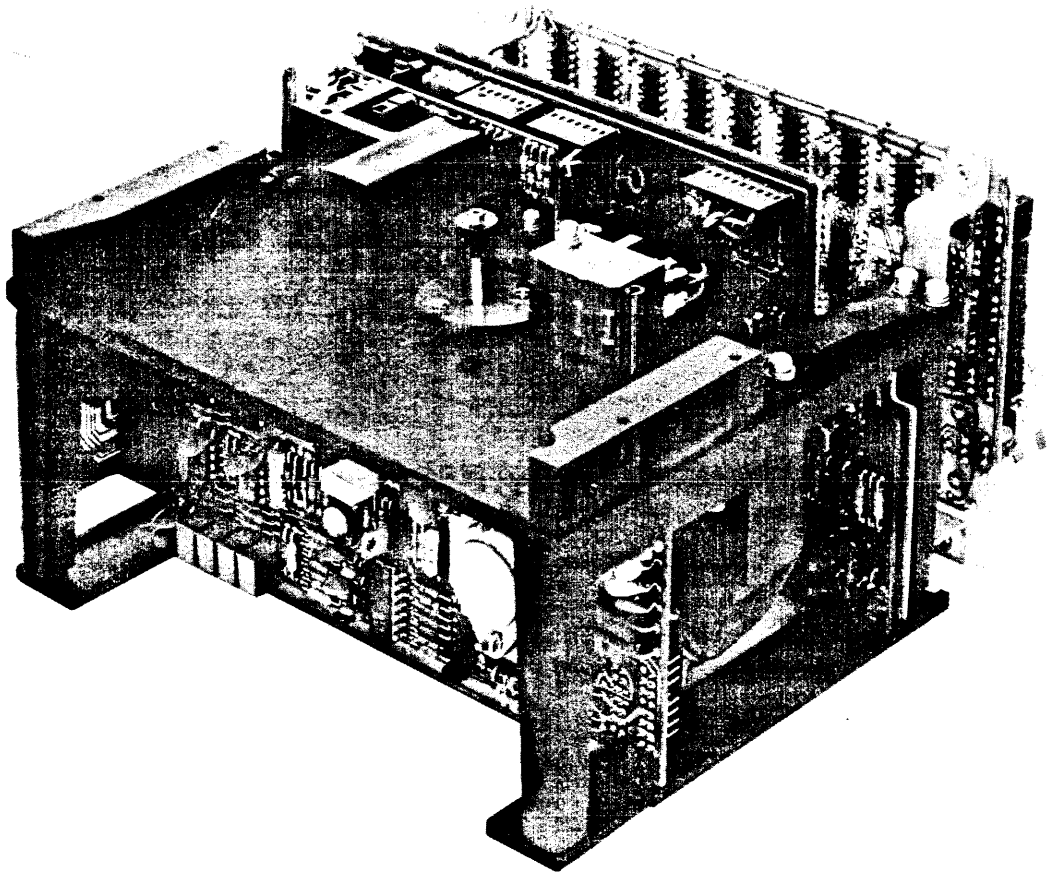
SERIES CMTD-3400S2
6400 BPI HIGH DENSITY
CARTRIDGE MAGNETIC TAPE DRIVE

OPERATION AND MAINTENANCE MANUAL



DATA ELECTRONICS INCORPORATED
11633 SORRENTO VALLEY RD., SAN DIEGO, CA 92121, (714) 481-0151

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DESCRIPTION

1.1 INTRODUCTION

This operation and maintenance manual covers the High Density Cartridge Magnetic Drive, Series CMTD 3400S2. The manual includes a unit description, installation, theory of operation, maintenance procedures, and a spare parts list.

1.2 GENERAL CARTRIDGE DRIVE DESCRIPTION

The series CMTD 3400S2 is a cartridge device capable of 6400 BPI recording on a data cartridge built to ANSI Standard X3.55 – 1977 specifications. Up to 17.2 M Bytes of data (unformatted) can be stored on a 450 foot tape. The recording format is 4 track serial and the data transfer rate in both read and write mode is 192,000 bits per second.

An integral tape cleaner is standard, as is the CG mounted direct current motor which provides shock and vibration immunity in all three axis. Up to eight cartridge drives may be daisy chained (bussed) together, in which case drive and track selection are performed by the controller.

1.3 PLUG-IN SUBASSEMBLIES

The drive assembly may contain up to eight major plug-in subassemblies which are listed below:

a. Head Assembly

b. Servo Board Assembly

c. Data Board Assembly

d. Heat Sink Assembly

e. Switch/Sensor Assembly

f. Interconnect Board Assembly

g. Optional Control Board Assembly

h. Optional Codec Board Assembly

Figure 1-1 indicates subassembly locations.

1.4 CUSTOMER OPTIONS

Currently the Series CMTD 3400S2 is available in three versions:

- Basic Model (includes items a through f in paragraph 1.3)
- Basic Model with Control Board
- Basic Model with Control Board and Codec Board

The optional Control Board provides several functions which therefore need not be provided by the controller. These are:

- Customer selectable unit address
- Forward tape motion prevented at End of Tape (EOT-)
- Reverse tape motion prevented at Beginning of Tape (BOT-)
- High Speed only permitted between LP- (Load Point) and EW- (Early Warning)
- Automatic tape positioning to BOT (Beginning of Tape) after cartridge insertion, power on, or a rewind operation.

The optional Codec Board converts NRZ formatted data to the high density MFM format in the write mode and vice versa during read operations. This eliminates the need for NRZ-MFM conversion by the controller. Any approved high density data format may be input to the Data Board. In this case, the Codec Board would not be required.

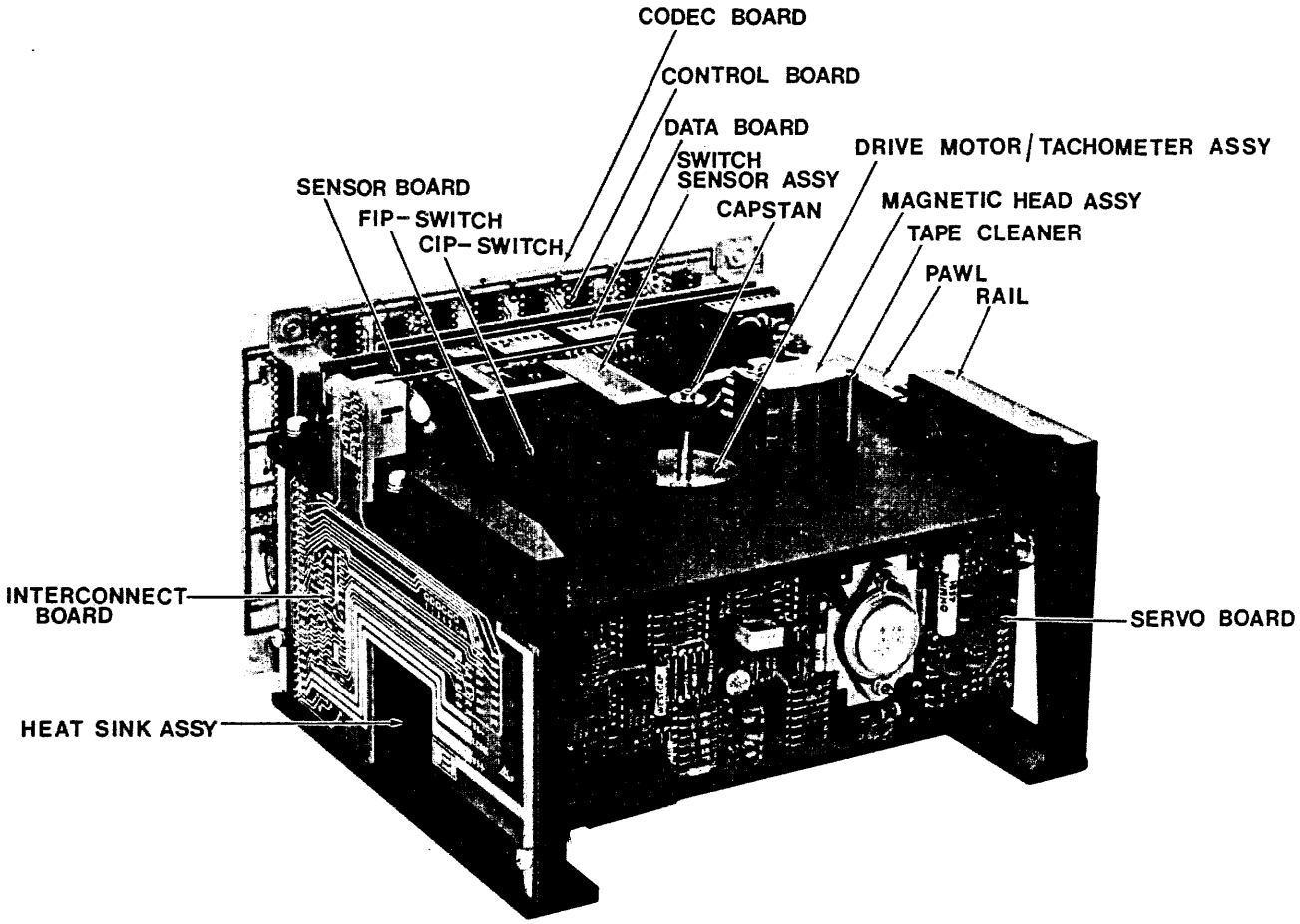


FIGURE 1-1. MAJOR SUBASSEMBLY LOCATIONS

1.5 MODEL CODES

Table 1-1 provides a guide to the model code stamped on the serial number identification tag affixed to each tape drive. For example, a 3447-45AC1ES2 model number describes the following drive:

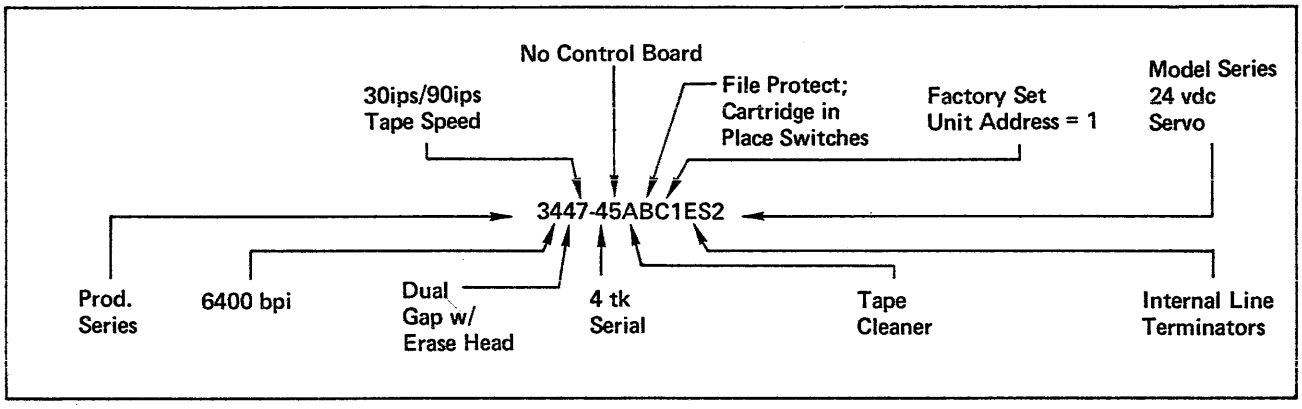


FIGURE 1-2. TYPICAL MODEL CODE

Product Series	Recording Density		Head Type		Tape Speed		Number of Tracks		Configuration		Options/Selections	
3	4	6400 bpi	4	Dual Gap w/ Erase (Read-While-Write)	3	30/120 ips	4	Four Tk Serial	4	Control Board Supplied	A	Integral Tape Cleaner
					7	30/90 ips			5	No Control Board Supplied	B	File Protect and Cartridge in Place Switches
											C	Unit Addressing factory set (Specify C1 C2)*
											D	Unit Addressing Customer Select*
											E	Internal Line Termination Supplied
											F	Codec Board Supplied

*C1 or C2 for Drives without Control Boards
D for Drives with Control Boards

TABLE 1-1. MODEL CODES

1.6 GENERAL SPECIFICATIONS

Table 1-2 provides the general specifications for the cartridge drive.

CMTD 3400S2 GENERAL SPECIFICATIONS	
Since specifications are subject to change, refer to DEI Product Specification 301,056 for latest performance data.	
– Cartridge	ANSI X3.55 – 1977 300' or 450' tape length
– Recording Density	6400 bpi, MFM or other high density codes
– Recording Mode	4-Track Serial
– Head Type	Dual Gap, Read-While-Write with Separate Erase
– Tape Cleaner	Integral
– Operating Speeds	30 ips Write, Bidirectional Read 90 ips Bidirectional Search and Rewind
– Transfer Rate	192,000 Bits/Sec
– Start/Stop Time	At 30 ips: 25/26 msec At 90 ips: 71/74 msec
– Nominal Start/Stop Distance	At 30 ips: 0.30/0.41 inches At 90 ips: 2.97/3.42 inches
– Instantaneous Speed Variation	±3% (Drive only, ±7% cartridge inclusive).
– Long Term Speed Variation	±2% (Drive only, ±3% cartridge inclusive).
– Data Reliability	Less than 1 Error in 10^8 Bits
– Interface Logic	TTL, Low True, $\leq$ 25 ma, 132 Ω Line impedance.
– Weight	4.0 lbs.
– Dimensions	4.25 inches H, 6.96 inches W, 5.72 inches D (7.75 inches D with Codec Board)
– Temperature	+5°C to +45° Operating -30°C to +60° Storage
– Relative Humidity	20% to 80% (non-condensing)

TABLE 1-2. GENERAL SPECIFICATIONS

1.7

Table 1-3 provides the power requirements of the various drive configurations.

Power / Drive Type	Drive Power Dissipation, Watts		Operating Conditions*	Current Requirements in Amperes (Tolerances Include Ripple)					
				+24VDC ± 15%		-24VDC ± 15%		+5 VDC + 5% -3%	
				AMPS		AMPS		AMPS	
	Typ.	Max.		Typ.	Max.	Typ.	Max.	Typ.	Max.
Basic Model	14.6	63.4	1 2 3 4	0.04 0.04 0.85 1.6	0.08 0.08 1.8 3.2	0.15 0.95 0.15 1.7	0.30 1.90 0.30 3.5	0.42 0.42 0.42 0.42	0.85 0.85 0.85 0.85
Basic Model with a Control Board	17.0	67.2	1 2 3 4	0.04 0.04 0.86 1.6	0.08 0.08 1.7 3.1	0.15 0.95 0.15 1.7	0.30 1.9 0.30 3.5	0.90 0.95 0.95 0.95	1.8 2.0 2.0 2.0
Basic Model with a Control Board and Codec Board	18.5	68.9	1 2 3 4	0.05 0.05 0.87 1.6	0.10 0.10 1.7 3.1	0.20 1.00 0.20 1.8	0.40 2.0 0.40 3.5	1.2 1.3 1.3 1.3	2.4 2.6 2.6 2.6

*Operating Conditions:

1. No tape motion, no write current.
2. Forward tape motion at 30 or 90 in./sec. (includes writing conditions at 30 in./sec.).
3. Reverse tape motion at 30 or 90 in./sec. and no writing.
4. Start/Stop Periods: 25 X 10^{-3} sec. to 30 in./sec., 71 X 10^{-3} sec. to 90 in./sec, 26 X 10^{-3} sec. from 30 in./sec. and 74 X 10^{-3} sec. from 90 in./sec.

General:

- All voltages measured at drive power connector.
- The ramp period current peaks do not occur simultaneously. A defective cartridge can extend ramp current periods.

Assumptions for power dissipation calculations:

Typical: Nominal voltages and typical currents, 2 starts and 2 stops per second, and running 50% of the remaining time.

Maximum: Nominal voltages and maximum currents and 17 starts and 17 stops per second.

TABLE 1.3. POWER REQUIREMENTS

SECTION 2
INSTALLATION

2.1 MOUNTING

Because of its unique CG motor mounting system, the cartridge drive may be mounted in any position except one in which the cartridge is inserted upward. In this position, tape residue removed by the tape cleaner can fall onto the tape. This might result in lost data.

Overall drive dimensions are provided in Figure 2-1. Panel mounting dimensions and ventilation requirements are provided in Figure 2-2.

2.2 FUSE REQUIREMENTS

The following fuses shall be connected in series with the +24 vdc, -24 vdc and +5 vdc lines from the external power supply for the cartridge drive:

Recommended Fuses:

+24 vdc: Buss AGC 3A, 250V (all drive versions)

-24 vdc: Buss AGC 3A, 250V (all drive versions)

+ 5 vdc:

Basic Model	Basic Model w/Control Board	Basic Model w/Codec Board
Buss AGC-1A, 250V	Buss AGC-2A, 250V	Buss AGC-3A, 250V

2.3 INPUT POWER CONNECTIONS

Table 2-1 indicates power connections for the various drive versions:

Drive Version	Connector
Basic Model; Basic Model with Control Board	P702, Servo Board
Basic Model with Control and Codec Boards	P702, Servo Board and P1, Codec Board

TABLE 2-1. POWER CONNECTION POINTS

Figure 2-3 indicates power connector locations, pin assignments and hardware part numbers.

2.4 POWER SUPPLY REQUIREMENTS

Table 1-2 provides power dissipation and current requirements under normal operating conditions.

2.5 SIGNAL CONNECTIONS

All interface signals except the differential signals are TTL compatible, low true signals.

Signal connections vary, depending on drive version. Table 2-2 indicates the interface signal connection points.

Drive Version	Connector:
Basic Model	P1, Interconnect Board (Figure 2-4)
Basic Model with Control Board	P600, Control Board (Figure 2-5)
Basic Model with Control; Codec Boards	P3, Codec Board (Figure 2-6)

TABLE 2-2. SIGNAL CONNECTION POINTS

Figures 2-4, 2-5 and 2-6 provide signal pin lists for the three drive versions. Connector part numbers are also included.

2.6 SIGNAL LINE TERMINATION

All signal lines except differential signals should be terminated as shown in Figure 2-7. These are the recommended signal terminations for 100-132 ohm cable.

Differential data lines RDA+/-, WDA+/- and DAD+/- are employed in drives without Codec Boards. SN75110 line drivers or equivalent, SN75107A line receivers or equivalent, and 100 ohm pulldown resistors should be configured as indicated in Figure 2-8 to provide proper termination for these differential signals.

Drives incorporating the optional Codec Board do not utilize differential inputs or outputs.

2.7 MULTIPLE DRIVE APPLICATIONS

It is possible to connect up to eight drives on a common bus cable. Proper line terminations should be made at the last drive in the daisy chain only. All other line terminator ICs and discrete resistors used for line terminations should be removed. Refer to Table 2-3 for their locations.

TERMINATIONS	DATA SIGNALS	CONTROL & STATUS SIGNALS
1. Basic Drive: Location Value	J4 Interconnect Board 100 ohm Pack	J3 Interconnect Board 220/330 ohm Pack
2. Basic Drive with Control Board: Location Value	J4 Interconnect Board 100 ohm Pack	U621 Control Board 220/330 Pack
3. Basic Drive with Control & Codec Boards: Location Value	R37, R38, R39, R40 Codec Board 330 ohm Discrete	U621 Control Board 330 ohm Pack

TABLE 2-3. LOCATION OF LINE TERMINATIONS

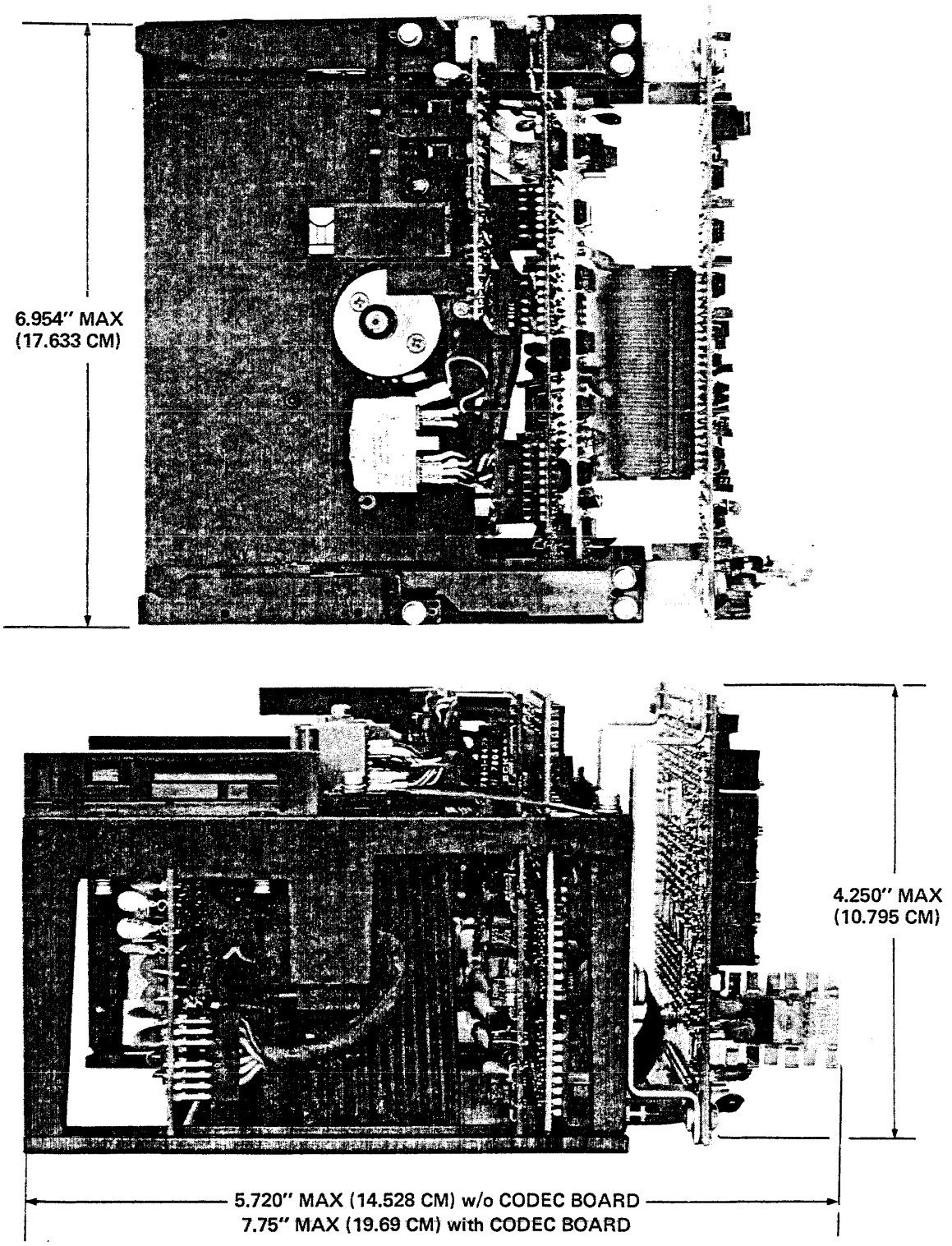


FIGURE 2-1. OVERALL DRIVE DIMENSIONS

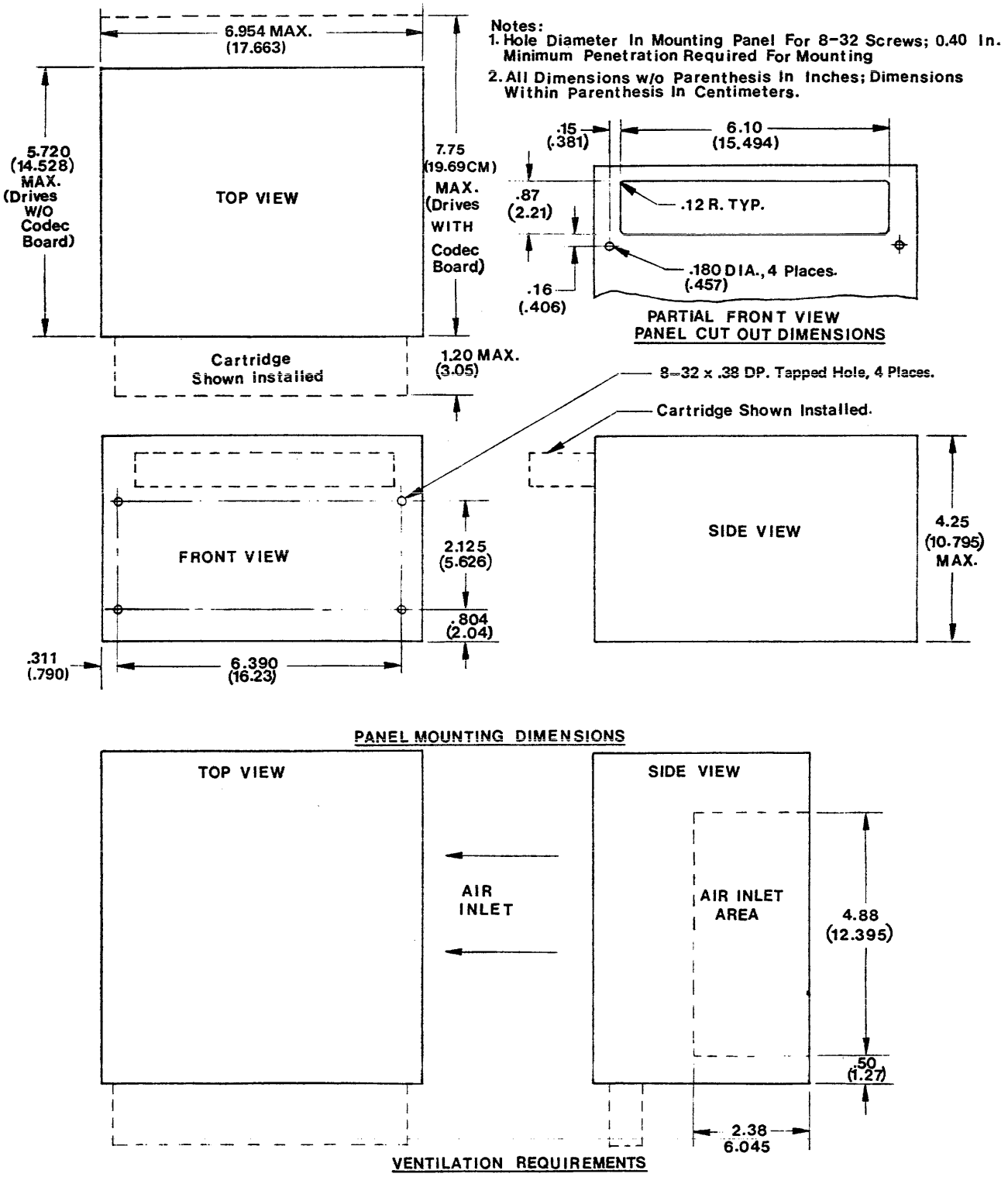
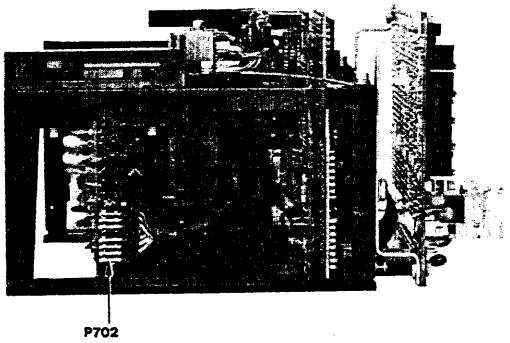
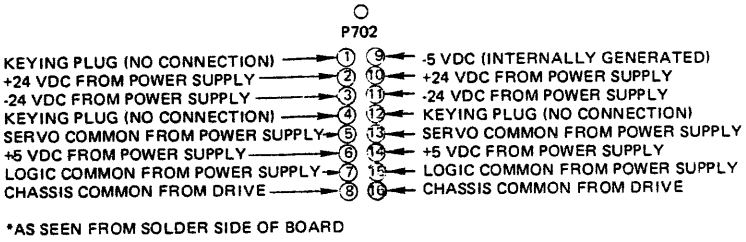


FIGURE 2-2. PANEL MOUNTING DIMENSIONS/VENTILATION REQUIREMENTS

SERVO BOARD POWER CONNECTIONS (P702)





*AS SEEN FROM SOLDER SIDE OF BOARD

NOTES

1. Power Connector Hardware
   Either Amp or Cannon Connectors may be used.

   A. Amp Power Connector Numbers

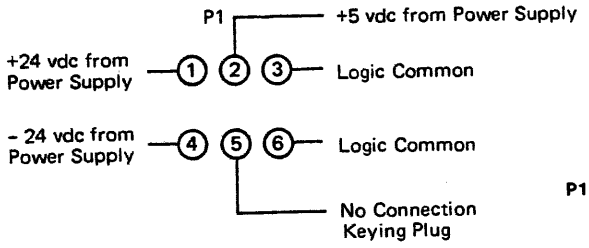
      Connector: Amp Part No. 1-86148-5 (DEI Part No. 500621) (1 required)
      Contact: Amp Part No. 86016-4 (DEI Part No. 500622 (13 required)
      Key Plugs: Amp Part No. 86286-1 (DEI Part No. 500623) (3 required)

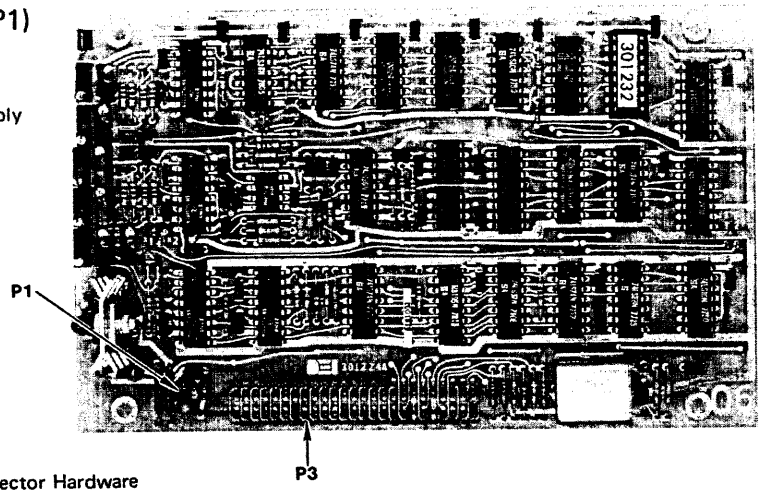
   B. Cannon Power Connector Part Numbers:

      Connector: Cannon Part No. 121-7326-10843 (DEI Part No. 500621) (1 req.)
      Contact: Cannon Part No. 11-9238-0091 (DEI Part No. 500622) (13 req.)
      Key Plugs: Cannon Part No. 225-7301-0031 (DEI Part No. 500623) (3 req.)

2. Servo, Logic, and Chassis Common must be tied together and to ground at one point in power supply.
3. Recommended wire size: 22 AWG
4. -5 vdc is generated in the Drive.
5. Chassis common is the physical case of the Drive. Servo common returns the ± 24 vdc currents and Logic Common returns the +5 vdc (Logic and Data Currents).

CODEC BOARD POWER CONNECTIONS (P1)





NOTES

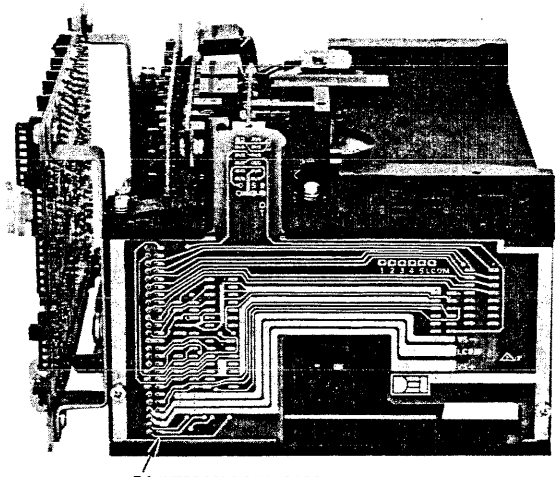
1. Codec Board Power, Connector Hardware

   A. Amp Power Connector Numbers

      Connector: Amp Part No. 1-86148-8 (1 Required).
      Contact: Amp Part No. 86016-4 (DEI Part No. 500118) (5 required).
      Key Plug: Amp Part No. 86286-1 (DEI Part No. 500119) (1 required).

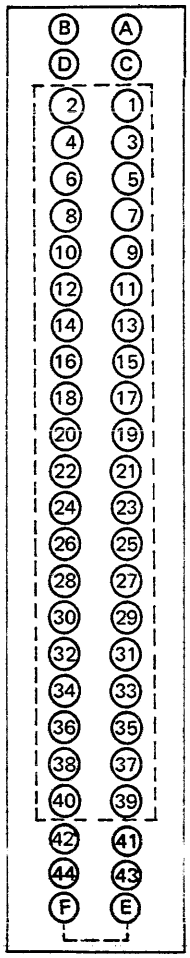
2. Recommended wire size: 22 AWG

FIGURE 2-3. POWER CONNECTIONS



P1 INTERCONNECT BOARD

P1 PIN IDENTIFICATION



(SOLDER SIDE OF INTERCONNECT BOARD)

DO NOT MAKE CONNECTIONS TO OTHER PINS.

1. CONNECTIONS ARE MADE TO P1 ON INTERCONNECT CIRCUIT BOARD ASSEMBLY

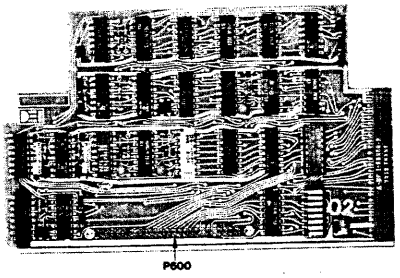
2. P1 MATES WITH 3M COMPANY PART NO. 3417-3000 (DEI PART NO. 500955). CABLE USED IS 3M COMPANY PART NO. 3350-40 CONDUCTOR

A, B, C, D, E, F, G, H, J, K } DRIVE SELECT NOT CONNECTED TO INTERFACE CABLE. SEE FIGURE 3-3 FOR STRAPPING.

DRIVE OUTPUTS		
Pin No.	**Signal**	**Signal Name**
5	FIP–	File Protected
6		File Protected Return
7	BLB–	Bulb–
8		Bulb Return
9	LTH–	Lower Tape Hole–
10		Lower Tape Hole Return
11	CIP–	Cartridge in Place–
12		Cartridge in Place Return
13	UTH–	Upper Tape Hole–
14		Upper Tape Hole Return
15	RDA+	
16	RDA–	Read Data 2
19	DAD+	Data Detected 1
20	DAD–	Data Detected 2
DRIVE INPUTS		
1	SL2–	Select Unit 2–
2		Select Unit 2 Return
3	SL1–	Select Unit 1–
4		Select Unit 1 Return
23	TR1–	Track 2^0
24		Track 2^0 Return
25	TR2–	Track 2^1
26		Track 2^1 Return
29	WDA+	Write Data 1
30	WDA–	Write Data 2
31	WEN–	Write Enable
32		Write Enable Return
35	FWD–	Forward Command
36		Forward Command Return
37	REV–	Reverse Command
38		Reverse Command Return
39	HSP	High Speed Command
40		High Speed Command Return

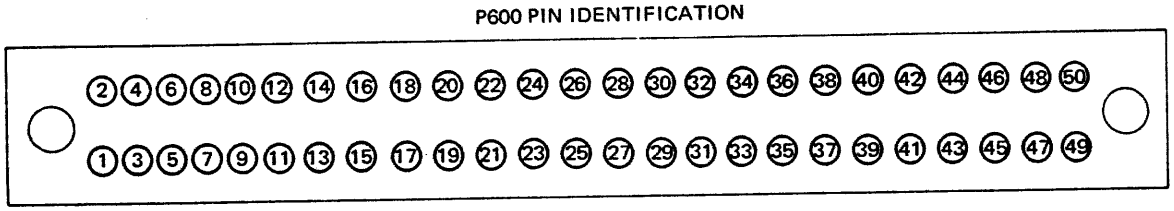
FIGURE 2-4. INPUT/OUTPUT SIGNAL CONNECTIONS: DRIVES WITHOUT CONTROL BOARD

CONTROL BOARD



MATING CONNECTOR IS 3M COMPANY PART NO. 3425-3000 (DEI PART NO. 500956).

P600 PIN IDENTIFICATION



DRIVE OUTPUTS

PIN NO.	SIGNAL	NAME
2 1	SLD–	Selected– Selected Return
4 3	RDY–	Ready– Ready Return
6 5	WND–	Write Enabled– Write Enabled Return
8 7	FLG–	Flag– Flag Return
10 9	LPS–	Load Point Sensed Load Point Sensed Return
12 11	FUP–	File Unprotected File Unprotected Return
14 13	BSY–	Drive Busy– Drive Busy Return
16 15	EWS–	Early Warning Sensed Early Warning Sensed Return
36 35	DAD+ DAD–	Data Detected (Differential) Data Detected (Differential)
40 39	RDA+ RDA–	Read Data (Differential) Read Data (Differential)

DO NOT MAKE CONNECTIONS TO OTHER PINS.

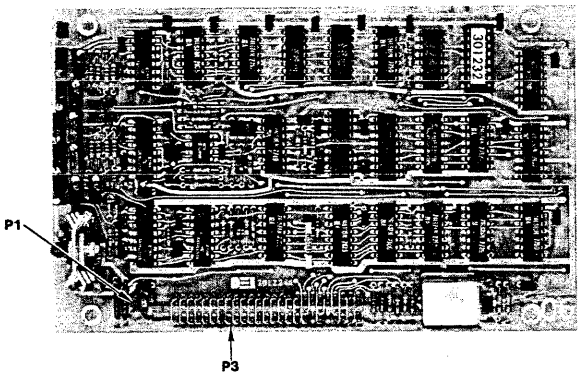
DRIVE INPUTS

PIN NO.	SIGNAL	NAME
18 17	RWD–	Rewind– Rewind Return
20 19	REV–	Reverse– Reverse Return
22 21	FWD–	Forward– Forward Return
24 23	HSP–	High Speed– High Speed Return
26 25	WEN–	Write Enable– Write Enable Return
28 27	SL1	Unit Select 2^0– Unit Select 2^0 Return
30 29	SL2–	Unit Select 2^1– Unit Select 2^1 Return
32 31	SL4–	Unit Select 2^2– Unit Select 2^2 Return
34 33	SLG–	Select Gate– Select Gate Return
44 43	WDA+ WDA–	Write Data (Differential) Write Data (Differential)
46 45	TR2–	Track Select 2^1– Track Select 2^1 Return
50 49	TR1–	Track Select 2^0– Track Select 2^0 Return

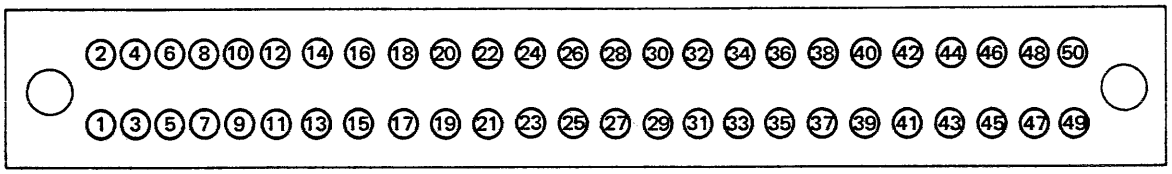
FIGURE 2-5. INPUT/OUTPUT SIGNAL CONNECTIONS: DRIVES WITH CONTROL BOARD

1. CONNECTIONS ARE MADE TO P3 ON CODEC BOARD.
2. P3 MATES WITH 3M COMPANY PART NO. 3425-3000 (DEI PART NO. 500956).

CODEC BOARD



P3 AS SEEN FROM COMPONENT SIDE OF CODEC BOARD



DRIVE OUTPUTS

PIN NO.	SIGNAL	NAME
2 1	SLD–	Selected– Selected Return
4 3	RDY–	Ready– Ready Return
6 5	WND–	Write Enabled Write Enabled Return
8 7	FLG–	Flag– Flag Return
10 9	LPS–	Load Point Sensed– Load Point Sensed Return
12 11	FUP–	File Unprotected– File Unprotected Return
14 13	BSY–	Busy– Busy Return
16 15	EWS–	Early Warning Sensed– Early Warning Sensed Return
36 35	RNZ–	Read NRZ Data– Read NRZ Data Return
38 37	RDS–	Read Data Strobe– Read Data Strobe Return
40 39	DAD–	Data Detected– Data Detected Return
48 47	WDS–	Write Data Strobe– Write Data Strobe Return

DRIVE INPUTS

PIN NO.	SIGNAL	NAME
18 17	RWD–	Rewind– Rewind Return
20 19	REV–	Reverse– Reverse Return
22 21	FWD–	Forward– Forward Return
24 23	HSP–	High Speed– High Speed Return
26 25	WEN–	Write Enable– Write Enable Return
28 27	SL1–	Unit Select 2^0– Unit Select 2^0 Return
30 29	SL2–	Unit Select 2^1– Unit Select 2^1 Return
32 31	SL4–	Unit Select 2^2– Unit Select 2^2 Return
34 33	SLG–	Select Gate– Select Gate Return
42 41	WDE–	Write Data Enable– Write Data Enable Return
44 43	WNZ–	Write NRZ Data– Write NRZ Data Return
46 45	TR2–	Track Select 2^1– Track Select 2^1 Return
50 49	TR1–	Track Select 2^0– Track Select 2^0 Return

DO NOT MAKE CONNECTIONS TO OTHER PINS.

FIGURE 2-6. INPUT/OUTPUT SIGNAL CONNECTIONS: DRIVES WITH CODEC BOARDS

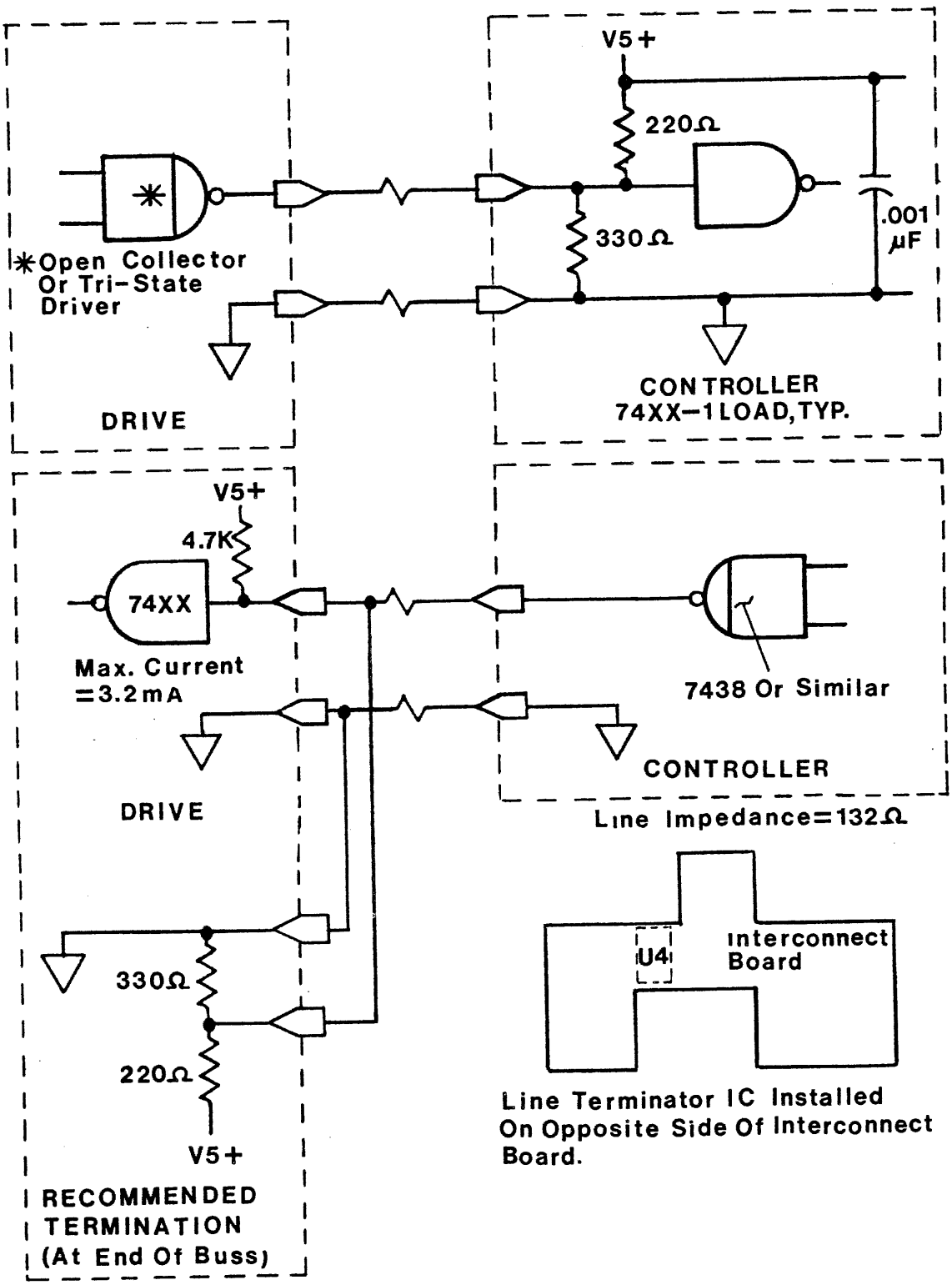


FIGURE 2-7. TTL SIGNAL TERMINATION

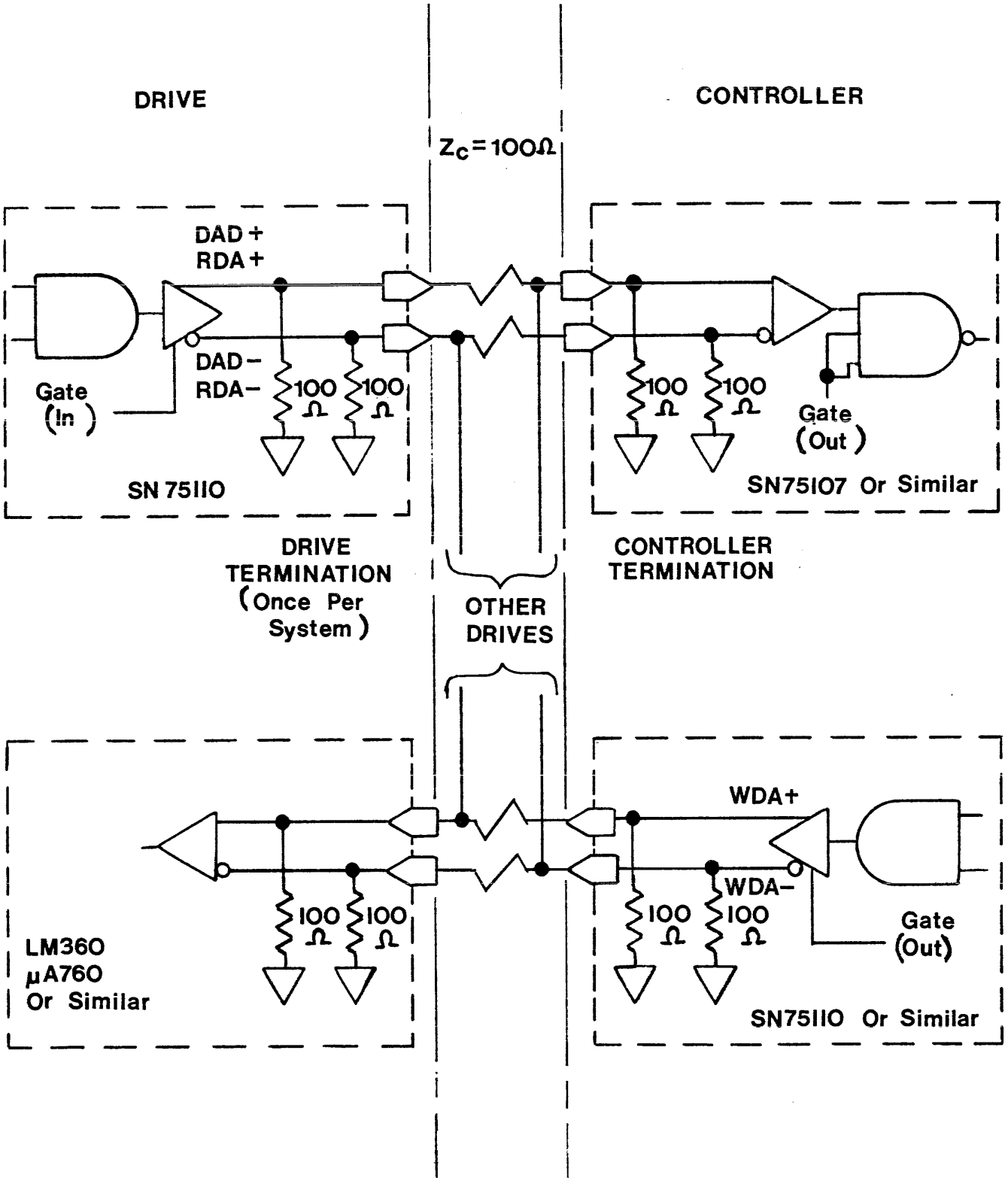
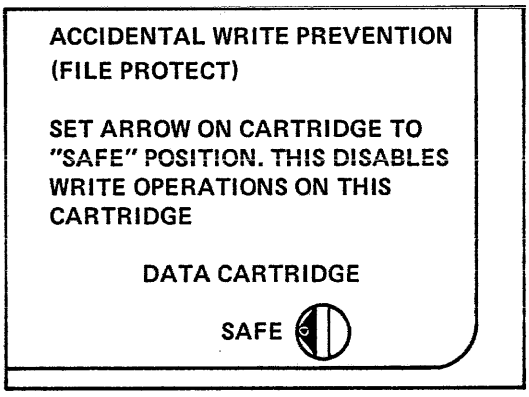


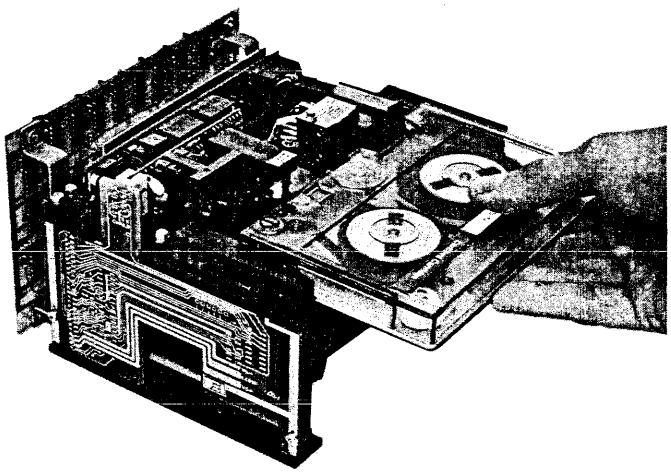
FIGURE 2-8. DIFFERENTIAL SIGNAL TERMINATION

SECTION 3
OPERATION

3.1 GENERAL

This section contains drive and track addressing procedures, as well as signal descriptions for all drive versions. Installation and removal of cartridges and file protect plug operation is described in Figure 3-1.





INSTALLATION

POSITION THE CARTRIDGE AT THE ENTRY OPENING AND SLIDE FORWARD UNTIL THE FIRST DETENT IS FELT. CONTINUE SLIDING CARTRIDGE FORWARD UNTIL IT IS FULLY ENGAGED

REMOVAL

TO REMOVE THE CARTRIDGE, SIMPLY PULL IT OUT OF THE DRIVE

FIGURE 3-1. CARTRIDGE INSTALLATION AND REMOVAL/FILE PROTECTION

3.2 TAPE POSITION HOLES AND RECORDING FORMAT

Figure 3-2 provides dimensions for the ANSI compatible holes which are sensed to indicate tape position to the controller. Also, please note that data should be written 6" beyond the load point hole and may continue 36" beyond the early warning hole at the end of the tape. Incidentally, in drives incorporating Control Boards, the tape will rewind past load point and past the first set of BOT holes, then stop (see Figure 3-2).

Load Point Sensed (LPS-) goes true after it is sensed in reverse mode. Since LPS- will later go false when the load point hole is detected in the forward direction, the controller should be designed to detect this sequence and output write data 200 msec after LPS- goes false.

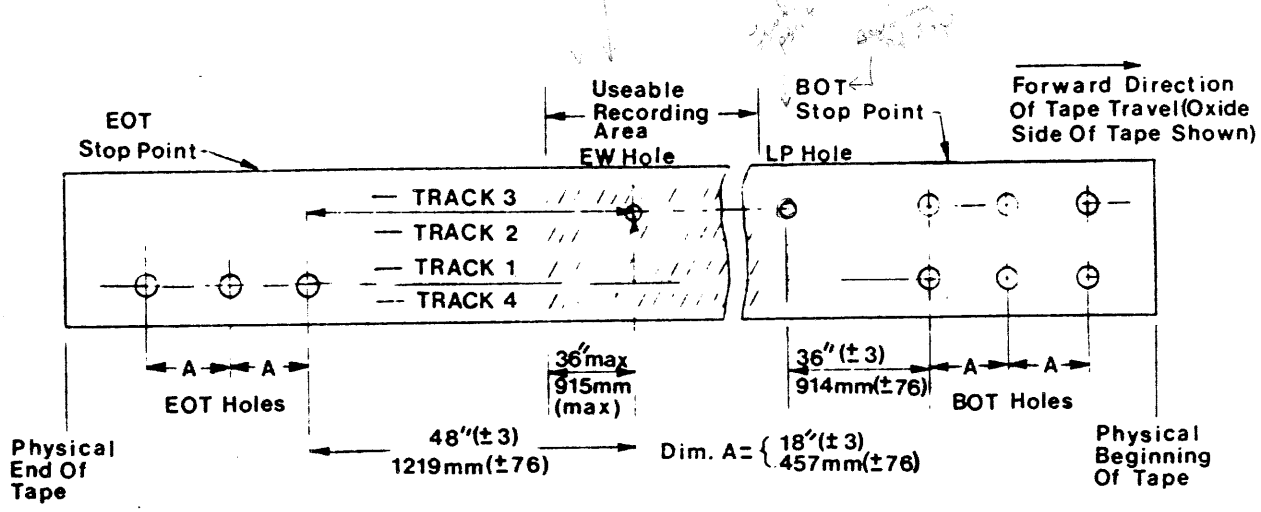


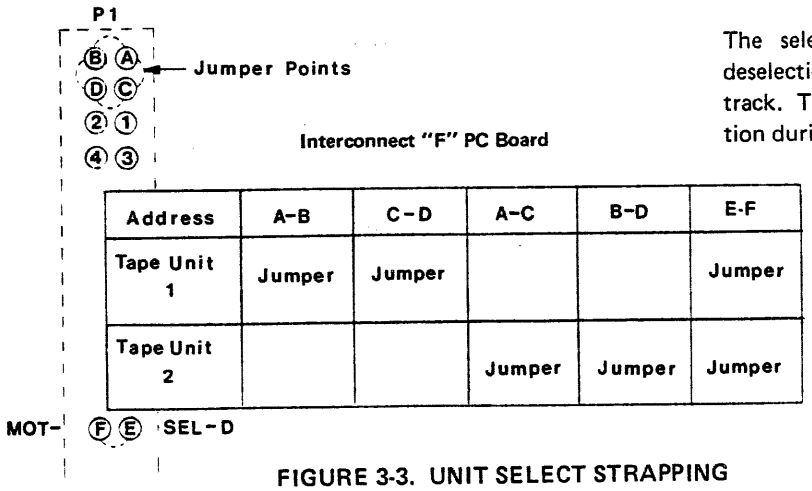
FIGURE 3-2. TAPE POSITION HOLES AND RECORDING FORMAT

3.3 INPUT/OUTPUT SIGNALS: DRIVES WITHOUT CONTROL BOARD

3.3.1 Drive Addressing

Two drives can share a common buss and are designated Unit 1 and Unit 2. SL1- true from the controller selects Unit 1; SL2- true selects Unit 2. The drive must be selected before it will return status information or accept commands.

Figure 3-3 indicates the strapping required on the Interconnect Board to accommodate unit selection. This is a factory modification made per customer specification.



Address	A-B	C-D	A-C	B-D	E-F
Tape Unit 1	Jumper	Jumper			Jumper
Tape Unit 2			Jumper	Jumper	Jumper

FIGURE 3-3. UNIT SELECT STRAPPING

3.3.2 Tape Track Addressing

The logic states of TR1- and TR2- signals from the controller select the read track during read operations and the write and erase tracks during write operations. Track selection is decoded as shown below:

Track Number (ANSI)	TR2-	TR1-
1	H	L
2	L	H
3	L	L
4	H	H

The selected track remains selected even after drive deselection to prevent accidental "glitching" of a default track. The controller must maintain proper track selection during all drive select operations.

Signal	Name	Description
WEN-	Write Enable	When true, enables the write and erase functions for the track number selected. Writing and erasing can occur only if the cartridge is in the unprotected state (i.e., can be written upon). This signal should be set true prior to tape motion, and remain set after drive motion has stopped (27 msec. after FWD– is set false). At least a 2 millisecond delay should be allowed after resetting Write Enable and before selecting a new track. WEN– will remain set after drive selection to prevent creation of glitches.
WDA+/-	Write Data (Differential)	These differential signals will modulate the write head to produce a recorded waveform on tape when WEN- is true and the cartridge is in the unprotected state (i.e., can be written upon). These signals shall continue to modulate the write head if WEN- is set true and the cartridge is not protected even when the drive is deslected. The change of WDA+:H to L and WDA–:H to L state shall cause a comparable change to be made on the RDA signal lines when read back in the same direction as recorded. The minimum clock period for data input should not allow the nominal resultant number of flux reversals to exceed 6400 per inch (2520 flux reversal/cm).
FWD-*	Forward	Causes Forward tape motion. Tape speed is determined by the state of the High Speed signal (HSP– low = high speed; HSP– high = low speed.)
REV-*	Reverse	Causes reverse tape motion. The speed is determined by the High Speed signal (HSP– low = high speed; HSP– high = low speed.)
HSP-	High Speed	Causes the tape to move at high speed in the direction set by FWD- or REV-.
*Simultaneous FWD- and REV- commands will not damage the drive. However, tape motion would be unpredictable.		

TABLE 3-1. INPUT SIGNALS: DRIVES WITHOUT CONTROL BOARD

Signal	Name	Description
FIP-	File Protected	When true, the read data on the cartridge is protected (i.e., cannot be written upon).
BLB-	Bulb	When true, power is applied to tape drive (+5 Vdc present) and sensor bulb is drawing current.
UTH- LTH-	Upper Tape Hole Lower Tape Hole	UTH- true indicates an upper tape hole has been sensed. LTH- true indicates a lower tape hole has been sensed. These signals are true for period of sensor activity ($\geq$100 μsec) only. The hole period for simultaneous upper and lower hole detection (BOT) shall overlap by $\geq$50 μsec.
CIP-	Cartridge in Place	CIP- true indicates a tape cartridge is installed in the drive.
RDA+/-	Read Data (Differential)	This differential signal is a near replica of the write data written onto the tape. The read signal is available during periods of drive selection. The read signal lines should only be examined for valid data when DAD is true. There is no internal thresholding of the RDA +/— signal.
DAD+/-	Data Detected (Differential)	When true, this differential level indicates valid read data is present. Read data is present. Read data should be examined during DAD true time. The DAD signal is thresholded internally against three levels (Read, Write and High Speed) as a function of operation. DAD+/- will go true less than 16 μsec. after the first valid data transition is read from tape. It will remain true if at least two data transitions which also exceed the threshold criteria are read from tape in the 16 μsec. period. The DAD signal will remain true for up to 62 μsec. after the last valid data transition is read from a block.

TABLE 3-2. OUTPUT SIGNALS: DRIVES WITHOUT CONTROL BOARD

3.4 INPUT/OUTPUT SIGNALS: DRIVES WITH CONTROL BOARD

3.4.1 Drive Addressing

Up to eight drives can be daisy chained together. Each unit is addressed individually by issuing the following signals:

SLG- Select Gate: When true, enables selection per the unit select address code. SLG- prevents erroneous drive selection from occurring during changes in the unit select address.

SL4-, SL2-, SL1- Unit select address from controller in the form of a binary number (true low): 2^2 is SL4-, 2^1 is SL2-, and 2^0 is SL1-. The address is decoded by the Control Board as shown in Table 3-3.

3.4.2 Tape Track Addressing

The logic states of TR1 and TR2 signals from the controller select the read track during read operations and the write and erase tracks during write operation. Track selection is decoded as shown below.

Track Number (ANSI)	TR2-	TR1-
1	H	L
2	L	H
3	L	L
4	H	H

The selected track should be selected just prior to, during and just after drive selection periods to prevent accidental alternate track selection

Tape Drive Selected	Logic Address (Unit Switch "ON")	L = Low State H = High State		
		SL4(2^2)	SL2(2^1)	SL1(2^0)
1	1	H	H	L
2	2	H	L	H
3	3	H	L	L
4	4	L	H	H
5	5	L	H	L
6	6	L	L	H
7	7	L	L	L
8	8	H	H	H

TABLE 3-3. DRIVE SELECTION

Signal	Name	Description
FWD-	Forward	When true, causes tape to move in a forward direction.
REV-	Reverse	When true, causes tape to move in a reverse direction.
HSP-	High Speed	When true, causes the tape to move at high speed in the direction selected by FWD- or REV-. Tape motion will proceed until the command goes false, or: a. An EOT hole is encountered in forward mode, causing tape to stop. b. A set of BOT holes in encountered in reverse mode, causing tape to stop. c. Forward and reverse commands are issued simultaneously, causing tape to stop. d. A rewind command is received. This overrules all other motion commands and initiates a rewind operation. e. The internally generated Ready signal goes false, causing tape motion to stop, (i.e., the cartridge removed). f. The loadpoint (LP) hole is sensed in reverse or the early warning (EW) hole is sensed in forward mode. Tape motion then drops from high to normal speed, except during an automatic rewind sequence.
RWD-	Rewind	When true, initiates a high speed rewind operation to a point between the first and second set of BOT holes. This position is recommended for unloading, since the data recording area is completely protected. The drive must be selected to start a rewind sequence but may be deselected after the sequence is commenced. Tape motion still automatically stops at BOT. Rewind will override all other tape motion commands. Successive rewind commands will not cause the tape to be "run off." Rewind mode is disabled if the internally generated Ready signal goes false, (i.e., the cartridge is removed).
WEN-	Write Enable	When true, shall enable the write and erase functions for the selected track. The writing and erasing processes occur only if the cartridge is in the unprotected state (i.e., can be written upon). This signal should be set prior to tape motion and will remain set after drive deselection. At least 2 milliseconds should be allowed between the reset of Write Enable and the changing of the track select signals. This signal is internally latched and reset with REV– or HSP– true.
WDA+/-	Write Data (Differential)	These differential signals modulate the write head to produce a recorded waveform on tape when WEN- is true and the cartridge is in the unprotected state (i.e., can be written upon). These signals shall continue to modulate the write head if WEN- is set and the cartridge is not protected. The minimum clock period for data input should not allow the nominal resultant number of flux reversals from exceeding 6400 per inch (2520 flux reversals/cm).

TABLE 3-4. INPUT SIGNALS: DRIVES WITH CONTROL BOARD

Signal	Name	Description
RDA+/-	Read Data (Differential)	These differential signals are near replicas of the write data written onto the tape. The read signal is available during drive selection periods. The read signal lines should be examined for valid data only when Data Detected is true. RDA+/— is not internally thresholded.
DAD+/-	Data Detected (Differential)	When true, this differential level indicates valid read data is present. Read data should only be examined during DAD true periods. DAD is internally thresholded against three leads (Read, Write and High Speed) as a function of operation. DAD+/- will go true less than 16 μsec. after the first valid data transition is read from tape. It will remain true if at least two data transitions which also exceed the threshold criteria are read from tape in the 16 μsec. period. The DAD signal will remain true for up to 62 μsec. after the last valid data transition is read from a block.
EWS-	Early Warning Sensed	Will be true and latched when the upper early warning hole (the warning prior to the end of tape holes) is passed in the forward direction. This signal will be reset when the early warning hole is subsequently passed in the reverse direction. When this signal is true, high speed is disabled. Low speed forward tape motion is allowed to proceed until the EOT hole is encountered at which point the drive will stop and accept only reverse commands.
SLD-	Selected	Will be true when the drive has received its proper unit address.
RDY-	Ready	Will be true when a cartridge is installed, the sensor lamp is drawing current, and +5 Vdc is applied to the drive.
BSY-	Busy	Will be true when the drive is in automatic rewind sequence (e.g., when a cartridge is first installed in the drive), or when the drive is executing a rewind, forward, or reverse command. This signal will go true when the command is received and will remain true until tape motion has stopped (i.e., 30 milliseconds after low speed motion has been commanded to stop and 80 milliseconds after high speed operation has been commanded to stop). In the case of receipt of a non-executed or illegal command (FWD- at EOT- or REV- at BOT-), this signal will be false, indicating the command is rejected.
FLG-	Flag	Will be true and latched after a rewind has been completed. This signal is reset false by subsequent receipt of a FWD-command.
WND-	Write Enabled	Will be true when a write enable condition is latched within the drive.
FUP-	File Unprotected	Will be true when a cartridge is installed and it is in the unprotected state (i.e., can be written on).
LPS-	Load Point Sensed	Will be true and latched when the upper load point hole (the warning of beginning of tape) is passed in the reverse direction. This signal will be internally reset when the load point hole is subsequently passed in the forward direction. When this signal is true, high speed will be disabled. Reverse tape motion is allowed to proceed until the BOT holes are encountered, whereupon the drive will stop and accept only forward commands.

TABLE 3-5. OUTPUT SIGNALS: DRIVES WITH CONTROL BOARD

3.5 INPUT/OUTPUT SIGNAL: DRIVE WITH CODEC BOARD

All drive which are equipped with Codec Boards are also supplied with Control Boards. Therefore, their I/O signals are the same as those listed in Table 3-5, except for the WDA+/- RDA+/– and DAD+/- signals, which are replaced by the signals described in Tables 3-6 and 3-7 below.

Signal	Name	Description
WDE-	Write Data Enable	A control level input which enables write data encoding (the sending of write data strobes and the writing of data on tape). The WEN-function is still required and will enable both writing and erasing. After cartridge is up to speed and other conditions are met, WDE– true will cause the drive to send the first data strobe and commence to record flux transitions on tape. The first strobe is sent $\leq$5.2 usec after WDE– goes true. All data to be written must include preambles, check characters and postambles.
WNZ-	Write Non-Return Zero Data	During the write data strobe period, the state of the input write data line is sensed as follows: WNZ = Low = 1, WNZ = High = 0 The state of WNZ- is examined only during the write data strobe period. The WNZ-signal must be steady 0.5μsec prior to the write data strobe true period (WDS = Low) but can change at the trailing (high going) edge of the data strobe.

TABLE 3-6. INPUT SIGNALS: DRIVES WITH CODEC BOARD

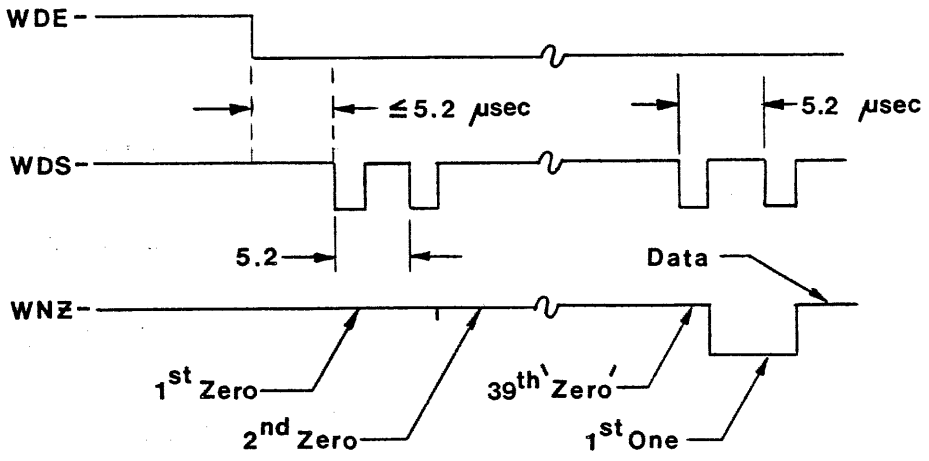


FIGURE 3-4. WRITE DATA TIMING

Signal	Name	Description
DAD-	Data Detected	Will be false except when data has been detected. Data detected requires the receipt of data from the drive without an intervening period of no read data. It will be true prior to the first read data strobe and can be used to sense data at high speeds.
RNZ-	Read Non-Return to Zero Data	During the read data strobe period RNZ is low (true) then the data is a 'one', if high then the data is 'zero'. The RNZ signal will remain steady at least 100 nsec prior to and during the entire RDS true period.
WDS–	Write Data Strobe	The write data strobe is generated within the Codec Board and is output to indicate when the drive is examining the state of the WNZ– signal (taking data). The low or true strobe period is 1.3 usec.
RDS–	Read Data Strobe	Read Data Strobe. Will be low for $\approx 1.3 \times 10^{-6}$ sec. indicating that RNZ can be sampled during this period.

TABLE 3-7. OUTPUT SIGNALS: DRIVES WITH CODEC BOARD

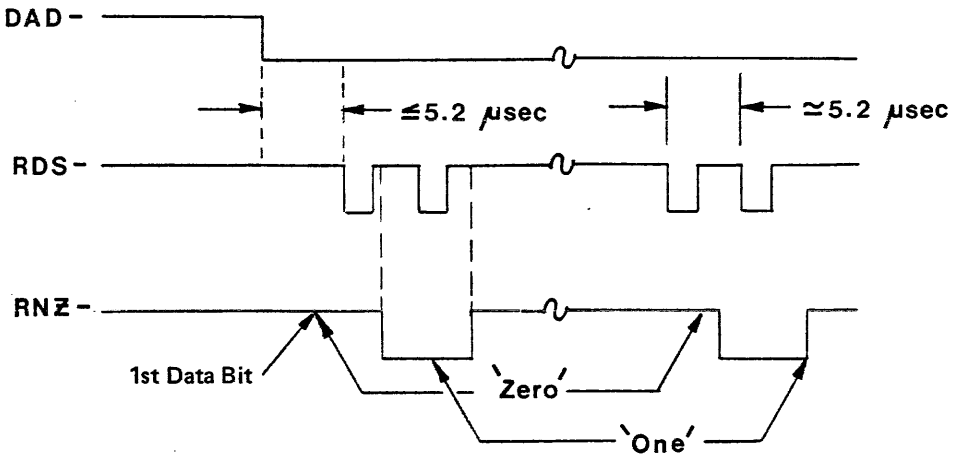


FIGURE 3-5. READ DATA TIMING

SECTION 4
THEORY OF OPERATION

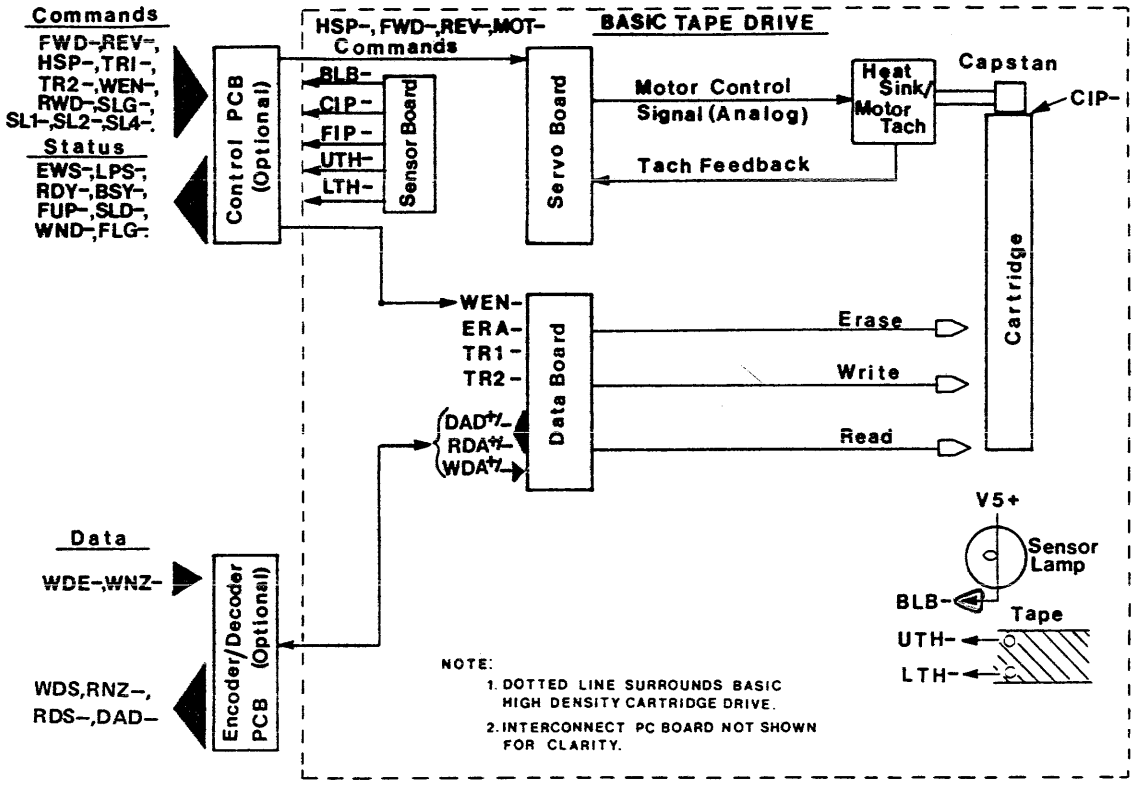


FIGURE 4-1. DRIVE BLOCK DIAGRAM

4.1 GENERAL (Refer to Figure 4-1)

This section describes the functions of the various boards and major components, as well as the functions of the status, data, and control circuitry.

4.2 MAJOR COMPONENT FUNCTIONS

4.2.1 Head Assembly

The head assembly consists of a closed magnetic circuit constructed of laminated high permeability metal with wound coils for inducing and detecting flux reversals on magnetic tape. The head assembly has read, write, and erase functions.

4.2.2 Sensor Assembly

The Switch/Sensor Assembly contains circuitry for sensing the Beginning of Tape holes, End of Tape holes, Load Point holes, and Early Warning holes which indicate tape position. This assembly also contains the File Protect and Cartridge in Place switches.

4.2.3 Interconnect Board

Besides functioning as a motherboard for the other circuit boards, the Interconnect Board contains provisions for line termination and most of the test points required for calibration adjustments and troubleshooting.

4.2.4 Control Board (Optional)

When installed, this board performs some of the tape motion control functions normally performed by the controller and thus simplifies controller design. Specific functions include:

a. Eight position unit address switch. Eight drives can share a common I/O buss.

b. Forward motion prevention at end of tape.

c. Reverse motion prevention at beginning of tape.

d. High Speed operation permitted between load point and early warning holes only.

e. Simultaneous forward and reverse commands will stop the tape.

f. Drive completes automatic and externally commanded rewind sequences.

g. Automatic positioning to BOT holes on cartridge installation and power up.

h. Write Enable (WEN) is internally latched and reset by High Speed (HSP-), Reverse (REV-) or Not Ready (RDY- False).

i. Bulb (BLB-), Cartridge in Place (CIP-) and +5V Supply gated to produce a Ready (RDY-) status signal.

j. Busy (BSY-) status signal goes true during tape motion; remains true during periods of tape motion.

k. A Flag (FLG-) status signal is provided to indicate completion of a rewind operation.

l. A Write Enabled (WND-) status signal is provided, indicating Write Enable has been latched.

m. Multiple rewind commands will not cause tape runoff.

n. Indicator drivers are provided for the operator control panel.

o. Unit address signals are provided for the operator control panel.

4.2.5 Data Board

This board connects directly to the magnetic head assembly. It contains the analog read circuitry and threshold detection circuitry, write data circuitry, ac erase circuit and the track selection circuitry.

4.2.6 Codec Board (Optional)

This board performs two major functions:

a. *Encoding.* (NRZ to MFM conversion of write data) An internal oscillator generates a strobe signal which is encoded with NRZ write data to produce self-clocking MFM encoded data.

b. *Decoding.* (MFM to NRZ conversion of read data). Differential MFM encoded read data is separated into a TTL NRZ read data strobe and TTL NRZ data. The preamble is automatically removed from the read data prior to transmission.

4.2.7 Servo Board

The Servo Board drives the dc motor. It provides all necessary servo control logic for translating digital tape motion control commands into analog motor signals and processes the tachometer signal to assure motor speed regulation. Its voltage regulator develops the ±15 volts and –5 volts required by the various drive subassemblies. In addition, the power shut down circuit automatically stops the drive motor in the event of power failure.

4.2.8 Heat Sink Assembly

The heat sink assembly contains the drive motor/tachometer, power transistor circuits and a heat sink. This plug-in module is center-of-gravity mounted so that the capstan maintains proper pressure on the cartridge drive roller regardless of drive position or attitude.

4.2.9 Cartridge Lock-In Assembly

Precision side rails position the tape cartridge with respect to the tape head and capstan. Spring-loaded pawl assemblies engage the upper surface of the cartridge base plate against a fixed, vertical reference surface and provide a secure fixed horizontal stop.

4.2.10 Modular Construction Concept

All boards except the Codec are connected to the Interconnect Board. Input and output signal and power connectors are mounted as shown in Figure 4-2.

4.3 TAPE DRIVE STATUS SIGNALS

Status signals to the controller/formatter vary, depending upon whether or not a Control or a Codec Board is employed. In tape drives without Control Boards, the status signals from the Sensor and Data Boards are output directly to the controller through the Interconnect Board. These signals are: Bulb (BLB-), Cartridge in Place (CIP-), File Protected (FIP-), Upper Tape Hole (UTH-), Lower Tape

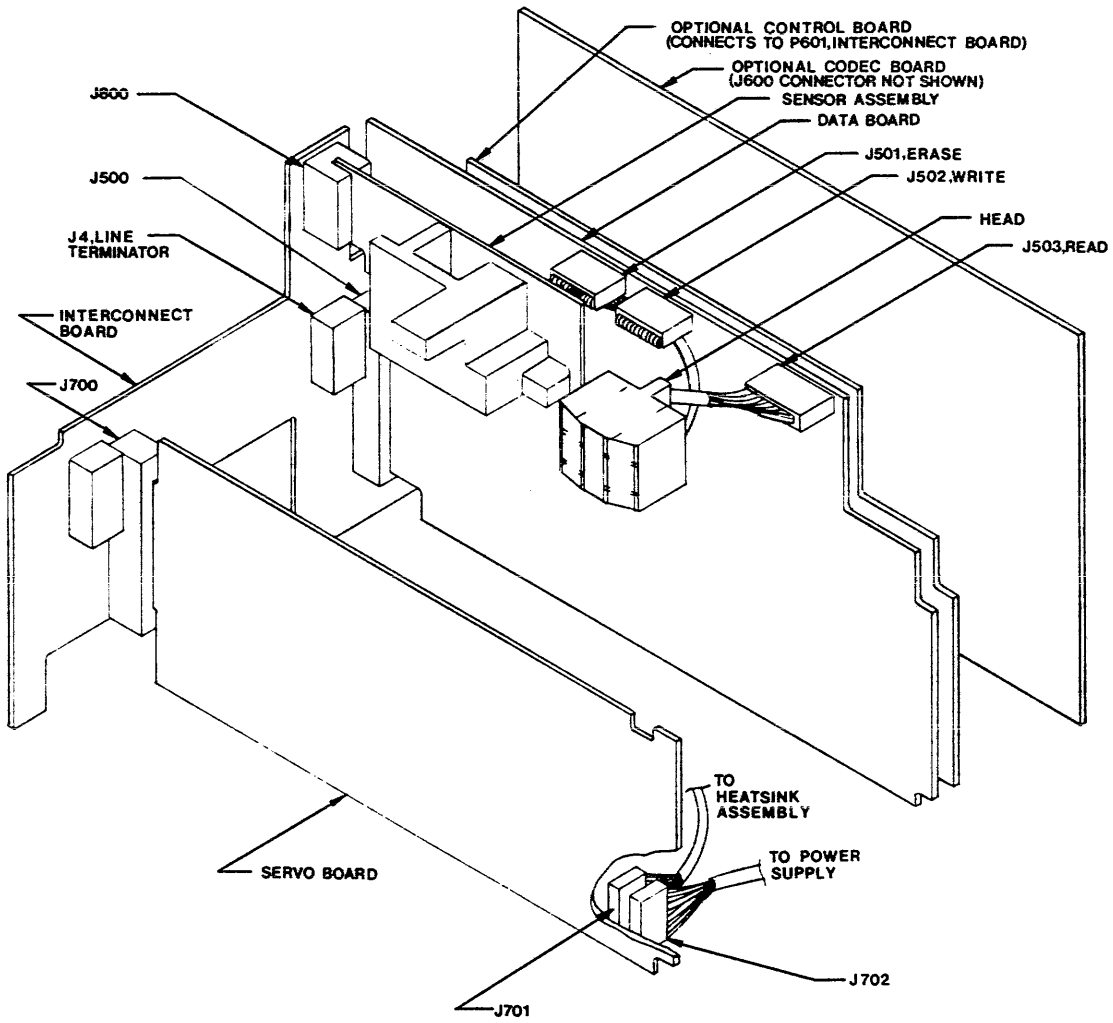


FIGURE 4-2. MAJOR SUBASSEMBLY INTERCONNECTIONS

Hole (LTH—), Read Data (RDA±) and Data Detected (DAD+/-). We shall deal with these basic status signals first.

4.3.1 CIP-, FIP-, BLB-, UTH-, LTH- Signals

Two microswitches in the Switch Sensor assembly determine the state of the Cartridge in Place (CIP-) and File Protect (FIP-) signals. CIP- goes low true whenever a cartridge is completely engaged, closing the right-hand switch as seen from the front of the drive. With the cartridge engaged, the left-hand File Protect switch will be closed only when the File Protect indicator arrow on the cartridge points away from the SAFE position. Under this condition, FIP- false will be issued to enable write operations. BLB- true indicates the photosensor's bulb is operating. If this bulb's filament opens, BLB-goes false, and the controller should disable tape motion commands.

Upper Tape Hole (UTH-) and Lower Tape Hole (LTH-) status signals go true whenever an upper or lower tape hole pass the sensors. The hole patterns shown in Figure 4-4 must be decoded to indicate tape position to the controller. Due to tape skew and other factors, Upper-Lower Hole combinations may not be detected simultaneously though the signals will overlap. There is built-in compensation for this in the Control Board. This same feature should be designed into the controller when the Control Board is not incorporated.

4.3.2 Status Signals from Control Board (Refer to Table 4-1)

In cartridge drives having Control Boards, the status signals are: Selected (SLD-), Ready (RDY-), Write Enabled (WND-), Flag (FLG-), Load Point Sensed (LPS-), File

Unprotected (FUP-), Busy (BSY-) and Early Warning Sensed (EWS-). The Control Board performs tape control and status signal gating functions which would otherwise be performed by the controller. When the drive is first selected by the controller, the state of select lines SL1; SL2, SL4, and Select Gate (SLG-) true are decoded and matched against the unit select switch setting. If there is a match, internally generated SL-1 true will reset a type D flip-flop and return SLD– true Drive Ready (RDY–) true is the product of gating CIP- and BLB- true with the +5 supply. Therefore, the cartridge must be inserted correctly, the tape sensor bulb must be illuminated and +5V must be present before RDY- true will be returned, indicating the drive is ready for its first command(s). Table 4-1 provides a truth table for drive status signals output from the Control Board. All outputs require that the drive be selected.

Drive Selected (SLD-) true:	SL1, SL2, SL4 are decoded and equal to drive address as programmed on switch and SLG true. Drive Select (SL-I-) true
Ready (RDY-) true:	Bulb (BLB-) true Cartridge In Place (CIP-) true V5+ true
File Unprotected (FUP-) true:	File Protect (FIP-L) false Drive Ready (RDY+) true
Load Point Sensed (LPS-) true	Slow Reverse (SLO REV–) true or Stop Reverse (STP REV–) true
Flag (FLG-) true:	Auto Rewind Sequence (ARS-) true
Write Enabled (WND-) true:	File Unprotected (FUP–) true SEL-I = True Reverse (REV–) false Auto Rewind Sequence (ARS–) false Rewind (RWD–) false High Speed (HSP–) false WEN– was set true
Early Warning Hole Sensed (EWS-) true:	SEL-I = True and Slow Forward (SLO FWD-) true or Stop Forward (STP FWD-) true
Drive Busy (BSY-) true;	Auto Rewind Sequence (ARS-) true or Forward (FWD-) true or Reverse (REV-) true or Timer true (30/80 msec.)

TABLE 4-1. STATUS SIGNAL TRUTH TABLE

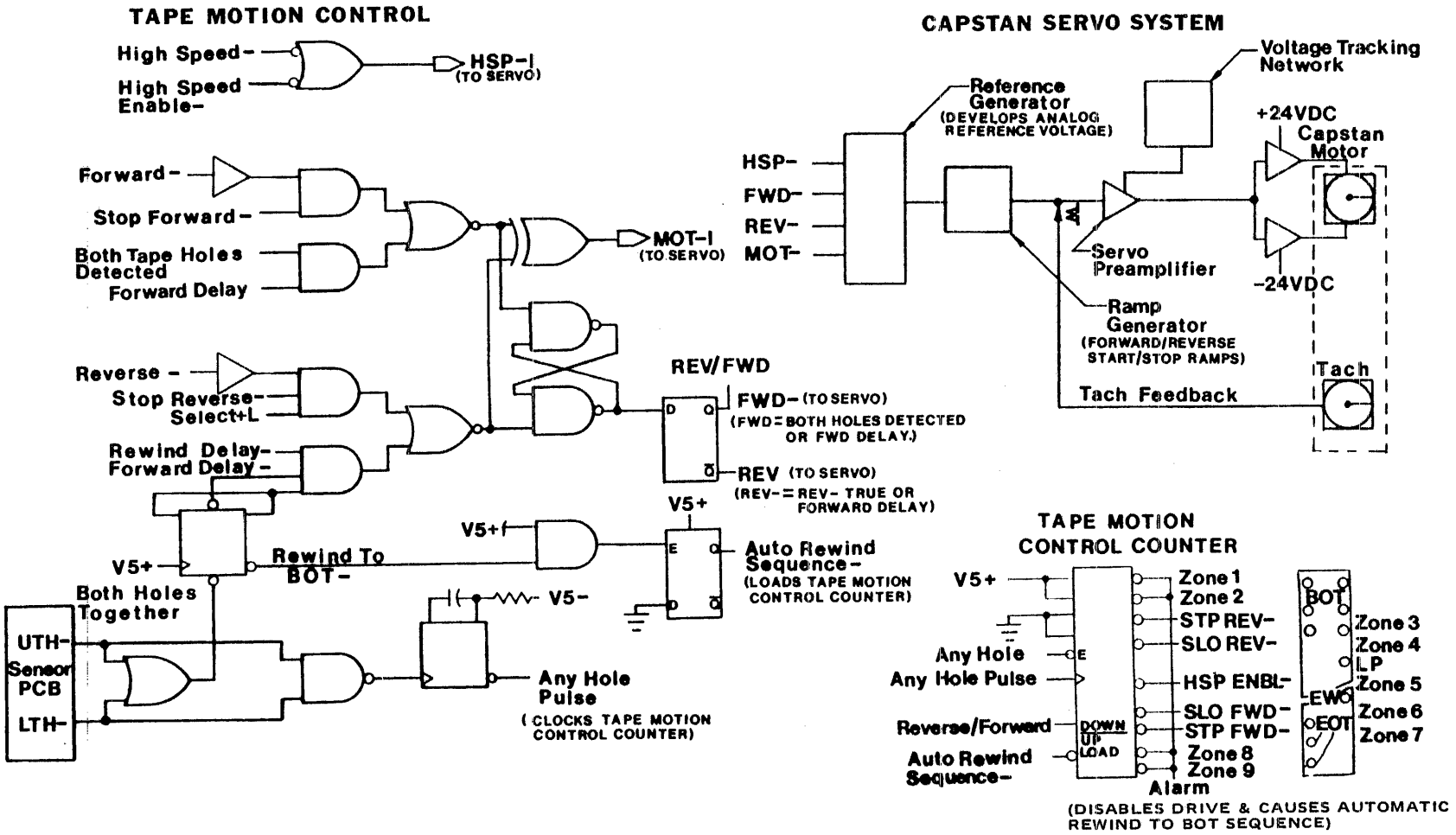


FIGURE 4-3. TAPE MOTION CONTROL

FUP-, or File Unprotect-, is produced by gating the status of the RDY- and FIP-L lines. Thus, FUP- true is used to tell the controller to not attempt write operations whenever an installed cartridge's File Protect switch is in the SAFE position.

LPS-, or Load Point Sensed, goes true to indicate the Load Point hole has been detected in reverse. This is because SLO REV- and STP REV-, two internally generated commands, are ORed together to develop the LPS- true status. Slow Reverse would be issued after the tape passes the Load Point hole. Stop Reverse replaces Slow Reverse when the Beginning-of-tape holes are sensed. LPS- goes false after the Load Point hole is sensed in the forward mode. Flag (FLG-) signal is set true to indicate a rewind operation or automatic rewind sequence has been completed. FLG- is reset false after a Forward command is issued.

Write Enabled (WND-) is latched true when the drive is selected, File Protect is false and WEN- has been issued by the Controller. WND- will go false when WEN is reset by the receipt of a Reverse or High Speed Command.

EWS (Early Warning Sensed) goes true to indicate the Early Warning hole has been detected during forward tape motion. EWS monitors the state of two internal tape motion commands, Slow Forward and Stop Forward. As with the Slow and Stop Reverse signals, these commands are ORed. Slow Forward goes true when the Early Warning hole is detected in the forward tape mode. Stop Forward- goes true when the first End of Tape hole has been sensed. EWS goes false when the Early Warning hole is sensed in reverse.

Busy (BSY—) true status signal is issued to the controller when the drive is executing a rewind, forward, or reverse command or is engaged in an automatic rewind sequence following cartridge loading. BSY— will go false approximately 30 msec after low speed tape motion has been commanded to stop and approximately 80 msec after stopping a high-speed tape motion. BSY— remains false following receipt of an illegal or unexecuted command.

4.4 TAPE MOTION CONTROL

(Refer to Figures 4-3; 4-4) With the cartridge inserted, a lamp within the sensor mechanism will illuminate either or both the top and bottom hole photosensors on the Sensor Board whenever a tape position hole is present. The Sensor Board outputs Upper and Lower Tape Hole true signals which are passed directly to the controller after gating with drive select in drives without Control Boards or to the Control Boards of units employing same.

The Control Board utilizes the tape holes to control tape position so that the tape can't run forward beyond the second End of Tape hole or reverse past the second set of Beginning of Tape holes. The tape is divided into nine zones as shown in Figure 4-4. Note these zones correspond to the spaces between the BOT, LP, EW, and EOT holes.

Zones 3 through 7 are the only permissible zones for tape motion, since zones 1, 2, 8, and 9 are close to the physical tape ends and not allowed operationally. In fact should one of these prohibited zones be detected in a drive with a Control Board, an internally generated ALARM signal is activated, causing the drive to automatically reposition the tape to Zone 3, the starting position. The zones are counted by using the upper and lower tape hole pulses to increment (in forward mode) or decrement (in reverse) an up/down counter connected to a demultiplexer.

When Zone 6 is detected with tape moving forward, a SLO FWD command is issued. After Zone 7 is reached, a STP FWD command is issued to stop tape motion. SLO REV- and STP REV- are similarly output when Zones 4 and 3 are detected in reverse. High speed operation is permitted only in Zone 5, at which time High Speed Enable will be true.

4.4.1 Automatic Load Sequence (Drives with Control Boards)

When the cartridge is first inserted with the drive under

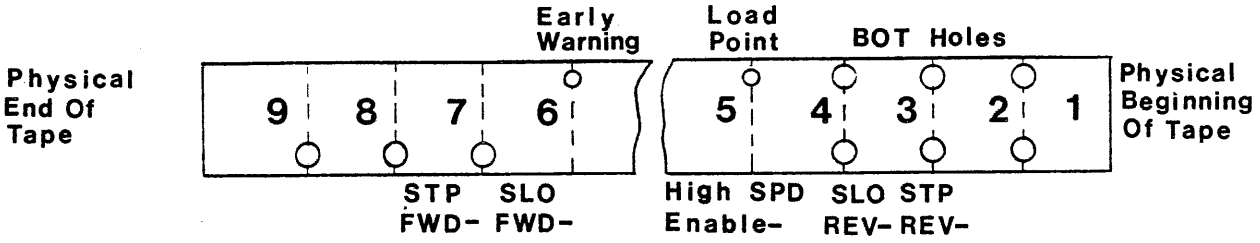


FIGURE 4-4. TAPE CONTROL ZONES

power, BLB- and CIP- true initiate the following automatic sequence to locate the beginning of tape:

1. All tape motion is delayed approximately one second for reasons of: 1, possible voltage stabilization during power up, 2, human factors, such as allowing the operator to release the cartridge and 3, to prevent erroneous tape hole sensing during cartridge insertion.

2. Tape runs forward for approximately one second to clear the third set of BOT holes. Tape then runs in reverse until the third set of BOT holes is again detected (Zone 3). The ARS- (Auto Rewind Sequence) signals goes low true, force loading the counter with the binary equivalent of decimal 3.

3. This indicates the tape is in Zone 3. The decimal 3 line on the demultiplexer goes low, issuing a STP REV- command to stop reverse tape motion.

4.4.2 Servo Operation (Refer to Figure 4-3)

The Servo Board develops the proper analog motor control current from the digital motion control commands. The servo stages include a reference voltage generator, ramp generator, servo amplifier, power amplifier, and voltage regulators.

High Speed (HSP-I), Forward (FWD-I), Reverse (REV-I) and Motion (MOT-I) commands are applied to a reference generator. When MOT-I is true with a tape motion command present, the reference generator develops the appropriate positive or negative analog voltage and current to initiate a fast or normal speed operation in forward or reverse mode.

Immediately after tape speed and direction are determined, the ramp generator initiates a linear ramp to the proper servo reference voltage. Ramp times are determined by an adjustable R-C network.

Ramps to and from the normal 30 ips tape speed are 23 msec, high speed 90 ips ramps are 69 msec. The ramp generator outputs a stable servo reference voltage after the ramp is complete.

Two Darlington transistor pairs control forward or reverse motor current in proportion to the positive (forward) or negative (reverse) servo amplifier output. The -24 Vdc line powers forward tape motion; reverse tape motion is powered by +24 Vdc.

Attached to the motor shaft, the tachometer monitors tape speed and outputs approximately 2.4 Vdc per 1000 rpm. This tachometer output is summed with the servo reference signal at the servo amplifier input.

Ramp time, tape speed, speed balance (reverse mode speed adjustment), and DC offset adjustments are provided and described in the maintenance section. The Servo Board also contains the voltage regulation network, which produces +14 Vdc, ± 15 Vdc, and -5 Vdc regulated voltages from the ±24 Vdc primary inputs. The regulator IC's are two 723 precision voltage regulators which develop the ±15 and +14 Vdc and one LM320K which produces -5 Vdc regulated voltages.

4.5 READ/WRITE OPERATIONS

For 6400 BPI writing, data must be converted from NRZ format to a high density format such as GCR or MFM and reconverted back into NRZ data with read data strobes during reading. This function must be performed by the formatter or by the optional Codec Board. The basic machine utilizes a Data Board which contains write head drivers, erase oscillators, data preamplifier, data filters, track decoder, head selector, and a read envelope threshold detector.

4.5.1 Write Data Generation (Refer to Figure 4-5)

Unlike NRZ data, MFM formatted zeros and ones are detected by their location within a bit cell (which is defined as the distance between adjacent clock pulses). Zero bits are written at the start of a bit cell. One bits are written at the center of the bit cell. Also, there will be no data transition when a zero bit is between one bits. This results in variable length data transitions which are defined in terms of T-times. (One T-time equals one/half bit cell). The shortest high-low-high transition defines a 111 or 000 pattern, which is a 2T time transition. The longest data transition, a 101 pattern, is 4T times in length. A 100 pattern would be 3T times in length.

To write data in drives without Codec Boards, high density data must be input as differential WDA+/- signals; then applied to the selected write head through the Data Board. In units employing the Codec Board, NRZ formatted data enters the drive as WNZ-, with WNZ low = 1 and WNZ high = 0. The Write Data Strobe (WDS-) is issued from the drive.

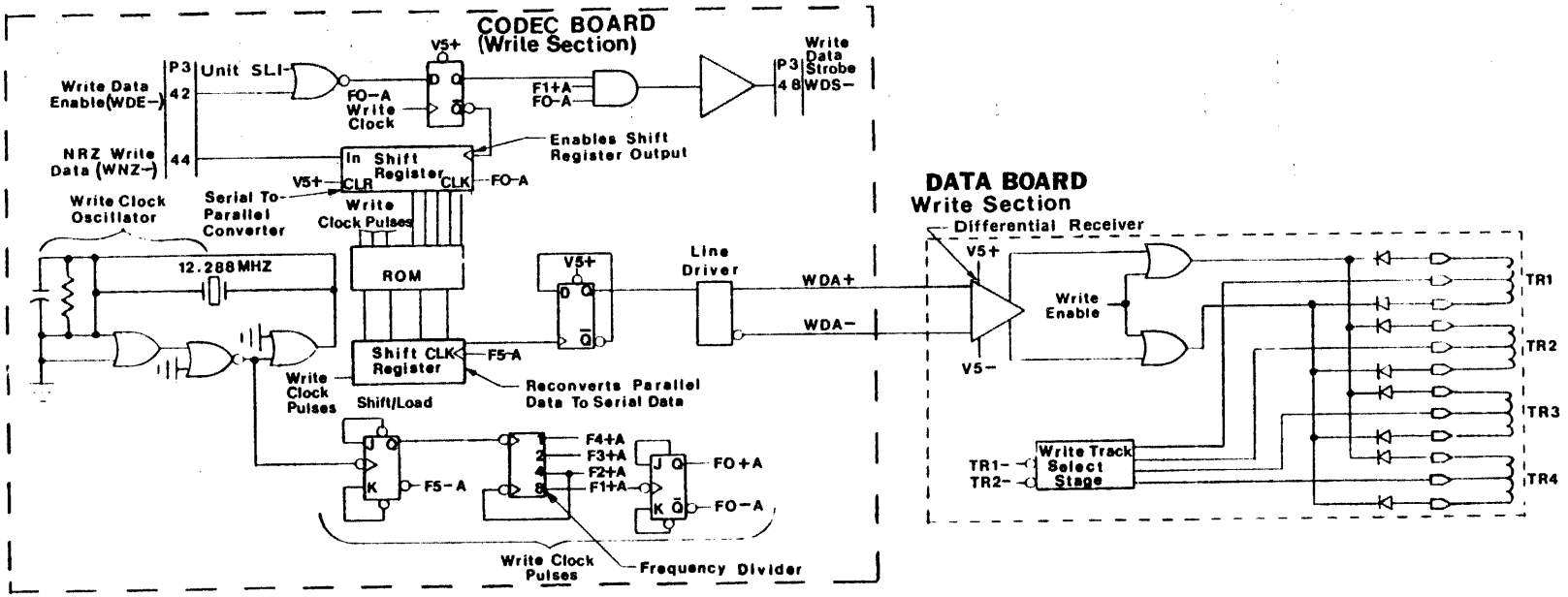


FIGURE 4-5. NRZ TO MFM ENCODING; WRITE DATA BLOCK DIAGRAM

Prior to write data transmission from the controller, WDE- (Write Data Enable-) and WEN- (Write Enable-) must be set true. WDE enables a Write Data Strobe (WDS-), which is derived from a 12.288 MHz oscillator.

After being processed by a read only memory and shift register, write data is reconverted to differential by a D type flip-flop and line driver; then output as WDA+ and WDA– to the Data Board. On the Data Board the signals are gated with Write Enable; then applied to the selected write head.

4.5.2 Read/Write/Erase Head Selection

This is performed by the Data Board. The status of Track Select lines TR1- and TR2- are applied to a Quad D latch which operates in conjunction with two BCD to decimal converters to select the correct track for reading, writing or erasing.

The high density drive utilizes an ac erase system. Normally, selecting a write track with Write Enable true simultaneously selects an adjacent erase track and activates the ac erase oscillator. This is done because track erasure is always required prior to writing. However, an optional separate control of the ac erase (ERA-) line is also available.

4.5.3 Read Envelope Detection (Refer to Figure 4-7)

To assure valid read data and discriminate against non-valid data the Data Board contains a read envelope threshold detection comparator network which disables the Data Detected signal unless the read envelope exceeds a certain predetermined voltage: 70 mV during normal read operations, 250 mV during a read after write operation, or 500 mV during a high speed search. Write Enable- (WEN-) true enables the 200 mV threshold; High Speed- true enables the 500 mV threshold.

4.5.4 Read Data Generation (Refer to Figures 4-6 and 4-7.)

The high density data read from the selected tape track is amplified to approximately 250 mV and filtered by a low pass network. This is usually a write compensated MFM signal which must be converted to the clocked NRZ Format. However, 6400 bpi GCR or any similar high density format could be employed.

Figure 4-6 illustrates the MFM and resultant NRZ read data while Figure 4-7 shows the stages of the Data and Codec Boards. The read data decoding stages include a desnake circuit, a phase lock servo, a timing pulse generator consisting of four one shots whose pulsewidths are controlled by the servo output, a data acquisition circuit, which includes a preamble stripper and a read data strobe generator.

The timing pulse generator of Figure 4-7 produces four sampling pulses of variable width. Each pulse is timed by the servo to equal one quarter of the bit cell. This division of the bit cell into four zones facilitates the detection of the mid bit transition which is peculiar to 'one' data bits of the MFM code.

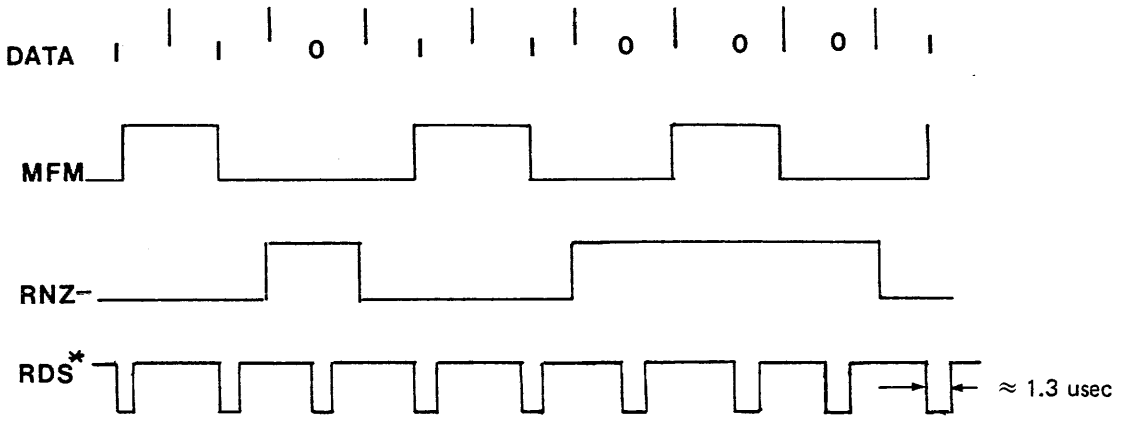


FIGURE 4-6. RNZ- AND RDS- TIMING

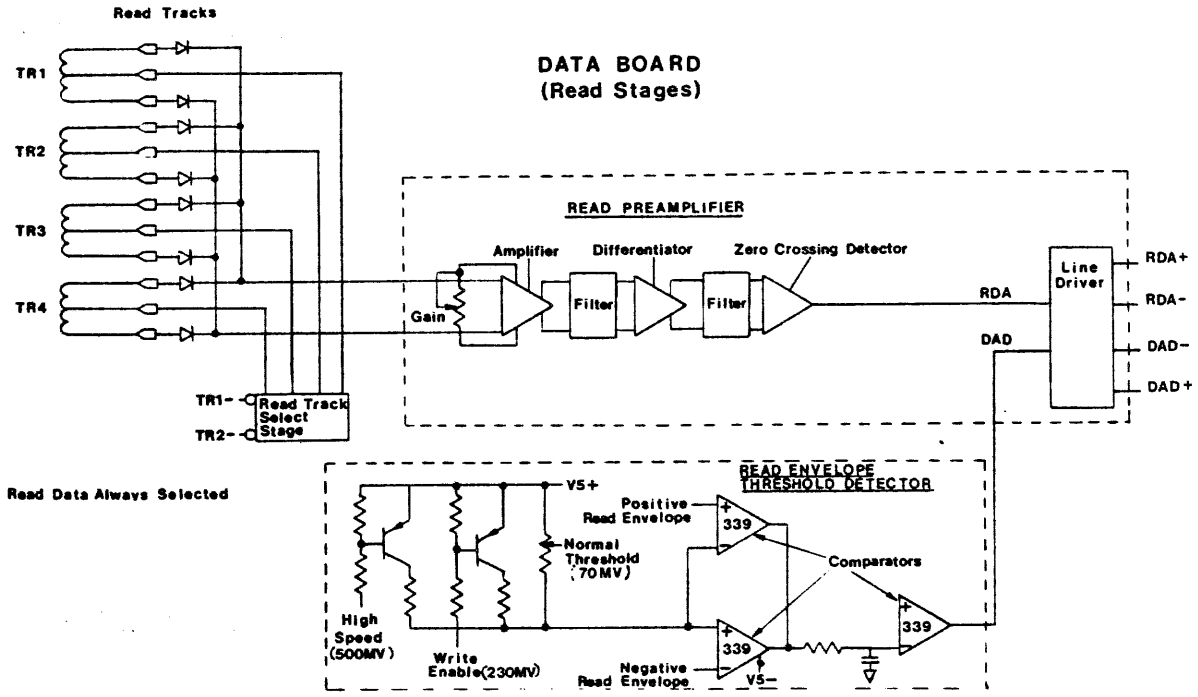


FIGURE 4-7A. READ BLOCK DIAGRAM

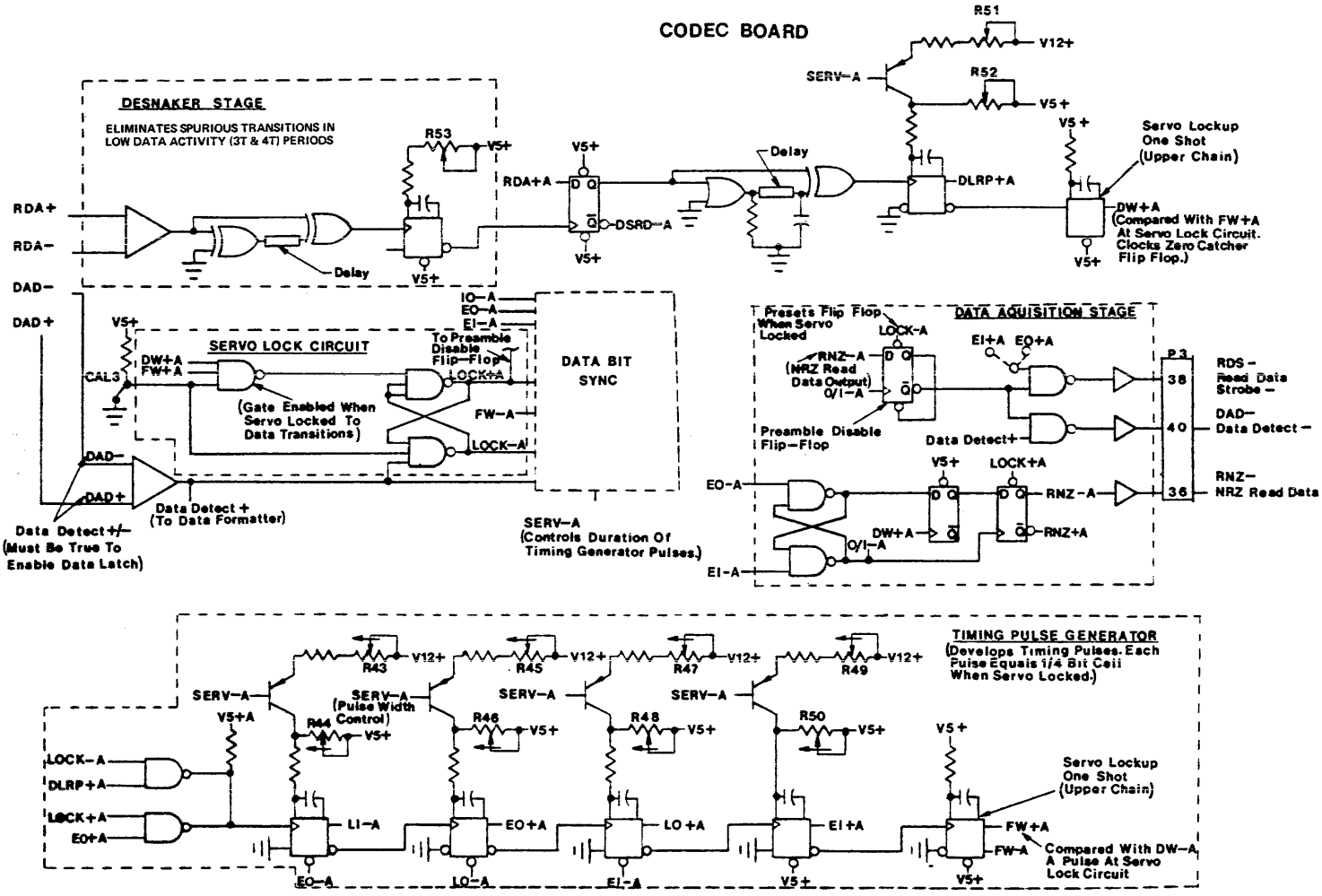


FIGURE 4-7B. MFM-to-NRZ DECODE DIAGRAM

According to the data pattern, two of the sampling pulses which represent 0 and 1 data bits are applied to the data acquisition network. This consists of a latch and two type D flip-flops which develop the NRZ data (RNZ-). The NRZ read data strobe (RDS-) is developed by another flip-flop/NAND gate combination which will automatically eliminate the all-zeroes read preamble by disabling the read data strobe during its occurrence. The circuit is designed to disable NRZ read data until servo lockup is achieved.

SECTION 5
MAINTENANCE

5.1 GENERAL

This section contains periodic maintenance, troubleshooting, removal and installation of parts, testing, and calibration.

5.2 PERIODIC MAINTENANCE

5.2.1 Magnetic Head Cleaning

The magnetic head should be cleaned daily if the tape drive is in regular use. Dirty heads may cause data dropouts during read and write operations. Use a non-residue, non-corrosive cleaning agent, such as duPont Freon TF or isopropyl alcohol, and a cotton swab to clean the head assembly. Be sure to wipe up any excess and allow the heads to dry prior to operating the drive.

> **CAUTION**
> Spray type head cleaners are not recommended because overspray may contaminate the motor bearings. Also, never clean the head with hard objects. This will result in permanent head damage.

5.2.2 Tape Cleaner Cleaning

(Refer to Figure 5-1) The tape cleaner removes loose tape oxide and other foreign material from the tape before it contacts the head. This foreign material accumulates in and around the tape cleaner and must be removed to ensure that the tape cleaner will continue to work effectively. The tape cleaner should be cleaned on the same schedule as the head.

To clean, insert a folded sheet of paper in the bottom of the cleaning slot of the cleaner. Slide the paper up, lifting the foreign material from the cleaner. Compressed air or a soft brush may be used to remove the foreign material from the area around the tape cleaner and head assembly. Alternately, the tape cleaner can be cleaned using the same materials used to clean the magnetic head.

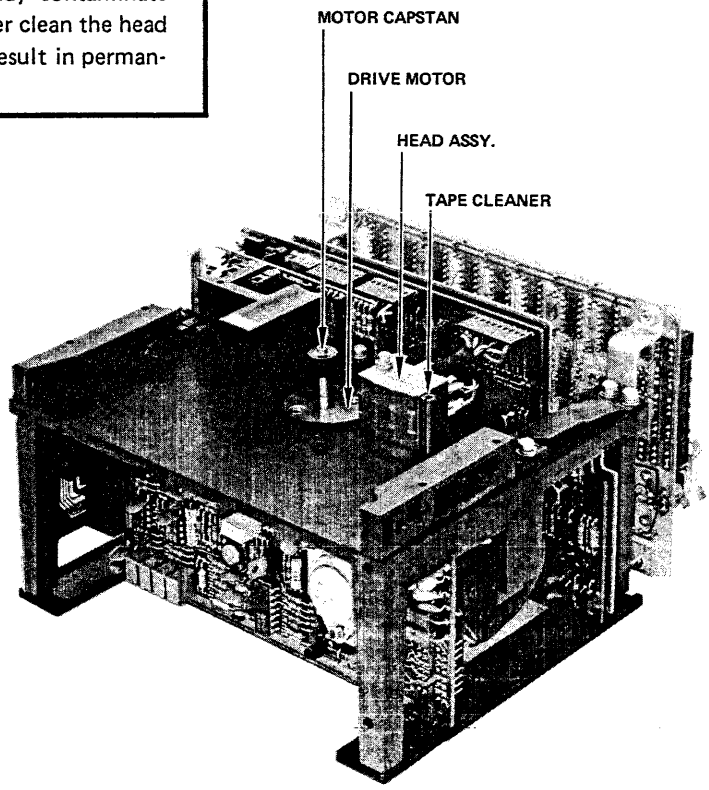


FIGURE 5-1. LOCATION OF PARTS REQUIRING PERIODIC CLEANING

> **CAUTION**
> Do not use hard objects to clean the tape cleaner! If the tape cleaner should become chipped, it could scratch the tape surface, resulting in lost data and/or permanent tape damage.

5.2.3 Motor Capstan Cleaning

The drive capstan is composed of hard polyurethane and must be cleaned after foreign material has built up. Clean, using isopropyl alcohol and a cotton swab. The cleaning schedule should be the same as for the head.

> **CAUTION**
> Be very careful not to permit cleaning solvent to contaminate the drive motor bearings.

5.2.4 Heat Sink, Circuit Board and Sensor Hole Cleaning

To prevent possible overheating, dust and dirt should be removed from the heat sink and drive assembly components as required. The time period between cleanings will vary widely, depending upon the operating environment. Use a soft brush and/or compressed air for cleaning. The sensor holes should be cleaned in the same manner.

5.3 DRIVE DISASSEMBLY

Refer to Figures 5-2, 5-3 and 5-4 for disassembly procedures. Reverse dissassembly procedure to reassemble drive.

5.4 TROUBLESHOOTING

The following troubleshooting information includes:

a. symptoms analysis for localizing the problem into one of three malfunction categories;

b. troubleshooting flowcharts (Figure 5-5);

c. servo and data adjustment procedures;

d. test point locations; and

e. potentiometer locations.

5.4.1 Symptoms Analysis

A. POWER MALFUNCTION:

1. Drive blows +24 VDC fuse in power supply or draws excessive current.
2. Drive blows -24 VDC fuse in power supply.
3. Drive blows +5 VDC fuse in power supply.

B. TAPE MOTION MALFUNCTION

1. Drive will not run in any mode.
2. Drive runs at low speed only.
3. Drive runs at high speed only.
4. Drive runs only forward (low and high speed).
5. Drive runs only reverse (low and high speed).
6. Motor creeps in either direction but responds to commands.
7. Motor creeps in either direction and does not respond to commands.
8. Motor turns but does not drive cartridge.
9. Motor "runs away" (into very high speeds).
10. Heat sink gets excessively hot without motion commands.
11. Inserting cartridge will not cause loading to BOT. (Drives with control boards.)
12. Motion causes excessive noise.
13. Motor runs slow at all modes.
14. Motor runs fast at all modes.
15. Ramp times are out of tolerance.
16. Motor runs at different speeds forward versus reverse.

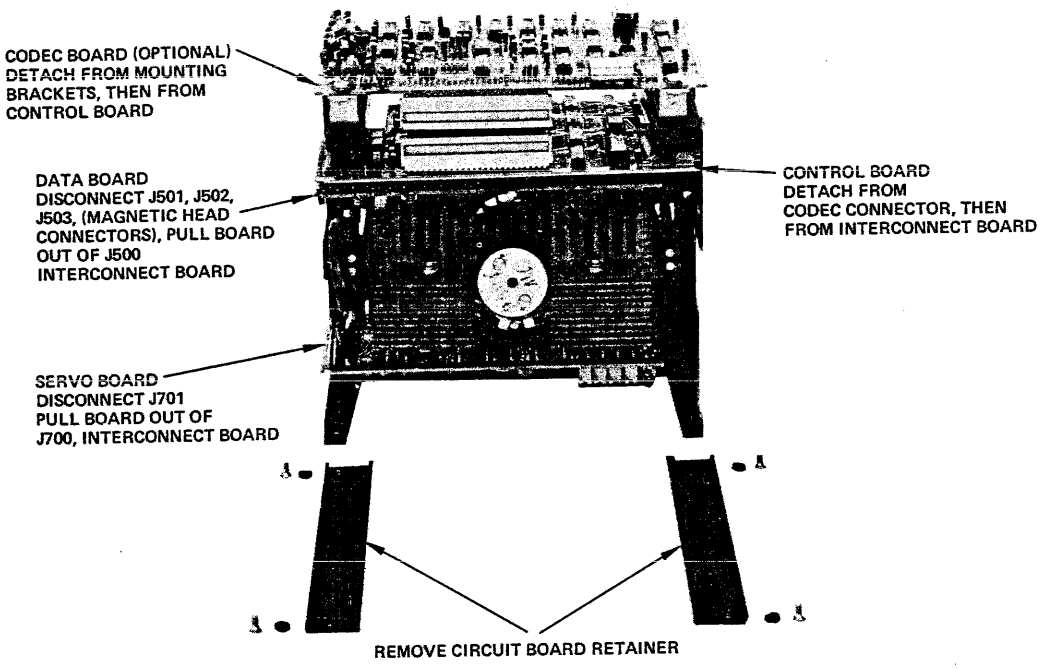
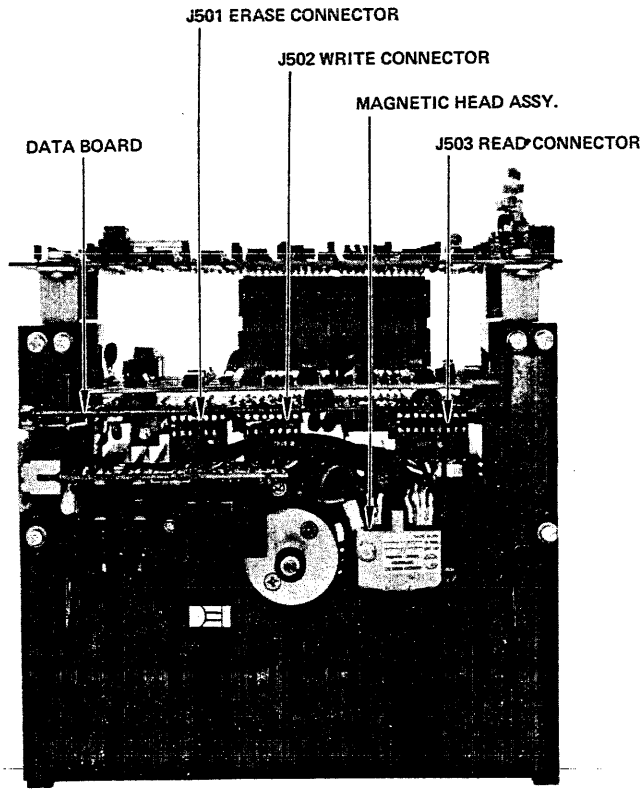


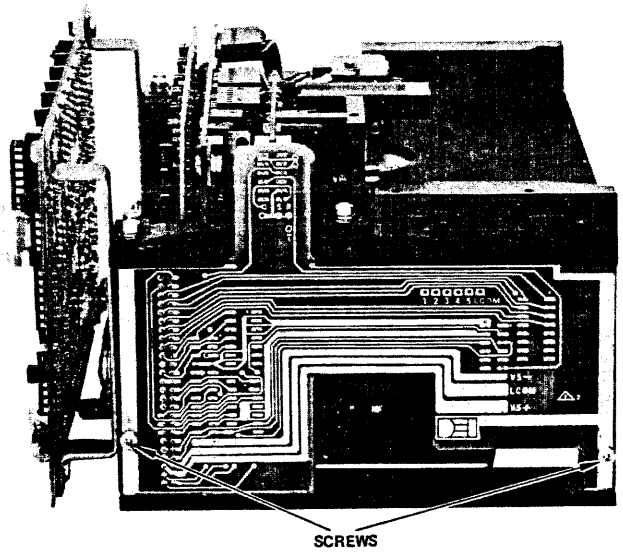
FIGURE 5-2. PC BOARD REMOVAL



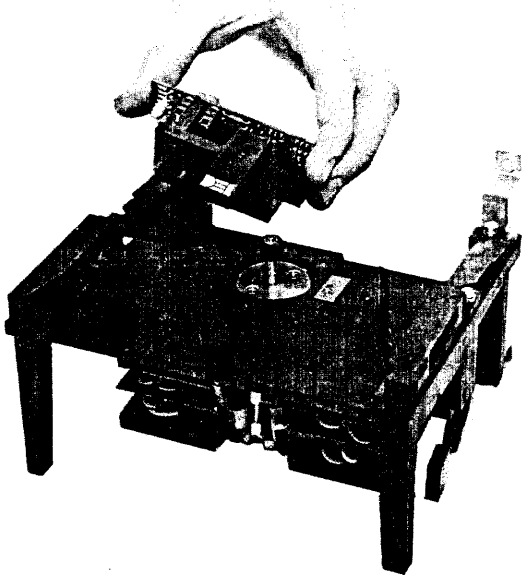
LOOSEN BUT DO NOT DETACH DATA BOARD TO GAIN ACCESS TO MAGNETIC HEAD CONNECTORS J501, J502, AND J503. THEN FOLLOW FIGURE 5-4.

FIGURE 5-3. MAGNETIC HEAD ASSY REMOVAL

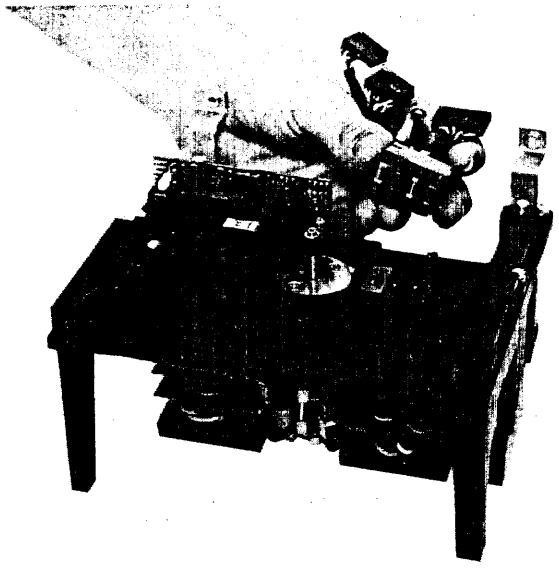
DETACH BOARDS AS DESCRIBED IN FIGURE 5-2



TO REMOVE THE INTERCONNECT BOARD DETACH ITS TWO MOUNTING SCREWS, SLIDE BOARD DOWN TO CLEAR CHASSIS FLANGE, THEN REMOVE INTERCONNECT BOARD FROM SENSOR BOARD.



DETACH SWITCH/SENSOR ASSEMBLY FROM CHASSIS BY REMOVING ITS TWO MOUNTING SCREWS. CAUTION: DO NOT DISASSEMBLE THE SWITCH/SENSOR ASSEMBLY, IT IS FACTORY ALIGNED AND NOT FIELD REPAIRABLE.



TO REMOVE THE HEAD ASSEMBLY: REMOVE ONE SCREW, ONE WASHER, AND INSULATOR.

NOTE: HEAD SURFACE CAN BE EASILY DAMAGED, SO BE CAREFUL WHEN REPLACING HEAD. SLIDE IT DOWNWARD AFTER POSITIONING IT ON ITS MOUNTING DOWELS.

TO REMOVE THE HEAT SINK ASSEMBLY: DETACH J701. THEN REMOVE FOUR SCREWS THAT SECURE EACH MOUNTING BLOCK. REMOVE THE MOUNTING BLOCKS AND LIFT THE HEAT SINK ASSEMBLY OUT OF THE BOTTOM OF THE UNIT. WHEN REPLACING, BE SURE TO PRESS END OF HEAT SINK SPRING INTO ITS MOUNTING HOLE COMPLETELY. ALSO REMEMBER TO PASS THE J701 CONNECTOR THROUGH ITS ACCESS SLOT IN THE DECK FRAME.

FIGURE 5-4. DRIVE DISASSEMBLY

C. STATUS MALFUNCTION:

(Drives *with* Control Boards)

1. No LPS or EWS signals.
2. No LPS signal – EWS present
3. No EWS signal – LPS present
4. EPS and EWS will not latch.
5. LPS, EWS will not unlatch.
6. Bulb not lit.
7. Ready status will not go true.
8. Busy status will not go true.
9. File unprotected status will not go true.
10. Selected status will not go true.
11. Write enabled status will not go true.
12. Flag status will not go true.
13. Indicators will not light (Operator panel).
14. Indicators light when not supposed to. (operator panel)

(Drives *without* Control Boards)

1. No UTH- or LTH- signals.
2. No UTH- signal. LTH- present.
3. UTH- and/or LTH- present at all times.
4. No LTH- signal. UTH- present.
5. No BLB- signal.
6. FIP- signal not functioning.
7. CIP- signal not functioning.

D. DATA MALFUNCTION:

1. Drive will not read, one track.
2. Drive will not read, all tracks.
3. Drive will not read or write.
4. Drive will not write but will read previously written tape.
5. Drive will not erase previous information written.
6. Excessive errors in reading while writing, but not in read only.
7. Excessive errors in read only but not in read while write mode.
8. Excessive data errors in all modes.

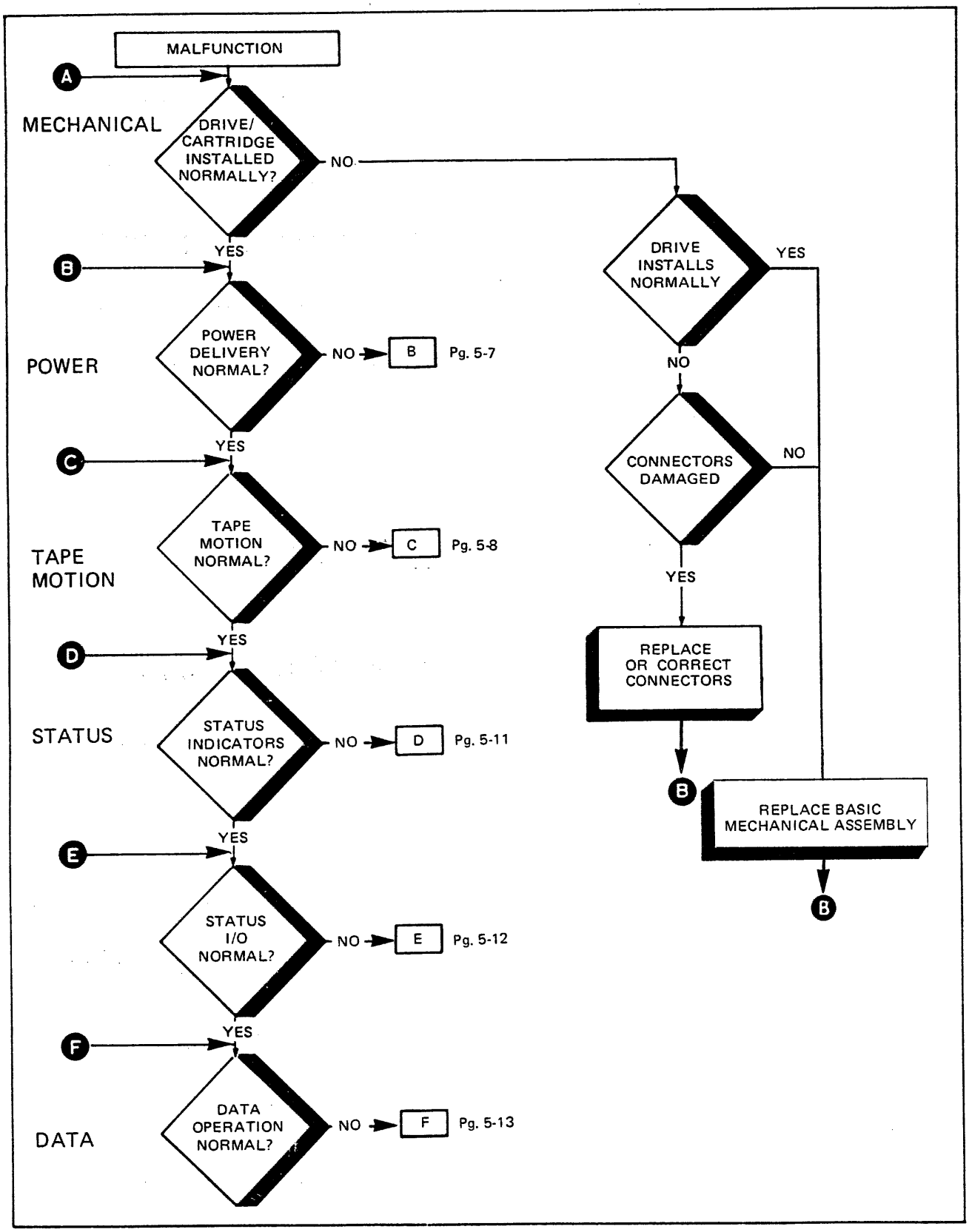


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 1 OF 8)

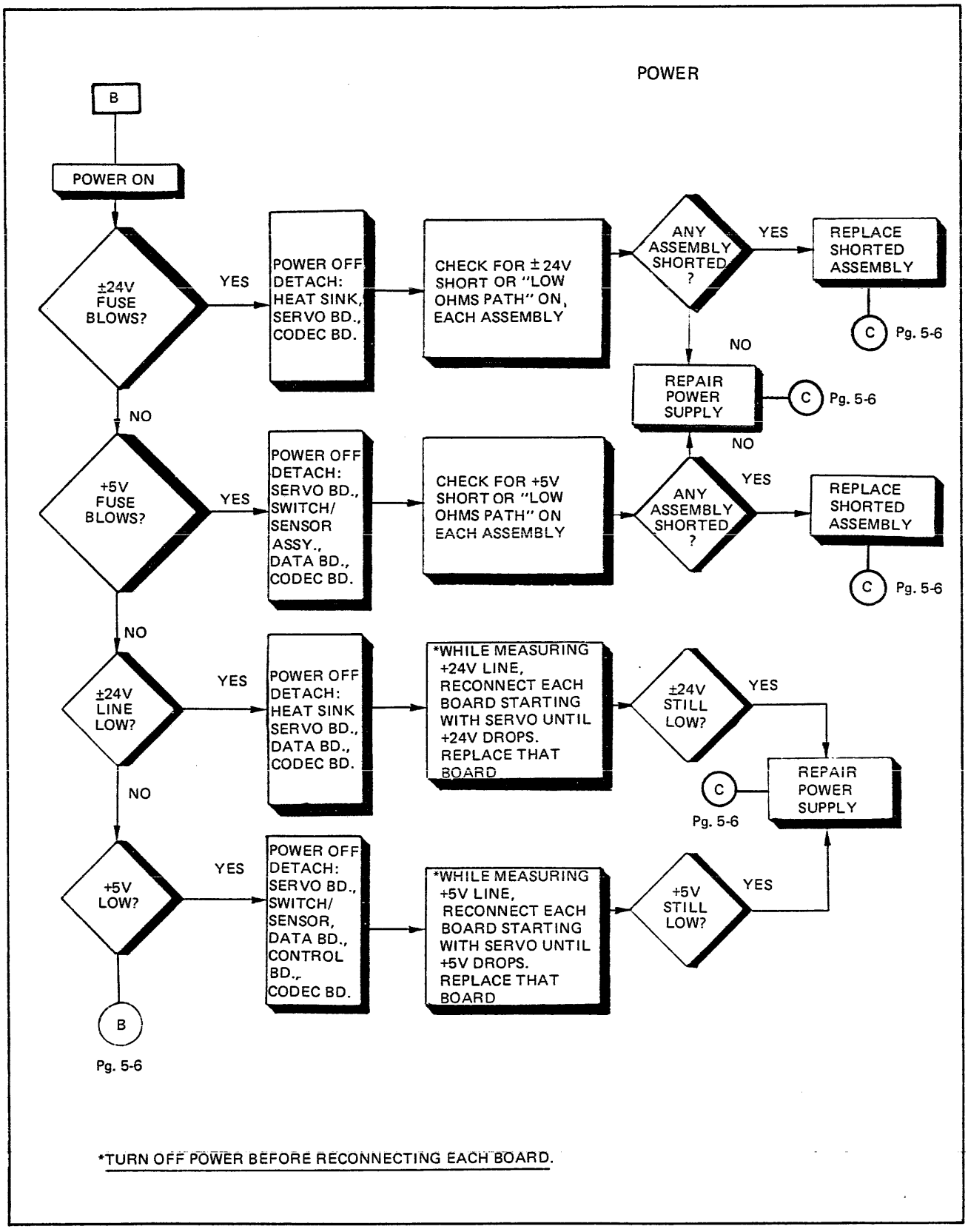


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 2 OF 8)

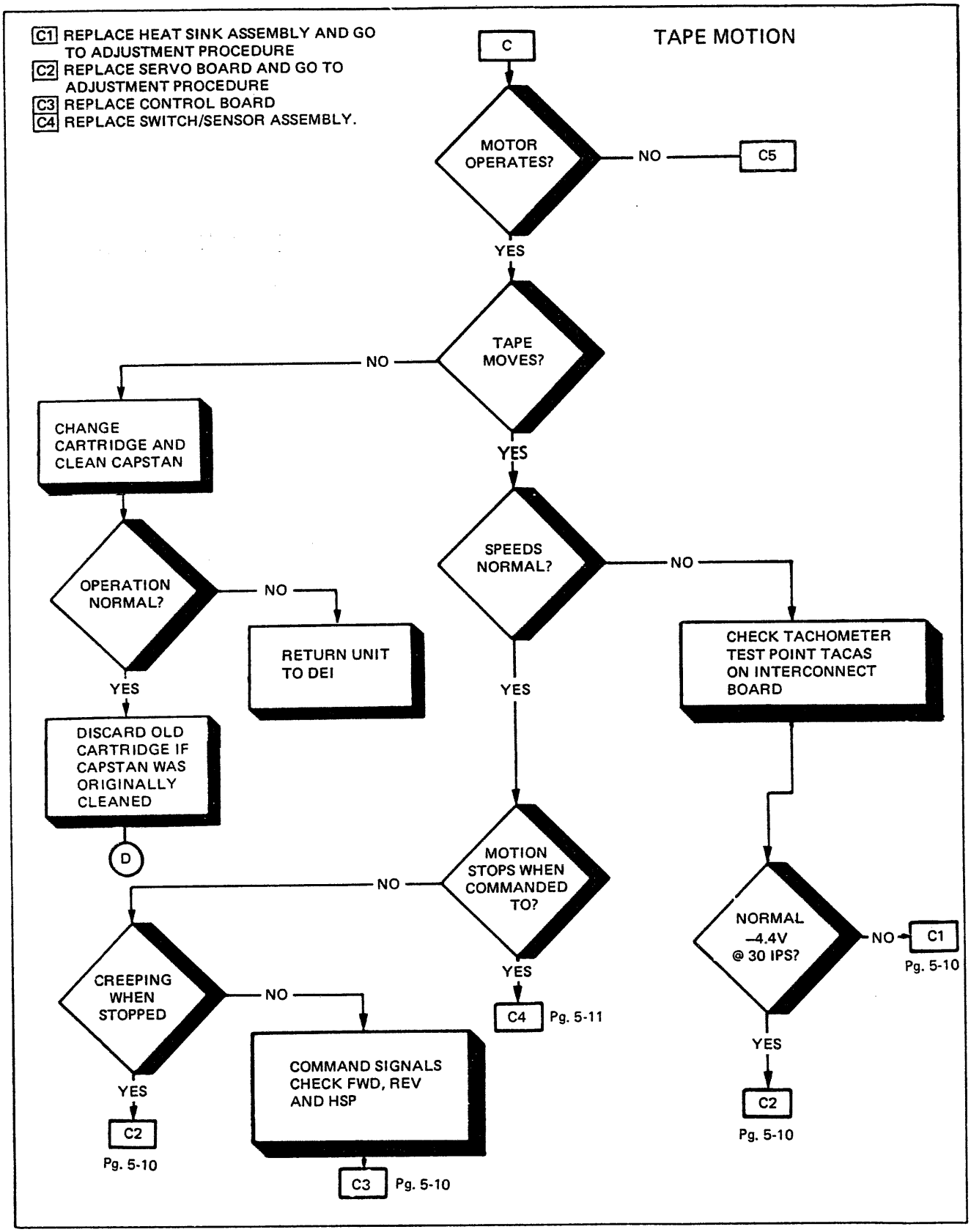


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 3 OF 8)

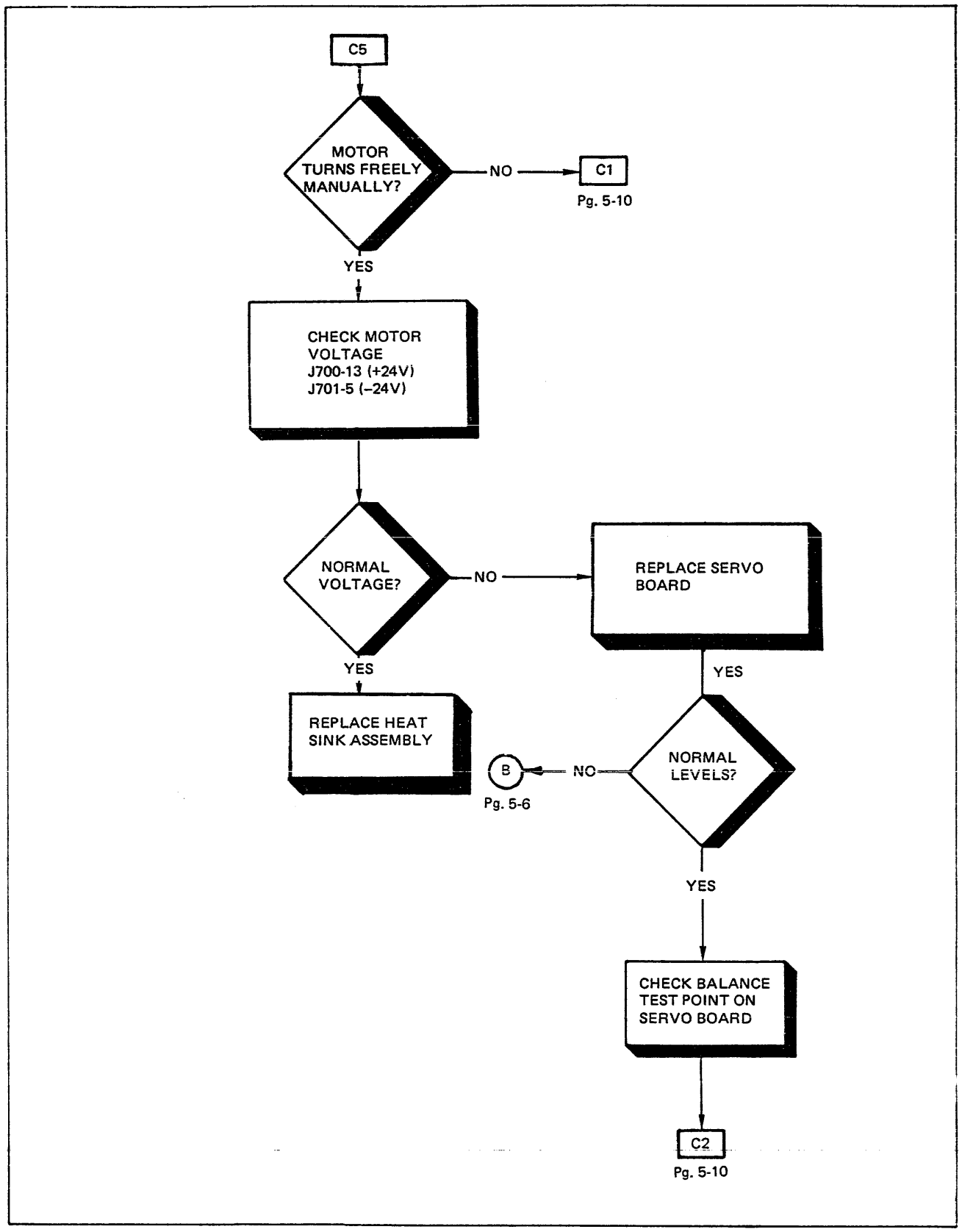


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 4 OF 8)

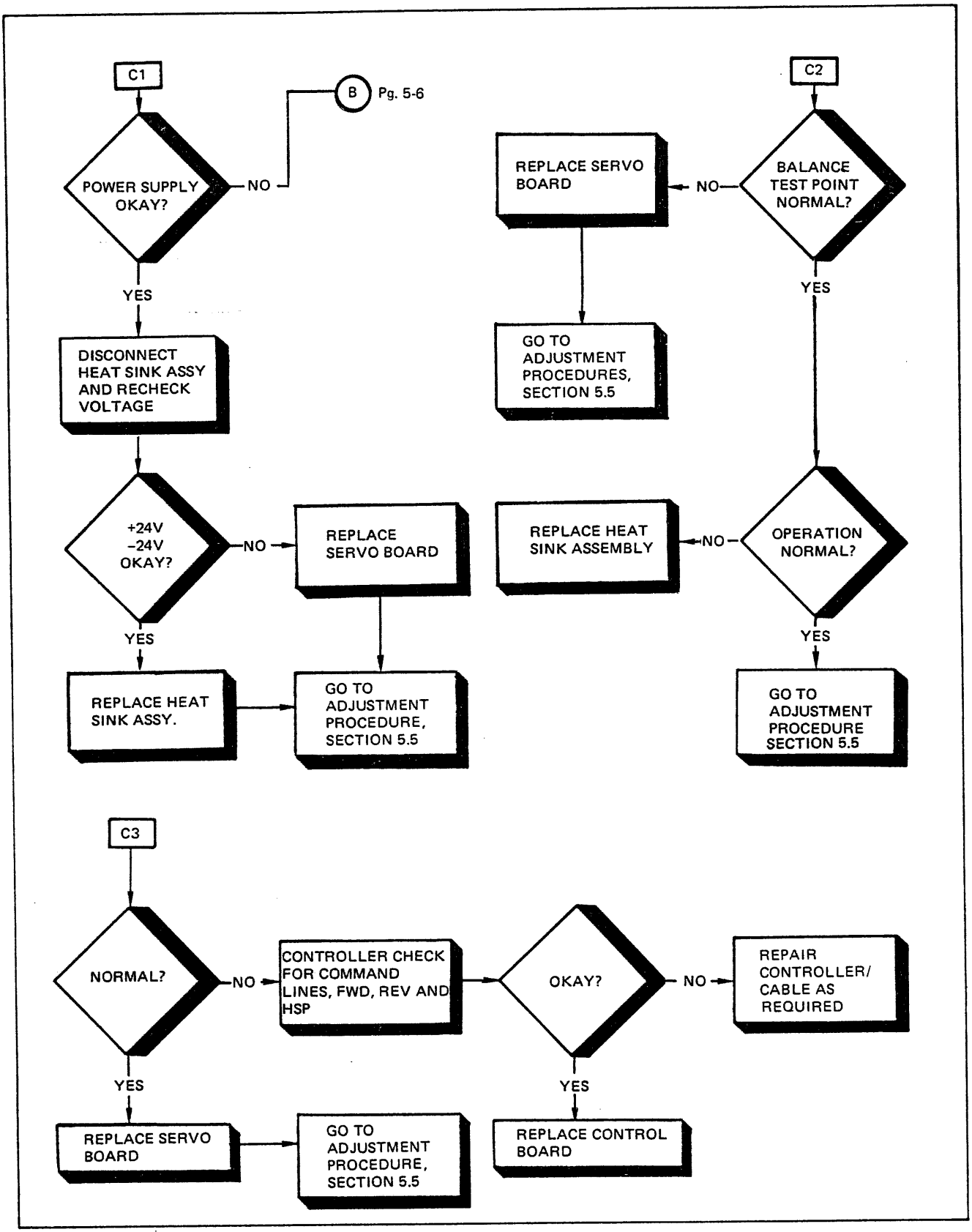


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 5 OF 8)

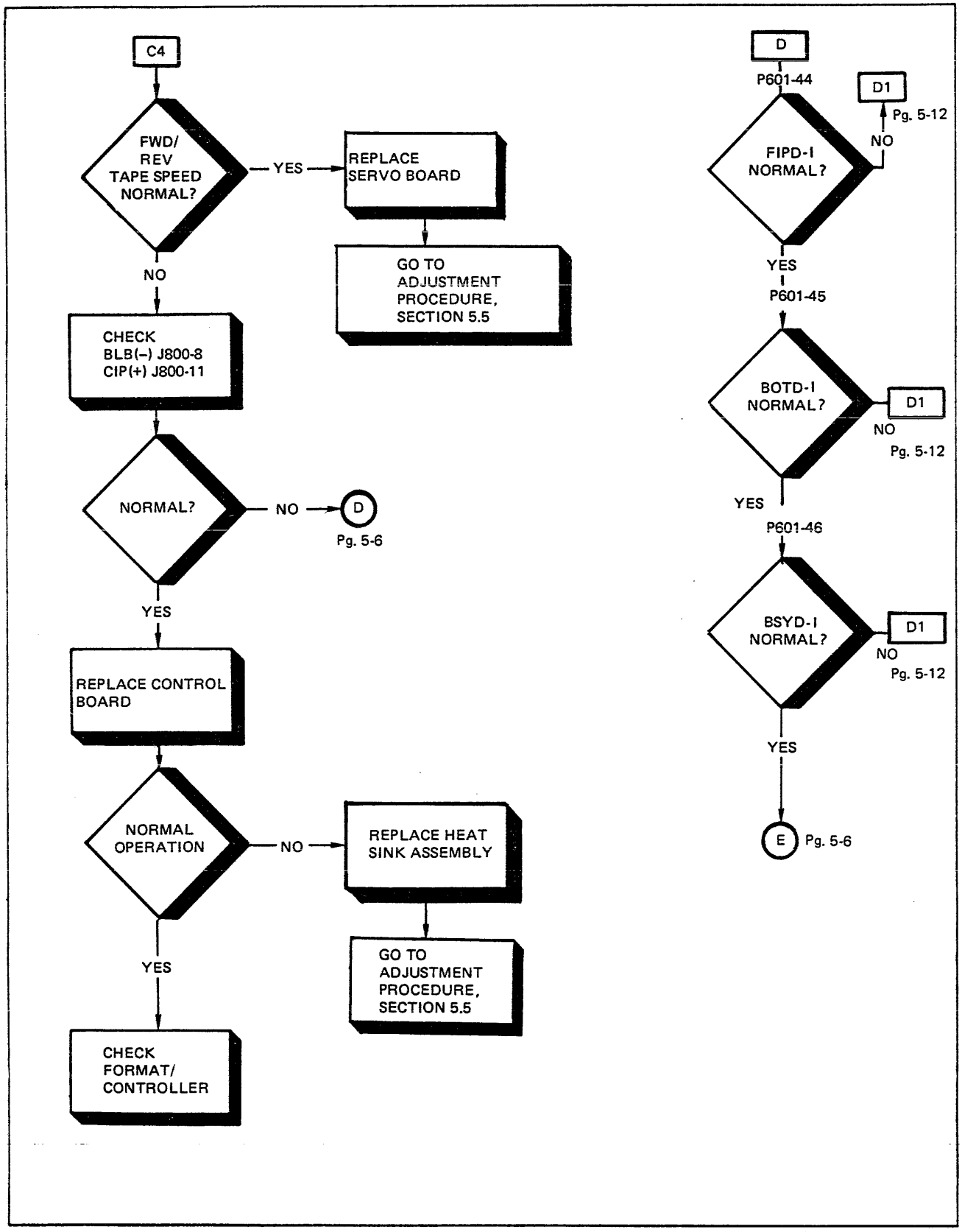


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 6 OF 8)

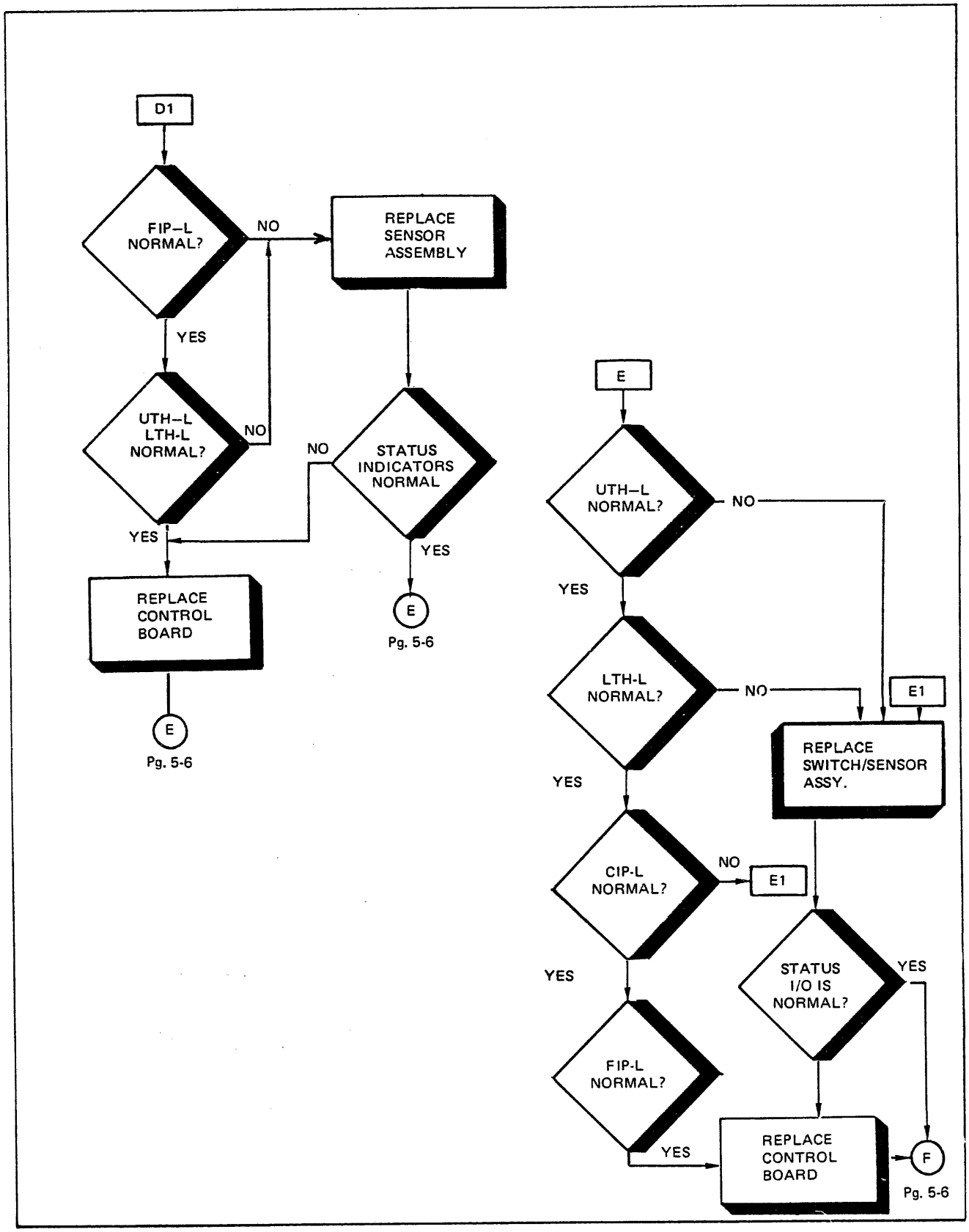


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 7 OF 8)

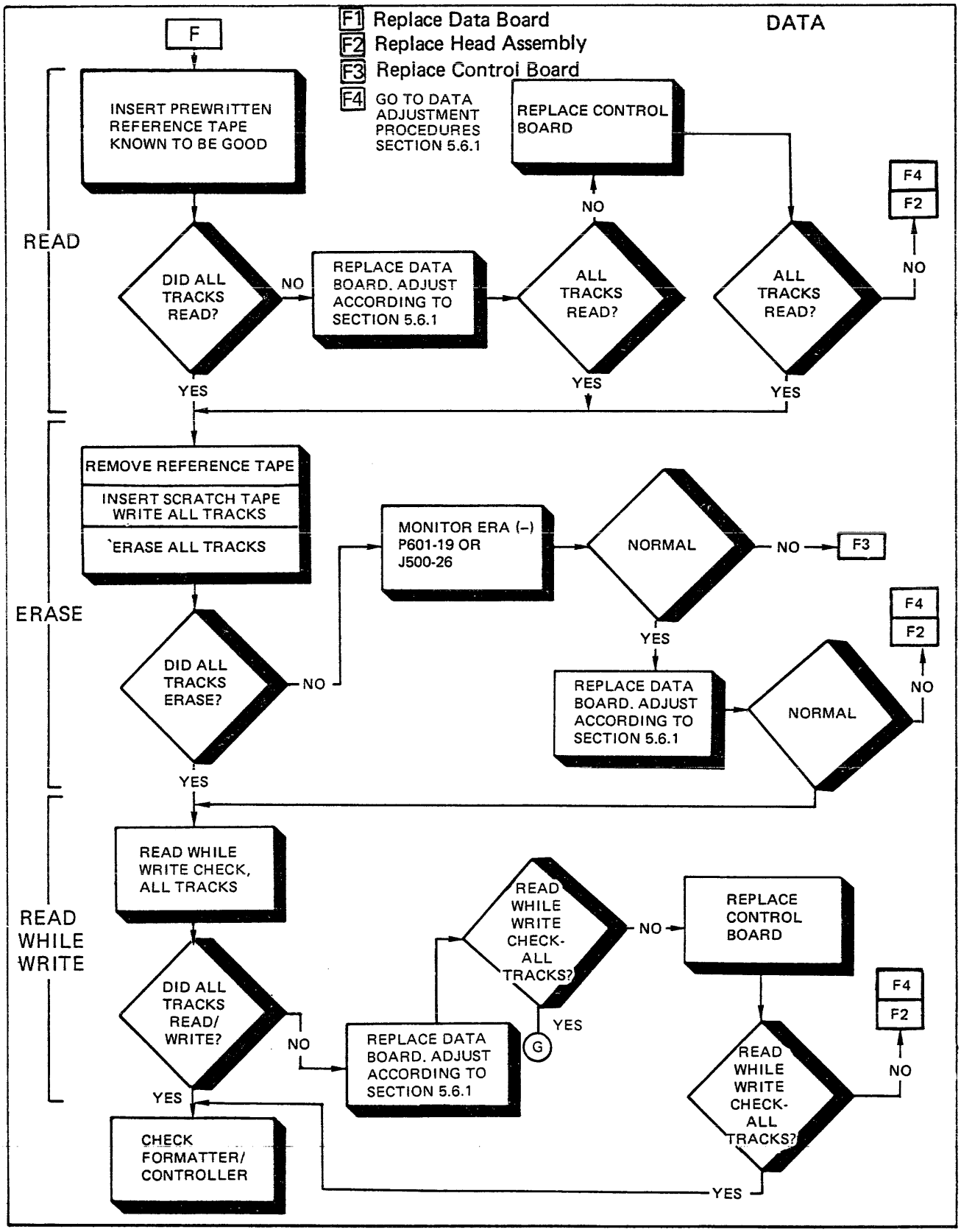


FIGURE 5-5. BASIC DRIVE TROUBLESHOOTING STRATEGY (SHEET 8 OF 8)

5.5 SERVO ADJUSTMENTS

Note: Warm up unit at least three minutes before making adjustments. The following paragraphs describe how the Servo Board is adjusted with the board installed. Low tape speed is 30 ips; high tape speed is 90 ips. The ramp time is 23 msec for low speed, 69 msec for high speed. Refer to Figures 5-6, 5-7, or 5-8.

5.5.1 Servo Power Adjustment

Object: To assure servo has balanced supply voltages. Generally not required, unless a ±15 volt regulator has failed.

Procedure:

a. Connect VOM or DVM reference lead to diode VR700, cathode.

b. Attach VOM or DVM test lead to pin four of operational amplifier U705. Record -15 vdc voltage to three figure accuracy (XX.XXX).

c. Adjust R765 until +15 vdc is within ±5 mv of the absolute value obtained at pin 4 of U705.

d. Adjust R765 until +15 vdc is within ±5 mv of the absolute value obtained at pin 4 of U705.

5.5.2 DC Offset Adjustment

Object: To balance dc offset in the servo circuit.

Procedure:

a. Attach VOM or DVM (voltage scale) to BALAS test point on the Interconnect Board. The reference lead should be attached to the cathode of diode VR700, Servo Board.

b. With power on (no motion command selected), adjust to "0" vdc (±5 mv) by adjusting potentiometer R761, Servo Board.

5.5.3 Tape Speed Adjustment

Object: To achieve accurate 30 ips forward and reverse operation. This is essential to proper read data recovery. A special Cartridge Speed Indicator (DEI No. 302028) is available which greatly simplifies tape speed adjustments. The indicator provides a direct digital readout of tape speed, eliminating deficiencies inherent in other adjustment methods.

Procedure:

a. Connect the drive to a DEI 302022 drive exerciser to obtain FWD-, REV-, and HSP- commands (or use local controller to run drive).

b. Insert the Cartridge Speed Indicator.

c. Issue a FWD- command. Adjust pot R764 on the Servo Board for 30 ips digital readout on the indicator.

d. Issue a REV- command. Adjust pot R763 for a 30 ips digital readout on the indicator.

e. Repeat steps c and d to achieve forward and reverse tape speeds within 0.05 ips of each other. (Forward and reverse speed adjustments are interactive.)

5.5.4 Start/Stop Ramp Adjustment

Object: To obtain equal, 23 msec start/stop ramps at 30 ips tape speed.

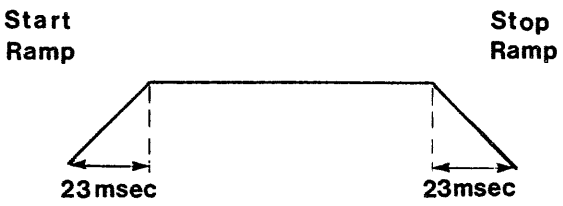
Procedure:

a. Toggle FWD- command line at 1 to 10 Hz.

b. Connect oscilloscope to RAMAS test point on the Interconnect Board.

c. Adjust pot R762 on Servo Board for 23 msec start ramp. Trigger on negative going leading edge of FWD signal.

d. Retrigger oscilloscope on positive going trailing edge. Start/stop ramps should be approximately equal.



e. Repeat steps a through d using a toggled 1 to 10 Hz REV- command to check reverse start/stop ramp times. Reverse mode start/stop ramps should approximately equal 23 msec.

5.6 DATA ADJUSTMENT

The following paragraphs describe the procedure for adjusting the gain in the read channel on the Data Board, Refer to Figure 5-7 or 5-8 and 5-9 for potentiometer test points and locations.

5.6.1 Read Data Gain Adjustment (Data Board)

Object: To adjust for a 1.9 vdc read envelope output on the lowest output signal track.

Procedure:

a. Using an external DEI 302030 Data Pattern Generator or its equivalent, write an "all ones" test pattern on all tracks in MFM format. (Data transfer rate is 192KBits/sec., 96KHz, at 30 ips. Other data sources may be used and none is required in drives having Codec Boards. (WDE– must be set true.)

b. Read back each data track while monitoring the read envelope (ENV+R) on the Interconnect Board. (Test point is J500-20). Determine track exhibiting lowest amplitude read envelope.

c. Adjust pot R513 on Data Board for 1.9 vdc in the read reverse pass just after writing the track with the lowest amplitude.

d. Recheck all data tracks. The read envelopes of each track should measure within ±0.1 vdc of each other.

5.7 CODEC BOARD ADJUSTMENT

Refer to Figure 5-8 for locations of potentiometers, test points, and jumper points.

Object: To develop timing pulses equal to one-quarter of the duration of one bit cell of read data over a wide range of frequencies.

Equipment Required: Codec Test Board, frequency generator, frequency counter, oscilloscope (refer to Figure 5-10 for test points), three jumpers, and a DVM or VOM.

Procedure:

a. Remove four screws fastening Codec Board to tape drive. Detach all mating connectors except the power connector.

b. Connect Codec Test Board to frequency generator and connector P3, the interface connector of the Codec Board. The test board develops differential read data and data detect enabling pulses from the frequency generator output.

c. With DVM or VOM, probe pin 2 of U28. Voltage should be +12 vdc (±0.6 vdc).

d. With DVM or VOM probe pin 2 of U11. Voltage should be –5 vdc (±0.25 vdc).

e. Measure voltage at cathode of CR1. Serv-A signal, now at idle, should measure 8.2 vdc (typical).

f. Using frequency counter, probe U15-6. Oscillator frequency should measure 12.288 MHz (typical).

g. Install jumpers on CAL1, CAL2, and CAL3 pins. (See Figure 5-10.)

h. Attach oscilloscope probe to U19-5 (SMPL+A). Adjust R53 to develop a 2 usec pulse.

i. Set frequency generator to output a 272 KHz squarewave. Feed signal directly to oscilloscope. Calibrate oscilloscope so that one bit cell (1/2 cycle) equals eight divisions.

j. Monitor U19-13 (DLRP+A) with oscilloscope. Adjust R52 to develop a two division squarewave.

k. Monitor U1-13 (LI+A) with oscilloscope. Adjust R44 to develop a two division squarewave.

l. Monitor U1-5 (EO+A) with oscilloscope. Adjust R46 to develop a two division squarewave.

m. Monitor U10-13 (LO+A) with oscilloscope. Adjust R48 to develop a two division squarewave.

n. Monitor U10-5 (EI+A) with oscilloscope. Adjust R50 to develop a two division squarewave on the oscilloscope.

o. Measure Serv –A (high) voltage of cathode of CR1. Serv –A (high) should measure 11.6 vdc (typical).

p. Detach CAL1 and CAL2 jumpers, leaving only CAL3 jumper connected.

q. Set frequency generator to 543 KHz. Recalibrate oscilloscope so that one bit cell (1/2 cycle) equals eight divisions at 543 KHz.

r. Monitor U19-13 (DLRP+A) with oscilloscope. Adjust R51 to obtain a two division squarewave.

s. Monitor U1-13 (LI+A) with oscilloscope. Adjust R43 for a two division squarewave.

t. Monitor U1-5 (EO+A) with oscilloscope. Adjust R45 for a two division squarewave.

u. Monitor U10-13 (LO+A) with oscilloscope. Adjust R47 for a two division squarewave.

v. Monitor U10-5 (EI+A) with oscilloscope. Adjust R49 for a two division squarewave.

w. Measure Serv +A (low) voltage at cathode of CR1. Voltage should measure 4.5 vdc (typical).

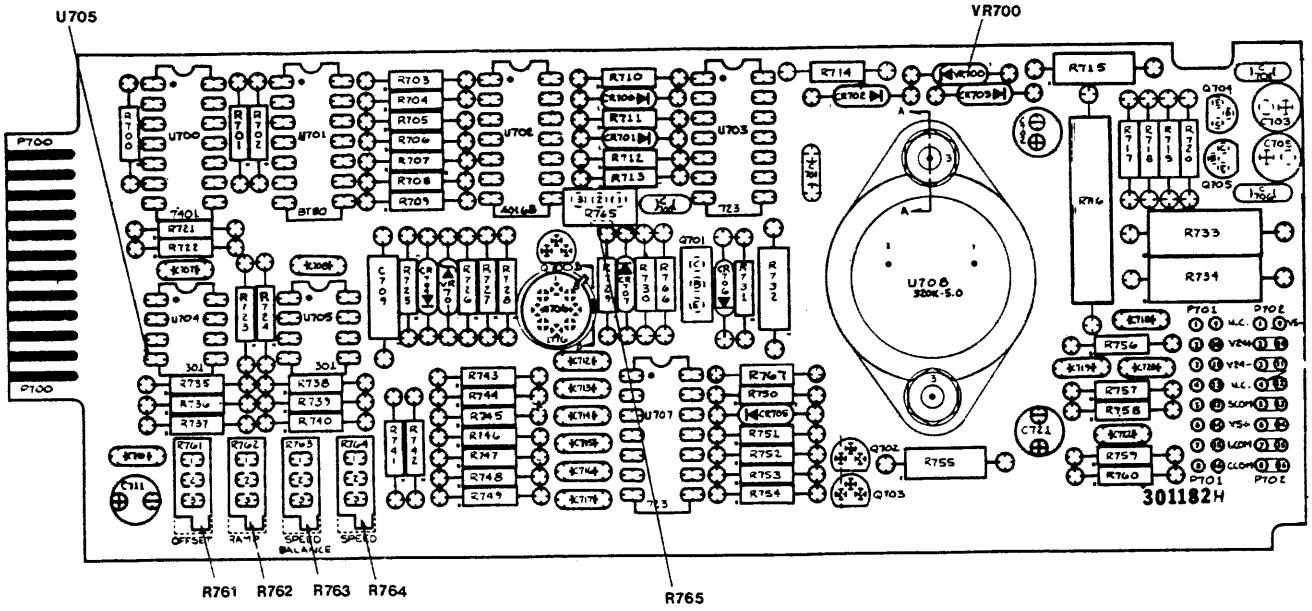


FIGURE 5-6. SERVO BOARD POTENTIOMETERS/TEST POINTS

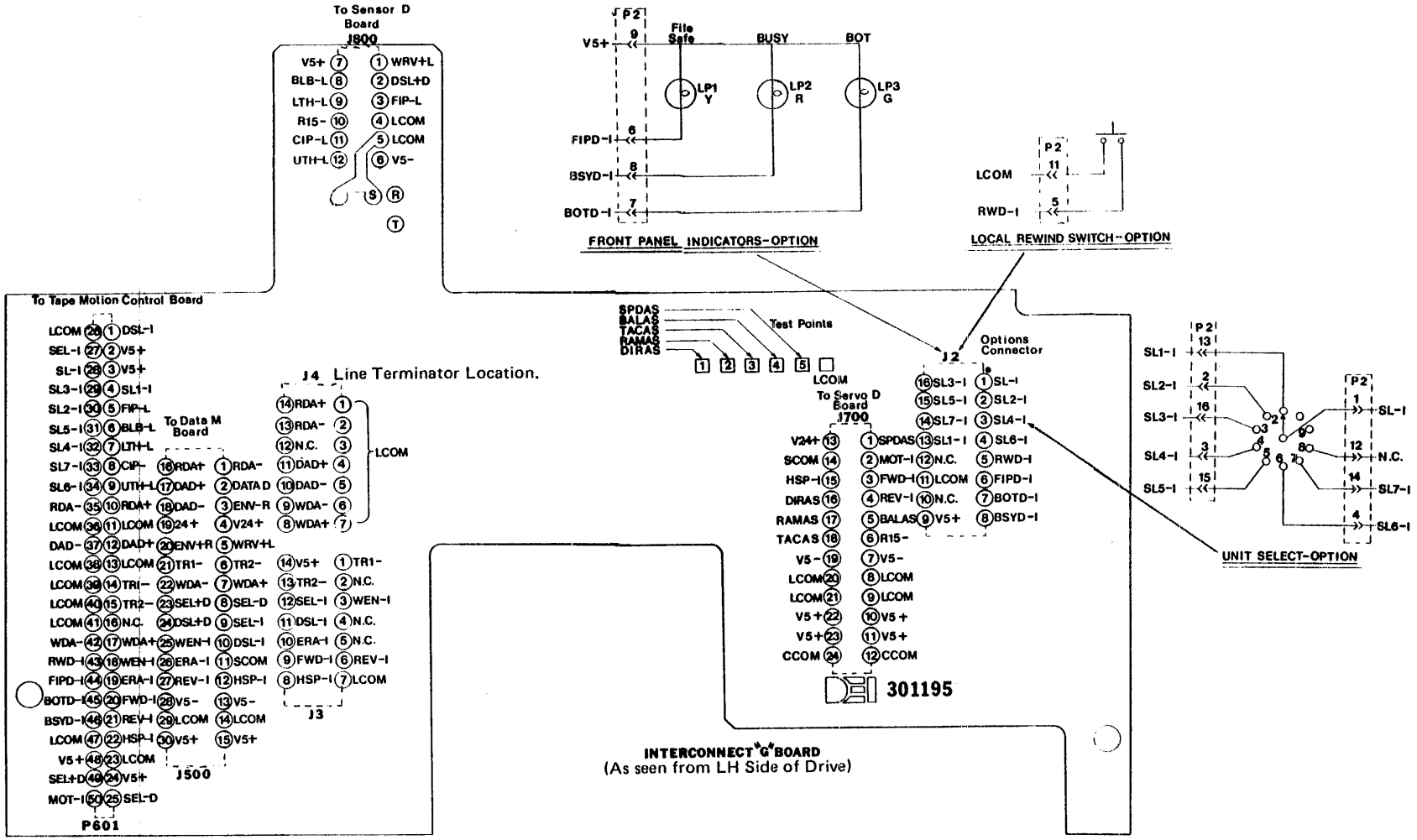


FIGURE 5-7. INTERCONNECT "G" BOARD (USED IN DRIVES HAVING CONTROL BOARDS)

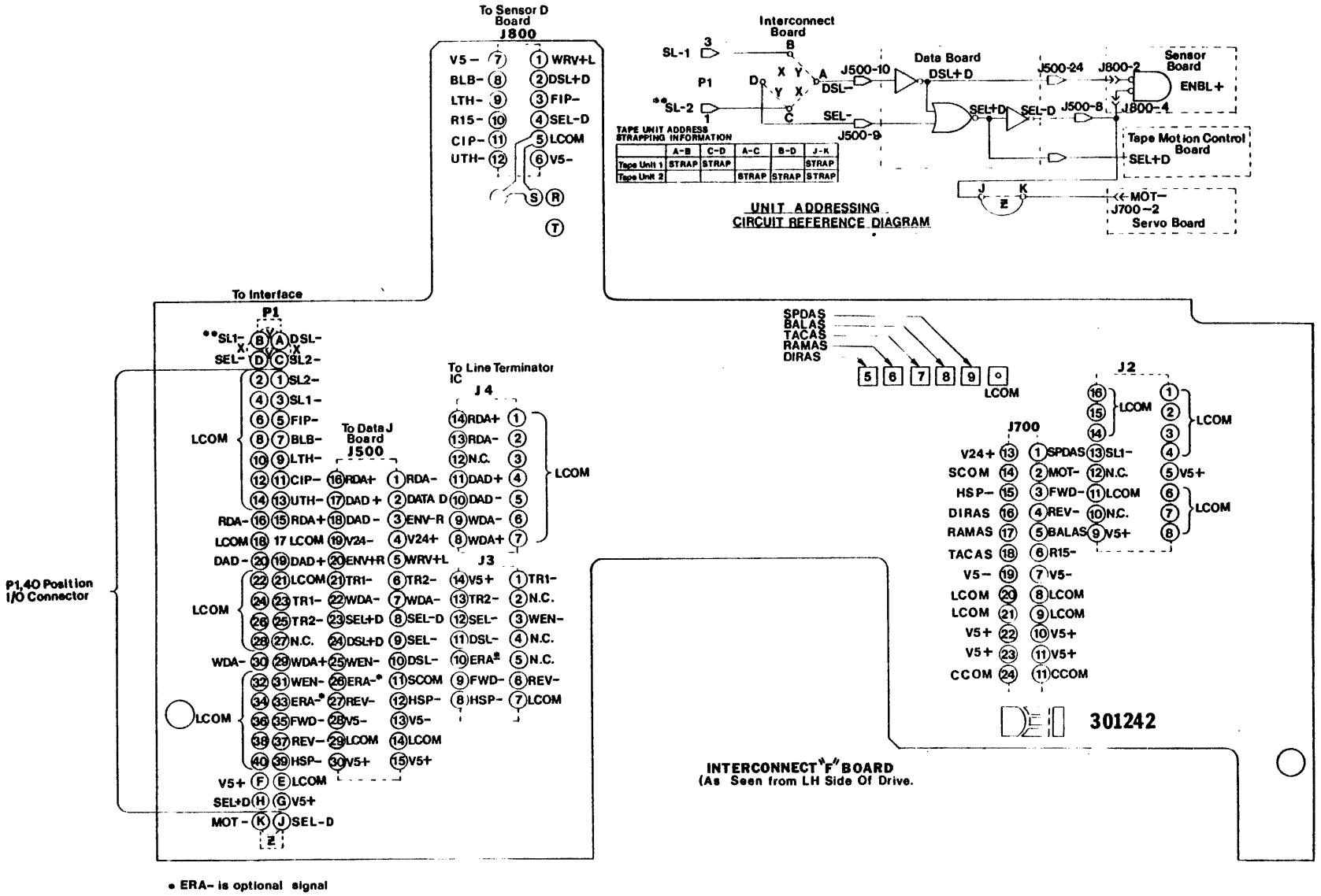


FIGURE 5-8. INTERCONNECT "F" BOARD (USED IN DRIVES WITHOUT CONTROL BOARDS)

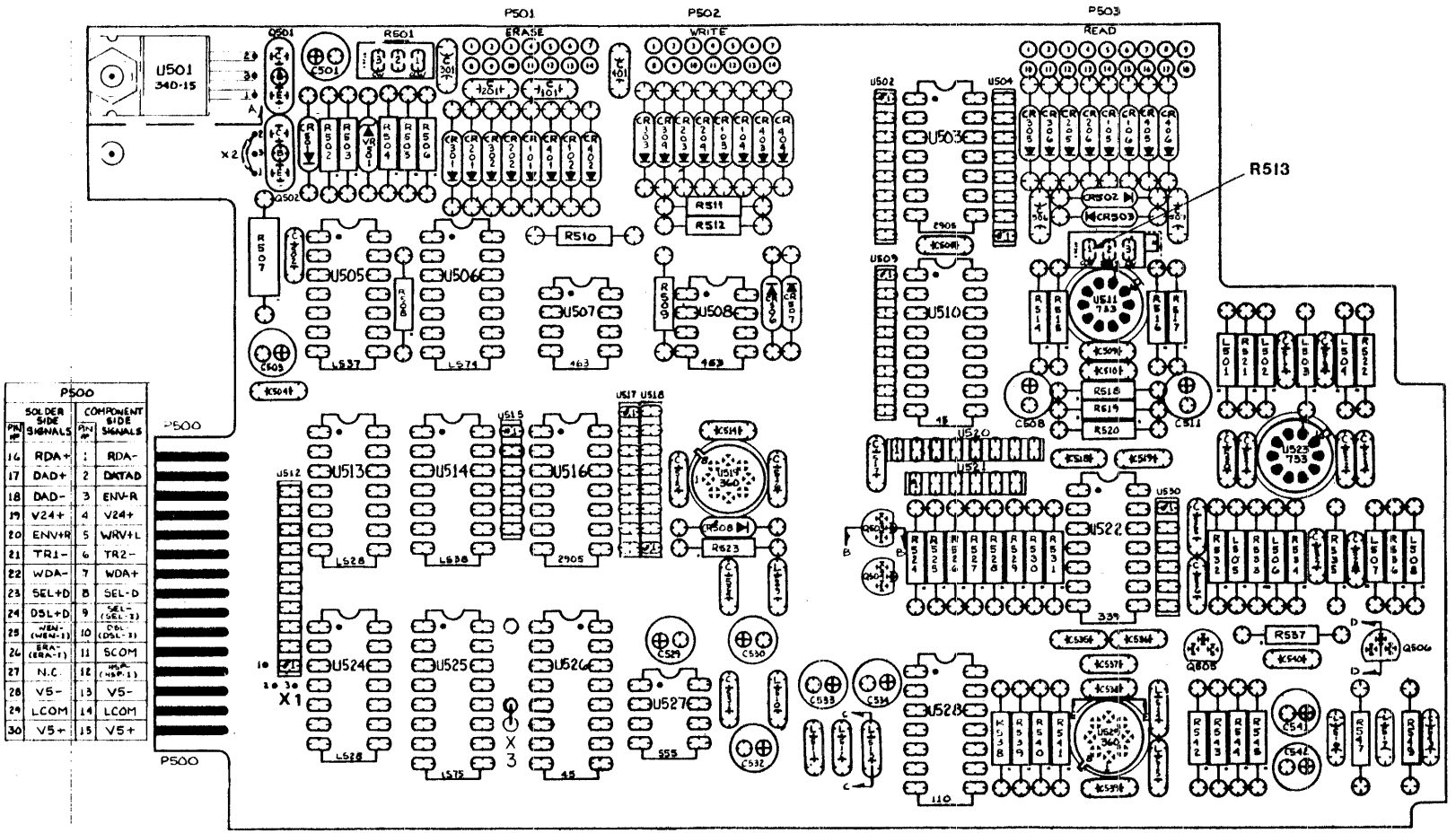


FIGURE 5-9. DATA BOARD POTENTIOMETERS

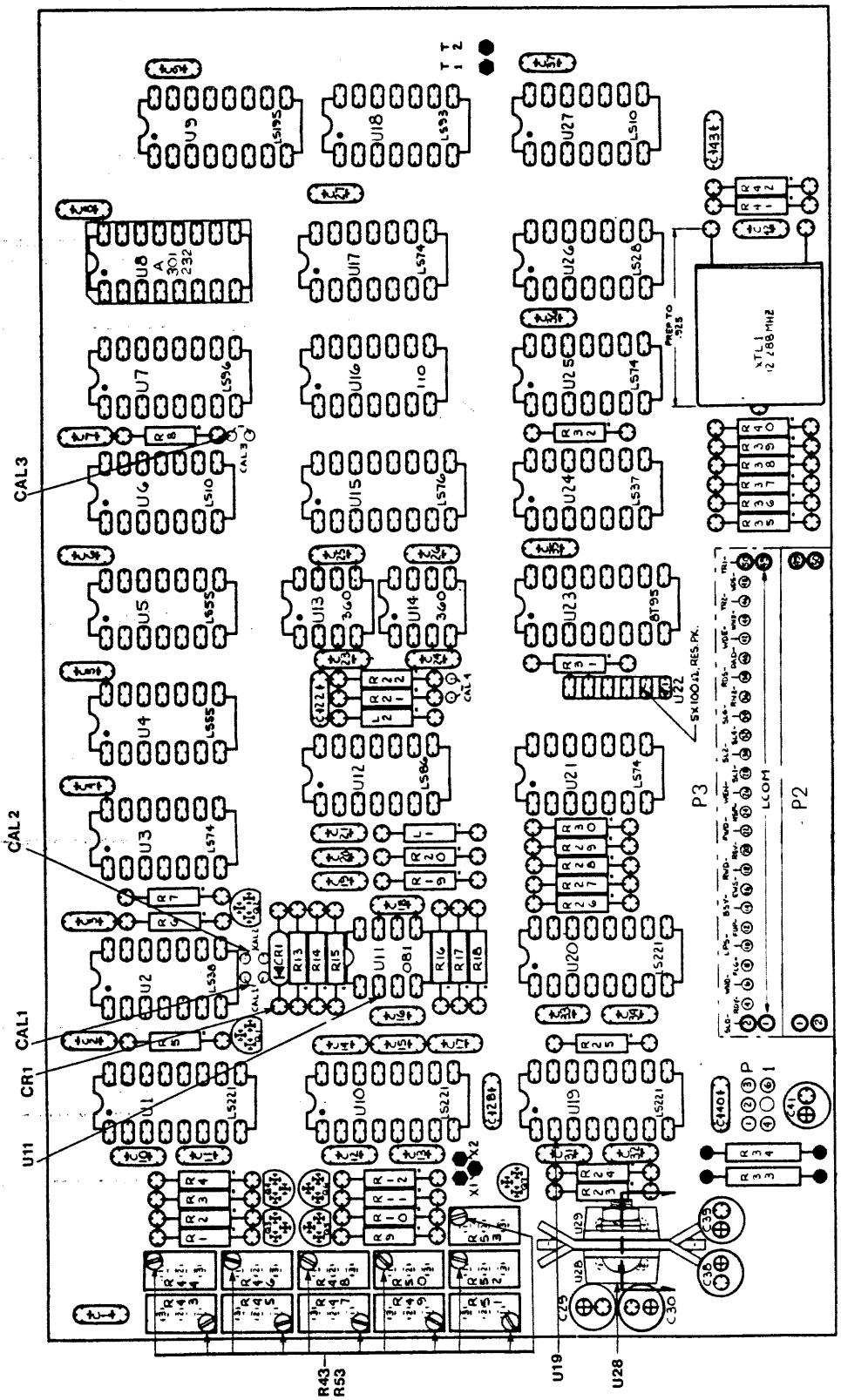


FIGURE 5-10. CODEC BOARD POTENTIOMETERS; JUMPER POINTS; TEST POINTS

SECTION 6
PARTS LIST

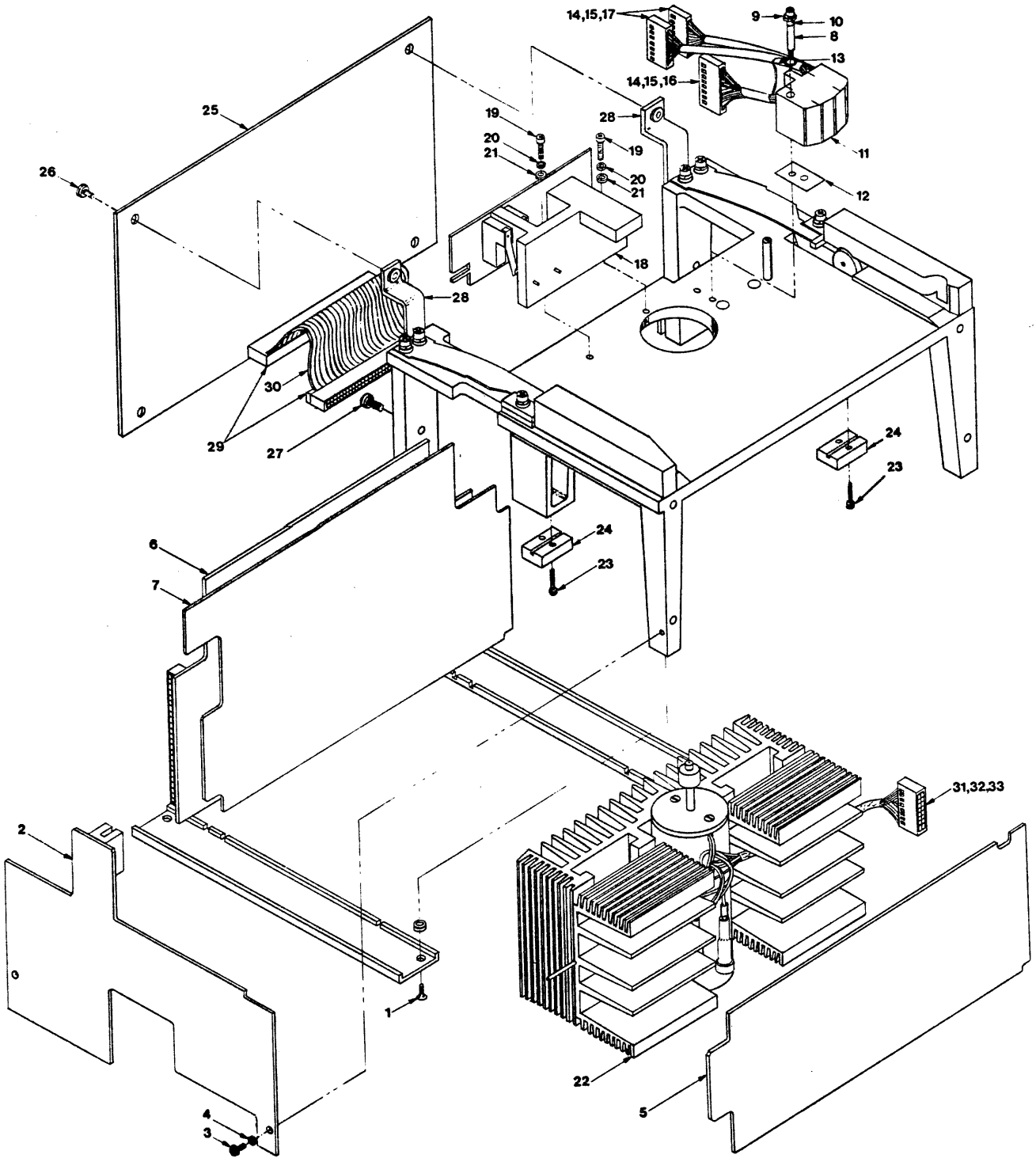


FIGURE 6-1. DRIVE ASSEMBLY

TABLE 6-1. DRIVE PARTS LIST

Item No.	Part No.	Description	Quantity
6-1-1	Commercial	Screw, Flat Head Phillips, 4-40 X 0.38" L	4
-2	D301073	Interconnect H Board (used in drive w/o Control Board)	1
-2	D301072	Interconnect G Board (used in drive with Control Board)	1
-3	Commercial	Screw, Phillips Fillister Head, 4-40 X 0.25" L	2
-4	Commercial	No. 4 Lockwasher, Split	2
-5	D301064	Servo D Board	1
-6	D301090	Control G Board (Optional)	1
-7	D301061	Data J Board (used in drive w/o Control Board)	1
-7	D301086	Data M Board (used in drive with Control Board)	1
-8	Commercial	Screw, Socket Hd Cap, 4-40 X 1" L	1
-9	Commercial	No. 4 Flatwasher	1
-10	500665	Shoulder Bushing	1
-11	D301060	Magnetic Head Assembly, 4-Track Serial (includes connectors)	1
-12	A300225	Magnetic Head Shim (part of magnetic head ass'y)	1
-13	500843	Terminal Lug (part of magnetic head assembly)	1
-14	500623	Keying Plug (part of magnetic head assembly)	4
-15	500622	Connector Contacts (part of magnetic head ass'y) (ITT Cannon 11-0238-0091)	38
-16	500917	Connector (part of magnetic head assembly) (ITT Cannon 121-7326-109)	1
-17	500916	Connector (part of magnetic head assembly) (ITT Cannon 121-7326-107)	2
-18	D301096	Sensor D Assembly (includes Sensor Board)	1
-19	Commercial	Screw, Phillips Fillister Head, 4-40 X 0.44" L	2
-20	Commercial	No. 4 Lockwasher, Split	2
-21	Commercial	No. 4 Flatwasher	2
-22	B301066	Heat Sink Assembly	1
-23	Commercial	Screw, Phillips fillister head, 4-40 X 0.38" L	4
-24	B301126	Motor Mount Block	2
-25	D301094	Codec Board (optional)	1
-26	Commercial	Screw, 6-32 X 0.25" L, Phillips pan head with internal starwasher	4
-27	Commercial	Screw, No. 10 Phillips pan head with internal starwasher, 10 – 24 X 0.38" L	2
-28	B301230	Bracket, Codec	2
-29	500956	Connector, 50 position (part of Codec Board) (3M 3425-3000)	2
-30	Commercial	3M Ribbon Cable, 3" L (3M Part No. 3350-50) (Part of Codec Board.)	1
-31	500621	Connector, 16 position (part of Heat Sink Ass'y) (ITT Cannon No. 121-7326-108)	1
-32	500622	Contact (part of Heat Sink Ass'y) (ITT Cannon No. 11-0238-0091)	9
-33	500623	Keying Plug (part of Heat Sink Ass'y) (ITT Cannon No. 225-7301-001)	1

The following parts are recommended for spares stocking to minimize down time.

Part No.	Description	Recommended Quantity
301096	Sensor D Assembly	1 per 25 drives
301066	Heat Sink Assembly	1 per 25 drives
301060	Magnetic Head Assembly	2 per 25 drives
301064	Servo D Board	1 per 25 drives
D301061	Data J Board (Drive w/o Control Board)	1 per 25 drives
D301086	Data M Board (Drive with Control Board)	1 per 25 drives
301073	Interconnect H Board (Drive w/o Control Board)	1 per depot
301072	Interconnect G Board (Drive with Control Board)	1 per depot
301090	Control G Board (Optional)	1 per 25 drives
301094	Codec Board (Optional)	1 per 25 drives

TABLE 6-2. DRIVE SPARE PARTS LIST

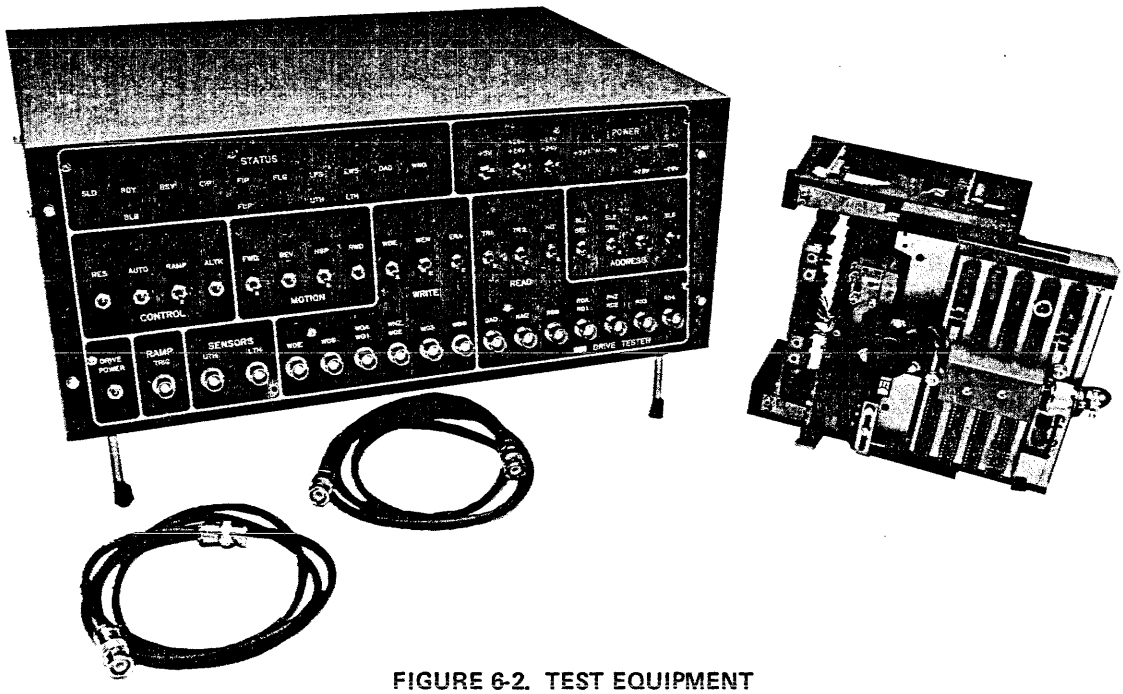


FIGURE 6-2. TEST EQUIPMENT

In addition to standard electronic test equipment, the tape drive requires certain specialized tools available from DEI. These items are:

DEI Part No.	Description	Recommended Quantity
302022	Drive Tester – permits off line drive testing	1 per depot
302030	Data Generator – produces all ones pattern and other patterns required for drive testing	1 per depot
302028	Cartridge Speed Indicator Provides a direct digital readout of tape speed, eliminating deficiencies inherent in other tape speed adjustment methods.	1 per depot
N.A.	Codec Test Board Converts TTL frequency generator output to differential read data and data detect signals for Codec Board adjustment	1 per depot

TABLE 6-3. OPTIONAL MAINTENANCE AND TEST EQUIPMENT