

CUSTOMER ENGINEERING DIVISION

WANG CARTRIDGE MODULE DISK DRIVE CDC MODEL 9448 CMD (PHOENIX DRIVE)



FIELD-LEVEL MAINTENANCE MANUAL

WANG

729-0199

+32V - CAPS UNDER POSITIONER

±5V

±20V (±15V ±12V ±6V)

FUSES

F1 10V

F2 5V

F3 45VAC

F4 45VAC

RELAY BOARD

| | | |
|-----|---|---------------|
| TB1 | 1 | -32V |
| | 2 | +32V |
| | 3 | $\frac{7}{-}$ |
| | 4 | -32V |
| | 5 | $\frac{7}{-}$ |
| | 6 | $\frac{7}{-}$ |

| | | |
|-----|---|--------|
| | | ? |
| TB2 | 1 | 250VAC |
| | 2 | 250VAC |
| | 3 | 250VAC |
| | 4 | 250VAC |
| | 5 | 250VAC |
| | 6 | 250VAC |
| | 7 | 250VAC |

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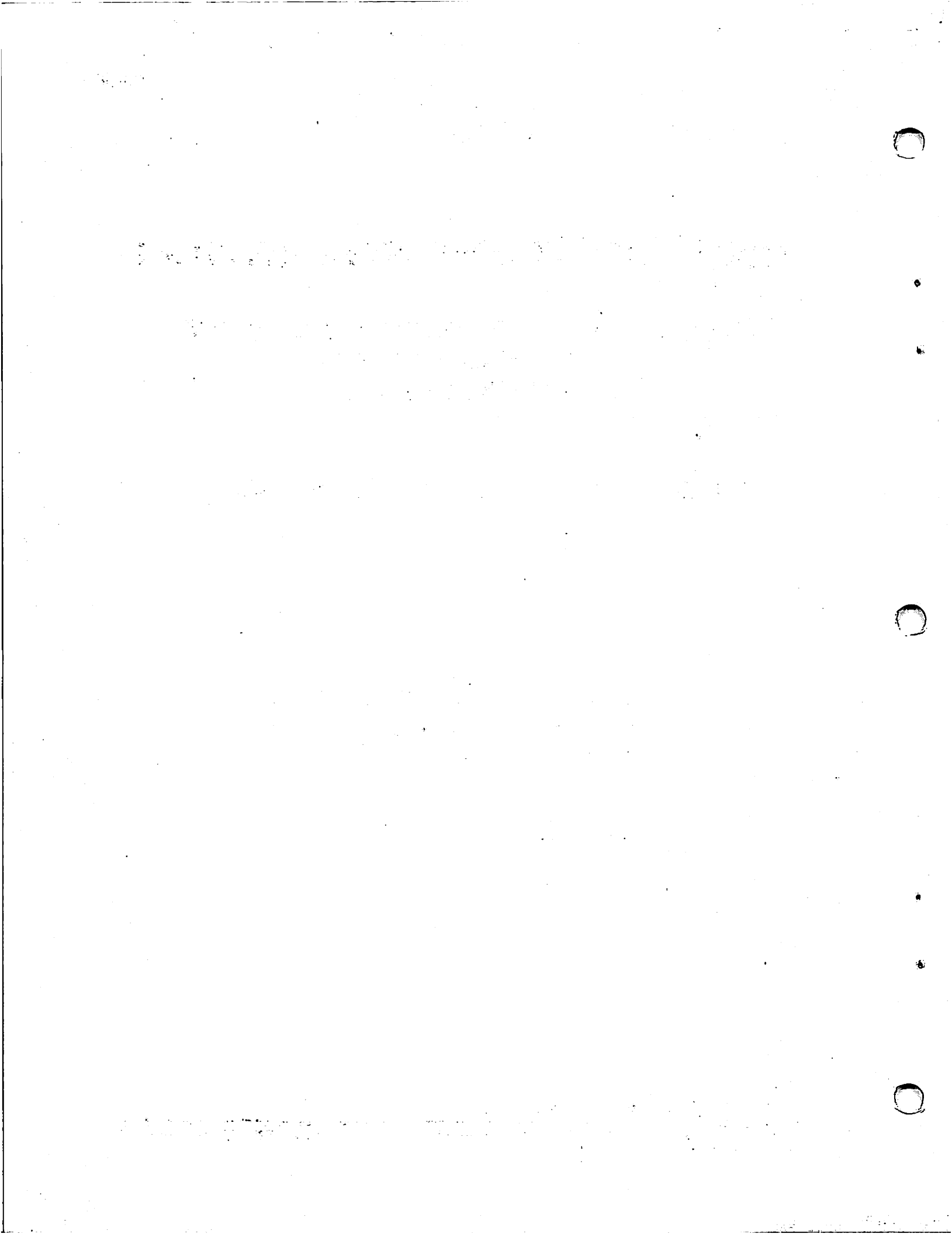


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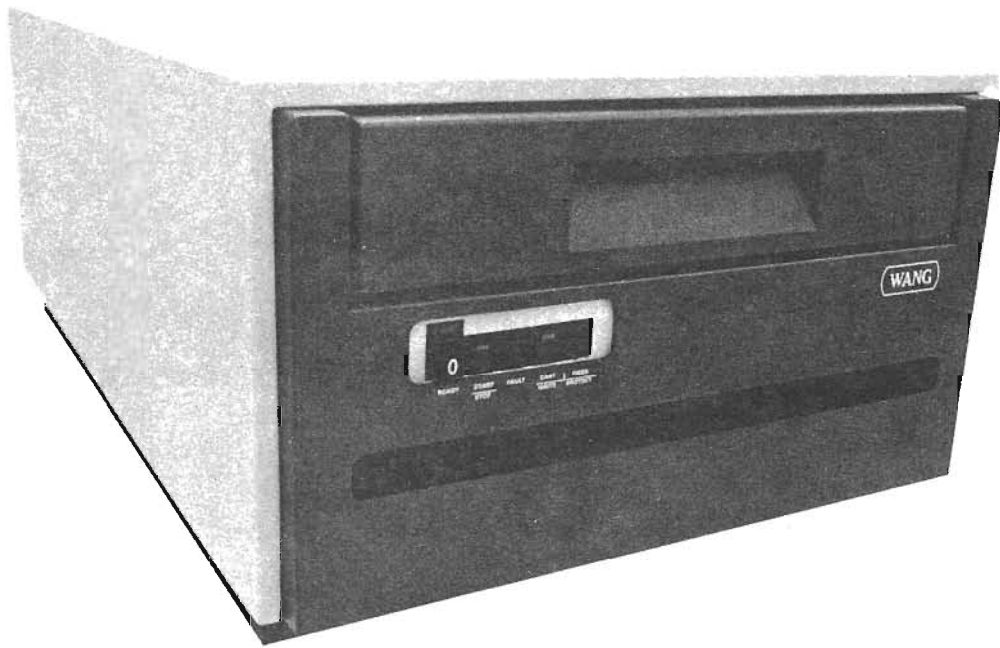
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WANG MODEL "PHOENIX" CARTRIDGE MODULE DRIVE (CMD)

CHAPTER I
INTRODUCTION

1.1 GENERAL

This manual contains data required to operate and maintain the CDC "PHOENIX" Model 9448 Cartridge Module Drive (CMD). This Disk Drive will be used with WANG 2200 Computers and Office Information System 140. Use this manual in conjunction with the Control Data Manual 75888415 Cartridge Module Hardware Maintenance Manual. The latest Revision (F) was released on 11/10/78.

1.2 DEVICE DESCRIPTION

The PHOENIX is a Cartridge Module Disk Drive (CMD) designed as a high performance, random access, mass memory device. The drive employs a linear positioner and a track density of 384 Tracks Per Inch (TPI) coupled with a 30ms average access time. This results in a 9.67 MHZ transfer rate.

Each platter on a PHOENIX drive has a total of 823 cylinders (819 available for use). There are 64 sectors on a track for the 2200VP, MVP and WP Systems, which add up to 52,416 sectors per platter. This will yield a total of 13,418,496 bytes per platter surface allowing 256 bytes per sector.

The 2200 VS System is formatted with 9 sectors per track with a storage capacity of 2048 bytes per sector. See TABLE 1-1.

The storage capacity for each of the three PHOENIX Models used with the 2200VP, 2200MVP and WP Systems is as follows:

| <u>MODEL</u> | <u>STORAGE IN BYTES</u> |
|--------------|-------------------------|
| 2280-1 | 26,836,992* |
| 2280-2 | 53,673,984* |
| 2280-3 | 80,510,976 |

* Office Information System 140 has same capacity drives with Word Processing Model numbers (XX80-1,2,3).

In all cases 13,418,496 bytes are removable and the remainder is on from 1 to 5 fixed surfaces, depending on the model.

There are 256 sectors (4 tracks) reserved on the fixed platters for error correction. The total usable space on a fixed platter is 13,484,032 bytes; however, at no time will the user be able to access more than 13,418,496 bytes.

The PHOENIX features a new 8080 microprocessor to control and monitor the drive. The microprocessor constantly monitors the disk speed, performs checks on Control Memory (ROM) as well as Main Memory (RAM).

1.3 MICROPROCESSOR HARDWARE DESCRIPTION

The basic microprocessor hardware consists of a processor (8080A), clock generator (8224), system controller and bus driver (8228), instruction memory (8708/8308), data memory (8111), interrupt logic, programmable timer (8253), and programmable peripheral interface units (8255A, called PPI). These elements are tied together on three common buses - Control, Data, and Address as illustrated in Figure 1-1..

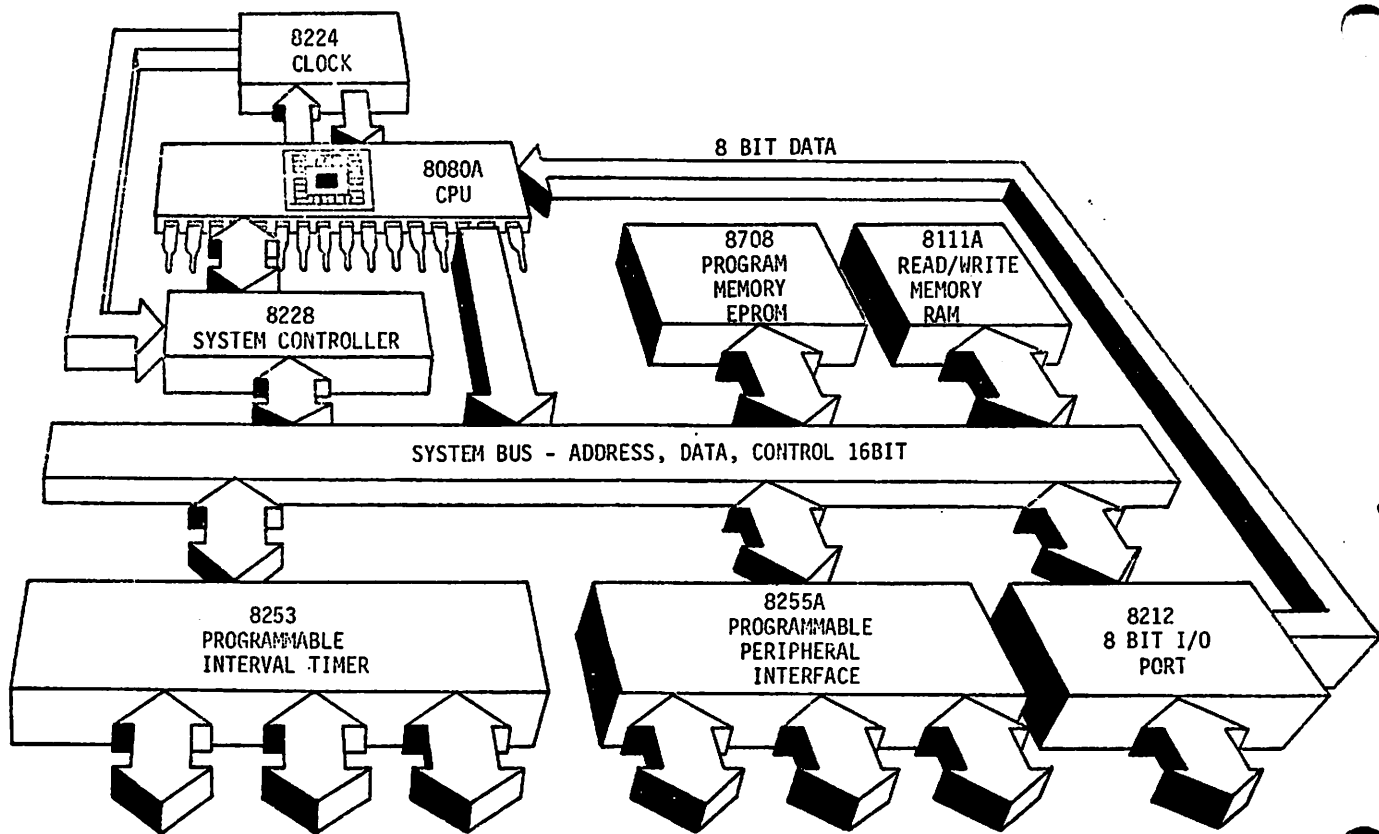


FIGURE 1-1 SYSTEM BUS - ADDRESS, DATA, CONTROL 16 BIT

TABLE 1-1
OPERATIONAL CHARACTERISTICS SUMMARY

| <u>CHARACTERISTICS</u> | <u>VALUES</u> | | |
|---------------------------------|-------------------------|-------------------|-------------------|
| TRACK DENSITY | 384 TPI | | |
| POSITIONING TIME | | | |
| Maximum Positioning time | 55 ms (track 0 to 822) | | |
| Track-to-track positioning time | 6 ms | | |
| Average positioning time | 30 ms | | |
| SPINDLE SPEED | 3600 r/min (+2.5,-3.5%) | | |
| LATENCY TIME (AVERAGE) | 8.33 ms (at 3600 r/min) | | |
| RECORDING | | | |
| Mode | MFM | | |
| Density (inner track) | 6038 bpi nominal | | |
| (outer track) | 4038 bpi nominal | | |
| Transfer rate (nominal) | 9.677 MHz | | |
| | <u>DRIVE CAPACITY</u> | | |
| | 2280-1 | 2280-2 | 2280-3 |
| | <u>26.8 Mbyte</u> | <u>53.6 Mbyte</u> | <u>80.5 Mbyte</u> |
| Total number of removable disks | 1 | 1 | 1 |
| Total number of fixed disks | 1 | 2 | 3 |
| Servo Surfaces | 2 | 2 | 2 |
| Data Surfaces | 2 | 4 | 6 |
| Minimum Data tracks | 1616 | 3232 | 4848 |
| Spare tracks | 30 | 60 | 90 |
| Disk Diameter (inches) | 14 | 14 | 14 |
| (millimeters) | 356 | 356 | 356 |
| Track Spacing (inches) | 0.0026 | 0.0026 | 0.0026 |

CHAPTER II INSTALLATION

2.1 GENERAL

This section describes the removal of the PHOENIX CMD Disk Drive from its shipping container, the initial inspection and final installation preparations.

The disk drives are shipped separately and installed into the PHOENIX Cabinet Assembly (279-4109) at the site. After unpacking, a cursory inspection of the Drive should be performed, prior to the Drive being installed into the furniture.

The following procedures are listed in the order that they should be performed:

1. UNPACKING the Disk Drive (PHOENIX)
2. UNPACK Disk Drive Furniture (Disk Stand (279-8055))
3. Check for visual damage to Disk Drive and furniture.
4. Install Disk Drive into Furniture.
5. Complete inspection of the Drive for possible damage enroute to site.

2.2 UNPACKING THE PHOENIX DISK DRIVE

1. Check shipping carton for damage. During the unpacking, exercise care that tools used do not come in contact with the disk unit.
2. Remove cardboard carton and packing materials from unit.
 - a. Cut the two metal straps shown in Figure 2-1
 - b. Open the top of the cardboard carton and remove Instapak that surrounds the Drive. See Figure 2-2. Be careful not to lose or dispose of hardware package that is shipped internally on top of the Drive unit.
 - c. Remove staples that secure the cardboard container to the wooden base that supports the Disk Drive. Remove and dispose of cardboard carton.

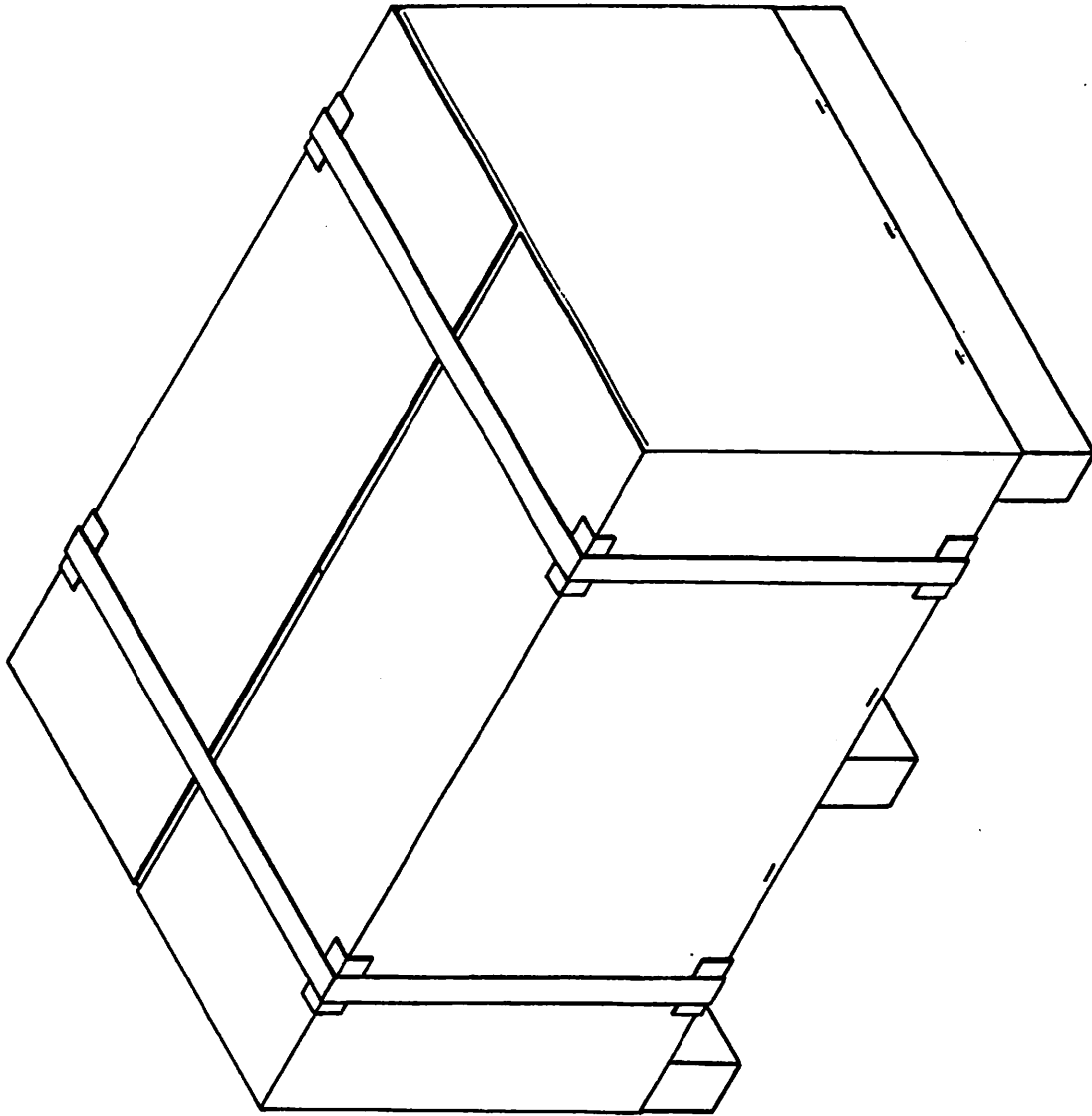


FIGURE 2-1 SHIPPING PACKAGE FOR PHOENIX DRIVE

- d. With the Disk Drive exposed, remove the four short metal hold-down brackets that secure the Disk to the wooden support base. See Figure 2-2.

The brackets clamp to the four corners of the metal base that support the disk and then bolt to the wooden skid. Remove the bolts from the skid to free the disk.

- e. Prior to removing the Disk from the wooden shipping platform (skid), raise one end of the drive at a time just enough to install the round white rubber mounts with the associated hardware. These mounts fit into the detent holes on the disk stand. The disk is now ready to mount on the stand.
3. Unpack the Disk Base Stand furniture. The furniture is packed in separate cardboard boxes. The Base Stand (P/N 279-8055) is in one box and the Disk Cover (P/N 279-4109) is in another. These two units are packed in cardboard containers with styrofoam corners to protect them from damage. Inspect for shipping damage prior to installing the Disk Drive. Insure that the stand has not been damaged. Set top cover of stand aside. Prepare bottom stand for mounting Disk Drive. Adjust the Base Stand levelers prior to mounting the drive. A final leveling of the Base Stand should be done after the disk drive is in position for testing and operating with the system. See figure 2-3.
 4. Lift and position the Disk Drive Unit onto the stand. (SEE CAUTION BELOW). Make sure the Disk Base Pan Assembly (P/N 279-1017) that is assembled to the PHOENIX drive has the support mounts installed prior to lifting it onto the stand. Insure that mounts are inserted into the indented alignment holes on the stand. With the Disk Drive mounted on the Stand, the installation checkout and inspection can proceed with no further handling problems.

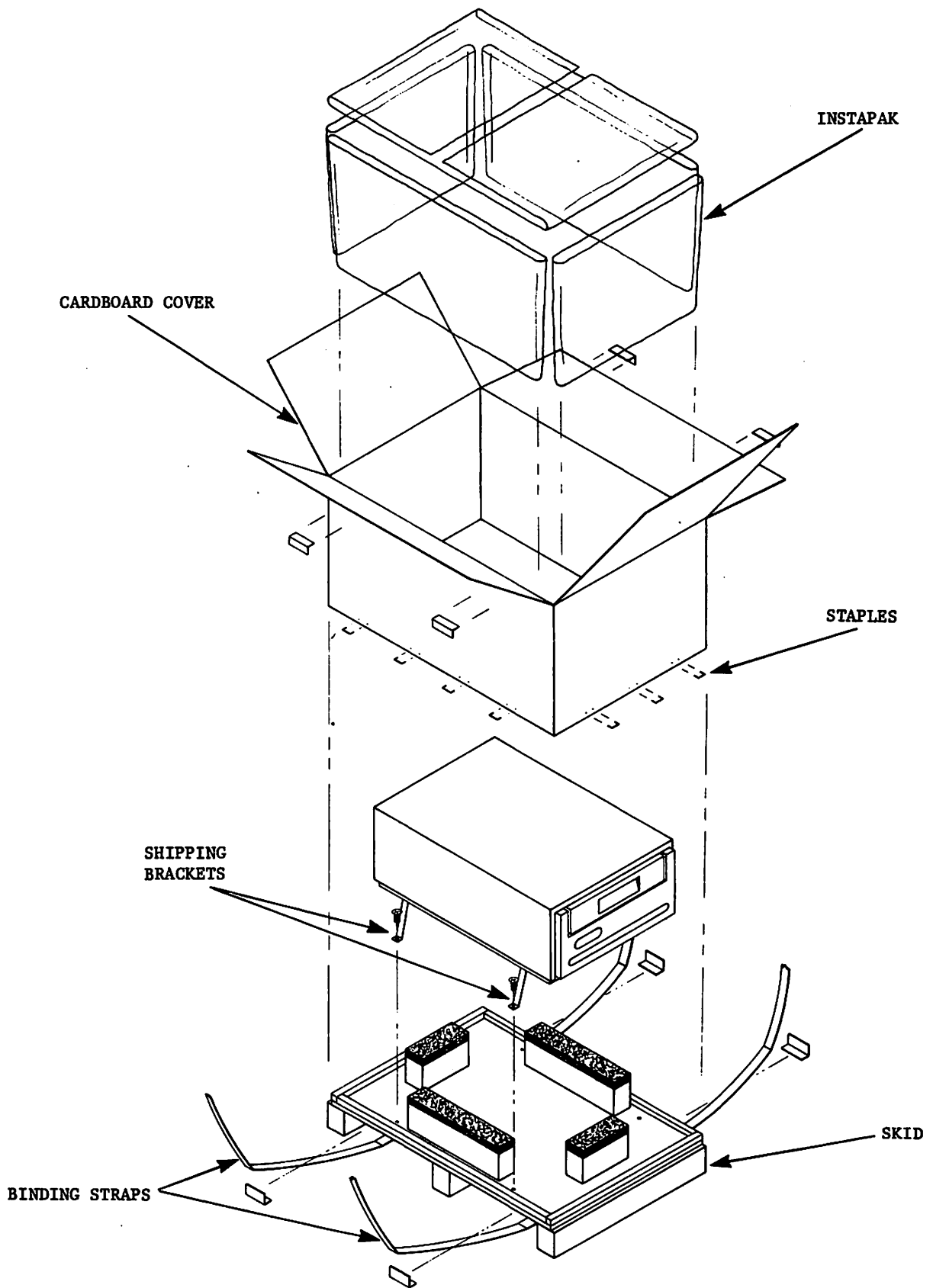


FIGURE 2-2 EXPLODED VIEW OF PACKAGED CMD

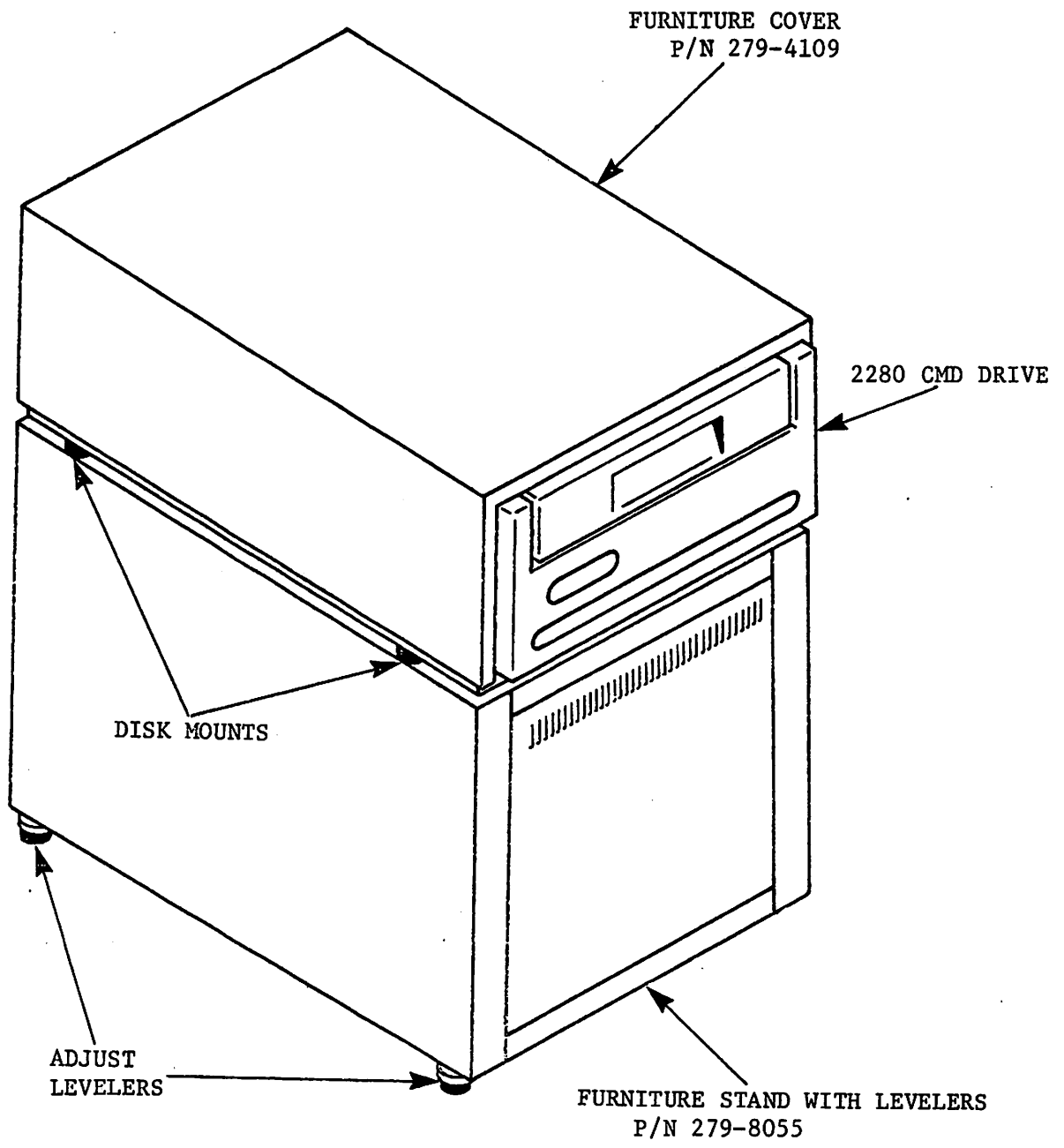


FIGURE 2-3 WANG 2280 CMD DRIVE MOUNTED ON STAND WITH COVER

5. After the Disk unit has been inspected per Section 2.3 for damage during shipment and other checks, the unit will be powered up and tested using the FTU. Once the unit is determined to be operational the disk stand cover can be installed and the unit connected to the operating system.

CAUTION:

Use lifting fork or other mechanical means
to lift unit. Use at least two strong
people if other means are not available.
Weight of the drive is approximately 175 lbs.

2.3 INSPECTION

Once the Drive unit is unpacked and mounted on the stand, inspect it for possible shipping damage. All claims for this type of damage should be filed promptly with the transporter involved. If a claim is filed for damages, save the original packing materials.

Inspect the unit as follows:

- A. Remove the top dust cover (See section 2.4) and inspect various items such as circuit boards, carriage assembly, and read/write heads for shipping damage. See Figure 2-4.
- B. Check that all packing material pieces are removed, and that the unit is clean inside. Raise the Base (DECK) to inspect inside the base pan. Refer to section 2.5.
- C. Check/Perform the inspection of the following items:
 1. Power supply is securely tightened.
 2. Check for packing in the cartridge receiver area.
 3. Inspect top of unit for loose wires and damaged components.
 4. Check the unit for any shipping or packing material that may be in the cartridge receiver area.
 5. Check the connectors on the bottom of the Electronics Module while the Deck Base is raised.

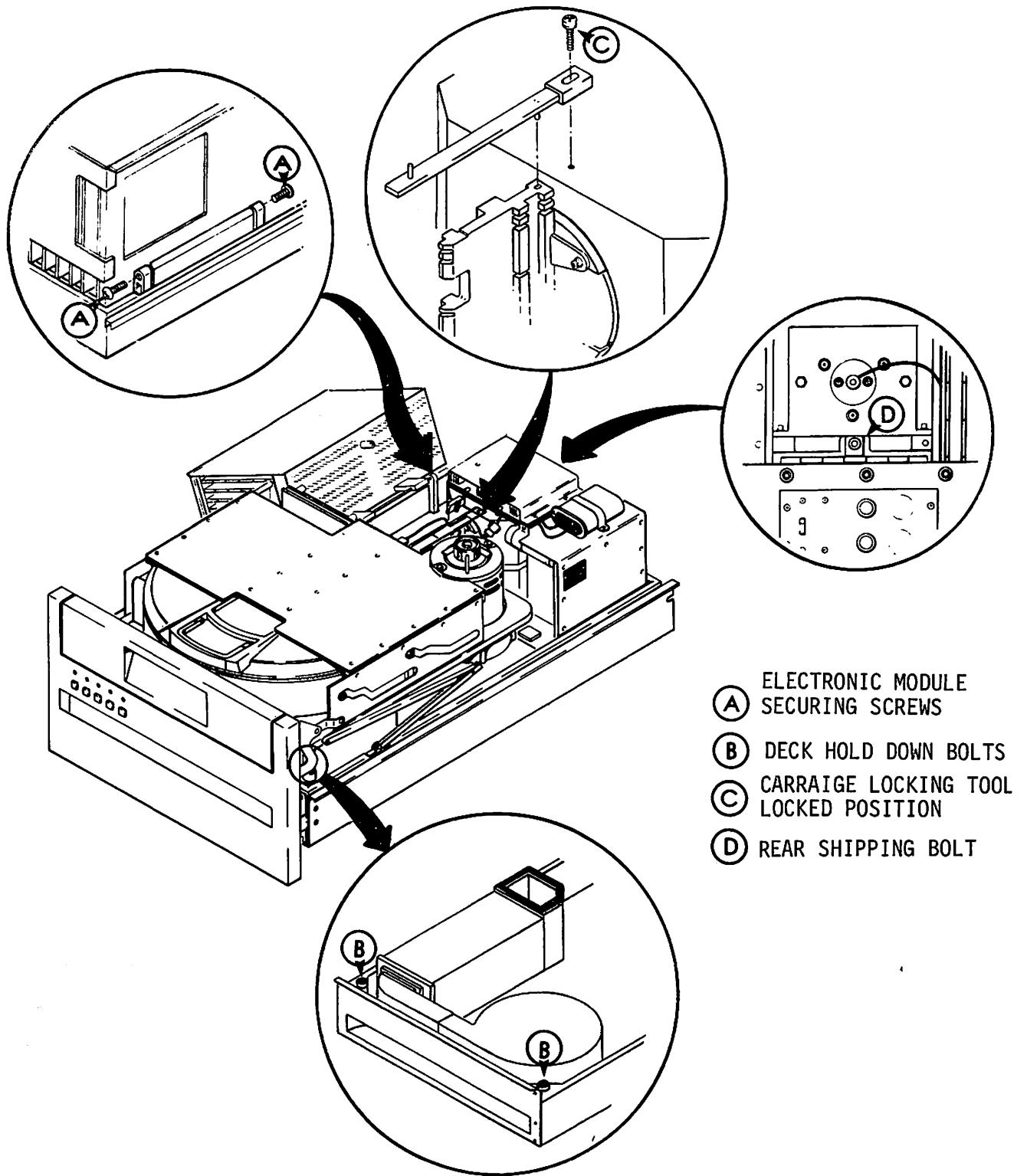


FIGURE 2-4 UNPACKING - (SECUREMENT AREAS)

6. Check the Deck Lowered Switch interlock located under the Electronic Module.

NOTE:

Electronic Module must be in maintenance position to open the Deck.

- D. Perform the procedure in Section 2.6 before attempting any check-out on the Disk Drive.

****CAUTION****

DO NOT POSITION THE CARRIAGE MANUALLY. SUCH ACTION COULD CAUSE THE READ/WRITE HEADS TO LOAD AND CAUSE DAMAGE TO THE HEADS AND DISKS.

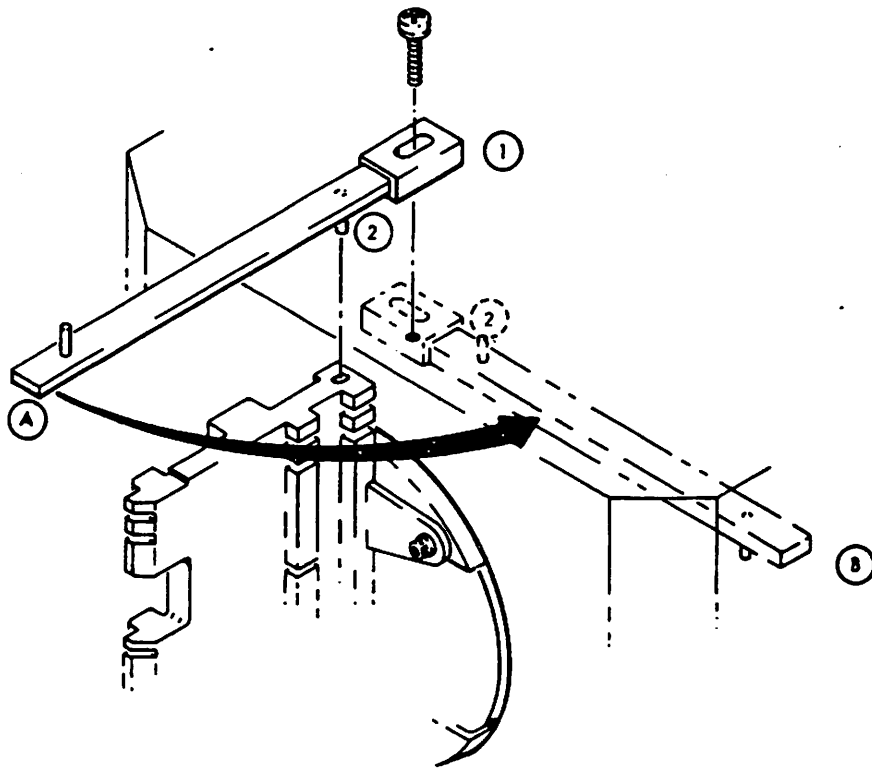
THE UNIT SHOULD NOT BE SHIPPED OR MOVED ANY SIGNIFICANT DISTANCE WITHOUT THE CARRIAGE LOCK PIN IN PLACE. THIS PREVENTS THE HEADS FROM LOADING AND DAMAGING THE DISKS AND/OR HEADS.

(See Figure 2-5--Carriage Locking Tool)

2.4 COVER REMOVAL AND REPLACEMENT

Perform the following procedure to remove and replace the dust cover on the unit. See Figure 2-8.

- A. Remove the two screws at the rear of the unit which secure the top cover. Lift the cover up and to the rear. Remove it from the unit. The front end of the cover is secured only by two short tabs which fit into two slots in the front panel.
- C. To replace the cover, insert the two tabs at the front of the cover into the two slots in the front panel. Lower the cover into place and install the two screws at the rear of the unit to secure the cover.



- (A) CARRIAGE LOCK PIN (2) IN SHIPPING POSITION.
- (B) CARRIAGE LOCK PIN (2) IN OPERATING POSITION

FIGURE 2-5 CARRIAGE LOCKING TOOL - SHIPPING POSITION

2.5 RAISING THE BASE DECK ASSEMBLY

Perform the following procedure to gain access to items under the base deck assembly (First, remove the top cover - Paragraph 2.4).

- A. Using a 3/16 inch hex driver remove the two screws "B" which secure the deck casting to the shock mounts at the front of the unit. (Figure 2-4) Make sure rear shipping bolt and spacer have been installed so that the weight of the deck does not shear the rear shock mounts. (Figure 2-6)
- B. Remove the two screws which secure the Electronic Module and loosen or remove the lower I/O cable clamp by loosening or removing one or both of the screws securing it. Lift the Electronic Module and swing it out to the side. Be careful not to allow the cables attached to the module to catch or chaff on anything. (Figure 2-4A)

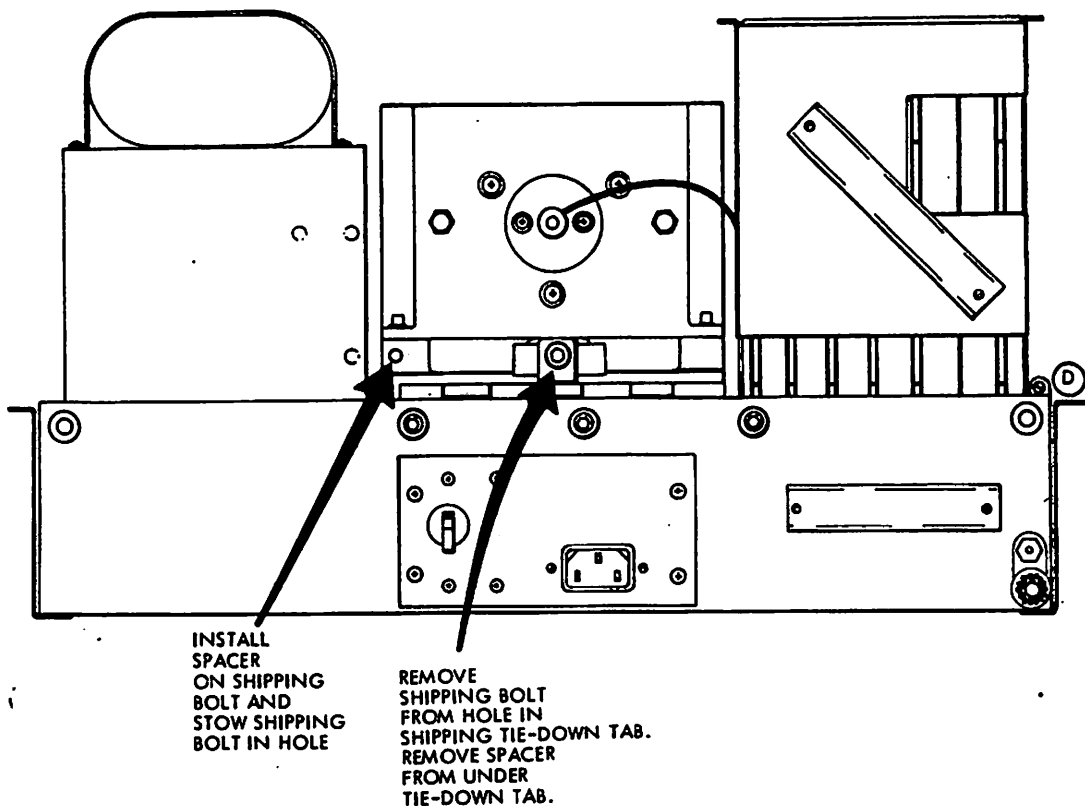
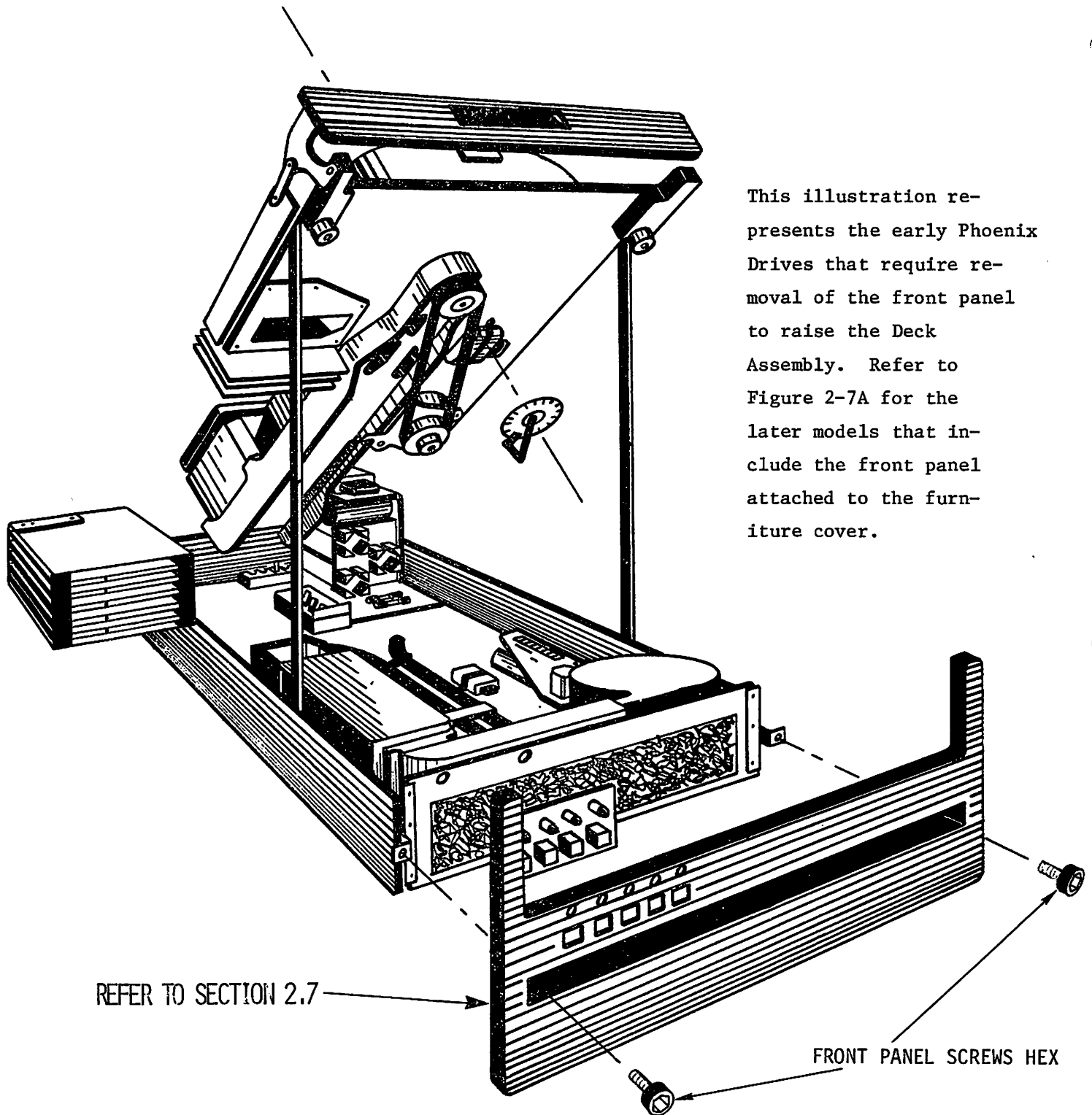


FIGURE 2-6 SHIPPING BOLT AND SPACER

- C. Remove the two screws which secure the front panel and remove the front panel. (Figure 2-7)
- D. Lift the deck assembly until the two support legs are straight, then lower the deck to the point where the two legs support the deck. Help should be obtained in straightening the two legs.

2.6 LOWERING THE BASE DECK ASSEMBLY

- A. Lift the deck until the support legs can be pushed toward the rear to unlatch them. Hold the deck with both hands and push both support arms to the rear with one of the fingers on each hand. Use both hands to lower the deck into place. The deck is capable of a small amount of movement, so be careful not to allow the pack access door mounting bracket to strike the control panel PWA. Also, be sure that the wiring harness to the Electronics Module does not get pinched between the deck and the base pan. Be sure motor pulley is clear of cables.
- B. When lowering the Deck Assembly, care must be taken to avoid pinching of cables.
- C. Reinstall the two screws which secure the deck to the shock mounts.
- D. Restore the Electronics Module to its normal position by swinging it up and lowering it into the base pan. Reinstall the two screws to secure the Electronics Module and secure the I/O cable clamp by tightening the two screws which secure it.
- E. Replace the front panel and secure it with the two screws removed in step 3. (Figure 2-7)



This illustration represents the early Phoenix Drives that require removal of the front panel to raise the Deck Assembly. Refer to Figure 2-7A for the later models that include the front panel attached to the furniture cover.

FIGURE 2-7 DECK ASSEMBLY - RAISED

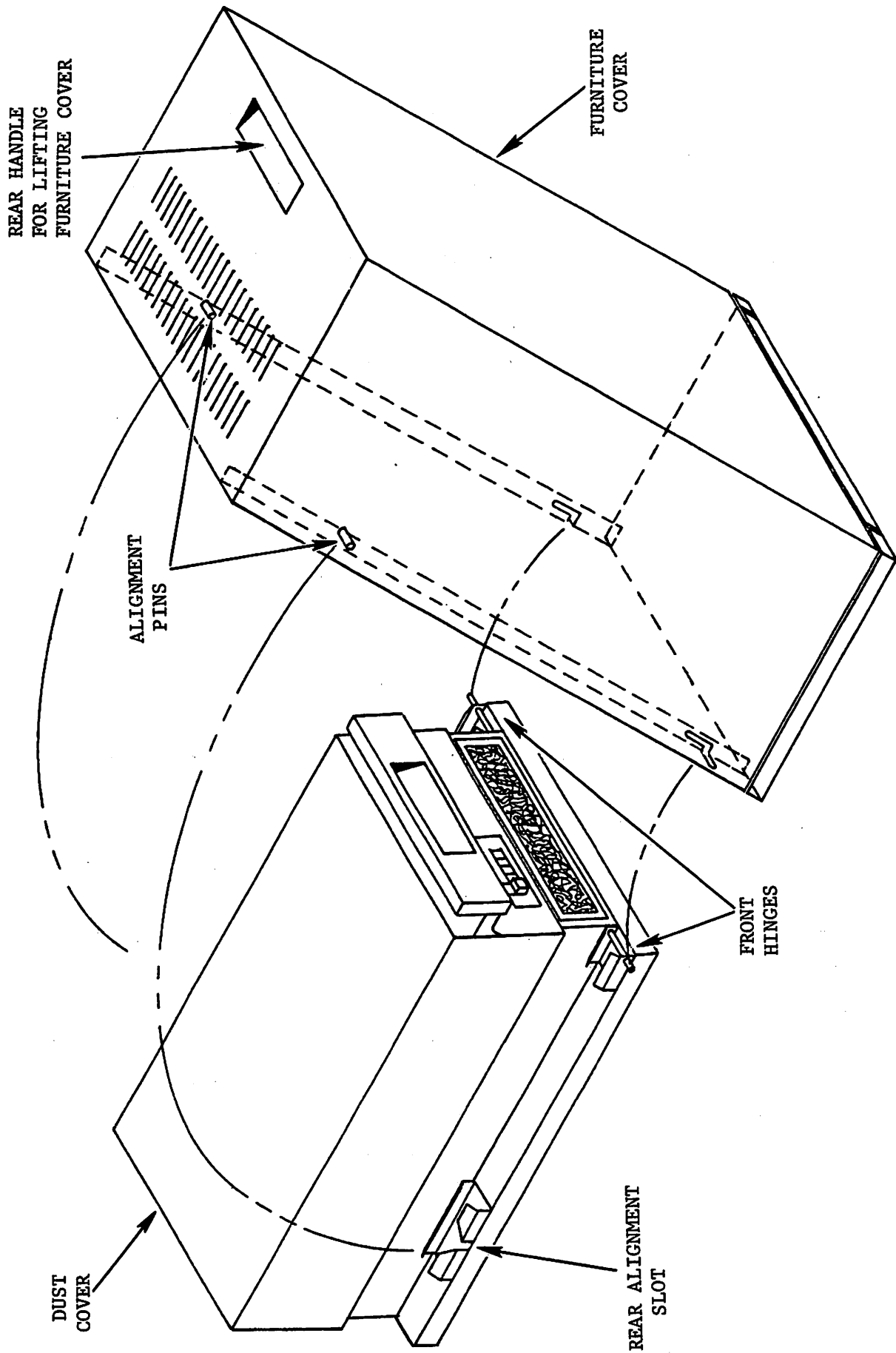


FIGURE 2-7A NEW FURNITURE COVER FOR PHOENIX DRIVE

- F. Remove the rear shipping bolt and spacer which were installed in paragraph 2.5A. Insert the bolt through the hole in the spacer and insert bolt into stowage hold.
- G. (See Figure 2-5.) Remove the screw which secures the carriage Locking Tool. Lift the Locking Tool to remove the locking pin from the hole in the carriage. Swing the locking tool around to the operating position. Reinstall the screw to secure the locking tool to the magnet in the operating position.
- H. Inspect the cabling on the Electronic Module for proper seating of the connectors to the pins.
- I. Replace the top dust cover.

2.7 MODIFICATION OF THE PHOENIX FRONT PANEL AND FURNITURE COVER

The dust cover (black) is internal to the furniture cover. See Figure 2-8. The furniture cover P/N 279-4109 has been modified since the earlier deliveries to the field. The furniture cover now has a charcoal colored front panel that replaces the original illustrated in figure 2-7. The original front panels of the CMD consisted of two sections as illustrated in APPENDIX A (Fig. A-7). By removing the two mounting screws the panels can be separated from the drive exposing the prefilter. The new cover is installed by hinging the front of the cover to pins installed on the front sides of the drive base. Refer to figure 2-7A. Erect the cover vertically and slowly lower the cover over the rear of the drive. To remove the new cover, lift the cover with the built in handle and lift from the front hinged pins. The new charcoal colored front panel has cutouts for accessing the drive controls.

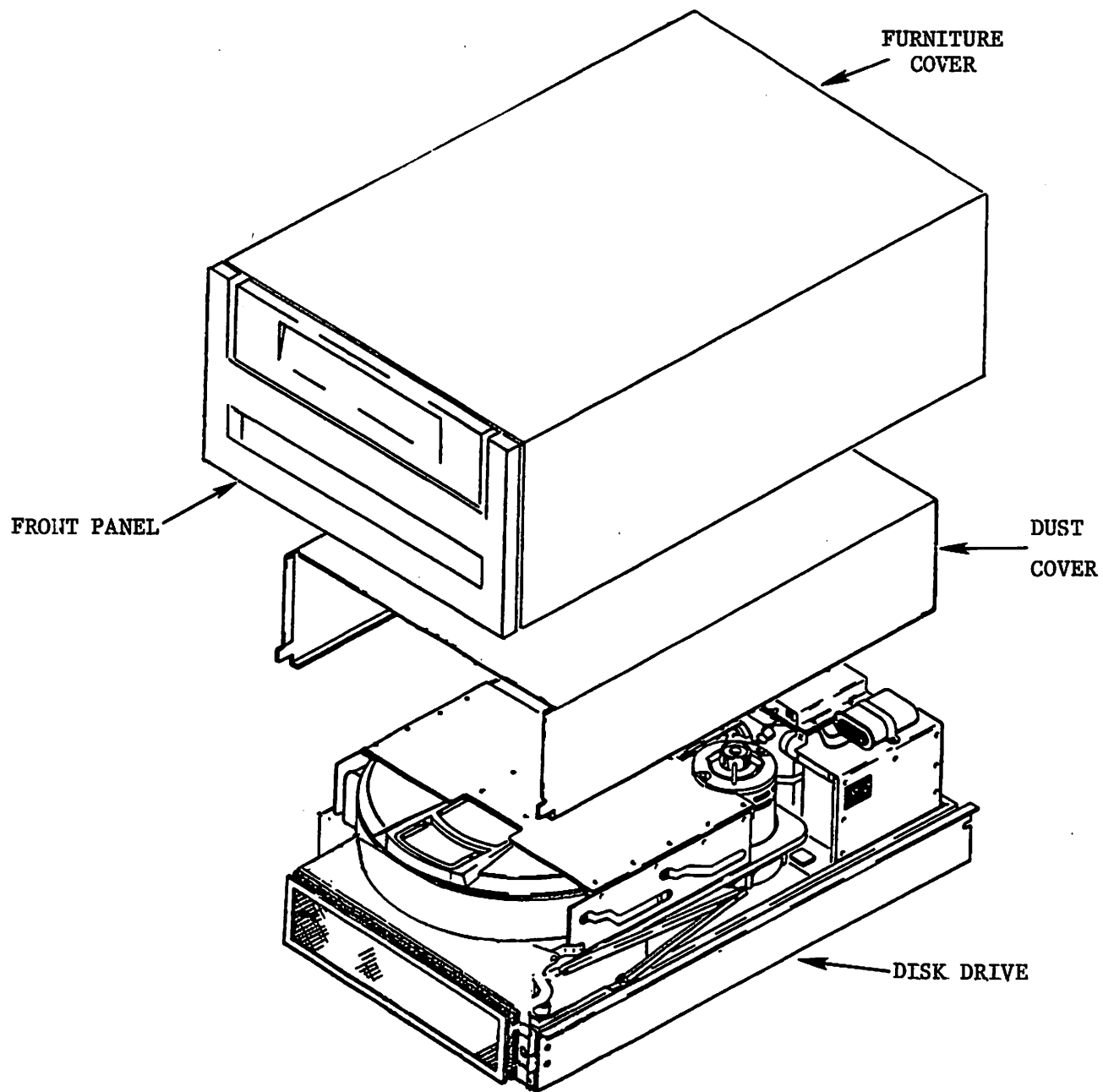


FIGURE 2-8 FURNITURE AND DUST COVERS



CHAPTER III
PRELIMINARY INFORMATION PRIOR TO
OPERATIONAL CHECK OUT

3.1 GENERAL

This section describes the disk drive components relative component location, and the proper testing procedures.

3.2 DEVICE LAYOUT

The unit configuration and major component/assembly locations are illustrated in Figures 3-1, 3-2 and 3-3. See additional illustrations in Appendix A for Component/Assy identification etc.

3.3 SAFETY AND SPECIAL MAINTENANCE PRECAUTIONS

Before proceeding with maintenance, Field personnel should become familiar with the following safety and maintenance precautions. Failure to adhere to these practices may result in equipment damage and/or injury to personnel.

A. SAFETY PRECAUTIONS

1. Use care when power is applied to the unit. Various voltages are present on the terminal block (TB1) on top of the voice coil magnet.
2. Keep hands away from the actuator during seek operations and when reconnecting leads to the voice coil. Emergency retract voltage may be present which could cause sudden reverse motion of the carriage.
3. Use the carriage locking pin when performing head alignment to prevent personal injury.
4. Get help when raising and lowering the deck.

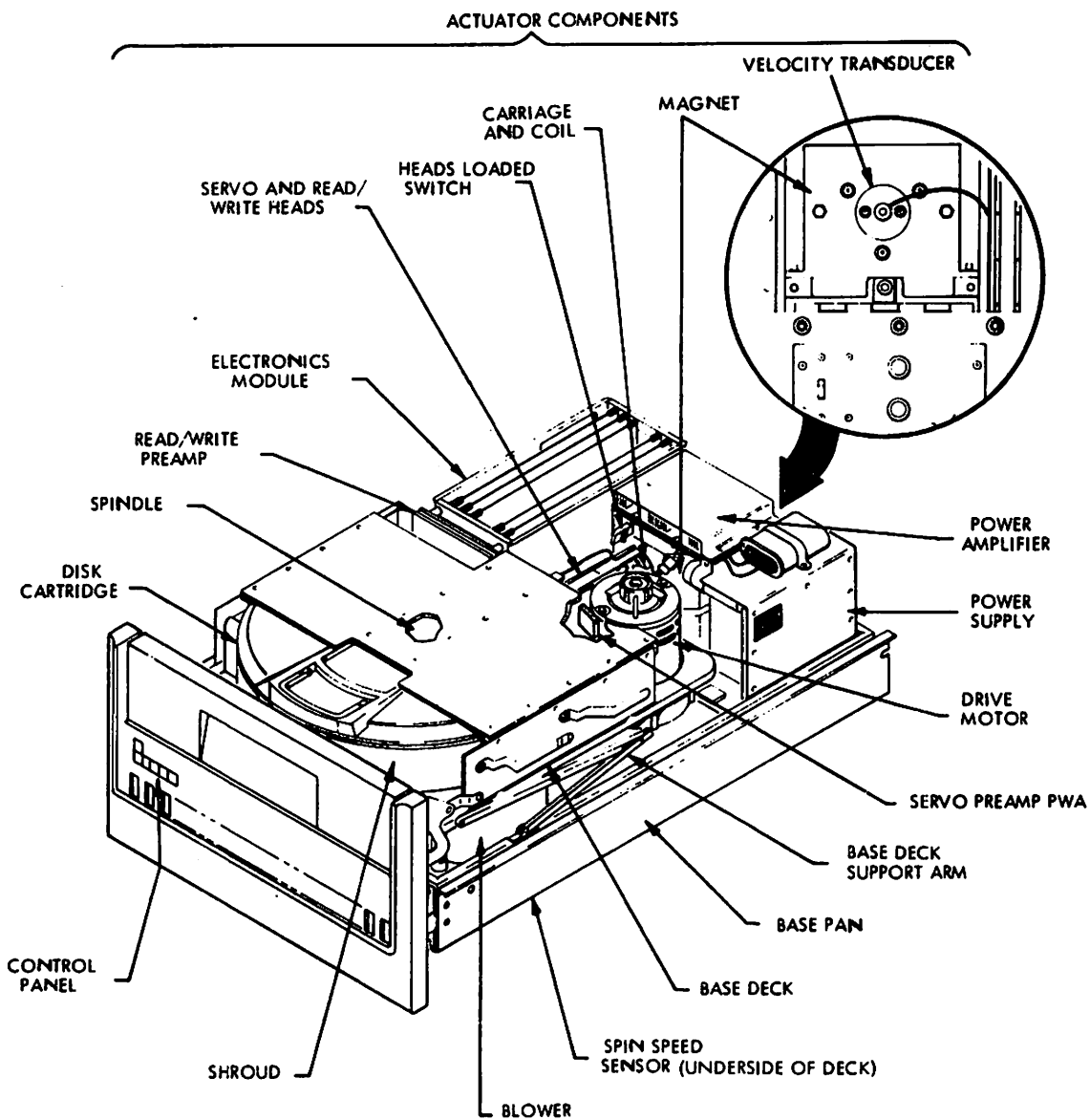


FIGURE 3-1 DEVICE LAYOUT (TOP VIEW)

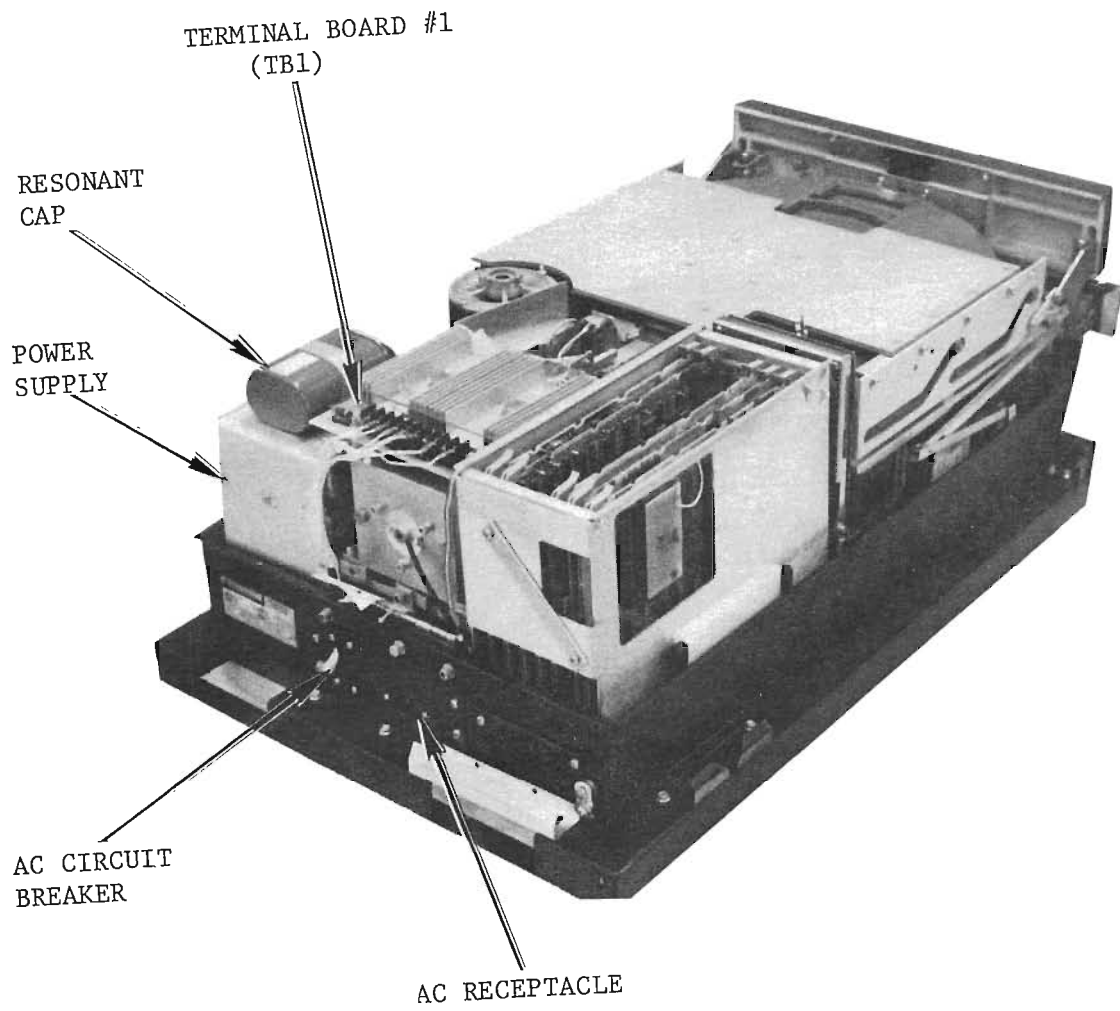


FIGURE 3-2 CMD POWER DEVICE

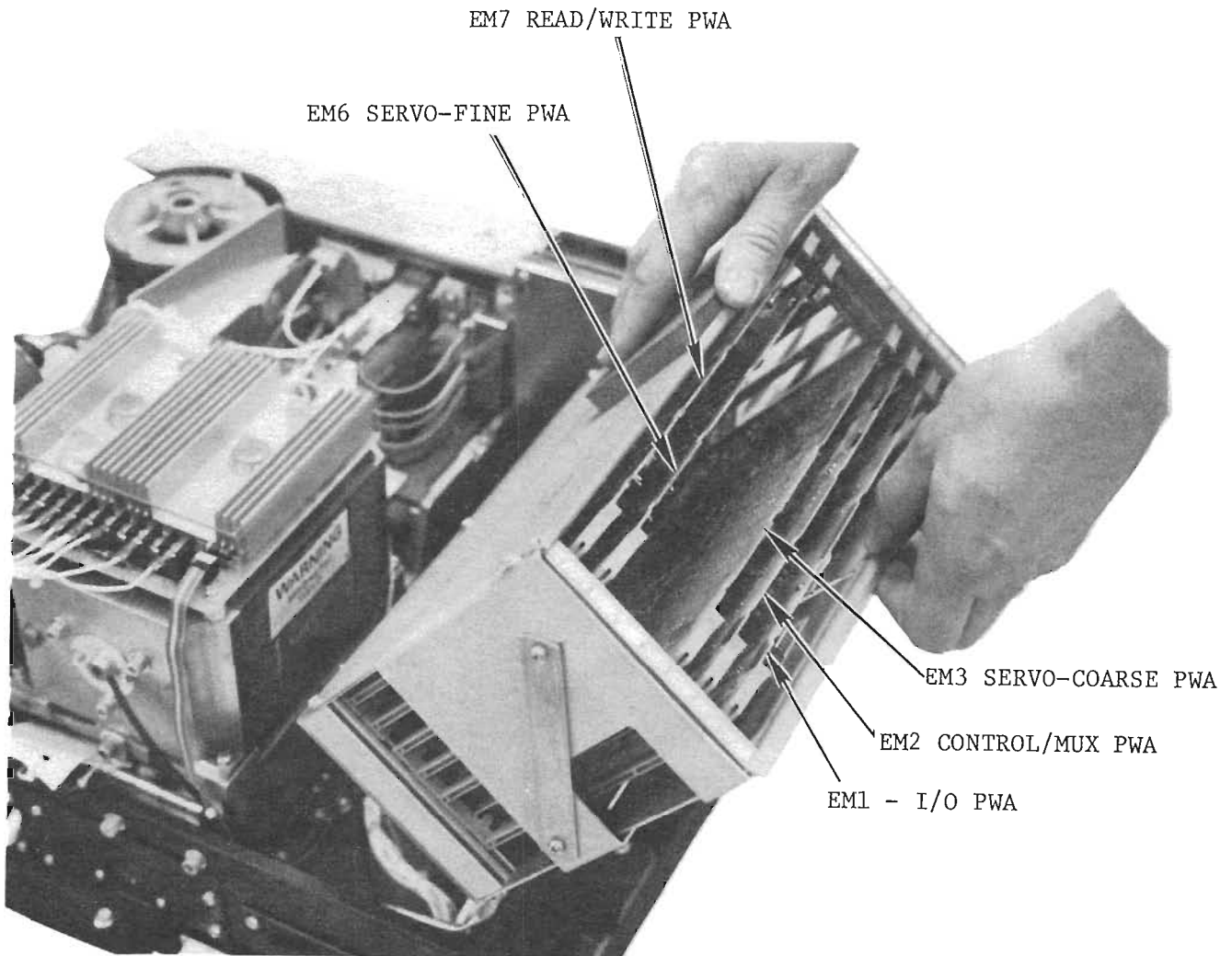


FIGURE 3-3 CMD ELECTRONIC MODULE BOARD LAYOUT

B. SPECIAL MAINTENANCE PRECAUTIONS

****CAUTION****

DO NOT USE THE CIRCUIT BREAKER TO REMOVE AC POWER FROM THE UNIT UNTIL THE DISK HAS STOPPED ROTATING. THE BLOWER MUST REMAIN ON WHEN THE DISK IS ROTATING TO PREVENT THE ROTATING DISK FROM SUCKING IN UNFILTERED AIR.

1. Use caution when working near the heads. Fingerprints can damage the heads. If the heads are touched, clean them immediately.
2. Keep the pack access door closed unless maintenance is required. This prevents dust from entering the pack area. The deck should not be left in the raised position unless absolutely necessary for maintenance. When leaving the area of the unit, lower the deck to prevent contaminants from falling into the absolute filter exit which could be blown into the disk area when normal operation is restored.
3. Keep all watches, disk packs, meters, and other test equipment at least two feet away from the voice coil magnet when the cover of the unit is removed.
4. Use the scratch pack for maintenance procedures. Do not use the customer's data pack for any maintenance purpose.
5. Do not use the CE alignment disk pack unless specifically directed to do so. These packs contain prerecorded alignment data that can be destroyed if the test procedure requires the drive to write. This alignment data cannot be generated in the field.

6. Do not insert or remove any PWA board without first turning the AC Power circuit breaker off.
7. Immediately manually retract the carriage, if the power to the spindle motor is lost while the heads are loaded and the voice coil lead wire is disconnected. Otherwise, the heads will crash when the disk speed decreases and the heads cease to fly.
8. If the drive fails to retract the heads and stop the spindle when the START/STOP switch is placed in the STOP position, disconnect the voice coil lead wire connector and manually retract the carriage before troubleshooting the malfunction.
9. Never load the heads manually when the spindle is not up to speed. It is recommended that the heads never be loaded manually while any disks are in the drive, even though they are up to speed.

CHAPTER IV
CONTROLS - INDICATORS - SWITCH SETTINGS

4.1 GENERAL

The contents of this section describe the following:

- A. Operator Control panel - located left front of unit.
(Figure 4-1)
- B. Fault indicators - located on the Control/Mux PWA Slot #2 of the Electronic Module. (Figure 4-2)
- C. Switch Settings - located on the I/O PWA slot #1 of the Electronics Module (Figure 4-3) and Servo Coarse, PWA Slot #3 (Figure 4-5).
- D. Switch setting - located on Servo Fine PWA Slot #4 (Figure 4-4)

NOTE: THE MAINTENANCE SWITCHES AND FUNCTIONS ARE LOCATED IN
CHAPTER 4--TABLE 4-2

4.2 OPERATOR CONTROL PANEL

Table 4-1 and Figure 4-1 describe the location, nomenclature and function of the operational controls and indications.

4.3 FAULT INDICATORS - (See Figure 4-2)

Located on the Control Mux PWA is a bank of seven LED maintenance indicators numbered CR1 through CR7; which have four different uses. They are used for the following:

- A. Displaying non-microprocessor detected faults.
- B. Displaying the present cylinder address held in the Microprocessor.
- C. Displaying microprocessor-detected faults.
- D. Assisting in velocity gain adjustment.

As viewed from the component side of the PWA, CR1 is leftmost and CR7 is rightmost, with a separation between CR1 and CR2 that is slightly wider than that between the rest of the indicators.

4.4 SWITCH SETTINGS

Table 4-2 and Figures 4-3 and 4-4 describe the location, nomenclature and function of the Maintenance Switches and their related settings.

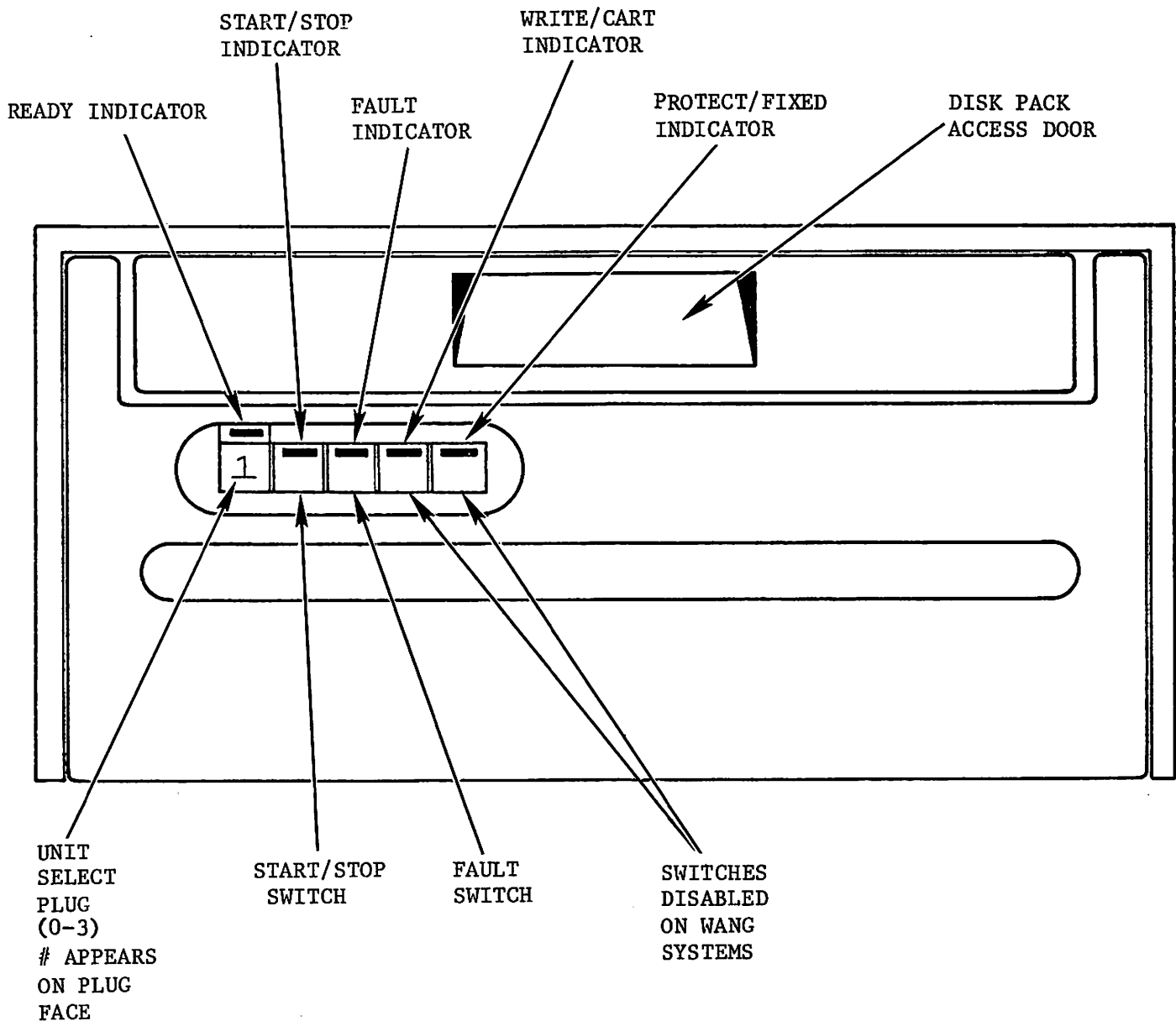


FIGURE 4-1 OPERATOR CONTROLS AND INDICATORS

TABLE 4-1
CONTROLS AND INDICATORS

| CONTROL OR INDICATOR | FUNCTION |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>CONTROL PANEL</u> | <u>CONTROL PANEL</u> |
| START/STOP (switch) | <p>Start switch energizes spindle motor and initiates the first seek mode provided the following conditions are met:</p> <ol style="list-style-type: none"> 1. The AC circuit breaker is ON. 2. The disk cartridge loading door is closed and latched with cartridge in place. The Deck is in the lowered position. 3. FAULT light is OFF (certain fault conditions do not exist - see Section 4). 4. Ground on the PICK and HOLD lines if in REMOTE start mode, or if the LOCAL start mode has been selected once started, only ground on HOLD is required to start. (REMOTE/LOCAL start mode selection switch is on I/O PWA). REMOTE/LOCAL switch should be in the "LOCAL" position. |
| START (indicator) | <p>Located within the START/STOP switch, this indicator lights only when the START/STOP switch is operated inward, turns off when switch is released. Not all units have a START indicator.</p> |

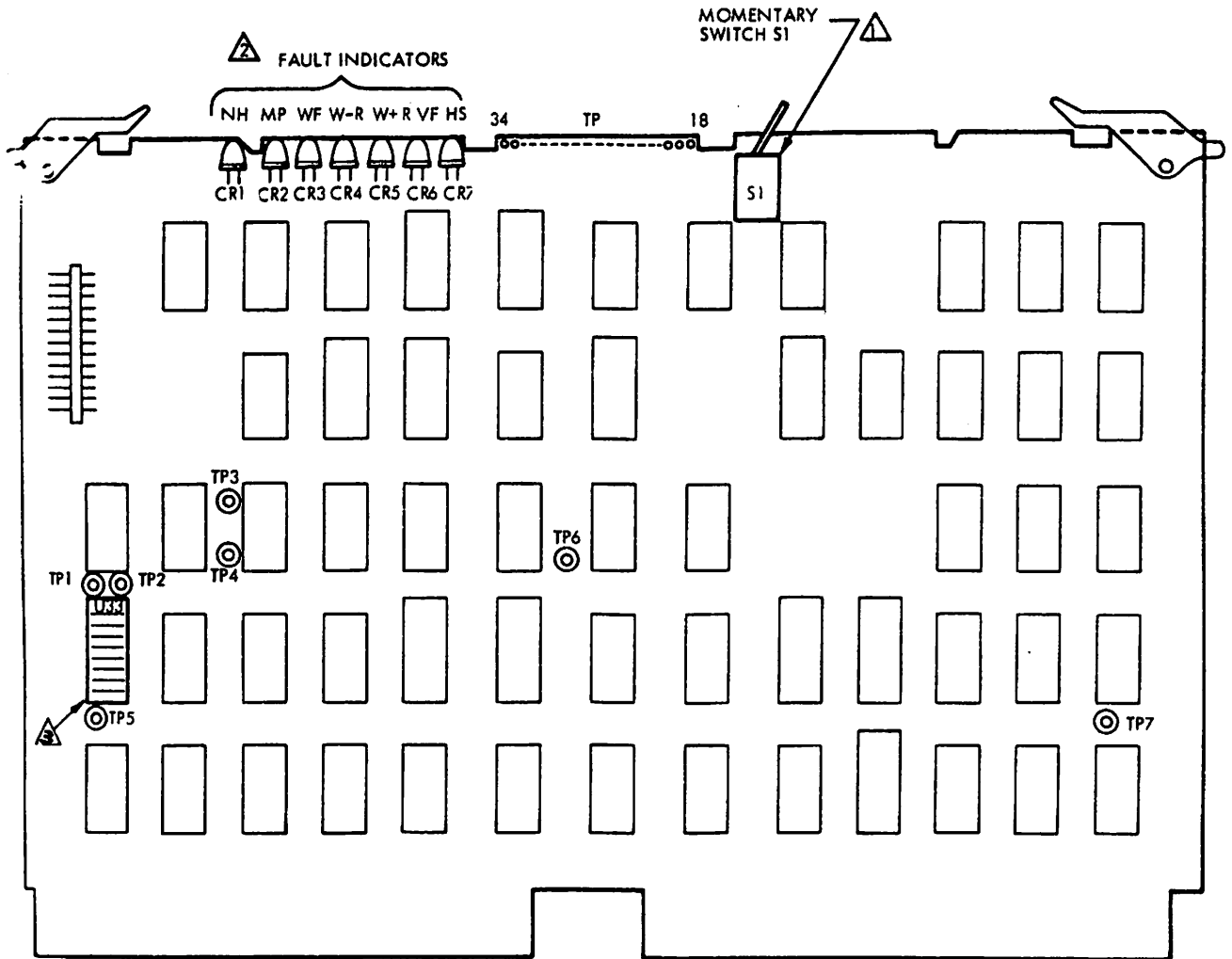
TABLE 4-1 (Cont'd)
CONTROLS AND INDICATORS

| CONTROL OR INDICATOR | FUNCTION |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| READY (indicator) | Positioned on the START/STOP switch. READY indicates unit ready status. The READY indicator is illuminated whenever unit is up to speed and heads are loaded and no fault requiring manual intervention exists within the unit. The READY light will blink throughout the spindle start and stop procedure. |
| FAULT (switch) | Clears certain fault conditions when operated. Refer to Section 6, Maintenance. |
| FAULT (indicator) | Located on the FAULT switch.* Indicates any fault condition when illuminated. Turns OFF when fault condition cleared by operating the FAULT switch. |
| PROTECT FIXED (indicator) | Indicates that the fixed volume of the drive is write-protected. |
| PROTECT FIXED switch | When operated inward, this switch disables the write driver for the fixed media. Alternate Action switch. This switch is disabled in all Wang Systems. |

*Does not indicate Seek error.

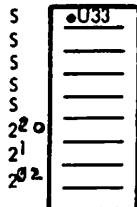
TABLE 4-1 (Cont'd)
CONTROLS AND INDICATORS

| CONTROL OR INDICATOR | FUNCTION |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROTECT CART. (indicator) | Indicates that the removable volume cartridge of the drive is write protected. |
| PROTECT CART. (switch) | When operated inward, this switch disables the write driver for the removable cartridge. Alternate action switch. This switch is disabled in Wang Systems. |
| UNIT SELECT (plug/socket) | A plastic plug which generated the computer I/O channel unit number by closing coded switch contacts in the socket into which it fits. The top of the plug is marked with a number from 0 to 3 representing the unit number. The proper numbered plug should be installed during the installation. |
| <u>DISK PACK ACCESS DOOR</u> | |
| Disk Pack Access Door Latch | The Disk Pack Access Door is unlatched by lifting with the fingers on the latch (A) that is under the lip of the recess in the access door. The latch will not release the door catch until after the spindle motor has stopped rotating and the interlock solenoid releases the catch. The START/STOP switch must also be released (OUT) before the solenoid will release the catch. In the event of the loss of AC power the interlock solenoid will not release the catch in order to prevent damage to the cartridge. |



- ▲ SHOWN IN "OFF" POSITION
- ▲ THE FAULT TYPE ABBREVIATIONS SHOWN ARE ETCHED ON THE PWA UPSIDE DOWN NEXT TO THE APPLICABLE INDICATOR.
- ▲ BINARY WEIGHTS MUST BE PROGRAMMED TO INDICATE DEVICE CAPACITY, BY INSERTING JUMPER (ITEM 62) INTO SOCKET U33 S IS SPACE.

30MEG 2°
 60 MEG 2° 2'
 90 MEG 2° 2''



* SEE APPENDIX "A" FOR TEST POINT IDENTIFICATION

FIGURE 4-2
 ELECTRONICS MODULE CONTROL/MUX PWA -
 (WITH FAULT INDICATORS AND FAULT RESET SWITCH)

TABLE 4-2
 MAINTENANCE SWITCHES AND FUNCTIONS

| SWITCH | NAME | LOCATION | FUNCTION |
|--------|-------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1 | Fault Clear | Cntl/Mux PWA | <p>Momentary toggle switch which performs several functions in conjunction with the Maintenance Display Indicators CR1 - CR7 as follows:</p> <ol style="list-style-type: none"> 1. Resets the fault latches when in the non-microprocessor fault display mode. 2. The Same actuation of S1 that resets fault latches (#1 above) also initiates the present cylinder address display mode and causes the two highest order binary bits of the present address to be displayed on CR6 and CR7. Subsequent S1 actuations display the remainder of the cylinder addresses and a separator state. 3. After the separator state following cylinder address display, actuations of S1 cause the microprocessor-detected error condition to be displayed on CR3-CR7, resets the M.P. fault store and sets fault code into the fault latches for display on CR3-CR7. |

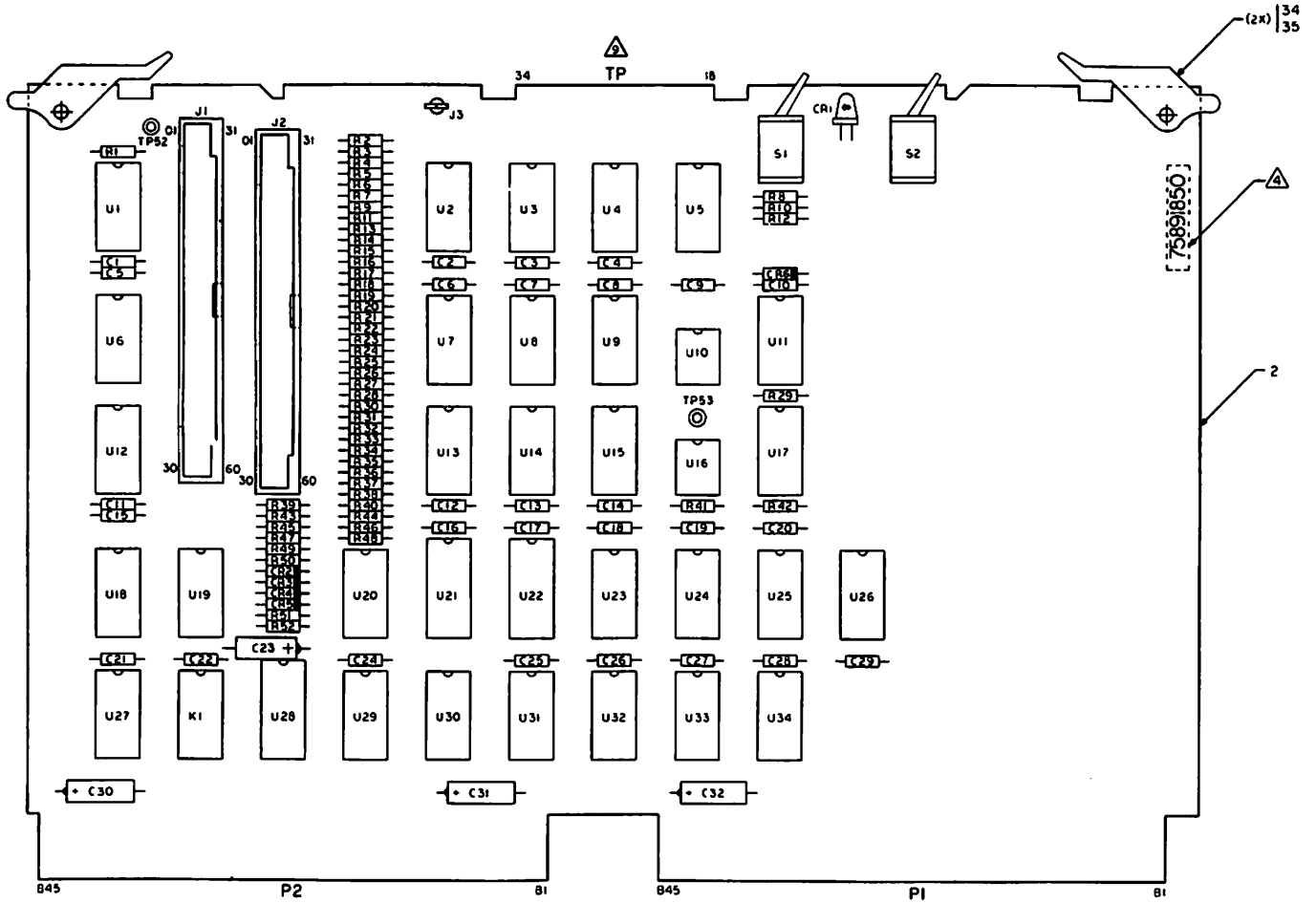
TABLE 4-2 (Cont'd)
 MAINTENANCE SWITCHES AND FUNCTIONS

| SWITCH | NAME | LOCATION | FUNCTION |
|--------|--------------------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1 | Data/Servo Select | Servo Fine PWA | Used for head alignment. Select either read data or servo dibits for use in aligning the read/write or servo heads. Positioning this switch has no effect unless the Head Alignment Extender PWA is plugged into EM4 and a special cable is connected from J2 of the Servo Fine PWA to J1 on the extender. Chapter IX discusses the use of this switch and switches on the extender. |
| S1-8 | Velocity Gain Adj Enable | Servo Coarse PWA | When S1-8 is in the ON position it enables the use of the fault latches and fault indicators CR3- CR7 (on the Control/Mux PWA) to display the status of the servo system velocity gain adjustment. The switches S1-1 through S1-8 are OFF when switched to the right side of the switch. See Figure 4-5 and refer to Table 4-3 for more information on the use of this switch. |

TABLE 4-2 (Cont'd)
 MAINTENANCE SWITCHES AND FUNCTONS

| SWITCH | NAME | LOCATION | FUNCTION |
|--------------------------|----------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1-1* through S1-7 | Sector Number Select | Servo Course PWA | The voltages on the seven outputs of this switch are interpreted as a seven digit binary number by the microprocessor. It is used by the M.P. to generate the number of sector pulses per revolution required by the drive user. See paragraph 3.10.1. in the CDC Hardware Maintenance Manual for more details on these switches. Refer to Table 4-3. |

* Not used normally for maintenance, but mentioned here to complete the description of switch S1 on the Servo Coarse PWA.

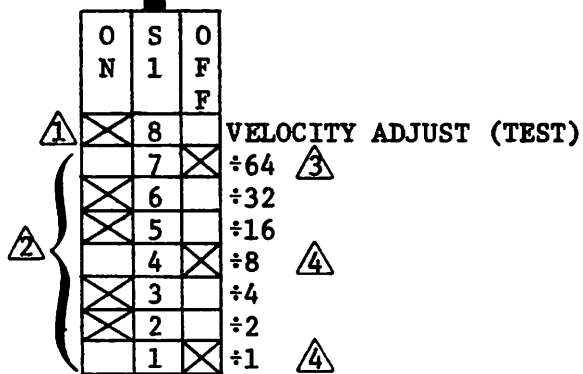
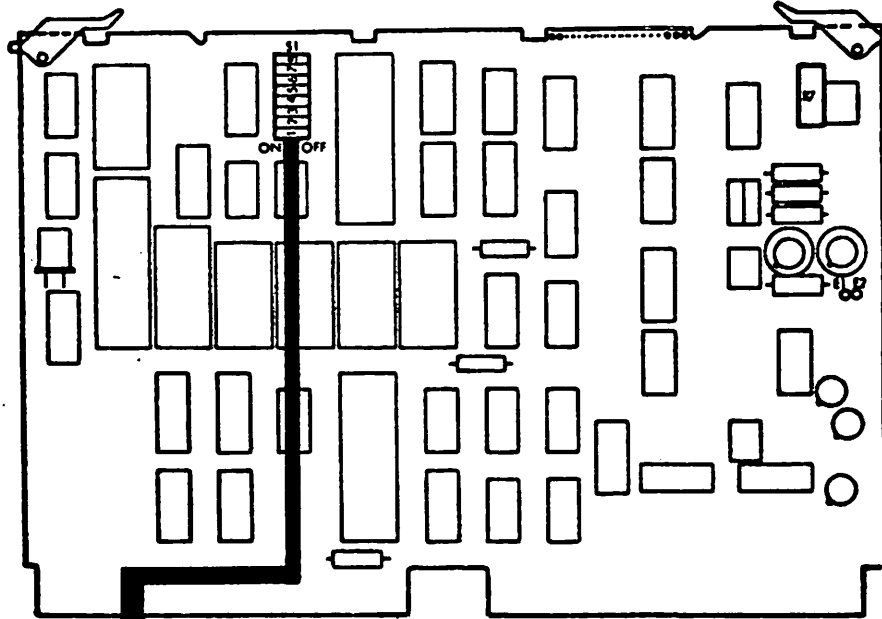


* SEE APPENDIX "A" FOR TEST POINT IDENTIFICATION

FIGURE 4-3 I/O CIRCUIT PWA PCB

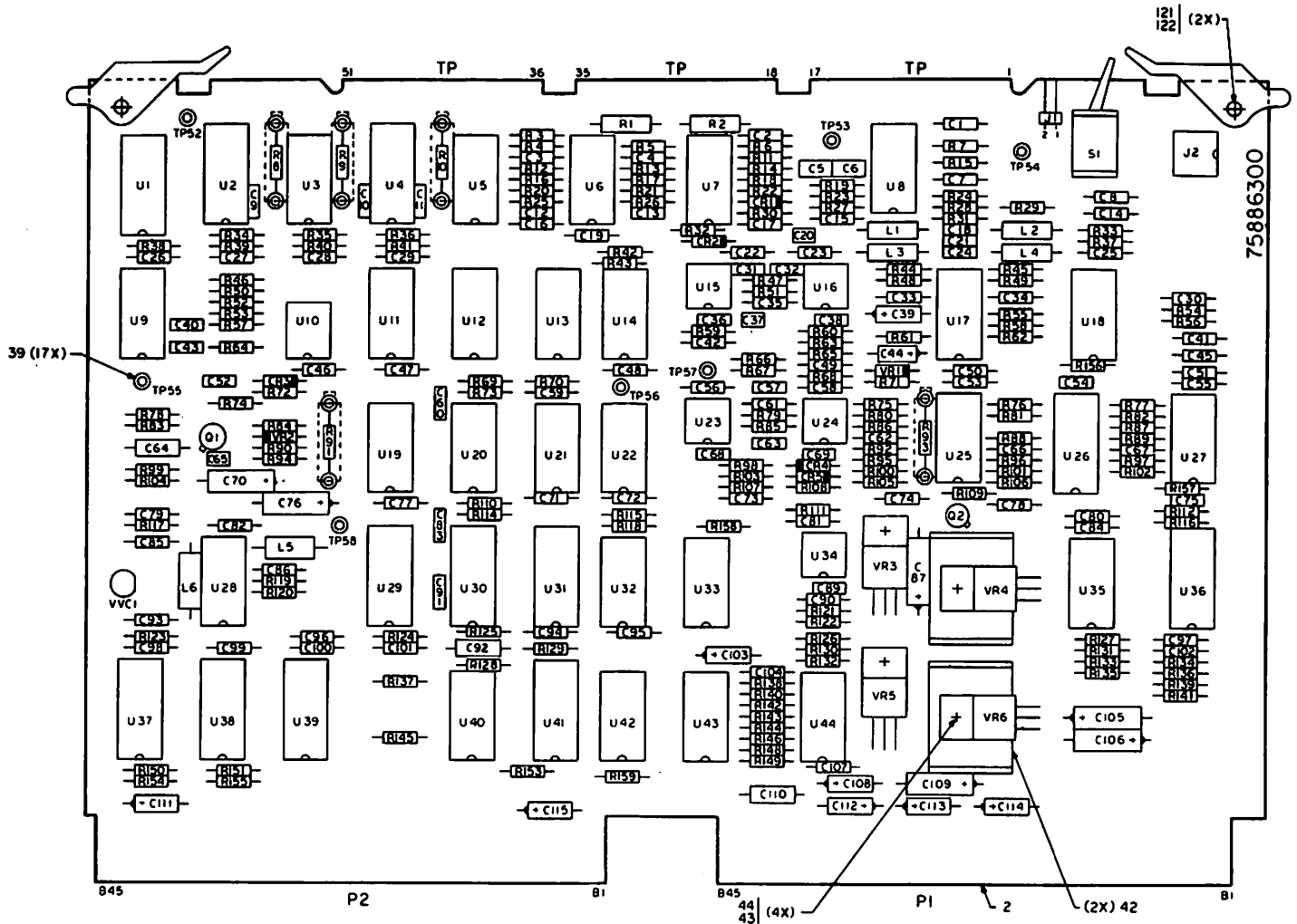
COURSE SERVO BOARD

☒ INDICATES SELECTION



- NOTES: ① S1 MUST BE ON (DOWN) FOR NORMAL I/O OPERATION.
- ② NO. OF SECTORS ARE SET BY SELECTING COMPLEMENT I.E., FOR 64 SECTORS SET S1-7 OFF AND S1-1 THRU S1-6 ON.
- ③ FOR 2200 64 SECTOR
- ④ FOR 2200VS 9 SECTORS

FIGURE 4-5A MICROPROCESSOR PCB - (SERVO-COURSE)



* SEE APPENDIX "A" FOR TEST POINT IDENTIFICATION

FIGURE 4-4 DATA/SERVO PCB - (SERVO FINE)

SERVO COARSE

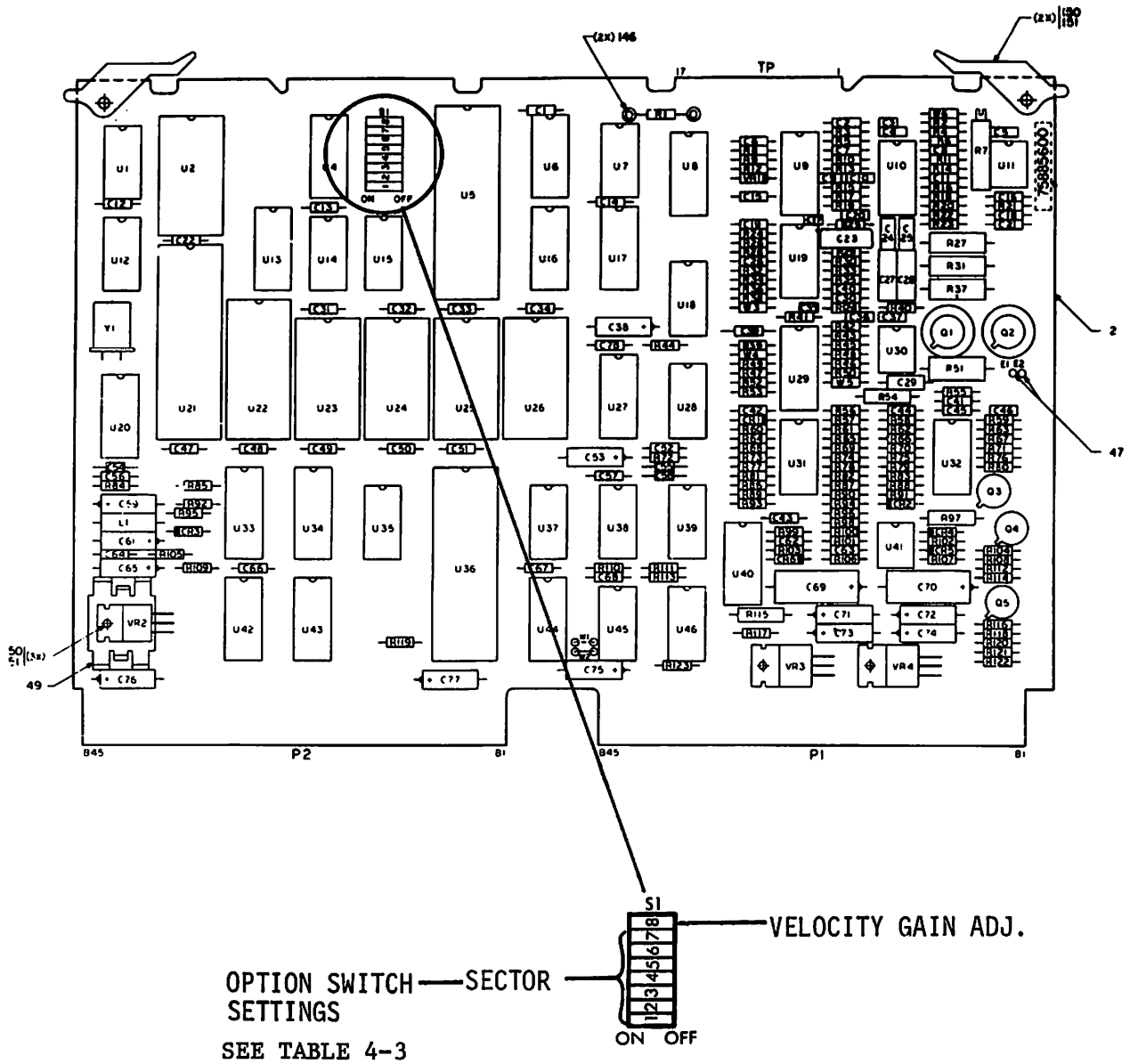
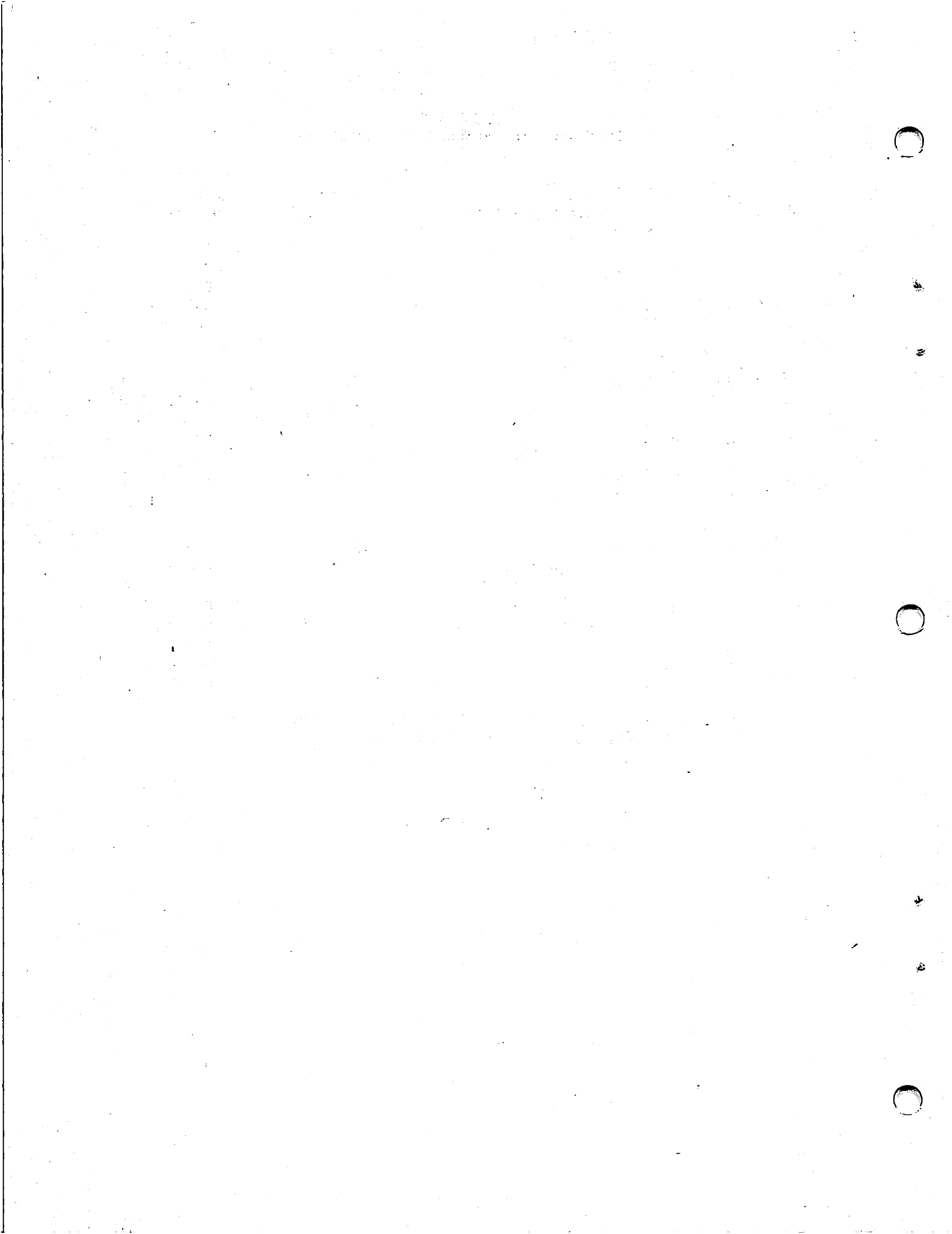


FIGURE 4-5 MICROPROCESSOR PCB - (SERVO COARSE)

TABLE 4-3
SERVO-COARSE SECTOR OPTION SWITCHES

| S1-- | | | | | | | Number of Sectors (in decimal) | Includes Sector Numbers | |
|------|----|----|---|---|---|---|--------------------------------------|-------------------------------|--|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | | | |
| 64 | 32 | 16 | 8 | 4 | 2 | 1 | (Binary Weight) | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | | 1 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | | 2 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | | 3 | |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | | 4 | |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 | | 5 | |
| --- | | | | | | | etc.* | --- | |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | | 8 | |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | | 9 | |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | | 16 | |
| --- | | | | | | | etc.* | --- | |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | | 24 | |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | | 32 | |
| --- | | | | | | | etc.* | --- | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | | 64 | |
| --- | | | | | | | etc.* | --- | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 126 | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 127 | |

* The intervening values follow the binary/decimal number equivalence rules and can easily be filled in by the reader.



CHAPTER V
INITIAL POWER APPLICATION

5.1 PRELIMINARY CHECK

Prior to preparing for the initial power application, assure that the following items have been accomplished.

- A. Interior of unit is clean.
- B. Carriage Locking pin is in operating position.
- C. Plug AlPl (Voice Coil Power) disconnected
- D. AC Breaker off.

5.2 PRELIMINARY CONNECTIONS

Install as follows:

- A. "A" Cable to I/O Board. (See Figure 5-1)
- B. "B" Cable to Cntl Mux
- C. Terminator to I/O board of last drive.

5.3 POWER APPLICATION

A. POWER CABLE

Plug the power cable into the AC outlet. The outlet should be 120V 15A 60HZ, 2-pole 3 wire connector.

B. AC BREAKER

Turn the AC Breaker on. The blower should start immediately. If the blower doesn't activate, check the connector for AC Power. Do not try to start the Disk until blower is operating.

C. REMOTE/LOCAL (REM/LOC) SWITCH (I/O Board)

Set the REM/LOC switch on the I/O PCB (located in the electronics module) to LOC.

****NOTE****

If a fault exists, clear the fault before continuing.

D. LOAD WORK (Scratch) CARTRIDGE

Insert the Work (Scratch) cartridge in the unit by opening the front door, sliding in the cartridge and then closing the door. See section 5.5 for the proper procedure to install the Disk Cartridge.

E. START SWITCH

Activate the Start switch on the Operator Panel. The Spindle should start turning after approximately a 6 second delay.

****NOTE****

Allow the unit to run for 5 min.

5.4 POWER SHUTDOWN

- A. Activate the start/stop switch to stop the unit.
- B. When spindle has ceased movement, turn off AC Breaker.
- C. Connect A1P1 (Voice Coil Power) and turn on Breaker.
- D. Activate start/stop switch to start.
- E. Carriage should load in approx. 20-30 sec.
- F. If drive is cabled to an FTU, refer to Section 3.6 for FTU operation.
- G. Run FTU program for diagnostics.

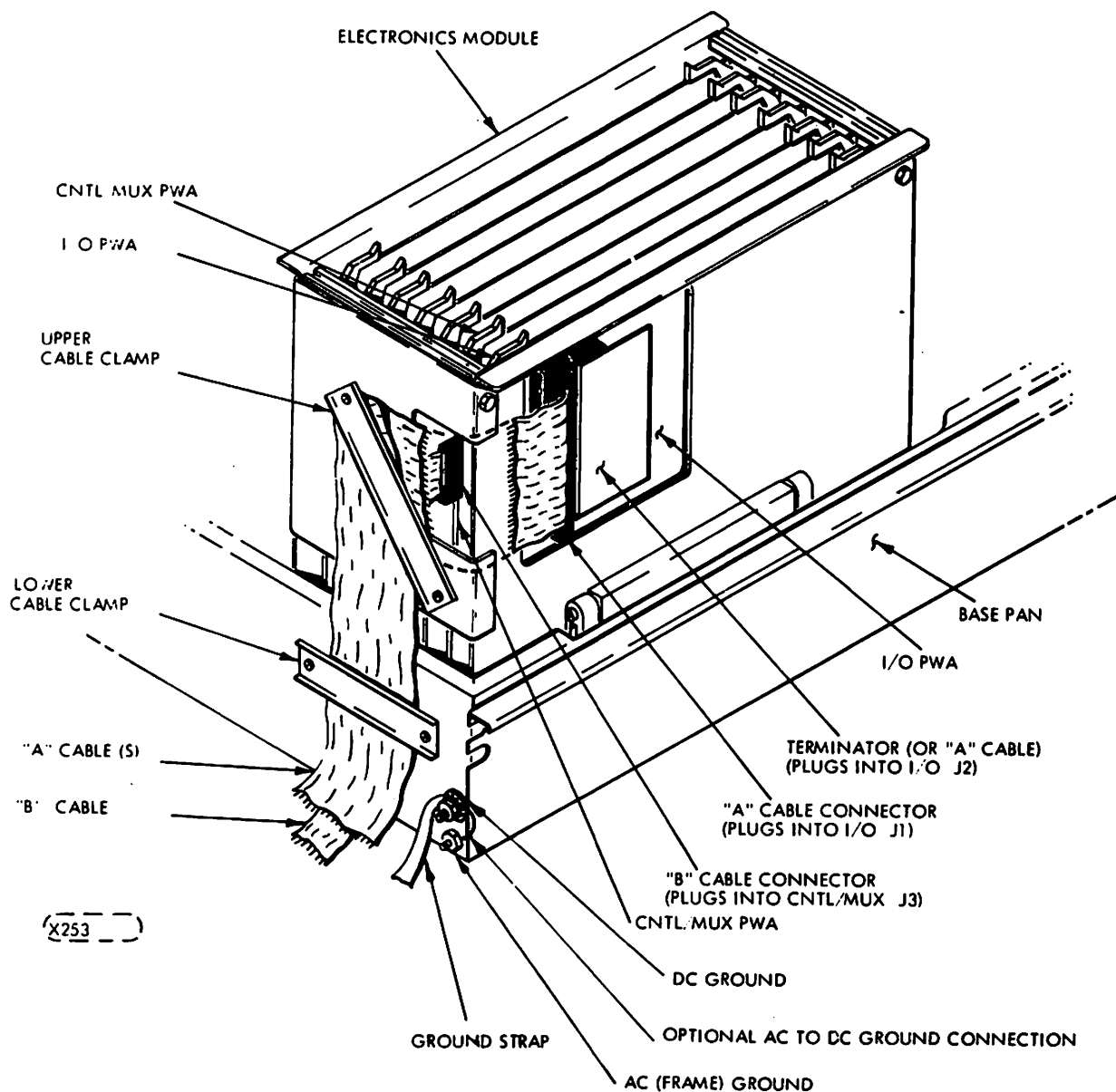


FIGURE 5-1 I/O CABLE INSTALLATION

5.5 DISK CARTRIDGE INSTALLATION

The Disk Cartridge must be stored in the same environment as the CMD Drive for 60 minutes preceding its use.

1. Release latch under lip of access door that is recessed and pull down access door. See figure 5-2

NOTE: Power must be ON, the START/STOP switch out, and FAULT lamps must be off to release lock on cartridge door.

2. To separate dust cover from the disk cartridge, push cover release button toward center of cartridge.

3. Disengage dust cover from disk cartridge. Set cover aside upside down to prevent dust from collecting inside the cover.

CAUTION

Make certain that the Read/Write heads are fully retracted.

4. Slide disk cartridge into receiver track, ensuring that the head opening is toward rear of the drive.

5. Push handle down. Push cartridge rearward until it stops.

6. Close cartridge access door and press the door closed until it is latched. The cartridge slides into place on the spindle automatically as the access door is closed.

7. Store cartridge cover upside down in some convenient location.

8. Operate START/STOP switch to apply power to spindle motor.

NOTE: If the spindle motor will not rotate, disk cartridge access door may not be properly closed, the cartridge may not be properly seated on the spindle chuck or the cartridge receiver/base may not be all the way down on the lower chassis.

5.6 DISK CARTRIDGE REMOVAL

5.6.1 NORMAL REMOVAL

Refer to figure 5-2 for the following procedure.

1. Operate START/STOP switch to stop drive (Switch out).
2. Pull down the cartridge access door after the READY indicator ceases blinking and extinguishes entirely.
3. Pull the cartridge out of the receiver with sufficient force to overcome the detent action.
4. Place the dust cover in position on the cartridge and fold over top handle.

NOTE: The handle may be swung out to carry the cartridge but do not push the cover release button.

5. Close the access door if another cartridge is not installed.

5.6.2 POWER FAILURE OR EMERGENCY STOP REMOVAL

Refer to section 2.8.2 of the CDC Hardware Maintenance Manual.

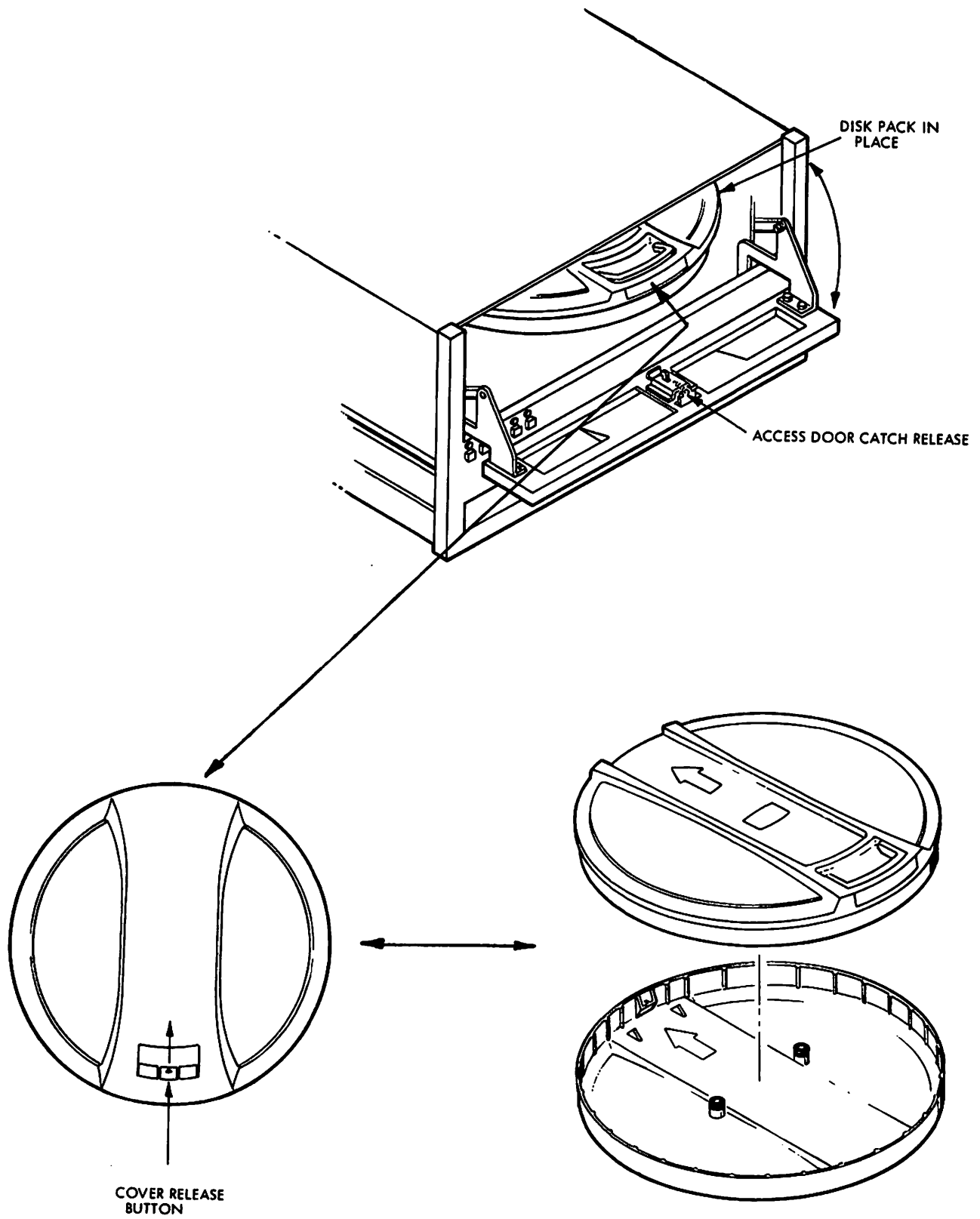


FIGURE 5-2 DISK CARTRIDGE INSTALLATION/REMOVAL

CHAPTER VI
CHECKS AND ADJUSTMENTS

6.1 GENERAL

6.2 HEADS LOADED SWITCH ADJUSTMENT

- A. Stop and power down.
- B. Remove the disk cartridge.
- C. Remove the top cover.
- D. Identify the heads loaded switch leadwires.
- E. Connect a multimeter (set at RX1) across the switch terminals.
- F. With the carriage retracted, the multimeter should indicate zero ohms.

****CAUTION****

THE HEADS MUST NOT BE PERMITTED TO LOAD ON
THE DISK; THEREFORE DO NOT MOVE THE CARRIAGE
TOO FAR FORWARD.

- G. Slowly move the carriage toward the spindle while observing the multimeter. The multimeter MUST indicate infinite ohms when the carriage has traveled $0.25 \pm (0.1)$ inch from full retract stop. (The distance is measured from the rear edge of the carriage to the magnet.) If an adjustment is needed, proceed to step H. If no adjustment is needed, proceed to step I.

****CAUTION****

MAKE CERTAIN THAT THE CARRIAGE IS FULLY
RETRACTED WHILE PERFORMING STEP H.

- H. Loosen the screws securing the heads loaded switch to the mounting bracket. Adjust the switch position until it actuates after a 0.25 inch travel from full retract stop.
- I. Install the top cover.
- J. Install the disk cartridge.
- K. Set the AC POWER circuit breaker to ON.
- L. Press the START switch to activate the drive.

6.3 PULSE CIRCUITS TESTS

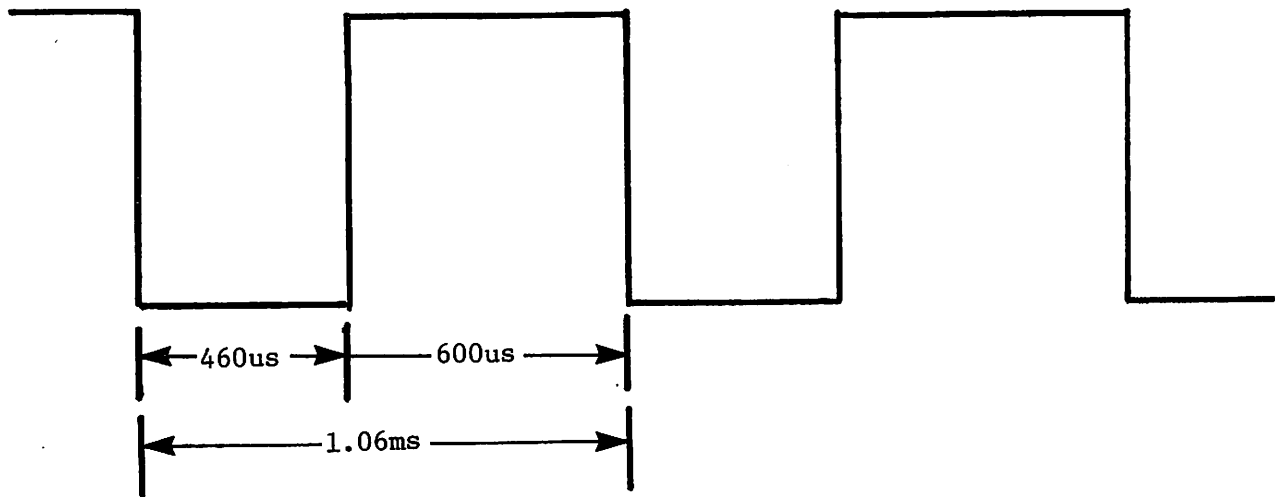
A. SPIN SPEED SENSOR TEST

1. Put the Unit in STOP mode. When the disk has stopped completely, turn OFF the AC circuit breaker.
2. Connect the oscilloscope probe channel A to TP16 of the Servo-Course PWA.
3. Set the oscilloscope vertical sensitivity to 2 Volt/Div for channel A & B. Set the horizontal sensitivity to 0.1 Millisec/Div.
4. Set the AC POWER circuit breaker to ON. Activate the START switch.

5. When the READY indicator comes on, the unit should be up to speed. The pulse width of the Spin Speed Sensor pulses should be approximately 120 us (this is not critical and varies slightly with spindle speed). See Figure 6-1 "A". The width after shrinking is more important (Ref step 6).

6. Change the horizontal sensitivity to 1us per div. and connect channel B probe to P2-B07 of the Servo-Coarse PWA. The pulse should be shrunk to about 1 us in duration (100 ns min, 8.5 us max). See Figure 6-1 "B".

A. BEFORE SHRINKING



B. AFTER SHRINKING

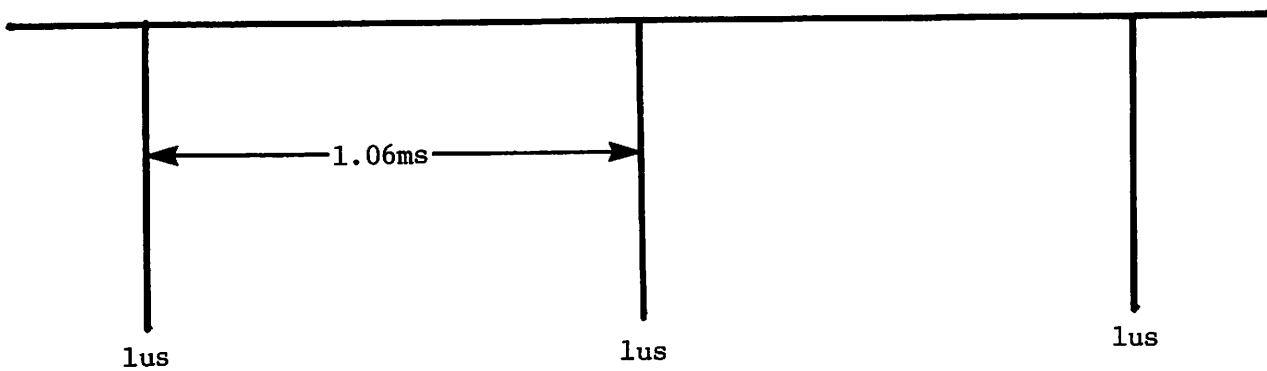


FIGURE 6-1 SPIN SPEED WAVEFORMS

6.4 SERVO SYSTEM ADJUSTMENT AND DISABLING PROCEDURE

There is only one adjustment that is required by field service personnel; this is the Velocity Gain Adjustment. Misadjustment of this control may cause difficulties that appear to be malfunctions of the hardware. If any servo PWA is replaced or swapped between drives and a malfunction appears that wasn't there before, check velocity gain.

A. VELOCITY GAIN ADJUSTMENT

1. Position switch S1-8 on the Servo Coarse PWA to the OFF (open contacts) position (right side down). See Fig. 4-2.
2. Actuate the momentary switch on the Control/Mux PWA (S1) and observe the fault indicators.
3. The velocity gain is adjusted to the correct value using adjustable resistor R7 on the Servo Coarse PWA.
4. When S1 on the Control/Mux PWA is actuated, the carriage seeks to and stops at track 822.
5. One of the Fault indicators #3 through #7 will light to indicate the status of the Velocity gain.
6. Table 6-1 below relates the interpretation of the Fault indicators when S1 is activated and indicates which way to turn R7 in order to bring the Velocity gain into proper adjustment.
7. Each time S1 is actuated, the drive performs a seek to track 822 and the Microprocessor calculates and stores the velocity of the carriage.
8. The value of stored velocity is compared with the correct value in the Microprocessor which then commands one of the indicators #3 through #7 be activated, depending on the results of the comparison.

TABLE 6-1
VELOCITY GAIN ADJUSTMENT TABLE

| INDICATOR# | INTERPRETATION | SERVO COURSE R7 ADJUSTMENT |
|------------|-------------------------|--------------------------------|
| CR 3 | Velocity gain very low | Turn clock-wise coarse |
| CR 4 | Velocity gain low | Fine tune clock-wise |
| CR 5 | Velocity gain all right | No adjustment necessary |
| CR 6 | Velocity gain high | Fine tune counter clock-wise |
| CR 7 | Velocity very high | Turn counter clock-wise coarse |

Adjust Resistor R7 slowly and actuate S1 after each R7 adjustment until only Fault indicator #5 is on, and then continue to turn the R7 adjustment screw an additional 1/4 turn in the same direction. Return S1-8 on the Servo Coarse to its normal (ON) position.

6.5 SERVO DISABLE PROCEDURE

If it should be necessary to disable the servo system, follow the procedure given below:

****NOTE****

This procedure does not disable the
Emergency Retract Circuit.

- A. STOP and power down.
- B. Remove the top cover of the unit.
- C. Remove the Servo Coarse PWA from the Electronics Module.
- D. Connect/Jumper Pin E1 to E2. These are located in the middle, right side (component side) of the Servo Coarse PWA. (Jumper #726-9679)
- E. Replace Servo Coarse PWA. Apply power as needed.
- F. Remove jumper on E1 and E2 when it becomes necessary to enable the servo system again.
- G. Replace top cover and restore to normal operation.

CHAPTER VII
FIELD TEST UNIT (FTU) TB216

7.1 INTRODUCTION

The CONTROL DATA TB216 Field Test Unit (FTU) is a portable, self-contained tester for exercising and/or simulating ON-LINE operations in Storage Module Drives (SMD's), and Cartridge Module Drives (CMD's).

The FTU is housed in a suitcase-type carrying case that provides a front panel assembly, a logic chassis, and an integral power supply. The circuitry of the tester is based on a microprocessor and associated integrated circuits. (See ~~APPENDIX A~~ ^{FIGURE 7-1} for FTU illustration.)

The suitcase contains space for storing the power cable, all required I/O cables, the head alignment card, and the CMD head alignment adapter. The head alignment card plugs into the logic chassis and permits individual head alignment, using the tester LED display to indicate head offset.

7.2 FUNCTIONAL DESCRIPTION

The TB216 provides seven access modes, six read/write modes, and three modes for determining head selection.

7.2.1 Access Modes

In Access Mode (seeks), the movable heads in the drive are positioned over a particular cylinder on the disk pack.

Direct Seek

The drive under test performs a single seek to the cylinder number selected by the operator.

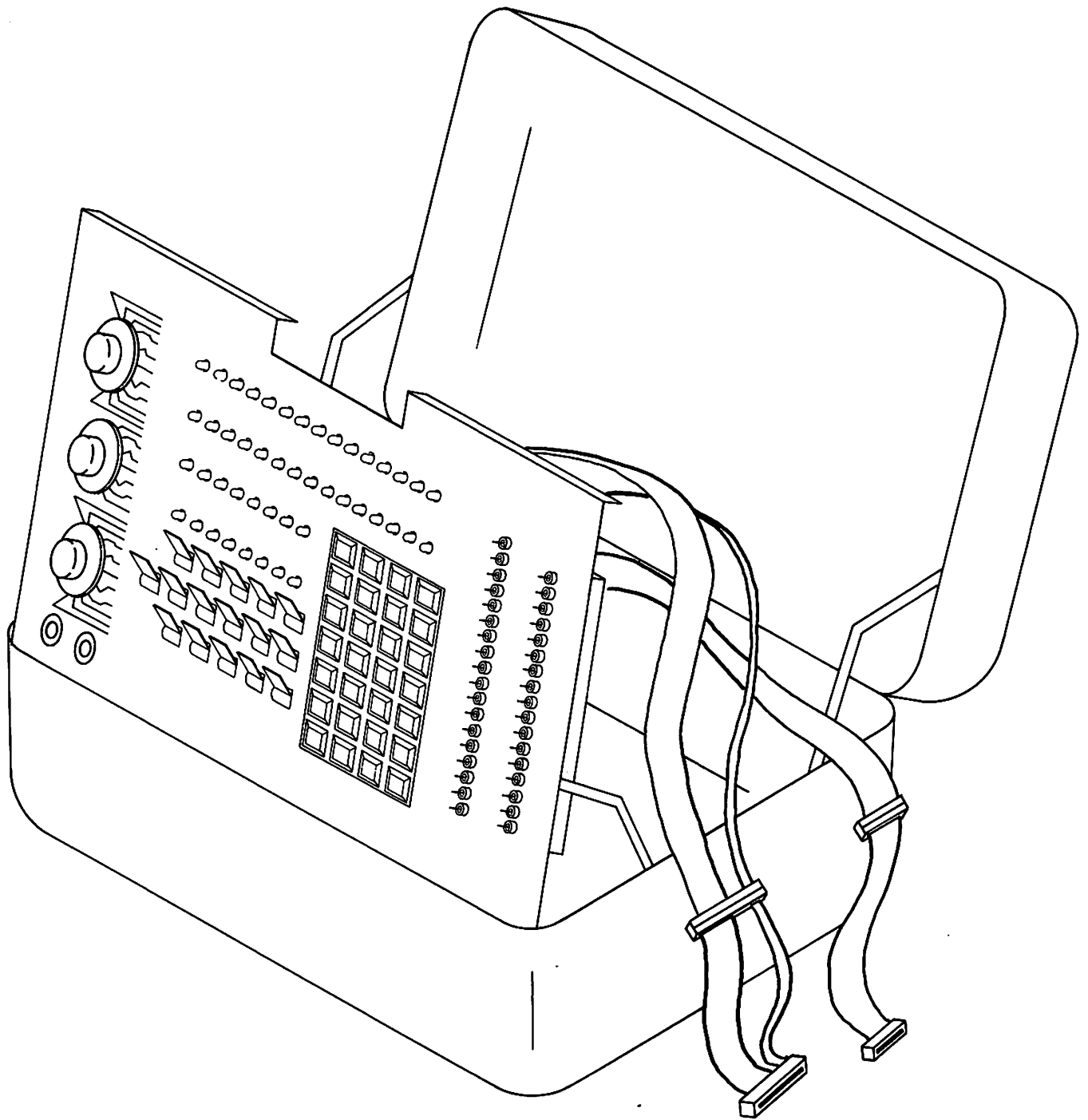


FIGURE 7-1 FIELD TEST UNIT (FTU)

Direct Continuous

The drive performs seeks between cylinder zero and the cylinder number selected by the operator.

Sequential Forward

Starting at cylinder zero, the drive performs sequentially increasing seeks at cylinder intervals selected by the operator. After seeking the last track, it will return to cylinder zero and repeat the operation.

Sequential Reverse

Starting at the maximum cylinder, the drive performs sequentially decreasing seeks at cylinder intervals selected by the operator. After seeking cylinder zero, it returns to the maximum cylinder and repeats the operation.

Sequential Forward/Reverse

Starting at cylinder zero, the drive performs sequentially increasing seeks up to the maximum cylinder followed by sequentially decreasing seeks down to cylinder zero. The seeks are in increments selected by the operator.

Random Seek

The drive seeks cylinder addresses generated randomly by the microprocessor.

X to N Seek

The drive seeks from each cylinder to every higher numbered cylinder and back, thus performing all possible seeks.

7.2.2 Read/Write Modes

The TB216 generates serial NRZ write data at a rate determined by the servo clock signal transmitted from the unit under test. When a repeated access mode is selected, a read/write operation is completed at the selected cylinder. Then a seek is initiated to the next cylinder address (as determined by the access mode) and the read/write operation repeated. This seek -- read/write sequencing continues until the end of test or until the STOP key is pressed. For Direct Seeks, the read/write operation continues at the selected cylinder (depending upon the head select mode) until the STOP key is pressed.

The mode of head selection chosen determines the number of tracks read or written during each read/write operation. For manual head selection, the FTU reads or writes only the track under the head selected. For sequential head selection, the FTU sequences the heads so as to read or write each track in the cylinder. When the highest numbered head has been exercised, the drive seeks to another cylinder (except in Direct Seek) and repeats the read/write operation at that new cylinder, starting with head zero.

Write Format

The FTU writes each selected track with the appropriate track address and a repetitive 16-bit data pattern that has been entered on the FTU keyboard. The FTU also provides a means for indicating a defective track when using the Write Format mode.

Write/ Read Format

The FTU commands the drive to alternate between writing the appropriate track address and repetitive data pattern and then reading them back on each selected track.

Write

After the track address has been read and verified, the FTU writes each selected track with a repetitive 16-bit data pattern that has been entered on the FTU keyboard.

Read

The FTU commands the drive to read data from each selected track after the track address has been read and verified.

Write/Read

The FTU commands the drive to alternate between writing a repetitive data pattern and then reading it on each selected track.

Access Only

The FTU does not command a read or write operation after each track is accessed.

7.3 OPERATION OF THE FTU

7.3.1 Operating Voltage Selection

The FTU is connected at the factory for use with a 120 VAC 50/60 Hz power source. By changing internal connections, the FTU may be converted to operate at 100, 200, 220, or 240 VAC. For each connection, the FTU will operate with a line frequency of either 50 or 60 Hz. To change the nominal input voltage, perform the following:

1. Open the FTU cover, Raise front panel assembly.
2. Remove five screws securing the transformer terminal block cover to power supply assembly and remove cover to expose terminal strip. See Figure 7-2.
3. Relocate jumper wires and wires connected to RFI filter on terminal strip. Refer to Figure 7-3.

TRNSFORMER
TERMINAL
BLOCK
COVER

TERMINAL
STRIP

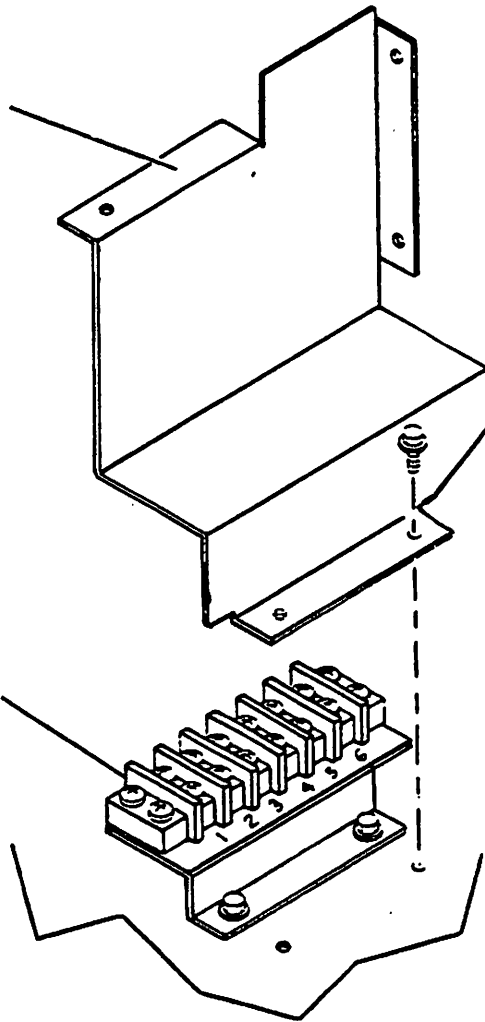


FIGURE 7-2 ACCESSING TERMINAL STRIP TB216

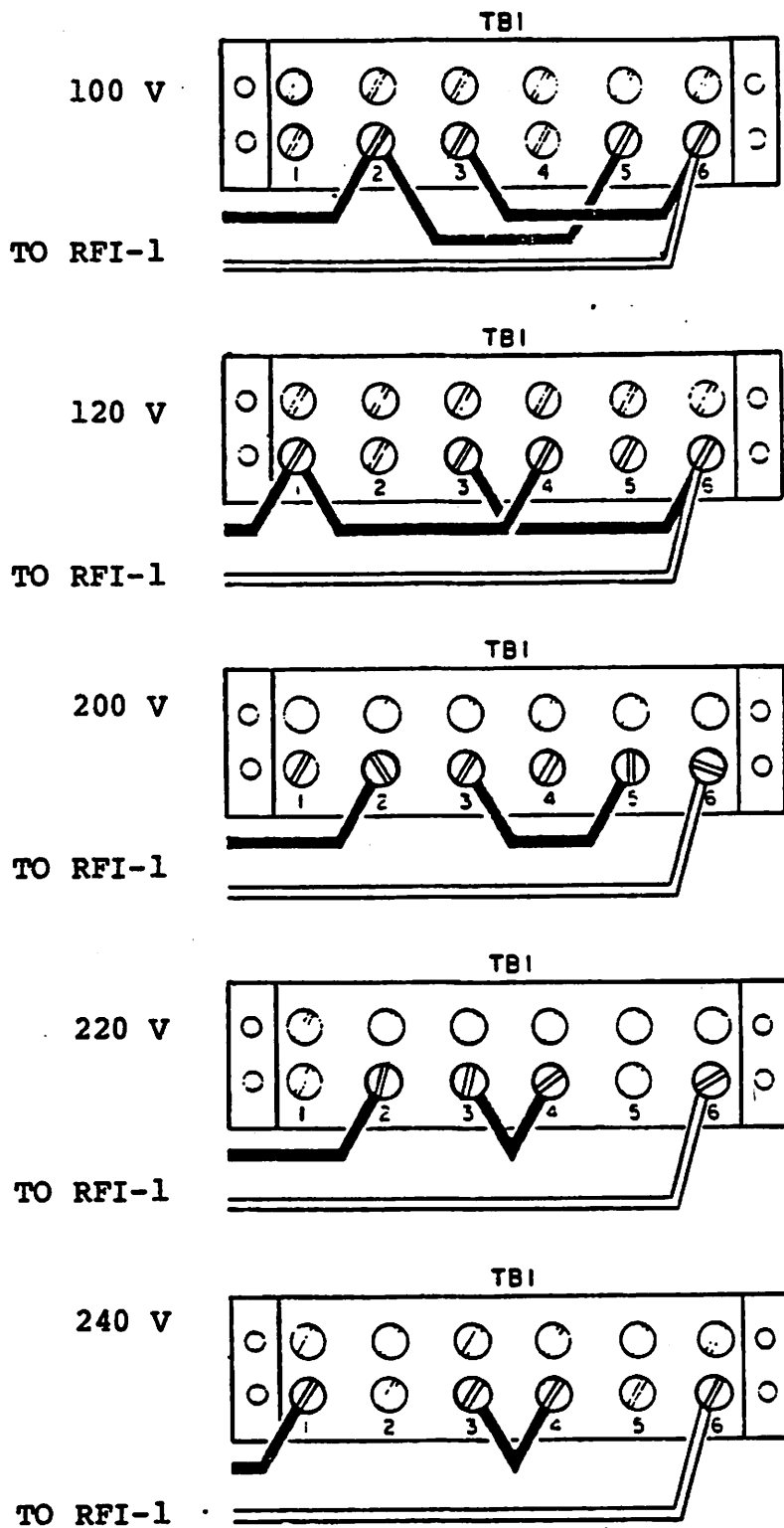


FIGURE 7-3 TERMINAL STRIP CONNECTIONS TB216

4. Replace transformer terminal block cover, securing it with hardware removed in step 2.

NOTE:

Perform step 5 for 200, 220, or 240 VAC operation.

5. Cut off molded power plug at end of power cord. Replace with a locally procured plug as follows:
 - a. Connect black wire (Phase 1) to Brass colored terminal.
 - b. Connect white wire (Neutral) to silver colored terminal.
 - c. Connect green wire to ground terminal.
6. Lower front panel assembly. FTU ready for operation with new line voltage.

7.4 CONTROLS AND INDICATORS

The functional descriptions of the controls and indicators located on the front panel of the tester (Figure 7-⁴~~2~~) are given in general terms below. Switch positions are listed in the left column, and the drive and/or tester operation corresponding to the switch setting is described in the right hand column labelled FUNCTION. The same arrangement pertains to the Keyboard keys. Finally the LED indicators are listed with descriptions of the conditions causing them to light.

The only control not located on the front panel is the ON/OFF power circuit breaker. It is located on the power supply module.

CONTROL/INDICATOR

FUNCTION

DATA ENTRY This is a rotary switch that is set to allow specific information to be entered into the FTU memory through the keyboard. Information can be entered in hexadecimal, decimal or binary code unless otherwise specified. Each switch position enables a display on one of 16 LED's mounted on the top row of the front panel. The LED's indicate data previously entered in that segment of memory. A description of each switch position follows:

DEVICE TYPE: A four character code is loaded into the FTU. This code programs the FTU to exercise a specific type of drive. 80-1 8901 80-2 8903 80-3 8905

UNIT NUMBER: The logical address of the drive being tested, determined automatically by the tester, is displayed on the top row of 16 LEDs.

DESTINATION: The track destination for a direct seek is loaded into the tester's memory in the Direct Seek and Direct Continuous mode.

HEAD: With the HEAD toggle switch in the MAN position, a specific movable head address is selected.

RECORD: A specific record address is loaded, provided that the RECORD toggle switch is in the MAN position.

FIXED HEADS: The number of fixed heads is loaded, and the microprocessor is set up for fixed head access.

DATA PATTERN: A sixteen bit data pattern is entered into the tester memory. In write operations, this data pattern is repeated throughout the data field.

STATUS BYTES: Up to sixteen different status words are displayed on the top row of 16 LEDs which indicates the code of the status word which was entered on the keyboard. Error bypass information and 512 memory locations may also be loaded by pressing the CLR ENT key to enter data.

SEEK INCREMENT: In sequential access modes, the FTU is programmed to command seeks to every nth cylinder after the number "n" has been entered on the keyboard. For example, if three is entered, the drive will seek every third cylinder. With no entry, the seek increment is one, and no cylinders are skipped in the sequence.

MPU ADDRESS: A valid MPU address can be entered via the keyboard and displayed on the bottom row of 16 LEDs. When the LOAD key is pressed, the address is transferred to the top row of 16 LEDs and the data at this address is then displayed on the bottom row of 16 LEDs. This operation is for use only by an operator who is extremely knowledgeable in the microprocessor machine language.

MPU DATA: For a given MPU address, new data can be entered on the keyboard and loaded by pressing the LOAD key. The bottom row of LEDs displays the new data in the left eight bits and the next address in the right eight bits. The address on the top row of 16 LEDs is incremented by one. This operation is for use only by an operator who is knowledgeable in the microprocessor machine language.

B: A valid write code must be entered if the drive is to be commanded to write on the diskpack. Otherwise, the WT PROT LED will flash.

C: Ordinarily, the number of sectors used by the drive is automatically calculated by the FTU. In this position, the FTU can be programmed to operate on a different sector count.

D: A maximum data length, other than that calculated by the FTU, is loaded into the tester's memory.

E-F: Unused

READ/WRT SELECT SWITCH This is a rotary switch which determines the operation performed by the drive after each track has been accessed. A description of each switch position follows:

WRT FORMAT: The address and data pattern is written on the selected track.

WRT/RD FORMAT: The drive alternates between writing the address and data pattern and then reading them back on a selected track.

WRITE: The data pattern is written on a selected track after the address has been read and verified. On drives that transmit MFM read data to the tester, the address is not read.

READ: The data pattern is read from a selected track after the address has been read and verified. On drives that transmit MFM read data to the tester, the address is not read.

WRT/RD: Alternately, the data pattern is written and then read on a selected track.

ALIGNMENT: In head alignment procedures, the offset of a selected head is displayed in coded form on the bottom row of 16 LEDs.

ACCESS ONLY: After accessing a cylinder, the FTU does not command any write or read operations.

7: The drive randomly performs either a write or a read operation on each selected track.

8-F: Unused.

ACCESS SELECT
SWITCH

This is a rotary switch that enables selection of any of a number of accessing modes for the drive. These modes vary from a direct seek to a particular cylinder to a more complicated pattern of seeking between different cylinders. A description of each switch position follows:

MANUAL TAGS: The Tag and Bus Data displayed on the bottom row of 16 LEDs will be put on the I/O lines when the GO key is pushed.

DIRECT SEEK: When the GO key is pressed, the drive seeks to the particular cylinder stored in the destination register. With the SINGLE/CONT switch in the CONT position and the EOT STOP switch up, the seek will be commanded 10,000 times. With the EOT STOP switch down, the seek will be commanded until the STOP key is pressed.

DIRECT CONT: The drive continuously seeks between cylinder zero and the cylinder stored in the destination register until the STOP key is pressed. The drive can be commanded to seek continuously between two tracks other than the zero track by loading the first track in the destination register, switching to DIRECT SEEK, and then pressing the GO key; after switching to DIRECT CONT and reloading the destination register with the second track, this type of continuous seeking will occur from the time the GO key is pressed until the STOP key is pressed. With the EOT STOP switch up, 10,000 seeks will be performed.

SEQ FORWARD: The drive seeks to cylinder zero and then sequences up to the maximum cylinder. Then, if the EOT STOP toggle switch is in the up position, the test will end. Otherwise, the drive will return to cylinder zero and continue to sequence up until the STOP key is pressed.

SEQ REVERSE: The drive seeks to the maximum cylinder and then sequences down to cylinder zero. Then, if the EOT STOP toggle switch is in the up position, the test will end. Otherwise, the drive will return to the maximum cylinder and continue to sequence down until the STOP key is pressed.

SEQ FWD/REV: Starting at cylinder zero, the drive seeks sequentially upward to the maximum cylinder and then seeks sequentially downward to cylinder zero. With the EOT STOP switch in the UP position, the test will end after one complete sequence. Otherwise, it will continue until the STOP key is pressed.

- RANDOM SEEK:** The drive seeks to cylinder addresses randomly generated by the microprocessor until the STOP key is pressed or after 10,000 seeks with the EOT STOP key is pressed.
- X TO N SEEK** The drive seeks from each cylinder to every higher-numbered cylinder and back, thereby performing all possible seeks. This seeking continues until all possible combinations of seeks have been completed with the EOT STOP switch up or until the STOP key is pressed.
- FIXED VOLUME:** Pressing the ^{SEL DRV}~~GO~~ key sets up the FTU to access CMD fixed volume only. Pressing the ^{Go}~~SEL DRV~~ key sets up the FTU to access both fixed volume and removable disk pack.
- LAMP TEST:** Pushing the GO button causes all LEDs except the +5 and -5 LEDs to flash on and off. A +5 or -5 LED not lighted indicates power not being applied to the FTU, failure of the FTU power supply, or the failure of one or both of the LEDs.
- SELF TEST:** The processor performs a limited self-test routine on the FTU. During the test, the RD and WT LEDs alternately flash. Failure of the self-test is indicated by the RD and DATA ERR LEDs flashing alternately. If the test is satisfactory, it ends with the RD LED on steadily. Then all switch positions can be checked out; changing any switch position results in a change in the LED display. Normally self-test is performed with the EOT STOP, DATA ERROR and ADDR ERROR OVERRIDES in the down position.

- B: The microprocessor program jumps to the MPU Address entered on the bottom row of 16 LEDs when the GO key is pressed.
- C: Average access time for the drive can be measured for certain access modes by pressing the GO key. The RD/WRT SELECT switch must be in the ACCESS ONLY position. Calculation of this is done automatically after 10,000 seeks in DIRECT SEEK, DIRECT CONT, and RANDOM SEEK; calculation is down at the end of test for sequential seeks. Each group of four LEDs in the top row represents a Binary Coded Decimal digit, the least significant one being 0.1 ms and the most significant one 100 ms with a maximum displayed value of 999.9 ms.

D-F: Unused.

TOGGLE SWITCHES The toggle switches on the FTU and their respective switch positions are described below.

HEAD SWITCH: This is a three-position switch that is used for movable head sequencing.

MAN: A particular head can be selected using the number loaded with the DATA ENTRY switch in the HEAD position.

SEQ: At each accessed track, the same operation is performed with each head in sequence.

RAN: At each accessed track, one head is randomly selected for the desired operation.

RECORD SWITCH: This three-position switch allows different patterns of record addressing.

MAN: A particular record can be selected using the number loaded with the DATA ENTRY switch in the RECORD position.

SEQ: At each accessed track, record addresses are selected sequentially.

RAN: At each accessed track, one record is randomly selected for the desired operation.

PROCESSOR SWITCHES These three toggle switches are associated with the microprocessor.

START/RESET: They are primarily intended for use during
 RUN/HALT: maintenance of the FTU and are of no concern to
 STEP: the operator of the tester. In normal operation, the switches are respectively in the START and RUN positions (STEP is spring-loaded).

SINGLE/CONT SWITCH This toggle switch allows the choice of single or continuous accessing of tracks.

SINGLE: An access is performed only once by the drive.

CONT: An access is performed 10,000 times with the EOT STOP switch up or until the STOP key is pressed.

-/+ SWITCH: This is a three-position toggle switch that directs the drive to offset the carriage for better data recovery.

-: An offset is ordered away from the spindle.

center: No offset is called for (normal position).

+: An offset is ordered toward the spindle.

LATE/EARLY SWITCH: This is a three-position toggle switch that allows the shifting of read data strobes away from nominal timing to check error recovery.

LATE: The drive read strobes are shifted to a later time with respect to data.

center pos: The drive strobes at nominal timing (normal position).

EARLY: The drive read strobes are shifted to an earlier time with respect to data.

WRITE FLAG/OFF switch: In the up position, the FTU will command the drive to write a flag on a bad track provided that:

- a. RD/WRT SELECT switch is set to WRT FORMAT or WRT/RD FORMAT.
- b. ACCESS SELECT switch is set to DIRECT SEEK.
- c. HEAD switch is set to MAN.

In the up position, while performing a WRITE or READ operation, the FTU will stop if a flag bit is found.

WRITE/PROT/OFF switch: In the up position, this switch protects the drive from being commanded to write by the tester.

AM/SECTOR switch: This toggle switch allows the choice of Address Mark or Sector mode of operation.

AM: The drive writes or reads an Address Mark.

- SECTOR:** The writing and reading of data is referenced to the sector count.
- EOT STOP/OFF switch** With the END of Test switch in the up position, in sequential seeks, the test will stop after one complete sequence. Placed in the up position during self-test, this switch causes the error display to be bypassed which facilitates troubleshooting the FTU with an oscilloscope.
- DATA ERROR OVERRIDE/OFF switch** With this switch in the up position, the FTU will not stop an access sequence when a data error is found. In self-test, a data error in the MPU is bypassed; with the switch up, the MPU continually loops when there is a data error.
- ADDR ERROR OVERRIDE/OFF switch** With this switch in the up position, the FTU will not stop an access sequence when an address error is found. In self-test, if there is a data error, that address will be skipped, the address counter will be incremented and the program will continue.
- SHIFT PATT/DATA PATT switch:** In the DATA PATT position, the same data pattern is repeated throughout the entire accessing sequence. In the SHIFT PATT position, each time the drive seeks a new track, the data pattern is shifted one bit to the left, and the sixteenth bit becomes the first bit.
- SEQ PWR switch:** In the SEQ PWR position, the FTU commands the drive to power up, provided that
- a. The drive is the REMOTE mode.
 - b. Primary power is available at the drive.
 - c. The drive START switch is ON (indicator lighted).

KEYBOARD PANEL: The result of pressing each keyboard key is given in the following description:

Data keys 0-F: New data can be entered with these keys. Entered data is displayed on the bottom row of 16 LEDs.

HEX key: Pressing this key results in the conversion of the decimal number in the lower display to hexadecimal form.

DISP key The data in the upper display will be transferred to the lower display, and the data in the lower display will be transferred to the upper display.

CLR ENT key: This key is used to clear the entry displayed in the bottom row of 16 LEDs when an incorrect entry has been made.

LOAD key: Pressing the LOAD key transfers the data entry in the second row of 16 LEDs to the top row of 16 LEDs and loads it into memory via the DATA ENTRY switch while clearing the second row.

DEC key: The hexadecimal number in the lower display is converted to decimal.

BIT key: When pressed prior to the data entry, the data will be entered bit-by-bit in binary form.

SEL DRV key: Pressing this key initiates a drive selection sequence.

CLR FLT key: Pressing this key initiates a fault clearing sequence.

- RTZ key: Pressing this key initiates the drive by commanding a return-to-zero seek.
- CLR key: This key clears the display and all status, and it resets the tester.
- GO key: Pressing this key initiates the selected tester operation.
- STOP key: When this key is pressed, the tester is stopped at the end of the operation in progress.
- LED DISPLAY: A description of the condition, causing each of the LEDs to be lighted, is given below.
- Top row of 16 LEDs: These LEDs indicate in binary form data that has been loaded into the tester's memory. Possibilities include:
- a. A keyboard data entry that has been loaded with the LOAD button.
 - b. A previous entry indicated by the DATA SELECT rotary switch.
 - c. A status word.
- Bottom row of: 16 LEDs: These LEDs indicate data that has been entered on the keyboard before the LOAD button has been pressed. When a status word is being displayed, the code of the status word is displayed on this row of LEDs. Head alignment offset is also displayed on this row of LEDs.

I/O RDY LED: This LED indicates that a Device Type has been loaded and that the transmitters and receivers have been enabled.

UNIT RUN LED: The drive is in the process of performing a commanded operation.

ON CYL LED: The FTU is receiving an On Cylinder signal from the drive.

RDY LED: The FTU is receiving a Unit Ready signal from the drive.

WT PROT LED: The FTU is receiving a Write Protect signal from the drive.

SELD LED: The FTU is receiving a Unit Selected signal from the drive.

SEEK ERROR LED: The FTU is receiving a Seek Error signal from the drive.

FLT LED: The FTU is receiving a Fault signal from the drive.

BUSY LED: The FTU is receiving a Busy signal from the drive. The BUSY LED will also flash while the FTU is waiting for a Ready signal during a select drive command.

FLAG LED: When a flag is read, the FLAG LED lights and stays on until the CLR key is pressed.

DATA ERROR LED: The FTU has detected a discrepancy between the data pattern written by the drive and the data pattern read by the drive.

ADD ERR LED: The address information received from the drive differs from the requested address.

RD LED: The FTU is commanding a Read operation.

WT LED: The FTU is commanding a Write operation.

CLK LED: The Read Clock signal is coming from the drive.

+5 LED: The power supply in the FTU has a +5 volt output.

-5 LED: The power supply in the FTU has a -5 volt output.

RUN LED: The microprocessor in the FTU is running.

7.5 TEST POINTS AND JACKS

Thirty-three test points and two head alignment jacks are located on the front panel of the tester. Many of these test points serve a dual purpose; the signal found on them depends on whether a standard interface or multiplexed interface is being used. In this case, the signal designation for standard and multiplexed interfaces are printed to the left and right of the test point respectively. One label is valid for both interfaces when it appears alone to the left of test point.

Table 7-1 list the test points as they appear on the FTU front panel. Two banana jacks for head alignment are located in the lower left corner of the front panel. The black and red leads from the head alignment card plug into the jacks marked - and + respectively.

TABLE 7-1. TEST POINTS

| STD Label | STD Definition |
|-------------------|----------------------------------------|
| AM FOUND | Address Mark Found from the drive |
| NOT USED | Not used |
| ON CYL | On Cylinder from the drive |
| READY | Ready Signal from the drive |
| NOT USED | Not used |
| NOT USED | Not used |
| SK ERR | Seek Error from the drive |
| FAULT | Fault signal from the drive |
| RD GATE | Read Gate to the drive |
| RD CLK | Read Clock from the drive |
| RD DATA | Read Data from the drive |
| WRT GATE | Write Gate to the drive |
| WRT CLK | Write Clock to the drive |
| WRT DATA | Write Data to the drive |
| AM GATE | Address Mark Gate |
| READ ERR | A Read Error is detected in the tester |
| GND | Ground Test Point |
| TAG 1 | Tag 1 to the drive |
| TAG 2 | Tag 2 to the drive |
| TAG 3 | Tag 3 to the drive |
| BOB ₀ | Bus Out Bit 0 to the drive |
| BOB ₁ | Bus Out Bit 1 to the drive |
| BOB ₂ | Bus Out Bit 2 to the drive |
| BOB ₃ | Bus Out Bit 3 to the drive |
| BOB ₄ | Bus Out Bit 4 to the drive |
| BOB ₅ | Bus Out Bit 5 to the drive |
| BOB ₆ | Bus Out Bit 6 to the drive |
| BOB ₇ | Bus Out Bit 7 to the drive |
| BOB ₈ | Bus Out Bit 8 to the drive |
| BOB ₉ | Bus Out Bit 9 to the drive |
| BOB ₁₀ | Bus Out Bit 10 to the drive |
| INDEX | Index Signal from the drive |
| SECTOR | Sector Signal from the drive |

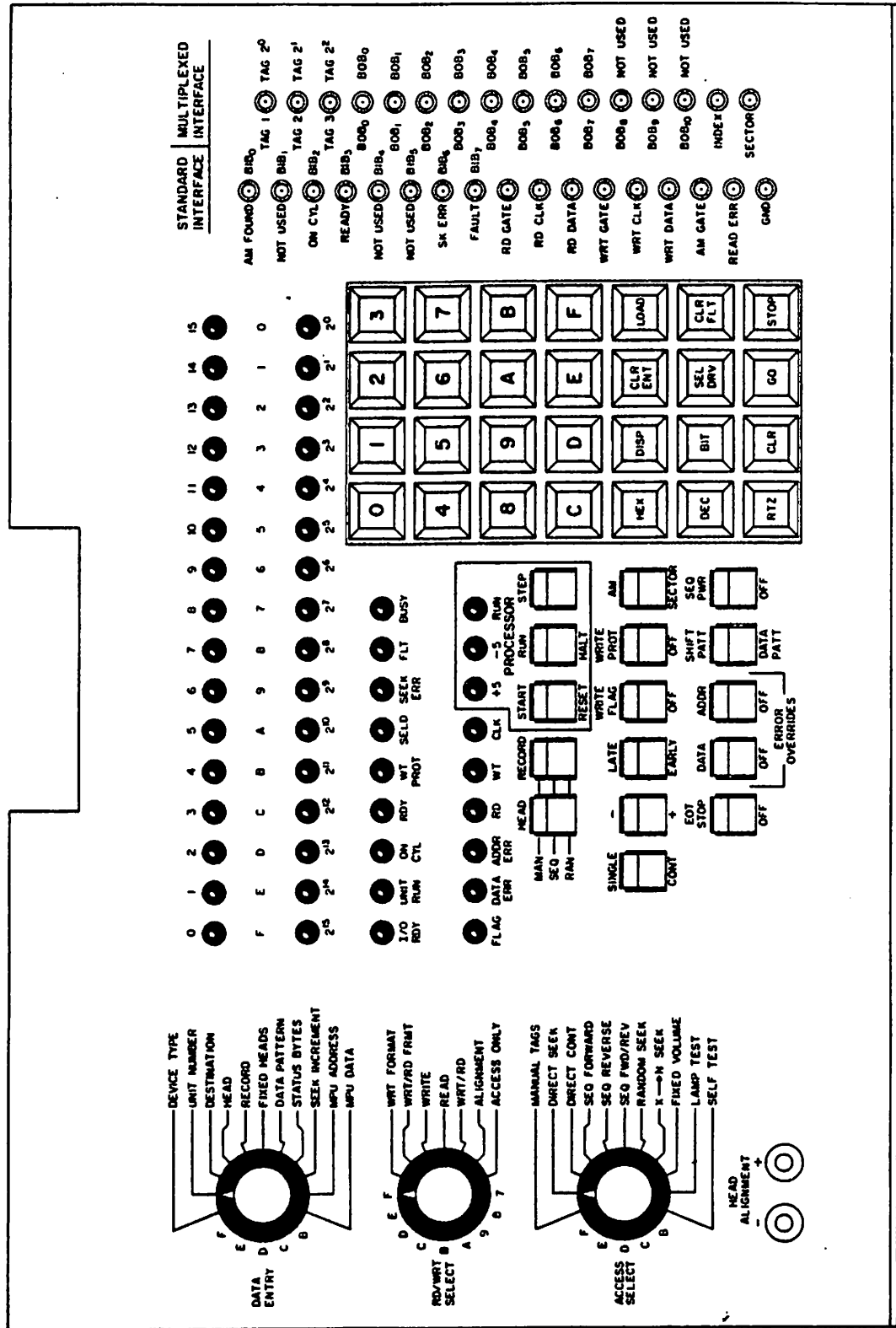


FIGURE 7-4. TB216 CONTROL PANEL

7.6 OPERATING PROCEDURES TB216

7.6.1 GENERAL

The TB216 Field Test Unit is capable of many more specific tests that can be described in this manual. The procedures given below represent a sampling of the tests performed most often. Acquainting yourself with these procedures is the first step toward becoming familiar with the FTU. Refer to the information in the CONTROLS AND INDICATORS section of this manual as a guide to using the FTU in ways other than those described below.

After performing the preliminary setup, operating the tester requires choosing the desired read/write mode and accessing pattern. The setting of the SINGLE/CONT toggle switch dictates whether an individual seek or a series of seeks is commanded. The toggle switches for HEAD and RECORD allow selection of a manual head and record in conjunction with the DATA ENTRY switch; alternatively, these may be sequenced or chosen randomly. Finally, the tester begins exercising the drive when the GO key is pressed.

Preliminary Setup

1. Remove power from drive to be tested.
2. Disconnect system I/O cables from drive.
3. Connect A cables to J1 and J2 of AJHX card (#2 slot in FTU logic chassis). Connect B cable to J3 of AJHX card.
4. Attach A cables to drive I/O connector with 60-pin adapter cable. Attach B cable directly to drive I/O connector. No adapter is needed for B cable. (Refer to Figure 7-4.)

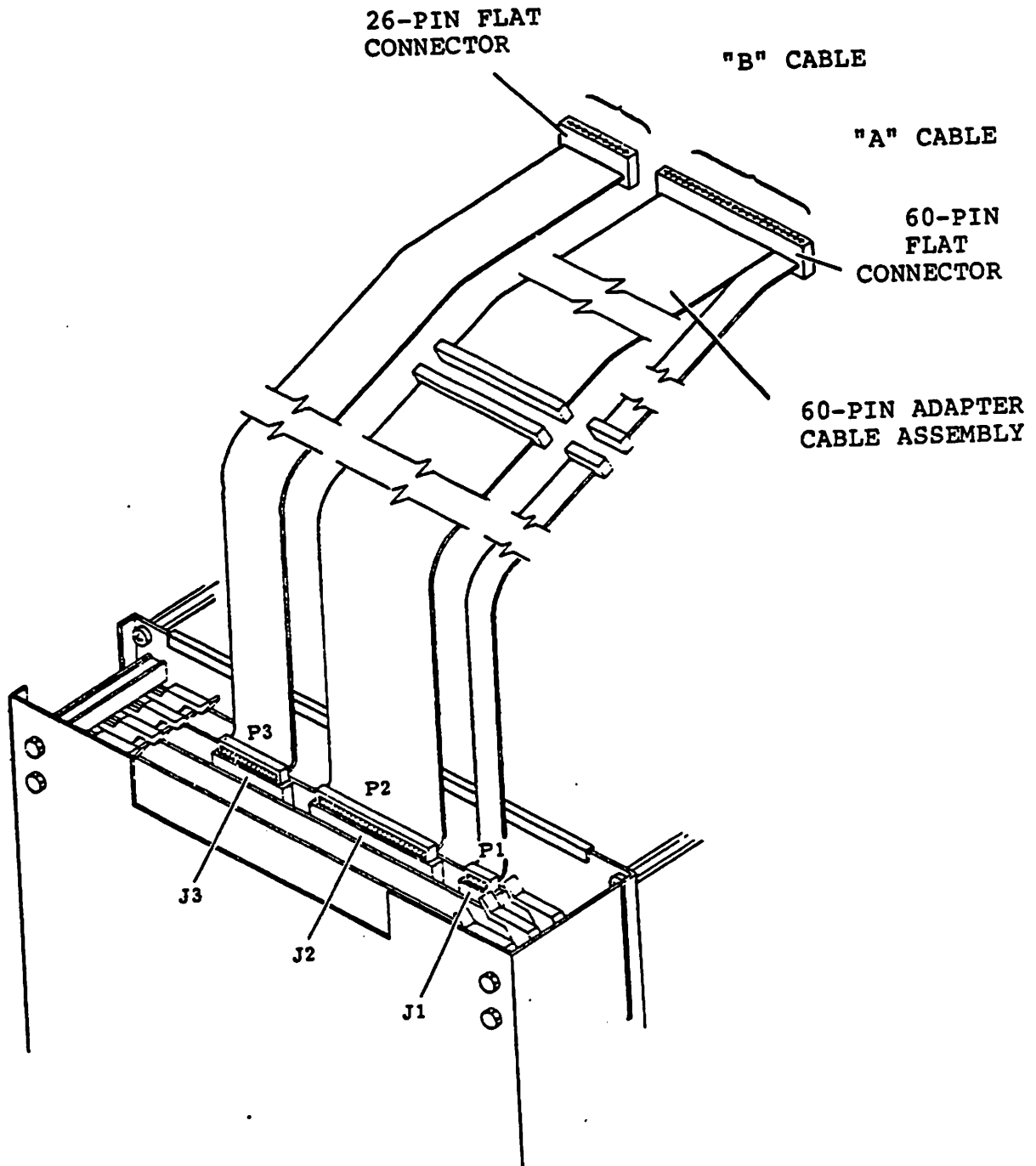


FIGURE 7-5 TB216 CABLE ASSEMBLIES

5. Place FTU PROCESSOR toggle switches in the RESET and HALT positions. Apply power to FTU and throw FTU circuit breaker to ON position. Place FTU PROCESSOR toggle switches START and RUN positions.
6. Set the following switches as shown for normal testing:

| <u>SWITCH</u> | <u>POSITION</u> |
|-----------------------|-----------------|
| START/RESET | START |
| RUN/HALT | RUN |
| SINGLE/CONTINUOUS | CONTINUOUS |
| -/+ (Carriage Offset) | CENTER (Off) |
| LATE/EARLY | CENTER (Normal) |
| WRITE FLAG | OFF |
| WRITE PROT | ON |
| AM/SECTOR | SECTOR |
| EOT STOP | OFF |
| DATA ERROR OVERRIDE | OFF |
| ADDR ERROR OVERRIDE | OFF |
| SHIFT PATT/DATA PATT | DATA PATT |
| SEQ PWR | OFF |

7. Install scratch pack on drive to be tested.
8. Apply ac power to drive. Turn on power switch on drive, and, if drive is set up for REMOTE power-up, place tester SEQ PWR switch in up position.

9. Determine the Device Type code for the drive being tested.

| <u>DRIVE</u> | <u>MODEL</u> | <u>CODE</u> | |
|--------------|--------------|-------------|------------------|
| BK5XX | 75MB | 0905 | |
| BK7XX | 288MB | 0919 | 2780-1 8901 |
| CMD | ALL | 8905 | 2 8903 3 8905 |

Place DATA ENTRY switch in DEVICE TYPE position and key in the Code. Press LOAD key.

10. Ensure that WRIT PROT switch is up. Select drive by pressing SEL DRV key. The BUSY LED will flash until selected signal has been sent by drive. When heads are loaded, SELD LED LIGHTS.

To ACCESS
1. R ONLY
PRESS SELDRV w/ ACCESS
SELECT NR. IN F VOL POS.
2. F ONLY
SW. TO F VOL + PRESS
SELDRV

11. Press RTZ key on tester keyboard.

3. BOTH
SW. TO F VOL + PRESS GO

The drive is now ready for exercising. It has performed a seek to cylinder zero. Directions for some of the more routine tests are given in the following procedures. The remaining functions may now be programmed into the tester.

7.6.2 Write Format/Sequential Forward

SEE TAC 11027 III. A. 7
To R/W ALL TRACKS, NEW SET UP.

1. Perform preliminary setup.
2. Place DATA ENTRY switch in DATA PATTERN position and enter four hexadecimal characters on the keyboard to form a 16-bit data pattern. Press LOAD key.
3. Place DATA ENTRY switch in B position and enter the write protect code (5754). Press LOAD key. Turn off WRITE PROT toggle switch.

NOTE:

Step 4 applies to CMDs only.

4. Place ACCESS SELECT switch in FIXED VOLUME position. then perform either 4a or 4b depending on whether it is desired to select only fixed volume (4a) or both the removable pack and fixed volume (4b).
 - a. Press ^{SEL DRV}~~GO~~ key to select fixed volume only.
 - b. Press ^{GO}~~SEL DRV~~ key to select both removable pack and fixed volume.
 - c. Press SEL DRV w/ ACCESS SELECT SW. NOT IN FIXED VOL. POSITION TO SELECT REM. PACK ONLY.
5. Place RD/WRT SELECT switch in WRT FORMAT position.
6. Place ACCESS SELECT switch in SEQ FORWARD position.
7. Place HEAD toggle in SEQ position.
8. Place RECORD toggle in SEQ position.
9. Press GO key.
10. Observe that the cylinder address is being sequenced by placing DATA ENTRY switch in STATUS BYTES Position, pressing the 1 key, and looking at top display of 16 LEDs.
11. Terminate test early, if desired, by pressing STOP key. Otherwise, with EOT STOP switch in the up position, the test will end when all possible seeks have occurred once.
12. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.3 Write/Read Format - Sequential Forward

1. Perform preliminary setup.
2. Place DATA ENTRY switch in DATA PATTERN position and enter four hexadecimal characters on the keyboard to form a 16-bit data pattern. Press LOAD key.
3. Place DATA ENTRY switch in B position and enter the write protect code (5754). Press LOAD key. Turn off WRITE PROT toggle switch.

NOTE:

Step 4 applies to CMDs only.

4. Place ACCESS SELECT switch in FIXED VOLUME position. then perform either 4a or 4b depending on whether it is desired to select only fixed volume (4a) or both the removable pack and fixed volume (4b).
 - a. Press ^{SEL DRV}~~80~~ key to select fixed volume only.
 - b. Press ⁶⁰~~SEL DRV~~ key to select both removable pack and fixed volume.
 - c. PRESS SEL DRV w/ ACCESS SELECT NOT IN FIXED VOL. TO SELECT REMOVABLE ONLY.
5. Place RD/WRT SELECT switch in WRT FORMAT position.
6. Place ACCESS SELECT switch in SEQ FORWARD position.
7. Place HEAD toggle in SEQ position.
8. Place RECORD toggle in SEQ position.
9. Program the tester to stop if an error is read, if desired, by leaving the DATA and ADDR ERROR OVERRIDE switches down. With these switches up the FTU will continue exercising the drive when an error is read. (See "Flagging a Bad Track." 7.6.8)

10. Press GO key.
11. Observe that the cylinder address is being sequenced by placing DATA ENTRY switch in STATUS BYTES Position, pressing the 1 key, and looking at top display of 16 LEDs.
12. Observe WT and RD LEDs to assure that each track is read after the data pattern has been written on it.
13. Terminate test early, if desired, by pressing STOP key. Otherwise, with EOT STOP switch in the up position, the test will end when all possible seeks have occurred once.
14. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.4 Seeking Between Two Tracks

1. Perform preliminary setup.
2. Place RD/WRT SELECT switch in ACCESS ONLY position.
3. Place ACCESS SELECT switch in DIRECT SEEK position.
4. Place DATA ENTRY switch in DESTINATION position and key in first cylinder address. Press LOAD key.
5. Press GO key followed by STOP key.
6. Place ACCESS SELECT switch in DIRECT CONT position. Key in second cylinder address. Press LOAD key.
7. Press GO key.

NOTE:

To observe each cylinder address, perform step
8. Otherwise, skip to step 9.

8. Place SINGLE/CONT toggle switch in SINGLE position. Place DATA ENTRY switch in STATUS BYTES position and press the 1 key. Press GO key twice and look at top display of 16 LEDs each time.
9. Return SINGLE/CONT toggle switch to CONT position and press GO key. The drive will seek between the two designated cylinders 10,000 times with EOT STOP switch in up position.
10. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.5 Random Seek/Access Only

1. Perform preliminary setup.
2. Place RD/WRT SELECT switch in ACCESS ONLY position.
3. Place ACCESS SELECT switch in RANDOM SEEK position.
4. Press GO key.
5. Observe that the cylinder address is being sequenced by placing DATA ENTRY switch in STATUS BYTE position, pressing the 1 key, and looking at top display of 16 LEDs.

NOTE:

To command each seek individually, perform step 6. Otherwise, skip to step 7.

6. Place SINGLE/CONT toggle switch in SINGLE position and press GO key for each seek. Return SINGLE/CONT toggle switch to CONT position.

7. Terminate test early, if desired, by pressing STOP key. Otherwise, with EOT STOP switch in up position, the test will end when 10,000 seeks have been completed.
8. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.6 X To N Seek/Access Only

1. Perform preliminary setup.
2. Place RD/WRT SELECT switch in ACCESS ONLY position.
3. Place ACCESS SELECT switch in X To N SEEK position.
4. Press GO key.
5. Observe that the cylinder address is being sequenced by placing DATA ENTRY switch in STATUS BYTE position, pressing the 1 key, and looking at top display of 16 LEDs.
6. Terminate test early, if desired, by pressing STOP key. Otherwise, with EOT STOP switch in up position, the test will end when all possible seeks have occurred once.
7. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.7 I/O Line Check

In this test, the tester commands the drive to seek only those cylinders which are numbered by powers of 2 (i.e. 1,2,4,8,16, etc.). This is useful for checking the I/O lines.

1. Perform preliminary setup.

2. Place DATA ENTRY switch in SEEK INCREMENT position.
3. Enter 8000 on keyboard and press LOAD key.
4. Place RD/WRT SELECT switch in ACCESS only position.
5. Place ACCESS SELECT switch in X To N SEEK position.
6. Press GO key.
7. Observe that the cylinder address is being sequenced by placing DATA ENTRY switch in STATUS BYTE position, pressing the 1 key, and looking at top display of 16 LEDs.
8. Press STOP key to end test.
7. Press CLR and RTZ keys. The tester is now ready to be programmed for the next test.

7.6.8 Flagging a Bad Track

With the ERROR OVERRIDE switches down and a WRT/RD FORMAT or WRT/RD test in progress, the tester will stop exercising the drive in the event of a data or address error. Before flagging the track on which the error occurred, first WRITE and the READ the track several times to ensure that the error was not a random one.

1. Program tester to command operations on bad track.
 - a. Place DATA ENTRY switch in STATUS BYTES position, press the 1 key and observe cylinder address of bad track in hexadecimal form on top display of 16 LEDs.
 - b. Press DISP key to move cylinder address to bottom display of LEDs.

- c. Place DATA ENTRY switch in DESTINATION position.
 - d. Press DEC key to convert bottom display from hex to BCD.
 - e. Press LOAD key.
2. Program tester to command operations at bad head address.
 - a. Place DATA ENTRY switch in STATUS BYTES position, press the 2 key and observe head address in hexadecimal form on top display of 16 LEDs.
 - b. Press DISP key to move head address to bottom display of 16 LEDs.
 - c. Place DATA ENTRY switch in HEAD position.
 - d. Press DEC key to convert bottom display from hex to BCD.
 - e. Press LOAD key.
 3. Place HEAD toggle switch in MAN position.
 4. Place RECORD toggle switch in SEQ position.
 5. Place ACCESS SELECT switch in DIRECT SEEK position.
 6. Place RD/WRT SELECT switch in WRT/RD and SINGLE/CONT toggle switch in SINGLE position.
 7. Press GO key and note whether ADDR ERR or DATA ERR LEDs light. Repeat this step several times. If either LED lights consistently, the track is bad. Flag bad track by performing steps 8, 9, and 10. Otherwise, skip to step 11.
 8. Place WRITE FLAG toggle switch in up position.

9. Place RD/WRT SELECT switch in WRT FORMAT position.
10. Press GO key.

NOTE:

- When any operation other than a formatting one is being down and WRITE FLAG toggle switch is up, the tester will stop when a write flag is detected.
11. Place WRITE FLAG toggle switch in OFF position.
12. Press RTZ and CLR keys.
13. Return to the WRT/RD procedure that was in progress prior to discovering bad track.

7.6.9 Releasing Processor From a Loop

It is possible for the processor to get hung up in a loop if it is given an illegal command. This is evidenced by the keyboard STOP, GO, CLR, and RTZ keys having no effect on the condition of the UNIT RUN LED. In this situation, the operator has two options. One option is initializing the tester again by reentering all the previously entered parameters. However, a more convenient option is the following:

1. Place PROCESSOR RUN/HALT switch in HALT position.
2. Press STOP key.
3. Place PROCESSOR RUN/HALT switch in RUN position.
4. Press GO key.

The FTU will continue in the test at the point where the malfunction occurred.

7.6.10 WRITE PROTECT CODE

It is necessary to enter a write protect code on the FTU keyboard to enable to FTU to command Write Operations. This adds additional protection against writing on a disk pack. To do this, perform the following procedures:

1. Ensure that WRITE PROT toggle switch is in OFF position.
2. Place DATA ENTRY switch in B. position.
3. Enter 5754 on keyboard.
4. Press LOAD key.

The FTU is now ready to command Write operations.

7.7 HEAD ALIGNMENT (THIS ALIGNMENT IS PERFORMED USING FTU TB216) (See Chapter IX for alignment with 726-5611 Alignment Kit)

7.7.1 GENERAL

This section is intended to be used in conjunction with the head alignment procedure in Chapter IX of this manual for the drive being tested. This manual outlines the specific procedures and specifications for head alignment using the Alignment Kit vs The FTU.

The information given here relates to operation of the FTU and interpretation of the displays of head offset on the FTU.

7.7.2 FTU Preparation

Perform the following four steps to prepare the tester for head alignment.

1. Perform Preliminary Setup described in this chapter under Operating Procedures.

2. Connect test leads between jacks on head alignment card IN DRIVE and HEAD ALIGNMENT jacks on FTU front panel. Observe proper polarity.
3. Set X1/X.1 switch on the Head Alignment Card to X1 position. Leave switch in X1 position regardless of other instructions in drive manual.
4. Place RD/WRT SELECT switch on FTU in ALIGNMENT position.
5. Data Entry Switch to Destination
6. Access Select Switch to Direct
7. Issue a RTZ
8. Enter 0400 into LED buffer and LOAD.
9. Depress GO
10. Disk Drive will seek to track 400.
11. Depress Go.

After completing the previous 12 steps, proceed with head alignment as directed in the applicable drive manual. After reading the following paragraphs on offset displays, select the appropriate display on the FTU.

7.7.3 Offset Displays

Three different LED displays of head offset voltage are possible. All three displays use the bottom row of 16 LEDs, and in Table 7-~~X~~², they are labelled 0 through F, just as they are on the FTU front panel. In all three cases, LED F lights when the offset is negative.

NOTE:

If LED "F" is Flashing, Input signals are too low for the _FSV to OPERATE.

Pushing the HEX key and then the GO key sets up a pure binary display. LED 0, the least significant bit, represents one millivolt. For example, if LEDs 0, 1, 2, and 4 are lit, the offset is 23 mV. If LEDs 6 and F are lit, the offset is -64mV.

Pushing the DEC key and then the GO key sets up a binary-coded decimal display. LEDs 0 through 3 represent the least significant digit (from 0 to 9 mV). LEDs 4 through 7 represent the next digit (from 10 to 90 mV). LEDs 8 through B represent the next digit (from 100 to 900 mV). LED C represents an offset of one volt. For example, if LEDs 0, 3, 5, 6, and A are lit, the offset is 469 mV.

Pushing the BIT key and then the GO key sets up a third type of display. Each of the nine LEDs on the right side of the display (0 through 8) represents an increment of 10 mV. Each of the next five LEDs (9 through D) represents an increment of 100 mV. If the offset is 600 mV or more, LED E is lighted. For example, if LEDs F, A, and 5 are lit, the head offset is -260 mV.

TABLE 7-2 TB216 OFFSET DISPLAY

| LED Designation | Representation (In Mv) | | |
|--------------------|------------------------|----------|---------------|
| | DEC Mode | HEX Mode | BIT Mode |
| 0 | 1 | 1 | 10 |
| 1 | 2 | 2 | 20 |
| 2 | 4 | 4 | 30 |
| 3 | 8 | 8 | 40 |
| 4 | 16 | 10 | 50 |
| 5 | 32 | 20 | 60 |
| 6 | 64 | 40 | 70 |
| 7 | 128 | 80 | 80 |
| 8 | 256 | 100 | 90 |
| 9 | 512 | 200 | 100 |
| A | 1024 | 400 | 200 |
| B | Not Used | 800 | 300 |
| C | Not Used | 1000 | 400 |
| D | Not Used | Not Used | 500 |
| E | Not Used | Not Used | 600 And Above |
| F | -Sign | -Sign | -Sign |

7.8 STATUS BYTES TB216

7.8.1 GENERAL

Sixteen Status Bytes are available to the operator of the TB216 FTU. They are numbered from hexadecimal 0 to F. To call up a particular Status Byte, place the DATA ENTRY switch in STATUS BYTES position and press the corresponding key on the keyboard. The number of the chosen Status byte appears on the right hand 4 LEDs on the bottom row. The Status Byte appears on the top row of 16 LEDs. For each of the 16 Status Bytes, Table 7-3 gives the value assigned to each LED.

- Tag-Bus I/O (0) This Status Byte displays tag and bus signals as they are sent from the FTU to the drive.
- Cylinder (1) This Status Byte displays the cylinder on which the drive is operating. The binary value assigned to each LED is given in Table 8-1.
- Head (2) This Status Byte displays the head with which the drive is performing a read/write operation. The display pattern is identical to the Head display. This is readily visible only in manual or random record.
- Sector (4) When the drive has been selected, this Status Byte indicates the total number of sectors being used by the drive. During read/write operations, the sector on which the drive is reading or writing is indicated. This is readily visible only in manual or random record.
- Pattern (5) This Status Byte displays the 16-bit data pattern that has been entered in tester memory and is repeated in the data field written by the drive.
- Address Error Counter (6) This Status Byte displays a count of the number of address errors occurring during an extended read operation. Unless the ADDR ERROR OVERRIDE toggle switch is in the up position, the drive will stop reading when an address error occurs.
- Data Error Counter (7) This Status Byte displays a count of the number of records which contain data errors. Unless the DATA ERROR OVERRIDE toggle switch is in the up position, the drive will stop reading when a data error occurs.

| | |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Flag/Pass Counters (8)</u> | Display bits 0 through 7 indicate how many passes the drive has made through the disk pack in an extended seek operation. Display bits 8 through F indicate the number of flagged tracks detected in a read operation. |
| <u>Seek Counter (9)</u> | This Status Byte displays a count of the number of seeks performed in a multiple seek operation. |
| <u>Average Access Time (A)</u> | This Status Byte displays the average access time for a series of seeks. The display is binary-coded decimal where each group of four LEDs represents a decimal digit. The least significant digit is in tenths of milliseconds. |
| <u>Access Time Counter B, C</u> | These two displays indicate the total access time required for a series of seeks. This is a binary representation where the lower order 16 bits comprise the C Status Byte, and the higher order 16 bits comprise the B Status Byte. The readout is in tenths of milliseconds. |
| <u>Cylinder Destination 1 (D)</u> | When the drive is performing a continuous seek between two cylinders, this Status Byte indicates the address of the first cylinder. |
| <u>Cylinder Destination 2 (E)</u> | When the drive is performing a continuous seek between two cylinders, this Status Byte indicates the address of the second cylinder. |
| <u>MUX Status (F)</u> | NOT USED |

CHAPTER 8

FAULT DIAGNOSIS

8.1 FAULT SWITCHES AND RELATED DECODING

A. FAULT SWITCHES AND INDICATORS

Fault switches and indicators are provided for aiding the maintenance personnel in diagnosing problems in the drive. These switches and indicators are mounted on the printed circuit boards in the Electronic Module. Only Maintenance Personnel will operate these switches.

A set of seven LED fault display indicators are mounted on the top of the CONTROL/MUX PWA board (EM2). Two types of faults can be displayed on these indicators:

1. Non-microprocessor or logic detected faults.
2. Error conditions detected by the microprocessor board (SERVO COARSE PWA).

Figure 4-2 illustrates the fault display indicators on the CONTROL/MUX PWA board and the reset switch (S1) which resets the display and brings up new information which is displayed on the indicators. The FAULT CLEAR switch on the front panel of the Disk Drive is also used to reset the logic detected faults but does not reset the fault history F/Fs as S1 does. Also, the FAULT CLEAR switch does not operate to place microprocessor faults on the LED displays as S1 does. In addition to logic detected faults and microprocessor fault summary, the fault indicators can display the present cylinder address (from the last seek) and velocity status of the servo system (slow, fast or O.K.). See TABLE 8-1 for indicator displays and codes for the faults that can be analyzed. Only those switches and indicators which are solely intended for maintenance purposes are discussed in this Chapter.

TABLE 8-1 FAULT DISPLAY INDICATOR SUMMARY

| <u>LOGIC DETECTED FAULT INDICATOR</u> | <u>MICROPROCESSOR (M.P.)DETECTED FAULT</u> |
|-------------------------------------------|-------------------------------------------------------|
| CR1 NO HEAD SELECT FAULT (NH) | CR1 not used |
| CR2 OFF | ON |
| CR3 WRITE FAULT | HIGHEST ORDER M.P. FLT CODE SUMMARY BIT (2^4)* |
| CR4 WRITE OR READ WHILE OFF CYL. (W-R) | M.P. FAULT CODE BIT (2^3) |
| CR5 WRITE OR READ FAULT (W+R) | M.P. FAULT CODE BIT (2^2) |
| CR6 VOLTAGE FAULT (VF) | M.P. FAULT CODE BIT (2^1) |
| CR7 HEAD SELECT FAULT (HS) | M.P. FAULT CODE BIT (2^0) |

* In the Microprocessor Fault Code Summary mode, two types of information are displayed:

1. The phase of operations where the fault occurred.
2. The type of fault.

From 1 to 12 phases could be displayed and from 1 to 16 faults. All of the applicable phases are displayed in serial order first and then all of the fault codes applicable in serial order. See TABLE 8-3 for more details.

8.2 MAINTENANCE AIDS

8.2.1 Maintenance Switches and Indicators

Maintenance switches and indicators are listed with a brief functional description in Table 4-2. Interpretation of the Control/Mux Fault Display Indicators is listed in Table 8-2. These switches and indicators are located on the CONTROL/MUX, I/O SERVO COARSE and SERVO FINE PWAs in the Electronic Module.

Figure 4-2 as viewed from the component side of the CONTROL/MUX PWA, shows CR1 as the leftmost indicator and CR7 is rightmost, with a separation between CR1 and CR2 that is slightly wider than that between the rest of the indicators. This space is to separate CR1 from CR2 and the other indicators which have multiple meanings, with the meaning depending on the settings of switches.

The normal situation is to have S1-8 on the SERVO-COARSE PWA in the ON position and S1 on the CONTROL/MUX PWA in the OFF position.*

Under these conditions indicators CR1-CR7 are abbreviations which represent these non-microprocessor detect faults. Table 8-2 relates the definitions of the abbreviations. For example, "NH" means "NO HEAD SELECT FAULT", "MP" means "MICROPROCESSOR FAULT CODE ACTIVE", "WF" means "WRITE FAULT", and so on. Table 8-2 also charts the different ways in which the indicators CR1-CR7 are used (called Display Modes).

*S1 is a momentary action switch and remains OFF until manually activated.

TABLE 8-2. INTERPRETATION OF CONTROL/MUX FAULT DISPLAY INDICATORS

| DISPLAY MODE | SWITCH/INDICATOR | | | | | | | | DESCRIPTION OF INDICATOR MEANING/ FUNCTION |
|--------------|------------------|-----------------|-----|-----|----------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | SI-8 (SVO-CRSE) | CONTROL/MUX PWA | | | | | | | |
| | SI (SWITCH)** | CR1 | CR2 | CR3 | CR4 | CR5 | CR6 | CR7 | |
| 1 | 1 | 0 | 1 | 0 | * | * | * | * | NO HEAD SELECT FLT. Indicates that an attempt has been made to select a non-existent head. |
| 1 | 0 | 0 | * | 0 | * | * | * | * | Lights only when M. P. is active. |
| 1 | 0 | 0 | * | 0 | 1 | * | * | * | WRITE FAULT. Indicates that a loss of AC or DC write current has occurred. |
| 1 | 0 | 0 | * | 0 | * | 1 | * | * | WRITE OR READ OFF CYL. Indicates that an attempt was made to write or read during a seek, RTZ or volume change. |
| 1 | 0 | 0 | * | 0 | * | * | 1 | * | WRITE AND READ FLT. Indicates an attempt to write and read simultaneously. |
| 1 | 0 | 0 | * | 0 | * | * | * | 1 | VOLTAGE FLT. Indicates a below normal voltage. |
| 1 | 0 | 0 | * | 0 | * | * | * | * | HEAD SELECT FLT. Indicates a multiple head select (2 or more heads selected). |
| 2 | 0 | 1A | 0 | 1 | ‡ | 0 | 0 | C ₉ C ₈ 512 256 | The two highest order bits of the present cylinder address displayed by first S1 actuation. Resets mode 1 fault. |
| 2 | 0 | 2A | 0 | 1 | ‡ | C ₇ C ₆ C ₅ C ₄ 128 64 32 16 | | | The next high order four bits of present cylinder address displayed by second S1 actuation. |
| 2 | 0 | 3A | 0 | 1 | ‡ | C ₃ C ₂ C ₁ C ₀ 8 4 2 1 | | | The lowest order four bits of the present cylinder address displayed by third S1 actuation. |
| 3 | 0 | 4A | 0 | 1 | 0 | 0 | 0 | 0 | Separator state between cylinder address display mode and Microprocessor Fault Summary display mode. |
| 4 | 0 | A | 0 | 1 | M ₄ M ₃ M ₂ M ₁ M ₀ | | | | A hexadecimal coded, binary number (M ₄ --M ₀) is displayed which indicates a microprocessor detected error condition. The actuation of S1 displays the code from the first fault store location that contains an error code. Subsequent actuations of S1 displays all other error codes stored, displaying one at a time until all have been displayed. Each location is cleared when displayed. Table 6-7 lists all error codes and meaning of each. 0111111 indicates all M. P. Fault Summary Codes have been displayed. |
| | | | | | ETC. ETC. ETC. | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| 4 | 0 | XA | 0 | 1 | M ₄ M ₃ M ₂ M ₁ M ₀ | | | | |
| 4 | 0 | A | 0 | 1 | 1 | 1 | 1 | 1 | |
| 5 | 1 | A | 0 | 0 | 1 | 0 | 0 | 0 | Servo velocity gain adjust display. CR3 ON indicates velocity is very slow during seek to max cyl. *** |
| 5 | 1 | A | 0 | 0 | 0 | 1 | 0 | 0 | CR4 ON indicates velocity slow during seek to max cyl. |
| 5 | 1 | A | 0 | 0 | 0 | 0 | 1 | 0 | CR5 ON indicates velocity all right during seek to max cyl. |
| 5 | 1 | A | 0 | 0 | 0 | 0 | 0 | 1 | CR6 ON indicates velocity fast during seek to max cyl. |
| 5 | 1 | A | 0 | 0 | 0 | 0 | 0 | 1 | CR7 ON indicates velocity very fast during seek to max cyl. |

NOTES:

"1" means switch OFF or indicator "ON";
 "0" means switch ON or indicator "OFF".

*Any or all of these indicators could be ON at the same time except CR2 which has no meaning in Mode 1. The fault description defines the meaning of that indicator in whose column the "1" appears.

**"A" means a momentary actuation of this switch. (Its output goes to ground). "1A" means first actuation of the switch; "2A" means second actuation, etc.

***A seek is made to maximum cylinder number with each S1 actuation.

+Always "0" except when cyl. address is zero, then it's "1".

8.3 MAINTENANCE INDICATOR DISPLAY MODES

A. DISPLAY MODE 1 (Display of Non-Microprocessor Detected Faults)

1. As shown in Table 8-2, this display mode occurs only when the M.P. detects switch S1-8 on the Servo-Coarse PWA being on the ON position and S1 on the Control/Mux PWA being in the OFF position.* One or more of the fault indicators CR1 and CR3 - CR7 can be turned on after a non-microprocessor detected fault occurs, so more than one at a time could be ON. The fault latches that drive the CR1 - CR7 indicators directly, can be reset only by S1 (on Cntl/Mux) or Power-ON Master Reset.

*S1 is a momentary action switch and remains OFF until manually actuated.

2. However, the non-microprocessor detected faults are also stored in another register whose outputs go across the interface. This latter register is reset from the interface or front panel CLEAR switch or S1 (but only if the fault conditions are gone). Actuating S1 to reset the fault latches also starts Display Mode 2 or 4.

B. DISPLAY MODE 2 (Display of the Present Cylinder Address)

1. When S1 on the Control/Mux PWA is actuated in display mode 1, the fault latches are reset, CR2 indicator is turned ON, and indicators CR6 and CR7 display the highest order two binary bits of the present cylinder address (the address used by the drive in performing the last seek operation). S1 need only be actuated momentarily. When S1 is actuated a second time, the information displayed by CR6 and CR7 will be cleared and CR4 through CR7 will then display the next four high order binary bits of the present cylinder address. The third actuation of S1 will change the information displayed on CR4 and CR7 to the low order four binary bits of the present cylinder address. CR3 will always be zero except when the cylinder address digit displayed on CR4-CR7 is zero at which time CR3 will turn ON. The ten bits displayed as described above are to be interpreted as three hexadecimal numbers representing the address of the last seek performed by the drive. At the time the cylinder address bits are displayed, the location storing the address is cleared.

Therefore, before a new present cylinder address could be displayed, a new seek to a different volume or different cylinder would have to be performed.

NOTE

Even though S1-8 is ON no faults will be displayed unless the Microprocessor causes them to be displayed.

C. DISPLAY MODE 3 .

1. The next (fourth) actuation of switch S1 after the three actuations of Display Mode 2 turns off CR3 - CR7 leaving only CR2 ON. This is a separator state between Display Mode 2 and Display Mode 4. The only way Display Mode 3 can be entered is through Display Mode 2, but display mode 4 can be entered through Display Modes 1 or 3. Display mode 3 does not occur if display mode 2 does not occur. If display mode 3 does not occur, it should be recognized that the first three actuations of S1 constituted the first three M.P. Fault Summary codes in display mode 4. Therefore, the first three codes should be written down as one cannot be sure what the code represents until the fourth S1 actuation which will be either the separator code (display mode 3) or a fault code of display mode 4.

D. DISPLAY MODE 4

1. Assuming that display modes 2 and 3 occurred first, the fifth actuation of S1 places operation in Display Mode 4 which is called the "Microprocessor Fault Summary" mode. This is the mode that displays the Microprocessor-detected errors. The Microprocessor has a fault store area in its RAM where it stores a different binary code number for each error detected.
2. The fifth actuation of S1 as mentioned above will display on CR3-CR7 the code in the first fault store location where an error code is stored. Those locations in the fault store where no error code has been stored will not be displayed.

3. Subsequent actuations of S1, displays all other error codes stored, displaying them one at a time until all error codes have been displayed. Table 8-3 lists all the error codes and the meaning of each. The next S1 actuation after the last error code has been displayed, displays all ones on CR2 - CR7 (all lights ON). The next actuation after all ones, displays all zeros (all lights OFF but CR2). Subsequent actuations of S1 jumps the displays back and forth between ones and zeros on CR2 - CR7 until some operation is performed by the drive (i.e., seek, read or write, RTZ, etc.). After the drive gets back in the idle mode after an operation, it will be in Display Mode 1 again. Display mode 4 could directly follow mode 1 in some situations. A typical situation would be after a seek was commanded but the ready and "ON-track" condition was never reached. Any time the cylinder address is cleared and a new seek is not completed, modes 2 and 3 would be skipped.
4. If the fault readout process is somewhere in mode 4 when a seek is performed, operation returns to mode 1. The M.P. error codes still stored in the M.P. fault store (i.e., those which hadn't been displayed before the seek occurred) remain there and will be displayed the next time mode 4 is in process. Any new faults which may be stored before operation returns to mode 4 through subsequent actuations of S1 in the normal manner will be displayed with the remaining faults.

E. DISPLAY MODE 5

1. When S1-8 on the Servo-Coarse PWA is placed in the OFF position. (right side of switch depressed when facing switch from component side of PWA), the servo system velocity can be displayed on CR3-CR7. Section 6.4 describes the use of this display mode in adjusting the servo velocity gain.

TABLE 8-3
MICROPROCESSOR FAULT CODES AND MEANINGS

Codes 01 through 0C represent the 12 phases of operation that are checked by the microprocessor. Codes 0F through 1E represent the fault types that could have occurred in one of the phases. In display mode 4, the phase codes are read out in order first and then the fault codes in order. Code hex 1F is read after the last fault code is read out.

| <u>HEX CODE</u> | <u>BINARY CODE*</u> | <u>PHASE OF OPERATION</u> |
|-----------------|---------------------|---------------------------------|
| 01 | 00001 | RETURN TO TRACK CENTER |
| 02 | 00010 | WAIT FOR COARSE SEEK COMPLETION |
| 03 | 00011 | AFTER SEEK SETTLING |
| 04 | 00100 | IDLE LOOP |
| 05 | 00101 | RETURN TO ZERO MOTION |
| 06 | 00110 | END OF VELOCITY TABLE |
| 07 | 00111 | HEAD LOAD |
| 08 | 01000 | AWAIT AGC DURING HEAD LOAD |
| 09 | 01001 | AWAIT TRACK CENTER-LOAD OR RTZ |
| 0A | 01010 | SETTLING-LOAD OR RTZ |
| 0B | 01011 | OFFSET ACTIVE |
| 0C | 01100 | CLEAR OFFSET SETTLING |

| <u>HEX CODE</u> | <u>BINARY CODE*</u> | <u>FAULT TYPE</u> |
|-----------------|---------------------|---------------------------------------------------------------------------------------|
| 0F | 01111 | SPINDLE DID NOT START/STOP IN 2 MINUTES AFTER ERSLO/ERSTP WAS NOT NOTED (10000/10100) |
| 10 | 10000 | SPINDLE START GT 70 SEC |
| 11 | 10001 | NO SPINDLE MOVEMENT |
| 12 | 10010 | NO DRIVE TO SOLID STATE RELAY |
| 13 | 10011 | SOLID STATE RELAY FAILURE |
| 14 | 10100 | STOP TIMEOUT |
| 15 | -10101 | EMERGENCY RETRACT FAILURE |
| 16 | 10110 | NORMAL RETRACT FAILURE |
| 17 | 10111 | CYLINDER ADDRESS GT 822 |
| 18 | 11000 | OFF TRACK GT 1200 USEC |
| 19 | 11001 | UNEXPECTED AGC IN HEAD LOAD |
| 1A | 11010 | LOST AGC |
| 1B | 11011 | RPM FAULT |
| 1C | 11100 | LOST SPEED PULSES |
| 1D | -11101 | ALLOWED TIME EXPIRED |
| 1E | 11110 | NO TRACK LOCK IN SETTLING |
| 1F | 11111 | MICROPROCESSOR FAULT CODE SUMMARY READOUT IS COMPLETE |

*CR3-CR7. "1" means light ON. "0" means light OFF.

8.4 TABLES OF FAULT TYPES VERSUS OPERATIONAL PHASES

Tables 8-4 through 8-8 show the different fault codes that could show up for various phases of drive operation monitored by the microprocessor. For example in Table 8-5, "Seek Operation", an error in phase 03 (AFTER SEEK SETTling) would also show one or more of the fault types 11010, 11101 and 11110 (Ref Table 8-3).

TABLE 8-4
SPINDLE START AND STOP

ERROR

| PHASE | 10000 | 10001 | 10010 | 10011 | 10100 | 01111 |
|-------|----------------|-------|-------|-------|----------------|----------------|
| STOP | | | | | X ¹ | X ² |
| START | X ³ | X | X | X | | X ⁴ |

1 = 30 SEC TIME LIMIT

2 = MAY OCCUR ONLY 2 MIN AFTER 10100 Code

3 = 70 SEC TIME LIMIT

4 = MAY OCCUR ONLY 2 MIN AFTER 10000 CODE

TABLE 8-5
SEEK OPERATION 1*

ERROR

| PHASE | 10111 | 11010 | 11101 ¹ | 11110 | 11011 |
|-------------------------|-------|-------|--------------------|-------|-------|
| 01 | | | X | | |
| 02 | | X | X | | |
| 03 | | X | X | X | |
| 06 | | X | X | | |
| No Phase Code stored | X | | | | X |

*1 = 80 ms TIME LIMIT

TABLE 8-6
RTZ^{1*} and Head Load^{2**}

ERROR

| PHASE | 11001 | 11010 | 11011 | 11100 | 11101 | 11110 |
|-------------------------|-------|-------|-------|-------|-------|-------|
| 05 | | | | | X | |
| 07 | X | | | | X | |
| 08 | | | | | X | |
| 0A | | X | | | X | X |
| 09 | | | | | X | |
| No phase Code stored | | | X | X | | |

*1 = 500 ms TIME LIMIT

**2 = 300 ms TIME LIMIT

TABLE 8-7
HEAD RETRACT

ERROR

| PHASE | 11101 $\triangle 1$ | 10101 $\triangle 2$ |
|-------------|---------------------|---------------------|
| No Phase | X | X |
| Code Stored | | |

$\triangle 1$ = 440 ms TIME LIMIT

$\triangle 2$ = 500 ms TIME LIMIT (MAY OCCUR ONLY AFTER 11101
ERROR CODE 1)

TABLE 8-8
IDLE AND OFFSET

ERROR

| PHASE | 11010 | 11110 | 11101 | 11000 | 11100 | 11011 |
|-------------|-------|----------------|----------------|-------|-------|-------|
| 04 | X | X ¹ | | X | | |
| 0B | X | | | | | |
| 0C | X | X | X ² | | | |
| No Phase | | | | | | |
| Code Stored | | | | | X | X |

1 ONLY IF 11000 ALSO PRESENT

2 20 ms TIME LIMIT

CHAPTER IX
CMD HEAD ARM ALIGNMENT

9.1 GENERAL

This section describes the Head Alignment for the 2280 CMD Disk Drive using the CMD Alignment Kit. If the more recent FTU Model (TB216) described in Chapter 7 is available, refer to Section 7.7 for the latest alignment procedure. The tools and equipment required to perform the Head Alignment with the CMD Alignment Kit are as follows:

9.2 TOOLS REQUIRED

| <u>NOMENCLATURE</u> | <u>WLI #</u> |
|--------------------------------|--------------|
| Head Alignment Tool | 726-9699 |
| PWA Head-Alignment Extender Bd | 726-9678 |
| PWA Extender Bd | 726-9675 |
| Head Alignment Cable #1 | 726-9680 |
| Head Alignment Cable #2 | 726-9681 |
| Torque Wrench | 726-9661 |
| Special Tip (CMD only) | 726-9696 |
| CE Cartridge | 726-9683 |

9.3 EQUIPMENT REQUIRED

The equipment required for the head arm alignment procedure is listed below.

- A. Field Test Exerciser (FTU) or system controller, P/N (726-9698)
- B. CMD Alignment Kit, P/N (726-5611)
- C. Carriage Locking Tool (stowed on actuator magnet), P/N 726-9682
- D. Head Alignment Tool P/N 726-9699
- E. C.E. Cartridge, P/N 726-9683

9.4 CMD HEAD ARM ALIGNMENT

This section describes the procedure which should be used to align the heads of the Cartridge Module Drive (CMD) and describes the operation of some of the equipment used.

****CAUTION****

THE MAINTENANCE MANUAL SPECIFICALLY INSTRUCTS FIELD PERSONNEL TO USE THE CORRECT TOOLS AND TO CONFORM TO CERTAIN PROCEDURES WHEN PERFORMING "HEAD ARM ALIGNMENT".

THIS CAUTION IS INTENDED TO EMPHASIZE THE CRITICAL NATURE OF THIS PROCEDURE AND HOPEFULLY PREVENT ANY HEAD ARM OR ALIGNMENT TOOL DAMAGE DUE TO UNFAMILIARITY.

- A. Read and understand the "Head Arm Alignment" procedure as explained in the maintenance manual (CDC #7588415).
- B. Use only the specified alignment tool and calibrated torque screwdriver/bit.
- C. Ensure that the alignment tool is clean and is not damaged.
- D. Ensure that the head mounting screws are tightened to the specified torque requirement. (Damage to the tool or head arm can occur if adjustment is attempted on a head that has been excessively tightened.)
- E. When inserting the adjustment tool, locate the head arm slot with the tip of the tool, prior to applying any turning force.
- F. When turning the tool, enough inward force should be applied on the tool, so as to prevent the tip of the tool from disengaging from the adjustment slot.

9.5 PROCEDURES

Head alignment procedures described in this Chapter are listed in order of their presentation:

- A. General CMD Alignment Principles.
- B. Initial Head Alignment Procedure.
- C. Cartridge Read/Write Data Head Alignment Procedure.
- D. Cartridge Servo Head Alignment Procedure.
- E. Fixed Disk Module Data Read/Write Head Alignment Procedure.
- F. Fixed Disk Module Servo Head Alignment Procedure.

9.6 GENERAL CMD ALIGNMENT PRINCIPLES

A. GENERAL

The head alignment is accomplished on all heads by first mechanically aligning each of the fixed disk module heads when the module is first installed. Figure 9-2 shows how the oblong slot in the side of the head arm is "eyeball" aligned in the center of the round hole ⑤ in the carriage. An RTZ command then positions the fixed servo head on track zero, and with that carriage position as a reference, the cartridge servo head is aligned. If only the two cartridge heads need to be aligned, the fixed servo head is positioned to track zero and the cartridge servo head aligned. Once the cartridge servo head is aligned, it is used as a reference for aligning the cartridge data head. Once this alignment is made, only the cartridge heads are normally aligned after that.

****NOTE****

Any change in initial position of the fixed disk module servo head affects the alignment of all the fixed disk module data heads. Since there are no alignment tracks on or available to the fixed disk module data heads, these heads are not normally adjusted. However, should it be necessary to align one or more of the fixed disk module heads after the initial alignment, a procedure is given at the end of this section which describes the means of re-alignment of a fixed disk module servo or data head, though it is more involved than the normal procedure.

B. ALIGNMENT EXTENDER

Head alignment on the CMD requires an alignment extender PWA to adapt the CMD Head Alignment PWA (AZPV or HFSV PWA one of which is part of the kit) for use with the CMD electronics module (See Figure 9-1). The AZPV or HFSV Head Alignment PWA operates as described in the following paragraphs.

C. HEAD ALIGNMENT PWA

The Head Alignment PWA (called AZPV or HFSV hereafter) develops an alignment voltage derived from a voltage the Servo and Read/Write Preamplifiers produce from read head signals. When reading from a C.E. cartridge the voltage from the AZPV or HFSV PWA will be proportional to the distance that the cartridge servo (or data) head is offset from the track centerline. The drive actuator should have been positioned to the track zero centerline as defined by the fixed disk module servo head when aligning the cartridge servo head or to the Track Zero centerline as defined by the cartridge servo head when aligning the cartridge data head. To measure the voltage proportional to the offset which is produced by the AZPV or HFSV PWA connect a null meter to the AZPV or HFSV PWA as shown in Figure 9-1.

1. TOGGLE SWITCHES

There are three toggle switches on the AZPV or HFSV PWA which control the AZPV or HFSV PWA operation. These are shown in Figure 9-1 and their operation is described below.

S1 This switch changes the polarity of the alignment voltage produced on the AZPV or HFSV PWA. This switch is used when null meter readings are taken for the purpose of calculating the offset of the head being aligned.

S2 This switch selects the head output which will be used as an input to the AZPV or HFSV PWA. Position "S" selects the tracking servo head as an input to the AZPV or PFSV PWA (The tracking servo head is the one selected by S1 on the Head Alignment Extender PWA). Position "R/W" selects whichever of the cartridge heads (servo or data) that have been selected by the BUS OUT interface lines or by S1 on the Servo Fine PWA located in EM6.

S3 This switch selects the sensitivity range of the AZPV or HFSV PWA. In the "X.1" position, the alignment voltage is attenuated by a factor of 10. Head alignment error cannot be accurately measured with S3 in this position. In the "X1" position, the alignment voltage is not attenuated and the head alignment error can be accurately measured.

2. INDICATORS

Four indicators are provided on the HFSV PWA (but not on AZPV) to ensure that the PWA is operating properly and is receiving the proper data. These indicators are described as follows:

- POWER - When lighted, indicates that power is applied to the PWA.
- INPUT - When lighted, indicates that the voltage levels of the input signals are too low for the alignment PWA to operate.
- BAD TRACK - When lighted, indicates a short duration loss of input to the HFSV PWA. A one shot circuit maintains the lighted condition for at least four seconds. When S1 is switched from P to N or N to P, the indicator will light for its four second cycle each time the switch is moved.
- MODE - When lighted, it indicates that either S2 is in the "S" (servo) position or S3 is in the "X.1" position. When either of these conditions exist (light on), read/write head alignment error cannot be measured.

3. WHEN TO ALIGN THE HEADS

Head alignment is required on a new drive before leaving the factory, when a used drive has a fixed disk module replaced, and when any of the drive servo or data heads are replaced. If a head replacement is required because of contact between the disk and the head, the disk module involved should also be replaced, as a new head would not fly over a damaged disk.

9.7 INITIAL HEAD ALIGNMENT PROCEDURE

Following is a description of the initial head alignment procedure; that is, the procedure to be used when aligning the heads for the first time on a new unit or when the fixed disk module is replaced.

1. Operate the START switch to the STOP position to stop the drive motor. Wait until the motor has stopped. That is, when the READY indicator has stopped blinking.
2. Install the "C.E." cartridge (P/N 726-9683) and activate the write protect switches located on the operator control panel.
3. Set AC circuit breaker in the rear of the unit to OFF position.
4. Raise the case cover assembly.
5. Install the AZPV or HFSV Head Alignment PWA into the Head Alignment Extender PWA (P/N 726-9678) (See Figure 9-1) and install the entire assembly into the electronics module location EM4.
6. Install the two head alignment cables between the Head Alignment Extender PWA, the Servo-Fine PWA (located in EM6) and the Read/Write Preamp PWA as illustrated in APPENDIX B Figure (B-1).

NOTE

Make sure that the arrow on the connector head lines-up with pin 1 of both connectors J1 and J2 on the Head Alignment Extender PWA and the Servo-Fine PWA.

7. Set switch S1 on the Head Alignment Extender PWA to "FXD" position.
8. Connect the null meter leads to test points Z and X on the AZPV or HFSV PWA (red wire to "+").
9. Connect FTU to drive. Refer to FTU maintenance manual for installation instructions.

****NOTE****

The FTU meter can be used instead of the alignment kit meter. However, if the FTU meter is used, ignore the bottom scale. Refer to the FTU Maintenance manual.

10. Connect oscilloscope to ground and dibit test points (marked "Read Signal) on the Head Alignment PWA (AXPV or HFSV).
11. Remove screws which secure the electronics module to the hinge bracket and carefully lift the module directly up and slowly swing it out to the side and leave in the rest position.

****CAUTION****

USE ONLY HEAD ALIGNMENT TOOL P/N 726-9699.
USE OF A DIFFERENT TOOL CAN CAUSE PERMANENT
DAMAGE TO HEAD/ARM AND CARRIAGE.

INSPECT HEAD ADJUSTMENT TOOL FOR DAMAGE
(NICKED, SCRATCHED, ETC.) AT ADJUSTMENT END.
END SHOULD HAVE A POLISHED SURFACE WHERE IT
ENTERS CARRIAGE. POLISH END WITH CROCUS
CLOTH IF ALUMINUM DEPOSITS ARE PRESENT, AND
WIPE CLEAN. DO NOT USE EMERY CLOTH, SAND-
PAPER, OR FILES, WHICH CAN PERMANENTLY DAM-
AGE HEADS AND CARRIAGE HOLES. DO NOT USE A
DEFECTIVE TOOL. REPAIR OR REPLACE TOOL IF
DAMAGE EXISTS.

USE CARE WHEN USING THE HEAD ALIGNMENT TOOL
THE TOOL SHOULD SLIP EASILY THROUGH THE
ALIGNMENT HOLE (IN THE CARRIAGE) AND INTO
THE SLOT IN THE HEAD/ARM. WHEN ADJUSTING
THE HEAD, THE TOOL SHOULD TURN FREELY IN THE
HOLE. IF ANYTHING MORE THAN A SMALL AMOUNT
OF FORCE IS REQUIRED TO ADJUST THE HEAD/ARM,
THE TOOL IS PROBABLY BINDING IN THE HOLE
(IN THE CARRIAGE).

12. Check the centering alignment slot of all heads (read/write data and servo) associated with the fixed disk module (5, Figure 9-2).

****CAUTION****

WHILE TORQUING THE HEAD CLAMPING SCREWS USE ONLY STRAIGHT ALLEN WRENCH AND KEEP IT AS PERFECTLY ALIGNED AS POSSIBLE WITH HEAD MOUNTING SCREW. IF CARE IS NOT TAKEN DURING THIS OPERATION, THE HEAD/ ARM MAY BE PUSHED OUT OF ALIGNMENT.

13. Torque all fixed pack head clamped screws to $12 \pm 1/2$ in-lb while observing the centering.
14. Torque the head clamping screws of the removable cartridge heads to $6 \pm 1/2$ in-lb.
15. Set AC power circuit breaker to ON.
16. Press START switch to start drive motor and load heads.
17. Perform thermal stabilization: Allow drive to run with heads loaded for a minimum of 30 minutes. If head/arm alignment check is being performed on more than one drive, the CE disk pack needs only a 15 minute purge per drive after head/arm alignment check has been performed on the preceding drive (provided drive under test has been running for 30 minutes immediately preceding check).

****CAUTION****

MAKE CERTAIN THAT NO ELECTRICAL CONDUCTORS SUCH AS THE CARRIAGE LOCKING TOOL, HEAD ALIGNMENT TOOL, SCREW DRIVER OR OTHER SUCH TOOLS COME IN CONTACT WITH THE HEATSINKS MOUNTED ON TOP OF THE VOICE COIL ACTUATOR.

18. Ensure the following switches are set in the position given:

S1 of Servo-Fine in "SERVO" position.

S1 of Head Alignment Extender PWA In "FXD" position.

S1 of AZPV or HFSV PWA in "N" position

S2 of AZPV or HFSV PWA in "RW" position

S3 of AZPV or HFSV PWA in "X1" position

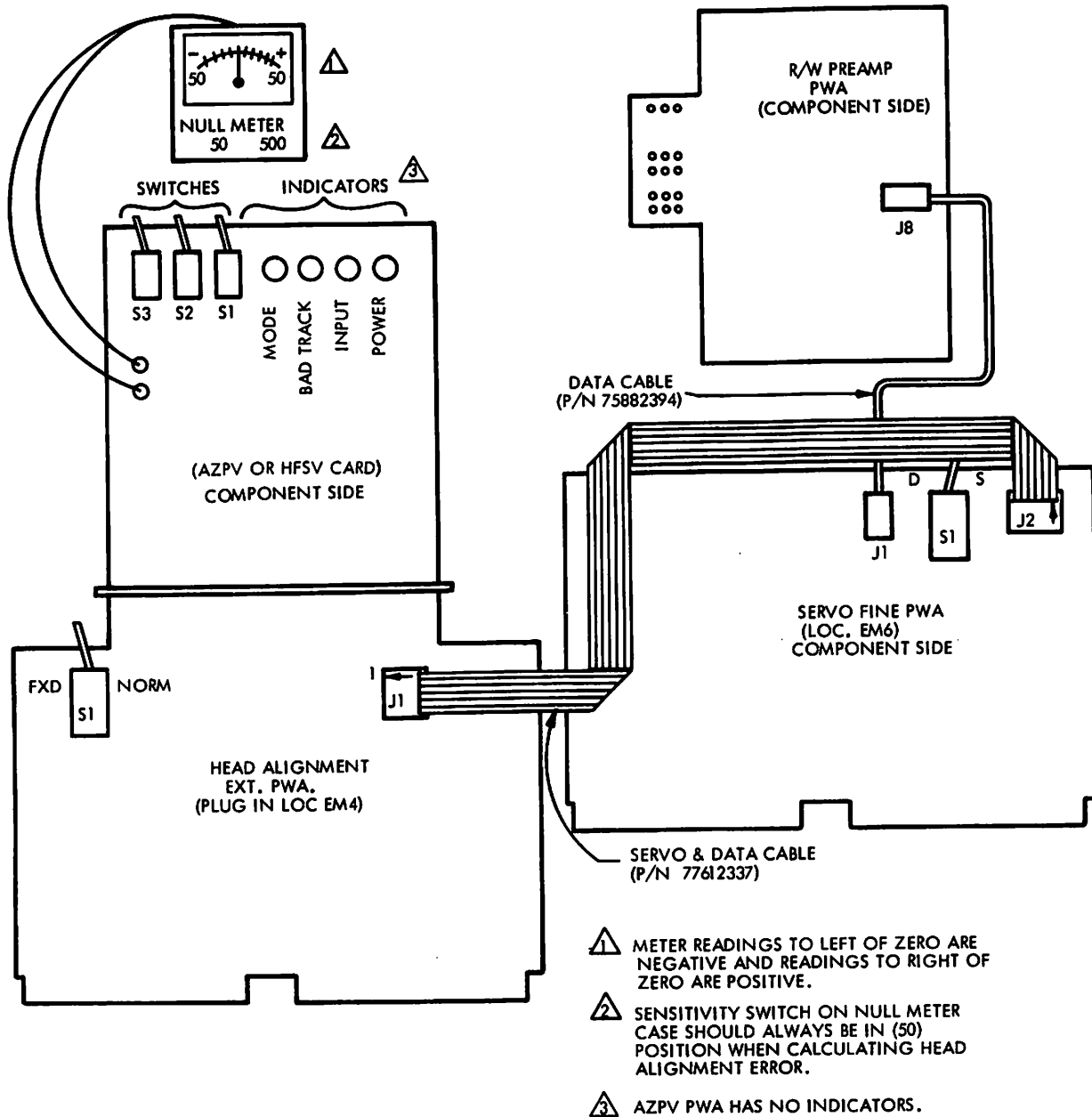
****NOTE****

All AZPV or HFSV PWA switches are positioned toward the rear of the drive.

19. Issue a RTZ command to the fixed disk. This command is necessary to initialize the servo on track "0" of the FIXED PACK.

****CAUTION****

WHENEVER THE HEADS ARE ADJUSTED AND THE CLAMPING SCREWS ARE TURNED WHILE THE HEADS ARE FLYING, EXTREME CARE SHOULD BE TAKEN SO AS NOT TO MOVE THE CARRIAGE ASSEMBLY IN A LATERAL DIRECTION (RIGHT ANGLES TO THE NORMAL DIRECTION OF HEAD MOVEMENT). THE RESULTANT FORCE CAN ROTATE THE CARRIAGE ASSEMBLY AND CAUSE SEVERE DAMAGE TO THE HEADS AND DISKS. THIS MOTION CAN BE PREVENTED BY APPLYING SUFFICIENT COUNTER FORCE ON THE OPPOSITE SIDE OF THE CARRIAGE AS SHOWN BY THE LARGE ARROW IN FIGURE 9-2.



Refer to parts listing in Appendix A for Data Cables.

FIGURE 9-1 HEAD ALIGNMENT BLOCK DIAGRAM

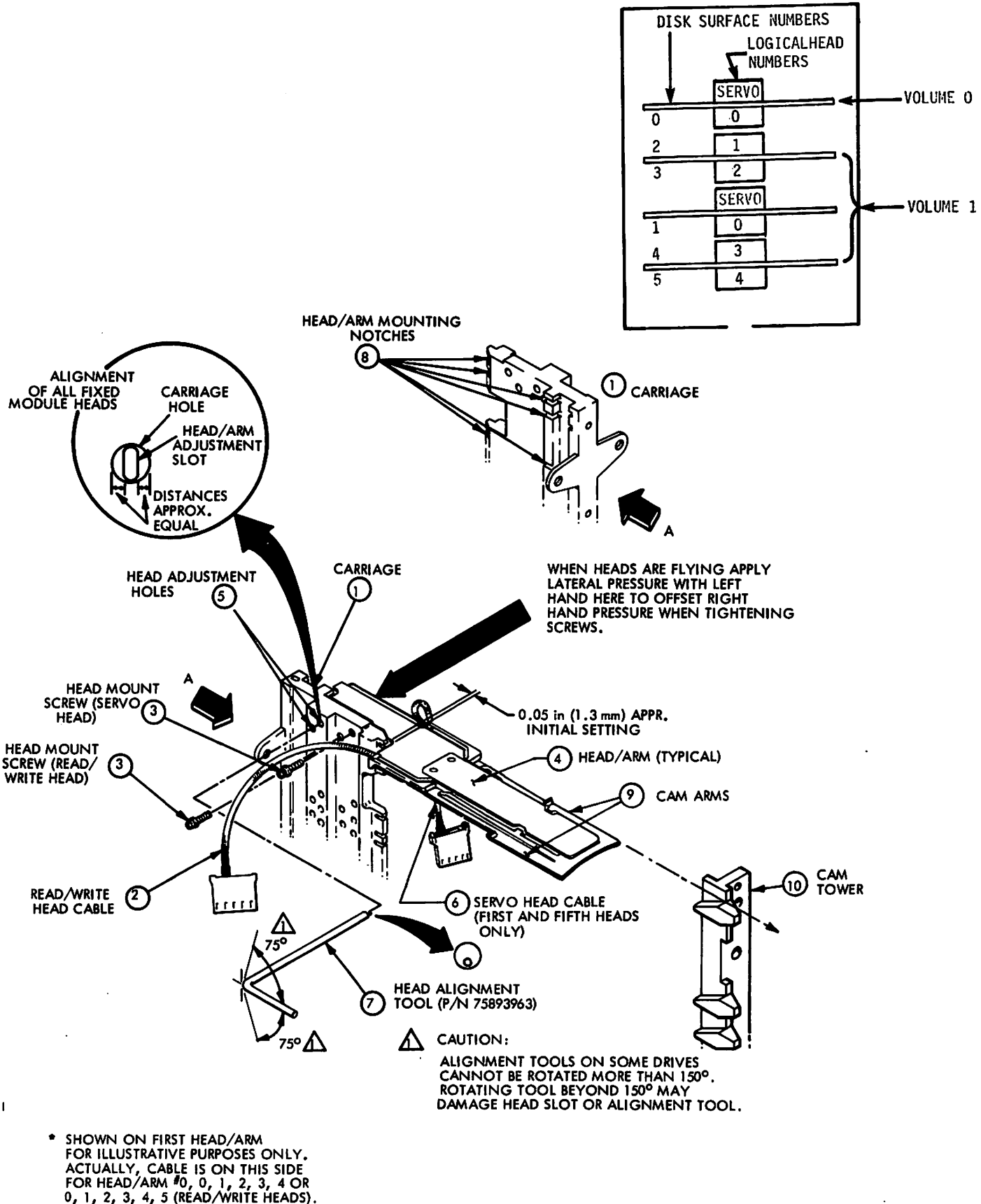


FIGURE 9-2 HEAD/ARM REMOVAL AND REPLACEMENT AND ALIGNMENT

20. Assuming the head alignment tool is to be manipulated with the right hand, place the left hand with the side of the pointer finger against the carriage assembly on the opposite side from where the head alignment tool is inserted. Apply pressure with the left hand only when the right hand applies pressure and then try to apply equal pressure with both hands (see step 21 below).
21. Using a head alignment tool (P/N 726-9699) move the cartridge servo head toward the rear of the drive until the outer guard-band is reached. The outer guard band can be located by observing the waveform on the oscilloscope (see Figure 9-3). The waveform shape and amplitude remains constant throughout the guard-band.
22. Once the guard band has been located use the tool to move the cartridge servo head toward the disk center until cylinder number zero is reached. This can be determined by the meter reading of null (centered) and a scope waveforms as shown in Figure 9-3. Remove the head alignment tool.

****NOTE****

Steps 21 and 22 should be repeated to ensure that cylinder zero is captured.

- 23 Perform a seek to cylinder 404. The Null meter should be set to its least sensitive range.
24. Install the Carriage Locking Tool. See Figure 2-5

OSCILLOSCOPE SETTINGS

LOGIC GROUND TO SCOPE GROUND

VOLTS/DIV

CH 1 - 0.5 V
CH 2 - NOT USED

TIME/DIV

A - 0.5 μ s
B - NOT USED

TRIGGERING

A - INTERNAL POSITIVE
B - NOT USED

PROBE CONNECTIONS (USE X10 PROBE)

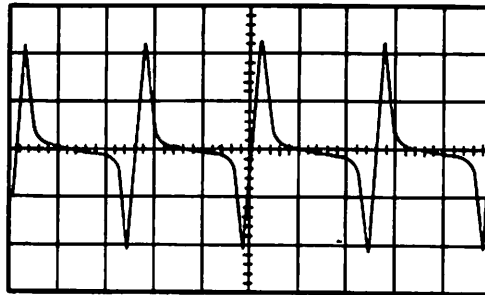
CH 1 TO FTU DIBITS JACK
CH 2 NOT USED

FIGURE 9-3 GUARD-BAND WAVEFORM PATTERN

OSCILLOSCOPE SETTINGS

LOGIC GND TO SCOPE GND

VOLTS/DIV

CH 1 - 0.2 V
CH 2 - NOT USED

TIME/DIV

A - 0.5 μ s
B - NOT USED

TRIGGERING

A - INTERNAL POSITIVE
B - NOT USED

PROBE CONNECTIONS (USE X10 PROBE)

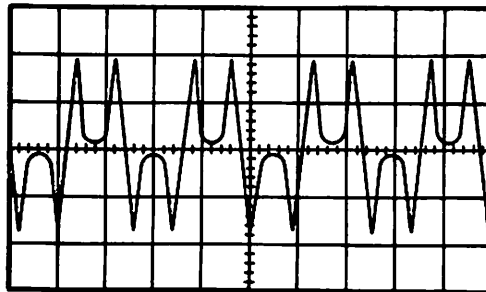
CH 1 TO FTU DIBITS JACK
CH 2 - NOT USED

FIGURE 9-4 BALANCED DIBIT PATTERN

25. Calculate the offset using the following procedure:
- a. Oscilloscope waveform should be similar to Figure 9-3.
 - b. Set null meter to its least sensitive range (switch S3 of AZPV or HFSV PWA must be on "X1").
 - c. Move S1 of AZPV or HFSV PWA to "P" and record meter reading.
 - d. Calculate the offset as described below.

$$(P) - (N) = \text{OFFSET}$$

****NOTE****

P is the meter reading with the POS/NEG switch in the POS position. N is the meter reading with the POS/NEG switch in the NEG position. Meter readings to the right of zero are positive. Meter readings to the left of zero are negative.

. EXAMPLE 1: $P = +20, N = +15; (P) - (N) = (20) - (15) = 5$

. EXAMPLE 2: $P = +20, N = -15; (P) - (N) = (20) - (-15) = 35$

. EXAMPLE 3: $P = -20, N = +15; (P) - (N) = (-20) - (+15) = -35$

26. Insert the head alignment tool again and remembering to offset any force applied by the tool hand with the other hand, adjust the cartridge servo head position to obtain a calculated offset of less than 50 mV.
27. Torque the servo head clamping screw to between 8 and 10 in-lb (1.26 to 1.38 Nm).

28. Re-calculate the offset and make any minor (only) adjustment required if the offset calculates to be greater than 50 mV. A minor (but only minor) adjustment can be made after the clamping screw has been tightened.
29. Remove the carriage locking tool, being careful to keep hands out of the way of the carriage in case it should retract. Torque heads to 12 in-lbs.
30. Perform a seek to cylinder 8.
31. Calculate the offset as described in step 25. Record the calculated offset indication for later reference.
32. Seek to Cylinder 800.
33. Calculate the offset as described in step 25. Record the calculated offset indication for later reference.

****NOTE****

The Oscilloscope waveforms at cylinders 8 and 800 should be similar to Figure 9-3. Calculated offset should be less than 350 mV. If either cylinder offset is greater than 350 mV repeat steps 23 through 29. Minor compensatory adjustments can be made at cylinder 404 in an attempt to effect the offset at cylinder 8 and 800. However, the final calculated offset can not exceed 75 mV at cylinder 404.

34. Set the following switches to the position given:
 - a. S1 of Servo Fine to "DATA".
 - b. S1 of Head Alignment Extender PWA to "NORMAL".
 - c. S1 of AZPV or HFSV PWA to "N".
 - d. S2 of AZPV or HFSV PWA to "R/W".
 - e. S3 of AZPV or HFSV PWA to "X1".

35. Command RTZ.

****NOTE****

This ensures that the drive will servo on the cartridge servo and select data head 0.

36. Repeat steps 23 through 33 for the cartridge data head.

****NOTE****

The calculated offset for the cartridge data head must be less than 40 mV at position (cylinder 404).

37. Command an alternate seek between cylinders 257 and 512 for a minimum of 30 seconds.

38. Check the cartridge servo head alignment. To do this set the following switches to the positions given:

- a. S1 of the Servo Fine PWA to "SERVO".
- b. S1 of the Head Alignment Extender PWA to "FXD".
- c. S1 of AZPV or HFSV PWA to "N".
- d. S2 of AZPV or HFSV PWA to "R/W".
- e. S3 of AZPV or HFSV PWA to "X1".

Seek to cylinder 404 and calculate the offset as in step 25 for the cartridge servo head. If the calculated offset is greater than 50 mV, repeat steps 23 through 33 and then 37 and 38.

39. Check the cartridge data head alignment. To do this, set the following switches to the positions given and perform the operations as specified:
 - a. S1 of the Servo Fine PWA to "DATA".
 - b. S1 of the Head Alignment Extender PWA to "NORM".
 - c. Select head 0 (i.e., issue RTZ command).
 - d. Seek to cylinder 8, 404 and 800 and calculate the offset for the cartridge data head at each of these three cylinders as described in step 25. If the calculated offset exceeds 75 mV at any of these alignment cylinders, repeat steps 31 through 36.
40. When head alignment is satisfactorily completed, press the STOP/START switch to stop the drive and wait until the spindle drive motor has stopped.
41. Remove the CE cartridge and install the cartridge into its protective cover.
42. Write Protect switches on the operators panel can be released if desired.
43. Set the AC circuit breaker (rear of drive) to the OFF position.
44. Remove the head alignment kit from drive:
 - a. Meter
 - b. AZPV or HFSV PWA and extender PWA
 - c. Cable from R/W preamp PWA to Servo Fine PWA
 - d. Cable from extender PWA to Servo Fine PWA

45. Return the Electronic Module to its normal position and install locking screws.

****CAUTION****

USE EXTREME CAUTION WHEN SETTING THE ELECTRONICS MODULE DOWN INTO ITS NORMAL POSITION. CABLES THAT ARE IN THE CLOSE PROXIMITY OF THE ELECTRONICS MODULE WILL BE DAMAGED IF CAUTION IS NOT USED.

46. Store the carriage locking tool in its normal operating position.
47. Install the drive cover assembly.

9.8 CARTRIDGE DATA HEAD ALIGNMENT PROCEDURE

A. GENERAL

The procedure for aligning a newly replaced cartridge data read/write head is given in the following paragraphs.

B. PROCEDURE

Refer to "Initial Head Alignment Procedure" in performing the following steps for the Cartridge Data Head.

1. Perform steps 1 through 11.
2. Perform steps 14 through 17.
3. Perform steps 31 through 34.
4. Perform steps 36 through 44.

9.9 CARTRIDGE SERVO HEAD ALIGNMENT PROCEDURE

A. GENERAL

The procedure for aligning a newly replaced cartridge servo head is given in the following paragraphs.

B. PROCEDURE

Refer to "INITIAL HEAD ALIGNMENT PROCEDURE" in performing the following steps for the CARTRIDGE SERVO HEAD.

1. Perform steps 1 through 11.
2. Perform steps 14 through 47.

9.10 FIXED DISK MODULE DATA READ/WRITE HEAD ALIGNMENT PROCEDURE

A. GENERAL

The procedure for aligning a newly replaced fixed disk module data read/write head is given in the following paragraphs.

B. PROCEDURE

****NOTE****

In order to recover data when changing a fixed disk module data read/write head the host system must be utilized in order to read the formatted surface involved.

1. Allow the drive to stabilize by running with heads loaded for a minimum of five minutes.
2. Seek to and attempt to read from the replaced head at cylinder 404 (a continuous loop read and error print-out is desired).

3. Install the carriage locking tool in the head alignment position.
4. Connect an oscilloscope so as to be able to look at the read analog differential voltage across TP1 and TP2 of the read/write preamp PWA. Move the newly replaced head slowly in the forward and reverse directions with the head alignment tool while watching the read voltage and the error print out. Adjust initially for maximum read voltage. Continue adjusting until no error occurs.
5. Torque the head clamping screw to between 8 and 10 in-lb. and readjust the head for zero error printout if necessary.
6. Repeat the fine tune adjustment step with the head alignment tool until the drive will read error free.
7. Remove the head alignment tool and torque to 12 in-lbs..
8. Remove the carriage locking tool. It should be noted that although the above procedure is designed to recover as much of the customer data as possible, the error rate performance cannot be guaranteed over the range of environmental extremes normally specified for the drive. Therefore, it is recommended that all of the data be recovered from and be rewritten on the surface covered by the newly replaced head.
9. Operate the STOP/START switch to the STOP position and wait for the drive to stop turning.
10. Set the AC circuit breaker to OFF.
11. Install case cover assembly.
12. Turn on AC circuit breaker and start the drive.

9.11 FIXED MODULE SERVO HEAD ALIGNMENT PROCEDURE

A. GENERAL

The procedure for aligning a newly replaced fixed servo head is given in the following paragraphs.

1. The fixed disk module servo head clamping screw should have been torqued to 4 1/2 in-lb when installed.
2. Plug the cartridge servo head connector into J3 (bottom header) of the Servo Preamp PWA.
3. Plug the fixed disk module servo head connector into J1 (top header).

****NOTE****

Refer to "Initial Alignment Procedure"
in performing the following steps.

4. Perform steps 5 through 11 for the fixed disk module servo head.
5. Perform steps 15 through 30 for the fixed disk module servo head.
6. Perform steps 34, 35 and 37 for the fixed disk module servo head.

****CAUTION****

MAKE SURE ADJUSTMENT IS ON THE FIXED
DISK MODULE SERVO HEAD.

7. Set CB1 to the OFF position.

8. Plug the Cartridge servo head connector into header J1 of the Servo Preamp PWA.

9. Plug the fixed disk module servo head connector into header J3 of the Servo Preamp PWA.

****NOTE****

It is recommended that the data on the fixed disk module be recovered and re-formatted subsequent to completion of the alignment procedure involving a fixed pack servo.

10. Set AC circuit breaker to the ON position.

11. Start the Drive.

12. Recover and reformat the fixed disk module data.

13. Stop the Drive.

14. Perform steps 40 through 44 of the "Initial Alignment Procedure."

CHAPTER X
MAINTENANCE SCHEDULE

10.1 GENERAL

Table 10-1 below defines the frequency of preventive maintenance to the Drive Components.

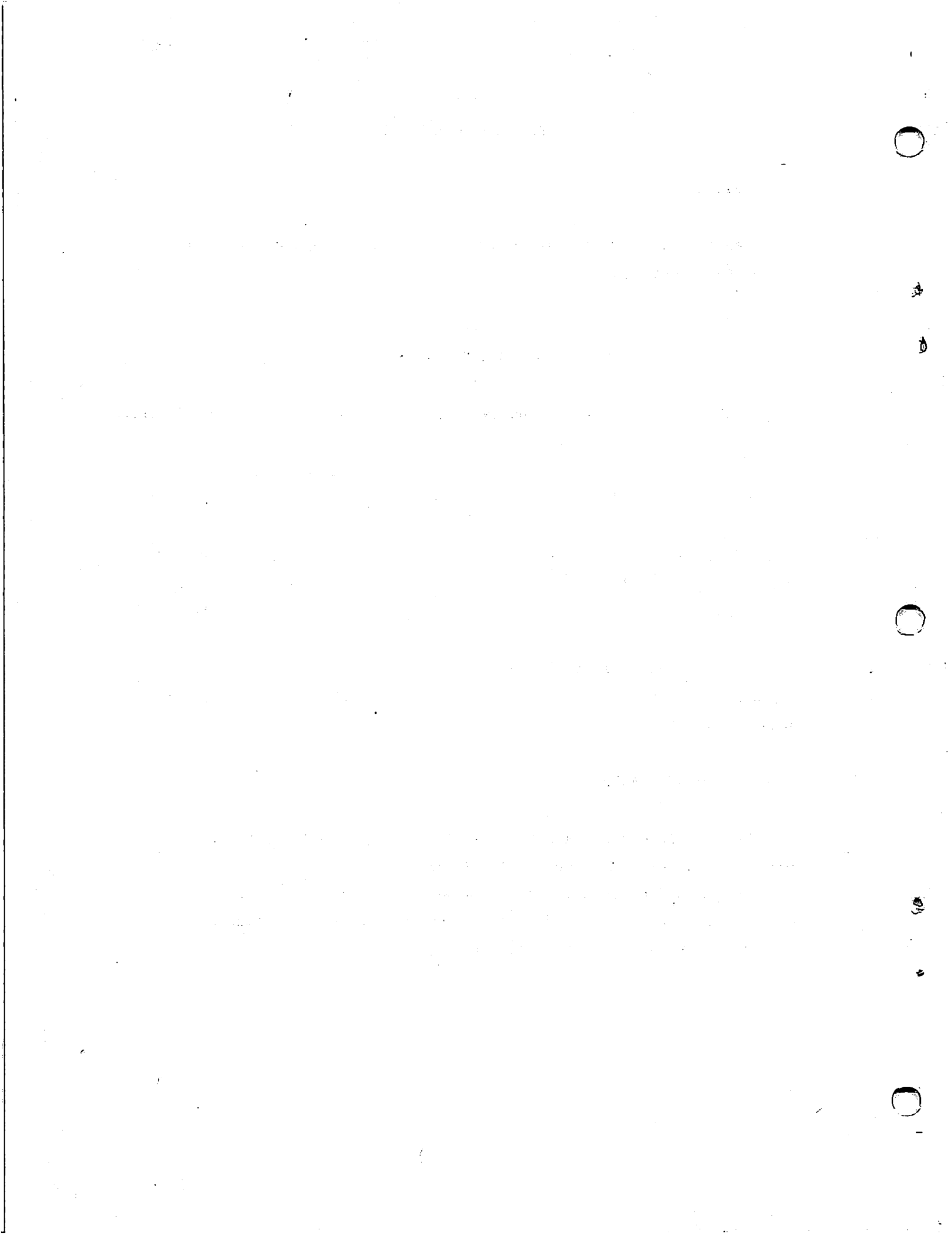
TABLE 10-1
SCHEDULED CLEANING AND INSPECTIONS

| Component | Daily | Weekly | Monthly | Quarterly | Semi-Annual |
|-------------------------------------------------|-------|--------|---------|---------------|---------------|
| Prefilter | | | | Check & Clean | |
| Inspect Actuator and Rails | | | | | Inspect XX |
| Clean Rails and Bearings | | | | | Inspect XX |
| Head Alignment | | | | | Check |
| Check P.S. Outputs (No adjustment) (Replace) | | | | xx | |
| Check Fine filter (Absolute) | | | | Check | Replace |

10.2 REFERENCE MANUAL

For the procedure on replacing any major assemblies, refer to Section 6 in the CDC Hardware Maintenance Manual 75888415.

Refer to Figures A-6 and A-7 in Appendix A for the Prefilter and Absolute filter locations and the method of access for cleaning and replacing during periodic maintenance.



APPENDIX "A"
ILLUSTRATIVE PARTS LIST
(PCB's AND DISCRETE COMPONENTS)

PHOENIX DISK DRIVE
PRINTED CIRCUIT BOARDS

| <u>WLI</u> | <u>SLOT</u> | <u>CDC #</u> | <u>DESCRIPTION</u> |
|------------|-------------|--------------|-----------------------------------|
| 5778 | 1 | 77616790 | PCB I/O EMI |
| 5779 | 2 | 77616600 | PCB CNTL/Mux EM2 |
| 5780 | 3 | 75885600 | PCB Servo/Course EM3 |
| 5782 | 6 | 75886300 | PCB Servo/Fine EM6 |
| 5783 | 7 | 75886350 | PCB Servo/Write EM7 R/w |
| 5784 | | 75885750 | PCB Servo/Fine Pre Amp R/w PR& |
| 5785 | | 75885950 | PCB Pwr Amp |
| 5786 | | 75898850 | PCB Relay CNTL |
| 5787 | | 75895150 | PCB Oper CNTL Pnl. |
| 5788 | | 75895250 | PCB Component Bd. |
| 5789 | | 75832900 | PCB Regulator |
| 5790 | | 75886100 | PCB Terminator |
| 5792 | | 75885800 | PCB Servo Pre Amp |

FTU CABLES

| | | |
|----------|----------|-------------|
| 726-6652 | 75145500 | 10 PIN (A4) |
| 726-6653 | 75145501 | 26 PIN (B5) |
| 726-6654 | 75145502 | 50 PIN (A2) |

PHOENIX DISK DRIVE
DISCRETE COMPONENTS

| <u>WLI</u> | <u>CDC #</u> | <u>DESCRIPTION</u> |
|------------|--------------|----------------------------------------------------|
| 726-5548 | 75010102 | Head Arm Assy, LOWER |
| 726-5549 | 75010103 | Head Arm Assy, UPPER |
| 726-5550 | 75010105 | Head Arm Assy, SERVO |
| 726-5559 | 92314113 | Belt 60 HZ (80) |
| 726-5629 | 50223603 | Xistor Pwr Amp Q3 ^{PLATE} _{LEFT} |
| 726-5630 | 50223703 | Power Amp Assy Q2 ^{FRONT} _{RT.} |
| 726-5747 | 95575000 | Rectifier |
| 726-5748 | 93418334 | Fuse 6A 250V |
| 726-5757 | 75880045 | Speed Sensor |
| 726-5758 | 75885996 | Filter Fine |
| 726-5759 | 75881911 | Filter Course & Gasket |
| 726-5760 | 77610050 | A/C Relay |
| 726-5761 | 75887871 | Static Spring |
| 726-5762 | 95583504 | CR2 Rectifier Blk. |
| 726-5763 | 50242201 | CR1 Rectifier Brdg |
| 726-5764 | 95588200 | Rectifier Sil. |
| 726-5765 | 75887484 | Rectifier MR 500 P.A. |
| 726-5766 | 95587107 | CKT BKR |
| 726-5767 | 77610140 | Switch PK-on, DK-DN, Car-R.T.N |
| 726-5770 | 22940807 | Relay 10A |
| 726-5771 | 22940808 | Relay 15A |
| 726-5773 | 75894102 | Velocity Xducer Assy |
| 726-5774 | 75886281 | Spindle Assy |
| 726-5775 | 75891689 | Drive MTR 60 HZ 726-6666 |
| 726-5776 | 75889886 | Blower MTR |
| 726-5777 | 77610705 | Power Supply Assy. |
| 726-5778 | 77616790 | PCB I/O EM1 |
| 726-5779 | 77616600 | PCB Cntl/Mux EM2 |
| 726-5780 | 75885600 | PCB Servo/Coarse EM3 |
| 726-5782 | 75886300 | PCB Servo/Fine EM6 |
| 726-5783 | 75886350 | PCB Read/Write EM7 |
| 726-5784 | 75885750 | PCB Read/Write Pre-Amp |
| 726-5785 | 75885950 | PCB Power Amp |

| | | |
|----------|----------|----------------------------|
| 726-5786 | 75898850 | PCB Relay Cont'l |
| 726-5787 | 75895150 | PCB Optr Cont'l Panel |
| 726-5788 | 75895250 | PCB Component Board |
| 726-5789 | 75832900 | PCB Regulator |
| 726-5790 | 75886100 | PCB Terminator |
| 726-5792 | 75885800 | PCB Servo Pre-Amp |
| 726-5793 | 93418324 | Fuse 1.25A 250V |
| 726-5794 | 93418239 | Fuse 10A 125V |
| 726-5797 | 77610706 | Power Supply 50Hz |
| 726-5798 | 75891690 | Drive Motor Assy 50Hz |
| 726-5799 | 92314127 | Belt 50Hz |
| 726-5800 | 75778718 | Power Card 50Hz |
| 726-5801 | 75889887 | Blower Motor 50Hz |
| 726-5813 | 75317102 | Transducer Assy |
| 726-5821 | 94394004 | Switch Start |
| 726-5822 | 94394001 | Switch, Fault |
| 726-5823 | 94394002 | Switch, Protect |
| 726-5824 | 94394108 | Switch Device Encoding |
| 726-5831 | 51853015 | Head Cable Clamps |
| 726-5832 | 75888775 | Resistor Wire Wound |
| 726-5833 | 75888776 | Resistor Wire Wound |
| 726-5834 | 95645628 | Capacitor 40V |
| 726-5835 | 75882865 | Door Assy |
| 726-5836 | 75883056 | Solenoid Door-Lock |
| 726-5837 | 75883465 | Cable Door-Lock |
| 726-6506 | 76204650 | Fixed Disk Module |
| 726-6511 | 75778719 | 6' POWER CORD |
| 726-8018 | 95033502 | Media Cleaning Solution |
| 726-9673 | 75882520 | TORQUE EXTENDER ADAPTER |
| 726-9675 | | Extender Board |
| 726-9677 | 75882565 | Guide |
| 726-9678 | 75886000 | PWA Hd. Alignment Ext. |
| 726-9679 | 77612622 | Jumper Ext. |
| 726-9680 | 77612337 | Head Align. CBL 1 |
| 726-9681 | 75882394 | Head Align. CBL 2 |
| 726-9682 | 75891573 | Carr. Link Tool |
| 726-9683 | 76204400 | CE Cartridge 1204-51 |
| 726-9693 | 82338800 | TB216 (FTU) Disk Exercisor |
| 726-9696 | D22628 | Torque Tip Short |
| 726-9699 | 75893963 | Head Alignment Tool |
| 726-5611 | 77440500 | Min Alignment Kit |

726-5889 D.P SHUNT
726-5933 WIRE WOUND RES.

PHOENIX COMPONENTS LIST

| <u>I.C.</u> | <u>WL #</u> | <u>CDC #</u> |
|-------------|-------------|--------------|
| 74S00 | 376-0228 | |
| 74LS00 | 376-0207 | |
| 74LS02 | 376-0208 | |
| 74LS03 | 376-0224 | |
| 7404 | 376-0002 | |
| 74S04 | 726-6537 | 88883700-2 |
| 74LS04 | 376-0180 | |
| 74LS05 | 726-6538 | 15145300-8 |
| 74LS08 | 376-0153 | |
| 74S10 | 376-0238 | |
| 74LS10 | 376-0209 | |
| 74LS11 | 376-0225 | |
| 74LS14 | 376-0322 | |
| 74S20 | 376-0230 | |
| 74LS20 | 376-0210 | |
| 74LS27 | 376-0245 | |
| 74LS32 | 376-0211 | |
| 74LS42 | 376-0212 | |
| 74S51 | 376-0184 | |
| 74LS51 | 376-0213 | |
| 74S64 | 376-0201 | |
| 74S74 | 376-0202 | |
| 74LS74 | 376-0155 | |
| 74S86 | 376-0271 | |
| 74LS86 | 376-0231 | |
| 74LS109 | 726-6539 | 15148000-1 |
| 74S112 | 726-5122 | 15158600-5 |
| 74LS138 | 376-0294 | |
| 74LS139 | 376-0226 | |
| 74S140 | 726-6540 | 15158700-3 |
| 74148 | 376-0171 | |
| 74LS157 | 376-0216 | |
| 74LS161 | 376-0233 | |
| 74LS164 | 376-0236 | |
| 74LS175 | 376-0160 | |
| 74S195 | 726-6541 | 15164418-4 |
| 74LS257 | 376-0204 | |
| 74LS279 | 726-5120 | 15148300-5 |
| 75107 | 376-0146 | |
| 75110 | 376-0255 | |
| 75452 | 726-6542 | 15113000-2 |
| 75461 | 726-6543 | 15161600-0 |
| 75472 | 726-6519 | 15164423-4 |
| 8080A | 377-0269 | |
| 8111 | 726-6536 | |
| 8212 | 726-8039 | |
| 8224 | 377-0337 | |
| 8228 | 377-0338 | |
| 8253 | 726-8040 | |
| 8255A | 726-8041 | |

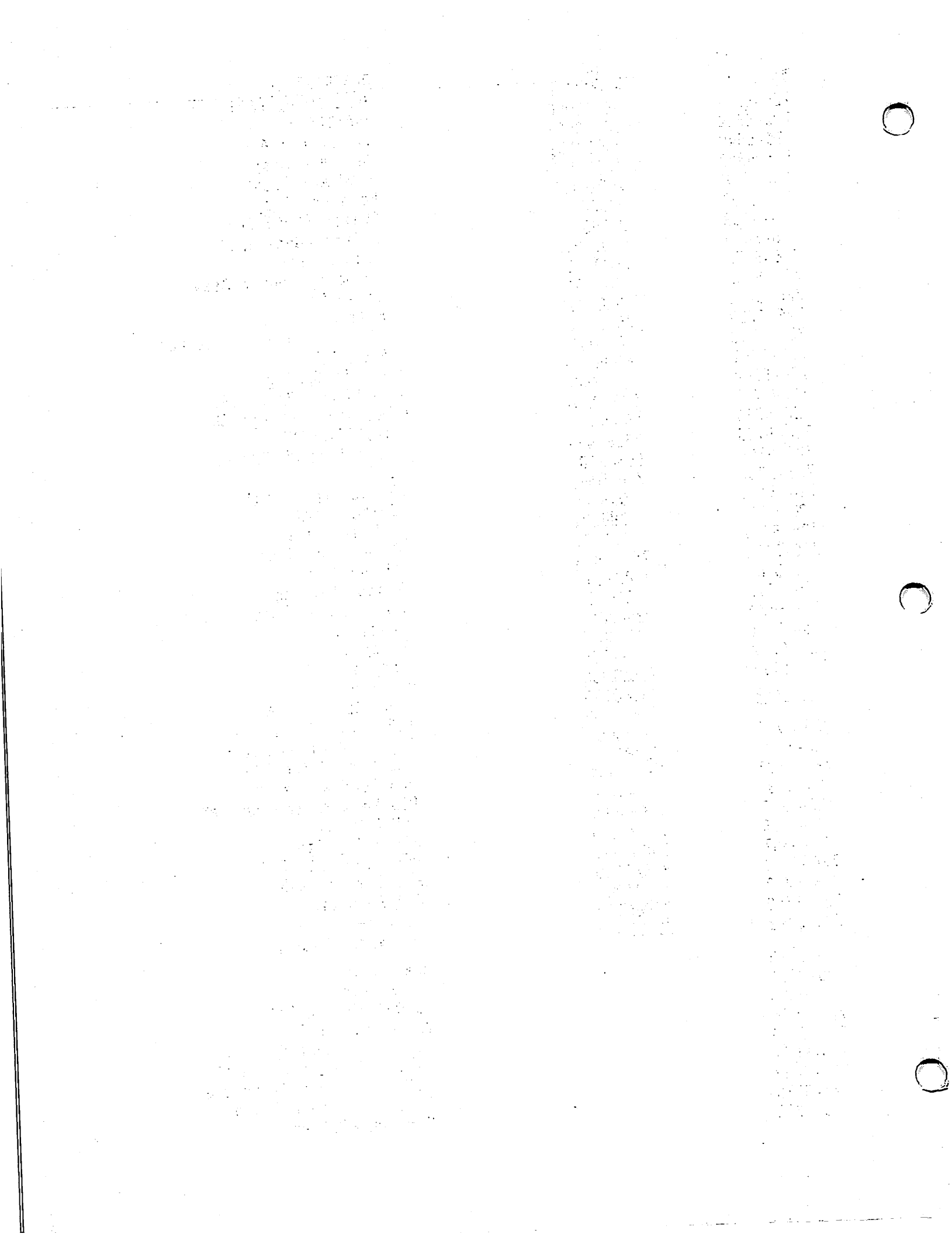
| | | |
|-----------|----------|------------|
| AM685DL | 726-6520 | 15164430-9 |
| CA3346 | 726-5352 | 94675200-3 |
| ECL1648 | 726-5806 | 15164422-6 |
| ECL10102 | 726-5711 | 15118000-7 |
| ECL10104 | 726-5712 | 15120900-4 |
| ECL10105 | 726-5713 | 15118100-5 |
| ECL10116 | 726-5716 | 15121100-0 |
| ECL10117 | 726-5805 | 15118600-4 |
| ECL10124 | 726-5717 | 15119400-8 |
| ECL10125 | 726-5718 | 15119500-5 |
| ECL10131 | 726-5719 | 15118500-6 |
| ECL12040 | 726-6527 | 15126400-9 |
| LF13201D | 726-6528 | 15164403-6 |
| LM339 | 376-0240 | |
| MC1408L8 | 726-6521 | 15132702-0 |
| MC1733CL | 726-6523 | 15163100-9 |
| MC1776CP1 | 726-6524 | 15164425-9 |
| MC4741CL | 726-6522 | 15164404-4 |
| MPQ1000 | 726-6529 | 77832297-4 |
| MPQ1500 | 726-6530 | 77832298-2 |
| MPQ6600-1 | 726-6531 | 75889250-9 |
| NE521FH | 726-6532 | 15123100-2 |
| 201A | 726-5840 | 15156600-7 |
| 3437 | 376-0291 | |
| 9324DC | 376-0325 | |
| 9602 | 376-0104 | |

| <u>Volt. Reg.</u> | <u>WL #</u> | <u>CDC #</u> |
|-------------------|-------------|--------------|
| 78M06 | 726-5807 | 15161101-9 |
| 78M12 | 726-5808 | 15161100-1 |
| 78M15 | 726-5809 | 15161102-7 |
| 79M06 | 726-5810 | 15137901-3 |
| 79M12 | 726-5811 | 15137903-9 |
| 79M15 | 726-5812 | 15137902-1 |
| HYBRID | 726-5890 | 15162000-2 |

| <u>Trans.</u> | <u>WL #</u> | <u>CDC #</u> |
|---------------|-------------|--------------|
| 2N1893 | 726-6526 | 51751900-5 |
| 2N2222A | 726-0179 | 51795600 |
| 2N2905A | 726-5860 | 51585100-4 |
| 2N2907A | 726-0905 | 72035901 |
| 2N3771 | 726-6535 | 94791000-6 |
| 2N4860A | 726-5625 | 75888005-8 |
| 2N5583 | 726-6533 | 77612002-4 |
| BFR91 | 726-6534 | 77612004-0 |
| MJ11016 | 726-5769 | 75887208-9 |
| PMD16K100 | 726-5630 | 50223703-5 |
| PMD17K100 | 726-5629 | 50223603-7 |
| 7 AMP | 726-5891 | 95689901-7 |

| <u>Rectifier</u> | <u>WLI#</u> | <u>CDC #</u> |
|------------------|-------------|--------------|
| 3 AMP 100V | 726-5764 | 95588200-6 |
| MR 751 | 726-5747 | 95575000-5 |
| Silicon | 726-5869 | 94825000-7 |

| WLI # | CDC # | DESCRIPTION |
|----------|----------|--------------------------|
| 726-5559 | 92314113 | Belt 60 HZ (60) |
| 726-5747 | 95575000 | Rectifier |
| 726-5629 | 50223603 | Xistor Pwr Amp |
| 726-5548 | 75010102 | Head Arm Assy |
| 726-5549 | 75010103 | Head Arm Assy |
| 726-5550 | 75010105 | Head Arm Assy |
| 726-5687 | 94363700 | Switch (Cntl Pnl) |
| 726-5688 | 94363701 | Switch (Cntl Pnl) |
| 726-5689 | 94364816 | Switch Prog. |
| 726-5773 | 75894102 | Velocity Xducer Assy |
| 726-5757 | 75880045 | Speed Sensor |
| 726-5758 | 75885996 | Filter (fine) |
| 726-5759 | 75881911 | Filter (course) & Gasket |
| 726-5760 | 77610050 | A.C. Relay |
| 726-5761 | 75887871 | Static Spring |
| 726-5762 | 95583504 | Rectifier Block CR2 |
| 726-5763 | 50242201 | Rectifier Bridge CR1 |
| 726-5764 | 95588200 | Rectifier Sil. |
| 726-5765 | 75887484 | Rectifier MR 500 P.A. |
| 726-5766 | 95587107 | CKT Bkr |
| 726-5767 | 77610140 | Switch (pack-on) |
| 726-5768 | 62048200 | Switch intlk |
| 726-5774 | 75886281 | Spindle Assy |
| 726-5775 | 75891689 | Drive Mtr 60 HZ |
| 726-5776 | 75889886 | Blower Mtr |
| 726-5769 | 75887208 | Xistor Pwr Amp |
| 726-5777 | 77830535 | Power Supply Assy |
| 726-5770 | 22940807 | Relay 10A |
| 726-5771 | 22940808 | Relay 15A |
| 726-5772 | 77612005 | Led (amber) |
| 726-5778 | 75891850 | PCB I/O EMI |
| 726-5779 | 75880150 | PCB Cntl/Mux EM2 |
| 726-5780 | 75885600 | PCB Servo/Course EM3 |
| 726-5781 | 75886000 | PCB Head align Ext EMY |
| 726-5782 | 75886300 | PCB Servo/Fine EM6 |
| 726-5783 | 75886350 | PCB Read/Write EM7 |
| 726-5784 | 75885750 | PCB Read/Write Pre Amp |
| 726-5785 | 75885950 | PCB Pwr Amp |
| 726-5786 | 75886200 | PCB Relay Cntl |
| 726-5787 | 75885850 | PCB Oper Cntl Pnl. |
| 726-5788 | 75880650 | PCB Component Bd. |
| 726-5789 | 75832900 | PCB Regulator |
| 726-5790 | 75886100 | Terminator |
| 726-5792 | 75885800 | PCB Servo Pickup |
| 726-9698 | | New F.T.U. |
| 726-9661 | | Torque Wrench |
| 726-9696 | | Torque Wrench Bits |
| 726-9676 | | Alignment Tool |
| 726-9680 | | Head Alignment Cable #1 |
| 726-9681 | | Head Alignment Cable #2 |
| 726-9683 | | C.E. Alignment Cartridge |
| 726-9675 | | P.W.A. Extender Board |
| 725-0711 | | Scratch Platter |



I/O PWA

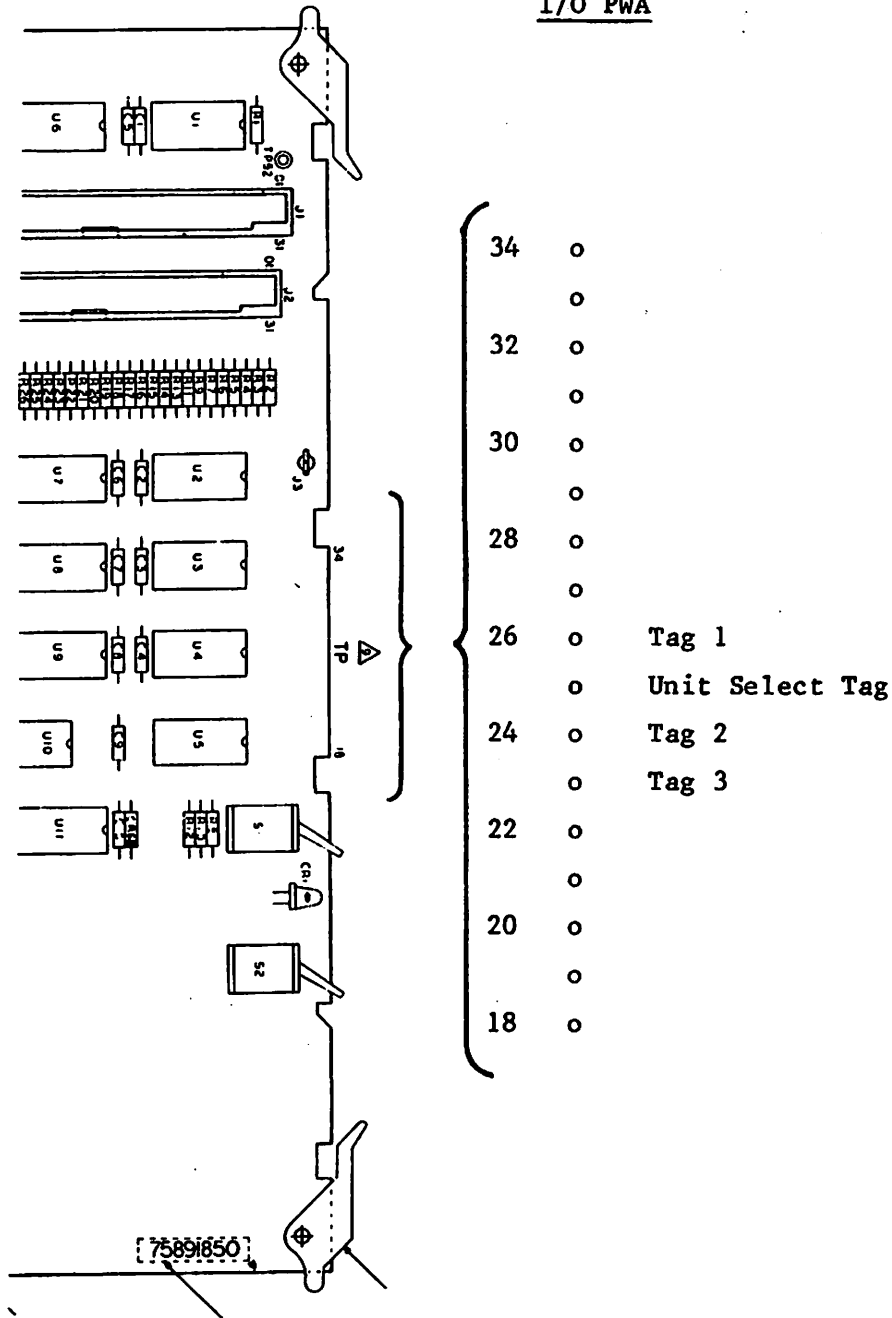


FIGURE A-1 I/O PWA TEST POINT (TP) SIGNALS

CNT/MUX PWA

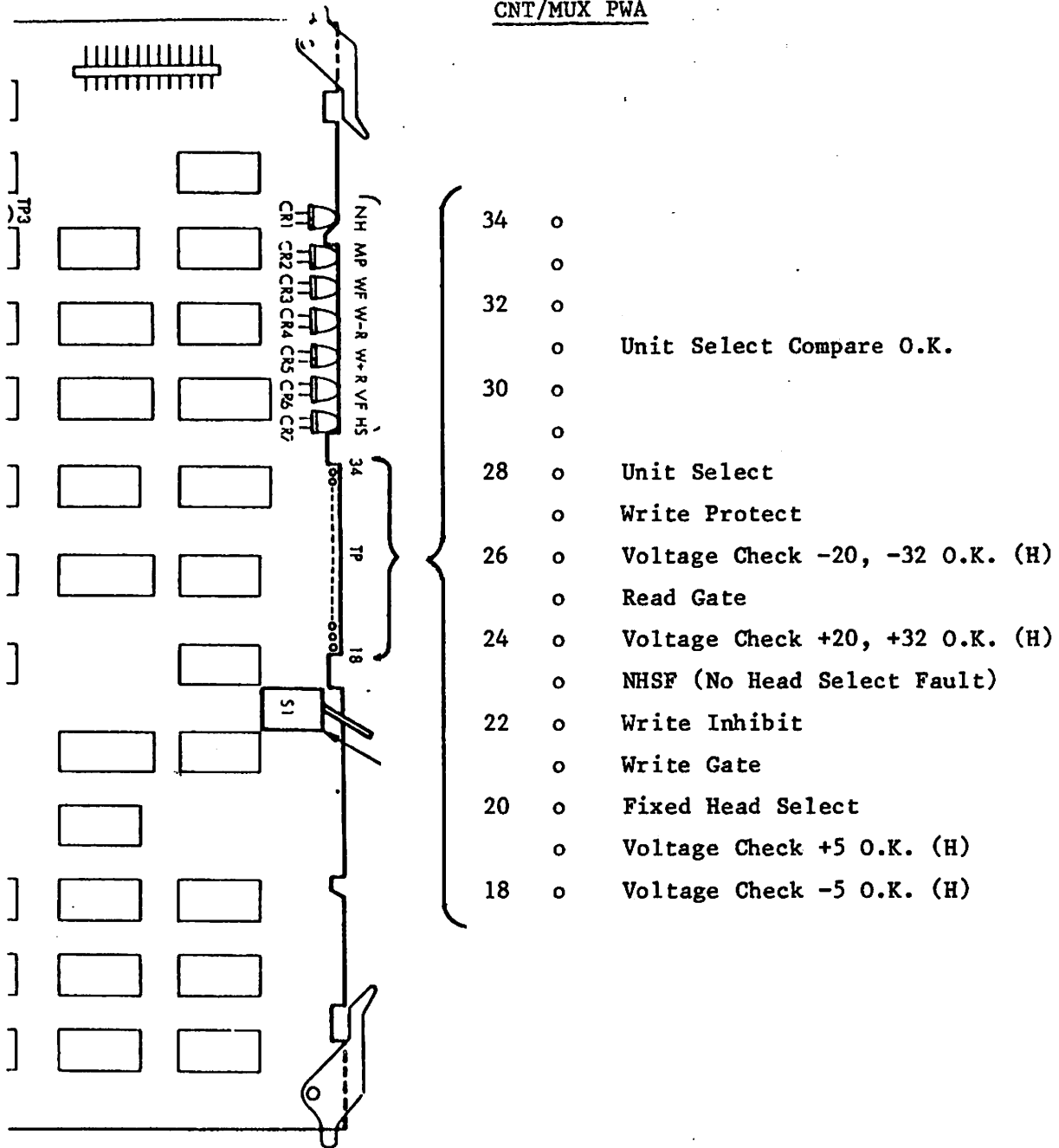
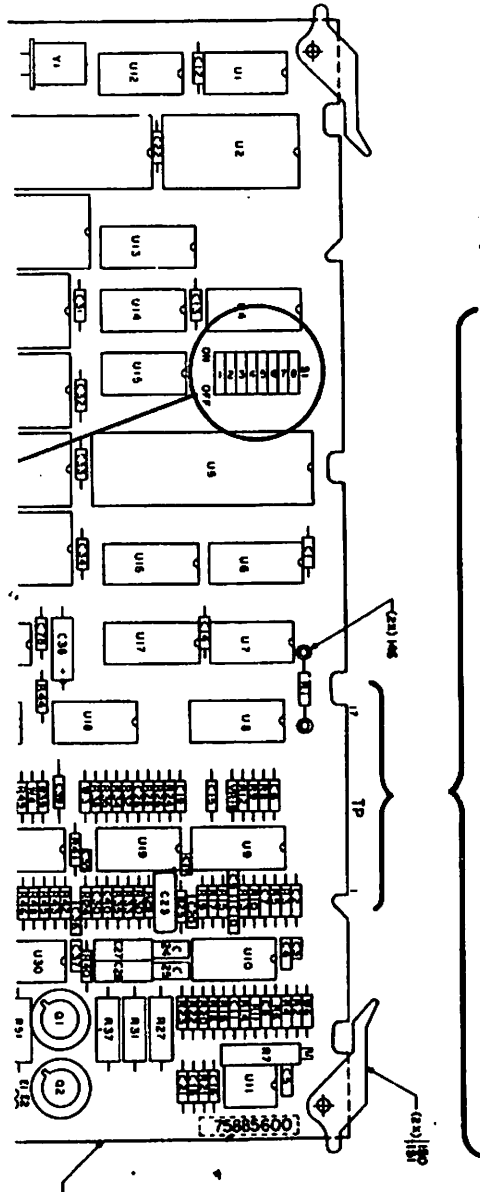


FIGURE A-2 CNT/MUX PWA TEST POINT SIGNALS

SERVO COARSE

- 17 o Cylinder Pulse Shrunk To 1.5 us
- o Spin Sensor Pulse (600 us)
- 15 o Cylinder Pulse
- o Unload Voltage
- 13 o Track Center
- o
- 11 o Offset Change Detector
- o 60 Hz Runout Compensator
- 9 o Found Track Center
- o
- 7 o Velocity Current AMP
- o Notch AMP Output
- 5 o Emergency Retract Velocity Control
- o Summing AMP Output
- 3 o Velocity
- o
- 1 o

FIGURE A-3 SERVO COARSE TEST POINT SIGNALS

SERVO FINE

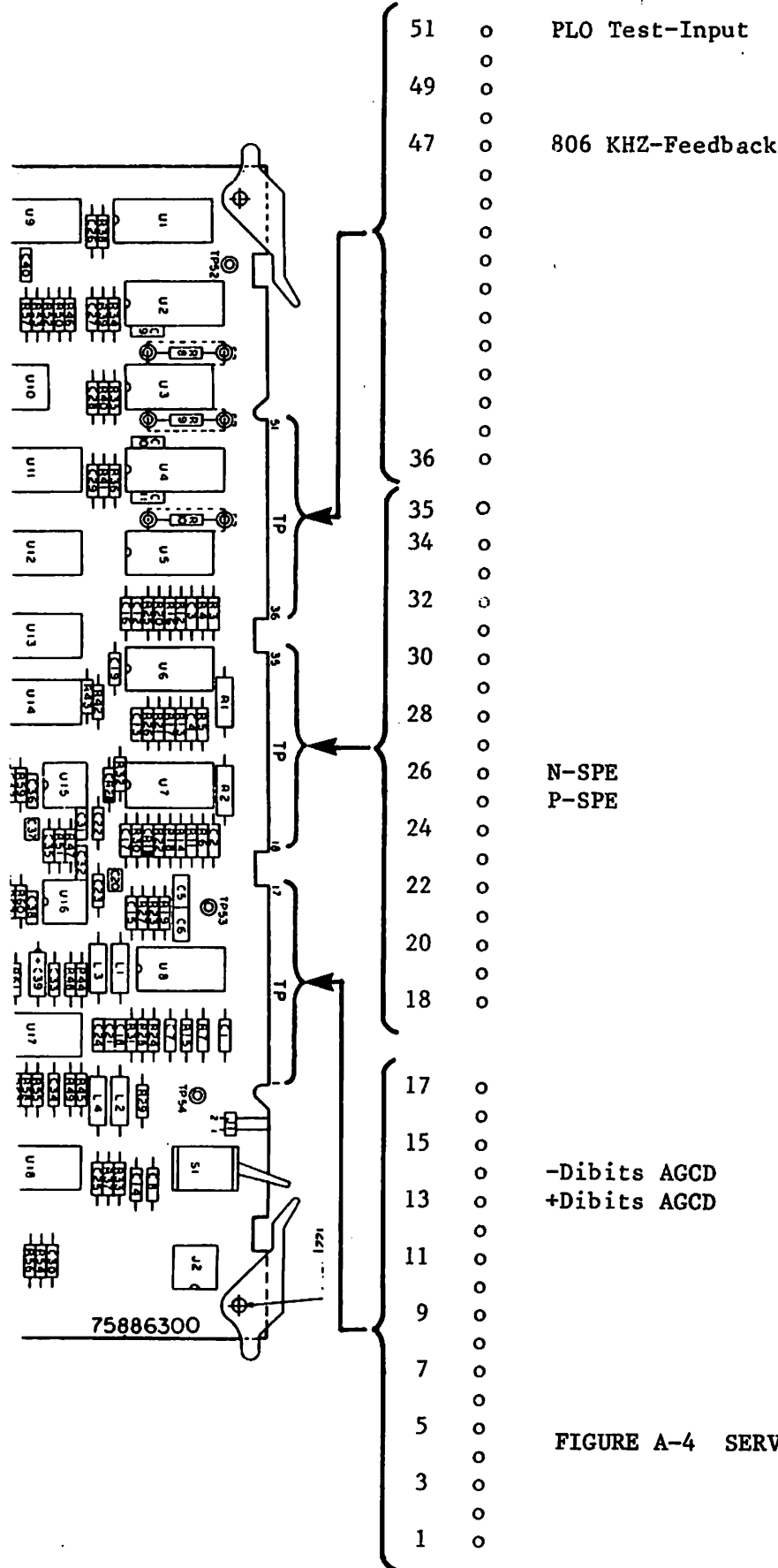


FIGURE A-4 SERVO FINE TEST POINT SIGNALS

READ/WRITE

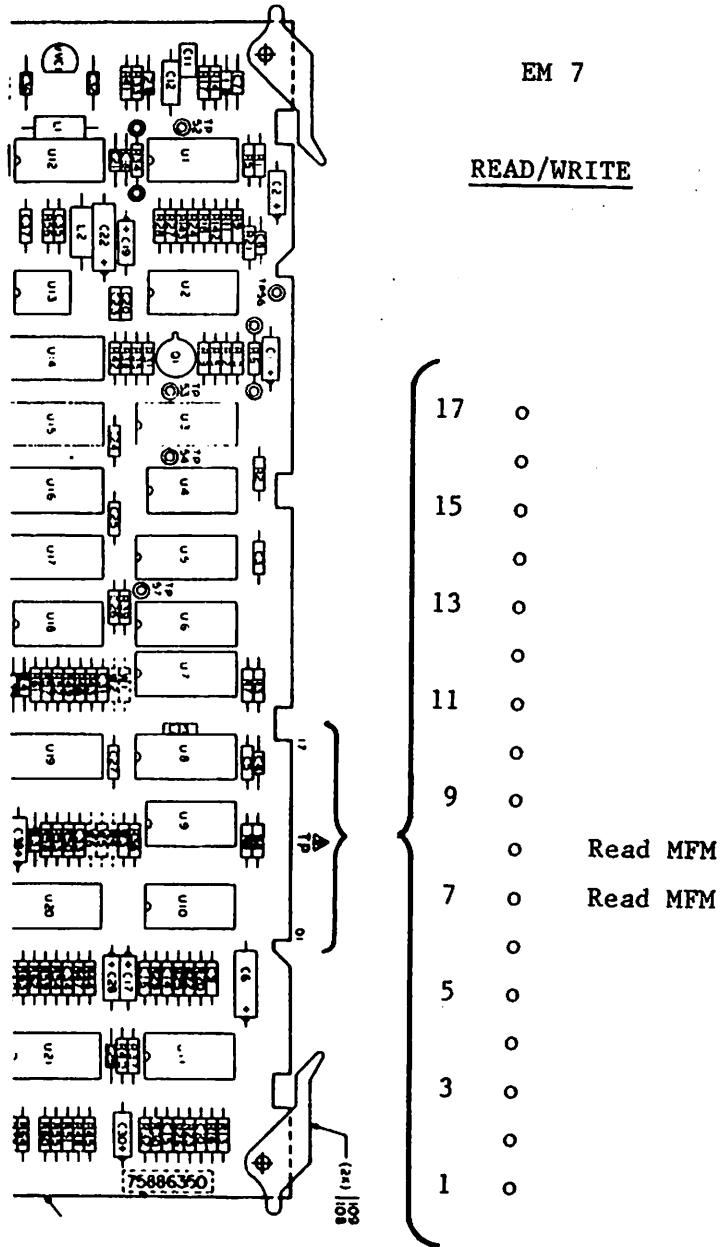


FIGURE A-5 READ/WRITE CIRCUIT BOARD TEST POINT SIGNALS

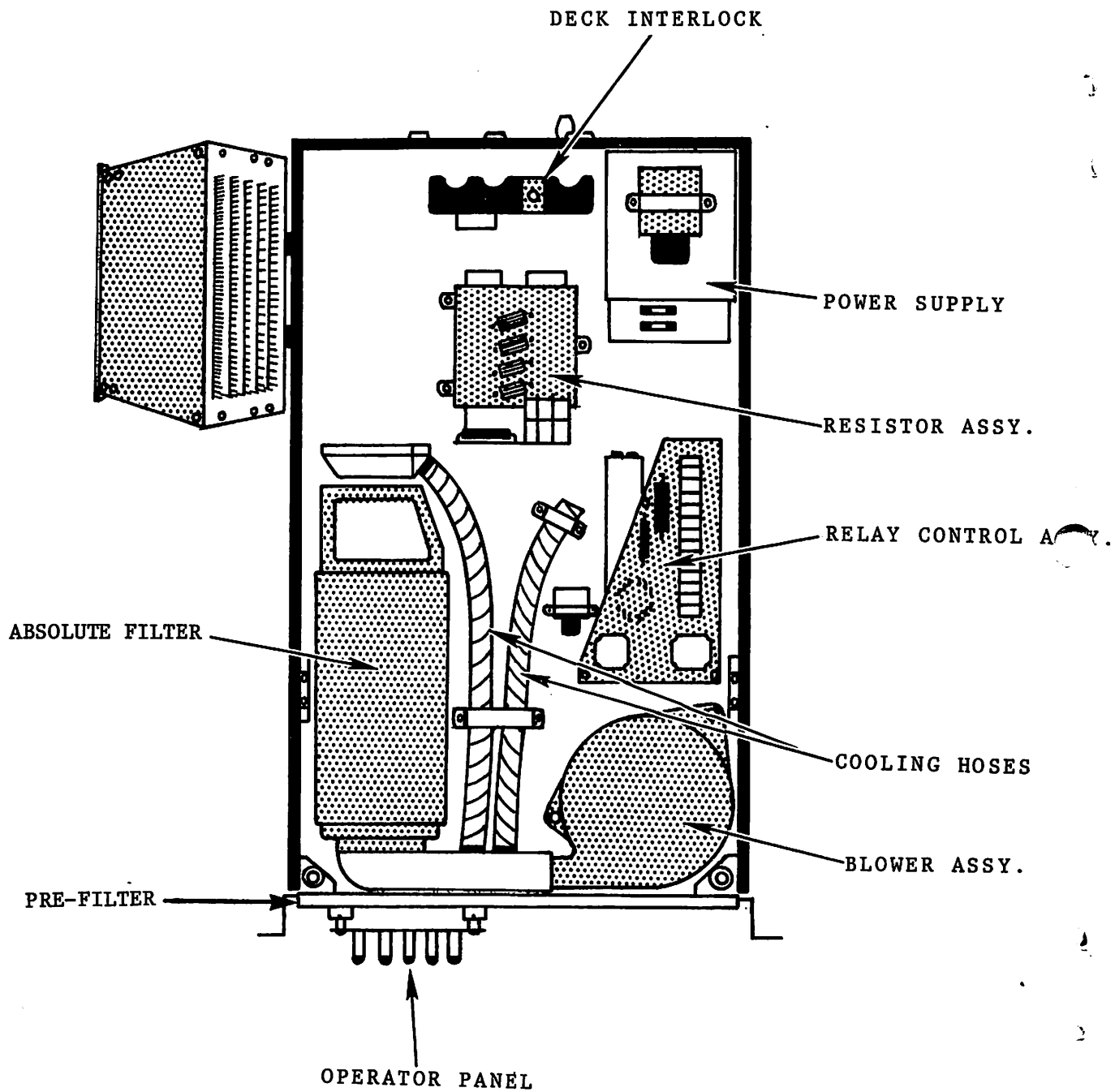


FIGURE A-6 DEVICE LAYOUT (BASE PAN)

THESE PANELS REMOVED FOR
REVISED FURNITURE COVER
WHICH CONTAINS CHARCOAL
COLORED FRONT PANEL

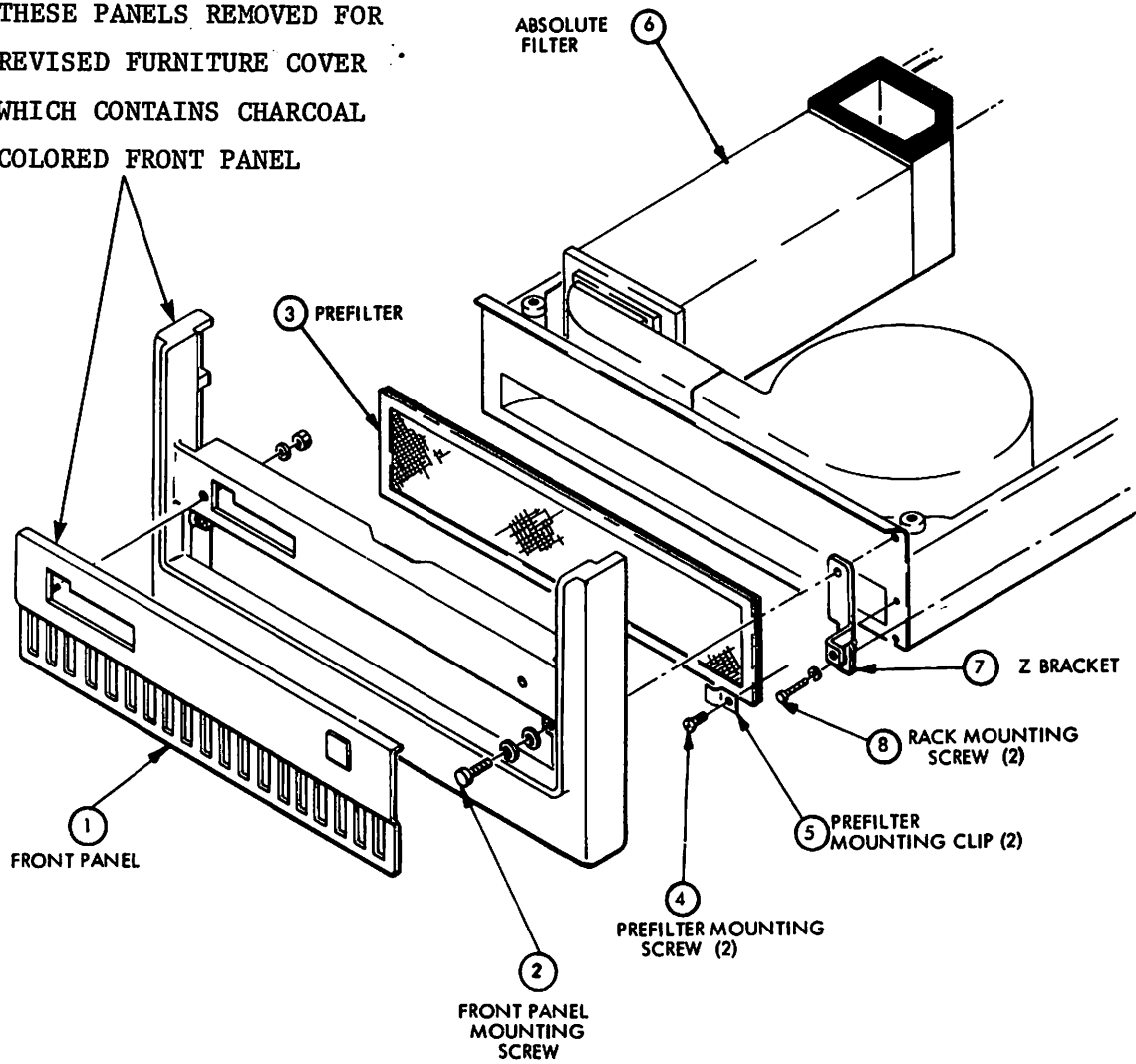


FIGURE A-7 FILTER REMOVAL AND REPLACEMENT

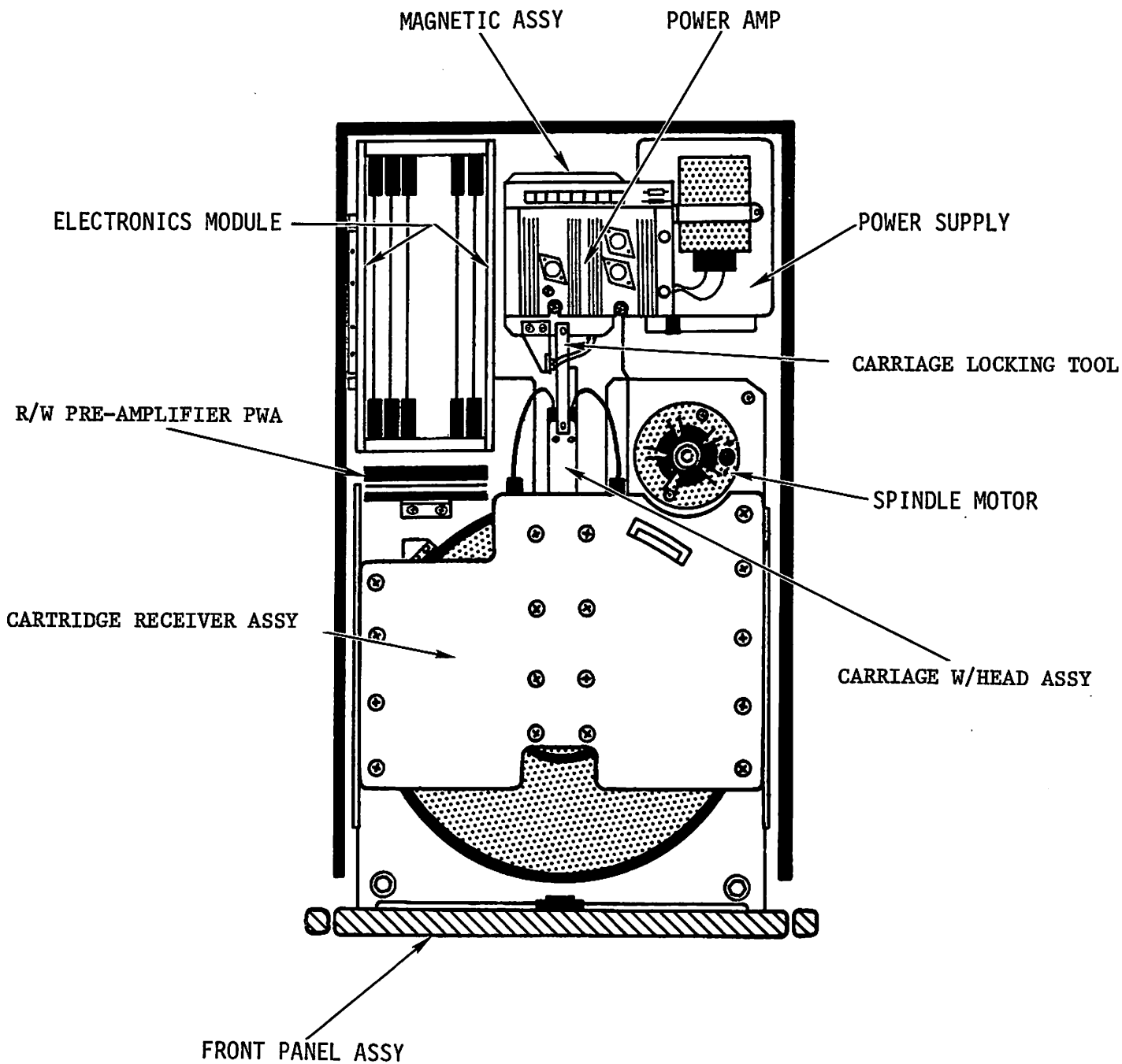


FIGURE A-8 DEVICE LAYOUT (TOP VIEW)

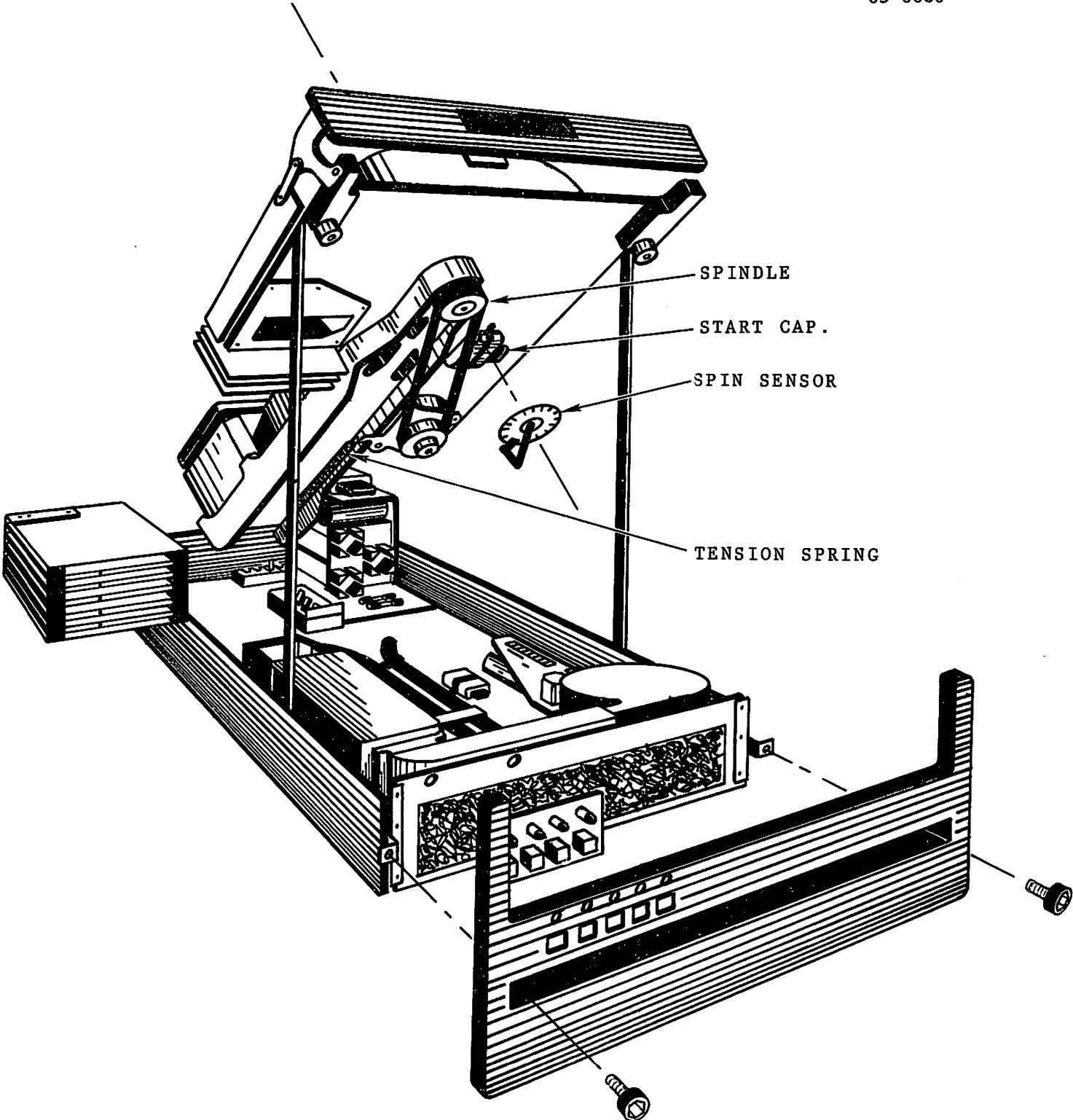
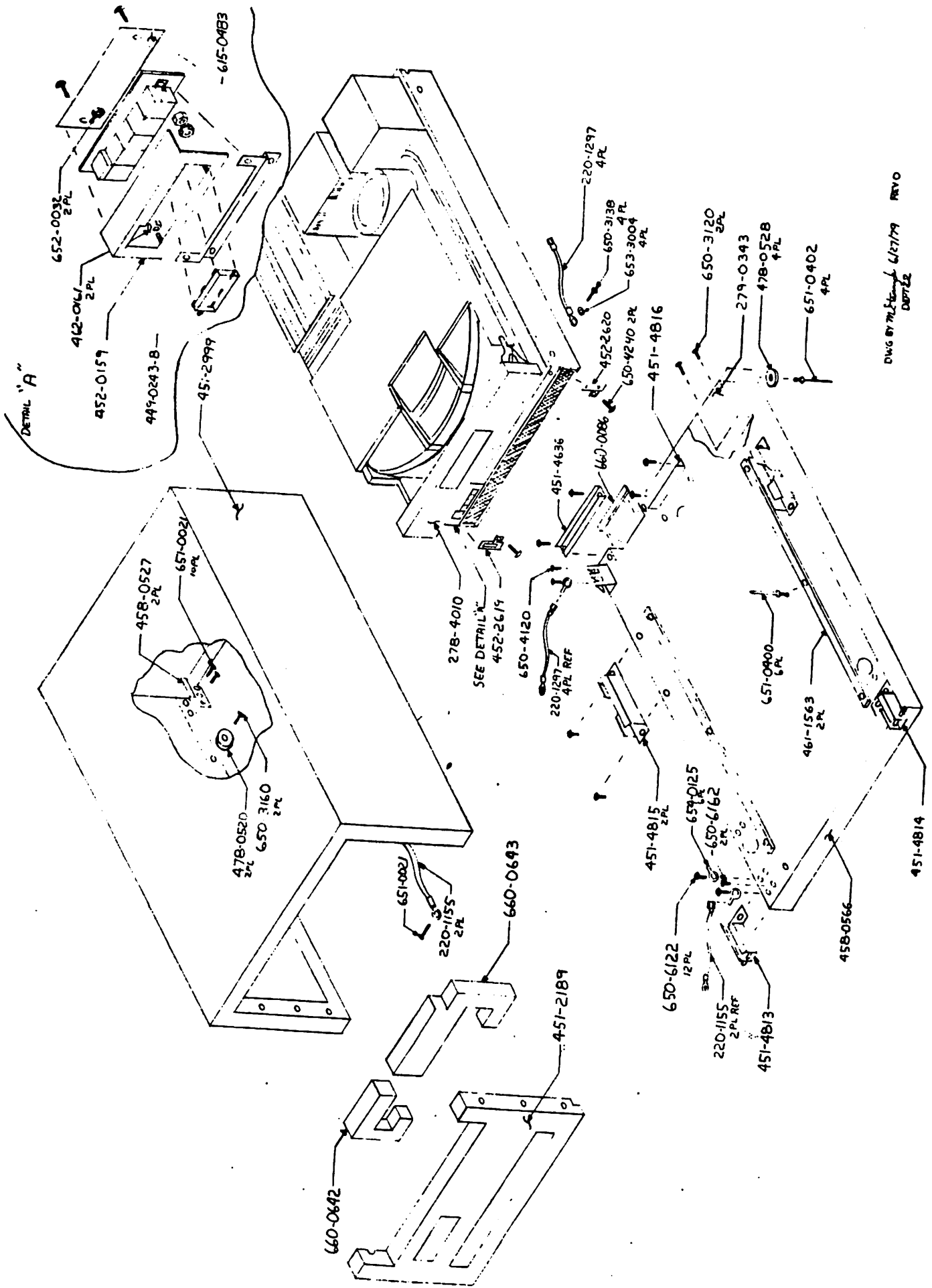


FIGURE A-9 DEVICE LAYOUT (DECK ASSEMBLY RAISED)



DWG BY M.L. [Signature] 6/27/79 REV 0
 08722

2280 PHOENIX DISK DRIVE

FIGURE A-10

The Exploded view of the "PHOENIX" Disk Drive is added to Appendix A for an additional source of Part Numbers to assist in replacing defective or broken parts. Insert this illustration into Appendix A as Figure A-10. See list of parts below:

2280 PHOENIX DISK DRIVE PARTS

| | | |
|------------|--------------------------------------|-----------------|
| 220-1155 | Wire & Lug Assy | B6482-12 |
| 220-1297 | Wire & Lug Assy | 2280 |
| 278-4010 | 96 Meg Phoenix Drv. 60HZ tested | |
| 279-0343 | 2260C/928C2 Switch Box Assy | |
| 449-0243-B | Cover Keycap (Bronze) | |
| 451-2189 | Cover, Front Silkscreen | 2280 D6684-1020 |
| 451-2999 | Cover Top Weld | 2280 B6884-1021 |
| 451-4636 | Brkt, CBP Clamp FS6 | C6853-575 |
| 451-4815 | Brkt, Rear Hold Down | 2280 C6884-1014 |
| 451-4816 | Brkt, Rear Stop | 2280 B6884-1016 |
| 452-0159 | Plate, Dress Kbd | 2280 C6884-1010 |
| 452-2619 | Clamp Inner Cover (LH) | C6884-1026 |
| 452-2620 | Clamp Inner Cover (RH) | C6884-1026 |
| 458-0526 | Ground Wipe Frame FS6 | B6863-609 |
| 458-0527 | Ground Wipe Frame FS6 | B6863-61 |
| 458-0566 | Frame, Top Wldmnt FS6 | DT E6863-811 |
| 461-1563 | Block Spacer | 2280 C6884-1017 |
| 462-0161 | Spcr 6-32 UXIC .250 OD .187L | |
| 478-0520 | Stop Cover | 2280 B6884-1015 |
| 478-0528 | Foot, Top Frame | 2280 B6884-1019 |
| 615-0483 | Insulator, PC Board | 2280 B6884-1012 |
| 650-3120 | 6-32 x 3/8 Pan Hd Phil ms ss sems | |
| 650-3138 | Scr 6-32 3/8 Pan Hd Phl ss | |
| 650-3160 | 6-32 x 1/2 Pan Hd Phl ss | |
| 650-4120 | 8-32 x 3/8 Pan Hd Phl ms ss sems | |
| 650-4240 | 8-32 x 3/4 Pan Hd Phl ms ss sems | |
| 650-6122 | 10-32 x 3/8 Flange Whiz-Lock ms Zinc | |
| 651-0021 | Scr #8 x 1/2 Self Tap Truss Hd T-B | |
| 651-0400 | Rivet Avdel 11250412 1/8 x 3/8 LG. | |
| 651-0402 | Rivet Avdel 11210615 3/16 x 7/16 LG. | |
| 652-0032 | 6-32 Lock-Nut Keps | 511-061800-00 |
| 653-3004 | #6 Ext. Tooth Lk Washer | |
| 654-0125 | Terminal Lug .200 Hole 1/4 spade | |
| 660-0642 | Fm Frnt Pnl Battle Right | B6884-1028 |
| 660-0643 | Fm Frnt Pnl Battle Left | C6884-1027 |

*Items not illustrated

| | |
|----------|----------------------------|
| 220-1336 | Short Power Cord (Pigtail) |
| 220-1220 | 10 Ft. Power Cord Assy. |



APPENDIX "B"
ILLUSTRATIONS

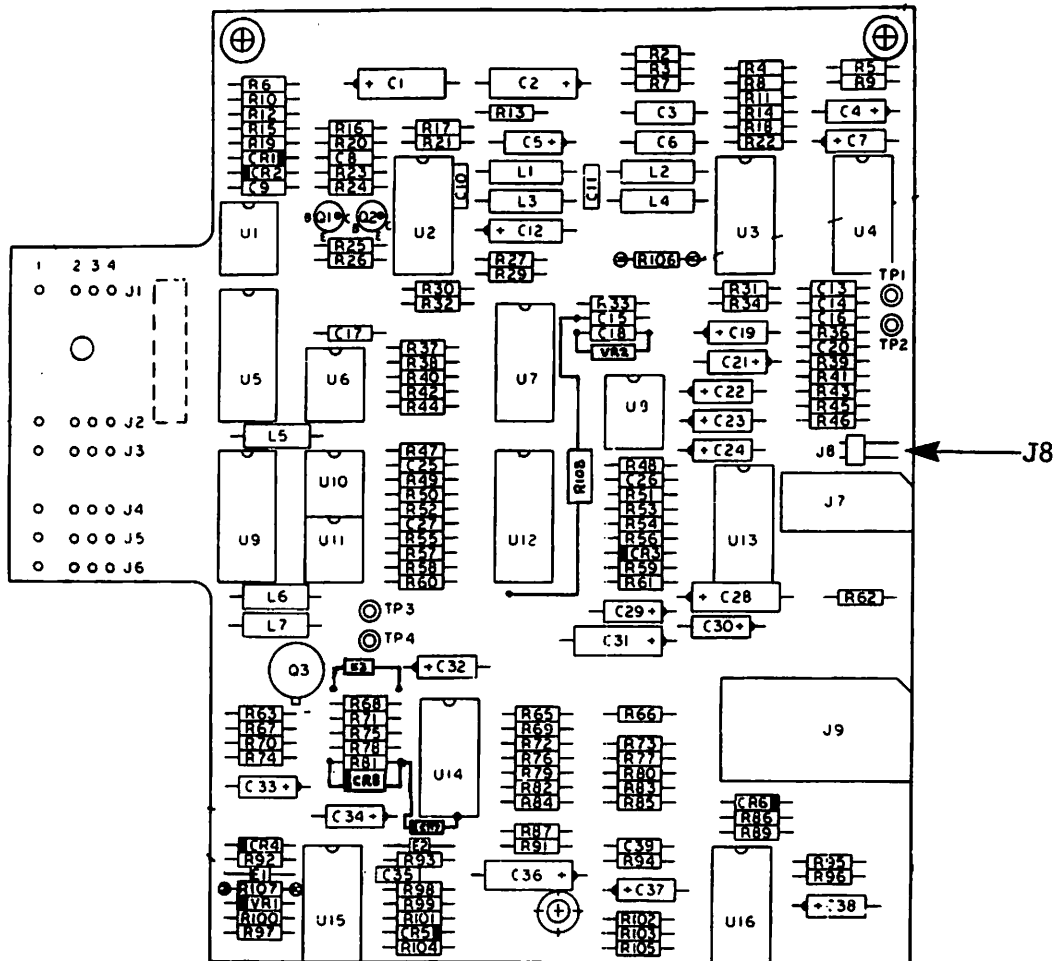


FIGURE B-1 READ/WRITE PREAMP CIRCUIT BOARD



North America:

| | | | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alabama Birmingham Mobile | District of Columbia Washington | Louisiana Baton Rouge Metairie | New Hampshire East Derry Manchester | Oregon Beaverton Eugene | Virginia Newport News Richmond |
| Alaska Anchorage | Florida Jacksonville Miami Orlando Tampa | Maryland Rockville Towson | New Jersey Howell Mountainside | Pennsylvania Allentown Camp Hill Erie Philadelphia Pittsburgh Wayne | Washington Seattle Spokane |
| Arizona Phoenix Tucson | Georgia Atlanta | Massachusetts Boston Burlington Littleton Lowell Tewksbury Worcester | New Mexico Albuquerque | Rhode Island Cranston | Wisconsin Brookfield Madison Milwaukee |
| California Fresno Inglewood Los Angeles Sacramento San Diego San Francisco San Mateo Sunnyvale Tustin Ventura | Hawaii Honolulu | Michigan Grand Rapids Okemos Southfield | New York Albany Buffalo Lake Success New York City Rochester Syracuse | South Carolina Charleston Columbia | |
| Colorado Denver | Illinois Chicago Morton Park Ridge Rock Island | Minnesota Eden Prairie | North Carolina Charlotte Greensboro Raleigh | Tennessee Chattanooga Knoxville Memphis Nashville | Canada Wang Laboratories (Canada) Ltd. Don Mills, Ontario Calgary, Alberta Edmonton, Alberta Winnipeg, Manitoba Ottawa, Ontario Montreal, Quebec Burnaby, B.C. |
| Connecticut New Haven Stamford Wethersfield | Indiana Indianapolis South Bend | Missouri Creve Coeur | Ohio Cincinnati Columbus Middleburg Heights Toledo | Texas Austin Dallas Houston San Antonio | |
| | Kansas Overland Park Wichita | Nebraska Omaha | Oklahoma Oklahoma City Tulsa | Utah Salt Lake City | |

International Subsidiaries:

| | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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