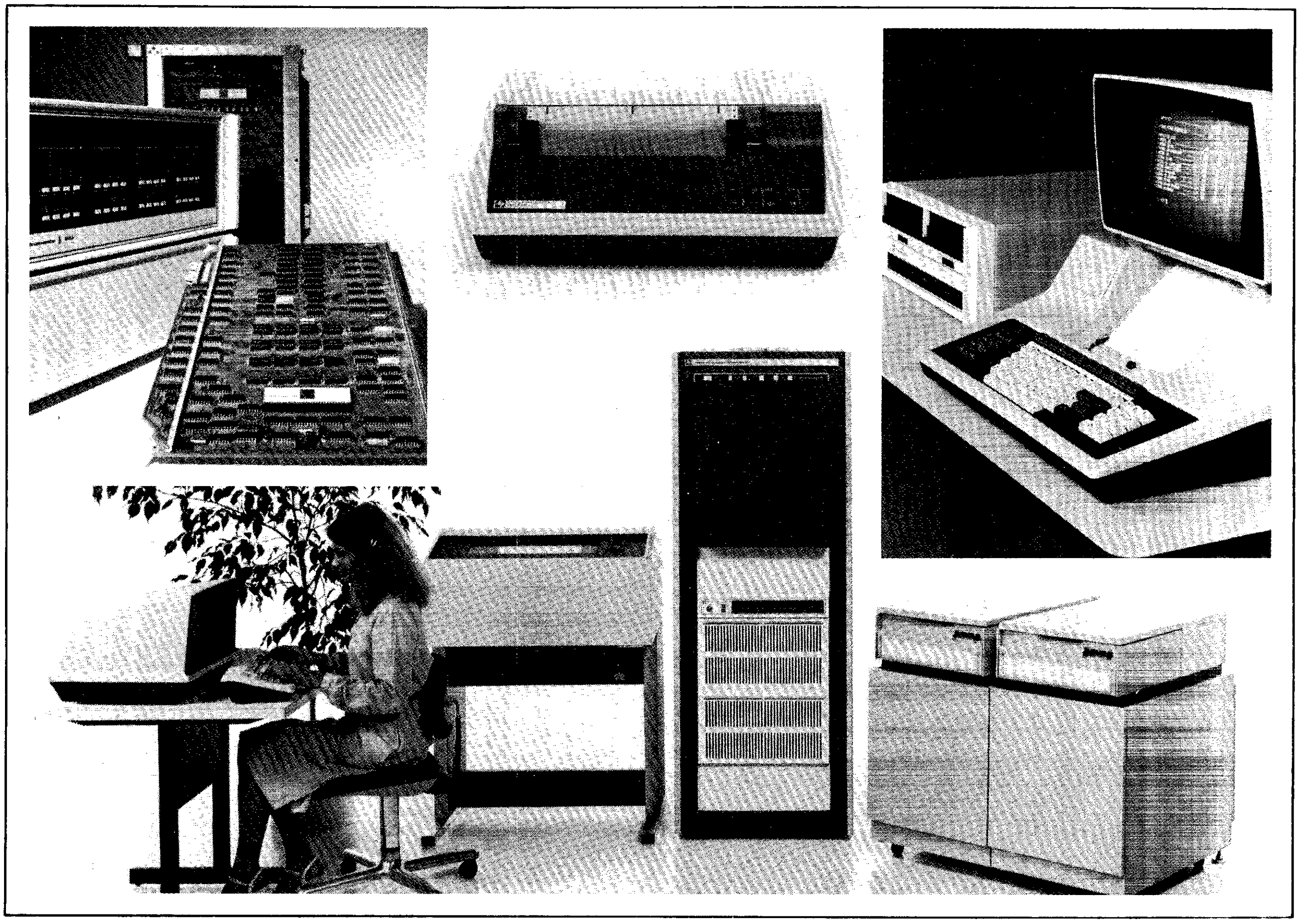
# Model 990 Computer
# DS25/DS50 Disk Systems
# Installation and Operation



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# PREFACE

This manual provides detailed instructions for installing a moving-head disk system for use with a Model 990 TILINE* Computer. It contains information required to program the computer to use the disk system. Information about the controls and indicators of the disk drives and disk pack handling instructions are also given. The information in this manual is divided into the following four sections:

**Section**

1. General Description — Briefly describes the features and major components of the disk system to acquaint the reader with the system.

2. Installation — Provides step-by-step instructions for unpacking and installing the disk system.

3. Programming — Presents information for use by a programmer in designing software which interfaces directly with the disk system. This information is in addition to that contained in related 990 Computer manuals listed below.

4. Operation — Describes the controls and indicators of the disk system.

If you would like for one of Texas Instruments' service personnel to install the disk drive system for you, please contact your local Texas Instruments Sales or Service Office. These offices can also obtain additional information for you concerning the disk drives if you should decide to perform maintenance on the equipment.

The following documents contain additional information related to the Models DS25/DS50 Disk Drives.

| Title | Part Number |
|---|---|
| *Model 990/5 Computer Hardware User's Manual* | 946294-9701 |
| *Model 990/10 Computer Hardware Reference Manual* | 945417-9701 |
| *Model 990/12 Computer Hardware User's Guide* | 2264446-9701 |
| *Model 990 Computer TMS 9900 Microprocessor Assembly Language Programmer's Guide* | 943441-9701 |
| *Model 990/10 Computer Program Development System Operation Guide* | 945256-9701 |
| *Model 990 Computer Diagnostics Handbook Volumes 1 through 7* | 945400-9701 through 945400-9707 |
| *Trident Disk Operation and Installation Manual* | 947529-9705 |

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# SECTION 1

# GENERAL DESCRIPTION

## 1.1 GENERAL

The Models DS25/DS50 Disk Drive Systems (shown in Figure 1-1) are random-access, data storage moving head disk drive devices which provide mass-storage memory for Model 990 TILINE* Computers. A DS50 disk drive system can store up to 178 formatted megabytes in 44.6 megabyte increments (for a system consisting of four disk drive units).

The system features:

- Single circuit board disk controller
- Automatic track switching (across head and cylinder boundaries)
- Variable record formats, from one sector to full track
- Up to four disk drives (all the same model) per controller, with overlapped seek capability
- Individual disk drive interrupt masking
- Controller FAULT indicator
- BUSY, INTERRUPT, and CLOCK indicators
- System configuration parameters and header information readable with command
- Strobe and head offset capabilities
- Read data transfer inhibit command for verifying data
- Integral voltage-controlled VFO (Variable Frequency Oscillator)
- Dynamic spindle brake that allows pack change in less than one minute
- Track following servo
- Automatic power sequencing of disk drives
- DX10 operating system support.

The DS25/DS50 disk drives use a magnetic, high-density (4040 bits per inch), disk pack and flying heads which move laterally over the disk surfaces to select different cylinders. The disk drive includes the mechanical, electro-mechanical, and electronic components required to rotate the disk, perform track selection, and read and write data on the disk.

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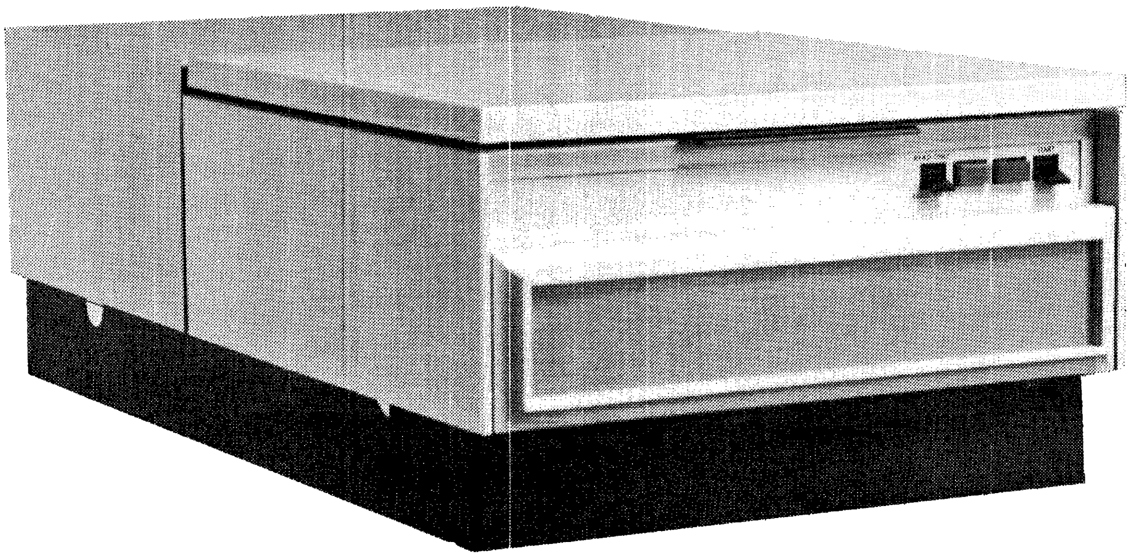

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**Figure 1-1. Model DS25/DS50 Disk Drive**

## 1.2 SYSTEM CONFIGURATION

Figure 1-2 illustrates the relationship of the major components of the disk drive system. The controller for the disk drive system is a full-width circuit board installed in the computer chassis that interfaces with the TILINE data bus of the computer system.

Two cables are required to connect the controller to a primary disk drive. One cable, called the bus cable, has the control and status lines; the other cable, called the radial cable, has the serial data and clock lines. When secondary disk drives are connected to the system, the drives are interconnected in a daisy-chain fashion, and also an individual radial cable is connected from the controller to each drive.

**1.2.1 TILINE BUS.** The TILINE is an asychronous, high-speed, 16-bit data transfer bus, with the associated control lines that transfer data between the central processing unit (CPU), the memory, and the disk files. Any full-size circuit board plugged into the 990 computer chassis may engage the TILINE bus and participate in data transfers. The TILINE bus is divided between two chassis connector slots (P1 and P2) in a full-width circuit board slot.

Two classes of TILINE users interface with the TILINE bus. Controllers of the bus are called TILINE masters and the respondents are called TILINE slaves. The disk controller is both a master and a slave. It is a slave when receiving commands from the CPU and a master when contending for the TILINE bus to transfer data to or from the CPU memory.

Data is transferred between the TILINE data bus and the disk controller as parallel, 16-bit words. Address information is transferred as parallel, 20-bit words.

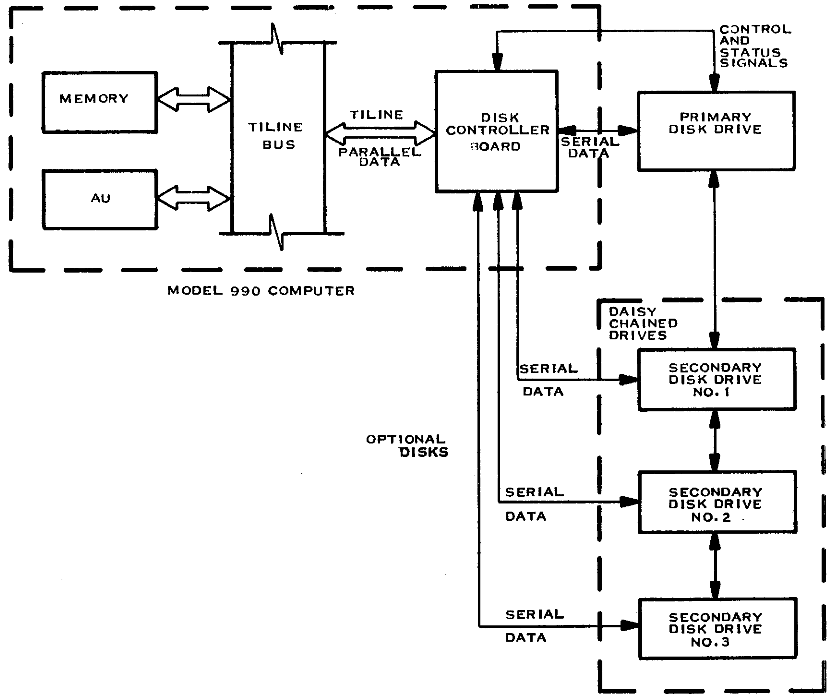



**Figure 1-2. Disk System Simplified Diagram**

**1.2.2 DISK CONTROLLER.** Operations of the disk controller are initiated by instructions (commands) from the computer. These instructions are directed to slave memory addresses which have been assigned to the slave logic of the controller.

After a controller command has been initiated by the computer, the computer can no longer read or write to the slave addresses of the dedicated controller until the command is completed; however, slave cycles will terminate normally when the controller is busy.

After a command has been initiated, the controller may then become a TILINE master. The controller contends for TILINE access on a positional priority basis by cycle-stealing with the CPU and with any other TILINE master device that is active. After TILINE access is obtained, the controller transfers 16-bit parallel data words to and from the slave it has addressed (which, in most cases, is a computer memory module). In addition, the controller manipulates all of the disk interface data and control lines that enable the transfer of data between the controller and disk. The disk controller is autonomous, meaning that it is not dependent on any CPU action after it has been activated. Table 1-1 lists the specifications for the disk controller.

**1.2.3 DISK DRIVES.** From one to four disk drives may be controlled by one controller, if all the disk drives are the same model. The DS25 and DS50 disk drives are functionally identical; the primary difference between the two models is the storage capability. Nevertheless, multiple disk drives must be either all DS25 or all DS50. Table 1-2 lists the specifications for the disk drives and shows the differences between the two models.

A typical disk drive system configuration allows up to four disk drives to be operated by a single controller as shown in Figure 1-3. A bus cable connects the controller to the primary disk drive. A daisy-chain cable interconnects the remaining disk drives. A radial cable is connected from the controller to each disk drive in the system. The last disk drive in the system requires a terminator to be installed on the unused (bus out) connector. The terminator is a resistive device common to the disk drive system and must always be installed on the last machine in the sequence.

**Table 1-1. Disk Controller Specifications**

| Item | Specification |
|---|---|
| Controller Dc Power | +5V, 8 A<br>-12V, 250 mA |
| Controller Interface | 990 TILINE |
| Disk Format | |
| Bytes per Sector (Formatted) | 288 bytes (2304 bits) |
| Sectors per Track (Formatted) | 38 sectors (2:1 interlaced) |
| Bytes per Pack (Formatted) | |
| • DS25 | 22.3 megabytes |
| • DS50 | 44.6 megabytes |
| Drives per Controller | 4 (one type) |
| Data Buffer on Controller | 256 bytes (2048 bits) first-in/first-out |

**Table 1-2. Disk Drive Specifications**

| Item | Specification |
|---|---|
| Tracks per Cylinder | 5 read/write tracks; 1 servo track |
| Cylinders per Pack | |
| • DS25 | 408 (000 through 407) |
| • DS50 | 815 (000 through 814) |
| Bytes per Track (Unformatted) | 13,440 (107,520 bits) |
| Bytes per Cylinder (Unformatted) | 67,200 (537,600 bits) |
| Bytes per Pack (Unformatted) | |
| • DS25 | 27.4 megabytes (219.2 megabits) |
| • DS50 | 54.7 megabytes (437.6 megabits) |
| Bytes per Track (Formatted) | 10,944 bytes (87,552 bits) |
| Bytes per Pack (Formatted) | |
| • DS25 | 22.3 megabytes (178.4 megabits) |
| • DS50 | 44.6 megabytes (356.8 megabits) |
| Track Density | |
| • DS25 | 185 tracks per inch |
| • DS50 | 370 tracks per inch |
| Recording Density | 4040 bits per inch, nominal |
| Minimum Access Time | 6 milliseconds (single-track head repositioning) |
| Maximum Access Time | 55 milliseconds (end cylinder-to-end cylinder) |
| Average Access Time | 30 milliseconds |
| Pack Rotational Speed | 3600 revolutions per minute, ±5% |
| Maximum Latency Time | 17.6 milliseconds |
| Average Latency Time | 8.3 milliseconds |
| Recording Method | Bit serial Triple Frequency Modulation (TFM) |
| Data Transfer Rate | 806,000 bytes (6.45 megabits) per second |
| Bit Cell Time | 155 nanoseconds |
| Drive Start Time | 20 seconds (START to drive ready) |
| Drive Stop Time | 20 seconds (STOP to disk stopped) |
| Ac Power | See table 1-4 |

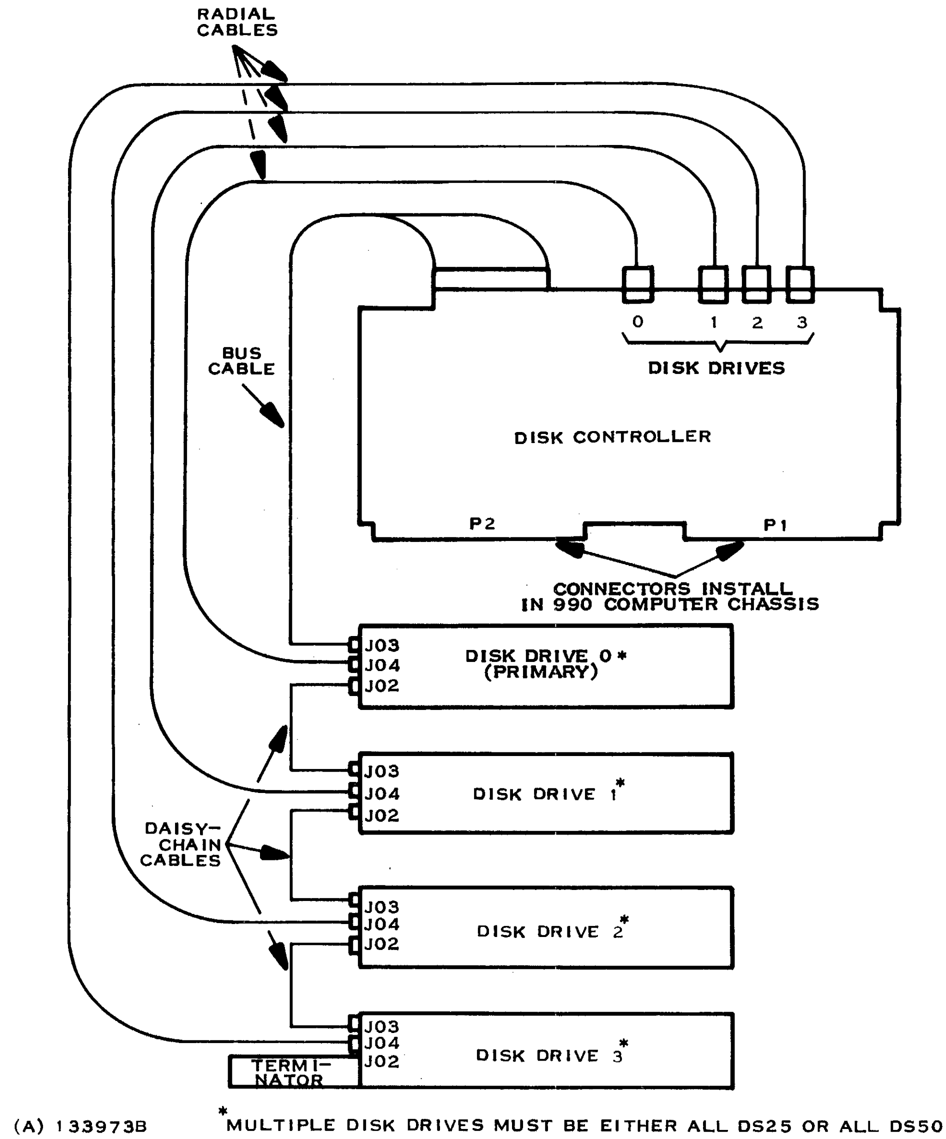
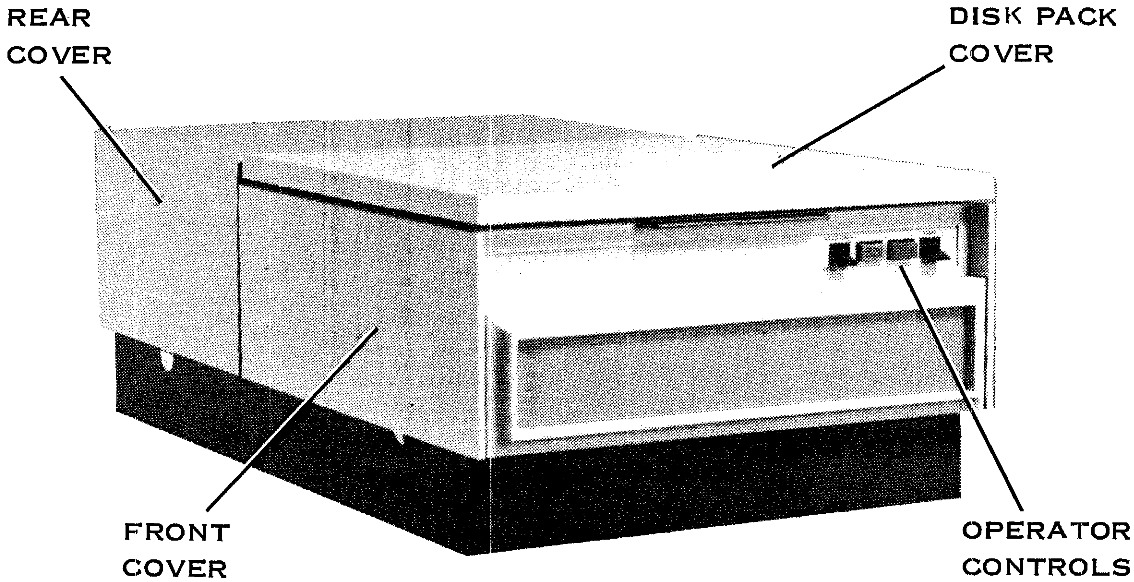



**Figure 1-3. Four Disk Drive System Interconnect Configuration**

**1.2.3.1 Disk Drive Assemblies.** Major assemblies of a disk drive are shown in Figure 1-4 and described in Table 1-3.

## 1.3 DISK DRIVE ELECTRICAL REQUIREMENTS

Table 1-4 lists the various drive types by part number with their input voltages. Voltages must be within the range shown; frequency tolerance is ±1%. The controller sequences the start-up of the disk drives at 20-second intervals; even so, because of the high starting current, a separate power circuit must be provided for each DS25/DS50 disk drive. It is recommended that each disk drive be provided with a dedicated 20-ampere circuit that can supply the starting current for eight seconds. Because of the high starting current, a drive cannot be started on a circuit that has a running drive.

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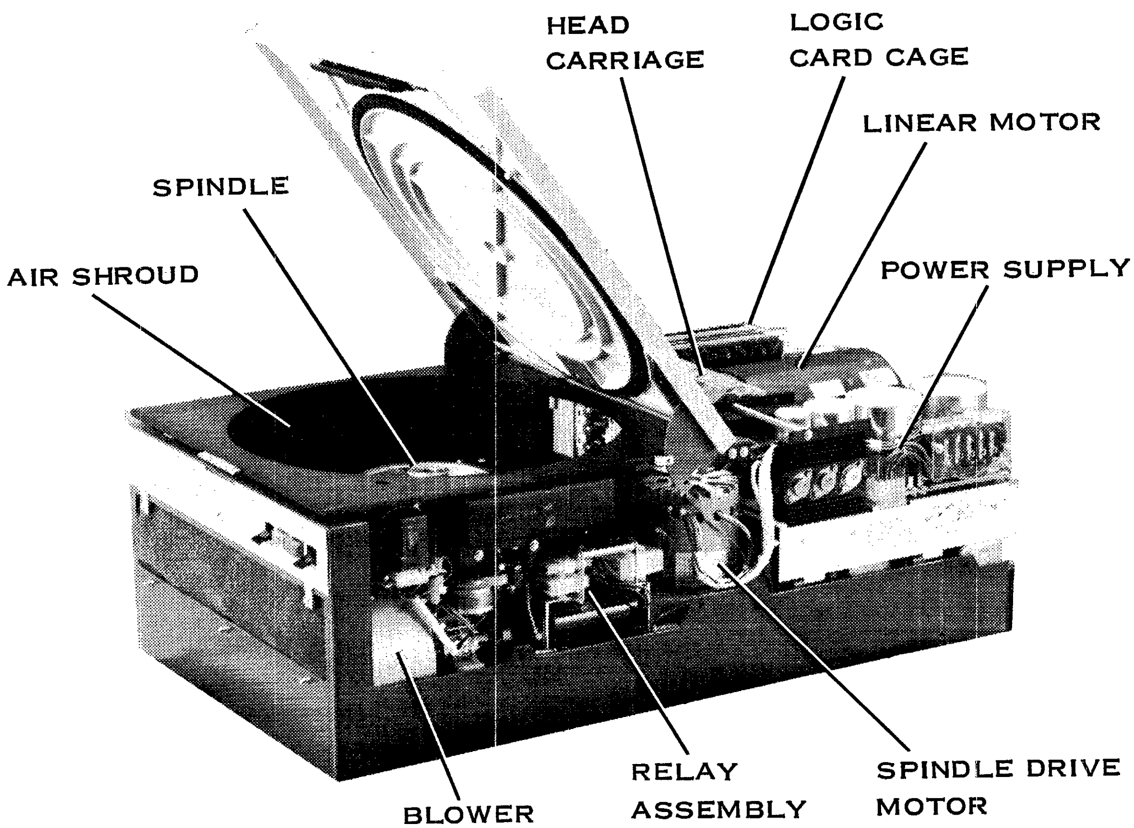


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**Figure 1-4. Disk Drive Major Assemblies**

**Table 1-3. Disk Drive Assemblies**

| Name | Function |
|---|---|
| Operator Controls | Location of all switches and indicators normally used by the operator. |
| Disk Pack Cover | Covers disk pack and seals pack area for positive air pressure. Lid is raised to load and unload pack. |
| Front and Rear Covers | Dress covers that are removable for maintenance. |
| Air Shroud | Surrounds the disk pack to contain and direct air flow to the pack from a blower. Also mounts pack area lid and disk cleaning brush assembly. |
| Spindle | Mounts disk pact. The spindle is turned by the spindle drive motor through a 1:1 belt drive system. |
| Head Carriage | Mounts one servo and five read/write heads in precise alignment with disk pack. Carriage can move the heads in and out under control of the head positioning linear motor. |
| Logic Card Cage | Contains disk drive control logic, read/write logic, and servo circuits mounted on six plug-in circuit boards. System I/O cables also plug into this assembly. |
| Linear Motor | Controls the head carriage to position the heads into and out of the disk pack. |
| Power Supply | Provides all necessary dc power to operate the disk drive. Also mounts the emergency retract relay. |
| Spindle Drive Motor | Turns the spindle through a 1:1 belt drive system. |
| Relay Assembly | Mounts relay and solid-state switches that perform power-up and power-down sequencing. |
| Blower | Supplies air flow to both the disk pack and the electronics at all times that the disk drive is powered up. |

Table 1-4. Disk Drive Electrical Requirements

| Part Number | Drive | Voltage | Current | |
|---|---|---|---|---|
| | | | Run | Start |
| 947524-0001 | DS50 | 100-127 Vac, 60 Hz | 7.5A | 30A |
| 947524-0007 | DS25 | | | |
| 947524-0002 | DS50 | 100-127 Vac, 50 Hz | 7.5A | 30A |
| 947524-0008 | DS25 | | | |
| 947524-0006 | DS50 | 208-220 Vac, 50 Hz | 4.5A | 13A |
| 947524-0012 | DS25 | | | |

# SECTION 2

# INSTALLATION

## 2.1 GENERAL

This section provides information for unpacking and installing the disk drives, and connecting the drives together as part of a 990 TILINE computer operating system.

The user should read this entire section before proceeding with the installation. Circumstances that are unique to the user's site may dictate that the installation procedures be performed in a different order than set forth in this section. Familiarity with the entire installation procedure will provide a basis for planning the task before starting.

**CAUTION**

Do not connect or disconnect any plug or circuit board when power is applied, since voltage transients may damage electronic parts.

The expansion guidelines for the DS25/DS50 disk drive systems allow daisy-chaining up to a total of four disk drives from one disk controller as described in Section 1. Available kit options are:

- *Primary Complete* — Includes a disk controller, one disk drive with disk pack, interconnecting cables, and terminator.
- *Interface Only* — Includes a disk controller and the cables to interface one disk drive.
- *Secondary Disk Drive* — Includes a disk drive with pack, radial cable, and daisy chain bus cable.

Major system components, along with the associated part numbers, are listed in Table 2-1. Kit components and additional options, along with the assembly part numbers and purchase price, may be obtained from Texas Instruments upon request. Components of a typical disk drive system are shown in Figure 2-1. Outline dimension drawings which indicate the stand-alone space requirements for the disk drives are shown in Figure 2-2.

Interrupt level assignments are required to interface the disk controller to the 990 computer TILINE bus. These connections are made at the factory before shipment for a standard configuration and installation. However, if necessary, the user may assign new interrupts to suit his needs. If new interrupts are required, these assignments and connections must be made during installation procedures.

Also, the following arrangements must be made during installation:

- TILINE address switches on the disk controller must be set to the slave address that the software program will use.
- The disk controller must be assigned a permanent location (slot) in the computer chassis.
- Movable jumpers must be installed on the controller to make it compatible with 990 TILINE computer operation.

**Table 2-1. Disk System Components**

| Component | Part Number |
|---|---|
| Model DS25 Disk Drive | 947524-0007 |
| Model DS50 Disk Drive | 947524-0001 |
| Cable Assembly, Daisy Chain | 947589-0001 |
| Cable Assembly, Bus | 947587-0001 |
| Terminator | 947528-0001 |
| Disk Pack | 947533-0001 |
| Controller Circuit Board, DS25 (PWB) | 940065-0002 |
| Controller Circuit Board, DS50 (PWB) | 940065-0001 |
| Controller Circuit Board, DS25 Fine Line PWB | 940065-0004 |
| Controller Circuit Board, DS50 Fine Line PWB | 940065-0005 |
| Controller Circuit Board, DS25 (Multi-Wire) | 947525-0002 |
| Controller Circuit Board, DS50 (Multi-Wire) | 947525-0001 |
| Radial Cable | 947616-0001 |
| Drawer Slide Kit | 947534-0001 |
| Console (Floor Stand) | 947535-0001 |
| Optional Length Daisy Chain Cable | 947589-0002 |

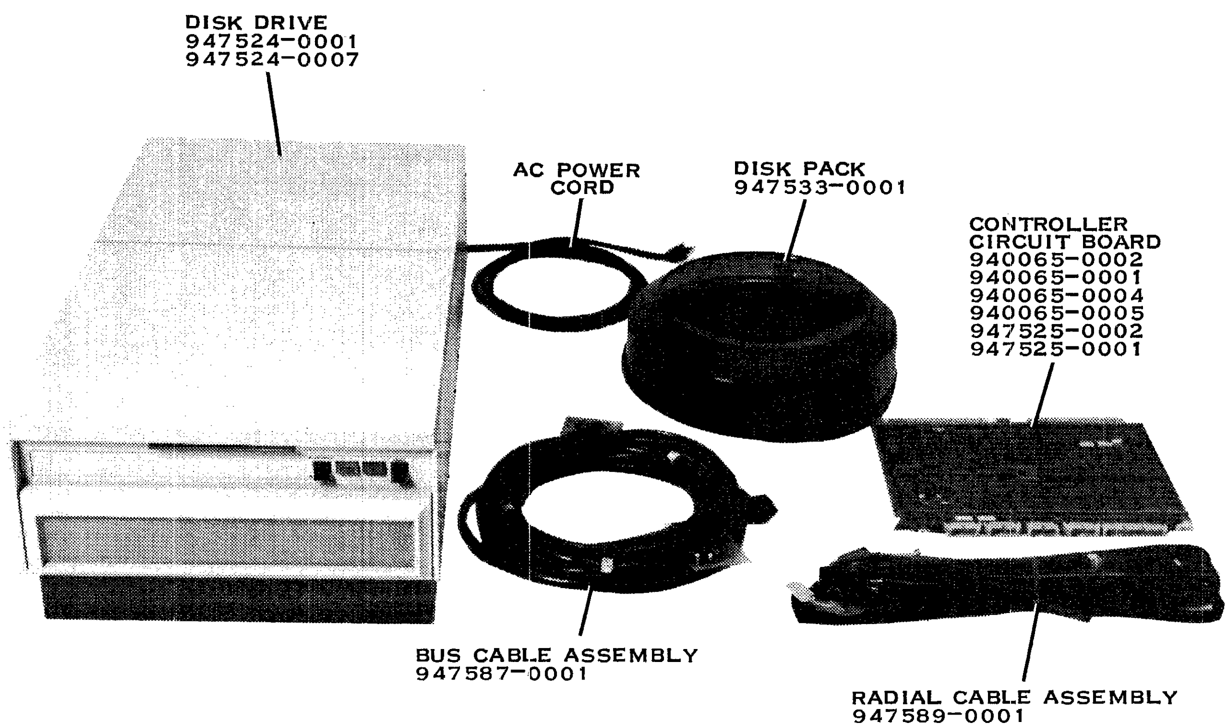


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**Figure 2-1. Typical Disk Drive Components Used with 990 TILINE Computers**

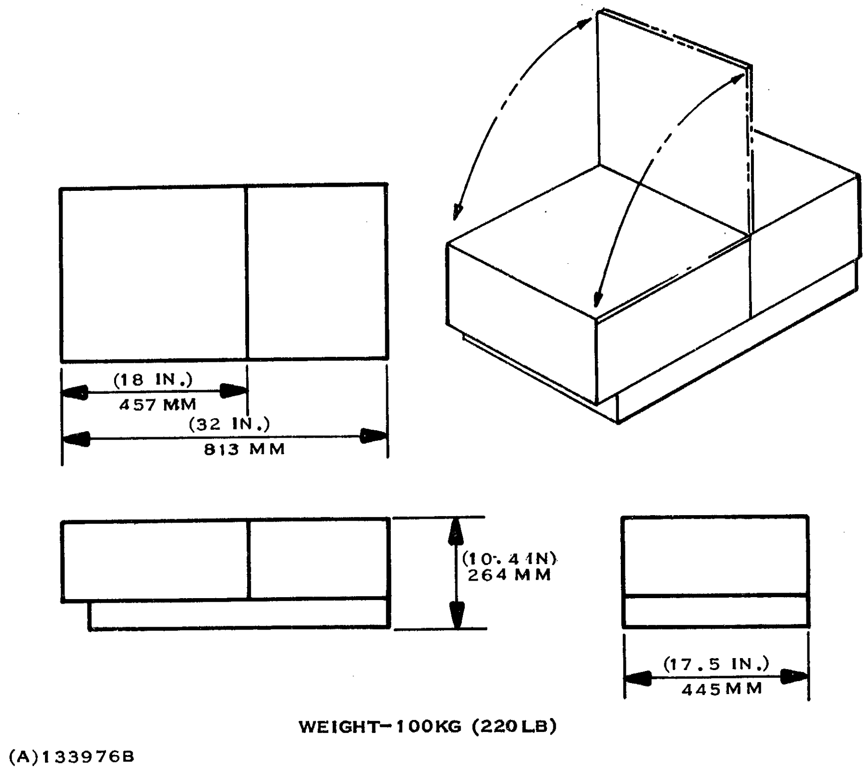



**Figure 2-2. Disk Drive Outline Dimensions**

## 2.2 UNPACKING

The disk drives are shipped in containers as shown in Figure 2-3. If the equipment is received at the same time as the computer system equipment, then the disk controller, the interconnecting cables, and technical manuals may be packed with the computer equipment. Otherwise, these items will be packaged separately from the disk drive in polyethylene bags and boxed with air cap pack filler material.

**2.2.1 UNPACKING THE DISK DRIVE.** Upon receipt of the container, inspect it to ensure that no physical damage occurred during shipment. If so, notify the carrier at once.

**NOTE**

The unpacked disk drive weighs approximately 100 kilograms (220 pounds). A portable hoist or hydraulic lift simplifies handling of the unpacked drive.

After preliminary inspection, unpack using the following procedures:

1. Move the unpacked container by fork lift to the receiving station workbench near the final location, if possible.

2. Cut and discard the metal bands securing the shipping container. Open the top flaps.

3. Remove the two spacers from the top of the inner container. Also, remove and retain any loose items packed between the inner and outer containers.

**CAUTION**

Be careful when cutting or slitting the cardboard containers. Be sure that the knife blade does not go through the container to the disk drive to mar the finish or damage the ac power cord.

4. Cut through the tape along the top of the inner container and open the top flaps.

5. Cut down and through the four corners of the outer container so that the four sides can be laid flat.

6. Repeat step 5 for the inner container.

7. Remove and retain any loose items that may be packed between the inner container and the disk drive.

8. Remove and retain the cardboard collar surrounding the drive. The plastic-enclosed drive is now fully accessible. Remove the tape that holds the plastic sheeting to the plywood base, but leave the sheeting in place to protect the finish of the drive.

9. Slide the front end of the drive, the plywood base, and the packing containers over the edge of the supporting bench just far enough to bend down the cardboard container and to remove the bottom front spacer.

10. On the bottom of the plywood base, locate two machine bolts that attach the base to the front of the drive frame. Remove both bolts.

11. Slide the rear end of the drive, the plywood base, and the packing containers over the edge of the support surface just far enough to remove the remaining bottom spacer and the two bolts that attach the back of the drive frame to the plywood base. Remove both bolts.

**WARNING**

**The center of gravity of the drive is towards the rear. Be careful when hoisting. Refer to Figure 2-4.**

12. Lift the drive free of its plywood base and the other packing materials, preferably using a hoist as described in steps 13 and 14. (Refer to Figure 2-4).

**WARNING**

**If the disk drive must be lifted without a hoist, have at least three men on hand — two to lift the drive and the third to remove the packing material and assist in lifting. Be careful to avoid injury to the fingers when setting the drive down.**

13. If a lifting hoist is available, observe the two wide grooves cut in the top of the plywood base to accommodate the webbing or lifting straps. Raise one end of the drive at a time; slip the nylon webbing lifting straps under the drive at these grooves. The loop diameter of the lifting straps should be maintained by a cradle or lifting bar.

14. Take up the slack in the lifting straps by raising the bar, and place several layers of corrugated cardboard cut from the collar between the top edges of the drive and each strap. The cardboard is used to protect the top covers from being distorted by the straps.

15. Lift the drive slightly and check for balance (the rear of the drive is heavier). Loosen and readjust the lifting bar for the proper balance point.

16. Lift the drive free of the plywood base and other packing material.

17. Move the drive by hoist or dolly to the checkout work station or final installation location.

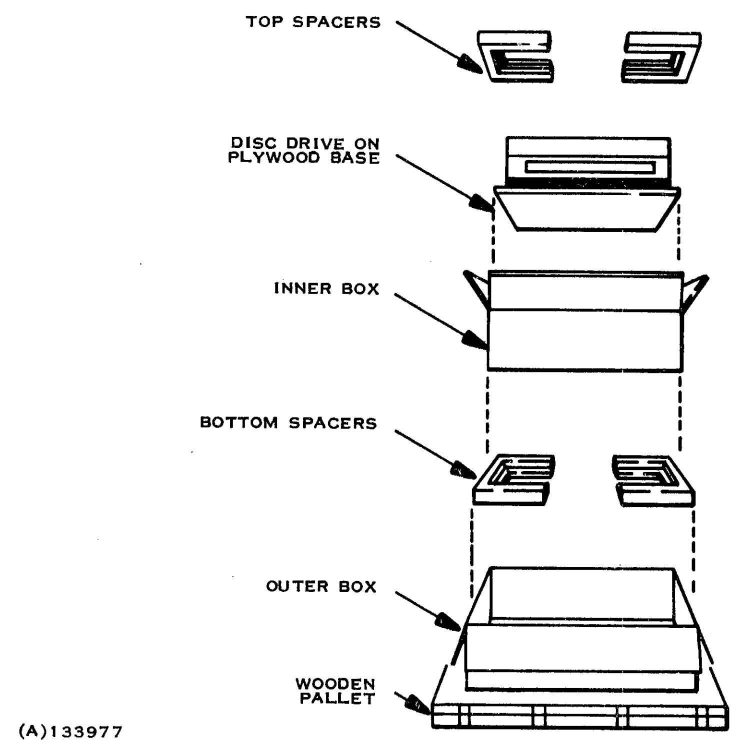



Figure 2-3. Disk Drive Shipping Configuration

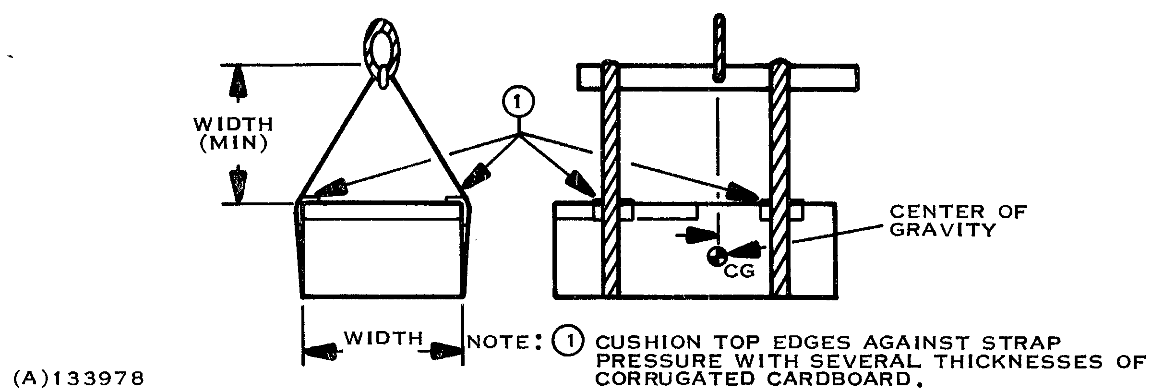



Figure 2-4. Hoisting Disk Drive

**2.2.2 SITUATING THE DISK DRIVE.** The disk drive may be installed and located to suit the convenience of the user. Two optional installations are:

- Tabletop installation using rubber feet or plywood base.
- Console (floor stand) mounting for a stationary location.

**NOTE**

Before installing the disk drive in its permanent location, perform all of the procedures of paragraph 2.3, since these procedures require removal of the exterior covers and work on the interior of the disk drive.

Installation of the four rubber feet, which are shipped as loose optional equipment, is most easily accomplished when the disk drive is suspended by the hoist. The feet are installed by screwing them into the threaded holes at each corner of the bottom plate. Otherwise, if the drive is situated on a supporting surface such as a tabletop, slide the front end of the drive over the edge of the table and install the two front feet. Raise the drive and slide it back onto the table. Repeat this procedure to install the two rear feet.

To locate the disk drive at a permanent place on a floor stand, obtain a console, part number 947535 (shown in Figure 2-5), place it at the desired location, and set the drive on the console. The front of the drive must be oriented towards the door with the latch. At the rear of the console is a cutout in the flange to accommodate cable routing to the disk drive. The mounting plate in the console has three holes for securing the disk drive to the plate. The bolts from the plywood shipping base may be used for this purpose.

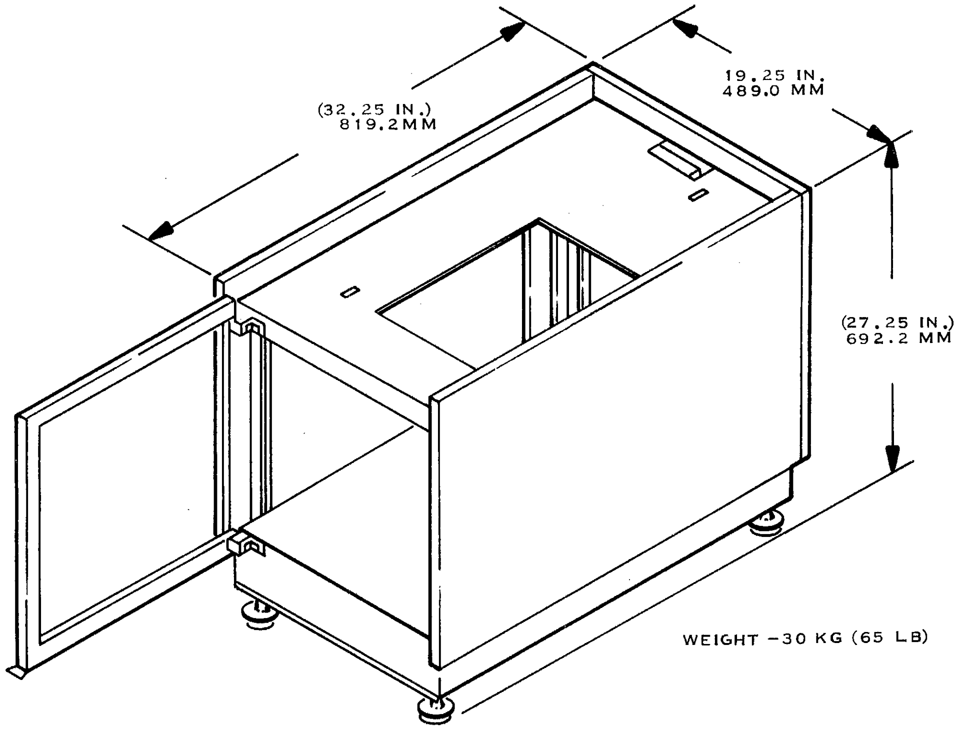



**Figure 2-5. Console for Disk Drive**

**2.2.3 UNPACKING ACCESSORIES.** If the disk drive is received separately from the computer equipment, the disk controller circuit board, the interconnecting cables, technical manuals, and other accessories will be in a separate box. The disk controller will be padded with protective material and sealed in a polyethylene bag. Be careful not to drop any of the articles. Keep all of the contents of the system together until an inventory and receiving inspection are made.

**2.2.4 UNPACKING, HANDLING, AND STORING DISK PACKS.** The disk packs are shipped in reusable corrugated shipping containers that are lined with polyurethane foam. The entire container, including the disk pack, can be handled by one person. The shipping container provides an adequate storage protection with no degradation of performance when stored under specified environments as described in following paragraphs. When storing disk packs in the shipping container, do not stack the containers more than eight high.

**2.2.4.1 Unpacking Disk Packs.**

**CAUTION**

Disk packs are precision instruments. Tolerances less than a micrometre are common. A little precaution in the handling and storing of disk packs can prevent costly re-run time and protect valuable data recorded on the disks.

Open the shipping container and unpack the disk pack as follows:

1. Inspect the shipping container for any evidence of damage, such as a crushed corner and torn or open holes in the carton.

2. Remove the disk pack from the shipping container and the protective bag. Remove the pack from the bottom cover and turn the pack upside down on the top cover and perform a visual inspection of the bottom protective disk. Look for any evidence of dents or scratches.

3. Always keep the top and bottom covers of the canister together when the pack is in use. Dust and lint can accumulate in an open canister and may later contaminate the pack.

4. Do not, under any circumstances, attempt to use a disk pack that you suspect is damaged because such usage can cause damage to the disk drives, such as causing a crash of the read/write heads.

**CAUTION**

The disk pack used with the DS25 and DS50 disk drives must be per Texas Instruments Specification 947533-0001. The recording surfaces in the disk pack must either be error free or have an error map label attached to the cover. The label should contain the manufacturer's name, disk pack part number and serial number, and the addresses of all bad tracks (see Figure 2-6).

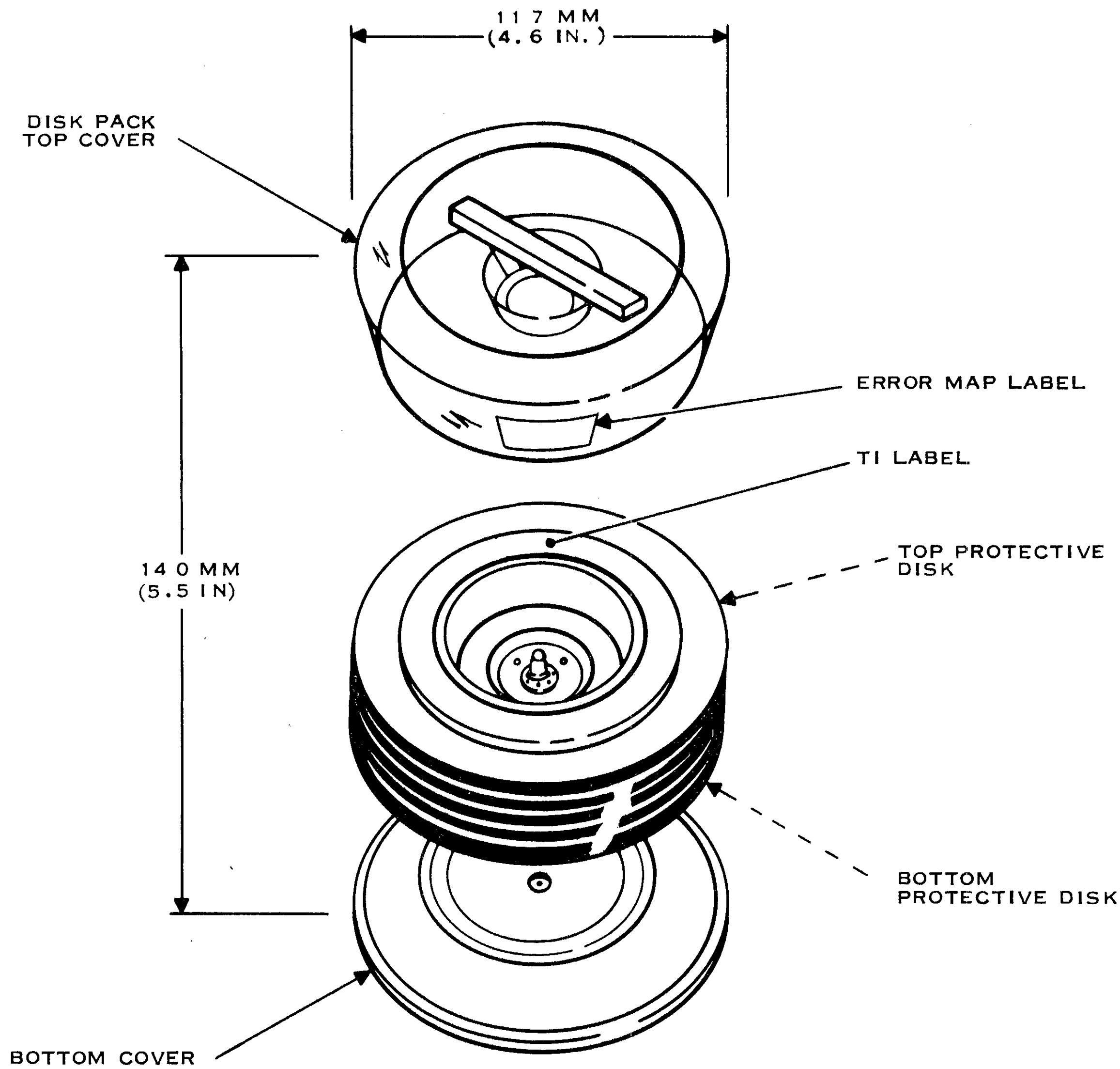
The case, or canister, of a disk pack consists of a plastic top cover with a handle and a bottom cover. (See Figure 2-6.) The handle locks with the pack spindle and the disk pack should be carried from place to place by the handle. The disk packs should be stored in the same room environment as the disk drive or brought into the room for temperature conditioning no less than 24 hours prior to use.

**2.2.4.2 Error Identification and Labeling.** Each disk pack must have an error map label attached to the disk pack side cover as shown in Figure 2-6. This label identifies the serial number of the disk pack and the track locations by cylinder and surface that the vendor has found to be bad. All track numbers are in decimal notation. The label also has additional space for Texas Instruments to label any additional errors that have been found by their testing. A blank error map label certifies that the disk pack is error free with no bad tracks.

Any single bit location designated as bad is defined as a noncorrectable error. Any track that has one or more bad bits is designated unusable and is flagged as a bad track. There must be no error on tracks 0 and 1 of the disk pack. A maximum of 25 bad tracks is allowed for each disk pack; and a maximum of seven bad tracks is allowed for each surface.

The address correlation between the DS25 and DS50 disk packs is as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| DS25 | 000 | x | 001 | x | 002 | ..... |
| DS50 | 000 | 001 | 002 | 003 | 004 | ..... |




NOTE

A DISK PACK HAS:

1. THREE RECORDING DISKS
2. FIVE DATA RECORDING SURFACES
3. ONE SERVO SURFACE
4. TWO (TOP AND BOTTOM) PROTECTIVE DISKS

(A)142207

**Figure 2-6. Disk Pack**

The DS25 disk drive reads every other track location so it looks at only every other track on a DS50 disk pack. This means that all odd locations on the DS50 disk pack are not used on a DS25 disk pack, so any odd addresses listed on the error map label can be ignored. Since the DS25 disk pack uses only every other address, any DS50 disk pack even address listed on the error map label should be divided by two to make it correspond to a DS25 disk pack address location. Because the DS25 disk drive has a larger head and reads more disk area, many (if not all) of the errors listed on the DS50 error map label will not be seen on a DS25 disk drive.

**2.2.4.3 Handling Disk Packs.** The following precautions should be observed when handling disk packs.

**CAUTION**

To prevent dust, dirt, and foreign material from entering a disk pack and contaminating the disks, the disk pack should always be in its canister when not in use.

1. Carry disk packs from place to place using the handle. The handle locks with the pack spindle and supports the pack only at its center. This eliminates any harmful forces from being transmitted to the disks or the hardware.
2. Always attach the bottom cover while holding the pack vertically by the handle.
3. Never set the disk pack on any surface without the bottom cover in place because the exposed sector disk can be bent easily.
4. Never stack disk packs.
5. To avoid affecting dual-plane balance, never disturb the lead weights adhering to the top and bottom clamp rings of the disk pack.
6. When loading a disk pack in a disk drive, be sure that the cover has been turned as far as it will easily turn. This guarantees complete and proper seating of the pack on the drive.
7. Never attempt to stop the pack from rotating on the drive. The spin-down time is drive controlled to minimize wear to the drive spindle bearings and prevent large torques from being transmitted to the components of the disk pack.

**2.2.4.4 Storing Disk Packs.** Observe the following precautions when storing disks.

**CAUTION**

Always store disk packs in their canisters (or shipping containers) on a flat surface in a horizontal position.

1. Operate the disk drives under the following specified conditions:

| | |
|---|---|
| Temperature: | 15.6° to 32.2°C (60° to 90°F) |
| Relative Humidity: | 8% to 80%, excluding all conditions that may produce condensation of moisture. |

2. Store the disk packs under the following conditions:

   Temperature: -40° to 66°C (-40° to 150°F)

   Relative Humidity: 8% to 80%, excluding all conditions that may produce condensation of moisture.

3. Disk packs that have been stored in, or subjected to, temperatures outside the operating range of the disk drive units (15.6° to 32.2°C) (60° to 90°F) should be conditioned to this operating environment at least 24 hours prior to use. During this period of conditioning, the disk packs should be removed from their shipping containers.

4. For long term storage, store the disk packs in their original shipping containers no more than eight high. The containers provide protection against dust and debris, large environmental changes, contamination by chemicals, and phsyical damage.

## 2.3 PREPARING DISK DRIVE

Preparation of the disk drive includes removing the exterior covers, removing the shipping bolt, visual inspection, removing the internal shipping restraints, checking the logic III circuit board jumper configuration, and checking for proper installation of the ground shorting jumper and the input power jumper. These preparations are described in the following paragraphs.

**2.3.1 REMOVING DISK DRIVE COVERS.** To remove the front cover, unscrew the three thumbscrews under the front bezel as shown in Figure 2-7. Then pull the cover straight forward until it clears the drive.

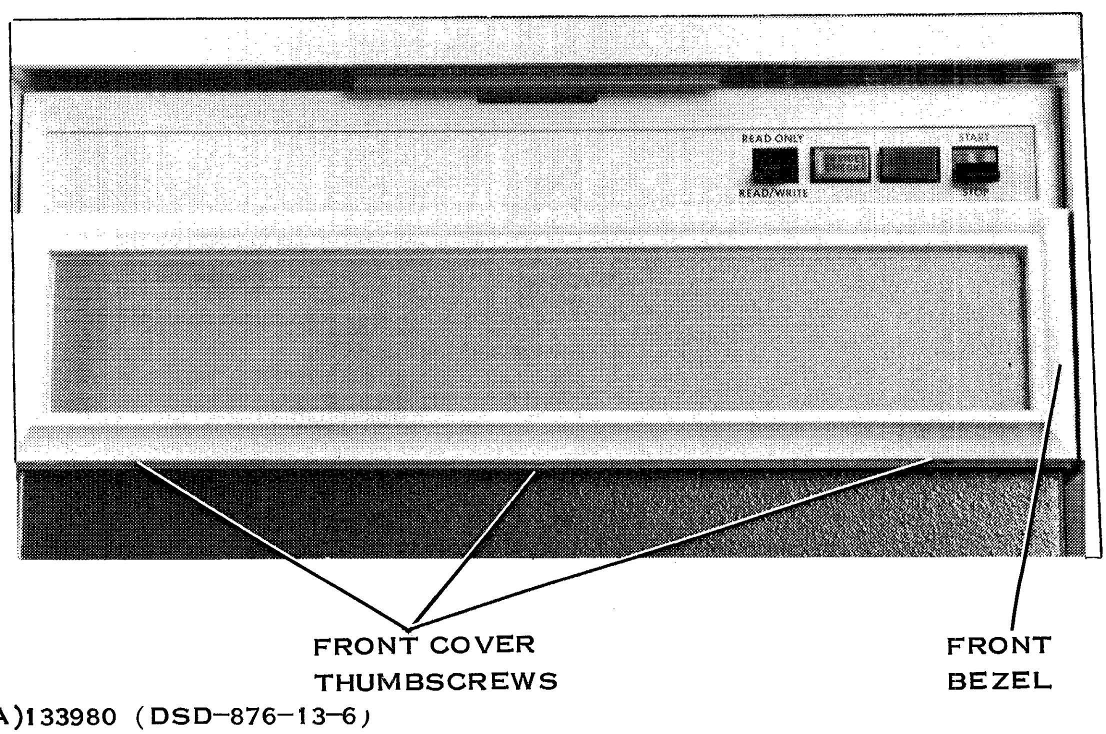



**Figure 2-7. Disk Drive Front View**

To remove the rear cover unscrew the two screws at the rear as shown in Figure 2-8. Then slide the cover rearward and lift up until it clears the drive.

**2.3.2 INSTALLING DISK DRIVE COVERS.** Installation of the covers is essentially the reverse of removal. The lip on the bottom of each cover must fit over the flange of the bottom case in order for the two covers to mesh together and to fit properly.

**2.3.3 REMOVING SHIPPING BOLT.** Located at the center of the disk drive rear panel is a 3/8-inch allen-head shipping bolt (see Figure 2-8) that locks the drive deck casting to the frame assembly during shipment. Remove the bolt, lockwasher, and flat washer and save for reshipment.

**2.3.4 REMOVING INTERNAL SHIPPING MATERIALS.** Remove the internal shipping materials and restraints per the following.

1. Remove the wooden shipping spacer between the linear motor and the bottom casing (to the right of the shipping bolt; see Figure 2-9) and save for reshipment.

2. Remove the glass tape that holds the plug-in circuit boards in the card cage assembly.

**CAUTION**

While removing the glass tape that secures the T-block assembly, hold the T-block in the retracted position. Otherwise, the heads may slide forward off their camming surfaces with the likelihood of head damage.

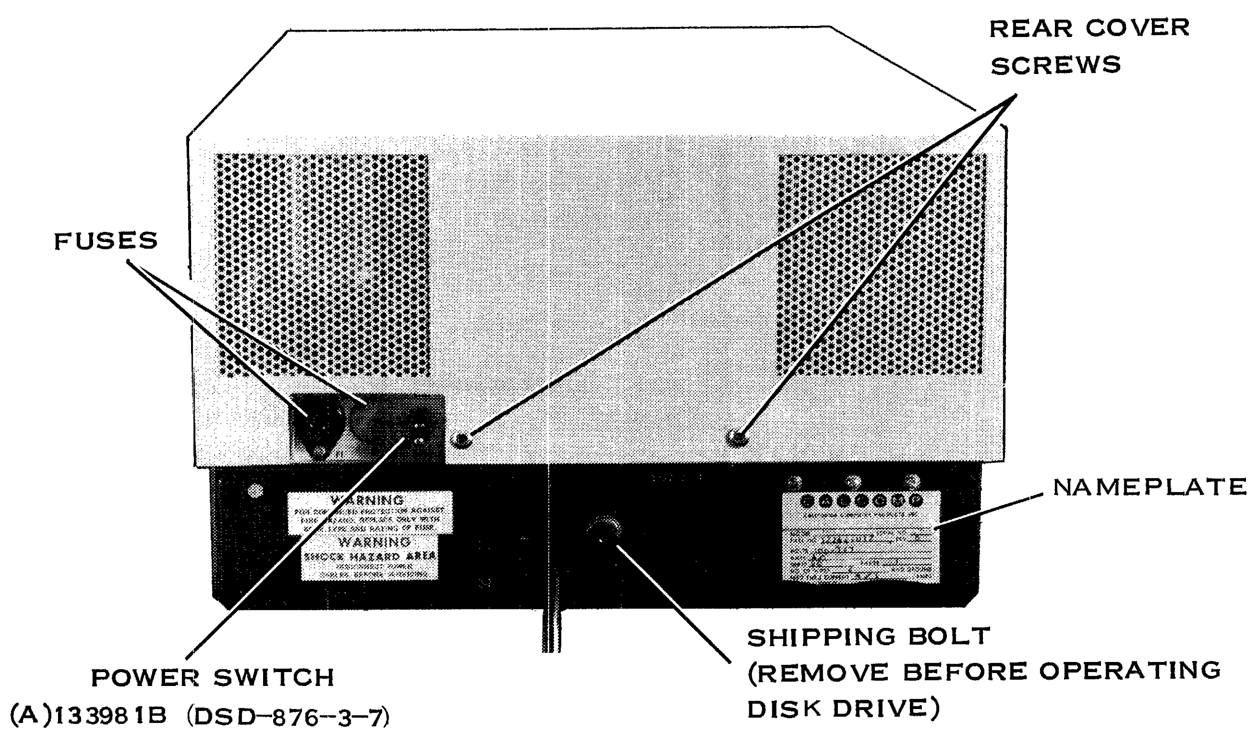



**Figure 2-8. Disk Drive Rear View**

3. Remove the transparent air shroud that encloses the retracted heads and T-block assembly. Cut the glass tape that secures the T-block assembly in the retracted position. See Figure 2-9.

4. Remove the glass tape from the T-block assembly and the linear motor. Reinstall the transparent air shroud.

5. Unlatch and open the disk pack area lid and check for tape or other packing material inside the disk pack air shroud, and remove any material found. Manually rotate the spindle to assure it will turn freely.

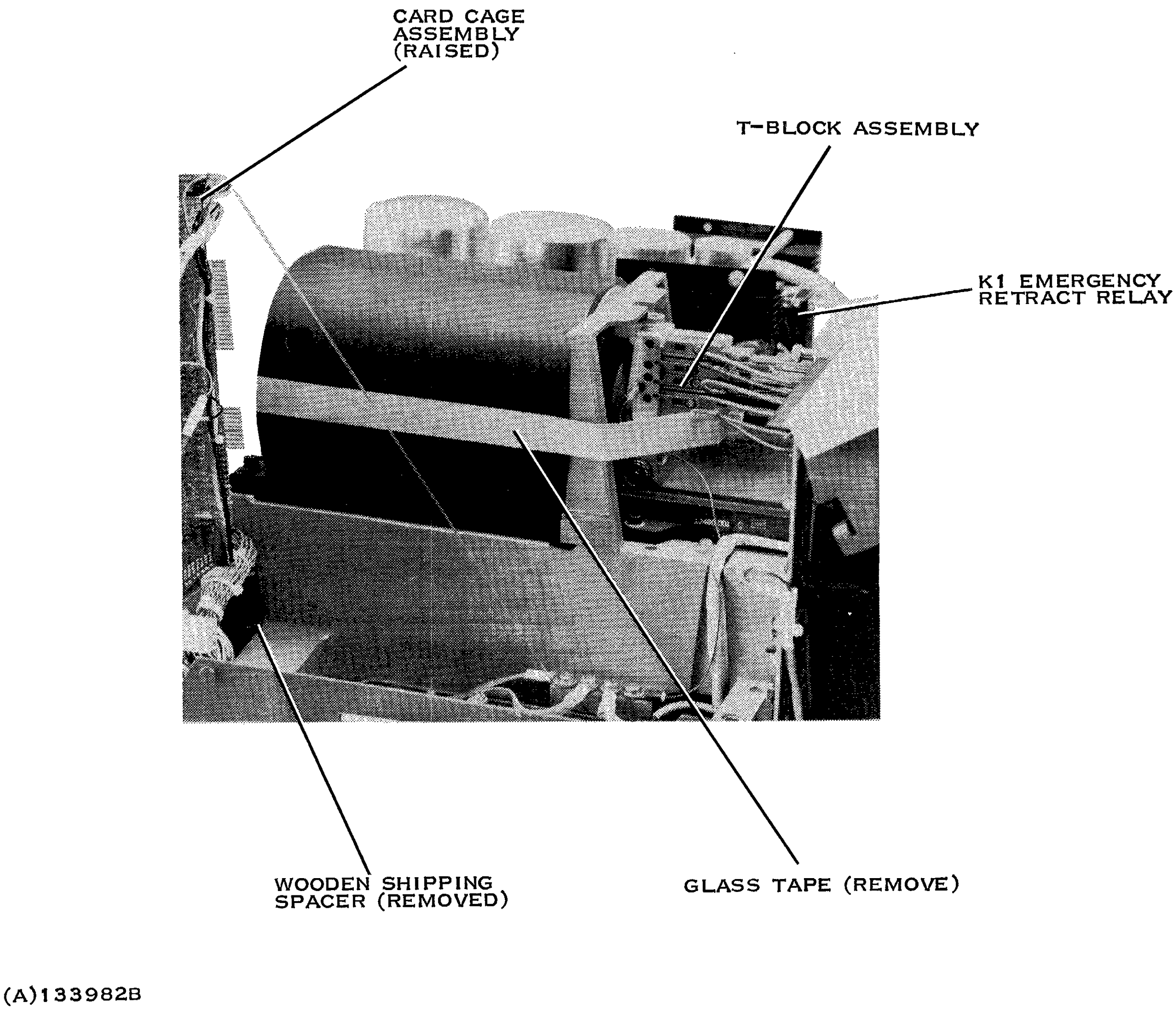



**Figure 2-9. T-Block Assembly Shipping Restraints**

**2.3.5 INSTALLING JUMPERS ON LOGIC III CIRCUIT BOARD.** If the disk drive is not shipped from the factory, jumpers must be installed on the logic III circuit board to establish the byte interval between fixed length sector markers on the disk; otherwise, the jumpers should be checked to be sure they are installed properly.

**NOTE**

> If the drive is received directly from the disk vendor, a plastic bag containing 12 jumpers should be taped outside of the card cage, and these jumpers should be used for making connections.

1. Remove the logic III circuit board assembly from card cage slot 5.

2. On the circuit board, locate IC sockets 6A and 6B which are used as jumper connectors. (Refer to Figure 2-10.) Install or verify the presence of the jumpers shown in the illustration. Also, remove or verify the absence of the jumpers indicated.

3. Reinstall the logic III circuit board in its slot.

**2.3.6 CHECKING POWER CONFIGURATIONS.** Prior to reinstalling the covers on the disk drive, verify that the internal power connections are made per the following instructions.

1. Check the identification plate at the rear of the drive for voltage, phase, and frequency of the input power required. Make sure these match the available power.

**WARNING**

> **Never operate the disk drive as a standalone unit without the ac and dc grounds being shorted together at the power supply. A potential as high as 60 volts can develop between the logic ground and the frame.**

2. Refer to Figure 2-11. Verify that the shorting jumper is installed on the appropriate spade terminal as follows:

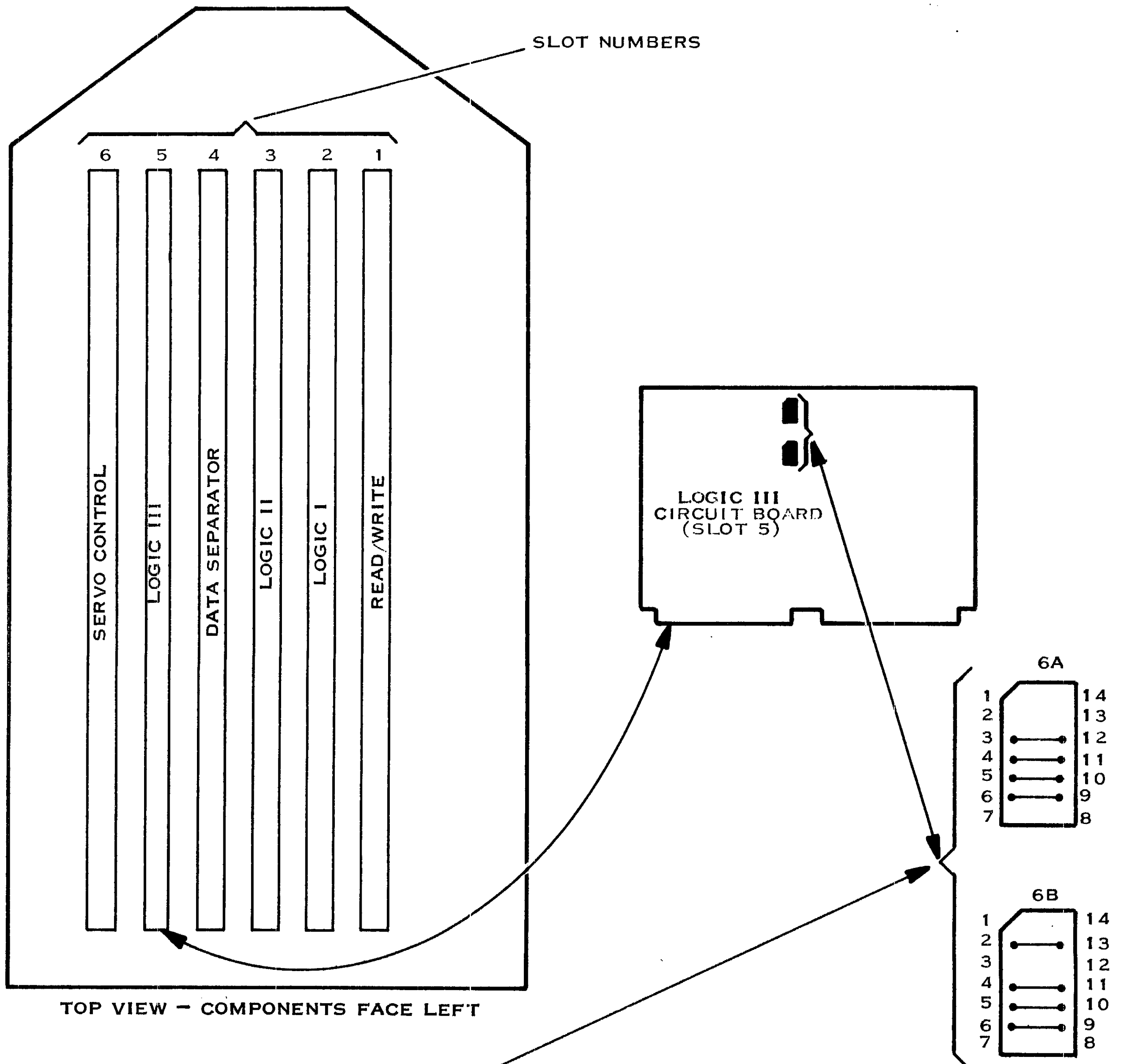
| Mode | Connect Jumper To |
|---|---|
| On-line (normal) | OPEN |
| Off-line (standalone) | GND SHORT |

3. Check terminal board TB2 (see Figure 2-11) on the power supply assembly for a jumper wire between the terminal marked ØB/NTL and the terminal corresponding to the source voltage available. Check the nameplate (see Figure 2-8) for voltage range and frequency restriction.

4. Remove the cover from the power cable terminal board TB1 and make sure that all three wires are connected as shown in Figure 2-12 and that the terminals are tight. Reinstall the cover.

**2.3.7 PURGING THE AIR FILTERING SYSTEM.** Before installing the disk drive system into the computer system, and after configuring power connections on the disk drive(s), purge the air filtering system(s). Perform the following steps to purge each disk drive air filtering system:

1. Turn the ac POWER switch to OFF.
2. Be sure the disk drive power cord is disconnected from the power source.
3. Remove the emergency retract relay on the power supply module (Figure 2-9).
4. Install a scratch pack on the disk drive (paragraph 2.7.1).
5. Connect the disk drive power cord to the proper power source.
6. Turn the ac POWER switch to ON.
7. Set the START/STOP switch to START.
8. Allow disk to spin up and to run with heads retracted for thirty minutes.
9. Set the START/STOP switch to STOP and allow disk to come to a complete stop.
10. Turn ac POWER switch to OFF.
11. Disconnect disk drive power cord from power source.
12. Reinstall emergency retract relay.
13. Reinstall disk drive external covers.




ADD JUMPERS

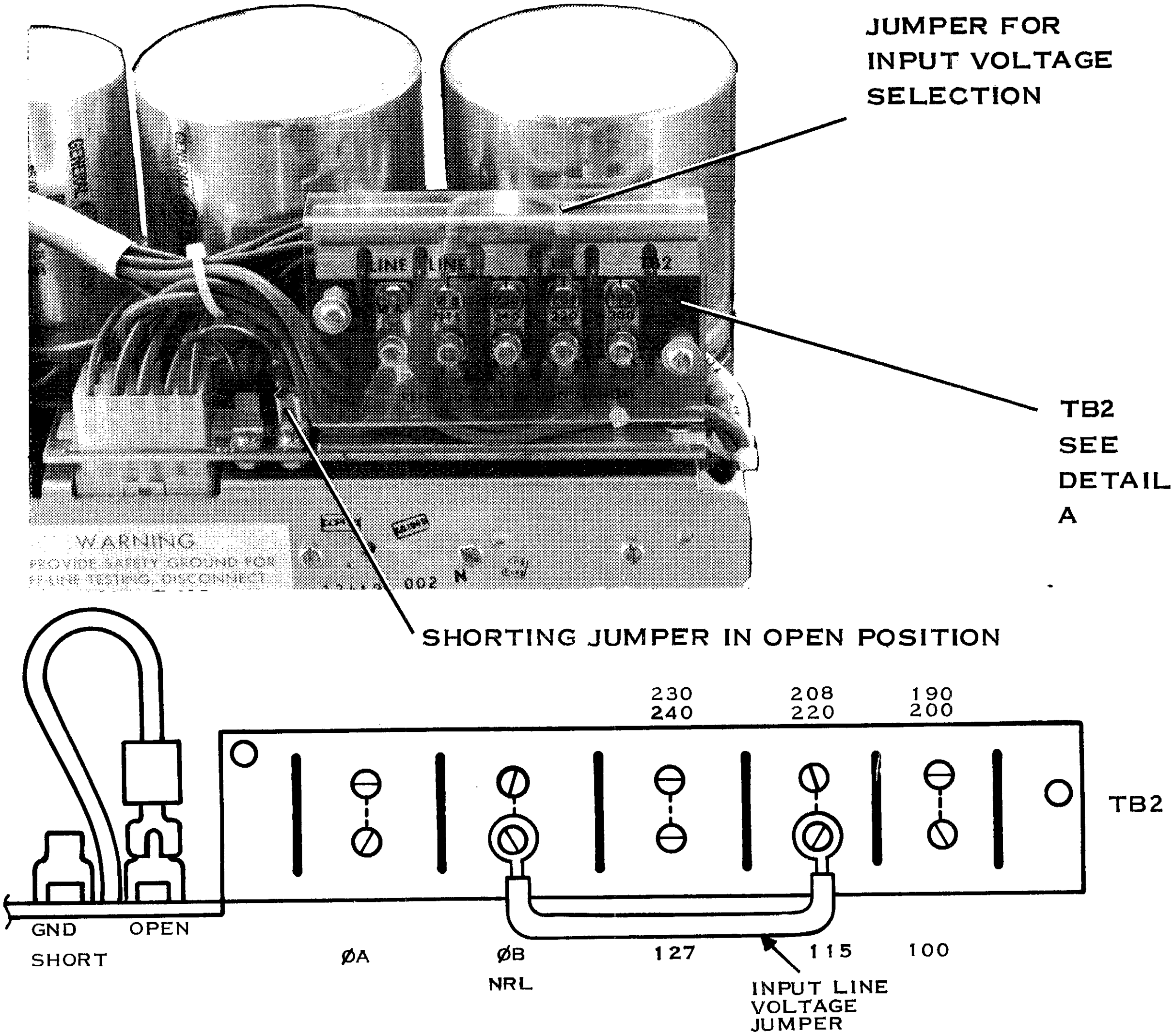
| SOCKET | JUMPER PINS |
|---|---|
| 6A | 3 — 12<br>4 — 11<br>5 — 10<br>6 — 9 |
| 6B | 2 — 13<br>4 — 11<br>5 — 10<br>6 — 9 |

REMOVE JUMPERS (IF ANY)

| SOCKET | PINS |
|---|---|
| 6A | 2 — 13<br>7 — 8 |
| 6B | 1 — 14<br>3 — 12 |

(A)133983A

**Figure 2-10. Jumper Configuration, Disk Drive Logic III Circuit Board**




(A) 133984B (DSD-876-13-3)　　DETAIL A

**Figure 2-11. Ground Short and Voltage Select Jumpers**

(A)133985 (DSD-876-13-1)

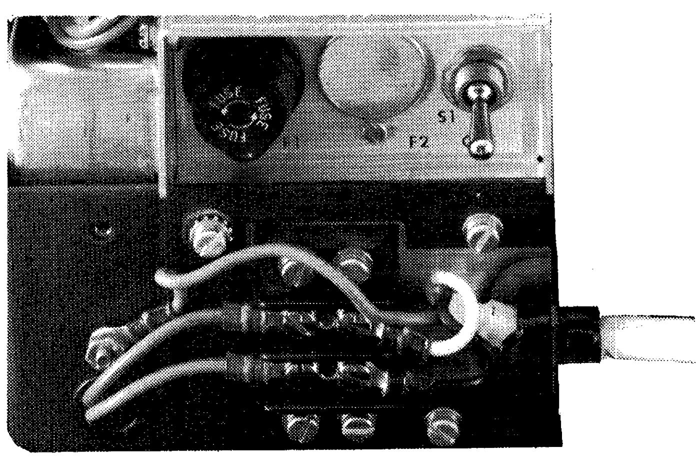



**Figure 2-12. Power Cable Terminal Board TB1**

## 2.4 COMPUTER CHASSIS PREPARATION FOR DISK CONTROLLER

If the disk drive system is shipped as part of the 990 computer system, the computer chassis will be received in a standard configuration with chassis slots assigned and interrupt connections properly made. Normally, the primay disk controller is installed in computer chassis slot 7 (in a 13-slot chassis); TILINE address is selected as >FFC00; interrupt level is 13; and the access granted connections are permanently made; i.e., a computer chassis shipped from the factory with a disk controller installed is correctly configured and no further preparation is necessary. However, if these preparations have not been made, or the standard configuration is to be changed, then the computer chassis must be adapated for the new configuration. If a nonstandard configuration is used, refer to *Model 990/10 Computer Hardware Reference Manual*, part number 945417-9701, for modification instructions. In addition, the power capacity of the computer chassis must meet the requirements of the disk controller and all other boards installed in the chassis. The disk controller requires eight amperes at the +5-volt level and 0.25 ampere at the −12-volt level.

Also, if a computer chassis slot other than slot 7 is selected, the access granted signal chain must be modified. This is accomplished by removing the jumper in the access granted circuit, as described in the following paragraph.

**2.4.1 RECONFIGURING ACCESS GRANTED CIRCUIT FOR NEW CHASSIS SLOT.** The TILINE access granted signal enters each master on backplane connector P2, pin 6. The signal leaves the master on P2, pin 5. Logic circuitry on the master controller allows the access granted output to be blocked to lower priority masters.

**2.4.1.1 Slot Preparation for 6-Slot and 13-Slot Chassis.** For chassis slots not occupied by TILINE masters, jumpers or etches on the motherboard are installed to assure continuity. By convention, the jumpers are installed at all available slot locations except slot 7. Slot 7 is reserved for the first TILINE master device, in this case, the disk drive controller. However, additional TILINE masters may be inserted at slot positions of higher or lower priority if the jumper connected between P2-5 and P2-6 is removed at the selected slot location.

Installing a TILINE controller circuit board in a location other than slot 7 requires that the TILINE access granted jumper be removed from the chosen slot and that the continuity of the TILINE access granted signal chain through all slots be preserved.

To reconfigure TILINE access granted signals for motherboard assemblies, part number 945015 (revisions C and above), jumpers are located on the right-hand side of the motherboard, accessible from the connector side. Refer to Table 2-2 to identify the jumper designators for each slot. Add or remove jumpers as necessary, using the following procedure, to achieve the desired configuration.

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

2. Remove the left access cover (as viewed from the front of the chassis). The cover is fastened by hex-head machine screws.

3. In a 13-slot chassis with a 20-ampere power supply, slots 1 through 6 are visible above the power supply. To work on these slots, proceed to step 4. To work on any other slots remove the power supply as follows:

    a. Disconnect the color-coded connectors from the component side of the power supply board.

    b. Unscrew the machine screws and standoffs which secure the power supply to the frame and to the motherboard.

c. Carefully pull the power supply board straight forward until the connector at the bottom center of the power supply board is disengaged from the pins protruding from the motherboard. Lift the power supply board out of the chassis.

4. The rear of the motherboard is now exposed. The P2 connectors are at the left side, nearest the fan. Refer to Figure 2-13 which gives detail views of the left end of the P2 connector in a 13-slot and a 6-slot chassis.

5. In the 13-slot chassis, the TILINE access granted jumpers (P2-5 to P2-6) are wire jumpers soldered to the connector pins as shown in view A of Figure 2-13. To remove a jumper, clip the jumper in two places and remove the excess wire.

6. In a 6-slot chassis, the jumpers are part of the printed circuit board etch as shown in view B. Note that pins 1 and 2 are concealed by the ground plane. To remove a jumper, cut the jumper etch at two points with an X-acto® knife and lift off or scrape away the excess conductor.

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

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

**CAUTION**

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

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

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

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

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

9. Reinstall the cover removed in step 2.

® Trademark of X-acto Corporation

Table 2-2. TILINE Jumper Connections

| Connector | Jumper |
|---|---|
| Slot 2 | E1 to E2 |
| Slot 3 | E3 to E4 |
| Slot 4 | E5 to E6 |
| Slot 5 | E7 to E8 |
| Slot 6 | E9 to E10 |
| Slot 7 | E11 to E12 |
| Slot 8 | E13 to E14 |
| Slot 9 | E15 to E16 |
| Slot 10 | E17 to E18 |
| Slot 11 | E19 to E20 |
| Slot 12 | E21 to E22 |

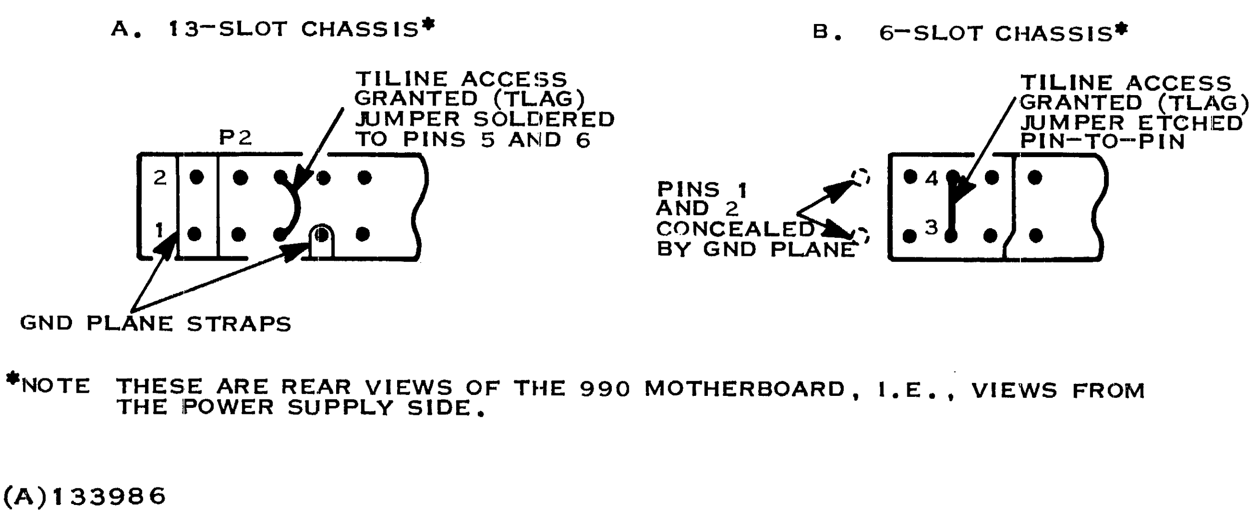



Figure 2-13. TILINE Access Granted Jumpers (P2-5) to (P2-6) on the 990/10 Backpanel

**2.4.1.2 Slot Preparation for 17-Slot Chassis.** Continuity of the TLAG jumpers in the 17-slot chassis is controlled by two socket-mounted dual inline package (DIP) switches, each with eight individual switch sections. These switches are accessible from the rear of the 17-slot chassis, as shown in Figure 2-14. To set or check these switches, perform the following steps.

1. Turn off power and unplug the chassis ac line cord. Allow about 30 seconds for the power supply bleeders to discharge the power supply capacitors.

**WARNING**

**Opening the chassis rear cover (power panel) exposes high voltages if the ac line cord is installed in a live socket. Do not contact the large filter capacitors on the power module.**

**CAUTION**

The wire hinges on the chassis rear cover do not allow the cover to pivot beyond 90 degrees. Attempts to open the chassis rear cover beyond 90 degrees may damage the hinge mountings.

2. Using a coin or flat-bladed screwdriver, release each of the 11 quarter-turn latches on the chassis rear cover. Pull the cover straight back 38 mm (1.5 inches) to extend the wire hinges, and then open the cover to the 90-degree position. The hinges are on the right as viewed from the rear of the chassis.

3. Refer to Figure 2-15, which shows the correspondence between switch sections and chassis slots. Set the appropriate switch segment OFF for any slot which is assigned to a TILINE master device, such as the DS25/DS50 disk controller. All other switch segments should be ON.

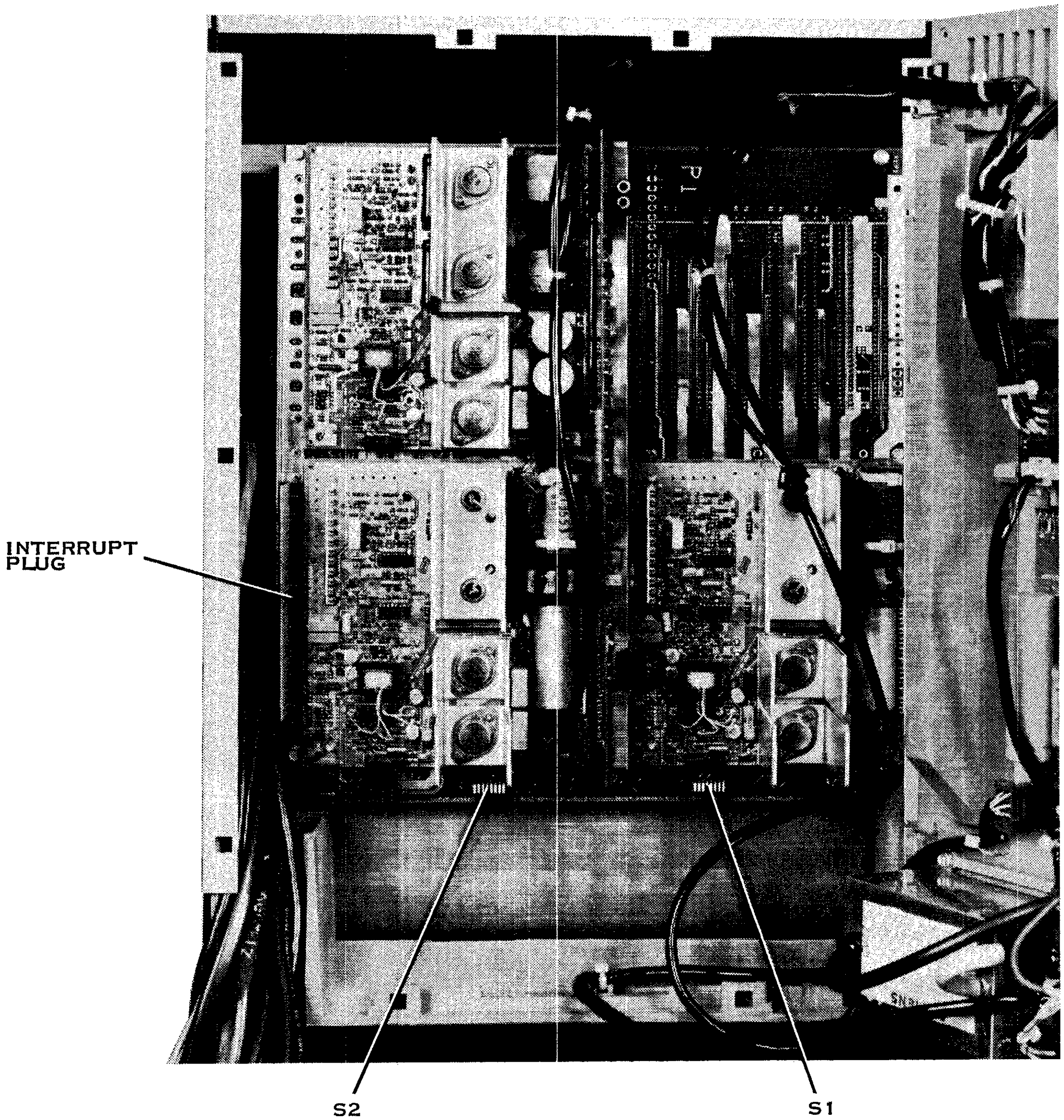
4. Interrupt assignments in the 17-slot chassis are made by a fixed jumper assembly or by a special user-selectable jumper assembly. Refer to the 990/12 User's Manual for information on changing interrupt assignments.

**CAUTION**

There is a possibility of interference between heat sinks in the chassis and modules mounted inside the rear access cover as the door is closed. Do not force the door closed if resistance is felt.

5. Rotate the door to a position parallel to the rear of the chassis, with hinges fully extended. Grasp the rear access cover at the left and right sides and push it straight back to its mounting position against the chassis.

6. Using a coin or screwdriver, lock the 11 quarter-turn latches which hold the access cover in position.

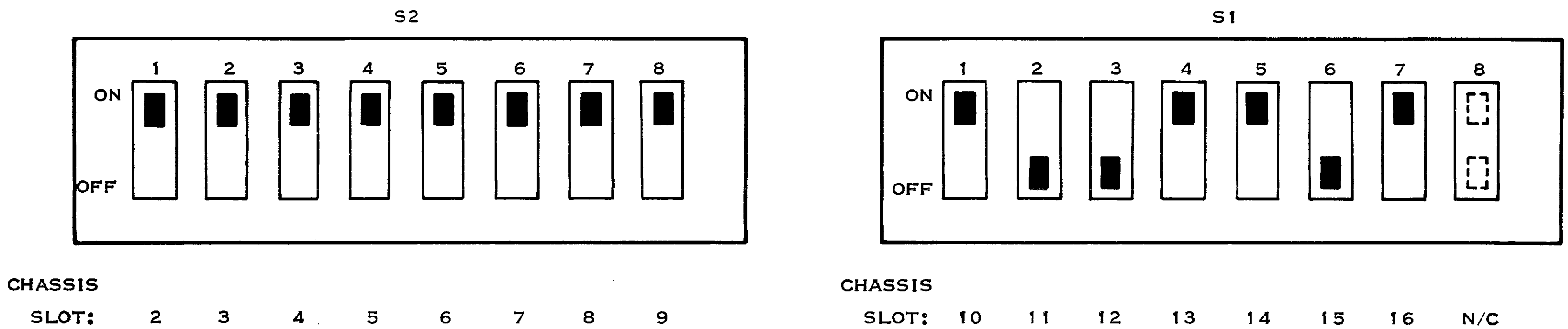



(A)141779

Figure 2-14. Interrupt Plug and TLAG Jumper Switches in the 17-Slot Chassis

ON = TLAG JUMPERED ACROSS SLOT (P2-6 TO P2-5)

OFF = TLAG NOT JUMPERED - CONTINUITY REQUIRES TILINE CONTROLLER




NOTES:

1. SWITCHES ARE SHOWN SET FOR:

| | |
|---|---|
| SYSTEM DISK CONTROLLER | - SLOT 11 |
| 979A TILINE MAGNETIC TAPE CONTROLLER | - SLOT 12 |
| FD1000 TILINE FLEXIBLE DISK CONTROLLER | - SLOT 15 |

2. EACH SWITCH SECTION MUST BE ON UNLESS A TILINE MASTER CONTROLLER IS INSTALLED IN THE CORRESPONDING CHASSIS SLOT. TILINE PRIORITY SYSTEM WILL NOT WORK IF SWITCHES ARE SET INCORRECTLY.

3. SLOT 17 DOES NOT REQUIRE A SWITCH.

(A)141767A

**Figure 2-15. 17-Slot Chassis TLAG Jumper Switch Settings**

## 2.5 PREPARING DISK CONTROLLER CIRCUIT BOARD

TILINE devices are assigned the permanent addresses that the software program uses. The standard factory-assigned TILINE word addresses are as shown in Table 2-3. Addresses other than the standard, factory-assigned addresses can be assigned.

**2.5.1 SELECTING DISK TILINE ADDRESS.** Each disk controller is assigned a TILINE slave address to allow the computer to communicate with the disk system. The address assignment is accomplished by selecting switch positions on the disk controller circuit board. These switches are located at D02 on the component side of the controller (see Figures 2-16 and 2-17). The assignment of TILINE addresses is from >FFC00 through >FFC78, corresponding to CPU addresses of >F800 through >F8F0. (The symbol > indicates hexadecimal notation.) Switch selections are made for the appropriate address as shown in Figure 2-18.

**2.5.2 INSTALLING MOVABLE JUMPERS.** The disk controller has a group of movable jumpers which are installed for compatibility with the particular type of computer in the system. The location of these jumpers is shown in Figures 2-16 and 2-17 for the PWB controller and the multiwire controller, respectively. Figure 2-19 shows the jumper configuration for the PWB controller and Figure 2-20 shows the jumper configuration for the multiwire controller. The slave address switches for the limited production wire-wrap configuration are shown in Figure 2-21.

**2.5.3 SELECTING MULTIWIRE CONTROLLER ROM.** Ensure that the proper type of ROM is installed in location K11 to correspond with the drive device as listed in Table 2-3.

T50 947581-0018

T25 947581-0019

**2.5.4 INSTALLING CONTROLLER IN COMPUTER CHASSIS.** With the system power off, install the controller circuit board in the standard 990 computer slot 7. If the controller is installed in any other chassis slot, the interrupt jumpers and the access granted circuit continuity on the motherboard must be reconfigured, as previously noted. Verify that the address switches on the controller are set to the correct TILINE address.

Install the controller with the component side of the board towards the top of the computer chassis. Be sure that the board is fully seated and the ejector tabs are locked in place.

**Table 2-3. Standard TILINE Addresses**

| TILINE Word Addresses | CPU Byte Addresses | Device |
|---|---|---|
| >FFC00 - >FFC07 | >F800 - >F80F | 1st Disk Controller |
| >FFC10 - >FFC17 | >F820 - >F82F | 2nd Disk Controller |
| >FFC20 - >FFC27 | >F840 - >F84F | 3rd Disk Controller |
| >FFC30 - >FFC37 | >F860 - >F86F | 4th Disk Controller |
| >FFC40 - >FFC47 | >F880 - >F88F | 1st Tape Controller |
| >FFC48 - >FFC4F | >F890 - >F89F | 2nd Tape Controller |

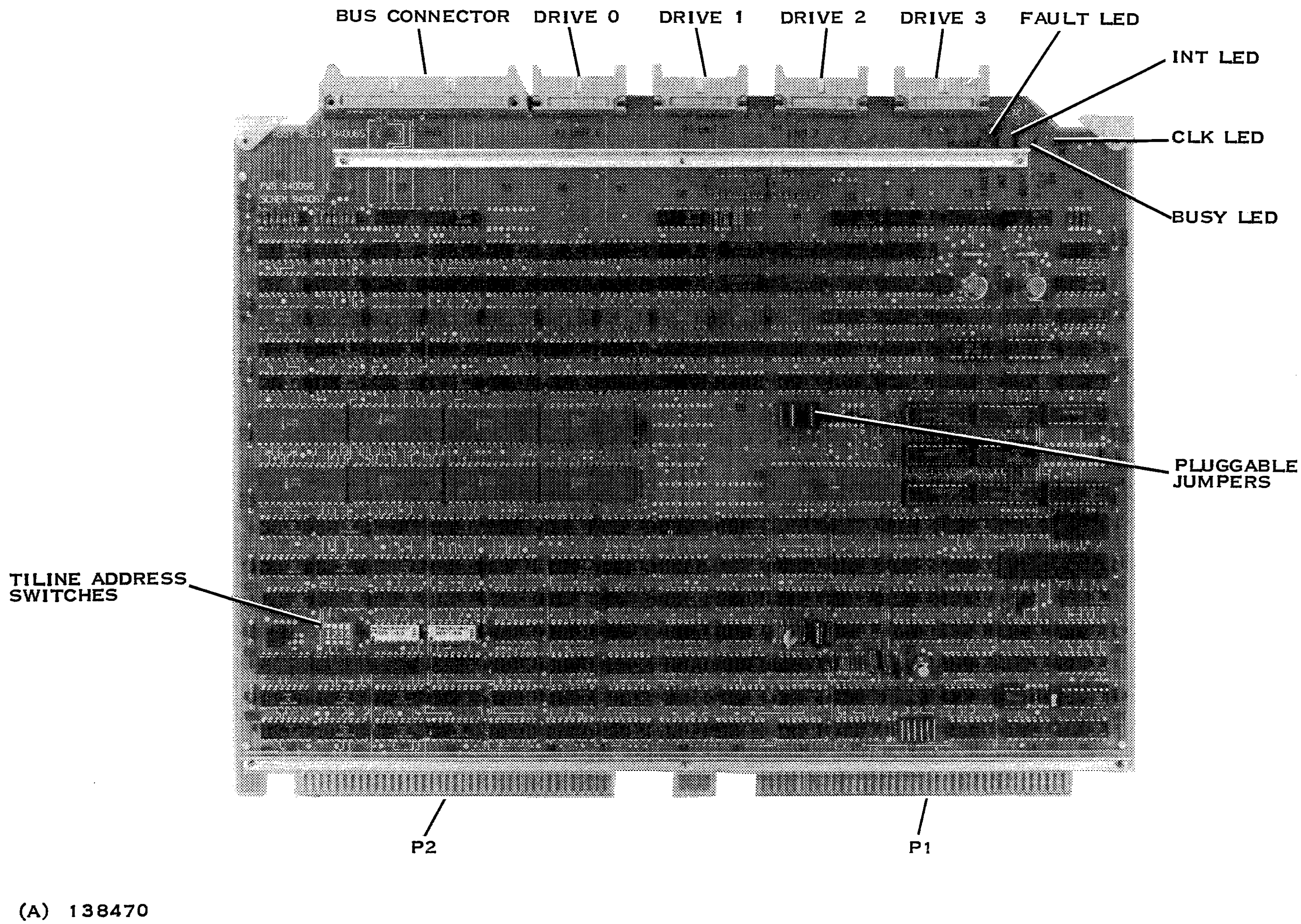



Figure 2-16. Disk Controller, PWB and Fine Line PWB

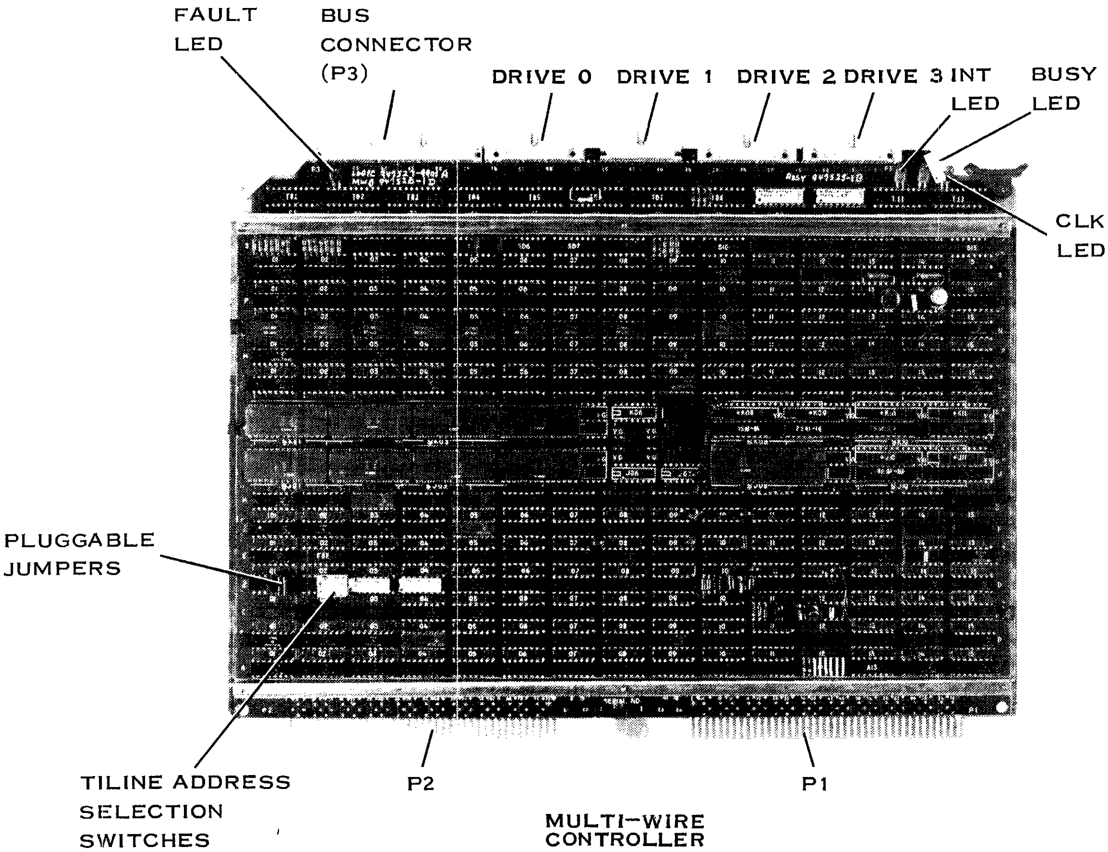
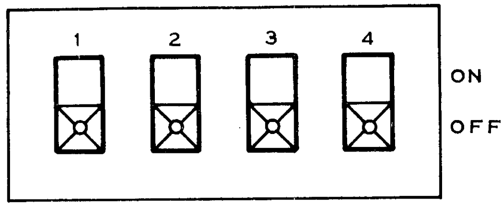



**Figure 2-17. Disk Controller, Multiwire**



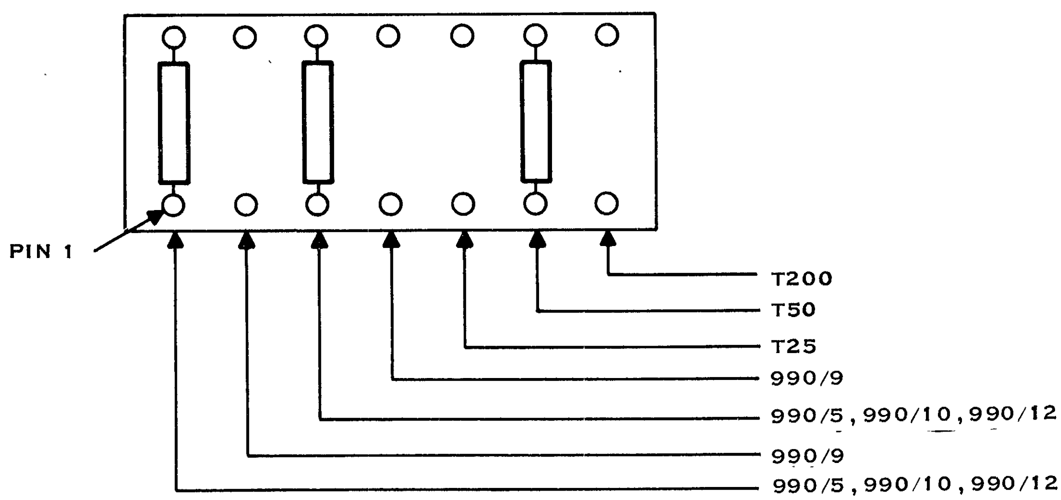

SWITCHES AT LOCATION D02, SHOWN SET AT CPU ADDRESS $F800_{16}$

| TILINE ADDRESS (HEXADECIMAL) | CPU ADDRESS (HEXADECIMAL) | SWITCHES 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|---|
| FFC00 | F800 | OFF | OFF | OFF | OFF | DISK CONTROLLERS |
| FFC08 | F810 | OFF | OFF | OFF | ON | DISK CONTROLLERS |
| FFC10 | F820 | OFF | OFF | ON | OFF | DISK CONTROLLERS |
| FFC18 | F830 | OFF | OFF | ON | ON | DISK CONTROLLERS |
| FFC20 | F840 | OFF | ON | OFF | OFF | DISK CONTROLLERS |
| FFC28 | F850 | OFF | ON | OFF | ON | DISK CONTROLLERS |
| FFC30 | F860 | OFF | ON | ON | OFF | DISK CONTROLLERS |
| FFC38 | F870 | OFF | ON | ON | ON | DISK CONTROLLERS |
| FFC40 | F880 | ON | OFF | OFF | OFF | OTHER TILINE SLAVES |
| FFC48 | F890 | ON | OFF | OFF | ON | OTHER TILINE SLAVES |
| FFC50 | F8A0 | ON | OFF | ON | OFF | OTHER TILINE SLAVES |
| FFC58 | F8B0 | ON | OFF | ON | ON | OTHER TILINE SLAVES |
| FFC60 | F8C0 | ON | ON | OFF | OFF | OTHER TILINE SLAVES |
| FFC68 | F8D0 | ON | ON | OFF | ON | OTHER TILINE SLAVES |
| FFC70 | F8E0 | ON | ON | ON | OFF | OTHER TILINE SLAVES |
| FFC78 | F8F0 | ON | ON | ON | ON | OTHER TILINE SLAVES |

(A)133988

**Figure 2-18. TILINE Address Switch Configurations, PWB, Multiwire Controller**

LOCATION K10 SHOWN CONFIGURED FOR 990/5, 990/10, OR 990/12 COMPUTER AND DS50 DISK DRIVE




(A) 138471A

**Figure 2-19. Movable Jumper Configuration PWB Controller and Fine Line PWB Controller**

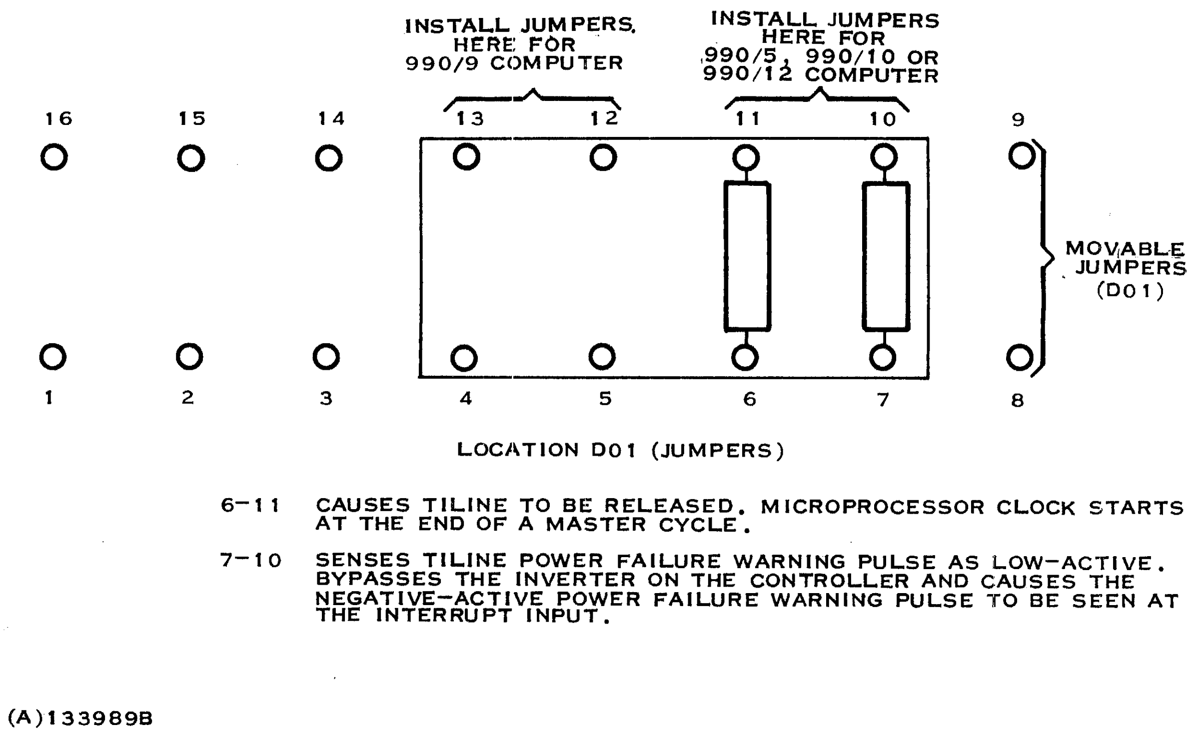
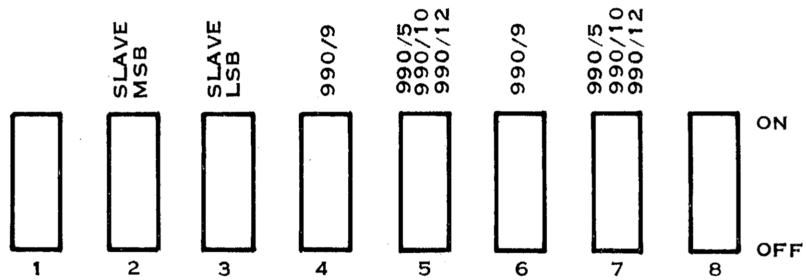



**Figure 2-20. Movable Jumper Configuration, Multiwire Controller**




SWITCHES AT D02

SLAVE ADDRESS SELECTION

| TILINE ADDRESS | CPU ADDRESS | SWITCHES | |
|---|---|---|---|
| | | 2 | 3 |
| FFC00 | F800 | OFF | OFF |
| FFC10 | F820 | OFF | ON |
| FFC20 | F840 | ON | OFF |
| FFC30 | F860 | ON | ON |

4 990/9

5 CAUSES THE TILINE TO BE RELEASED WHEN THE MICROPROCESSOR CLOCK STARTS AT THE END OF MASTER CYCLES

6 990/9

7 THE TILINE POWER FAIL WARNING SIGNAL IS RECEIVED LOW-ACTIVE. THIS SWITCH ALLOWS THE SIGNAL TO BE GATED TO THE INTERRUPT CIRCUITRY WITHOUT BEING INVERTED

(A)135584A

**Figure 2-21. Wire-Wrap Controller Switch Configuration**

## 2.6 INSTALLING DISK DRIVE SYSTEM INTERCONNECT CABLES

The bus cable and the radial cables between the disk controller and the disk drives should be installed carefully and routed in a manner to prevent damage to the connectors and the cables. When installing connectors at the controller, be sure the arrow or notch on the plug aligns with the arrow on the connector to assure correct orientation. When installing connectors at the disk drives, be careful not to damage or bend the pins. Be sure that the connectors are firmly seated and that the connector securing screws are installed to provide strain relief and to prevent possible signal loss.

**2.6.1 CABLE INSTALLATION FOR A SINGLE DISK DRIVE SYSTEM.** For a system with a single disk drive, install the cables as shown in Figure 2-22 and described in the following steps:

1. Disconnect all power from the disk drive system.

2. Connect the 947587-0001 bus cable to the bus connector (50-pin connector) on the top edge of the disk controller circuit board. Be sure the arrow on the PCB connector is aligned with the arrow or notch on the cable connector.

3. Connect the 947616-0001 radial cable to the drive 0 connector on the controller.

4. Route the bus cable and the radial cable towards the rear of the computer cabinet and secure in a plastic cable clamp mounted on the computer chassis.

5. At the disk drive, remove the screws that secure the rear cover. Remove the cover by lifting and sliding it towards the rear of the drive.

6. Connect the bus cable connector to J03 (bus input) of the disk drive. Install the securing screw that holds the connector PWB in place.

7. Connect the radial cable connector to J04 on the disk drive and install the screw that holds the connector PWB in place.

8. Install the 947528-0001 terminator in connector J02 on the disk drive and install the screw that holds the terminator in place. (The terminator is always installed in the bus out (J02) connector of the last disk drive in any system.)

9. Route the cables to the rear of the disk drive.

**CAUTION**

The DS25 and DS50 disk drives have optional primary input power configurations of 115 or 220 Vac, 50 or 60 Hz. The model number and the primary power requirements are stamped on the nameplate on the rear of each drive; therefore, verify that the power source is compatible before connecting the ac line cord.

**CAUTION**

The cabinet assembly is fused at 20 amperes. Since the disk drives require a sequencing current of up to 30 amperes (typically 24 amperes), an ac source external to the cabinet must be used to provide ac power for the disk drives.

10. Verify that the POWER switch on the rear of the disk drive is set to OFF. Connect the ac line cord to a 30-ampere ac power source (compatible with the disk drive nameplate specifications) external to the cabinet assembly.

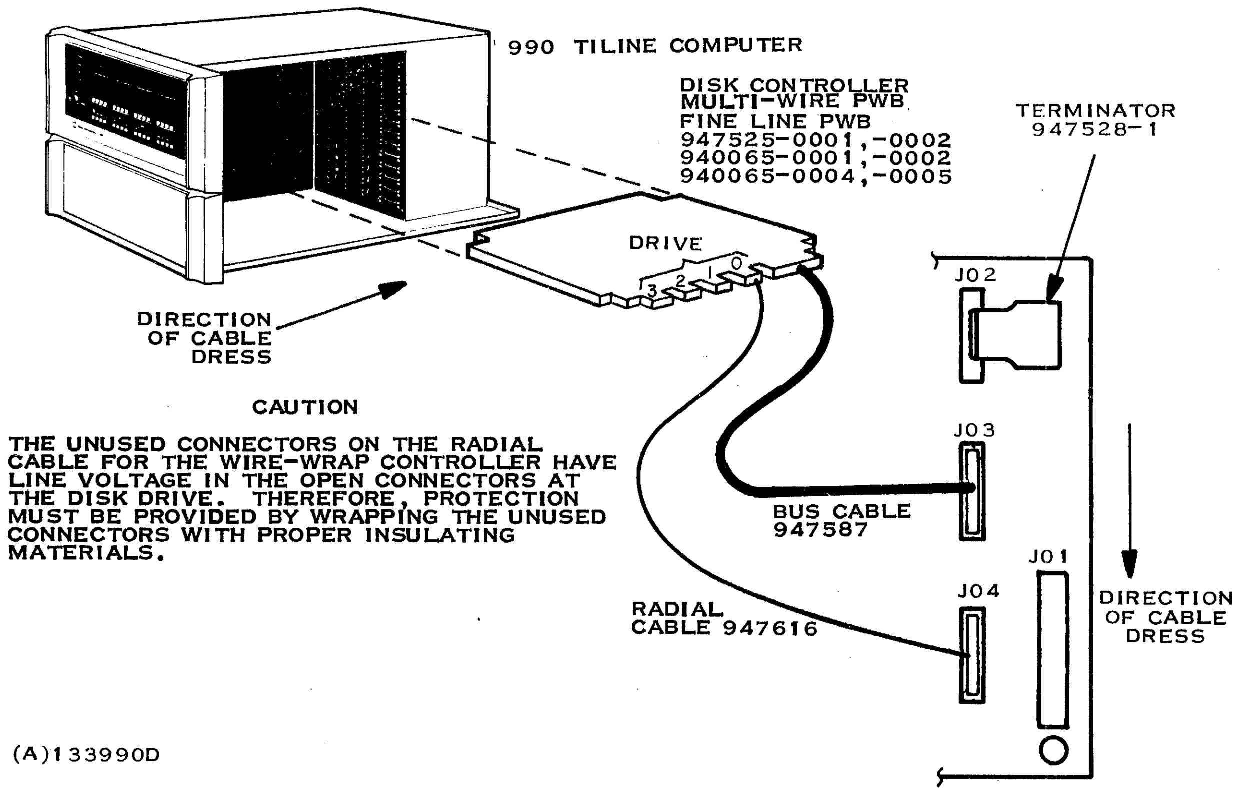



**Figure 2-22. Computer to Disk Drive Interconnections**

**2.6.2 CABLE INSTALLATION FOR A MULTIPLE DISK DRIVE SYSTEM.** In a multiple disk drive system, make the mechanical installation of the connectors and the cable routing the same as for a single disk drive system (refer to paragraph 2.6.1).

For a multiple disk drive system, install the cables as shown in Figure 2-23. The bus cable is connected from the bus connector on the controller to the bus in connector (J03) of the first disk drive (drive 0) in the system. The bus out connector (J02) of each disk drive in the system is connected via a daisy-chain cable to the bus in connector (J03) of the next successive disk drive in the series. The terminator is always connected to J02 of the final disk drive in the chain. An individual radial cable is connected from each connector (drive 0 through drive 3) on the controller to the J04 connector on each successive disk drive. All disk drives in a multiple disk drive system must be the same model.

## 2.7 INSTALLING AND REMOVING DISK PACK

WARNING

**The spindle and disk pack rotate at 3600 revolutions per minute when the drive is up to speed. Be sure the green File Ready indicator is extinguished and rotation has stopped before opening the air shroud lid.**

The installation and removal of disk packs from a disk drive require that power be applied to the drive. Therefore, the information in this paragraph should be coordinated with Section 4 for the procedures to apply power to the disk system.

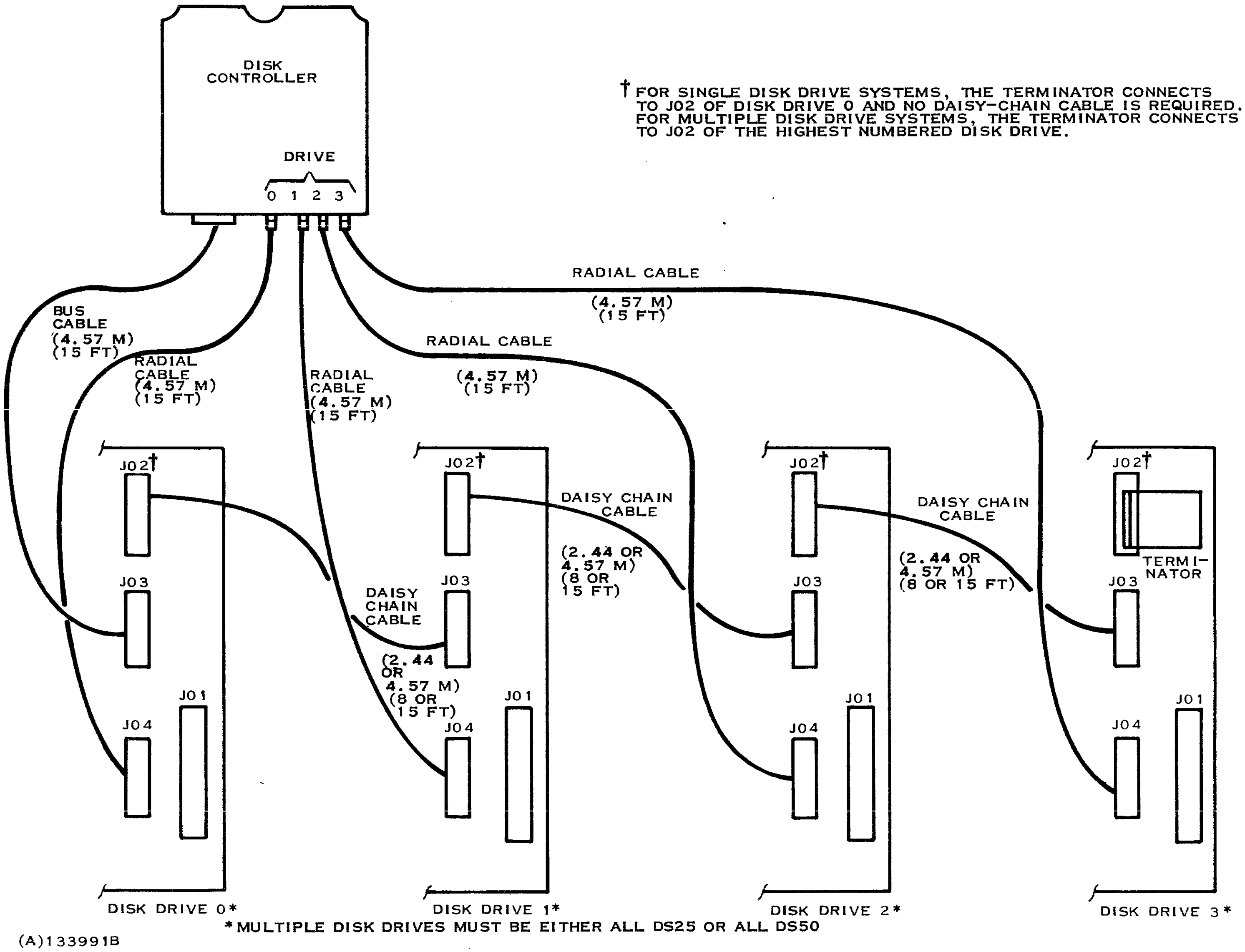



**Figure 2-23. Interconnections for Multiple Disk Drive System**

**2.7.1 INSTALLING DISK PACK.** To install a disk pack use the following procedure:

1. Make sure that the disk drive START/STOP switch is set to STOP and that the green File Ready indicator is extinguished.
2. Unlatch the air shroud lid of the disk drive and open the lid. The lid latch is located beneath the front edge overhang at the center.
3. Check the interior of the air shroud. The interior shroud should be clean, and the heads and brushes should be completely retracted from the disk pack area.
4. Remove the lower cover from the disk pack by pressing the two plastic ears together, and lower the top cover with the disk pack carefully onto the disk drive spindle.
5. Press down the top cover handle to engage the spindle-locking mechanism; rotate the handle clockwise to lock the disk pack to the spindle and to disengage the top cover.
6. Carefully lift and remove the top cover from the disk drive and close the air shroud lid. Make sure that the lid latch locks.
7. If the installed disk pack is a permanent record or is a head alignment pack, set the READ ONLY - READ/WRITE switch to READ ONLY to protect the pack from being written on. If writing is to be permitted, set this switch to READ/WRITE.
8. Store the top and bottom covers of the disk pack together to minimize dust accumulation inside the case.
9. Set the START/STOP switch to START.

**2.7.2 REMOVING DISK PACK.** To remove a disk pack from the disk drive, perform the following steps:

1. Stop rotation of the disk drive spindle by setting the START/STOP switch to STOP. The green File Ready indicator should start flashing.
2. Wait until the File Ready indicator stops flashing (about 20 seconds), unlatch the disk drive air shroud lid, and open the lid.
3. Separate the top and bottom covers of the disk pack and lower the top cover by the handle over the disk pack.
4. Press down the top cover handle to engage the spindle-locking mechanism; rotate the handle counter-clockwise to unlock the disk pack from the spindle and to reengage the top cover.
5. Lift the top cover and disk pack carefully from the disk drive and close the air shroud lid.
6. Replace the bottom cover on the disk pack and return the pack to storage.

# SECTION 3

# PROGRAMMING

## 3.1 GENERAL

This section provides information for the programmer to control the disk drive system via the assigned control words. Paragraphs 3.2, 3.3, and 3.4 give general information about issuing commands, interrupts, and command completion. Then, paragraph 3.5 and the subparagraphs thereof describe in detail the contents and formats of the eight control words shown in Figure 3-1 that are used in programming the disk controller.

Finally, paragraph 3.6 gives the hardware and firmware terminology definitions and describes the data formats that are processed by the disk controller. The user should refer to paragraph 3.6 and the subparagraphs thereof before attempting to write a software program if he is unfamiliar with the terminology and data formats of the controller used by the DS25 and DS50 disk drives.

## 3.2 PROGRAMMING THE DISK CONTROLLER

Program control of the disk controller and the disk drive system is relatively simple. To issue a command to the disk system, the programmer can move eight words to the disk controller over the TILINE in the same way that a word is moved to the memory of the 990 computer. Any 990 TILINE computer commands that read or modify memory can be used to communicate with the controller. The controller is assigned a block of memory addresses just as any other memory module. The controller can accept eight consecutive memory addresses.

The TILINE address for the controller is selected by a switch package on the controller as shown in Figures 2-16, 2-17 and 2-18. A total of 16 possible starting TILINE addresses may be selected. The possible range of starting TILINE addresses is from >FFC00 to >FFC78 (CPU addresses >F800 to >F8F0).

## 3.3 COMMAND CONTROL

The disk controller is initiated and interrogated by a TILINE master (normally the computer CPU) via a set of control words. These eight control words and their corresponding TILINE addresses are shown in Figure 3-1 and described in the following paragraphs.

An attempt by the software to write over certain bits of the disk system hardware that are not alterable by the software results in a normal cycle with no change occurring to the bits in the system. When the controller is busy (in a not idle state), any attempt to read or write will be aborted since the controller responds with a TLTM- (TILINE terminate) signal. When the controller is busy, no data transfer will occur for a write cycle; for a read cycle, bit 0 will be returned as a logic zero when the controller is busy. For a read command during a busy cycle, bits 1 through 15 are indeterminate (i.e., they may be either one or zero).

## 3.4 COMMAND COMPLETION

The disk controller can be programmed to run with or without interrupts. The following paragraphs describe both situations.

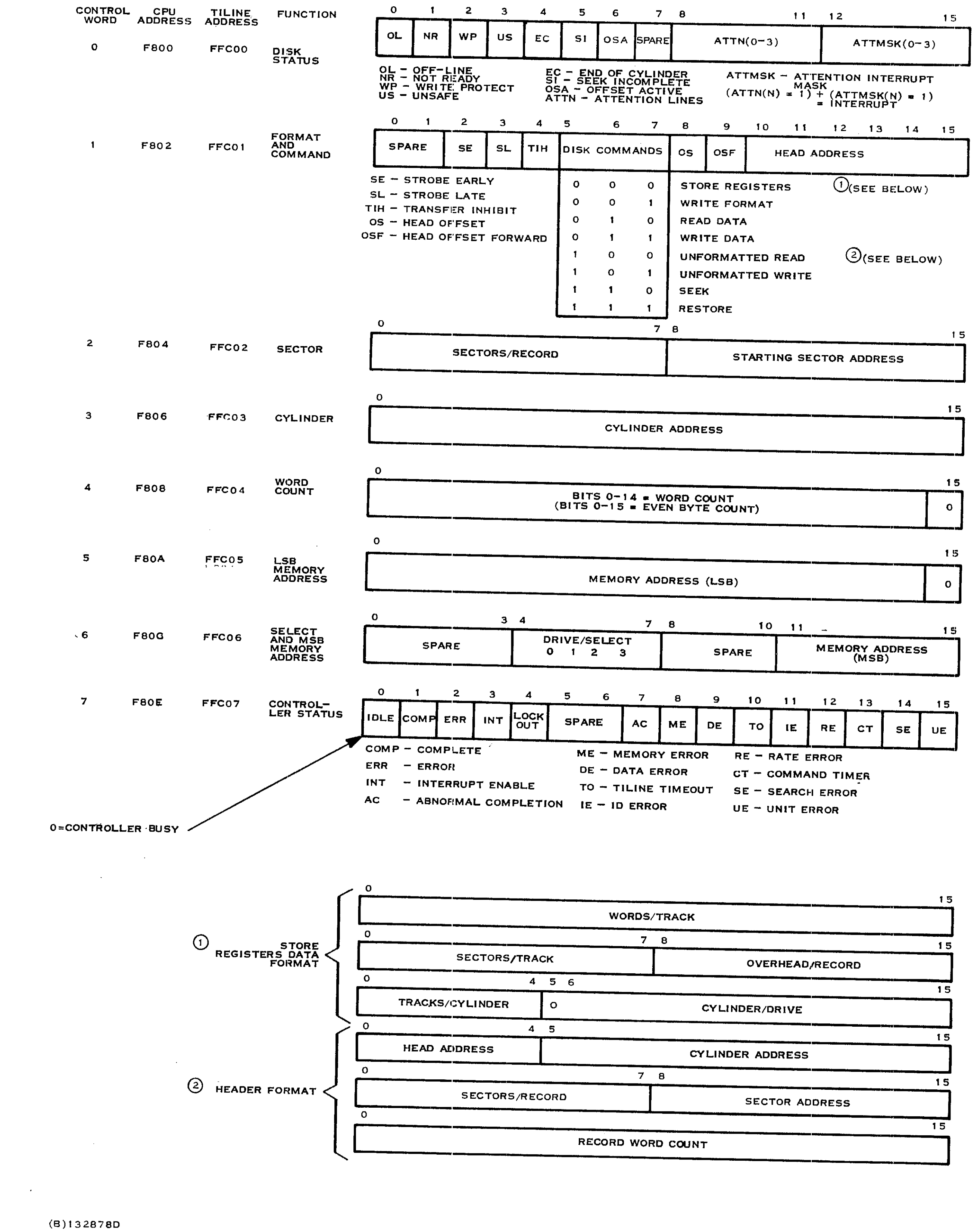



**Figure 3-1. Formats of Control Words**

**3.4.1 COMMAND COMPLETION WITHOUT INTERRUPTS.** If interrupts are not used, the computer program can determine if the controller has completed a command by reading bit 0 of control word 7. If bit 0 (idle bit) is zero, the disk controller is busy. When a command is complete, the idle bit and either the error bit or the complete bit will be set. If lockout is being used, it will be set after control word 7 is read and if the error bit was set, an error status bit will be set.

If the command was a Seek or Restore, the disk may still be busy, even after the controller has reported completion. To find out if the disk has completed a Seek or Restore command, the computer program should look at the disk status of word 0 for the disk drive to which the command was issued. If the disk drive has completed its operation, the attention line will be set or the ready bit will be off. Again, any data read from the disk slave addresses is only valid when the controller is idle.

**3.4.2 COMMAND COMPLETION WITH INTERRUPTS.** The controller can issue two kinds of interrupts to the computer. One interrupt will be issued when the controller completes any command, and one will be issued when the disk completes a Seek or Restore command.

**3.4.2.1 Command Completion Interrupts.** In order to have the controller signal the completion of a command by issuing an interrupt to the computer, the computer program should set the interrupt bit (bit 3) of control word 7 at the same time that the command is started by resetting the idle bit (bit 0).

**3.4.2.2 Seek and Restore Completion Interrupts.** Control word 0 contains four attention lines (one for each of the four disk drives that a controller can control) and four attention mask lines. When the attention bits and mask bits for any drive are both set, the interrupt line to the computer will be set.

**NOTE**

> The attention lines are always set only after the completion of independent Seek or Restore operations. For example, the attention lines will not be set after a Read Data operation.

The programmer can set or reset the mask bits by using any of the computer memory instructions. The computer cannot set or reset the attention bits directly, but only by executing a disk command which forces the disk to remove the attention line.

The correct way to use the control word 0 interrupts is to issue the Seek or Restore command to the controller; then after the controller reports completion, set the correct mask bit. When that drive finishes the Seek operation, an interrupt will be issued to the computer. The interrupt can then be cleared by resetting the mask bit. The TILINE interrupt is always reset when the controller goes from an idle to a busy condition.

**3.5 CONTROL WORD CONTENTS AND FORMATS**

The eight control words shown in Figure 3-1 can be used by the programmer to direct the activities of the disk. The format, content, and activities of each of these control words are described in the following paragraphs.

**3.5.1 DISK STATUS, CONTROL WORD 0.** When the controller is not busy, the disk status of control word 0 may be used. The bits of control word 0 (disk status) are shown in Figure 3-2.

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 — 11 | 12 — 15 |
|---|---|---|---|---|---|---|---|---|---|
| OL | NR | WP | US | EC | SI | OSA | SPARE | ATTENTION LINES (0-3) | ATTENTION INTERRUPT MASK (0-3) |

(A)133992A

**Figure 3-2. Disk Status Bits, Control Word 0**

Bits 0 through 6 of control word 0 contain individual status indicators from the selected disk drive. Bits 8 through 11 contain the attention line status of each of the disk drives connected to the controller. These attention lines can generate interrupts with the mask bits, 12 through 15. Each bit (refer to Figure 3-2) is defined as follows:

*Bit 0, Offline* (*OL*). When bit 0 is set, it indicates that the selected disk drive is not powered-up, not at the proper speed, or not loaded with a disk pack, or that an unsafe condition exists.

*Bit 1, Not Ready* (*NR*). When bit 1 is set, it indicates that the selected disk drive is in the process of performing a Seek operation, or that the heads are not loaded.

*Bit 2, Write Protect* (*WP*). When bit 2 is set, it indicates that the write protect status (READ ONLY switch) of the selected disk drive is on. When this switch is on, it inhibits the write logic within the disk drive. The drive must be deselected when changing the switch function.

*Bit 3, Unsafe* (*US*). When bit 3 is set, it indicates that the selected disk drive is unsafe. This means that the safety circuits that protect the recorded information are unsafe, and the unsafe condition must be removed before any more commands are attempted. If an unsafe condition occurs, then a Restore command can be issued to clear this condition.

*Bit 4, End of Cylinder* (*EC*). When bit 4 is set, it indicates that the head address register of the selected disk drive contains an illegal head address. This means the head address has been incremented beyond four, or an illegal head address has been received.

*Bit 5, Seek Incomplete* (*SI*). When bit 5 is set, it indicates that the selected disk drive has failed to complete a Seek operation because of a disk malfunction. When this status is detected, the software must initiate a Restore command before attempting to execute any other command.

*Bit 6, Offset Active.* When bit 6 is set, it indicates that the heads are in an offset position (see paragraph 3.5.2, bits 8 and 9).

*Bit 7* is not used.

*Bits 8 through 11, Attention Lines* (*0-3*). These bits are set by the attention lines from each of the disk drives connected within the disk system. When an attention line bit is set, it indicates that a power-on sequence is complete, a seek command is complete, or a Restore command is complete. These attention lines are not gated by drive select. The individual lines are capable of generating the controller interrupt when the associated attention interrupt mask bit is set.

*Bits 12 through 15, Attention Interrupt Mask* (*0-3*). These bits enable the assigned disk drive to interrupt. The TILINE interrupt will be set when the attention interrupt mask is on, the associated disk attention line is returned by the disk drive, and the controller is idle. Software may disable the interrupt source by resetting the attention line(s) by performing a Read Data, Write Data, or Unformatted Read operation. The attention line is turned off when the disk accepts a read enable signal from the controller.

**3.5.2 FORMAT AND COMMAND, CONTROL WORD 1.** Control word 1 is used for format and disk commands and surface selection. The bits of this control word are shown in Figure 3-3 and defined as follows:

*Bits 0 and 1.* Bits 0 and 1 are not used, so they should be set to zero.

**NOTE**

Bits 2 and 3 of this control word use an offset strobe to recover data that may be marginal.

*Bit 2, Strobe Early (SE).* When this bit is set to logic one, the controller sets the strobe early bit in the disk control word, causing the data strobe to be advanced. This bit is used with the Read Data and the Unformatted Read commands in an attempt to recover data that yields errors when read with a nominal strobe setting.

*Bit 3, Strobe Late (SL).* When bit 3 is set to logic one, the controller sets the strobe late bit in the disk control word, causing the data strobe to be retarded. This bit is used with the Read Data and the Unformatted Read commands in an attempt to recover data that yields errors when read with a nominal strobe setting.

*Bit 4, Transfer Inhibit (TIH).* When bit 4 is set to logic one, the controller will not transfer any disk words into memory when a Read Data command is specified. The purpose of this bit is to allow data verification by relying on the cyclic redundancy character (CRC) check without having to provide a buffer in memory for the specified block. After the Read Data command is completed, this bit will be reset by the controller.

*Bits 5, 6 and 7, Disk Commands.* These three bits are used to make up any one of the eight different commands that are illustrated in Figure 3-1. These bits are listed in Table 3-1 and are described briefly in the following:

**NOTE**

Details of the contents, format, and programming procedures for the disk commands are given later in this section. Refer to paragraph 3.5.9 and subparagraphs thereof.

- Store Registers (000) — Used to ascertain which disk drive is connected to the controller and to establish parameters for that particular disk.
- Write Format (001) — Used for formatting or reformatting a single track.
- Read Data (010) — Reads formatted data from the disk and transfers the data to the specified TILINE address.
- Write Data (011) — Transfers data from a TILINE address and controls the formatted data being written on the disk.

- Unformatted Read (100) — Reads data from the disk without regard to record ID or record boundaries and transfers the data to the specified TILINE address.
- Unformattted Write (101) — Transfers data from a TILINE address and writes the data on the disk without regard to record boundaries.
- Seek (110) — Positions the read/write head over the cylinder specified by the cylinder address.
- Restore (111) — Positions the head over cylinder 0.

**NOTE**

Bits 8 (OS) and 9 (OSF) are used for Read commands only and will be automatically reset by the controller if issued with a write command.

*Bit 8, Head Offset (OS).* When bit 8 is set to logic one for a Read Data command, the disk drive is placed in the offset mode. The purpose of this mode is to facilitate the recovery of marginal data. When either Read command with head offset (OS) is specified and the controller encounters the end of cylinder (EC) disk status (control word 0) with a nonzero transfer word count, then the controller terminates with a unit error (UE) controller status (control word 7). Bit 8 is automatically cleared by the controller before a Write Data, Write Format, or Unformatted Write command is executed.

*Bit 9, Head Offset Forward (OSF).* When bit 9 is logic one, bit 8 is logic one, and either Read Data or Unformatted Read is specified, then the disk drive head is offset *toward* the spindle. When bit 9 is logic zero, bit 8 is logic one, and either Read Data or Unformatted Read is specified, then the disk drive head is offset *away* from the spindle. Bit 9 is automatically cleared by the controller if a Write Data, Write Format, or Unformatted Write is specified.

*Bits 10 through 15, Head Address.* The field consisting of bits 10 through 15 selects one of the read/write heads. The valid range of the DS25 and DS50 disk drives is >00 through >04.

| 0 | 1 | 2 | 3 | 4 | 5 | 8 | 9 | 10 15 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | SE | SL | TIH | DISK COMMANDS | OS | OSF | HEAD/SURFACE ADDRESS |

(A)133993A

**Figure 3-3. Format and Command Bits, Control Word 1**

**Table 3-1. Disk Command Bits**

| Bits 5 6 7 | Command |
|---|---|
| 0 0 0 | Store Registers |
| 0 0 1 | Write Format |
| 0 1 0 | Read Data |
| 0 1 1 | Write Data |
| 1 0 0 | Unformatted Read |
| 1 0 1 | Unformatted Write |
| 1 1 0 | Seek |
| 1 1 1 | Restore |

**3.5.3 SECTOR, CONTROL WORD 2.** Control word 2 is used for a determination of the number of sectors per record and the address of the sector. The bits of this control word are shown in Figure 3-4 and defined as follows:

*Bits 0 through 7, Sectors per Record.* A disk can be formatted into variable length data records with a fixed number of sectors per record for a given track. The number of sectors per record multiplied by the number of records per track will not exceed the fixed number of sectors per track of a particular disk drive. Format calculations are given in paragraph 3.6.1.

*Bits 8 through 15, Starting Sector Address.* This field selects the sector number at which the controller will start a read or write operation. The controller adds the sectors per record parameter to the starting sector address to calculate the address of subsequent data records on a track, when multiple records are transferred. The range of sector addresses is >00 to >25.

**NOTE**

If the sectors per record for a track do not equal one, then the programmer must be sure that sector addresses that correspond to record boundaries are used.

A starting sector address larger than the maximum sector address will result in a TILINE timeout (TT) status because the controller will not find a starting sector address at which to start executing the command.

| 0 — 7 | 8 — 15 |
|---|---|
| SECTORS/RECORD | STARTING SECTOR ADDRESS |

(A)133994A

**Figure 3-4. Sector Bits, Control Word 2**

**3.5.4 CYLINDER, CONTROL WORD 3.** The cylinder address is selected by bits 0 through 15 of control word 3 (see Figure 3-5). The valid number ranges are:

DS25 >0000 — >0197

DS50 >0000 — >032E

An invalid cylinder address will result in a termination and unit error (UE) controller status (control word 7) being set. The disk status (control word 0) will indicate unsafe (US) status.

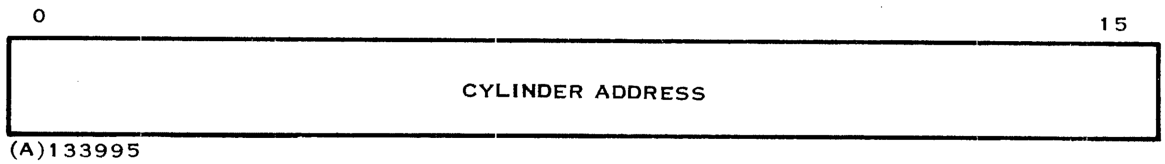



**Figure 3-5. Cylinder Bits, Control Word 3**

**3.5.5 WORD COUNT, CONTROL WORD 4.** The word count is controlled by control word 4 (see Figure 3-6). For all four Data commands, this field selects the number of 16-bit data words which will be transferred between the disk and the TILINE. The number of words is limited by the available TILINE memory and the disk memory from the starting disk address to the last sector of the last track. An attempt to transfer from a nonexistent TILINE memory will result in a TILINE time-out (TT) status (control word 7) for the controller. For a Write Format command, this field specifies the record word count.

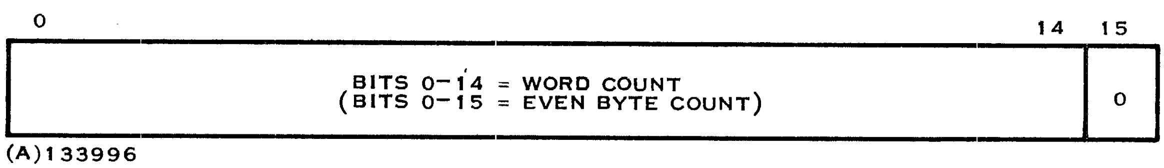



**Figure 3-6. Word Count Bits, Control Word 4**

**3.5.6 LSB MEMORY ADDRESS, CONTROL WORD 5.** The LSB memory address is determined by control word 5 (see Figure 3-7). By the use of this control word, the software selects the 15 least significant bits (LSB) of the TILINE memory address for the starting address of a data transfer. The controller fetches or stores data through the TILINE bus at sequential addresses until the word count decrements to zero. The central processing unit (CPU) byte selection bit (bit 15) is ignored by the controller.

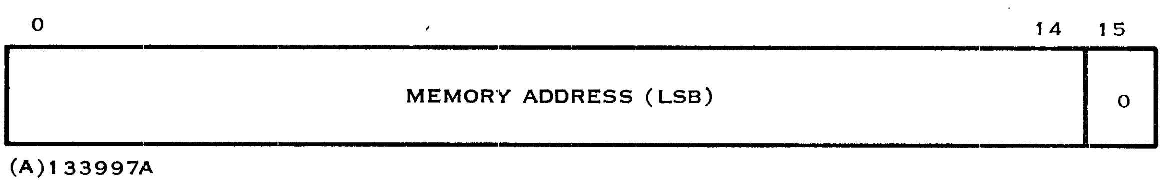



**Figure 3-7. LSB Memory Address Bits, Control Word 5**

**3.5.7 DRIVE SELECT AND MSB MEMORY ADDRESS, CONTROL WORD 6.** The drive select and MSB memory address are controlled by control word 6, (see Figure 3-8). (Bits 0 through 3 and 8 through 10 of this field are not used.)

*Bits 4 through 7, Drive Select.* The value of the drive select field is used to select one of four disk drives attached to the disk controller. Only one disk drive may be selected at a time, as follows:

Bit 4 — Disk Drive 0

Bit 5 — Disk Drive 1

Bit 6 — Disk Drive 2

Bit 7 — Disk Drive 3

*Bits 11 through 15, Memory Address (MSB).* This field selects the five most significant bits of the TILINE memory address. These 5 bits are concatenated to the 15 LSB memory address bits of control word 5 to complete the 20-bit TILINE address.

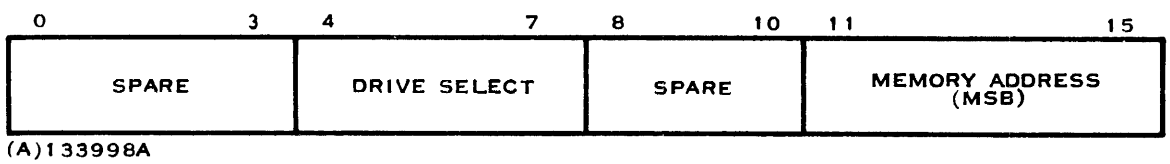



**Figure 3-8. Drive Select and MSB Memory Address Bits, Control Word 6**

**3.5.8 CONTROLLER STATUS, CONTROL WORD 7.** The controller status field, shown in Figure 3-9, is utilized to provide error information and controller status information to the TILINE. Bits 0 through 4 are used primarily to report controller completion and error information, whereas bits 7 through 15 are used to convey the error status information about the controller. The individual bits and their functions are described in the following.

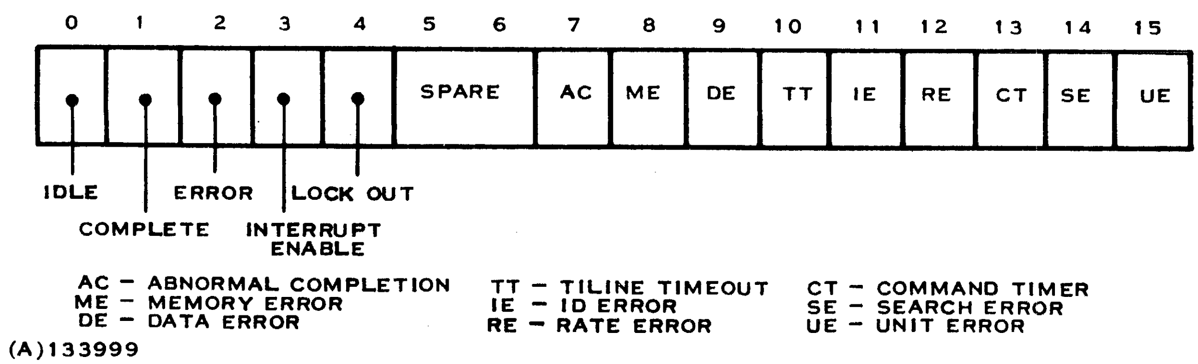



**Figure 3-9. Controller Status Bits, Control Word 7**

*Bit 0, Idle.* Bit 0 of this field is logic zero when the controller is busy (performing a sequence, etc.). The software clears bit 0 to activate the disk controller to start execution of the command bits (bits 5 through 7) of control word 1. When a command is successfully completed, or terminated because of an error condition, the disk controller sets bit 0 to logic one. At the same time, the controller sets bit 1 of this field for a successful completion, or sets bit 2 if the operation is terminated as the result of an error condition.

*Bit 1, Complete.* Bit 1 is set when a command is completed without encountering an error. The bit may be reset by the software when servicing the interrupt.

*Bit 2, Error.* Bit 2 is set by the controller when an operation is terminated as the result of an error condition. This bit may be reset by the software when servicing the interrupt or the status that was generated.

*Bit 3, Interrupt Enable.* Bit 3 enables the controller interrupt when the complete bit (bit 1) or the error bit (bit 2) is on. This interrupt enable does not affect the drive attention interrupts which are controlled by the attention mask of control word 0.

*Bit 4, Lock Out.* Bit 4 is set to a logic one by the controller when control word 7 is read while the controller is idle. This bit is intended for use with multiprocessor systems.

*Bits 5 and 6 are not used.*

*Bits 7 through 15, Controller Status.* Bits 7 through 15 of control word 7 are controller status bits that represent the status of the controller after a command has been executed. The bits contain valid information when the error bit (bit 2) is on.

*Bit 7, Abnormal Completion* (*AC*). Bit 7 is set if a disk operation is terminated because an I/O Reset, Power Failure Warning, or Master Power Reset is detected on the TILINE. (This bit is set when the disk is powered-up.)

*Bit 8, Memory Error* (*ME*). This bit will be set after completion of one of three disk commands: Write Data, Write Format, or Unformatted Write, when it has been determined that a memory error occurred during the time that data was being transferred from the TILINE to the disk controller. (This is normally a parity error.)

*Bit 9, Data Error* (*DE*). This bit will be set during either a Read operation if any of the calculated check characters did not match the check character read from the disk data record(s) or ID words. This means the CRC did not compare because of a parity error on the disk. All data transfer operations are terminated after a DE is encountered.

*Bit 10, TILINE Timeout* (*TT*). This bit will be set if the controller addresses a nonexistent memory address. TT causes command termination. The timeout period is $10 \pm 2$ microseconds from the time TILINE Go (TLGO—) is generated.

*Bit 11, ID Error* (*IE*). This bit will be set when an ID word comparison error occurs during the ID verification of a Read Data or Write Data command. Verification includes comparison of ID words 1 and 2 and CRC checking. If bit 9 is also set, it indicates that the CRC for ID words preceding the data was not good. IE causes command termination.

*Bit 12, Rate Error (RE).* This bit will be set when a timing error is encountered in the transfer of data between the TILINE master control and the disk interface. Two examples of timing errors follow:

1. During either Read operation, the disk interface exceeds the capacity of the data buffer. The buffer remains full when the controller does not transfer the previous word across the TILINE before the next word is assembled.

2. During either Write operation the disk interface empties the data buffer before completing the writing of a data sector.

*Bit 13, Command Timer (CT).* This bit will be set when the 100 ± 20 millisecond command timer expires before an operation is completed. The timer acts as a dead-man timer which is reset when a Seek operation is executed, a head address is set or incremented, the controller is in the idle condition, or disk sequence is being executed.

*Bit 14, Search Error (SE).* Bit 14 will be set when the controller does not detet a sync character (>19) within one physical sector while attempting to read from the disk.

*Bit 15, Unit Error (UE).* The unit error status bit (bit 15) will be set when an operation is terminated because of a disk drive error. The disk status register can be examined by software to determine the cause of the UE. The following may cause a UE:

1. Drive not ready.
2. Drive off-line.
3. Drive unsafe.
4. Seek incomplete.
5. Write operation is attempted on write-protected drive.

**3.5.9 DISK COMMANDS.** As previously explained, disk commands are specified by bits 5, 6, and 7 of control word 1. The values of these bits provide the eight disk commands listed in Figure 3-10. These disk commands are described in the following paragraphs.

| 0 1 | 2 | 3 | 4 | 5 7 | 8 | 9 | 10 15 |
|---|---|---|---|---|---|---|---|
| SPARE | SE | SL | TIH | DISK COMMANDS | OS | OSF | HEAD ADDRESS |

| 5 | 6 | 7 | |
|---|---|---|---|
| 0 | 0 | 0 | STORE REGISTERS |
| 0 | 0 | 1 | WRITE FORMAT |
| 0 | 1 | 0 | READ DATA |
| 0 | 1 | 1 | WRITE DATA |
| 1 | 0 | 0 | UNFORMATTED READ |
| 1 | 0 | 1 | UNFORMATTED WRITE |
| 1 | 1 | 0 | SEEK |
| 1 | 1 | 1 | RESTORE |

(A)134000A

**Figure 3-10. Command Format**

**3.5.9.1 Store Registers Command.** The Store Registers command causes the controller to store up to three words starting at the specified TILINE address. As shown in Figure 3-11, the contents of the three words will contain the following information:

*Word 1* — This word contains the total number formatted words that can be recorded on a disk track. The number is $5472_{10} = 1560_{16}$.

*Word 2* — This word contains the sectors per track and the number of bytes of overhead per record parameters to be used in the calculations of the format parameters. Bits 8 through 15 of this word specify the overhead per record, and this number is equal to zero ($00_{16}$) for the DS25 and DS50 disk drive. Bits 0 through 7 of this word specify the number of sectors per track, which is $38_{10} = 26_{16}$.

*Word 3* — This word contains the number of tracks per cylinder and the number of cylinders per drive as follows:

| Item | Bits | Model DS25 | Model DS50 |
|---|---|---|---|
| Tracks/cylinder | 0 — 4 | $5_{10} = 05_{16}$ | $5_{10} = 05_{16}$ |
| Cylinders/drive | 5 — 15 | $408_{10} = 198_{16}$ | $815_{10} = 32F_{16}$ |
| Composite | 0 — 15 | $2998_{16}$ | $2B2F_{16}$ |

An example of list words for a Store Registers command is given in Table 3-2.

**3.5.9.2 Write Format Command.**The Write Format command is used for formatting a new disk media or for reformatting an existing media. One complete track is formatted per command. An example of a Write Format command is given in Table 3-3.

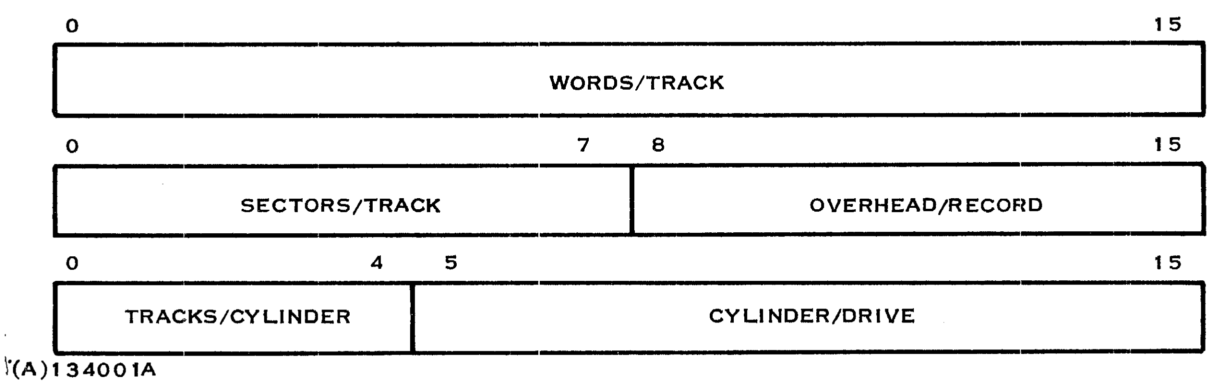



**Figure 3-11. Store Registers Data Format**

**Table 3-2. Example of List Words in Store Registers Command**

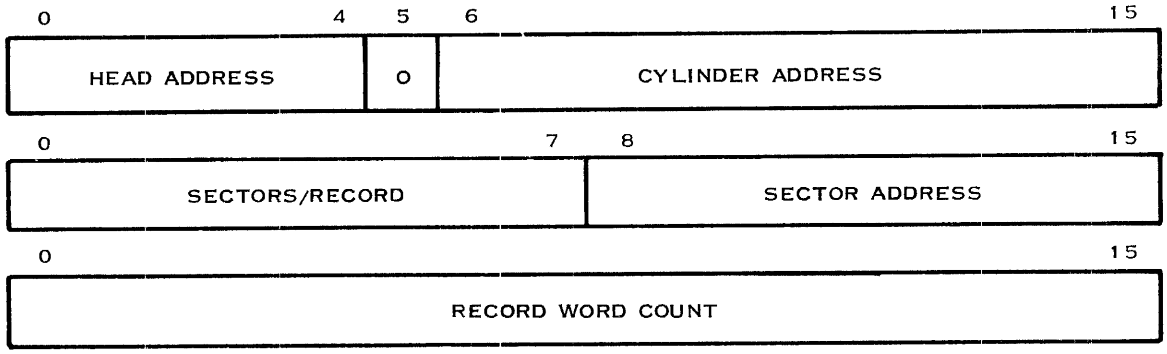
| Word | Data | Comments |
|---|---|---|
| 0 | 0000 | Clears the disk status |
| 1 | 0000 | Command |
| 2 | 0000 | Not used |
| 3 | 0000 | Not used |
| 4 | 0006 | Three words |
| 5 | 1000 | Put three words into memory starting at TILINE address >00800 |
| 6 | 0800 | Drive 0[1] |
| 7 | 0800 | Set lockout. Reset idle and all status bits |

Note:
[1]A drive does not have to be selected, but if no drive is selected, the disk status after the command is complete will have the not ready and off-line status bits set.

**Table 3-3. Example of Write Format Command**

| Word | Data | Comments |
|---|---|---|
| 0 | 0000 | |
| 1 | 0101 | The command is in bits 5 through 7; the surface address equals 1. |
| 2 | 0300 | The record will be three sectors long. The sector address is not used. |
| 3 | 00CA | Cylinder address selected is >CA |
| 4 | 0360 | Word count = Maximum for 3 sectors per record |
| 5 | 1000 | Memory address |
| 6 | 0800 | Drive 0 |
| 7 | 1800 | Use interrupts and leave lockout set. |

After initialization, the controller checks for unit errors by examining the disk status (off-line, not ready, unsafe, write protect, or seek incomplete), seeks the specified cylinder, and sets the specified head address. The controller assembles the ID words from its internal registers and counters and records the word(s) on the disk at the specified disk track address as shown in Figure 3-12. The controller records the data field following the ID words with the data word in the specified TILINE address repeated for all data word positions. The controller formats each sector on the track with ID words, data, and the required gaps. Each sector has a maximum physical data field of 144 words. All sectors have ID words written. The value for the record word count (ID word 3) is specified by control word 4.




(A)134002A

**Figure 3-12. Header Data Format**

**3.5.9.3 Read Data Command.** The Read Data command specifies the number of 16-bit words that will be transferred from the specified disk address to the specified TILINE addresses. An example of a Read Data command is given in Table 3-4.

After initialization, the controller checks for unit errors by examining disk status (off-line, not ready, unsafe, seek incomplete), seeks the specified cylinder, sets the specified head address, reads the ID words for the first sector that passes under the read head, verifies the contents of ID words 1 and 2, stores the contents of ID word 3, verifies the CRC character following the ID words, waits for the correct starting sector, and then starts assembling 16-bit words from the data fields and transferring them to the specified TILINE addresses, if transfer inhibit is not specified. The CRC character for both the ID field and data field is verified for sectors from which data is being transferred.

A failure to verify an ID word results in an ID error status (bit 11) and termination of the Read Data operation. If the CRC is incorrect for the ID field from which data is being read, data error status (bit 9) is also set. When the controller encounters the end of a record but the remaining transfer word count is nonzero, the controller automatically continues reading data on the next sequential record of the track, if it exists.

When the remaining transfer word count is zero but the controller has not encountered the end of a record, then the controller discontinues transmitting data words across the TILINE but continues to read data from the disk until the end of record is encountered so that the CRC character(s) can be checked before loading status.

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, reads the ID words for the first sector to pass under the read head, verifies the contents of ID words 1 and 2, stores the contents of ID word 3, verifies the CRC character following the ID words, waits for sector zero, and continues to read words from the disk and transfer them to the TILINE, if transfer inhibit is not specified.

When the controller encounters the end of a cylinder, and the remaining transfer word count is nonzero, and head offset is not specified, the controller automatically seeks the next cylinder, selects head address zero for the new track, reads the ID words for the first sector to pass under the read head, verifies the contents of ID words 1 and 2, stores the contents of ID word 3, verifies the CRC character following the ID words, waits for sector zero and continues to read words from the disk and transfer them to the TILINE if transfer inhibit is not specified. If the end of cylinder occurs, and the remaining word count is nonzero, and head offset is specified, the operation will terminate with unit error and the resultant unit error will be the end of cylinder.

Table 3-4. Example of Read Data Command

| Word | Data | Comments |
|---|---|---|
| 0 | 0000 | Clear the disk status |
| 1 | 0200 | Read surface 0 |
| 2 | 0300 | Three sectors per record, starting at sector 0[1] |
| 3 | 0000 | Cylinder 0 |
| 4 | 2000 | 1000 words |
| 5 | 0000 | TILINE memory address = >F8000 |
| 6 | 021F | Drive 2 |
| 7 | 0 | Interrupts and lockout not used |

Note:
[1]In this example, the format of all of the tracks read must be three sectors per record or an error will be flagged.

**3.5.9.4 Write Data Command.** For a Write Data command the controller transfers the number of specified 16-bit words from the specified TILINE addresses to the specified disk addresses. After initialization, the controller checks for unit errors by examining disk status (off-line, not ready, unsafe, write protect, or seek incomplete), seeks the specified cylinder, sets the specified head address, reads the ID words from the first sector that passes under the heads, verifies ID words 1 and 2, stores the contents of ID word 3, and verifies the CRC character following the ID words. If the ID words compare, the controller waits for the correct starting sector to pass under the heads, and then starts writing data on the disk. If the ID words fail to compare, the operation is terminated with an ID status error.

Data is written on the disk until the specified number of words have been transferred unless a terminate condition is encountered. When the number of words per record is greater than the words per sector, the controller continues to the next sequential sector. When the number of words to be transferred is greater than the number of words per record, the controller continues to the next sequential record. The next sequential record starts at the sector number whose value is equal to the beginning sector number of the last record plus the number of sectors per record.

When the transfer word count is less than the record word count, the controller fills the remainder of the record with zeros until the record word count has been decremented to zero.

The controller assembles the ID words from its internal registers and records the words on the disk at the specified sector address. A CRC character that pertains to the ID words is recorded on the disk. The data words are then written on the disk. After the last data word of the sector is written, the controller records the CRC character that pertains to the data. ID words are written for each sector on the disk.

When the controller encounters the end of a track for a cylinder and the remaining transfer word count is nonzero, the controller automatically increments the head address to the next track, starts reading the ID words of the first sector that passes under the head, verifies the contents of ID words 1 and 2, stores the contents of ID word 3, verifies the CRC character following the ID words, and continues the Write Data operation at sector zero.

When the controller encounters the end of a cylinder, and the remaining transfer word count is nonzero, the controller automatically seeks the next cylinder, selects head address zero for the new track, starts reading the first sector that passes under the heads, verifies the ID words and continues the write operation at sector zero.

**3.5.9.5 Unformatted Read Command.** Starting at the specified disk address, an Unformatted Read command transfers the specified number of 16-bit words from the disk to the specified TILINE addresses. The Unformatted Read command is used primarily for diagnostics and does not pay attention to sector boundaries. An example of an Unformatted Read command and the data received from the command is given in Table 3-5.

After initialization, the controller checks for unit errors by examining the disk status (off-line, not ready, unsafe, or seek incomplete), seeks the proper cylinder, sets the specified head address, and starts transferring data to the TILINE after the sync of the specified sector address is detected. The controller continues to read all consecutive information, without regard to end of record or end of track boundaries, until the specified number of words has been transferred or until a termination condition is encountered. A check for the CRC is performed at the end of the operation, and a data error status is reported if the CRC is not correct. This allows for error detection after the ID words if three words are specified in the word count.

**Table 3-5. Example of Unformatted Read Command**

| Word | Data | Comments |
|---|---|---|
| 0 | 0000 | |
| 1 | 0400 | Unformatted Read |
| 2 | 0001 | Sector per record not used, starting sector address = 1 |
| 3 | 0000 | Cylinder 0 |
| 4 | 0008 | 4 words |
| 5 | 1000 | TILINE memory address = >00800 |
| 6 | 0400 | Drive 1 |
| 7 | 1800 | Controller interrupts and lockout used |

**Data Received from Unformatted Read Command**

| Word | Data | Comments |
|---|---|---|
| 0 | 0000 | Track 0 |
| 1 | 0101 | Sectors per record = 1, starting sector address = 1 |
| 2 | 0002 | 4 bytes, 2 words per sector |
| 3 | 5F5F | CRC |

**3.5.9.6 Unformatted Write Command.** An Unformatted Write command transfers the 16-bit words from the specified TILINE address to the specified disk address. Basically, the controller locates the proper sector and writes the specified bytes.

After initialization, the controller seeks the specified cylinder, sets the specified head address, and starts writing data on the disk after the sector mark of the specified sector address is detected and the correct lead gap has been generated. The controller continues to write all consecutive information without regard to existing record boundaries until the specified number of words have been transferred or until a termination condition is encountered. The controller adds a sync character to the beginning of the data and a CRC character at the end.

**3.5.9.7 Seek Command.** The Seek command performs an independent Seek operation. An example of a Seek command is given in Table 3-6.

The Seek command positions the head of the selected drive over the cylinder that is specified by control word 3. After the controller determines that no unit errors are present by interrogating the disk status (off-line, not ready, unsafe, or seek incomplete), the controller initiates the Seek operation. After the disk drive starts seeking, the controller loads complete status and terminates. Seek complete is determined by either monitoring the attention lines or by enabling the attention interrupt mask in control word 0. If disk status errors are encountered prior to initiating a Seek operation, the controller unit error and error status bits are set and the controller terminates. The disk status that caused the termination can be found in control word 0.

**3.5.9.8 Restore Command.** The Restore command is basically a follow-up on an unsafe condition at the disk drive. The Restore command is required if a seek incomplete disk status is detected by the software or if an unsafe disk status occurs. The Restore command positions the heads of the selected unit over cylinder zero. Before initiating the restore operation, the controller determines if a unit error exists by examining the off-line disk status. After the controller initiates the Restore command, complete status is loaded into controller status. Restore complete is determined by either monitoring the attention line or by enabling the attention interrupt in the disk status control word 0. If a unit error is encountered before the Restore command is initiated, then the unit error status is loaded into control word 7.

**Table 3-6. Example of Seek Command**

| Word | Data | Comments |
|---|---|---|
| 0 | 0001 | Enable interrupts for drive 3 |
| 1 | 0600 | Seek surface is not used |
| 2 | 0000 | Sector per record and starting sector address not used |
| 3 | 0003 | Cylinder 3 |
| 4 | 0000 | Word count not used |
| 5 | 0000 | Memory address not used |
| 6 | 0100 | Drive 3 |
| 7 | 1800 | Controller interrupts and lockout used |

## 3.6 FORMATS AND DEFINITIONS

This paragraph gives the formats of the data written on the disk surfaces in a pack and a definition of hardware and firmware terms as related to software programming.

### 3.6.1 DEFINTIONS OF TERMS.

*Disk Pack* — A disk pack consists of five disks mounted on a hub. Refer to Figure 3-13. The top and bottom disks serve only as protective covers. The three inner disks provide five data-recording surfaces and one servo surface.

*Servo Head and Surface* — The prerecorded servo surface is read continuously by the servo head when the heads are loaded. Signals from the servo surfaces are processed by the disk drive to provide reference for:

- Detecting guard bands and recording zones on the disk recording surfaces.
- Positioning and spacing the data tracks on the recording surfaces.
- Generating track-crossing clocks for positive track location during Seek operations.
- Detecting on-track null points and off-track error signals.
- Detecting start-of-track index markers.

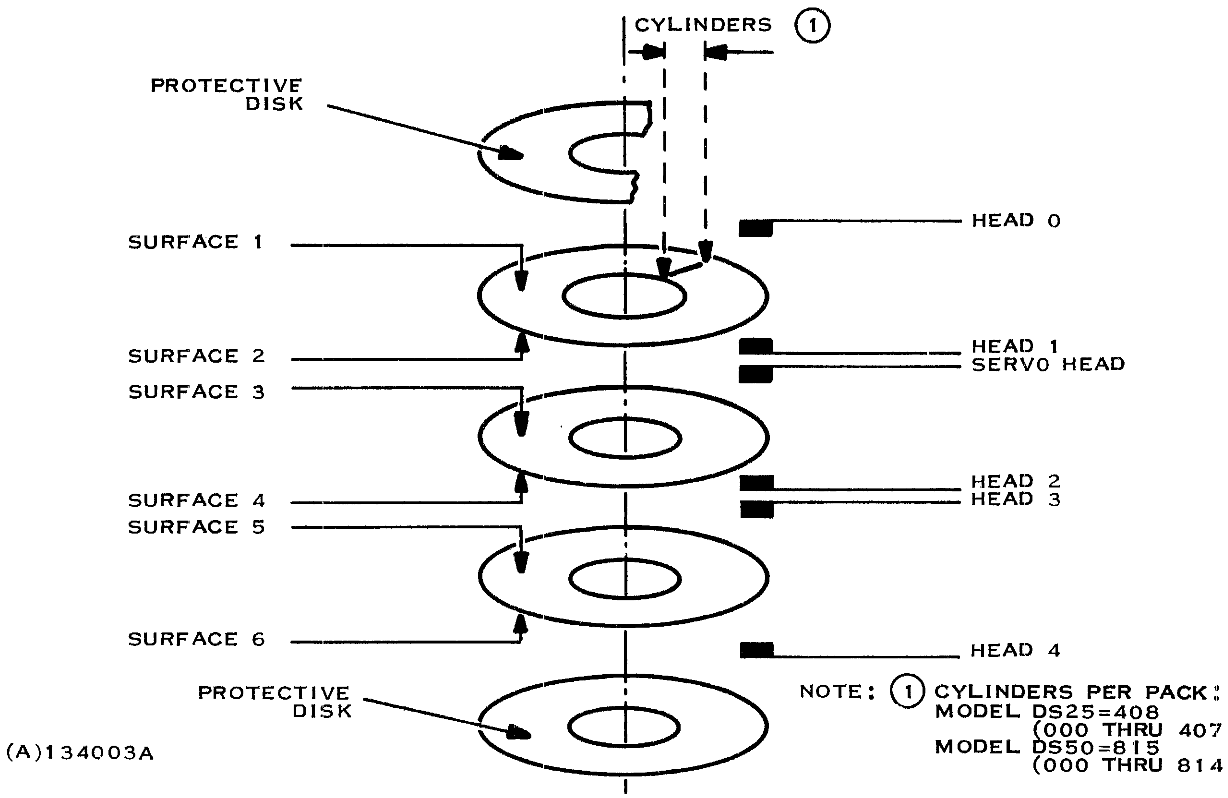



**Figure 3-13. Head and Surface Configuration in Disk Pack**

*Read/Write Heads* — The five read/write heads (0 through 4) are mechanically locked to the servo head via the carriage assembly and fly on an air boundary in close proximity to the recording surface, so the heads never actually contact the rotating disk surfaces in normal operation.

*Disk Recording Surfaces* — There are five data recording surfaces in a disk pack; the recording zone on each surface consists of a maximum of 815 cylinders for the DS50 drive and 408 cylinders for the DS25 drive. The relationship between the data recording tracks and the servo tracks is shown in Figure 3-14.

*Recording Tracks* — A track consists of the recording area on a disk starting at an index mark and ending at the next index mark (in time). The track is subdivided by sector marks generated by the disk drive. Sector 0 starts at the first sector mark that occurs after the time of the index mark. The timing relationship between index and sector marks is shown in Figure 3-15.

In order to accomplish the data transfer rates of the disk drive, the sectors are interlaced, which means that the physical sectors are not numbered consecutively. As an example, if the controller has finished its transfer of data at sector 0, then sector 1 is found at the *second* sector mark following sector 0, instead of being located at the *next* sector mark following sector 0.

All of the tracks on a disk surface delineate cylinders that may be used for data recording. The DS50 disk drive utilizes all 815 (000 through 814) cylinders, whereas, the DS25 disk drive uses only the even-numbered cylinders (000, 002, 004 .... 814) which are numbered 000 to 407. Refer to Figure 3-13.

*Data Word* — A data word on the disk is 16 bits long. The number of data words in a record is selectable by the programmer up to a maximum number. To find the maximum number of words in one record use the following formula:

$$\text{Maximum words/record} = \frac{\text{Total words/track - [(Number records/track) X overhead]}}{\text{Number records/track}}$$

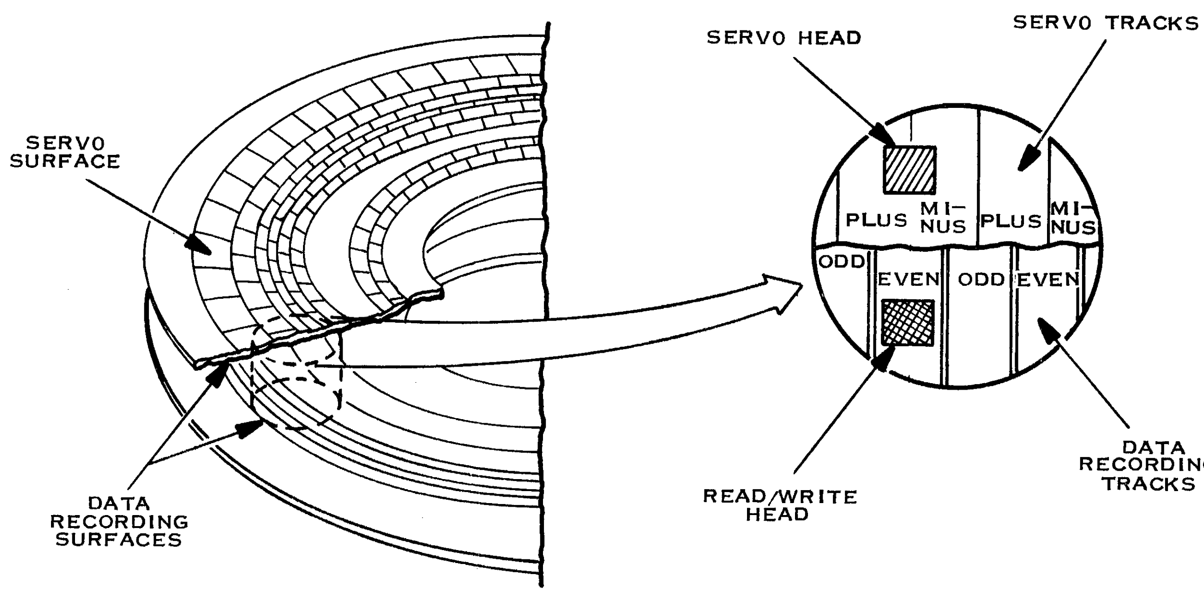



**Figure 3-14. Disk Servo and Recording Surfaces**

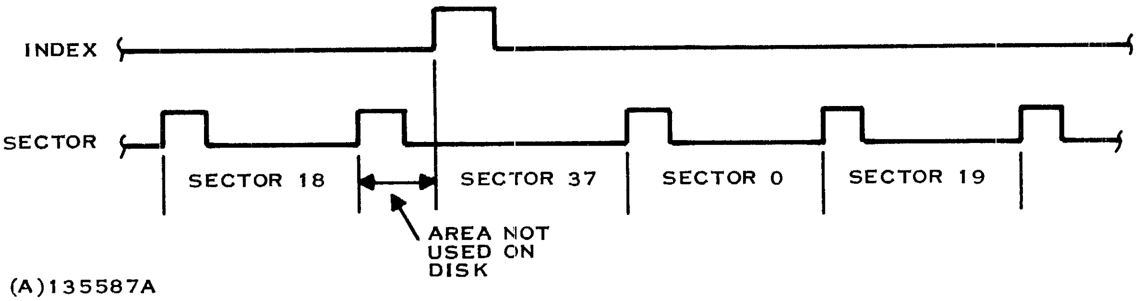



**Figure 3-15. Timing Relationship Between Index and Sector Marks**

*Sector* — Each track is divided into 38 sectors. The format of data recorded on a track consists of sectors of equal length which are separated by gaps. Gaps are automatically inserted by the controller to ensure reliable data recovery at each sector address over the range of operating temperatures and from recorded media exchanged between disk systems of the same type.

**NOTE**

This controller uses fixed length sectors which will not allow data to be written across sector gaps; therefore the effective overhead is zero, indicating that there is no gain in efficiency when logically writing over sector boundaries.

The sector format parameters interrelate according to the following formula:

$$S = \frac{W}{X+O}$$

S = Sectors per track ($38_{10}$)
X = Data words per sector ($144_{10}$ max.)
O = Overhead words per sector (zero for DS25/DS50 disk drives)
W = Unformatted words per track ($5472_{10}$)

$$Y = \frac{R+O}{U} = \frac{R}{144}$$

Y = Number sectors per record
R = Number words per record
O = Overhead words per record (zero)
U = Unformatted words per sector ($144_{10}$)

**3.6.2 SECTOR FORMAT.** A sector is a continuous recorded bit stream on a disk track which starts at a unique sector mark. A sector contains the fields shown in Figure 3-16. These fields are described in the following paragraphs.

**3.6.2.1 Gap 1.** This field of continuous logic zeros is used to compensate for late sector mark variations and to allow sufficient time for the data separator to lock-in before the sync character is encountered. The size of gap 1, expressed in both bytes and time, is 38 bytes and 48 microseconds.

**3.6.2.2 Sync (Synchronization Character).** The disk controller uses the sync character to determine the start of intelligible data from the disk drive. After detecting the sync character, the bits in the data stream that follow the sync character are grouped into words for controller processing. The sync character is >19 (binary 00011001).

(1)

| GAP 1 (2) | SYNC (3) | ID (4) | E D C 1 (5) | DATA (6) | E D C 2 (7) | GAP 2 (8) |
|---|---|---|---|---|---|---|

NOTES

(1) A SECTOR MARK OCCURS AT THE BEGINNING OF EACH SECTOR.

(2) GAP 1 IS ALL ZEROES.

(3) THE SYNC CHARACTER THAT BEGINS THE DATA STREAM IS $19_{16}$.

(4) THE THREE ID WORDS DEFINE:

A. HEAD ADDRESS AND CYLINDER ADDRESS
B. SECTORS PER RECORD AND SECTOR ADDRESS
C. RECORD WORD COUNT

(5) THE ERROR DETECTION CODE (EDC) IS VERIFIED BY THE CYCLIC REDUNDANCY CHARACTER (CRC) GENERATED IN THE CONTROLLER.

(6) THE DATA CONSISTS OF 16-BIT WORDS UP TO A MAXIMUM OF 144 WORDS.

(7) AN EDC CHECK IS PERFORMED AFTER THE DATA IS TRANSFERRED.

(8) GAP 2 IS NOT WRITTEN ON THE DISK AND IS USED TO PREVENT DATA LOSS IN CASE OF AN EARLY SECTOR MARK WHEN A WRITE OPERATION IS BEING EXECUTED.

(A)134006A

**Figure 3-16. Format of a Sector Record Bit Stream**

**3.6.2.3 ID (Identification) Words.** The three ID words are used by the controller to perform a check on the addressing and positioning mechansim of the disk drive. The controller automatically generates the words for Write Data commands. The words are checked against controller hardware registers after an initial track is located or after an automatic track increment occurs for a Write Data or Read Data operation. The ID words are formatted as follows:

ID WORD NO. 1

| 0 – 4 | 5 | 6 – 15 |
|---|---|---|
| HEAD ADDRESS | 0 | CYLINDER ADDRESS |

(A)134007

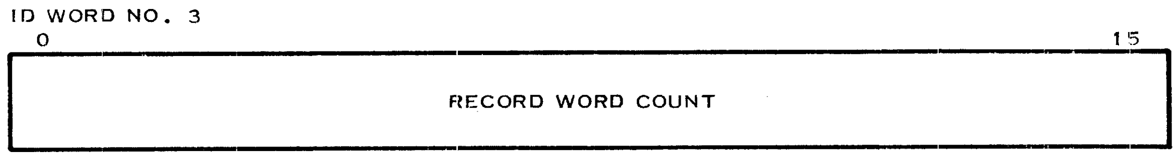
*ID Word No. 1* defines the track address. Bits 0 through 4 constitute the head address. Bit 5 is zero. Bits 6 through 15 constitute the cylinder address.

ID WORD NO. 2

| 0 – 7 | 8 – 15 |
|---|---|
| SECTORS/RECORD | SECTOR ADDRESS |

(A)134008A

*ID Word No. 2* designates the number of sectors allocated per physical data record on this track. The sector address is the sector number within the track where this ID is recorded. This ID word is used to ensure that the controller's sector counter is in sync with the selected disk drive.




(A)134009

*ID Word No. 3* is the record word count that defines the size of the record which may include one or more sectors. All records on a track are the same length. The Write Format command ensures this condition by formatting one track per command. The word count of the ID word is stored in the controller to define the end of the data record during data transfers.

**3.6.2.4 Error Detection Code (EDC) Number 1.** This word is 16 bits of information generated by passing the three ID words through the CRC generator.

**3.6.2.5 Data.** The data field is a group of 16-bit words of information from the computer, up to a maximum of 144 words for each sector.

**3.6.2.6 Error Detection Code (EDC) Number 2.** This word is 16 bits of information generated by the controller by passing the data field through the CRC generator.

**3.6.2.7 Gap 2.** Gap 2 is a field where nothing is written, used to compensate for early sector mark variations. The size of gap 2 expressed in both bytes and time is 12 bytes and 15 microseconds.

# SECTION 4

# OPERATION

## 4.1 GENERAL

This section explains the front panel controls and indicators that are available to the operator for placing the disk drive in a normal operating configuration. Normally, the disk drive is operated on-line and controlled by the 990 computer and the software operating system, or operated under the direction of a diagnostic test program. Therefore, operator intervention and the manipulation of controls for on-line operation are minimal.

**NOTE**

For a multiple disk drive system, the drives must be powered-up one at a time in sequence because of the high power consumption when the spindle is coming up to speed. Refer to the end of this section for power sequencing information.

Operator front panel controls and indicators are illustrated in Figure 4-1 and described in Table 4-1.

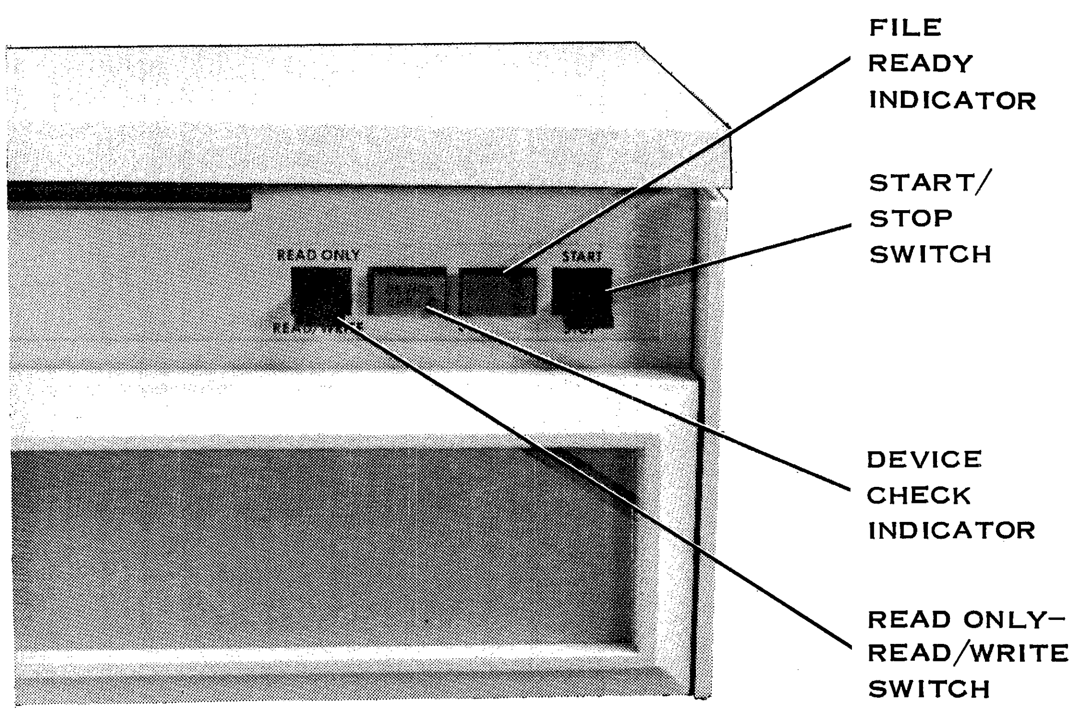



**Figure 4-1. Front Panel Controls and Indicators**

Table 4-1. Operator Controls and Indicators

| Control | Description |
| --- | --- |
| READ ONLY-READ/WRITE Switch | Two-position toggle switch that provides disk pack file protection. READ ONLY position inhibits write commands from writing on pack (an operational Device Check). READ/WRITE position enables both data-read and data-write operations to be performed. Any changes in the state of this switch are ignored if the drive is selected by the controller. This is to prevent the operator from interrupting a disk write operation. The disk drive may be deselected by performing an I/O Reset or by selecting another drive. |
| DEVICE CHECK Indicator | Indicator which lights when a Device Check error has been detected by the drive and remains lit until the controller resets the Device Check error detector or until the drive is powered-down. Condition of the indicator lamp can be tested by temporarily swapping positions with the green file ready indicator lamp. The indicator may appear lit in a dark room but cannot be noticed in normal lighting. |
| File Ready Indicator | Indicator that flashes during power-up and power-down sequencing. The drive is in the Ready condition (powered-up and heads loaded) when the indicator stays lit. |
| START/STOP Switch | Two-position toggle switch that permits manual power-up and power-down sequencing. START position turns on the spindle drive motor, initiates a brush cycle, and loads the heads. (Heads will not load and a seek incomplete will result if a disk pack is not installed or an unsafe condition exists.) The STOP position retracts the heads, turns off the spindle drive motor, and activates the dynamic brake to stop the disk pack. |

## 4.2 OPERATING DISK DRIVES

**NOTE**

For manual or automatic sequencing of disk drive in a multiple drive system, refer to paragraph 4.2.2.

Normally, the disk drive system is operated on-line using the disk controller and the 990 computer system. To put the disk drive in a ready condition for normal operation, perform the following steps:

1. Verify that a disk pack is properly installed. (Refer to Section 2 for installation instructions.) Check that the air shroud is latched closed.

2. Verify that the ac line cord is installed in a compatible power outlet. Verify that the disk drive PWR ON/OFF switch on the rear of the drive is set to ON.

3. Check the position of the READ ONLY - READ/WRITE switch. It should be set to READ ONLY for file protection or set to READ/WRITE to allow writing on the disk pack.

4. Set the START/STOP switch to START. The spindle drive motor should start and indicate by sound that the speed is increasing. The green File Ready indicator should start flashing.

5. After about 20 seconds, the green File Ready indicator should stop flashing and remain lit. The DEVICE CHECK indicator should be extinguished.

**NOTE**

If the File Ready indicator continues to flash, this means the first seek operation has not been completed. In that case, set the START/STOP switch to STOP, wait for the spindle to stop rotating, and repeat step 4 to attempt a restart.

If the indications of step 5 are normal, the disk drive is ready for on-line operations under control of the computer and the software program. No further operator intervention is required unless a change of the disk pack is requested or the red DEVICE CHECK light comes on, indicating that a malfunction has occurred.

**4.2.1 CLEARING A DEVICE CHECK.** Most Device Check errors will be cleared by the operating system or the diagnostic tests via the controller when the disk drive is on-line. However, if the disk drive is being operated off-line, or the red DEVICE CHECK indicator lights when the drive is operating on-line, intervention of the operator is required. Proceed as follows:

1. Set the START/STOP switch to STOP. Wait for the green File Ready indicator to stop flashing, and then set the START/STOP switch to START.

2. If the red DEVICE CHECK indicator lights again after power-down and power-up sequencing, an equipment malfunction is indicated and maintenance action is required.

**4.2.2 SEQUENCING DISK DRIVES DURING POWER-UP.** Following a TILINE Master Reset operation, which occurs upon power-up, the disk controller will be busy for a minimum of 20 seconds before it starts sequencing the disk drives. The reason for this delay is to allow for spindle stop-time in the event of a power transient. After the 20 seconds have elapsed, the controller will sequence to the first disk drive, drive 0, and will systematically start up each drive that is connected to the system in an ascending order.

When the spindle of a disk drive starts to rotate, an initial start-up current of 30 amperes for 115-volt drives, and 13 amperes for 220-volt drives, is required. In about 20 seconds after start-up, the current will decay to essentially zero, at which time the controller sequences the next drive.

After sequencing drive 0, the controller will check if drive 1 is installed. If it is, the controller will wait 20 seconds before sequencing drive 1. If drive 1 is not installed, the controller will sequence drive 1 without delay and check if drive 2 is installed. This procedure will continue until all drives have been sequenced, allowing 20 seconds minimum between sequences of installed drives.

While the controller is in the disk sequence mode, it will be busy and will not be able to execute any commands. The sequence mode will last a minimum of 20 seconds and a maximum of 80 seconds, depending upon how many drives are installed.

If the operator wants the automatic sequencing to take place, then he must use the following procedure:

1. Turn off power to the computer system.
2. Make sure the ac line cords of all drives and components are connected to a power source.
3. Set the PWR switch on all disk drives to ON.
4. Set the START/STOP switch on all disk drives to START.
5. Apply power to the computer system.

If the operator does not choose this option of automatic sequencing, then he must perform the power-up sequence manually, using the START/STOP switch on each disk drive, and allowing a minimum of 20 seconds between successive starts.

**4.3 MAINTENANCE AIDS**

As illustrated in Section 2, the disk controller has four LEDs that indicate the status and operating condition of the disk drive system. These indicators are:

- FAULT — When the FAULT indicator lights, a microprogram type of failure has occurred and the controller must be repaired. Under normal conditions, the FAULT indicator is not lit; it lights if the command timer on the controller times out, indicating that the controller-initiated operation was not completed within the prescribed 100 ± 20 milliseconds. Faulty components such as ROMs or 3002 CPE elements can cause the FAULT indicator to light.

- CLK — The CLK indicator is always lit under normal operating conditions, which means the microprocessor clock is running. If this LED is extinguished, it means the controller cannot get access to the TILINE or is hung in a master cycle. A possible fault condition indicated by an inoperative CLK LED could be improper wiring of the access granted signal line, since the controller's clock is stopped during a TILINE master cycle.

- BUSY — When the BUSY indicator is lit, the controller is in the process of executing a command; servicing a TILINE I/O Reset, master power reset, or power failure warning; or is in a sequence routine. When the indicator is lit, the disk drive system cannot accept any commands. The BUSY indicator can be monitored for 20 seconds following power turn-on to the disk drives being sequenced.

- INT — When the INT indicator is lit, the controller is issuing a TILINE interrupt. The INT indicator lights when the controller's master interrupt is active. This indicator is useful in analyzing system interrupt problems, or for displaying the interrupt activity and the response of the controller. The external interrupt signal can be activated, and the INT indicator lit, in two ways:

    1. When the interrupt enable bit, and either the complete bit or error bit, are set, the controller can set the interrupt flip-flop. This lights the INT indicator and sends an external interrupt signal to the TILINE.

    2. When the disk drive responds with an attention signal that compares to the preset attention mask, the resulting signal is ANDed with a busy signal, and an interrupt is sent to the TILINE and the INT indicator is lit.

The controller clears the interrupt and extinguishes the INT indicator when the computer responds to the interrupt signal and resets the error bit or complete bit, or clears the attention mask bits.

**4.3.1 INTERFACE/DEGATE SWITCH.** This two-position toggle switch is located on the top edge of the disk drive logic I card (see Figure 2-10 for logic I card location in disk drive), and is accessible only when the rear cover is removed. The INTERFACE position enables normal, on-line operation, permitting the disk drive to be selected by the controller. The DEGATE position disconnects the disk drive from the controller and enables the inputs from the T2000A/B exerciser for off-line maintenance operation of the disk drive. For normal operation, verify that this switch is set to INTERFACE (see Figure 4-2).

**4.3.2 CLEANING DISK DRIVE AIR FILTERS.** The disk drive has two air filters, the intake air filter and the absolute air filter, for removing dust, lint, etc., from the air that circulates through the disk pack area. The intake air filter is a foam element located behind the bezel of the front cover. It prefilters all air going to the blower and should be cleaned once a month. The absolute air filter inside the disk drive should be replaced every six months of normal use, or more often in extremely dirty environments. Access to the absolute air filter is gained by removing the disk pack and then removing the air shroud assembly. Instructions for replacing this filter are given in the field maintenance instruction manual.

To remove and clean the intake air filter, perform the following steps:

1. Remove the three thumbscrews located under the front cover bezel (see Figure 2-6).

2. Slide the front cover forward to gain access to the intake air filter.

3. Pull out the foam filter element from its recess in the front of the disk drive.

4. Wipe the inside of the recess with a damp, lint-free cloth. Dry the recess well.

**CAUTION**

**Do not operate the disk drive with the intake air filter removed, because this will cause the absolute air filter inside the drive to load up prematurely.**

5. Wash the foam filter element in a weak solution of detergent in warm water, rinse the element thoroughly in cold water, and blow the element *absolutely dry* with air before reinstalling it.

6. Reinstall the clean, dry filter element (or a new filter element if the old one shows signs of deterioration) in the filter recess.

7. Reinstall the front cover in the reverse order of removal.

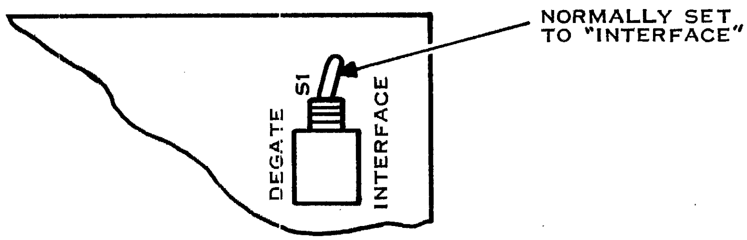



Figure 4-2. Interface/Degate Switch

**4.3.3 QUALIFIED VENDOR OR MANUFACTURER DISK PACK PREVENTIVE MAINTENANCE.** Preventive maintenance is necessary for mass memory disk system disk packs on a regularly scheduled basis. The following subparagraphs explain the basis for this requirement and the procedures for scheduling the preventive maintenance.

**NOTE**

Regular preventive maintenance (PM) procedures must be performed on all disk packs and disk cartridges every six months.

The disk pack is one of today's most advanced mass information storage systems. However, this seemingly ideal system requires special care to maintain optimum performance. Manufacturers originally considered disk packs and disk cartridges to be maintenance free. However, they have come to realize that regular cleaning and inspection are necessary to prevent costly system crashes, rerun time, and loss of valuable data. Regular PM is necessary on disk packs to alleviate costly problems that can arise to degrade the quality of data storage, render the disk packs unusable, or damage disk drives.

The need for PM arises in the following manner: Read/write heads fly over disk surfaces on an air bearing of 20 to 135 microinches, depending on the type of disk pack. Contamination in the form of dust, grease, metal filings, smoke particles, etc., build up on disk recording surfaces, decreasing the separation between read/write heads and disk surfaces (see Figure 4-3).

**CAUTION**

**Damaged or questionable-quality disk packs must never be installed in a disk drive. Disk drives must not be used without a clean and serviceable air filter. To prevent damage to the disk packs, the filter must be checked at least twice a year, and monthly in dusty or nontemperature-controlled locations.**

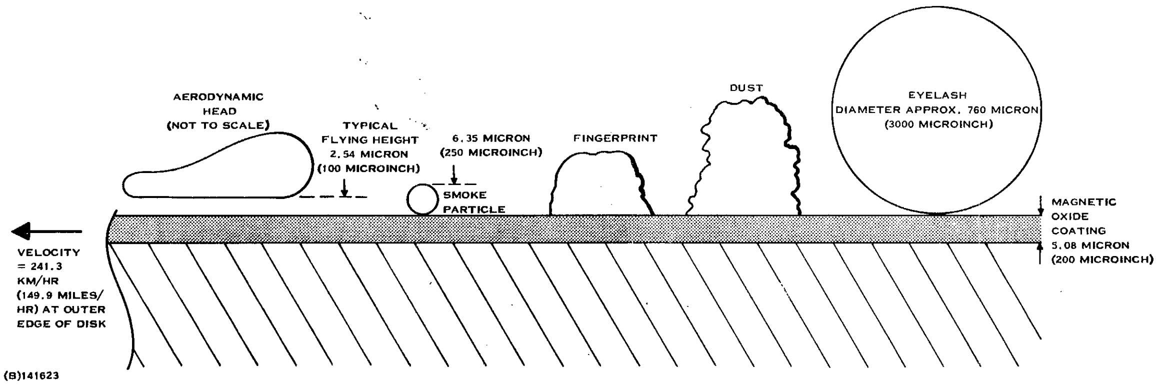



**Figure 4-3. Disk Contaminants**

Disk contaminants cause temporary errors, retries, and data checks. At this stage, most data should be recoverable by thorough cleaning of the disk surfaces. If foreign particles are allowed to build up, head crashes and other permanent damage to heads and disk surfaces are inevitable.

For these reasons, all disk packs should be removed from service and PM performed by a qualified vendor or manufacturer every six months. Contact the local TI sales and service office for help in locating a qualified, convenient vendor. Normally the PM is performed at the customer's location.

During the PM procedures, the vendor should clean and inspect the following areas in the disk pack:

- Top and bottom for cracks, chips, dirt, wear
- Spindle retainer for condition and wear
- Trim shield retaining screws for condition and tightness
- Spindle lock for wear, dirt, binding
- Thrust bearing, races, washers for damage and wear
- Hub and cone area for dirt, film, nicks, burrs
- Index (bottom protective) disk for bends, damage, axial runout
- Recording disks for surface damage and axial runout.

The vendor performing PM on disk packs will indicate the status of each pack cleaned and inspected. This will detail whether the pack is good, requires repair, or is nonrepairable. Many problems can be corrected by cleaning, but if a pack is found to be damaged, it must not be used again and should be scrapped or repaired before returning to service. Replacing disk packs can be costly, but quite inexpensive compared to system downtime due to disk drive crash or loss of data on a pack. Some packs may be repairable, in which case the repairs are usually done at the PM vendor's office.

# ALPHABETICAL INDEX

## INTRODUCTION

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 with the right side of the listing reference the following manual areas:

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  Tx-yy

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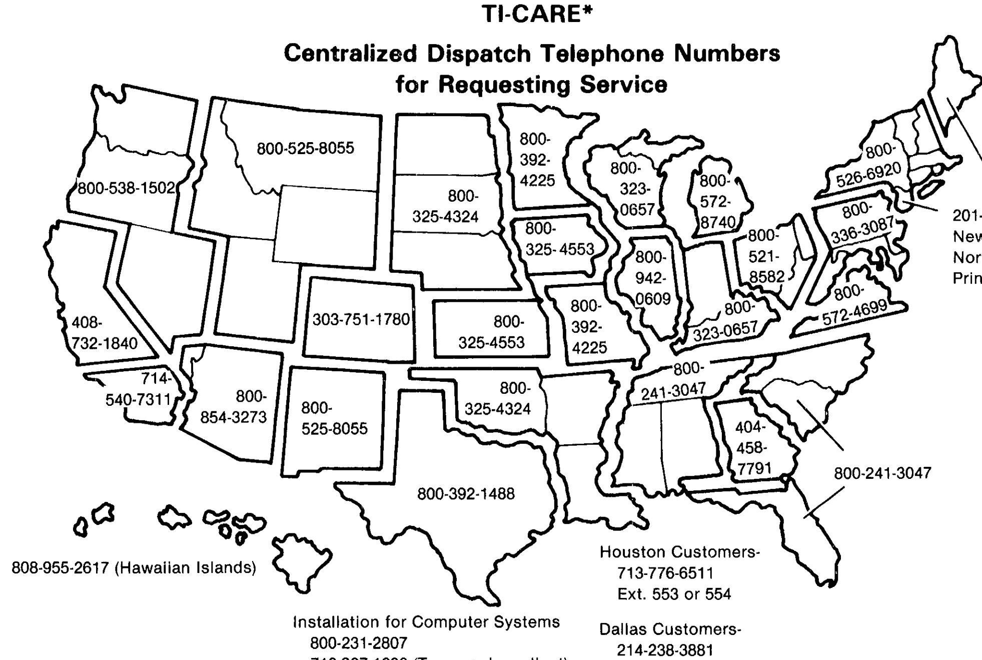


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