operation is still in progress, and others indicate that the operation has successfully completed.

The status is continually changing when an operation is in progress. Most codes flash on and off very rapidly and are not recognizable. Others remain on for several seconds.

If an error occurs, the status indicates the type of error and where in the sequence the error occurred. The error code remains active until the proper action is taken to reset the drive.

Table 4-4 Status Code Summary

Status Code	Description
	Normal Motor Stop:
01	Retracting heads to landing zone
02	Stopping motor
03	Motor stopped OK
	Normal Motor Start:
07	Motor start in progress (no jog)
08	Motor start in progress (including jog)
09	Speed OK too soon
0A	Too long to get up to speed (retry)
0B	Too long to get up to speed (sensor fault)
0C	Too many start-up failures (no retry)
0D	Too many start-up failures (sensor fault)
0E	Motor speed too high
0F	Motor speed too low
10	Speed loss recovery with seek error
	Motor Stop During Recovery From Speed Drop:
11	Unloading heads
12	Stopping motor

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	Motor Start During Recovery From Speed Drop:
18	Motor start in progress (including jog)
19	Speed OK too soon
1A	Too long to get up to speed (retry)
1B	Too long to get up to speed (sensor fault)
1C	Too many start-up failures (no retry)
1D	Too many start-up failures (sensor fault)
1E	Motor speed too high
1F	Motor speed too low
	Normal Load:
21	Heads loaded before load begins
22	Fault after power -- amplifier driver enabled
25	Demodulator active time-out
26	Cylinder pulse time-out
27	Fault after load complete
28	Code 22 and too many retries
2B	Code 25 and too many retries
2C	Code 26 and too many retries
2D	Code 27 and too many retries

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	Normal RTZ:
30	Cannot move in from outer guard band
31	Lost demodulator active before turnaround
33	Time-out during RTZ
34	Back up into outer guard band
35	Turnaround
36	Out of guard band too soon
37	Cannot find cylinder pulse at track 1
38	Find fine enable
39	Settle in on track 0
	Normal Guard Band:
40	Inner guard band detected during normal seek
41	Inner guard band detected during on-cylinder routine
42	Inner guard band detected while on cylinder
43	Outer guard band detected during normal seek
44	Outer guard band detected during on-cylinder routine
45	Outer guard band detected while on cylinder
	Normal Seek Time-Out:
46	Seek time-out

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	(Normal) Cannot Stop On Track During On-Cylinder Routine
47	Too long to get on-cylinder sense
48	Demodulator active lost during on-cylinder routine
49	Too many cylinder pulses during settle-in time
4A	Too many on-cylinder drop-outs
	Normal On Track
4B	Off cylinder
4C	Lost demodulator active while on cylinder
4E	Voltage fault while on cylinder
	(Normal) Illegal Cylinder Address Greater Than 710
4D	Illegal cylinder address
	Reset Dummy RTZ Mode Canceled
50	Recovery from low Vcc reset
51	Recovery from MPU hang reset
52	Recovered from low Vcc reset and subsequent speed loss
53	Recovered from MPU hang and subsequent speed loss
5B	Too many fan faults (greater than 10)
5C	Fan fault
5F	PIA test failure
80	Fault before seek begins
90	Recovered from speed loss

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	Load and Fault Detected Before Seek Error Was Set
A1	Heads loaded before load begins
A2	Fault after retract relay set
AS	Demodulator active too late
A6	Cylinder pulse time-out
A7	Fault after load complete
A8	Code 22 and too many retries
AB	Code 25 and too many retries
AC	Code 26 and too many retries
AD	Code 27 and too many retries
	RTZ and Fault Detected Before Seek Error Was Set
B0	Cannot move in from outer guard band
B1	Lost demodulator active before turnaround
B3	Time-out during RTZ
B4	Backup into outer guard band
B5	Turnaround
B6	Out of guard band too soon
B7	Cannot find cylinder pulse at track 1
B8	Find fine enable
B9	Settle in on track 0

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	Guard Bands and Fault Detected Before Seek Error Was Set
C0	Inner guard band detected during normal seek
C1	Inner guard band detected during on-cylinder routine
C2	Inner guard band detected while on cylinder
C3	Outer guard band detected during normal seek
C4	Outer guard band detected during on-cylinder routine
C5	Outer guard band detected while on cylinder
	Seek Time-Out and Fault Detected Before Seek Error Was Set
C6	Seek time-out
	Cannot Stop On Track During On-Cylinder Routine and Fault Detected Before Seek Error Was Set
C7	Too long to get on-cylinder sense
C8	Demodulator active lost during on-cylinder routine
C9	Too many cylinder pulses during settle-in time
CA	Too many on-cylinder drop-outs
	On Track and Fault Detected Before Seek Error Was Set
CB	Off cylinder
CC	Lost demodulator active while on cylinder
CE	Voltage fault while on cylinder
	Illegal Cylinder Address Greater Than 710 and Fault Detected Before Seek Error Was Set
CD	Illegal cylinder address

Table 4-4 Status Code Summary (Continued)

Status Code	Description
	Reset Dummy RTZ Mode Active
D0	Recovery from low Vcc reset
D1	Recovery from MPU hang reset
	MPU Power-Up Test
FF	MPU failed power-up test

4.3.3 MT3200 Operation
The following paragraphs describe how to power up, load, and unload the MT3200. Operator preventive maintenance, and error conditions and codes are also discussed.

4.3.3.1 MT3200 Power-Up Procedures. Section 1 contains a detailed description of all the controls. To check for proper operation before installation, proceed as follows:

1. Connect the power cord.

2. Clean the tape path as directed in paragraph 4.3.3.6.

3. Apply power to unit and verify that the unload indicator is illuminated. (Allow for normal delay of approximately five seconds.) For error indicators refer to paragraph 4.3.3.9, paragraph 4.3.3.10, and Table 4-9.

4. Ensure that tape is wound completely onto reel.

CAUTION

The top cover and front panel door are locked during tape-loading functions. An attempt to open either the top cover or front panel door before the tape is unloaded causes mechanical damage to the locking mechanism.

5. Open the front panel door by pressing down gently on the top (center) of the door.

6. Insert the tape into the front panel of the unit with

the write-enable ring side down.

7. Close the front panel door.

8. Actuate the LOAD switch. The access doors are now locked. When the load sequence is completed, the load indicator remains illuminated.

9. Check that the load indicator remains illuminated following a rewind sequence.

10. Check the ONLINE switch and indicator by pressing repeatedly and observing that the online indicator is alternately illuminated and extinguished. Leave the drive in the offline state (indicator extinguished).

11. Press the UNLOAD switch. When the tape is unloaded (unload indicator illuminated), open the front panel door and remove the tape reel. Close the front panel door.

The power-up sequence is now complete, and the tape is ready for use.

4.3.3.2 Loading the MT3200. To load the tape for the MT3200, proceed as follows:

CAUTION

Do not attempt to open either the top cover or front panel door during a load operation or while tape is loaded in the transport. Both the front panel door and top cover are locked during tape load functions.

1. Apply power to the unit and verify that the unload indicator is illuminated. (Allow for normal delay of five seconds.)

2. Verify that the write-enable ring, if used, is fully seated.

3. Ensure that the tape is wound completely onto the reel.

4. Open the front panel door by pressing down gently on the top (center) of the door.

5. Insert the tape into the front of unit with the write-enable ring side down.

6. Tip the edge of the reel that is inside the unit upward slightly to clear the supply hub.

7. Place the tape completely inside the unit.

8. When the door is closed, verify that the reel does not touch the door.

9. Close the front panel door.

10. Press the LOAD switch. The access doors are now locked. The load indicator remains lit after the load sequence completes.

An automatic load failure causes all the indicators except the unload and online LEDs to flash. To correct this problem, proceed as follows:

1. Remove the tape reel (refer to paragraph 4.3.3.3).

2. Clean the reel with an antistatic cloth (commercially available) to remove any static.

3. Crimp the end of the leader slightly with your fingers to aid the automatic load feature.

4. Replace the reel and retry the above procedure.

NOTE

Pressing the ONLINE switch during the load sequence places the transport online when the BOT marker is sensed by the transport.

4.3.3.3 Unloading the MT3200. To unload the MT3200 tape, proceed as follows:

1. Press the UNLOAD switch. The MT3200 must be in offline mode (online indicator extinguished).

NOTE

During the unload sequence, the unload indicator flashes and the access doors remain locked. When the unload sequence completes, the unload indicator remains illuminated and the access doors then unlock.

2. Open the front panel door when the unload indicator remains illuminated.

3. Carefully lift up the reel to clear the supply hub and remove the reel from the unit.

4. Close the front panel door.

4.3.3.4 MT3200 Manual Load. To load the tape after a failure of the autoloading routine, proceed as follows:

1. Extend the unit on its slides to clear the equipment rack.

2. Place the unit in the operator-maintenance access position by lifting the top cover sides behind the front panel. Place the cover stay in the slot provided.

3. Place the reel of tape on the supply hub. Ensure that the reel is evenly seated on the hub.

4. Depress and hold the manual unlock button located behind the front panel door on the bottom left-hand side of the tape reel opening. Simultaneously rotate the supply hub clockwise until the supply reel is locked in place.

5. Thread the tape along the path shown in Figure 4-4. Carefully move the tachometer assembly away from the takeup hub.

6. Wrap tape once clockwise around takeup hub, and gently replace tachometer assembly.

7. Continue to wrap tape for five more revolutions of the takeup hub. Ensure that the tape is seated correctly on the guides and threaded properly over the head assembly.

8. Close the top cover and place the transport in the normal operating position.

9. Depress and hold the HI DEN switch, then press the LOAD switch and release both. The slack is removed from the tape, and it advances forward until the BOT tab is positioned at the photosensor. The load indicator illuminates, which indicates that the MT3200 is ready for use.

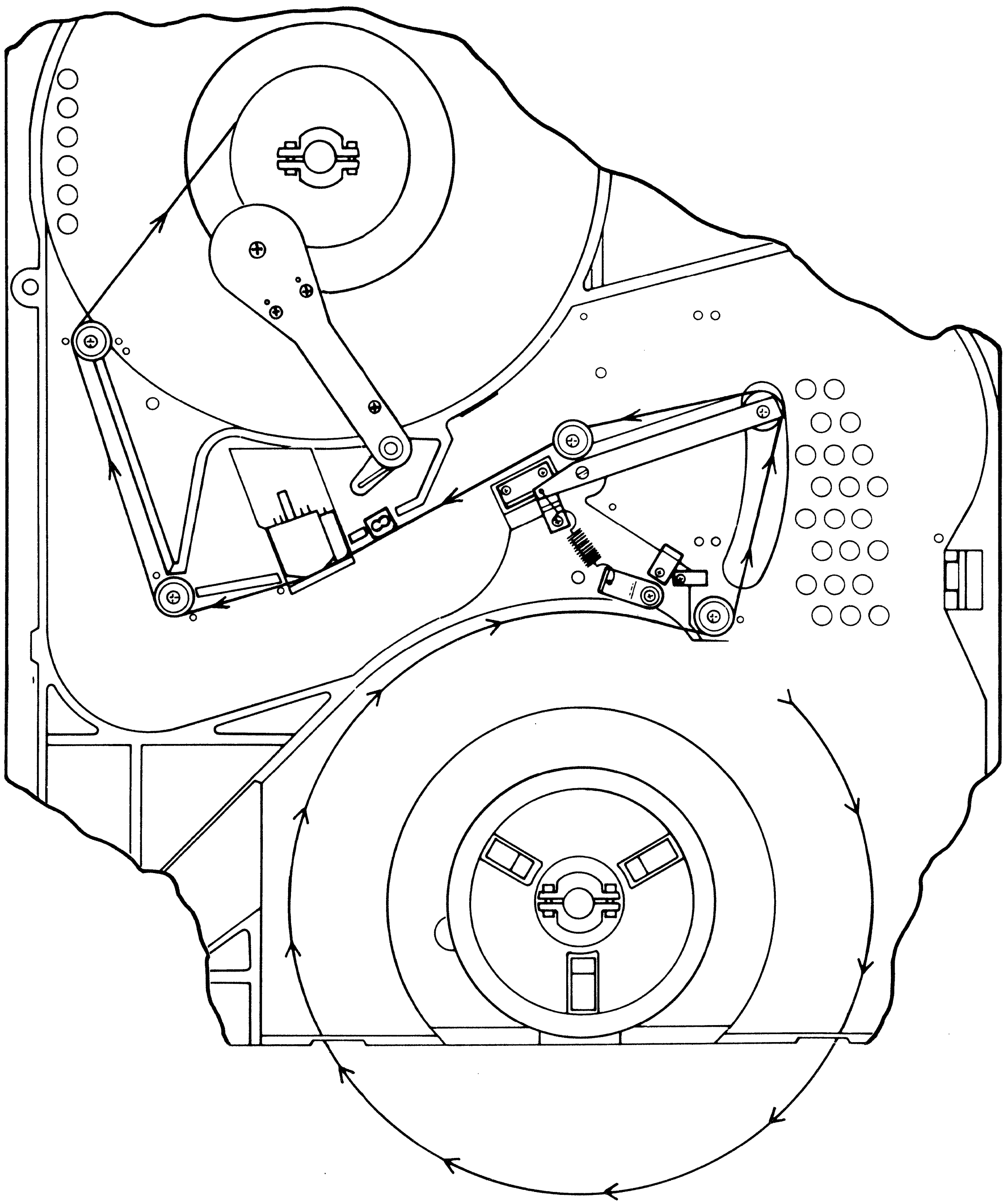

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Figure 4-4 Tape Threading Path

4.3.3.5 MT3200 Manual Unload. If for any reason the MT3200 cannot complete the rewind and unload sequence, the tape reel can be rewound manually as follows:

1. Place the transport in the operator-maintenance access position (refer to the previous procedure).

2. Rotate the supply reel in a counterclockwise direction to rewind the tape onto the supply reel.

3. Depress and hold the manual unlock button, which is located behind the front panel door on the bottom left-hand side of the tape reel opening. Simultaneously rotate the supply reel counterclockwise until it rotates freely and can be removed from the unit.

4.3.3.6 MT3200 Operator Preventive Maintenance. For routine cleaning, place the MT3200 in the operator-maintenance access position. Figure 4-5 shows the maintenance access position for the tape unit. Figure 4-6 identifies the locations of the items that require routine cleaning.

CAUTION

Do not apply a cleaner directly from the container to the surface to be cleaned. Always apply the cleaner to a swab or a wipe first, and carefully remove any excess. The tachometer roller and roller guides contain precision bearings. Solvents allowed to run into the bearings will break down the lubricant.

CAUTION

Rough or abrasive materials can scratch sensitive surfaces of the head, resulting in permanent damage. Other cleaners, such as alcohol-based types, can cause read/write errors.

The recommended cleaning materials are a lint-free cloth, solvent resistant swabs, and a liquid tape cleaner (Freon(TM)). Refer to Figure 4-6 for the locations of items that require routine cleaning. Table 4-5 describes the preventive maintenance schedule.

To access the tape path area for routine cleaning, proceed as follows:

1. Switch the MT3200 power to the off position.

2. Pull the unit out on the rack-mount slides until the locks engage.

3. Open the top cover by lifting the sides directly behind the front panel. Place the cover stay in the slot provided.

4. Perform the required maintenance.

5. Close the top cover to return the drive to the operating position.

6. Release the slide locks and push the unit back into the equipment rack.

7. Switch the unit power on.

Freon is a trademark of E. I. Du Pont de Nemours and Co., Inc.

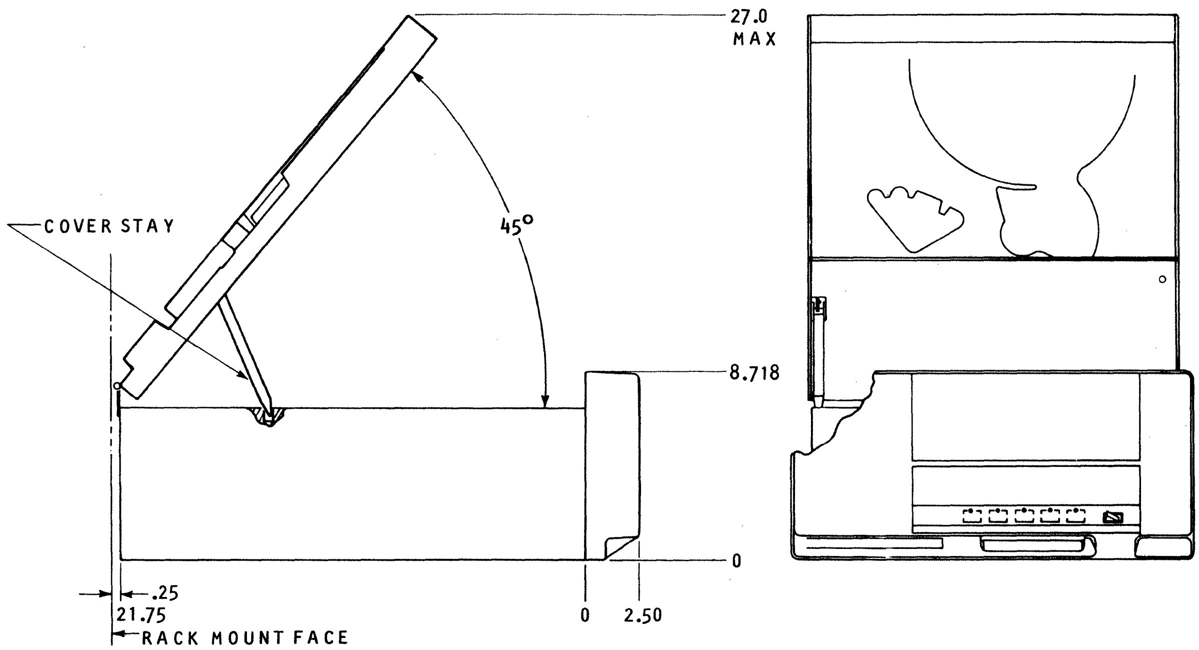

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Figure 4-5 Operator Access Position

The following paragraphs describe the cleaning procedures for the numbered items in Figure 4-6.

Tachometer Roller (Number 8). Use a swab moistened with tape-path cleaner. Gently wipe the entire roller surface. You can rotate the roller by manually and slowly turning the takeup hub.

Takeup Hub (Number 9). Use a swab or a wipe moistened with tape-path cleaner. Rotate the hub manually while gently wiping the tape wrapping surface.

Roller Guides (Numbers 3, 4, and 5). Use a swab moistened with tape-path cleaner. Rotate each roller and gently wipe the tape contact surface-flanges or washers.

Reel Hub Pads (Number 1). Use a swab or a wipe moistened with tape-path cleaner. Wipe the contact surface of each pad and remove any debris around the pad.

Head (Number 7). Use a swab or a wipe moistened with head cleaner. Wipe the entire face of the head and attached erase bar, paying particular attention to the recessed areas.

CAUTION

Rough or abrasive materials can scratch sensitive surfaces of the head, resulting in permanent damage. Other cleaners, such as alcohol-based types, can cause read/write errors.

Tape Cleaner (Number 6). Use a swab moistened with head cleaner. Wipe each blade along its length. Remove accumulated oxides from the recessed area between the blades.

CAUTION

Exercise care to avoid damage to the sharp edges of tape cleaner blades.

Front Panel and Door. Use a wipe moistened with plastic cleaner.

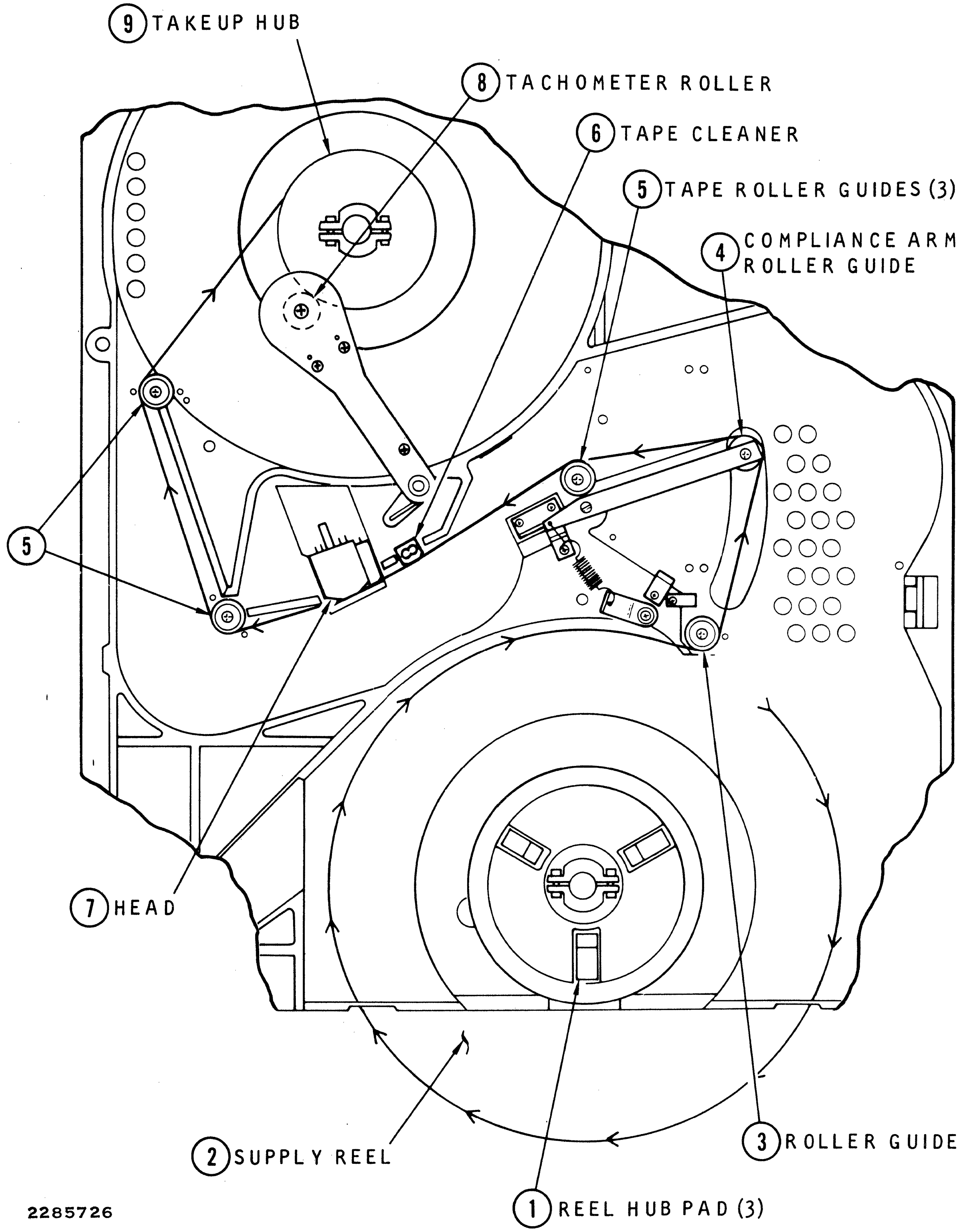

Figure 4-6 Tape Path and Related Parts

Top Plate Casting. Use a cloth moistened with plastic cleaner. Wipe the oxide dust from the tape-path area. Be careful not to get dirt on the head, rollers, and associated parts. Avoid disturbing the sensors.

Filter. Locate and remove the filter from inside the airduct opening at the lower left of the front panel (refer to Figure 4-7). Clean the filter with low-pressure compressed air (or a vacuum) in the opposite direction of airflow and reinstall.

Table 4-5 MT3200 Preventive Maintenance Schedule

Maintenance Operation	Frequency (Hours)	Quantity to Maintain
Tachometer roller	8	1
Takeup hub	8	1
Roller guides	8	5
Reel hub pads	8	3
Head	8	1
Tape cleaner	8	1
Front panel and door	As required	1
Top plate casting	As required	1
Filter	1000	1

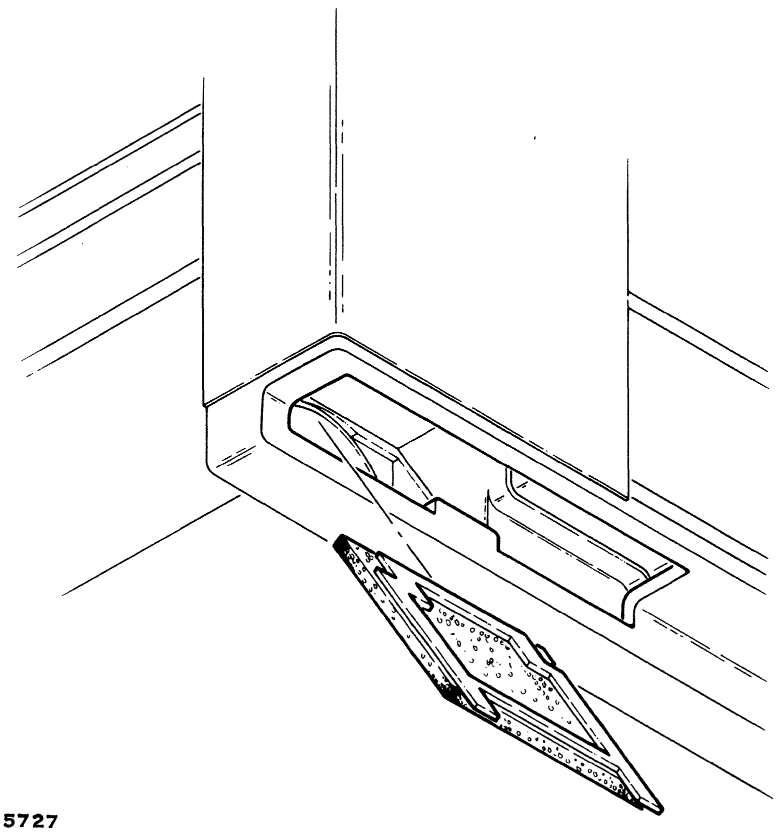

Figure 4-7 MT3200 Air Filter Removal

4.3.3.7 MT3200 Power-Up Self-Test Codes. Table 4-6, Table 4-7, and Table 4-8 describe the front panel display during each power-up self-test (PUST) and indicate where the failure occurred.

Table 4-6 Tests 1 Through 6 PUST Failure Codes

PUST Test	Failure	Level 1 Display	Level 2 Display	Remarks
1	Low ROM (U5L)	10000	--	Checksum error
2	High ROM (U3L)	01000	--	Checksum error
3	Low RAM (U5N)	11000	--	Data-test error
4	High RAM (U3N)	00100	--	Data-test error
5	CIO-Test	10100	--	Press LOAD switch for the level 2 display
	*CIO-Z1	10110	00010	IC-U9L failure
	*CIO-Z2	10101	00001	IC-U11L failure
	*CIO-Z3	10111	00011	IC-U13L failure
6	Early Test Exit	01100	--	Generally indicates a failure in tests 1 through 5; tests for early PUST abort when TEST is pressed and held during power-up.

NOTE:

*CIO is the microprocessor computer I/O. The first two bits on the right flash to indicate failure.

NOTE

All failure information is lost when the TEST switch is pressed to enter the diagnostic mode.

A failure in test 7 causes the load, unload, and online LEDs to flash. Press the LOAD switch once to display the level 2 failure information. Level 2 through level 5 information is presented in two alternating 4-bit nibbles. The high-order nibble appears when the HI-DEN LED illuminates. When the HI-DEN LED is extinguished, the low-order nibble appears. Table 4-7 includes the level 2 through level 5 information that is available when the LOAD switch is pressed from one to four times respectively. For example, press the LOAD switch once for level 2 information, and press it twice for the level 3 information.

A failure in tests 8 through 13 causes the front panel LEDs to flash the failed test number. Refer to Table 4-8 and press LOAD a second time to display level 2 information about the failure.

Read all the failure information and press the TEST switch to put the unit in the diagnostic mode. When the test indicator flashes enter the service-aid access codes. Press the TEST switch to put the unit in the diagnostic mode after all the front panel LEDs flash.

Table 4-7 Test 7 PUST Failure Codes

Level 1 Display	Level 2* Low	Level 2* High	Level 3* Low	Level 3* High	Reason
11100					DMA/cache circuits
					DMA failure
	10000	00001			Base address error
	01000	00001			Word count error
	11000	00001			No count rollover
	00100	00001			Addition not 0
	10100	00001			No terminal count
	01000	00001			Cache RAM circuits
	10000	00001			Address error (low to high)
	01000	00001			Address error (high to low)
			10000	00001	RD7 - U10T
			01000	00001	RD6 - U11R

Level 4* Low	Level 4* High	Level 5* Low	Level 5* High	Reason
00100	00001			RD5 - U11T
00010	00001			RD4 - U9P
00000	10001			RD3 - U9R
00000	01001			RD2 - U10P
00000	00101			RD1 - U11P
00000	00011			RD0 - U10R
		10000	00001	Read parity error (U9T)
		01000	00001	Write parity error (U9T)

NOTE:

* Press the LOAD switch to access successive failure code levels.

Table 4-8 Tests 8 Through 13 PUST Failure Codes

PUST Test	Level 1 Display	Level 2 Low	Level 2 High	Reason
8	00010			CIO initialization failure
9	10010			DAC/ACD test failed
		10000	00001	DAC failed auto-zero
		01000	00001	Reference voltage (VIN5) error
10	01010			Servo-motor test failed
		10000	00001	Unexpected drive voltage
		01000	00001	Unexpected electromotive force (EMF) on supply motor
		11000	00001	Unexpected EMF on takeup motor
		00100	00001	Takeup motor EMF out of tolerance
		10100	00001	Takeup motor rotation out of tolerance
11	11010			Tachometer test failed
		10000	00001	Either of the two phases missing
		or		
		01000	00001	
		11000	00001	Both phases missing
		00100	00001	Phase separation out of tolerance
12	00110			EOT/BOT test failed
		10000	00001	BOT failed
		01000	00001	EOT failed
13	10110			Compliance arm voltage out of tolerance
		10000	00001	Reset voltage too low
		01000	00001	Reference voltage (VIN6) error

4.3.3.8 MT3200 Error Conditions. Operating failures or fault conditions are indicated by various front panel display patterns. Fault indications are either normally caused by the tape or operator and can be avoided by following the proper operating procedures or are machine malfunctions and require correction by an experienced service technician.

4.3.3.9 MT3200 Operator Error Codes. Operator errors occur during normal tape loading operation. They produce error codes that are displayed as an even, on-off pattern on the front panel. Refer to Table 4-9 for more information.

Press the LOAD switch to clear the error condition after the problem is corrected, and reenter the load sequence. A machine malfunction is indicated if an error condition occurs when the proper operating procedures were followed.

4.3.3.10 MT3200 Transport Error Codes. Transport errors indicate a serious deviation from the normal operating routine of the MT3200. Each error code represents a unique binary pattern on the front panel indicators. The indicators flash a quick double-pulse to alert the operator. These errors inhibit the MT3200 and may require correction by a service technician. They can be cleared only by turning the power off. Refer to Table 4-9 for these error codes and troubleshooting instructions.

Table 4-9 Transport and Operator Error Codes

Error Code No.	Binary Display	Conditions	Action
3	11000	The unit detected more than 3700 feet of tape beyond the BOT marker.	Try a different tape reel.
4	00100	Compliance-arm circuit voltage levels out of tolerance during the autoload sequence.	1. Check that tape is properly wrapped around takeup hub. 2. Contact certified technician.
6	01100	The unit received a Write or Erase command for a file protected tape.	Possible host system failure. 1. Verify that write-enable ring is removed from the tape reel. 2. Contact technician.

Table 4-9 Transport and Operator Error Codes (Continued)

Error Code No.	Binary Display	Conditions	Action
7	11100	An illegal or undefined command was received by the MT3200 unit.	Possible host system failure. Check interface logic for floating or grounded inputs.
8	00010	Internal status self-check fault.	1. Note host command sequence, operating system program, and the version or release number. 2. Contact technician.
9	10010	Tape loading failure.	1. Clean and inspect the tape take-up hub. 2. Contact technician.
10	01010	Write edit failure.	New block size greater than original. Recheck block size.
11	11010	The number of write retries exceeded 16.	1. Try a different tape. 2. Clean the tape heads. 3. Contact technician.
12	00110	No end of block on read after write check.	Contact technician.
13	10110	Internal status self-check fault.	1. Note host command sequence, operating system program, and version or release number. 2. Contact technician.
14	01110	Tape travel beyond the EOT marker exceeded 18 feet.	Possible host system failure. Contact technician.
15	11110	Data block exceeded maximum block size allowed (32K bytes).	Possible host system write operation failure. Contact technician.

Table 4-9 Transport and Operator Error Codes (Continued)

Error Code No.	Binary Display	Conditions	Action
17	10001	The compliance arm exceeded its travel limits during normal operation.	Contact technician.
18	01001	Tape speed variation exceeds ANSI maximum of +/-10%.	Contact technician.
19	00110	Vertical parity error.	Contact technician.
20	00101	DMA failure. Word count not at 0 after time-out.	1. Verify that PUST test 7 completes successfully. 2. Contact technician.
21	10101	Excessive retries on write filemarks.	Contact technician.
24	00011	Parity error during cache RAM refresh cycle	1. Cycle power to force PUST and check for RAM fault. 2. Check cache RAM with PUST test 7 and rerun host program.
25	10011	Not enough tape on the takeup reel for manual load.	Add more tape to the takeup reel.
26	01011	Failure to peel the tape during automatic load.	Refer to paragraph 4.3.3.2.
27	11011	Door lock failure or the door/cover is open	Verify that the door is firmly seated.
28	00111	The servo failed, the hub jammed, or the hub is not locked for manual load.	Contact technician.
29	10111	The reel is upside-down, no tape is in the column, or there is a bad tape in path (TIP).	Contact technician.

Table 4-9 Transport and Operator Error Codes (Continued)

Error Code No.	Binary Display	Conditions	Action
30	01111	BOT marker is not detected within first 35 feet of tape. The tape leader must be a minimum of 6 feet in length.	Check tape leader length.
31	11111	The autoload failed after four tries.	Refer to paragraph 4.3.3.2.

Appendix A

Field Replaceable Parts

This appendix lists the field replaceable parts as well as the maintenance supplies and tools that are listed as part of the TI 979/979A/MT1600/MT3200 tool kit, TI part number 0943849-0700. The following are the maintenance tools and supplies that are part of this tool kit.

Item	TI Part Number
Status control	0943849-1700
Status control cable	0943849-1701
Skew monitor	0943849-1607

The following are the field replaceable parts and their respective TI part numbers for the WD/MT controller, the MT3200 tape unit, and the WD900 disk drives.

Table A-1 Field Replaceable Subassemblies and Parts

Description	TI Part Number
WD/MT Controller	
WD/MT controller board	2244780-0001
MT3200	
Air filter	2242374-0001
Air pump assembly	2242428-0001
Compliance arm assembly	2242429-0001
Cables	
Controller to transition board (short)	2244802-0001
Controller to transition board (long)	2244802-0001
Transition board to tape drive ribbon cable (2 required)	2244831-0001
EOT/BOT sensor assembly	2242421-0001
File protect sensor	2242420-0001
First roller guide	2242427-0001
Formatter	2242373-0001
Head assembly	2242430-0001
Power cord	
British 240 vac	2247599-0001
European 220 vac	2210558-0001
US 120 vac	0996289-0003

Table A-1 Field Replaceable Subassemblies and Parts (Continued)

Description	TI Part Number
MT3200 (Continued)	
Power supply	2242372-0001
Power switch	2242375-0001
Roller guide kit	2242426-0001
Solenoid coil	2242437-0001
Supply/takeup motor	2242424-0001
Supply hub assembly	2242423-0001
Take-up hub	2451342-0001
Tachometer assembly	2242425-0001
Tape-in-path sensor	2242422-0001
Transition board	2244779-0001
WD900	
Air filter	2244849-0001
Disk I/O cable (standard)	2244787-0001
Disk I/O cable (6 meter)	2244787-0002
Flat 60-pin I/O cable extender	2244830-0001
Flat 26-pin I/O cable extender	2244829-0001
Operator control panel	2242349-0001
Power cord	
British 240 vac	2247599-0002
European 220 vac	2210558-0002
US 120 vac	2247530-0004
Power supply	2242348-0001
I/O connector assembly	2244841-0001
Power supply -- 301	2541302-0001
I/O connector assembly	2244841-0002
I/O adapter kit, power supply -- 301	2541303-0001
Terminator	2242434-0001
Wye cable (standard)	2244845-0001
Wye cable (6 meter)	2244845-0002
138-Megabyte WD900	
Control board	2242355-0001
Data latch	2242353-0001
Motor control	2242356-0001
Head disk module	2242435-0001
Read/write	2242357-0001
CRUX bd, CDC 160M byte	2541400-0001
I/O single channel	2242455-0001
Fan assembly	2242350-0001
Power amplifier	2242354-0001
Operator control panel	2242349-0001
DC harness	2242433-0001
Cable assembly -- P14/P20	2242432-0001
Cable assembly -- P14/J31	2242431-0001
Field kit	2242352-0001

Table A-1 Field Replaceable Subassemblies and Parts (Continued)

Description	TI Part Number
425-Megabyte WD900	
Control board	2242367-0001
Brake and connector assembly	2242440-0001
DC power cable	2242436-0001
Fan assembly	2242370-0001
Field kit	2242365-0001
Head disk module	2242376-0001
I/O single channel	2242366-0001
Motherboard	2534858-0001
Power amp/motor speed	2242368-0001
Read/write	2242369-0001

Alphabetical Index

The following index lists key words and concepts from the subject material of the manual together with the area(s) in the manual that supply major coverage of the listed concept. The numbers along the right side of the listing reference the following manual areas:

* Sections -- References to sections of the manual appear as "Section x" with the symbol x representing any numeric quantity.

* Appendixes -- References to appendixes of the manual appear as "Appendix y" with the symbol y representing any capital letter.

* Paragraphs -- References to paragraphs of the manual appear as a series of alphanumeric or numeric characters punctuated with decimal points. Only the first character of the string may be a letter; all subsequent characters are numbers. The first character refers to the section or appendix of the manual in which the paragraph is found.

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  Tx-yy

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Manual Date: August 1986 **Date of This Letter:** ________

User's Name: ________ **Telephone:** ________

Company: ________ **Office/Department:** ________

Street Address: ________

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