

**TU10 DECmagtape
maintenance manual**

EK-TU10-MM-007

Preliminary Printing May 1971
1st Edition September 1971
2nd Printing January 1972
3rd Printing (Rev) July 1972
4th Printing December 1972
5th Printing April 1973
6th Printing (Rev) October 1973
7th Printing (Rev) December 1974
8th Printing March 1975
9th Printing (Rev) January 1976
10th Printing (Rev) August 1977

Copyright © 1971, 1972, 1973, 1974, 1975, 1976, 1977 by Digital Equipment Corporation

The material in this manual is for informational purposes and is subject to change without notice.

Printed in U.S.A.

The following are trademarks of Digital Equipment Corporation, Maynard, Massachusetts:

FLIP CHIP	DECtape
UNIBUS	DECsystem-10
PDP	DECmagtape

CONTENTS

	Page
CHAPTER 1 INTRODUCTION	
1.1 General Description	1-1
1.2 Magnetic Tape Fundamentals	1-2
1.2.1 Definitions	1-2
1.2.2 NRZI (Non-return to Zero – Change on a 1) Recording Technique	1-3
1.2.2.1 Definition	1-3
1.2.2.2 Format	1-3
1.3 Technical Characteristics	1-4
1.4 Reference Documents	1-5
CHAPTER 2 INSTALLATION	
2.1 Site Considerations	2-1
2.2 Unpacking and Inspection	2-2
2.3 Cabinet Installation	2-2
2.4 Cable Connections	2-4
2.4.1 Power Cable	2-4
2.4.2 Input/Output Cables	2-4
2.4.3 Bus Terminators	2-5
CHAPTER 3 OPERATION	
3.1 Controls and Indicators	3-1
3.2 Operating Procedures	3-3
3.2.1 Loading and Threading Tape	3-3
3.2.2 Unloading Tape	3-4
3.2.3 Restart After Power Failure	3-5
3.2.4 Restart After Fail-Safe	3-5
3.2.5 Tape Handling	3-5
CHAPTER 4 THEORY OF OPERATION	
4.1 Transport Control	4-1
4.1.1 Capstan Control	4-1
4.1.2 Reel and Buffer Controls	4-2
4.1.3 Motion Control Logic	4-6
4.1.3.1 Power Clear	4-6
4.1.3.2 Failure Detection	4-6
4.1.3.3 Loading Sequence Logic	4-7
4.1.3.4 Brake Release	4-7
4.1.3.5 Rewind Control	4-7
4.1.3.6 Forward BOT Delay	4-9
4.1.3.7 Ready and Transport Settling Down	4-9
4.2 Tape Unit Status Sensors	4-10
4.2.1 Write Lock	4-10

CONTENTS (Cont)

	Page
4.2.2	EOT/BOT Sensor 4-10
4.3	Manual Operation 4-11
4.4	On-Line Operation 4-12
4.4.1	Transport Selection and Status Reporting 4-13
4.4.2	Initiating Operations 4-13
4.4.3	Terminating Operations 4-15
4.4.4	Motion Delay 4-15
4.4.5	Read and Space Operations 4-16
4.4.5.1	TU10 DECmagtape Transports up to No. 10320 4-16
4.4.5.2	TU10 DECmagtape Transports Above No. 10320 4-19
4.4.6	Write Operation 4-21
 CHAPTER 5 MAINTENANCE	
5.1	Introduction 5-1
5.2	Daily (8-Hour) Preventive Maintenance Procedures 5-4
5.2.1	General Cleaning and Equipment Care 5-5
5.3	Monthly (160-Hour) Preventive Maintenance Procedures 5-5
5.3.1	Outer Door and Cabinet Interior 5-5
5.3.2	Cabinet Filter 5-6
5.3.3	Reel Motor Brakes 5-6
5.3.4	Control Box 5-8
5.3.5	Tape Path 5-8
5.3.6	Reel Hubs 5-9
5.4	Quarterly (500-Hour) Preventive Maintenance Procedures 5-11
5.4.1	Vacuum Motor Brushes 5-11
5.4.2	Diagnostic Checks 5-12
5.5	Semiannual (1000-Hour) Preventive Maintenance Procedures 5-13
5.5.1	Capstan Speed and DC Balance 5-13
5.5.2	Capstan Acceleration and Deceleration Times 5-14
5.5.3	Capstan Jilter 5-16
5.5.4	Static and Dynamic Skew 5-17
5.5.4.1	Mechanical Skew Measurement 5-17
5.5.4.2	Mechanical Skew Adjustment 5-20
5.5.5	Electrical Read Skew 5-26
5.5.6	Electrical Write Skew 5-28
5.5.7	Read and Write Slice Levels 5-29
5.5.7.1	Units Up to No. 10320 5-29
5.5.7.2	Units Above No. 10320 5-29
5.5.8	Industry-Compatible Tape Tracking 5-30
5.5.9	Power Supply Voltages 5-32
5.5.10	Read/Write Interlock Assembly 5-33
5.5.11	Tape Guide Rollers 5-33
5.5.12	Delay Diode Check 5-35

CONTENTS (Cont)

		Page
5.5.13	Tape Path Alignment	5-36
5.5.13.1	Tools Required	5-36
5.5.13.2	When to Perform	5-36
5.5.13.3	Objectives	5-36
5.5.13.4	Tape Path Alignment Procedure	5-37
5.5.14	Vacuum System Adjustments	5-56
5.5.14.1	Changing Operating Frequency	5-57
5.6	Replacement Procedures	5-58
5.6.1	Reel Motor Filter Elements	5-58
5.6.2	Foam Stripping (Casting Perimeter)	5-59
5.6.3	Vacuum Motor or Vacuum Motor Brushes	5-59
5.6.4	Reel Hubs	5-60
5.6.5	Vacuum Switches and Rubber Sleeves	5-61
5.6.6	Reel Motors and Brushes	5-62
5.6.7	Reel Motor Brakes	5-63
5.6.8	Capstan	5-63
5.6.9	Control Box	5-64
5.6.10	EOT/BOT Assembly	5-65
5.6.11	Head Plate	5-66
5.6.12	Power Supply	5-67
5.6.13	Capstan Motor	5-67
5.6.14	Vacuum System Belt Replacement	5-67
5.7	Brake Adjustment Procedure	5-68
5.8	Capstan Motor Tachometer Checking Procedures	5-69
5.8.1	Equipment Required	5-69
5.8.2	Checking Tachometer Voltage	5-71
5.9	Recommended Test Equipment and Spare Parts	5-71

APPENDIX A VOLTAGE, FREQUENCY, AND 7 TO 9 CHANNEL CONVERSIONS

A.1	General	A-1
A.2	Applicable Documents	A-1
A.3	Voltage Conversion	A-1
A.3.1	115 VAC-to-230 VAC Conversion	A-2
A.3.2	230 VAC-to-115 VAC Conversion	A-2
A.4	Frequency Conversion	A-3
A.4.1	60 Hz-to-50 Hz Conversion	A-3
A.4.2	50 Hz-to-60 Hz Conversion	A-3
A.5	Seven/Nine Channel Conversion	A-3
A.5.1	7-Channel-to-9-Channel Conversion	A-4
A.5.2	9-Channel-to-7-Channel Conversion	A-4
A.6	Master/Slave Conversion	A-4
A.6.1	Master-to-Slave Conversion	A-4
A.6.2	Slave-to-Master Conversion	A-4
A.7	Over/Under-Voltage Range Conversion	A-4

ILLUSTRATIONS

Figure No.	Title	Page
1-1	Typical System Using TU10 DECmagtapes	1-1
1-2	Reference Edge of Tape	1-2
1-3	Track-Bit Weight Relationship for Nine-Channel Transport	1-2
1-4	NRZ Format (Nine-Channel)	1-3
2-1	Cabinet Installation Diagram	2-1
2-2	Installation of Filler Strips	2-3
2-3	Transport Hold-Down Shipping Bracket	2-3
3-1	Operator Control Box	3-1
3-2	Tape Transport Mechanism	3-4
3-3	Tape Loop Operating Limits	3-6
4-1	Capstan Servo	4-2
4-2	Buffer Column and Vacuum Switches	4-3
4-3	Reel Motor Amplifier Equivalent Circuit	4-4
4-4	Brake Control	4-5
4-5	Brake Current Waveforms	4-6
4-6	Rewind Sequence Timing	4-8
4-7	Head and EOT/BOT Sensor Positions	4-9
4-8	Timing of DLY FOR Signal	4-9
4-9	Tape Markers, Recording Area, and Tape Wind	4-11
4-10	Write Operation Timing	4-14
4-11	Equivalent Circuit of Read Timing and Read Circuitry for One Track (Units Up to No. 10320)	4-16
4-12	Read Circuit Waveforms (Units Up to No. 10320)	4-17
4-13	Equivalent Circuit of Read Timing and Read Circuitry for One Track (Units Above No. 10320)	4-19
4-14	Read Circuit Waveforms (Units Above No. 10320)	4-20
5-1	TU10 Tape Transport Assemblies	5-2
5-2	Daily Equipment Care Areas	5-3
5-3	Reel Motor Brake Assembly	5-6
5-4	Stator Mounting	5-7
5-5	Examples of Head Assembly Wear Characteristics	5-9
5-6	Hub Composition	5-10
5-7	Compressor Waveform for FWD and REV	5-14
5-8	Compressor Waveform for REW	5-14
5-9	Deleted	
5-10	Acceleration and Deceleration Waveforms	5-15
5-11	Deleted	
5-12	Deleted	
5-13	Capstan Waveform Showing 6-1/2 Pulses	5-18
5-14	Capstan Jitter Waveform Magnified	5-18
5-15	Sync Pattern for Reference Track	5-19
5-16	Lead/Lag Patterns	5-19

ILLUSTRATIONS (Cont)

Figure No.	Title	Page
5-17	9-Channel Skew Plot	5-20
5-18	Head Plate Assembly (Right View)	5-21
5-19	Azimuth Error (0) Static View (Head Assembly, Left View)	5-21
5-20	Mechanical Skew Waveforms	5-21
5-21	Mechanical Skew Waveforms	5-21
5-22	Head Plate Assembly Mechanical Alignment	5-24
5-23	Head Plate Assembly (Front View)	5-25
5-24	Example of Peak Deflection	5-26
5-25	Switch Location Guide	5-27
5-26	Examples of Electrical Skew, Read and Write	5-28
5-27	Write Slice Level Measurement	5-29
5-28	Read Slice Level Measurement	5-29
5-29	Dipping Tape Section in Magna-see	5-31
5-30	Developed Tape Segment	5-31
5-31	Track No. 1 to Reference Edge Measurement	5-32
5-32	Read/Write Interlock Assembly	5-34
5-33	Tape Guide Roller Adjustment	5-34
5-34	M768 Diode Locations	5-35
5-35	Reel Hub Adjustment	5-38
5-36	Location of Upper and Lower Roller Guides	5-39
5-37	Roller Guide Adjustment	5-40
5-38	Machined Reference Surfaces Used to Establish Tape Path Plane	5-41
5-39	Measurement of Head Plate Mounting Surface (HMS)	5-43
5-40	Location of Shims Under Head Plate Assembly	5-44
5-41	Examples of Capstan Non-Perpendicularity	5-44
5-42	Location of Possible Capstan Burrs	5-45
5-43	Measuring Depth of Left Vacuum Column (LVC)	5-46
5-44	Head Plate Assembly Mounted in the Plane of the Tape Path	5-47
5-45	Alignment Glass	5-48
5-46	Using Alignment Glass to Load Tape	5-49
5-47	Capstan Motor Shim Placement	5-50
5-48	Capstan Motor Shim	5-51
5-49	Gap (Y) from Tape to Floor of Left Column	5-51
5-50	Measurement of Tape Gap (Y) with Penlight and Shim	5-52
5-51	Location of Upper Spring-Loaded Guide on Capstan	5-54
5-52	Capstan Wobble Check	5-55
5-53	TU10 Cover Assembly	5-56
5-54	Motor-Mounting Holes for 50/60 Hz Operation	5-57
5-55	Reel and Motors, Rear View	5-58
5-56	Vacuum Motor, Rear View	5-60
5-57	Reel Hub	5-61
5-58	Vacuum Switches	5-62
5-59	Capstan Adjustment	5-64

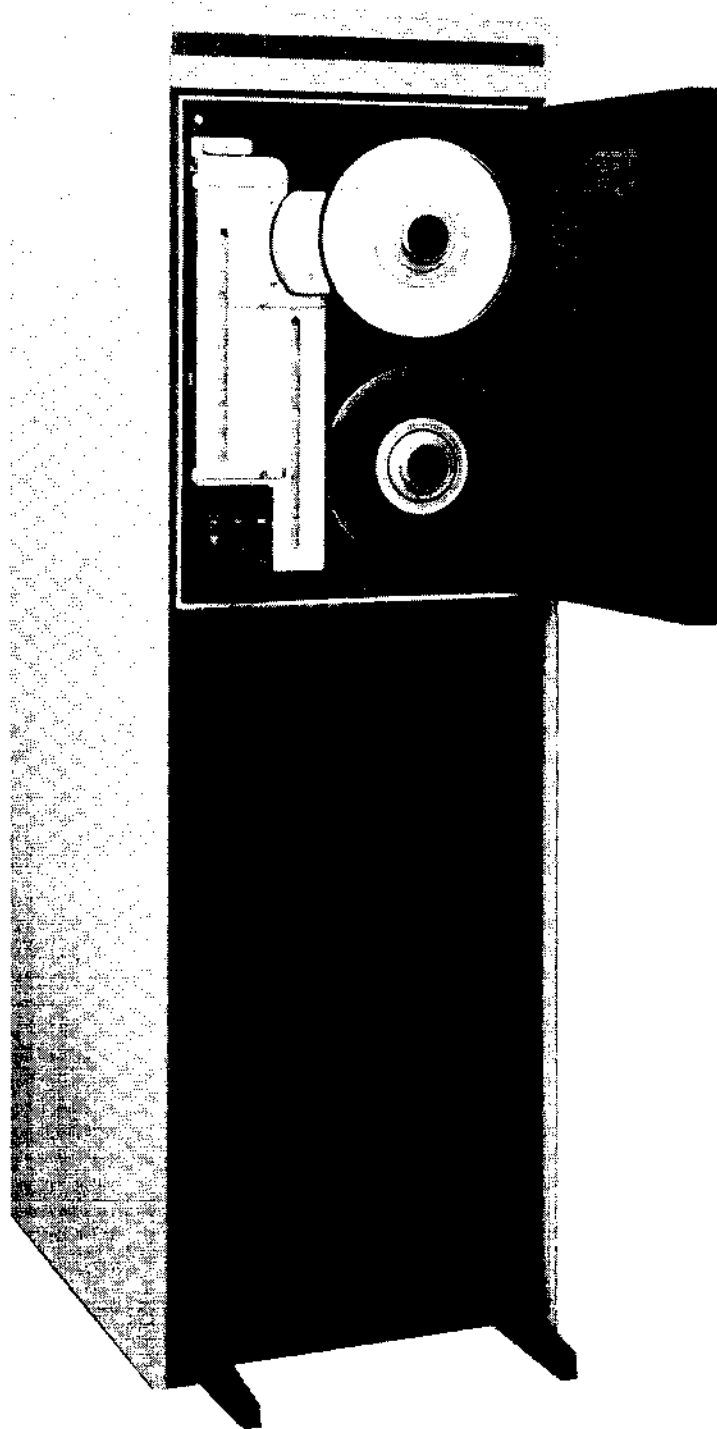
ILLUSTRATIONS (Cont)

Figure No.	Title	Page
5-60	EOT/BOT Assembly	5-65
5-61	Belt Tension Gauge	5-68
5-62	Jumper Wires – 2 Required	5-70
5-63	Tachometer Filter Circuit	5-70

TABLES

Table No.	Title	Page
1-1	TU10 DECmagtape Models	1-1
1-2	TU10 DECmagtape Specifications	1-4
2-1	TU10 Input/Output Cable Connections	2-4
2-2	TU10 I/O Cable Requirements	2-5
3-1	Control Box Switches	3-2
3-2	Status Indicators	3-2
5-1	Preventive Maintenance Schedule	5-4
5-2	Read Amplifier Pin Numbers	5-20
5-3	Read Buffer Pin Numbers	5-27
5-4	Magtape Tester Connections	5-29
5-5	Recommended Test Equipment and Alignment Tools	5-72
5-6	Control Box Spare Parts	5-72
5-7	Module Spare Parts	5-73
5-8	Power Supply Spare Parts	5-73
5-9	Miscellaneous Spare Parts	5-74
A-1	TU10 Configuration Designations	A-1

TU10 DECmagtape Maintenance Manual



5600-38

TU10 DECmagtape Transport

CHAPTER 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The TU10 DECmagtape reads and records digital data on magnetic tape in either 7- or 9-track format. Bit packing densities of 200, 556, and 800 bits per inch (bpi) are program selectable. A single capstan drives the tape in the forward or reverse direction at a speed of 45 inches per second (ips). Tape rewind speed is 150 ips.

The TU10 DECmagtape is available in eight different models (refer to Table 1-1). Each model incorporates a transport mechanism, head assembly, read/write electronics, motor control circuits, power supply, and cabinet. Newer TU10 DECmagtapes contain an induction motor vacuum system as well as other modifications. Those modified models (which bear serial numbers above approximately 10320) are discussed separately wherever maintenance differs from other TU10 DECmagtapes.

Table 1-1
TU10 DECmagtape Models

Number of Channels	115 Volts		230 Volts	
	60 Hz	50 Hz	60 Hz	50 Hz
9-Channel Slave	TU10-EE	TU10-EH	TU10-EF	TU10-EJ
7-Channel Slave	TU10-FE	TU10-FH	TU10-FF	TU10-FJ

The TU10 is fully compatible with the TC58, TC59, and TM10 controllers manufactured by DEC. Each controller accommodates up to eight TU10 DECmagtapes in any combination of 7- or 9-channel models. The TU10 is plug-compatible with the TU20 and TU30 transports, thus allowing the TU10 to be added to existing TU20 or TU30 magnetic tape systems. Figure 1-1 illustrates a typical system employing TU10 DECmagtapes.

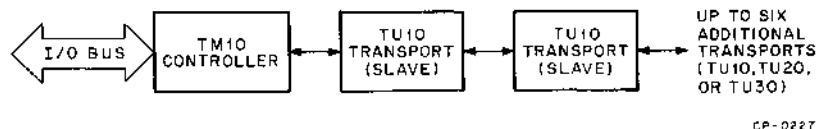


Figure 1-1 Typical System Using TU10 DECmagtapes

1.2 MAGNETIC TAPE FUNDAMENTALS

1.2.1 Definitions

Reference Edge – The edge of the tape as defined by Figure 1-2. For tape loaded on a TU10, the reference edge is toward the observer.

BOT (Beginning Of Tape) Marker – A reflective strip placed on the nonoxide side of the tape, against the reference edge, 15 feet (± 1 ft) from the beginning of the tape.

EOT (End of Tape) Marker – A reflective strip placed on the nonoxide side of the tape, against the nonreference edge, 25 to 30 feet from the trailing edge of the tape.

Nine-Channel Recording – Eight tracks of data plus one track of vertical parity. Figure 1-3 shows the relationship between track and bit weight for a nine-channel transport.

Tape Character – A bit recorded in each of the nine channels.

Record – A series of consecutive tape characters.

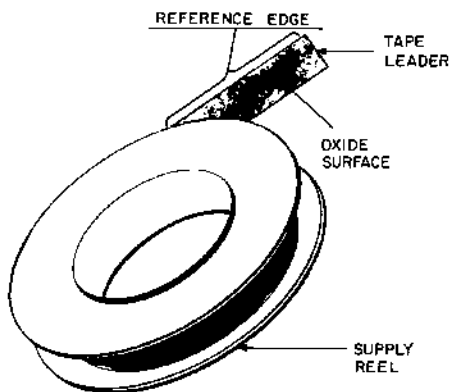
File – An undefined number of records (minimum = zero, no maximum).

Interrecord Gap (IRG) – A length of erased tape used to separate records (0.5 in. minimum for nine-track; maximum IRG is 25 ft).

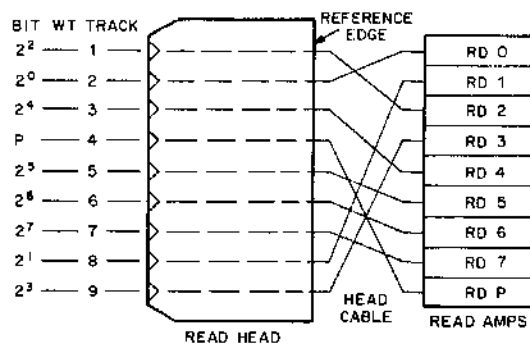
Extended IRG – A length of erased tape (3 in. minimum) optionally used to separate records. It must be used between BOT and the first record.

Tape Speed – The speed at which tape moves past the read/write heads; normally stated in inches per second.

Tape Density – The density of sequential characters on the tape. It is normally specified in bytes per inch (bpi). This is equivalent to characters per inch (cpi), since 800 bpi means that there are 800 tape characters per inch of tape.



10-1265



10-1264

Figure 1-2 Reference Edge of Tape

Figure 1-3 Track-Bit Weight Relationship for Nine-Channel Transport

Write Enable Ring – A rubber ring which must be inserted on the supply reel to allow the transport to write on the particular tape. This safety feature helps prevent accidental destruction of previously recorded data.

Tape Mark (TM) – A record written on the tape to designate the end of a file; sometimes referred to as a file mark (FMK). In the TU10, the tape mark is always preceded by an extended IRG.

1.2.2 NRZI (Non-return to Zero – Change on a 1) Recording Technique

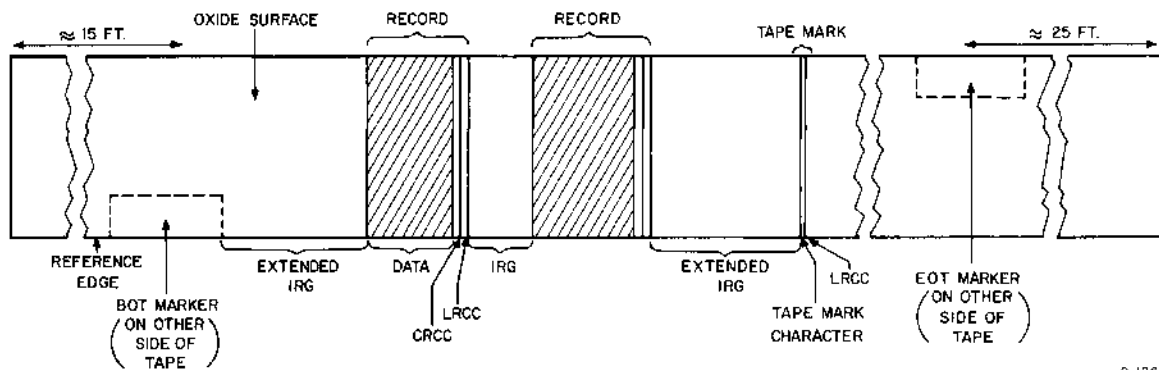
1.2.2.1 **Definition** – NRZI is a recording technique which requires a change of state (flux change) to write a 1, and no change of state (no flux change) to write a 0.

1.2.2.2 Format

Cyclic Redundancy Check Character (CRCC) – A check character that is written four character spaces after the last character of a NRZ record (nine-channel only). CRCC is derived by a complex mathematical formula applied to the characters written in the record. The result of this manipulation (CRCC) can be used to recover a lost bit in a record read from tape.

Longitudinal Redundancy Check Character (LRCC) – A check character written four character spaces after CRCC (nine-channel). LRCC consists of one bit of even parity for each track of data. For example, if track 1 had an odd number of 1s written in a record, then a 1 must be written in the LRCC bit associated with track 1.

Tape Mark – A nine-channel NRZ tape mark consists of one tape character (23_8), followed by seven blank spaces, and then LRCC (23_8). (CRCC is not written.) Figure 1-4 illustrates nine-channel NRZ tape format.



0-1263

Figure 1-4 NRZ Format (Nine-Channel)

1.3 TECHNICAL CHARACTERISTICS

Table 1-2 contains operational, environmental, mechanical, and electrical specifications for the TU10 DECmagtape.

**Table 1-2
TU10 DECmagtape Specifications**

Characteristic	Specification	
Packing Density		
7-Channel:	200, 556 and 800 bpi; program selectable	
9-Channel:	800 bpi	
Tape Speed		
Forward/Reverse:	45 ips (1.14 m/s)	
Rewind:	150 ips (3.8 m/s)	
Maximum Transfer Rate	36,000 characters per second	
Tape Motion Times		
Start:	Normal operating speed is reached within 9 ms after initiation of forward or reverse command.	
Stop:	Motion stops in less than 8 ms after removal of forward or reverse command.	
Electrical Skew	Deskewing effectively eliminates static skew.	
Recording Method	NRZI recording; industry-compatible	
Transport Mechanism	Single capstan; vacuum columns	
R/W Heads	Dual gap, read-after-write	
BOT, EOT Detection	Photoelectric sensing of reflective strip	
Interrecord Gap		
7-Channel:	≥ 0.75 in.	
9-Channel:	≥ 0.5 in.	
Tape		
Width:	0.5 in.	
Thickness:	1.5 mil	
Tape Reel		
Diameter:	10-1/2 in. (0.27m)	
Capacity:	2400 ft.	
Dimensions	Transport Less Cabinet	With H950 Cabinet
Depth:	25 in. (0.64m)	30 in. (0.76m)
Width:	19 in. (0.48m)	21 in. (0.53m)
Height:	26 in. (0.66m)	72 in. (1.83m)

Table 1-2 (Cont)
TU10 DECmagtape Specifications

Characteristic	Specification	
	Transport Less Cabinet	With H950 Cabinet
Weight	150 lb (70 kg)	450 lb (200 kg)
Temperature Limits	45°F (7°C) to 95°F (35°C)*	
Relative Humidity	20 to 95%, noncondensing*	
Air Volume (Inlet)	400 ft ³ /min., 190 l/s (top)	
Voltage	115 Vac ± 10%, 230 Vac ± 10%	
Frequency	50 ± 2 Hz, 60 ± 2 Hz	
Current @ 115V	6A, Surge 8A	
Current @ 230V	3A, Surge 5A	
Power/Heat Dissipation	1000W, 3400 Btu/hr	

* Magnetic tape operation is more reliable if the temperature is limited to 65° to 75°F (18° to 24°C) and the relative humidity to 40 to 60%.

1.4 REFERENCE DOCUMENTS

Refer to the following maintenance manuals for information on the associated magnetic tape controller:

TC58 Tape Controller, DEC-08-I4AB-D
TC59 Tape Controller, DEC-9A-I3BB-D
TM10 Tape Controller, A-MN-TM10-0-MAN1
TM11 Controller, EK-TM11-TM-004
TM8E Controller, DEC-8E-HMM3A-C-D
TMA11 Controller, DEC-11-HATMA-A-D

This material is available from the nearest DEC Field Office or from:

Digital Equipment Corporation
 Communications Services (Direct Mail)
 146 Main Street
 Maynard, Massachusetts 01754

CHAPTER 2

INSTALLATION

This chapter outlines TU10 unpacking and inspection procedures, cabinet installation, cable connections, and unit checkout. A brief discussion of TU10 site considerations is also provided. The DECmagtape is installed at the customer's site by DEC Field Service personnel. Customer personnel should not attempt to install the equipment.

2.1 SITE CONSIDERATIONS

The TU10 DECmagtape should be located in an area free of excessive dust and dirt or corrosive fumes and vapors. To ensure proper cooling, the bottom of the cabinet and the fan inlet at the top of the cabinet must not be obstructed. Adequate clearance must be provided for servicing the transport. Refer to Figure 2-1 for applicable cabinet dimensions. Temperature and humidity specifications are included in Table 1-2.

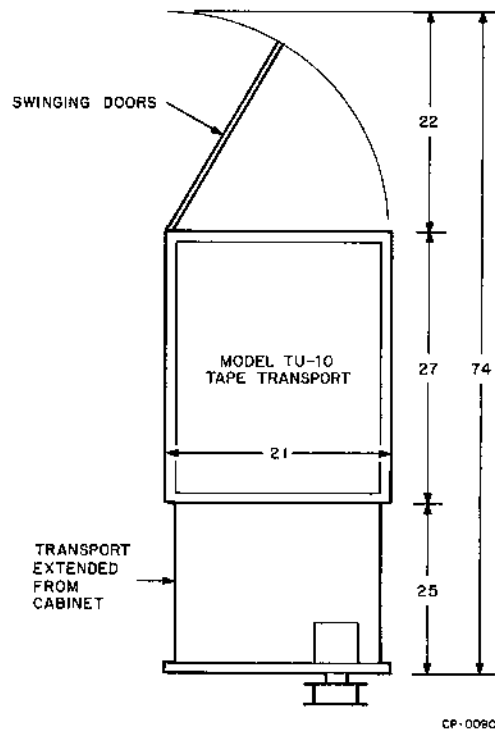


Figure 2-1 Cabinet Installation Diagram

2.2 UNPACKING AND INSPECTION

To unpack and inspect the TU10, proceed as follows:

Step	Procedure
1	Remove the outer shipping container by first removing all metal straps, fasteners, and cleats securing the transport to the skid.
2	After removing the outer container, remove the polyethylene cover from the cabinet.
3	Inspect external surfaces of the cabinet and related assemblies for possible shipping damage and report any damage to the local DEC Sales Office.
4	Remove the tape or plastic shipping pins from the cabinet rear access door.
5	Inspect the interior of the cabinet for possible damage to cables, loose or broken modules, or loose mounting rails.
6	Inspect the wiring side of the logic module mounting panel for bent pins, cut wires, loose external components, and foreign material. Any defects found should be corrected by DEC Field Service personnel.
7	Inspect the power supply for proper seating of fuses and power connecting plugs.
8	Remove the bolts securing the cabinet to the shipping skid.
9	Raise the adjustable leveling feet above the level of the casters. The cabinet should now be resting on the casters.
10	Use wood blocks and planks to form a ramp from the skid to the floor and carefully roll the cabinet off the skid.
11	After the cabinet is moved to the desired location, perform the Cabinet Installation procedure described in Paragraph 2.3.

2.3 CABINET INSTALLATION

The DECmagtape cabinet is provided with casters and adjustable feet. It is not necessary to bolt the cabinet to the floor unless conditions dictate otherwise. To install the TU10 cabinet, proceed as follows:

Step	Procedure
1	Lower the adjustable feet so that the cabinet is not resting on the casters.
2	Ensure that the cabinet is level.
3	If two or more cabinets are to be bolted together, install filler strips (P/N H952-G) between the cabinets as shown in Figure 2-2. Tighten the bolts that secure the cabinet groups together and then recheck that the cabinets are level.
4	After the TU10 DECmagtape has been positioned per the site plan, loosen the two shipping brackets that secure the transport to the rear of the cabinet frame (see Figure 2-3).

NOTE

If the DECmagtape is to be reshipped or installed in a new location, the shipping brackets should be repositioned and tightened.

5	If necessary, clean all outer surfaces.
---	---

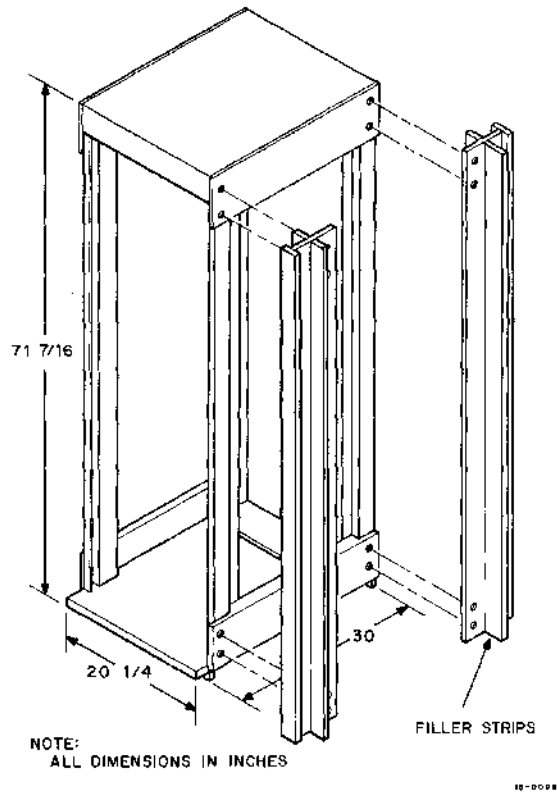


Figure 2-2 Installation of Filler Strips

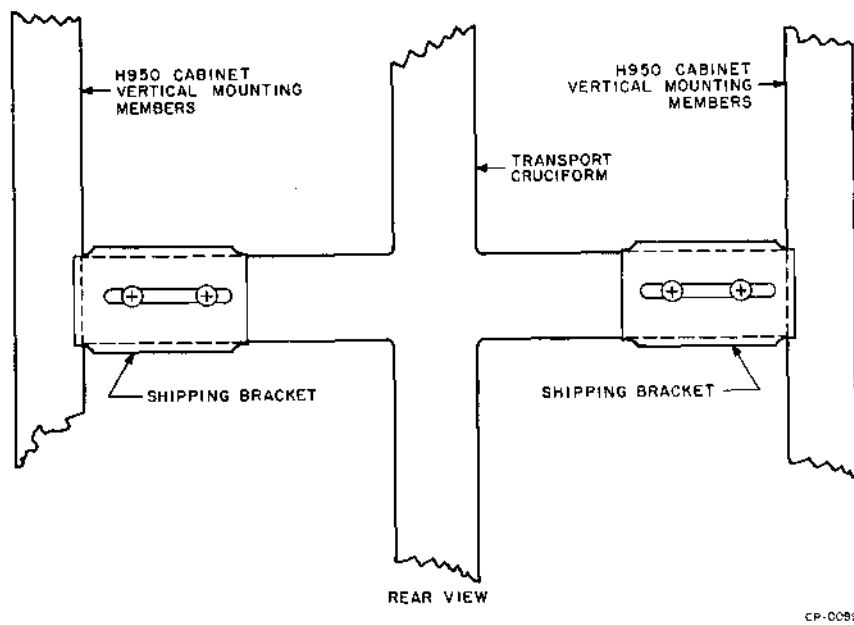


Figure 2-3 Transport Hold-Down Shipping Bracket

2.4 CABLE CONNECTIONS

2.4.1 Power Cable

The power cable supplied with the TU10 must be plugged into the socket at the rear of the power supply and the other end in the local power outlet.

CAUTION

Before connecting the TU10 to the local power source, ensure that the line voltage and frequency are compatible with the power requirements of the TU10.

2.4.2 Input/Output Cables

Table 2-1 lists the I/O cable connections for the TU10 DECmagtape.

Each TU10 is supplied with 15-ft I/O cables. The total cable length between the tape controller and the last transport on the bus is limited to 80 ft; therefore, 10-ft cables are available for systems employing more than 5 DECmagtape units. Cable part numbers are listed in Table 2-2.

NOTE

The TU10, slave or master, on the end of the bus will have a G741YA in slot B17 and a G741 in slot B18 and B19.

**Table 2-1
TU10 Input/Output Cable Connections**

TU10	TC58 TC59 TM10	TU20 TU30
A17/B17 Side 1	B01	C01/D01
A17/B17 Side 2	B02	C03/D03
A18/B18 Side 1	A01	C04/D04
A18/B18 Side 2	A02	C02/D02
A19/B19 Side 1 (not used)	(not used)	(not used)
A19/B19 Side 2	A03	C05/D05

**Table 2-2
TU10 I/O Cable Requirements**

From	To	Part Number	Qty
TU10	TC58/59	BC08-P-xx	2
	TM10	BC08-N-xx	1
TU10	TU10	BC08-N-xx	3
TU10	TU20	BC08-P-xx	2
		BC08-N-xx	1
TU10	TU30	BC08-P-xx	2
		BC08-N-xx	1

xx =	{	10 (10-ft cable)
		15 (15-ft cable)
		25 (25-ft cable)

2.4.3 Bus Terminators

The last (most remote) tape transport on the bus supplies power to the bus terminators. Therefore, ensure that the PWR ON/PWR OFF switch on the most remote transport is always in the ON position. Terminators are located in slots 17, 18, and 19 of the last unit. Type G741 modules are used in slots 18 and 19. A type G741YA module is used in slot 17.

NOTE

If drives are mixed, a TU10 must be the last transport on the bus.

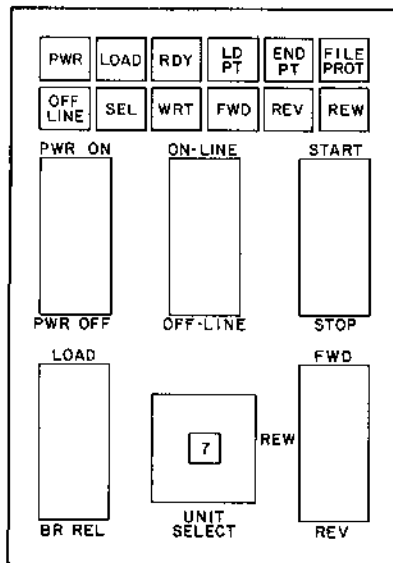
CHAPTER 3

OPERATION

This chapter is divided into two major paragraphs. Paragraph 3.1 describes the DECmagtape controls and indicators. Paragraph 3.2 contains operating procedures for loading and threading tape, unloading tape, and restarting the transport following a power failure or fail-safe condition. Tape handling precautions are also listed in Paragraph 3.2.

3.1 CONTROLS AND INDICATORS

The operator control box (see Figure 3-1) is mounted to the left of the file reel. The functions of the control box switches and indicators are listed in Tables 3-1 and 3-2, respectively.



CP-0093

Figure 3-1 Operator Control Box

**Table 3-1
Control Box Switches**

Switch	Function
PWR ON/PWR OFF	Applies power to entire TU10. Also, supplies power to the bus terminators if the tape transport is the most remote unit on the bus.
LOAD/BR REL	
LOAD Position	Enables vacuum motor, which draws tape into the buffer columns.
Center Position	Disables vacuum motor; brakes are full-on.
BR/REL	Releases brakes.
ON-LINE/OFF-LINE	
ON-LINE Position	Selects remote operation.
OFF-LINE Position	Selects local operation.
FWD/REW/REV	
FWD Position	Selects, but does not initiate, forward tape motion when transport is off-line.
REW Position	Selects, but does not initiate, tape rewind when transport is off-line.
REV Position	Selects, but does not initiate, reverse tape motion when transport is off-line.
START/STOP	
START Position	Initiates tape motion selected by FWD/REW/REV switch when transport is off-line.
STOP Position	Clears any motion commands when transport is off-line.
UNIT SELECT	Selects the tape transport unit by number (0-7). This number is used in the program to address the tape transport.

**Table 3-2
Status Indicators**

Indicator	Function
PWR	Indicates power has been applied to the transport.
LOAD	Indicates that vacuum is on and the tape is loaded into the buffer columns.
RDY	Indicates that the tape transport is ready (vacuum on and settledown delay complete); there is no tape motion.
LD PT	Indicates that the tape is at load point (Beginning of Tape)
END PT	Indicates that the tape is at end point (End of Tape).
FILE PROT	Indicates that write operations are inhibited because the write enable ring is not mounted on the file reel.

**Table 3-2 (Cont)
Status Indicators**

Indicator	Function
OFF-LINE	Indicates local operation by the control box.
SEL	Indicates the tape transport is selected by the controller (program).
WRT	Indicates that the program has initiated a write operation in the tape transport.
FWD	Indicates that a forward command has been issued.
REV	Indicates that a reverse command has been issued.
REW	Indicates that a rewind command has been issued.

3.2 OPERATING PROCEDURES

3.2.1 Loading and Threading Tape

Use the following procedure to mount and thread the tape:

Step	Procedure
1	Apply power to the transport by depressing the PWR ON switch.
2	Ensure the LOAD/BR REL switch is in the center position (this applies the brakes).
3	Place a write enable ring in the groove on the file reel if data is to be written on the tape. Ensure there is no ring in the groove if data on the tape is <i>not</i> to be erased or written over.
4	Mount the file reel onto the lower hub with the groove facing towards the back. Ensure that the reel is firmly seated against the flange of the hub. Ensure that the reel hub is securely tightened. Turn it clockwise.
5	Install the take-up reel (top) as described in Step 4.
6	Place LOAD/BR REL switch to the BR REL position.
7	Unwind tape from the file reel and thread the tape over the tape guides and head assembly as shown in Figure 3-2.
8	Wind about five turns of tape onto the take-up reel.
9	Set the LOAD/BR REL switch to the LOAD position to draw tape into the vacuum columns.
10	Select FWD and press START to advance the tape to Load Point. When the BOT marker is sensed, tape motion stops, the FWD indicator goes out, and the LOAD PT indicator comes on.

NOTE

If tape motion continues for more than 10 seconds, press STOP, select REV (reverse) and press START. The tape should move to the BOT marker (Load Point) before stopping.

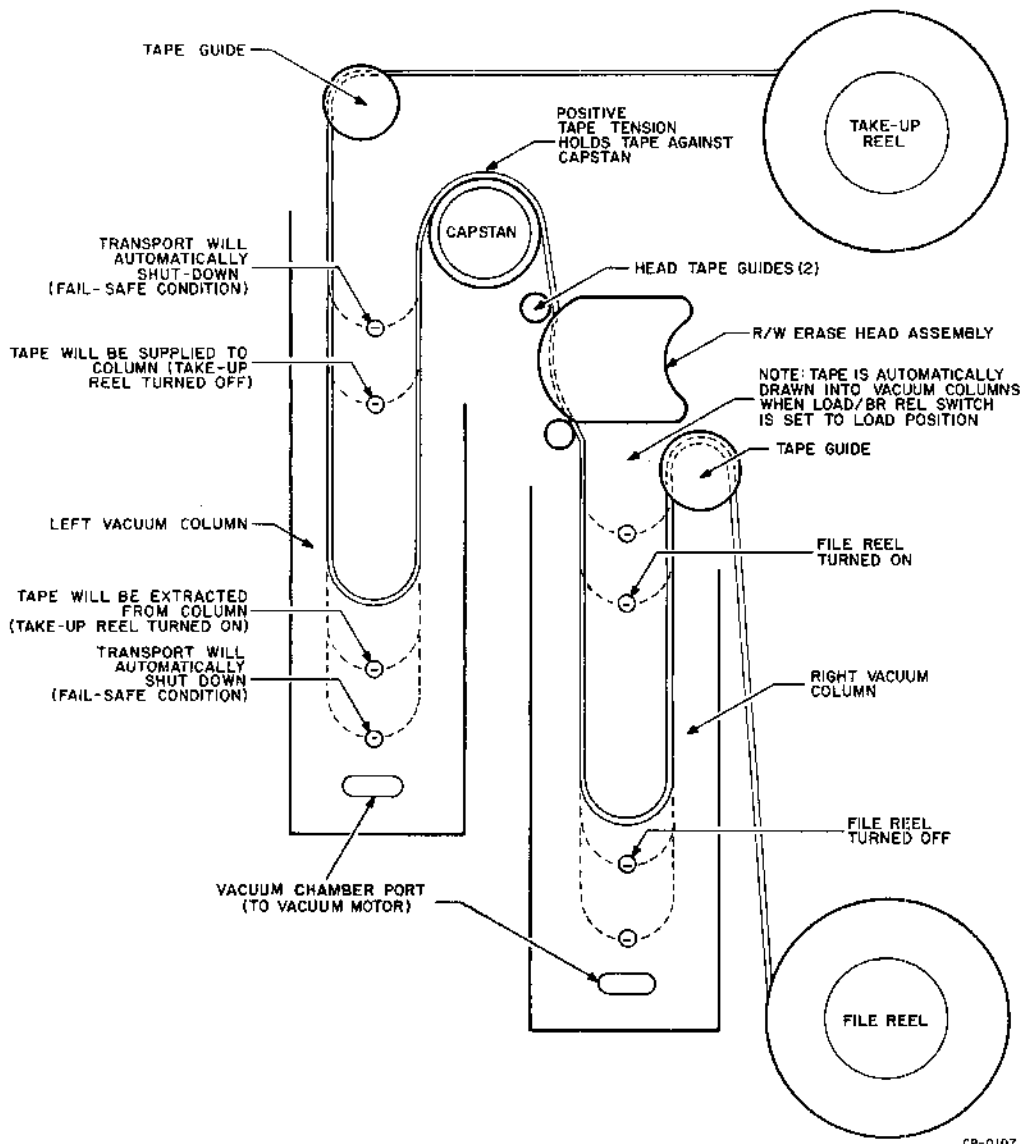


Figure 3-2 Tape Transport Mechanism

3.2.2 Unloading Tape

To unload the tape proceed as follows:

Step	Procedure
1	Press OFF-LINE switch if the transport has been operating in the on-line mode.
2	Press STOP switch and select REW.
3	Press START switch. The tape should rewind until the BOT marker is reached.
4	Press the LOAD/BR REL switch to release the brakes.

Step	Procedure
5	Gently hand wind the file reel in a counterclockwise direction until all of the tape is wound onto the reel.

CAUTION

When handwinding the tape, do not jerk the reel. This can stretch or buckle the tape which could cause irreparable damage.

6	Remove the file reel from the hub assembly.
---	---

3.2.3 Restart After Power Failure

In the event of a power failure, the DECmagtape automatically shuts down and tape motion stops without damage to the tape. Return of power is indicated when the PWR indicator lights. To restart the transport proceed as follows:

Step	Procedure
1	Press the LOAD/BR REL switch to release the brakes.
2	Manually wind the reels to take up any slack in the tape.
3	Set the LOAD/BR REL switch to the LOAD position to draw tape into the vacuum columns.
4	Set ON-LINE/OFF-LINE switch to the desired position and continue operation.

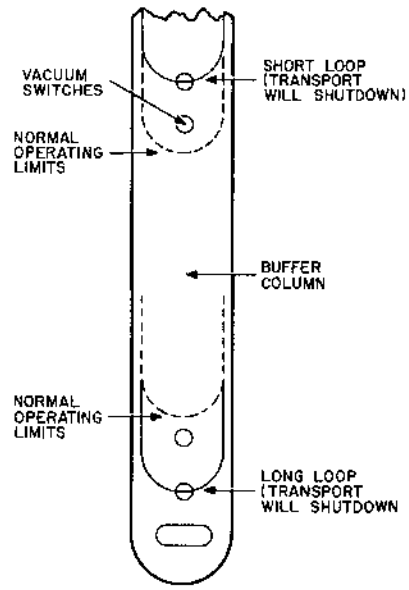
3.2.4 Restart After Fail-Safe

If the tape loop in either buffer column exceeds the limits shown in Figure 3-3, the vacuum system automatically shuts down and tape motion stops without damage to the tape. When this fail-safe condition occurs, the DECmagtape does not respond to on-line or off-line commands. To restart the transport, perform Steps 1 through 4 in Paragraph 3.2.3.

3.2.5 Tape Handling

Observe the following precautions when handling magnetic tape:

- a.* Always handle a tape reel by the hub hole; squeezing the reel flanges can cause damage to the tape edges when winding or unwinding tape.
- b.* Never touch the portion of tape between the BOT and EOT markers. Oils from fingers attract dust and dirt. Do not allow the end of the tape to drag on the floor.
- c.* Never use a contaminated reel of tape. This spreads dirt to clean tape reels and can affect tape transport operation.
- d.* Always store tape reels inside their containers. Keep empty containers closed so dust and dirt cannot get inside.
- e.* Inspect tapes, reels, and containers for dust and dirt. Replace take-up reels that are old or damaged.
- f.* Do not smoke near the transport or tape storage area. Tobacco smoke and ash are especially damaging to tape.
- g.* Do not place the DECmagtape near a line printer or other device that produces paper dust.
- h.* Clean the tape path frequently as described in Paragraph 5.2.1.



CP-0088

Figure 3-3 Tape Loop Operating Limits

CHAPTER 4

THEORY OF OPERATION

This chapter provides a detailed description of the TU10 control logic and read/write electronics. The DEC engineering drawings referenced in this chapter are contained in Volume 2 of the *TU10 Maintenance Manual*.

4.1 TRANSPORT CONTROL

The tape transport mechanism consists of the file reel, with its reel motor, brake, and vacuum-buffer column; the capstan, with its capstan motor and tachometer; the take-up reel with its reel motor, brake, and vacuum-buffer column; and the drivers and control electronics for the above.

4.1.1 Capstan Control

The heart of the transport mechanism is the capstan subsystem, which transports the tape across the read/write/erase head assembly at the proper speed. The capstan is controlled by a velocity-feedback servo loop, shown in Figure 4-1 and drawing TU10-0-03. The tachometer produces an output voltage proportional to the velocity of the capstan. The capstan servo preamplifier compares the tachometer output with a reference voltage that is proportional to the desired capstan velocity, and generates an appropriate error voltage. The error voltage is further amplified by the capstan power amplifier, the output of which drives the capstan motor. Thus, if the capstan is running slower than the desired speed, the error voltage, and, consequently, the voltage impressed on the capstan motor will increase, speeding up the capstan. If the capstan is running too fast, the capstan velocity will similarly be decreased. Due to the high gain of the error and power amplifiers, the capstan speed will not vary more than 1% from its desired velocity even under varying conditions of mechanical loads, power supply fluctuations, etc.

The power amplifier is designed with a "dead band", so that insignificantly small error voltages are ignored. This design feature prevents capstan "creep" due to slight error voltages produced by offset and drift in the preamplifier when the capstan should be stopped.

The power amplifier operates in push-pull mode from $\pm 11\text{V}$ power supplies. One side of the capstan motor is connected to the amplifier output and the other side is connected (through a small current-sensing resistor) to PWR COM INT. In normal operation, PWR COM INT is connected to PWR COM (ground) through a relay in the power supply. However, when tape is not loaded, or the fail-safe circuitry detects a malfunction in the unit that might cause damage to the tape, the relay opens, interrupting current to the motor and causing the capstan to come to a stop without damaging the tape. The fail-safe circuitry is explained in Paragraph 4.1.2.

To control the acceleration and deceleration rates of the capstan, the power amplifier contains current-limiting circuitry.

When the capstan is at rest and the servo receives a Forward command, the difference between the tachometer output (0V) and the output of the forward reference voltage generator is quite large. This causes the error

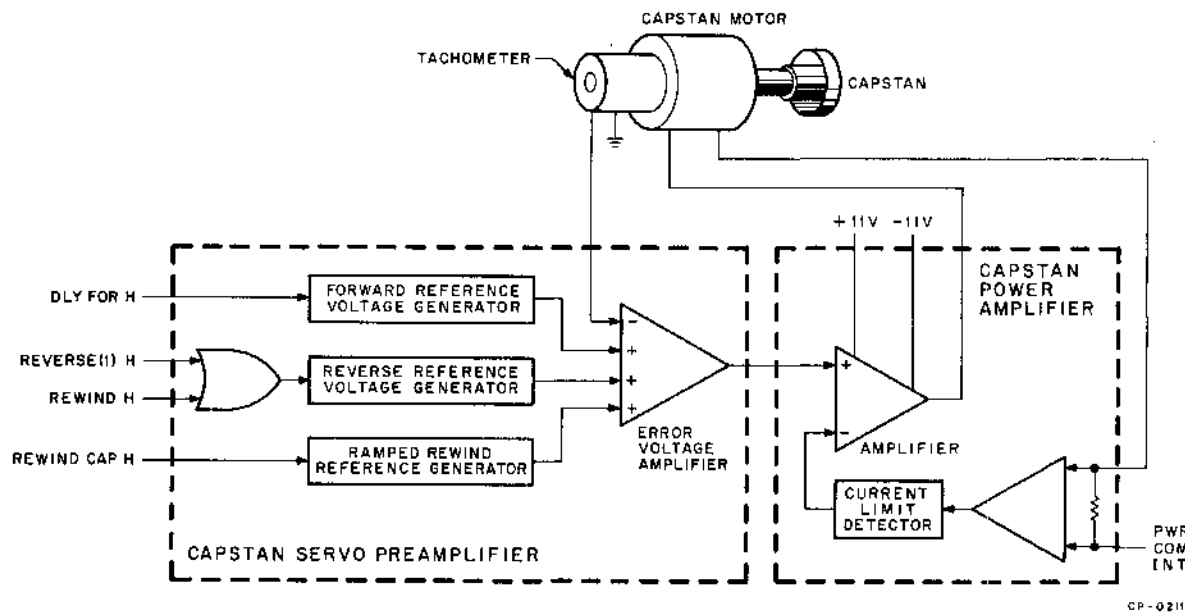


Figure 4-1 Capstan Servo

voltage amplifier to saturate, and remain saturated until the capstan velocity closely approaches its final 45 ips forward velocity. If the power amplifier did not contain current-limiting circuitry, it would also saturate, applying the full power-supply voltage across the capstan motor. The current through the motor, and, consequently, its acceleration rate, would then be a function of such loosely controlled parameters as power-supply voltage, motor armature resistance (a function of temperature), and the back-e.m.f. of the motor. By current-limiting the output of the power amplifier, the acceleration and deceleration rates of the capstan in normal (i.e., forward and reverse) operation become accurately controlled. This, in turn, maintains accurate control of the amount of tape traversed while accelerating and decelerating, allowing operation with short, well controlled interrecord gaps.

Due to the danger of “spooking” (slippage between adjacent layers of tape on the reels) which can damage tape by stretching or buckling it, the tape reels cannot be accelerated as quickly as the capstan for high-speed (rewind) operation. For normal (45 ips forward and reverse) operation, the vacuum columns buffer enough tape to allow time for the reels to catch up with the rapid accelerations and decelerations of the capstan. However, the buffer columns cannot contain enough tape to allow the capstan to accelerate and decelerate at its normal high rates to and from the 150 ips rewind velocity. For this reason, the rewind command logic produces two signals that control the rewind velocity of the capstan. When the rewind operation begins, REWIND H is asserted, causing the capstan to accelerate immediately to 45 ips. REWIND CAP H is then asserted, which causes the ramped rewind reference voltage generator to gradually increase the rewind speed, exponentially approaching 150 ips, at a rate at which the reels can be accelerated. When the rewind is completed, REWIND CAP H is first negated, causing the rewind reference voltage generator to gradually decrease the rewind speed. After the speed has been reduced to 45 ips, the REWIND H signal is negated, causing the capstan to rapidly come to a halt.

4.1.2 Reel and Buffer Controls

As explained in Paragraph 4.1.1, it is necessary to buffer a small amount of tape in a low-inertia reservoir to rapidly accelerate and decelerate the tape past the read/write/erase head assembly without “spooking” the tape on the file and take-up reels. For this purpose vacuum-buffer columns are used. The capstan does not directly move

tape from one reel to another; rather, it removes tape from one vacuum column and deposits it in the other. Each reel motion servo system endeavors to keep its vacuum-buffer column half filled with tape, ready either to supply or to take up tape as might be required by a sudden acceleration of the capstan. Figure 4-2 shows a buffer column and its tape-position-sensing vacuum switches. A vacuum port at the bottom of the buffer column provides vacuum, which draws the tape loop into the column with a constant tension independent of the position or velocity of the tape loop, thus ensuring good, uniform wrap of the tape on the reel. In normal operation, the position of the tape loop in the vacuum column is sensed by two vacuum switches, the upper motor switch and the lower motor switch. These vacuum switches close when subject to a vacuum exceeding 10 inches of water, and open when exposed to ambient air pressure. Thus, if the tape loop is above the vacuum switch in the buffer column, the switch is exposed to vacuum, the switch is then closed, and its corresponding signal (UVS for the upper Motor Switch or LVS for the lower Motor Switch) is then at ground. If, however, the tape loop is below the vacuum switch in the column, the switch is exposed to ambient pressure, it opens, and its corresponding signal is high.

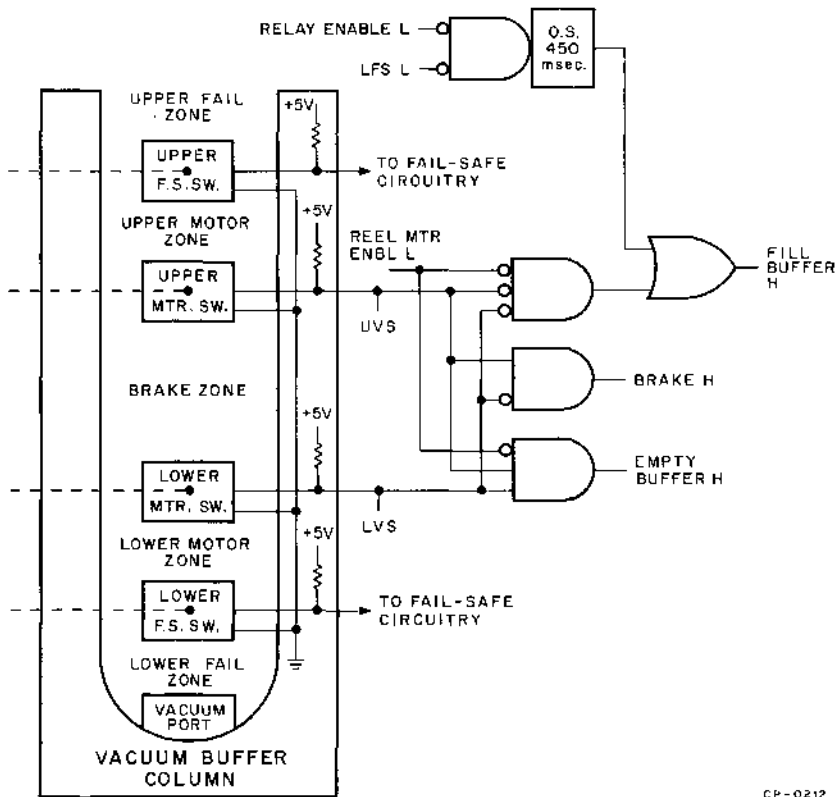


Figure 4-2 Buffer Column and Vacuum Switches

The reel servo system endeavors to keep the tape loop in the brake zone between the upper and lower motor switches. In this position, UVS is high and LVS is low, and braking is applied to the reel. Thus, if the capstan stops, the reel comes to rest with the tape loop in the brake zone.

If the capstan then begins to put tape into the buffer, the loop moves down until it passes the lower Motor Switch and enters the lower Motor Zone. At that point, braking is removed and a command is sent to the reel

motor amplifier to accelerate the reel in order to empty tape from the buffer. The tape loop continues to move down into the lower Motor Zone until the reel is emptying tape out of the buffer as fast as the capstan is putting it in. As the motor continues to accelerate the reel, the tape loop begins to move up again until it passes the lower Motor Switch and enters the braking zone. The motor is then turned off and braking is again applied. The tape loop continues to move up into the braking zone until the rate at which the reel motor is removing tape from the column is again equal to the rate at which the capstan is putting tape in, and as the reel continues to decelerate, the cycle repeats. Thus, the tape loop oscillates about the position of the lower Motor Switch. If the capstan, instead, removes tape from the buffer, the tape loop similarly oscillates about the upper Motor Switch as the motor and brake alternately accelerate and decelerate the reel while supplying tape to the buffer column at the average rate at which the capstan is removing it.

Figure 4-2 shows two additional vacuum switches, one near each end of the buffer column. These fail-safe switches are used to detect a failure in the tape transport mechanism that threatens to damage the tape. If the tape loop passes below the lower fail-safe switch or above the upper fail-safe switch, in either buffer column, power is removed from the capstan and reel motors, braking is applied to the reels, the vacuum motor is shut down, and all operations of the tape unit are halted. The fail-safe switches are located far enough from the ends of the buffer columns to guarantee that, in case of failure, tape motion will cease before the tape can be damaged.

Figure 4-3 shows an equivalent circuit of the reel motor driver. The reel motor is connected across a transistor bridge, which can connect the motor between the -16V and +16V INT power supplies in either direction. Under normal operating conditions, REEL MTR ENBL L is asserted, and the reel motor responds to control by the vacuum-switch signals. When UVS is low (upper vacuum switch closed), the reel motor is connected across the power supplies in the direction that drives tape into the buffer column. When UVS is high (upper vacuum switch open) and LVS is low, indicating that the tape is in the braking region, the reel motor is shut off. When both UVS and LVS are high, the reel motor is connected across the power supply in the direction that removes tape from the buffer.

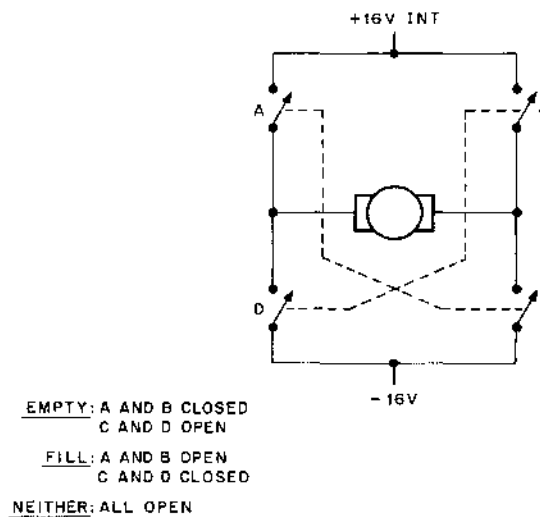
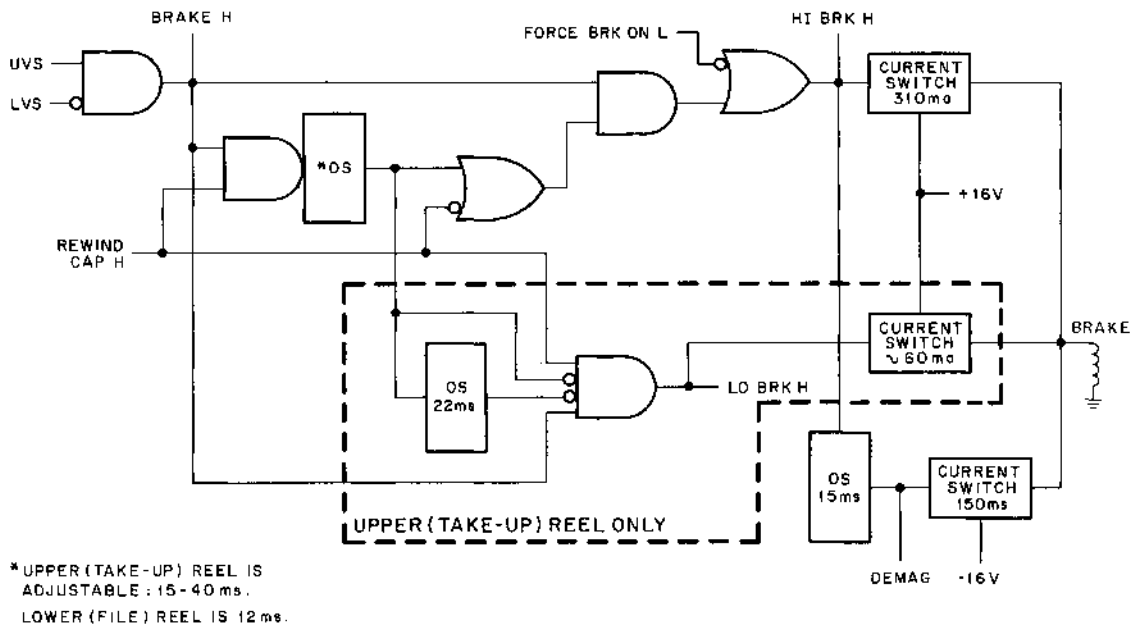


Figure 4-3 Reel Motor Amplifier Equivalent Circuit

The reel motor amplifier has an additional input, REEL MTR PULSE H, which is used during the loading sequence to start tape into the vacuum column. REEL MTR PULSE is asserted during the tape loading sequence to cause the reel motor to feed a few inches of slack tape into the buffer column, sealing the buffer column and allowing vacuum to build up in the column. The loading sequence is explained in more detail later.

When tape is not loaded, or when a failure is detected by the fail-safe switches, REEL MTR ENBL L is negated, disabling FILL BUFFER and EMPTY BUFFER signals from the vacuum switches (see Figure 4-2), and +16V INT is interrupted, removing power from the reel motors.

Figure 4-4 shows the brake control circuitry. The brakes used on the TU10 are electromagnetically-operated friction brakes. In normal 45 ips operation, when UVS is high and LVS is low (i.e., when the tape loop is in the braking zone), approximately 310 mA of current is driven through the brake winding. This produces enough torque to rapidly bring the reel to a stop. When the tape loop moves out of the braking zone, the current is shut off. Because the braking current tends to produce a significant residual magnetism in the brakes, a short (15 ms) pulse of about 150 mA current is applied in the reverse direction when the brakes are released to ensure complete demagnetization and release of braking.



LP-0214

Figure 4-4 Brake Control

During high-speed rewind, the operation of the braking circuitry must be modified somewhat to avoid stopping the reel whenever the tape loop enters the braking zone. Without this modification, the reel motor could not accelerate the reel to 150 ips rapidly enough to prevent failure. For this reason, when REWIND CAP H is asserted and the tape loop enters the braking zone, only a short pulse of braking is applied to the reel to slow it down, but not to bring it to a halt. In the case of the upper (take-up) reel servo, if the tape loop remains in the braking zone longer than about 50 ms, a low current of about 60 mA is applied to the brake, further decelerating the reel. In the case of the lower (file) reel, this is not necessary.

The difference in braking of the two reel systems occurs because the upper reel is dumping tape into the buffer during rewind and is, therefore, accelerated by torque resulting from the tape tension produced by the vacuum column; whereas the lower reel is removing tape from its buffer, and, therefore, the tape tension tends to decelerate the lower reel, making low drag braking unnecessary.

Figure 4-5 shows the brake current waveforms of each reel system during both 45 ips and rewind operations.

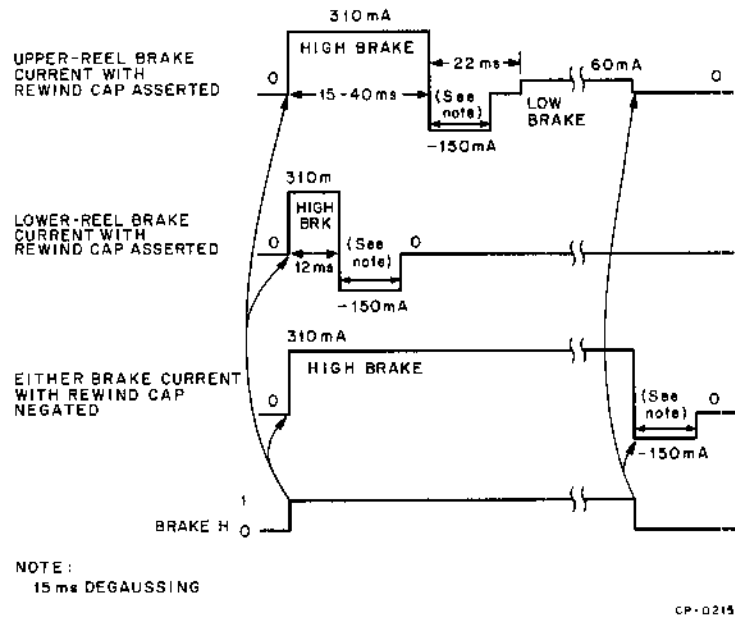


Figure 4-5 Brake Current Waveforms

Whenever tape is not loaded or the fail-safe switches detect a failure, and the LOAD/OFF/BRK RLS switch is not in the brake release position, FORCE BRK ON L is asserted. This signal causes high (310 mA) braking to be applied to both reels, regardless of the signals from the vacuum switches.

4.1.3 Motion Control Logic

The motion control logic, shown in drawing TU10-0-06, provides the necessary sequencing and control for loading tape, rewinding, brake release, and shutting the unit down if power or the tape unit itself should fail. Its main sections are listed and explained below.

4.1.3.1 Power Clear – The power clear circuitry consists of a power transient detector and one-shot. When the +5V power supply is turned on, the circuit produces a 400 ms PCLR pulse that resets all of the various status flip-flops of DECmagtape to the idle, unloaded, off-line condition, keeps all motors turned off, and asserts braking on the reels. Similarly, when the +5V power supply drops to approximately 4.4V, a PCLR pulse is produced that lasts for 400 ms or until the power supply drops too low to operate the power clear circuitry (approximately 3V).

4.1.3.2 Failure Detection – As explained in previous sections, there are two fail-safe switches in each buffer column that define the permissible limits of excursion of the tape loop in the column. If the tape loop in either

buffer column goes below its lower fail-safe switch, the switch opens and LFS H is asserted. If either tape loop is above its upper fail-safe switch, then UFS L is asserted. When VACUUM ON L is asserted, indicating that tape is loaded, and either LFS H goes to 1 or UFS L goes to 0, then the FAIL flip-flop is set (drawing TU10-0-06). The effect of FAIL(1) is essentially the same as that of the PCLR pulse, except that FAIL(1) is a level and remains asserted, preventing tape unit operation until manually reset by moving the LOAD/BRK RLS switch to its center or OFF position.

4.1.3.3 Loading Sequence Logic – Initiation and shutting down of the reel motors, brakes and function control logic is controlled by the loading sequence logic. The loading sequence logic consists of the RELAY ENBL flip-flop, the REEL MTR ENBL L and VACUUM ON L integrating one-shots, and their associated gating. The RELAY ENBL flip-flop is reset by the assertion of CLR RLY ENBL L, a signal made up of the OR of PCLR, FAIL(1), or the LOAD/OFF/BRK RLS switch being in the OFF position. When RELAY ENBL is reset the RELAY ENBL H signal itself is negated, turning off the vacuum motor; MTR PWR RELAY COIL is turned off, causing the power supply to interrupt PWR COM INT and +16V INT which turns off power to the reel and capstan motors; the REEL MTR ENBL L integrating one-shot is held to its 1 state, negating REEL MTR ENBL L; and the VACUUM ON L integrating one-shot is held to its 1 state, negating VACUUM ON L, and preventing the function control logic from responding to any command.

The RELAY ENBL flip-flop is set by LOAD PULSE L, a pulse produced when the LOAD/OFF/BRK RLS switch is brought to the LOAD position. When the RELAY ENBL flip-flop is set, RELAY ENBL H is asserted, turning on the vacuum motor; RELAY ENBL L is asserted clearing FORCE BRK on and causing the generation of REEL MTR PULSE; and MTR PWR RELAY coil is turned on, causing the power supply to turn on PWR COM INT and +16V INT. REEL MTR PULSE causes each reel motor to dump a small amount of tape into the top of its buffer column, sealing it and allowing vacuum to build up in the column. When the lower fail-safe switches in both vacuum columns sense vacuum, causing LFS to be negated, the overriding set inputs to the REEL MTR ENBL L and VACUUM ON L integrating one-shots are negated, allowing the one-shots to begin to time out. Approximately 300 ms is allowed for the vacuum to build up and stabilize before the REEL MTR ENBL L one-shot times out, asserting REEL MTR ENBL.

When REEL MTR ENBL is asserted, the reel servos can then function normally, bringing the tape loops to the middle of the buffer column. Approximately 260 ms thereafter, the VACUUM ON L one-shot times out, asserting VACUUM ON. This allows the function control logic to accept commands and also enables failure detection. The tape loading sequence is then complete, and the transport remains loaded until the RELAY ENBL flip-flop is reset.

4.1.3.4 Brake Release – When the FORCE BRK ON flip-flop is set, full braking is applied to both reels. It is set by CLR RLY ENBL L whenever the RELAY ENBL flip-flop is reset and is cleared whenever RELAY ENBL is set. FORCE BRK on can also be cleared by BRK REL L, the signal which is asserted when the LOAD/OFF/BRK RLS switch is in the BRK RLS position, provided that LFS H is asserted. Thus, the lower vacuum switches prevent brake release until the vacuum has drained out of the buffer columns. Moving the LOAD/OFF/BRK RLS switch from BRK RLS to the center OFF position causes CLR RLY ENBL L to be asserted, again setting the FORCE BRK ON flip-flop.

4.1.3.5 Rewind Control – Due to the limited rate at which the reels can be accelerated and decelerated, a special sequence of control signals must be generated to perform a high-speed rewind operation. The sequence is shown in Figure 4-6.

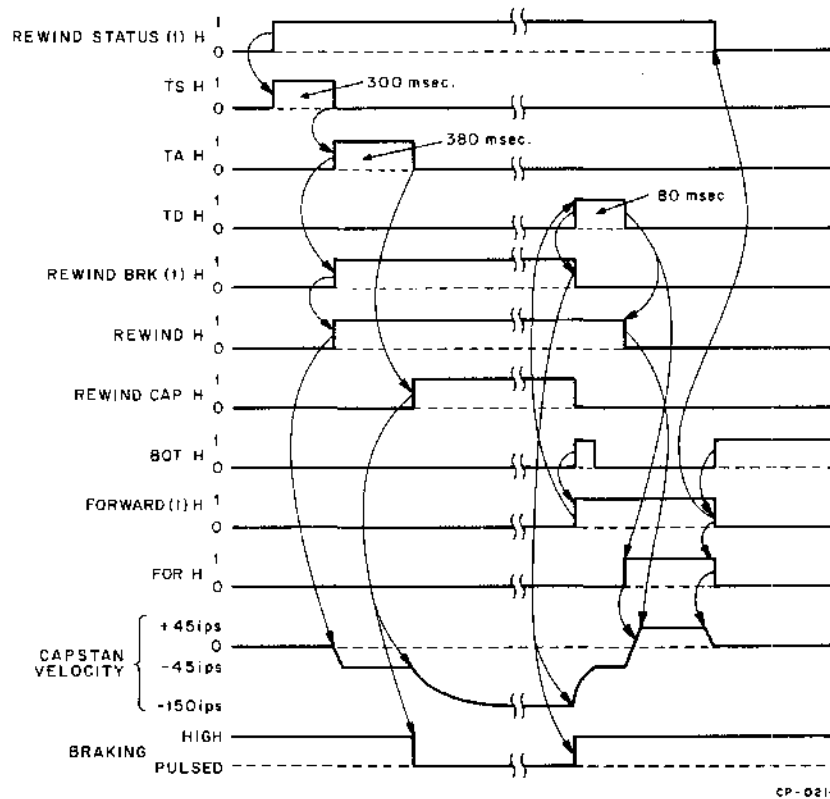


Figure 4-6 Rewind Sequence Timing

When the function control logic accepts a rewind command, it asserts REWIND STATUS(1) H, triggering the TS one-shot (drawing TU10-0-06). The TS one-shot times out for 300 ms, allowing the reels to come to a stop if they were still moving due to a previous operation. When TS times out, it triggers the TA one-shot, setting the REWIND BRK flip-flop and asserting REWIND H. The REWIND H signal causes the capstan servo to accelerate to 45 ips in the reverse direction.

After approximately 380 ms, TA times out and REWIND CAP H is asserted, causing the capstan servo to gradually increase speed to 150 ips, and causing the brake controls to operate in the pulsed rewind mode. Normally, rewinding continues until the function control logic detects the Beginning of Tape (BOT) marker. When BOT is detected, the function control logic asserts FORWARD(1) and removes REWIND STATUS(1). The assertion of FORWARD(1) L with REWIND BRK(1) asserted triggers the TD one-shot (drawing TU10-0-06, coordinates A7). The REWIND BRK flip-flop is cleared, negating REWIND CAP H and causing normal braking to be restored and the capstan servo to gradually decelerate to 45 ips, still travelling in the reverse direction past BOT.

After approximately 120 ms, TD times out, negating REWIND H and allowing the forward command to be passed to the capstan servo. The capstan then accelerates from 45 ips in the reverse direction to 45 ips forward. The tape then moves forward until the BOT marker is again detected. At this point, the function control logic clears both FORWARD(1) and REWIND STATUS(1), and the capstan comes to a stop, terminating the rewind.

The rewind control logic is designed so that if the rewind is terminated at any point in the sequence the operation will stop without failure and without danger of "spooking" the tape.

4.1.3.6 Forward BOT Delay — As shown in Figure 4-7, the EOT/BOT sensor is located some distance ahead of the read/write head on the tape path. Thus, when the tape is stopped with the BOT marker at the EOT/BOT sensor, the BOT marker is still some distance before the read and write heads. Because the industry-standard tape format requires that the first record be written at least 3 in. past the trailing edge of the BOT markers, all DEC magnetic tape controls must wait a specified length of time between initiating forward motion in the tape unit and commencing data transfers when starting an operation from BOT. This time period must be long enough to move the BOT marker past the write head and 3 in. beyond it.

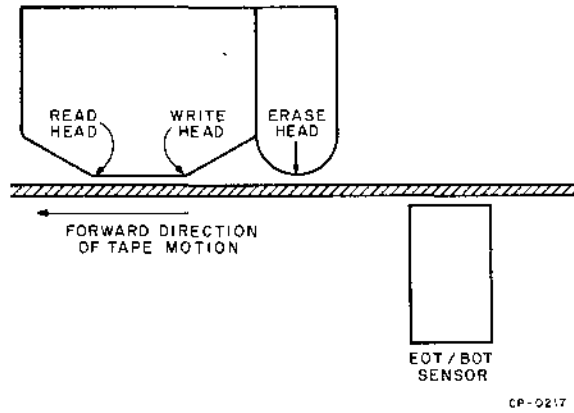


Figure 4-7 Head and EOT/BOT Sensor Positions

The TU10 EOT/BOT sensor is located about 1 in. closer to the write head than the sensors in some older Digital tape units. Consequently, to be compatible with other Digital tape units and controls, the TU10 must wait about 23 ms before starting forward from BOT. If BOT is asserted when FOR H is asserted, the rise of DLY FOR H will be delayed 23 ms. If BOT is not asserted, DLY FOR H will rise immediately upon the rise of FOR H. The relationship among FOR H, DLY FOR H, and BOT H is shown in Figure 4-8.

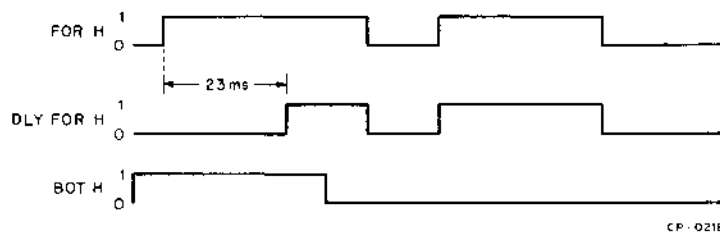


Figure 4-8 Timing of DLY FOR Signal

4.1.3.7 Ready and Transport Settling Down — The READY L and TRANSPORT SETTLING DOWN L signals indicate whether the transport is idle (ready to begin an operation) or settling down (coming to a halt after performing an operation). When the DEC magtape is on-line and selected by its controller, it transmits the signals to the controller to notify the controller when it is able to accept another command.

Whenever an operation is being performed, the function control logic asserts MOTION H. The OR of MOTION H (operation in progress) or LOCAL(1) H (unit off-line) sets the RUNNING H integrating one-shot (drawing TU10-0-06, coordinates C2), thereby negating READY L, and also inhibiting TRANSPORT SETTLING DOWN L. When both MOTION H and LOCAL(1) H are negated, the RUNNING H one-shot begins to time out and TRANSPORT SETTLING DOWN L is asserted, indicating that the transport is ready to accept a command to move tape in the same direction as the previous command. After approximately 10 ms, when the capstan has had time to come to a complete stop following any previous operation, the RUNNING H one-shot times out, negating TRANSPORT SETTLING DOWN L and, provided that VACUUM ON H is asserted, asserting READY L, thereby indicating that the unit is ready to accept any command.

4.2 TAPE UNIT STATUS SENSORS

4.2.1 Write Lock

To protect tapes from inadvertent erasure, tape reels are provided with a write-enable ring. If a reel of tape is mounted on the DECmagtape with its write-enabled ring removed, this condition is sensed and the DECmagtape will refuse to honor write commands. Further, if the transport is on-line and selected by its controller, it will assert transport bus signal BWRI H, indicating to the controller that it is write-locked.

The write lock assembly is shown schematically on drawing TU10-0-04, Sheet 1. The physical assembly is shown in Figure 5-17. The assembly consists principally of the write-lock solenoid and the write-lock switch. When no write-enable ring is inserted in the file reel, a feeler attached to the end of the solenoid shaft extends into the write-lock slot on the back of the reel. This feeler puts the write-lock switch in its normally closed position, asserting WRITE LOCK L. When a write-enable ring is inserted in the file reel, the ring pushes back the solenoid shaft, actuating the write-lock switch and negating WRITE LOCK L. If the write-enable switch is actuated when +12V INT is turned on, i.e., when tape is loaded in the buffer columns, the write-lock solenoid is engaged to withdraw the write-lock feeler from contact with the ring. This keeps the write-lock switch actuated until the tape is unloaded and reduces wear of the write-lock assembly and write-enable ring during tape unit operation.

4.2.2 EOT/BOT Sensor

To locate the beginning and end of the recording area on the tape, the load and end points are marked by reflective strips mounted on the non-oxide side of the tape. The dimensions and placement of these strips are shown in Figure 4-9. They are detected by the phototransistors of the EOT/BOT sensor assembly, shown schematically in drawing TU10-0-04, Sheet 2. The assembly is illustrated in Figure 5-24. The EOT/BOT assembly is located on the head mounting plate opposite to the tape cleaner. It consists of an EOT sensor phototransistor, located to detect light reflected from the EOT strip; a BOT sensor phototransistor, located to detect light reflected from the BOT strip; and a light-emitting diode (LED), located opposite the center of the tape, which illuminates both the EOT and BOT strips. The LED operates in the infrared region and produces no visible light. The outputs of the EOT and BOT signals are amplified, filtered, and converted to logic levels as shown on drawing TU10-0-05, to produce the logic signals EOT L, EOT H, BOT L, and BOT H.

The assertion of EOT H sets the END POINT flip-flop, which remains set until the tape is rewound or EOT is negated while the tape is travelling in the reverse direction. Thus, if the tape is moved forward past the EOT marker, END POINT remains set even after the marker is passed and is cleared only by rewinding or reversing the tape back past the EOT marker. Setting END POINT has the following effects:

- a. If the DECmagtape is off-line (LOCAL(1) H asserted), forward tape motion stops and the transport will not accept manual forward commands until the tape is rewound or reversed off of the EOT marker.

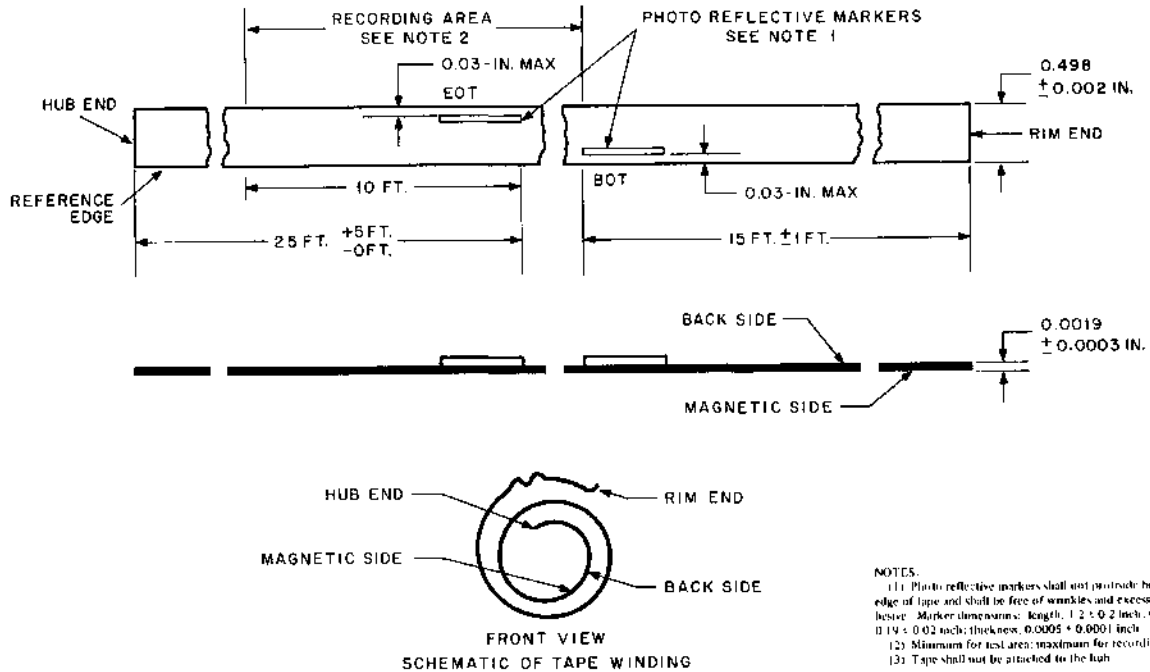


Figure 4-9 Tape Markers, Recording Area, and Tape Wind

- b. The End Point indicator lamp is lit.
- c. If the DECmagtape is on-line and selected by its controller, the transport bus signal BEOT H is asserted (drawing TU10-0-07), indicating to the controller that it has passed the End Point.

Note that if the DECmagtape is on-line, it will not automatically stop on detecting EOT. It is permissible to write data up to 10 ft past the End Point, and it is up to the programmer to ensure that he does not run past this point.

The assertion of BOT has the following effects:

- a. The DECmagtape accepts no new rewind commands,
- b. When the transport rewinds into BOT (REWIND STATUS(1) and FORWARD(0) and the rise of BOT H), the FORWARD flip-flop is set (drawing TU10-0-05); (see the description of rewind operation in Paragraph 4.1.3.5);
- c. When the transport moves forward into BOT, the FORWARD flip-flop is cleared. (If the REWIND STATUS flip-flop is set at this time, clearing FORWARD also clears REWIND STATUS, terminating the rewind sequence);
- d. The Load Point indicator lamp is lit;
- e. If the DECmagtape is on-line (LOCAL(0) asserted) and selected by its controller, it will assert the transport BUS signal BBOT H (drawing TU10-0-07), indicating to the controller that it is at BOT.

4.3 MANUAL OPERATION

Manual operation of the transport is effected by the operator control box switches (refer to Paragraph 3.1). The detailed operation of each of the switches is explained in this section (drawing TU10-0-04).

PWR ON/PWR OFF – When this switch is in the PWR ON position, POWER ON L is at ground. This signal operates a relay in the power supply to apply the line voltage to the power transformer.

LOAD/BR REL – This switch has three positions. In its center, or “off” position, OFF L is asserted to clear the FAIL and RELAY ENBL flip-flops. When the switch is brought to the LOAD position, OFF L is negated and LOAD PULSE L is asserted for a few microseconds, setting RELAY ENBL and initiating the tape loading sequence. When the switch is brought to the BR REL position, OFF L is asserted and BRK REL L is asserted for brake release. For a more detailed explanation of these operations, see the relevant paragraphs of the section on Motion Logic.

ON-LINE/OFF-LINE – When this switch is quiescent in either position, no output occurs to change the state of the transport. When it is moved from its ON-LINE to its OFF-LINE position, OFF-LINE L is momentarily asserted, setting the LOCAL flip-flop (drawing TU10-0-05, coordinates D6/7). When the ON-LINE/OFF-LINE switch is moved from its OFF-LINE to its ON-LINE position, ON-LINE L is asserted for a few microseconds, clearing the LOCAL flip-flop.

Unless a rewind operation is in progress, the assertion of either OFF-LINE L or ON-LINE L causes the assertion of LINE SW CL L (drawing TU10-0-05, coordinates A2/3), which, in turn, causes the assertion of INIT L, clearing the FORWARD, REVERSE, and REWIND STATUS flip-flops and bringing tape motion to a halt.

The LOCAL flip-flop controls the operating mode of the transport. When LOCAL is cleared, the transport is on-line and all operations of the transport are directed by the tape control via the Transport Bus. When LOCAL is set, the transport is off-line and is effectively isolated from the Transport Bus. In this mode, tape motion is controlled by the FWD/REW/REV and START/STOP switches, as discussed below.

FWD/REW/REV – This three-position switch selects the direction of tape motion for off-line operations. When it is in the FWD position, M FWD L is asserted; in the REW position, M REW L is asserted; and in the REV position, M REV L is asserted. These signals do not initiate tape motion, but are strobed by the START L pulse as explained below.

START/STOP – When this switch is moved from its START position to the STOP position, STOP L is asserted for a few microseconds. If the transport is off-line (LOCAL(1) asserted) this causes a corresponding pulse at INIT L, clearing the FORWARD, REVERSE, and REWIND STATUS flip-flops (drawing TU10-0-05) and bringing tape motion to a halt. When the START/STOP switch is moved to the START position, START L is asserted, causing a short, HIGH-going pulse at START PULSE H (drawing TU10-0-05, coordinates D2). This pulse is ANDed with LOCAL (transport off-line) and MOTION (no operation in progress) to produce a pulse that strobes the M FWD L, M REW L, and M REV L lines. The assertion of one of these lines causes the FORWARD, REWIND STATUS, or REVERSE flip-flop, respectively, to be set, initiating tape motion in the indicated direction. Note, however, that if BOT L is asserted, the signal that sets the REWIND STATUS flip-flop is gated off, because the tape is already at BOT. Note also that if END POINT(1) H is asserted and FORWARD is set, INIT L is asserted to clear the FORWARD flip-flop and prevent running off the end of the tape.

4.4 ON-LINE OPERATION

When the LOCAL flip-flop is in its 0 state, the DECmagtape is on-line. In this state, all operations of the transport are directed by the tape control unit via the Transport Bus. The Transport Bus consists of 40 wires that connect the tape control unit to up to 8 transports. Unlike the TTL signal levels of the logic within the DECmagtape itself which are nominally +3V at high and 0V at low, logic levels on the Transport Bus are 0V at their high levels and -3V at low to allow compatibility with existing tape systems. Therefore, all Transport Bus signals are transmitted and received via level converters as shown on drawings TU10-0-07, TU10-0-08, and TU10-0-09.

To reduce the number of bus connections, certain Transport Bus wires (BBOT, BEOT, BWRL, and BRWS) are bi-directional: transmitting command signals from the controller to the transport during one phase of operation, and transmitting other signals from the transport to the controller at other times. Another set of wires (BRDP, and BRD (0:7)) transmit timing information to the controller when the transport is beginning and ending operations, but transmits to the controller data read from the tape during the operations themselves.

4.4.1 Transport Selection and Status Reporting

All of the transports in a system are wired to the same Transport Bus wires, but only one transport can be logically connected to the bus at one time; i.e., only one transport can transmit its status to the tape control and respond to commands, and only one transport can be reading or writing data at a given time.

To select the particular transport to converse with the tape control, the control transmits a binary code on Transport Bus lines BSEL0, BSEL1, and BSEL2. Each transport on the bus compares this code to the transport number, determined by the position of its unit select switch (drawing TU10-0-07). If the selection code transmitted by the tape control matches the transport number, and if the transport is on-line, SELECT REMOTE is asserted and the transport logically connects itself to the Transport Bus. All other transports remain logically disconnected and neither transmit nor respond to bus signals.

When a transport is logically connected to the Transport Bus, it transmits status information to the tape control as follows:

- B7CH H Asserted if a 7-track, rather than 9-track head is installed on the transport;
- BBOT H – Asserted when the tape is positioned at Load Point;
- BEOT H – Asserted when the END POINT flip-flop is set;
- BWRL H – Asserted when the tape unit is write-locked;
- BRWS H – Asserted when the REWIND STATUS flip-flop is set;
- BSDWN H – Asserted when the tape unit is settling down following an operation, i.e., asserted for about 10 ms following the command to terminate an operation while the capstan is coming to a halt.
- BTUR H – Asserted when the tape unit is ready to receive any command, i.e., when the transport is neither performing an operation nor settling down following an operation.

As shown in drawings TU10-0-08 and TU10-0-07, the transport also generates two clock signals that are transmitted to the tape control when the transport is connected to the bus;

- BC800 Consists of a constant stream of clock pulses, present at all times, at the rate at which data is transferred at 45 ips and 800 bpi, i.e., at 36 kHz;
- BC556 Consists of a stream of clock pulses, valid whenever the transport is selected for operation at 556 bpi recording density, at the rate at which data is transferred at 45 ips and 556 bpi, i.e., at 25.02 kHz.

These clock signals are used by the tape control in timing functions and in interpreting record formats.

4.4.2 Initiating Operations

The sequence of bus signals during execution of read space and write commands is shown in Figure 4-10. The various on-line operations of the DECmagtape are controlled in a similar manner: The tape control sends the specified function and the transport responds by moving tape in the specified direction until the tape control sends a stop signal. The rewind and unload operations are an exception to this, in that they continue to

completion even after the control unit has sent a stop signal to the transport. These operations are explained in more detail later.

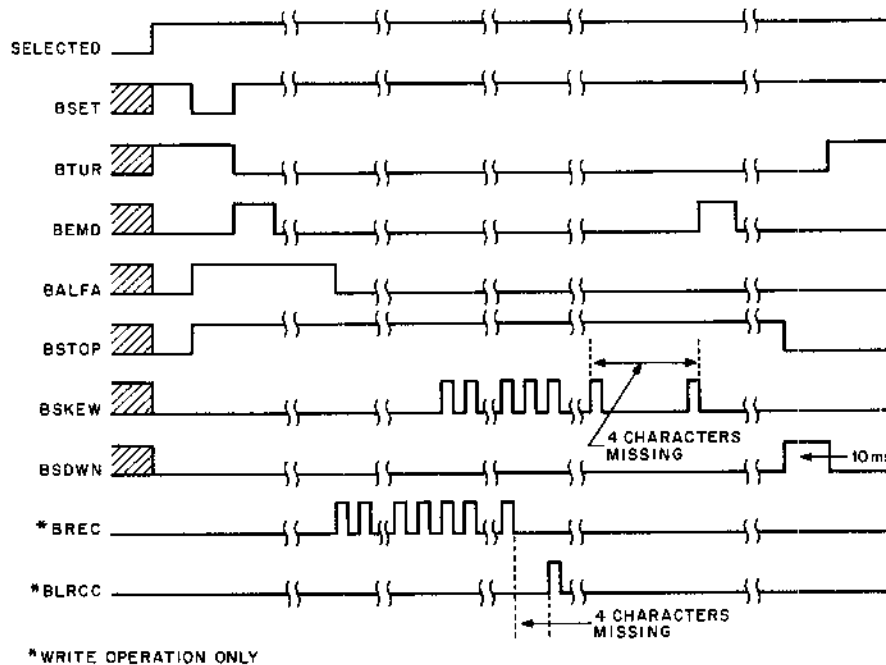


Figure 4-10 Write Operation Timing

On receipt of computer instructions, the tape control initiates operation by sending a negative pulse on the BSET line. Simultaneously, the particular tape function command is specified on the appropriate bus line(s). The command lines are listed and explained below (drawings TU10-0-05, TU10-0-07, and TU10-0-08).

BBOT H – When this line is HIGH (0V) at the HIGH-going (trailing) edge of BSET, (RFWD H and SET PULSE H), the FORWARD flip-flop is set, causing tape to move in the forward direction.

BREV H – When this line is asserted at the HIGH-going edge of BSET, the REVERSE flip-flop is set, causing tape to move in the reverse direction.

BEOT H – When this line is asserted at the HIGH-going edge of BSET, the REWIND STATUS flip-flop is set, initiating the rewind sequence and causing BRWS H to be asserted thereafter.

BRWS H – When this line is asserted at the HIGH-going edge of BSET and the tape unit is not write-locked, then the WRITE ENABLE flip-flop is set, turning on the write head drivers and beginning a Write operation. If, however, either BREV H (Reverse command) or BEOT H (Rewind command) is asserted at the trailing (HIGH-going) edge of BSET, then WRITE ENABLE will be cleared, because writing in the reverse direction is not allowed.

BWRL H – When this line is asserted at the HIGH-going edge of BSET, and BEOT H (Rewind command) is also asserted, then in addition to setting the REWIND STATUS flip-flop to initiate a rewind operation, the LOCAL flip-flop is set taking the unit off-line. This prevents a response to further commands from the tape control until the operator manually returns the transport to its on-line condition by moving the ON-LINE/OFF-LINE panel switch to its OFF-LINE position and then back to its ON-LINE position, clearing the LOCAL flip-flop.

Note that the function commands are sampled at the trailing (HIGH-going) edge of the BSET pulse. Several of the wires used to transmit function commands from the tape control to the transport are used at other times to transmit status information from the transport to the control. To prevent interference with the incoming function command signals, the transport removes its status from the BBOT, BEOT, BWRL, and BRWS lines when BSET goes low.

4.4.3 Terminating Operations

At the leading (LOW-going) edge of the BSET pulse, the tape control brings BSTOP to a HIGH (0V) level. For all operations except Rewind and Unload, BSTOP remains HIGH throughout the operation. When the tape control determines that tape motion should be stopped, it brings BSTOP to a LOW level (-3V). This generates CLEAR FUNCTION in the DECmagtape which clears the FORWARD and REVERSE flip-flops and brings tape motion to a halt (drawings TU10-0-07 and TU10-0-05).

For the Rewind and Unload operations, the tape control asserts BSTOP LOW soon after the trailing edge of BSET, but the function continues to completion; i.e., the fall of BSET has no effect, and the Rewind sequence continues until the transport stops at BOT.

4.4.4 Motion Delay

Records on tape are separated by blank areas, called interrecord gaps, of specified minimum length. The interrecord gaps allow the transport to accelerate the tape to operating speed before reading or writing. The transport must stop in approximately the middle of the interrecord gap after an operation in order to be able to accelerate to operating speed in either direction before beginning the next operation. Similarly, the transport must traverse a measured amount of tape before writing a record in order to leave a gap of the proper length between the record being written and the preceding record.

To control the length of tape traversed between initiating a command and beginning the record, the tape control unit times out an interrecord delay between sending the command and initiating data transfers. Similarly, to control the point in the interrecord gap at which the transport stops, the tape control times out an interrecord delay between reading the end of the record and sending BSTOP L to terminate tape motion.

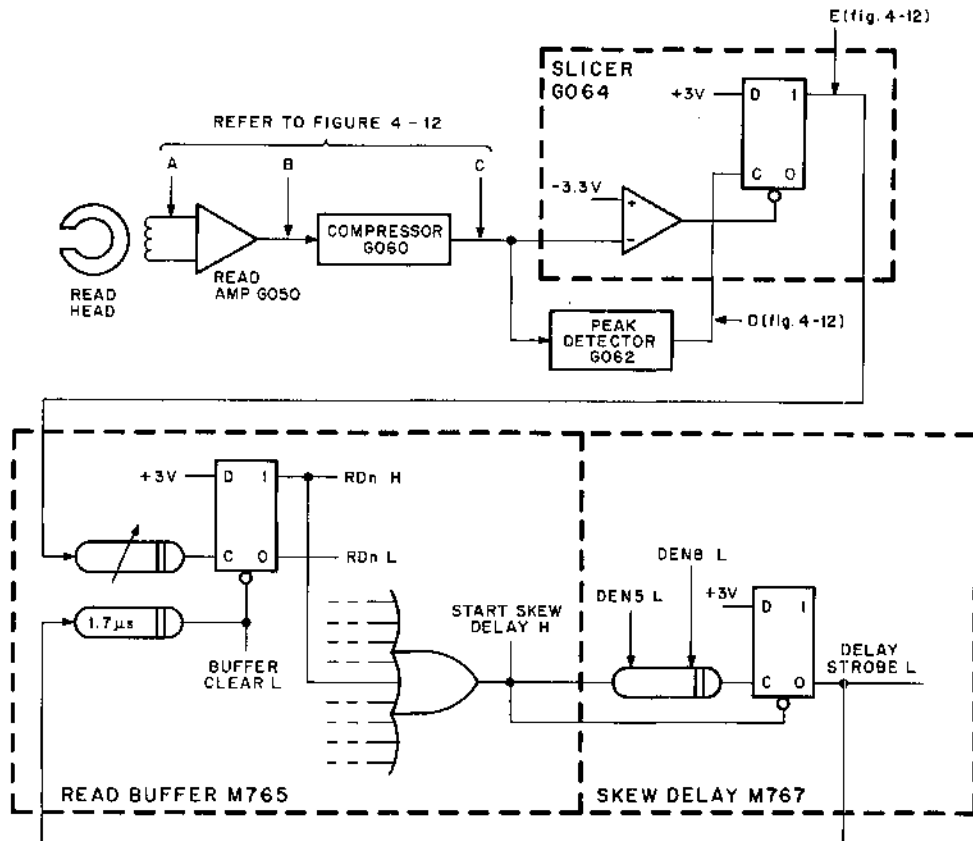
The interrecord delays are implemented by a count-down counter in the tape control, which is preset to a certain number and then counted down to zero by BC800 pulses received from the transport. Because the time to traverse a given length of tape while starting or stopping depends on the acceleration characteristics of the transport, and because several types of transports can be used with standard DEC tape controls, the tape control must interrogate the transport in order to determine the number of BC800 pulses required for the proper interrecord delay.

On transmitting a command to the transport prior to beginning the acceleration interrecord delay, and again on reading the end of the record prior to beginning the deceleration interrecord delay, the controller asserts BEMD H for a few microseconds, requesting the proper interrecord delay time. The DECmagtape responds by sending a code to the control that is a function of the command (Forward, Reverse, or Write) and the state of the BALFA Transport Bus line, a signal transmitted by the tape control which is HIGH for the acceleration delay and LOW otherwise. As shown on drawing TU10-0-08, the transport transmits the interrecord delay via the nine BRD(P, 0:7) lines, which are normally used to transmit read data from the transport to the control. When the tape control asserts BEMD H, the bus receiver generates DELAY OUT L (drawing TU10-0-07), which disables read data from the BRD lines and enables output of the appropriate interrecord delay code via these lines. The tape control then samples the code, negates BEMD H, and times out the appropriate delay before initiating data transfers or bringing BSTOP to a LOW state to stop tape motion.

4.4.5 Read and Space Operations

For the DECmagtape transport, there is no difference between a Read operation and a Space Forward operation; both are initiated by the tape control simply by commanding the transport to move tape in the forward direction. The Space Reverse operation differs from the Read/Space Forward operation only in the direction in which the transport is commanded to move tape. For all tape functions except Rewind and Unload (Read, Space, Forward, Space Reverse, and Write), the read circuits operate in essentially the same manner, and the transport transmits all data read to the tape control.

4.4.5.1 TU10 DECmagtape Transports up to No. 10320 – An equivalent circuit of one of the 9 (or 7) read channels is shown in Figure 4-11. Figure 4-12 shows possible read signal waveforms at the indicated points. For more complete and accurate representations, see drawings TU10-0-10 and TU10-0-08. Although for simplicity this discussion considers only one read channel, the user should remember that the read electronics includes either 9 or 7 identical, parallel read channels.



CP-0220

Figure 4-11 Equivalent Circuit of Read Timing and Read Circuitry for One Track (Units up to No. 10320)

The DECmagtape records and reads data in the NRZI (Non-Return-to-Zero Inverted) format, which means that each character written on tape contains at least one ONE bit. A ONE bit consists of a flux reversal, i.e., a reversal of the direction of magnetism of the tape. As the tape passes the read head, each flux reversal produces an output pulse of approximately 13 mV amplitude. Because alternate flux reversals in a given channel are of alternate

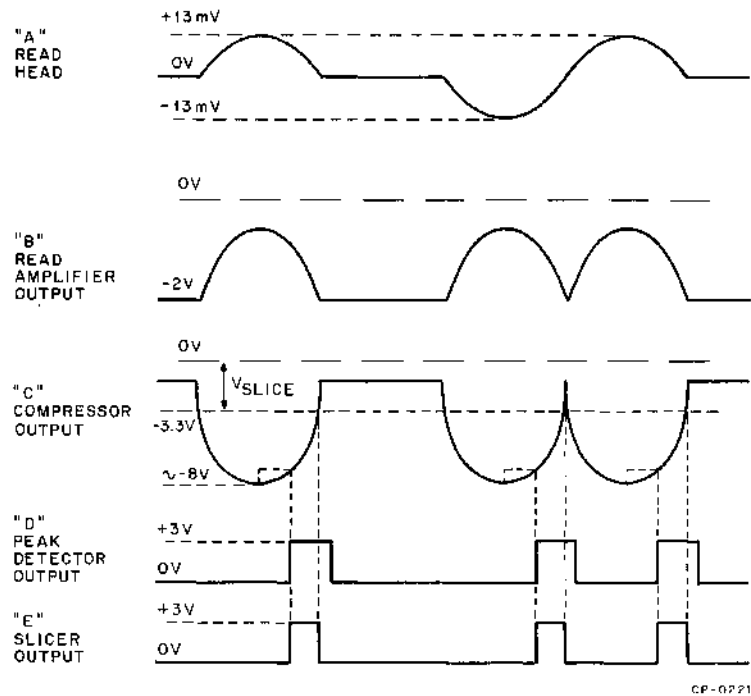


Figure 4-12 Read Circuit Waveforms (Units up to No. 10320)

polarity, the read head output pulses are of alternating polarity. The Read Amplifier (G050) amplifies and rectifies the read head output pulses, producing a positive-going pulse of approximately 1.5V amplitude peak-to-peak as each ONE bit passes the read head.

The Read Amplifier output is fed into the Compressor (G060) which inverts and amplifies the signal and logarithmically compresses the waveform. The Compressor also shifts the voltage level of the signal to an adjustable predetermined level to establish the Slice Voltage, discussed later in this section.

The output of the Compressor is routed to two circuits, the Peak Detector (G062) and the Slicer (G064). The Peak Detector is somewhat misnamed in that it does not actually detect the peak of the Compressor output waveform, but rather generates a positive-going logic level transition when the Compressor output swings approximately 1.4V more positive than its negative peak, on the trailing side of the Compressor output pulse (see Figure 4-12). This signal does, however, have a fixed phase relationship to the peak of the Compressor output independent of the magnitude of the Compressor output pulse due to the logarithmic transfer function of the Compressor.

The outputs of both the Compressor and Peak Detector are fed to the Slicer. The Slicer output normally goes HIGH at the HIGH-going edge of the Peak Detector output and remains HIGH until the Compressor output goes more positive than -3.3V. If, however, the Compressor output is more positive than -3.3V at the time of a HIGH-going transition of the Peak Detector output, the Slicer output will not go HIGH at all. The Peak Detector must be sensitive to low-level signal transitions in order that its output be accurately referenced to the signal peak, so as to avoid phase shift or skew between channels. This makes it very sensitive to low-level noise pulses. The Slicer eliminates this low-level noise by requiring that the Compressor output pulse exceed a certain voltage, called the Slice Voltage, in order to recognize a pulse as a valid ONE bit.

As mentioned earlier, the effective Slice Voltage is adjusted by the Compressor by means of shifting its quiescent output voltage up or down as desired. The Slice Voltage is adjusted to give maximum noise rejection while retaining the ability to read weak data from badly worn tapes. The Slicer output is a HIGH-going logic signal of a few microseconds duration each time a ONE bit is read. Due to both electrical and mechanical delays, the Slicer output pulses for the several read channels may be "skewed", or displaced in time, relative to each other. This skew consists of two components. Static skew is caused by errors in head alignment (azimuth error), tolerance in the location of read gaps relative to each other in the read head (gap scatter), and differing signal propagation delays through the read electronics, all of which result in a fixed time displacement of one channel relative to another. Dynamic skew is caused by variations in tape speed and position during both reading and writing (mechanical dynamic skew), magnetic effects during both writing and reading (write crosstalk, pulse crowding, etc.), and variable skew introduced in the read electronics, such as shift in the peak detection caused by superimposed noise, all of which produce skew between channels which varies with time.

The Read Buffer (M765), in conjunction with the skew delay section of the Clock and Skew Delay (M767), eliminates both static and dynamic skew so that all channels are aligned and the bits of a character can be read out in parallel. The Read Buffer receives and holds data from the Slicer. It consists primarily of nine data-holding flip-flops with delayed inputs. Each delay is implemented as an eight-bit shift register clocked at a shift rate of 576 kHz. Each shift register has an associated eight-position switch that selects the output from one of the eight stages of the shift register. Thus, according to the switch setting, the Slicer output pulse is delayed from one to eight stages, at approximately 1.7 μ s per stage. By adjusting the switch setting of each channel, static skew between channels can be "tuned out" and, reduced to less than 1/2 stage delay, or about 870 ns, maximum.

The output of each shift register delay line is fed to the clock input of the corresponding holding flip-flop (RD (P, 0:7)). The leading (HIGH-going) edge of each delayed Slicer pulse sets the flip-flop for that channel. The flip-flop outputs are transmitted to the tape control on Transport Bus lines BRD (P, 0:7) H (drawing TUI0-0-08). The outputs of all Read Buffer channels are ORed to produce START SKEW DELAY H. Thus, when the first bit is set, START SKEW DELAY H is asserted. This signal goes to the Skew Delay and enables the Skew Delay counter. The Skew Delay compensates for dynamic skew by providing a delay time in which all bits can be read for the particular character that is passing under the read head. When the Skew Delay times out, it asserts DELAY STROBE L. This causes the Transport Bus line BSKEW II to be asserted, informing the tape control that a character has been read and can be strobed from the BRD (P, 0:7) lines. After one period of the CLOCK L signal, approximately 1.7 μ s, the Read Buffer is cleared, negating START SKEW DELAY H. This causes the Skew Delay counter to be reset, and DELAY STROBE L is negated. The Read Buffer and Skew Delay are then ready for the next character.

To provide maximum immunity to skew, the Skew Delay should be equal to 1/2 the period between characters. The period varies according to the recording density of the tape being read; thus, the Skew Delay counter is initialized to a number that varies with the recording density. The tape control indicates the recording density by transmitting a code on Transport Bus lines B DEN5 H and B DEN8 H, as in the table below:

B DEN5 H	B DEN8 H	Density	Skew Delay
-3V	-3V	200 bpi	56 μ s
0V	-3V	556 bpi	20 μ s
any	0V	800 bpi	14 μ s

In concluding this discussion of the read electronics, two facts should be noted: First, the DECmagtape transport does not perform format recognition operations, such as parity checking and recognizing the end of the record; these functions are performed by the tape control. Second, for a character to be recognized and read from tape, it must contain at least one ONE bit; thus, tapes must be written with ODD parity if the data contains any all-zeros characters. (The BCD code, which is normally written with even parity, does not use the all-zeros character.)

4.4.5.2 TU10 DECmagtape Transports Above No. 10320 – An equivalent circuit of one of the 9 (or 7) read channels is shown in Figure 4-13. Figure 4-14 shows possible read signal waveforms at the indicated points. For more complete and accurate representations, see drawings D-BS-TU10-0-10 and D-BS-TU10-0-08. Although for simplicity this discussion considers only one read channel, the user should remember that the read electronics includes either 9 or 7 identical, parallel read channels.

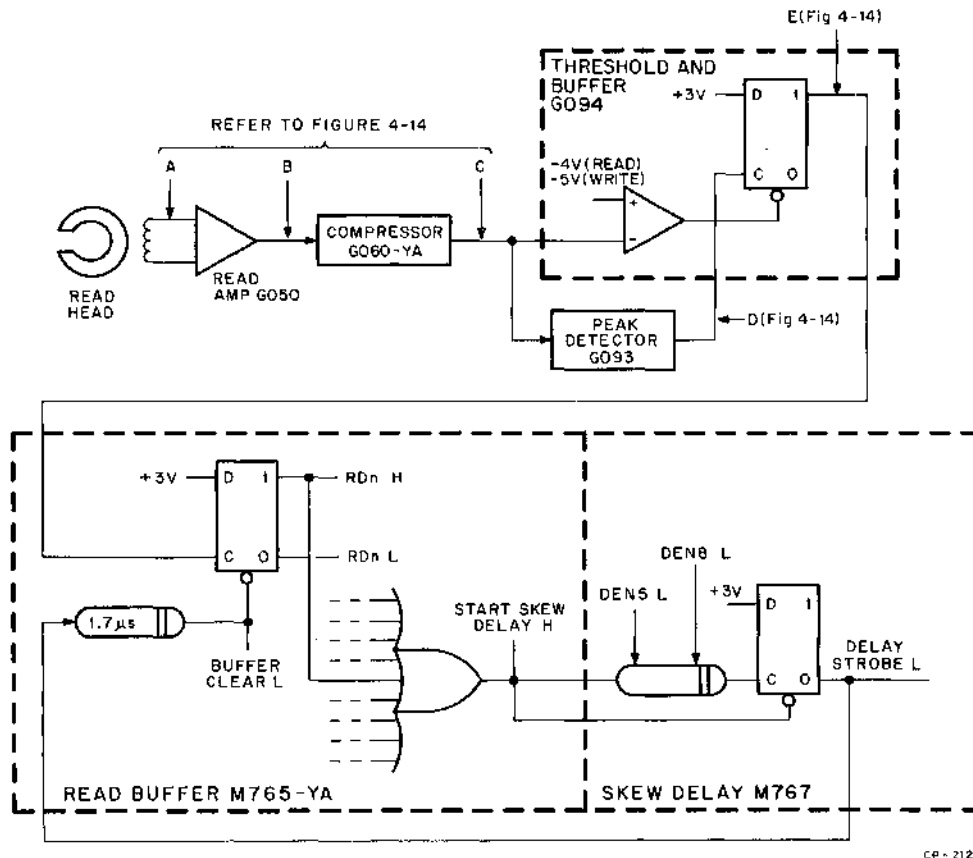


Figure 4-13 Equivalent Circuit of Read Timing and Read Circuitry for One Track (Units Above No. 10320)

The DECmagtape records and reads data in the NRZI (Non-Return-to-Zero Inverted) format, which means that each character written on tape contains at least one ONE bit. A ONE bit consists of a flux reversal, i.e., a reversal of the direction of magnetism of the tape. As the tape passes the read head, each flux reversal produces an output pulse of approximately 13 mV amplitude. Because alternate flux reversals in a given channel are of alternate

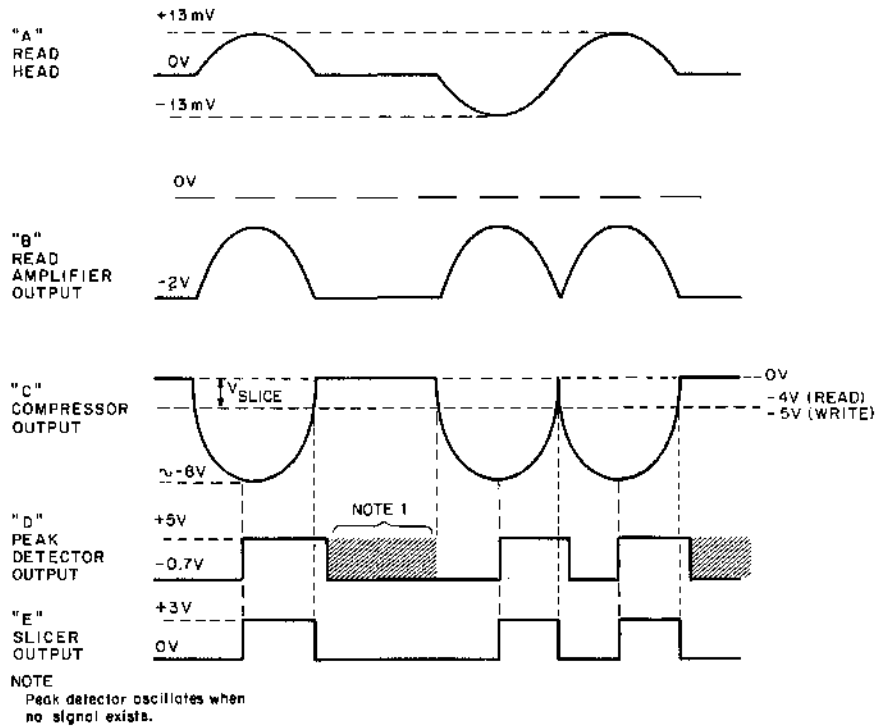


Figure 4-14 Read Circuit Waveforms (Units Above No. 10320)

polarity, the read head output pulses are of alternating polarity. The Read Amplifier (G050) amplifies and rectifies the read head output pulses, producing a positive-going pulse of approximately 1.5V amplitude peak-to-peak as each ONE bit passes the read head.

The Read Amplifier output is fed into the Compressor (G060-YA), which amplifies the signal in a logarithmic fashion. This logarithmic amplification tends to minimize variations in head output caused by differences in heads, tapes, or tape defects.

Unlike the G060 used in prior units, the G060-YA does not induce a variable dc offset in its output signal. Rather, its output always maintains a null signal level slightly (approximately 0.3V) below ground (Figure 4-14).

The Compressor output is routed to two circuits, the G093 Peak Detector and the G094 Threshold and Buffer. The G093 is a true peak detector, differentiating the input signal to produce a transition about one microsecond after the input peak occurs, regardless of the amplitude or shape of the peak. As Figure 4-14 indicates, the output of the G093 oscillates when no signal is fed to it.

The G094 compares the Compressor output to a reference voltage. That voltage should be between -3.5V and -4.0V when reading, and between -4.5V and -5.0V when writing. Whenever the G094 input from the Compressor exceeds (becomes more negative than) the reference voltage, the output of the G093 is enabled to clock a ONE into the corresponding position of the buffered output of the G094. That bit is automatically reset to a ZERO when the Compressor output climbs back above the G094 reference voltage.

The G094 output is next fed into the M765-YA Read Buffer, which differs from the M765 used in prior units only in that the shift register formerly used for deskewing purposes has been deleted. As a result, the 1.8 micro-second maximum latency between detection of a ONE at the G094 and detection of a ONE at the M765 has been eliminated.

4.4.6 Write Operation

The write circuitry is shown in drawing TU10-0-09. To initiate a Write operation, the tape control sends to the transport both the Forward and Write Enable commands (BBOT H and BRWS H with BSET). This causes tape to move forward and sets the WRITE ENABLE flip-flop, as previously discussed. The Write operation proceeds as follows: Prior to receiving the command, the head drivers are turned off so that no current flows through the write and erase heads, and all of the flip-flops in the write circuitry are reset. When the WRITE ENABLE flip-flop is set, the head drivers are turned on, putting current through the erase and write heads in the "erase" direction, and the tape begins to move forward. After the interrecord delay, the tape control begins sending characters of data to the transport. To do this, the tape control puts each character onto the BWD (P, 0:7) H Transport Bus lines, and when the character is to be written, it puts a positive pulse on the BREC H line. The assertion of BREC H produces two corresponding signals from the DECmagtape bus receivers: C STROBE L, which goes from 0V to -3V and WRITE STROBE H, which goes from 0V to +3V. The BWD (P, 0:7) H write data lines are connected to the resistor inputs of nine level-shifting, resistor-capacitor-diode gates. The diode (strobe) inputs of the gates are all driven by C STROBE L; at the falling edge of C STROBE L, negative-going pulses of about 100 ns duration appear at the outputs of those resistor-capacitor-diode gates whose resistor input has been enabled by a ONE (0V) input from its corresponding BWD line. The output pulses set corresponding flip-flops in the Write Skew Buffer. At the same time, WRITE STROBE H sets a flip-flop that causes a single ONE bit to be shifted into an eight-bit shift register called the Write Strobe Delay, which is shifted by the CLOCK L signal every 1.7 μ s. As the pulse is shifted through the Write Strobe Delay, it produces a HIGH-going pulse on each of the Write Strobe Delay outputs in turn. The reset input of each flip-flop in the Write Skew Buffer is connected through an eight-position switch to one of the Write Strobe Delay outputs. As the delayed WRITE STROBE pulse is shifted into the selected stage of the Write Strobe Delay shift register, the Write Skew Buffer flip-flop is cleared, producing a negative-going transition on its output if the flip-flop was previously set by a BWD input.

The outputs of the Write Skew Buffer are connected to the clock inputs of corresponding flip-flops in the Write Data Buffer. When a flip-flop in the Write Skew Buffer is set by its corresponding BWD line and is then cleared, it causes the corresponding bit of the Write Data Buffer to be complemented. The outputs of the Write Data Buffer determine the polarity of the current produced by the head driver for the corresponding channel. Thus, each time a bit of the Write Data Buffer is complemented, a flux-reversal (ONE bit) is written on tape.

To summarize, when the tape control asserts BREC H, the write data on BWD (P, 0:7) H is strobed into corresponding bits on the Write Skew Buffer. After a delay that is determined by a separate switch for each channel, each bit of the Write Skew Buffer that was set is cleared, causing corresponding bits of the Write Data Buffer to complement. This, in turn, reverses the direction of magnetization of the tape, writing a ONE. By adjusting the Write Strobe Delay switches for each channel, the writing of each channel can be delayed relative to the others so as to "tune out" write skew caused by head misalignment, gap scatter, etc.

After all the data characters of the record (including the CRC character, if any) have been written (as determined by the tape control), the tape control sends a positive-going pulse on the BLRCC H line to cause the LRCC (Longitudinal Redundancy Check Character) to be written. The BLRCC H pulse is received by a DECmagtape bus receiver that produces a corresponding pulse on LRCC STROBE H. Assertion of LRCC STROBE H causes every bit of the Write Skew Buffer to be set and initiates a pulse in the Write Strobe Delay. The effect is as though the tape control had sent a BREC H pulse with data of all ONES, with one exception: In the absence of a BREC H pulse, the J inputs of the J-K flip-flops that compose the Write Data Buffer are disabled; the K inputs are always enabled; thus, when the LRCC is written, the Write Data Buffer is set to ZERO, instead of being complemented. ONES (flux reversals) are written on tape in only those channels for which the Write Data Buffer was ONE prior to writing the LRCC. Because all bits of the Write Data Buffer were ZERO when the record began, were complemented each time a ONE was written in that channel, and are ZERO after the LRCC, it can be seen that the LRCC consists of even-forcing parity bits for each channel on the tape.

The read, write, and erase heads are arranged so that tape passes first over the erase head, then over the write head, and finally over the read head. During a Write operation, the read circuits are also active, reading the record after it is written and returning it to the tape control for verification of character parity and LRCC in order to ensure that the record was written correctly. During a Write operation, the read electronics perform exactly as during a Read operation, with one exception: The assertion of WRITE ENABLE(1) L causes the Compressor to shift the Slice Level, so as to require a stronger output pulse in order to recognize a ONE bit. This is done so that if the tape is nicked or badly worn, errors will result in the data read back, and the marginal quality of the record will be detected during the Write operation, when the record can easily be rewritten.

After writing LRCC, the transport continues to move tape, reading and verifying the record. When the tape control reads the end of the record, it begins the interrecord delay, after which it asserts BSTOP L, clearing the FORWARD flip-flop and bring tape motion to a halt. To ensure complete erasure of the interrecord gap, the WRITE ENABLE flip-flop remains set; therefore, the head drivers continue to put current through the erase and write heads in the erase direction (Write Data Buffer ZERO) until tape motion has come to a complete stop, as determined by the time-out of the RUNNING one-shot (drawing TU10-0-06 and TU10-0-05). The WRITE ENABLE flip-flop is then cleared, turning off current to the write and erase heads and completing the Write operation, simultaneously with the assertion of READY L.

In concluding this discussion of the Write operation, note that while the DECmagtape transport does generate the LRCC, character parity (vertical parity) is generated by the tape control, and data from the BWDP H line is written exactly like data from the BWD (0:7) H lines. Further, all checking of read data, including the LRCC, is performed by the tape control.

CHAPTER 5

MAINTENANCE

5.1 INTRODUCTION

This chapter contains preventive and corrective maintenance procedures for the TU10 DECmagtape. Table 5-5 lists the recommended test equipment. A list of spare parts for the TU10 is provided in Tables 5-6 through 5-9. Appendix A contains both voltage and frequency conversion information and 7- to 9-track conversion information. The major TU10 assemblies referenced throughout this chapter are shown in Figure 5-1. Access to the interior components of the TU10 is gained by rotating the service locks in the upper left-hand side and the lower right-hand side of the TU10 to release the unit from the cabinet (see Figure 5-2a).

NOTE

The recommended frequencies for performing the PM steps in these procedures are based on moderate usage of the equipment. In cases where usage is heavy, certain steps should be performed more frequently.

For example, steps 1 and 9 through 16 of the quarterly procedure assume that tape motion will not exceed 150 hours/quarter; if tape motion exceeds that figure, the steps should be performed more often. (Tape motion = Time spent actually moving tape; this must be decreased by 1/2 if software is not double-buffered, or if two drives exist on the same controller.)

Step 2 of the quarterly procedure assumes that vacuum on-time will not exceed 1000 hours/quarter; if vacuum on-time exceeds that figure, this step should be performed more frequently. (Vacuum on-time = Time that tape is loaded on a drive with vacuum on, whether or not the tape is actually moving.)

Steps 1 through 8 of the semiannual procedure assume that tape motion will not exceed 300 hours during a 6-month period; if tape motion exceeds that figure, these steps should be performed more frequently.

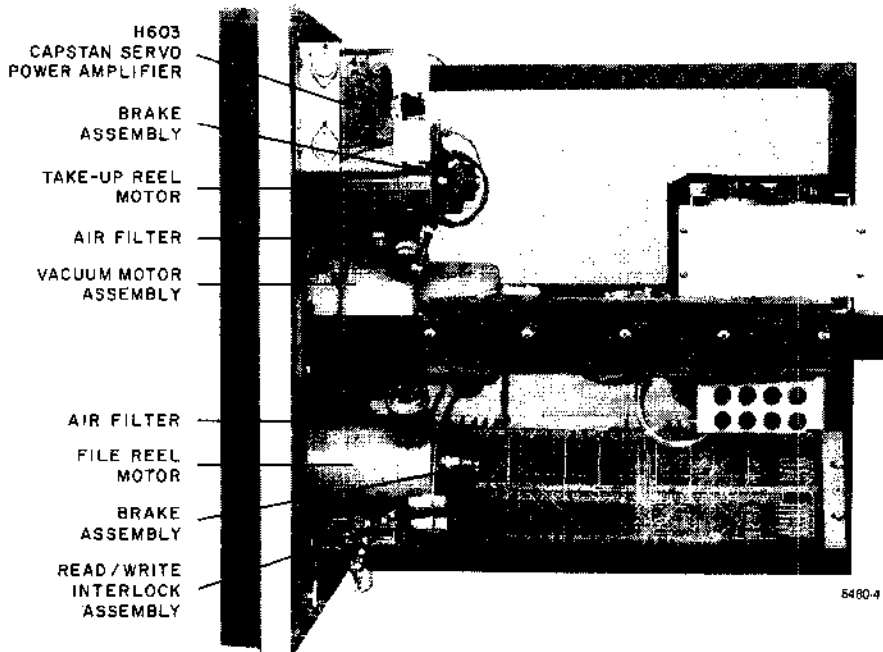
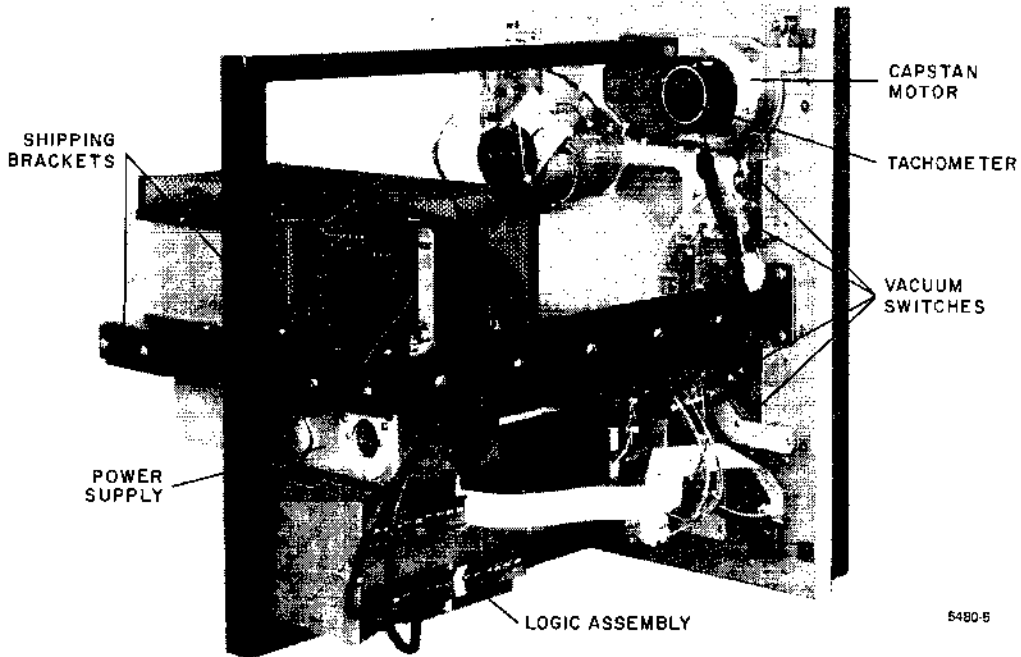
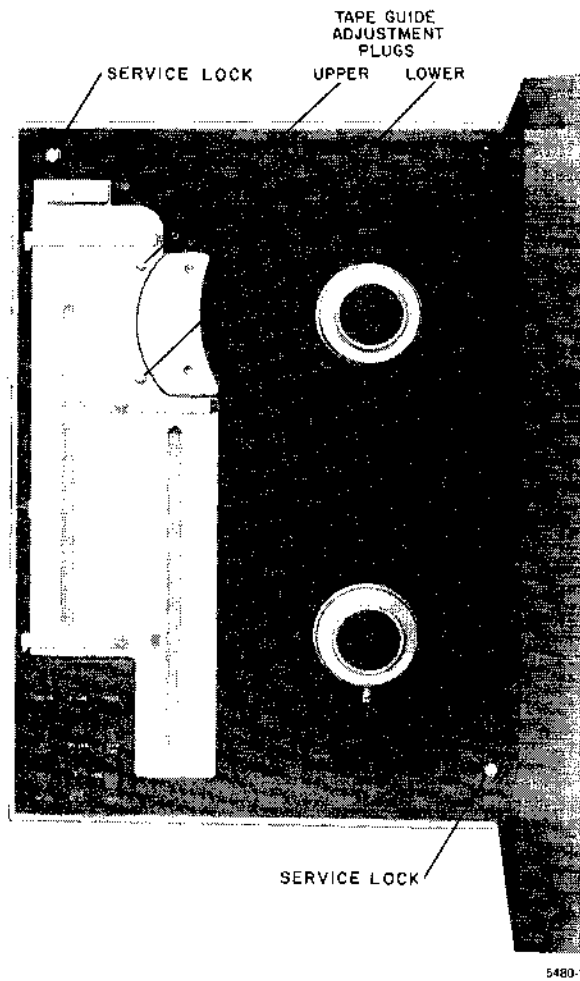
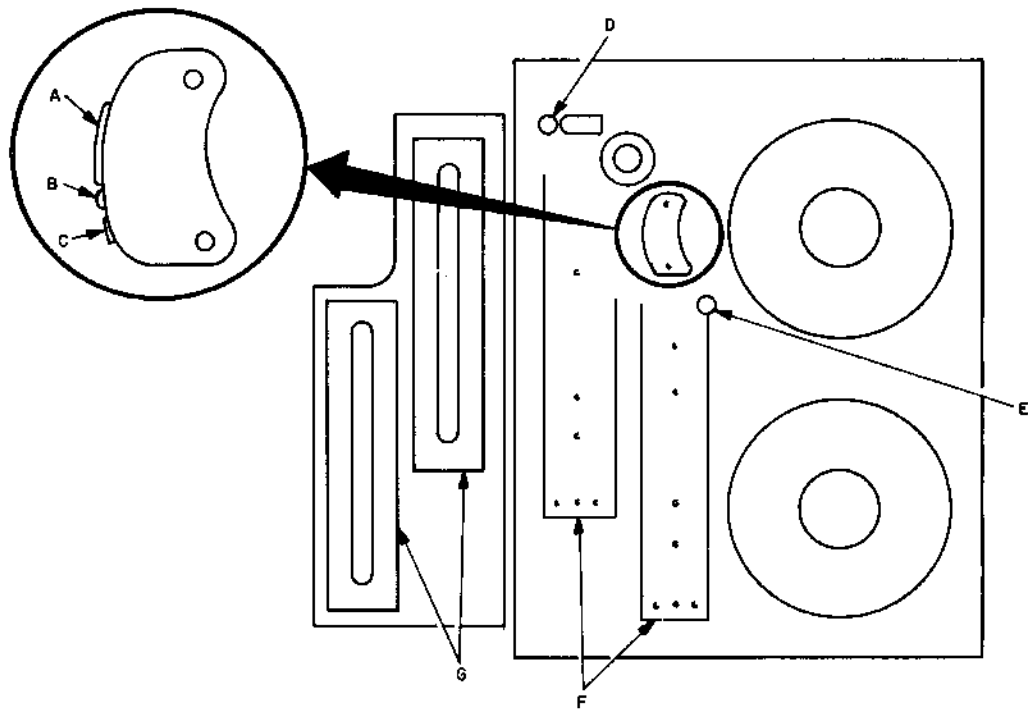


Figure 5-1 TU10 Tape Transport Assemblies



5480-1

a. Transport Service Locks



11 - 3357

b. Cleaning Areas

Figure 5-2 Daily Equipment Care Areas

5.2 DAILY (8-HOUR) PREVENTIVE MAINTENANCE PROCEDURES

The inspection and cleaning procedures described in this section should be performed daily to ensure optimum operation of the TU10 DECmagtape. A summary of these preventive maintenance procedures is listed in Table 5-1.

NOTE

Remove tape or wind all tape onto file reel prior to performing any of the cleaning procedures.

Table 5-1
Preventive Maintenance Schedule

Daily (8-Hour) (Paragraph 5.2)
Clean Read/Write Head
Clean Erase Head
Clean Tape Cleaner
Clean Roller Guide
Clean Vacuum Pockets
Clean Vacuum Door Glass
Monthly (160-Hour) (Paragraph 5.3)
Clean Outer Door
Clean Cabinet Interior
Clean Cabinet Filter
Disassemble and Clean Reel Motor Brakes
Check Operator Panel Switches and Indicators
Clean and Inspect Tape Path
Inspect Reel Hubs
Quarterly (500-Hour) (Paragraph 5.4)
Replace Vacuum Motor Brushes
Perform Diagnostic Checks
Semiannual (1000-Hour) (Paragraph 5.5)
Check Capstan Speed and DC Balance
Check Capstan Acceleration and Deceleration Times
Check Capstan Jitter
Check Static and Dynamic Mechanical Skew
Check Electrical Read Skew
Check Electrical Write Skew
Check Read and Write Slice Levels
Check Industry-Compatible Tape Tracking
Check Power Supply Voltages
Check Read/Write Interlock Assembly
Check Tape Guide Rollers
Check Delay Diodes
Align Tape Path
Adjust Vacuum System

CAUTION

Two types of DECmagtape cleaning fluid exist. One type is clearly labeled Freon TF113; the other is labeled only with a DIGITAL label. Freon TF113 is a mild solvent that will not harm capstans, painted surfaces, or plexiglass, and can be used to clean all parts of the tape drive. The other cleaning fluid contains a mixture of Freon and alcohol. It will attack painted surfaces and some plastics, particularly the plastic used on the capstan. When cleaning a tape drive with this type of fluid, use only water to clean the capstan, painted surfaces, and the plexiglass insert in the tape drive door. In all cases, whether using pure Freon or a Freon-alcohol mixture, care must be taken to ensure that no fluid comes in contact with magnetic tape.

5.2.1 General Cleaning and Equipment Care

1. Clean following with swab and DECmagtape Cleaning Fluid (DEC part no. TUC-01).
 - a. Read/Write Head (A in Figure 5-2b)
 - b. Erase Head (B)
 - c. Tape Cleaner (C)
 - d. Upper Roller Guide (D)
 - e. Lower Roller Guide (E) (Check carefully for freedom of lower spring-loaded washer guide)
2. Clean following with lint free cloth and DECmagtape Cleaning Fluid.
 - a. Vacuum Pockets (F)
 - b. Vacuum Door Glass (G)

NOTE

Certain conditions may cause the unit to require more frequent cleaning; e.g., high temperatures in excess of 80° F, high humidity in excess of 80 percent, new tape, dust environment, etc. Most errors are caused by dirt or oxide buildup.

5.3 MONTHLY (160-HOUR) PREVENTIVE MAINTENANCE PROCEDURES

The following procedures should be performed monthly, in addition to the daily (8-hour) procedures.

A summary appears in Table 5-1.

5.3.1 Outer Door and Cabinet Interior

Use a moistened or lint-free cloth to wipe off all material buildup on the reel hub surfaces, especially around the rubber ring. Dust and clean the outer door. Clean all dust from the interior surfaces of the cabinet using a vacuum cleaner with a brush attachment.

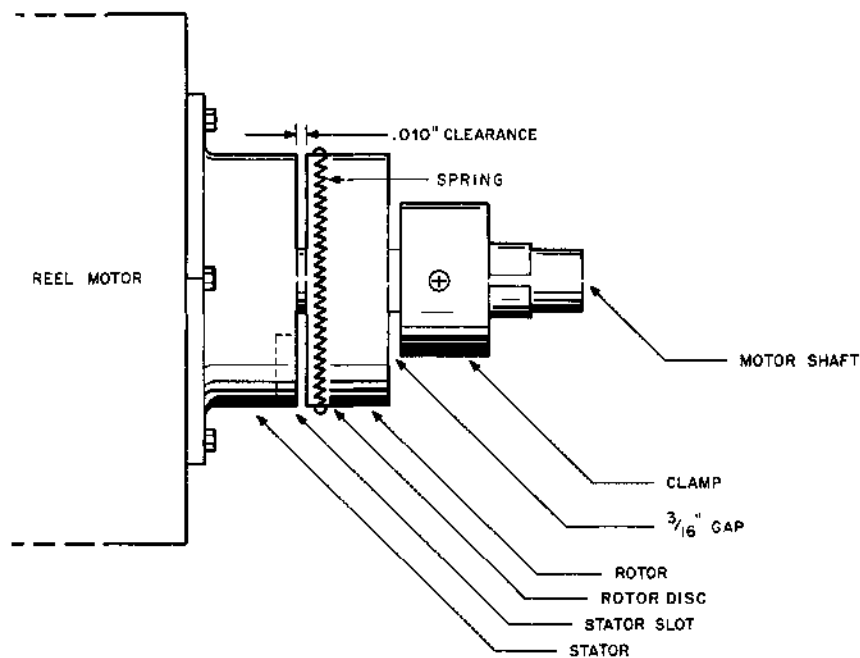
5.3.2 Cabinet Filter

Remove the cabinet filter and vacuum and wash it with water. Allow the filter to dry completely before re-installing it in the cabinet.

5.3.3 Reel Motor Brakes

Disassemble, clean, and reassemble the reel motor brakes according to the following procedure:

1. With power OFF, pull the transport out on its slides. (Access brakes from the right side of the transport; operation is identical for both reel motors.)
2. Loosen the Allen-head screw located on the clamp. (See Figure 5-3)



CP-1539

Figure 5-3 Reel Motor Brake Assembly

3. Remove the spring and brake assembly. Push a cotton swab through each of the inserts (locating holes) that hold the rotor disk and rotor to ensure that they are securely held in the rotor and that they do not protrude in such a way as to interfere with operation of the rotor disk. If inserts are loose, replace the brake assembly.
4. Using a clean, dry, lint-free cloth or wipe, clean the following:
 - a. The brake surface of the stator (Figure 5-4). (Stator is still on motor.)
 - b. Both sides of the rotor disk, including location pins.
 - c. The face of the rotor next to the rotor disk.

NOTE

Avoid skin contact with brake surfaces; body oils are detrimental to brake function.

5. Install the rotor disk into the rotor; select the mating combination that allows for smoothest insertion and retraction of rotor disk pins into the rotor locating holes. Try each of the 120-degree intervals for best fit.

NOTE

New brake assemblies have been burnished at the factory. Do not disassemble new assemblies.

6. Replace the brake, leaving a clearance of 0.010 inch between the rotor disk and the stator and a 3/16 inch clearance between the rotor and the clamp. In this position, the clamp should be clamping on the splits cut into the sleeve of the rotor, ensuring that the rotor is fastened securely to the reel motor shaft. When clearances are correct, tighten the Allen screw.
7. With the 0.010-inch feeler gauge inserted between the stator and the rotor, rotate the reel motor manually from the front of the unit to see that the brake is spaced uniformly all around. If necessary, rotate the brake at 120-degree intervals to determine the best position for uniform separation. (An excessively high or low spot is cause for replacing brake assembly.)
8. Remount the rotor spring between the rotor disk and the rotor.
9. When the above steps have been completed for both reels, rotate both reels, feeling for free rotation and listening to ensure that there is no squealing from stator/rotor disk contact.

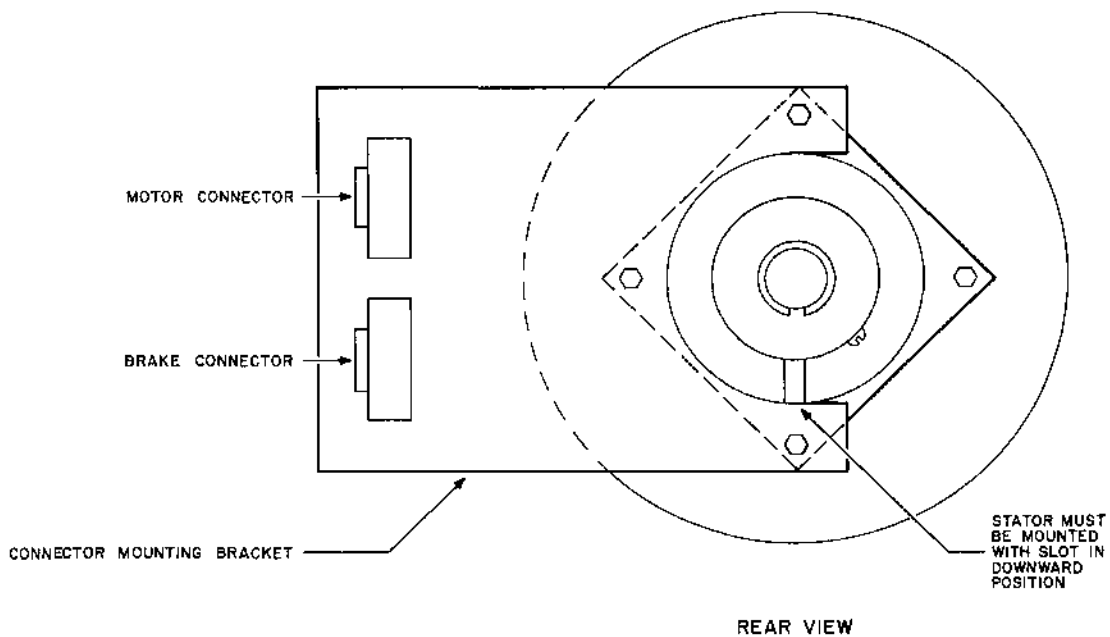


Figure 5-4 Stator Mounting

5.3.4 Control Box

Check the operator panel switches and indicators as follows. (Replace switches and/or indicators as required.)

1. Apply power to the TU10; ensure that the OFF-LINE and PWR indicators on the control panel are ON.
2. Place a scratch tape (with write ring) on the lower hub and secure the hub lock. Set the LOAD/BR REL switch to LOAD and then back to BR REL. Ensure that both reels turn freely and that the FILE PROT light does not light as the supply reel is rotated.
3. Thread the scratch tape through the tape path and take two wraps around the take-up reel. Set the LOAD/BR REL switch to LOAD; ensure that the LOAD indicator on the control panel comes ON.
4. Place the FWD/REW/REV switch to FWD; place the START/STOP switch to STOP and then back to START. Ensure that the FWD indicator is lit while the drive is moving the tape toward BOT, and that the LD PT indicator lights when the drive stops at BOT.
5. Run the tape forward for approximately 30 seconds; set the START/STOP switch to STOP.
6. Set the FWD/REW/REV switch to REV; press START. Allow the tape to run in reverse for approximately 10 seconds and ensure that the REV indicator is ON. Place the START/STOP switch in the STOP position.
7. Set the FWD/REW/REV switch to REW; press START. Ensure that the REW indicator is ON.
8. Set the ON LINE/OFF LINE switch to ON LINE. When the drive has completed the rewind operation in step 7, above, check that the RDY indicator comes ON. Check that the SEL indicator also comes ON if the controller is currently selecting this TU10.
9. Set the ON LINE/OFF LINE switch to OFF LINE and the LOAD/BR REL switch to BR REL. Dismount the tape and remove the write enable ring. Mount the tape and ensure that the FILE PROT indicator is ON. Rotate the reel; ensure that the FILE PROT indicator remains ON.

5.3.5 Tape Path

Clean the tape path and inspect it for wear as follows:

1. Turn power OFF. Remove and clean the take-up reel, using a Kimwipe dampened with water or Freon; inspect the take-up reel for cracks or loose center ring (hub interface). Replace if defective.
2. Remove supply reel (if installed). Using water- (or Freon-) dampened Kimwipes, clean the deckplate surfaces and front door.

CAUTION

Be careful not to saturate the Scotch-Lite lining on the vacuum column walls with fluid; this could cause damage to the lining.

3. Remove the head cover and open the vacuum door.

- Using a penlight flashlight, inspect the read/write head and erase head for oxide accumulation. A worn head will normally show oxide accumulation on the worn spot. If the read/write head is unevenly worn or if the erase head shows any wear, replace the head plate assembly. (Refer to Figure 5-5; shiny spots indicate uneven wear.)

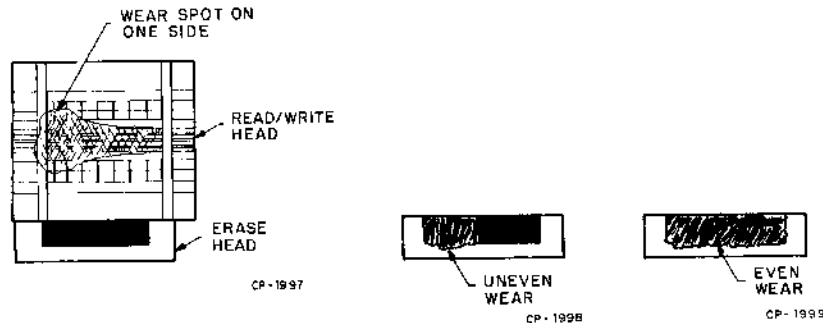


Figure 5-5 Examples of Head Assembly Wear Characteristics

NOTE

Wear spots of any kind on erase head are bad.

- Using DECmagtape cleaning fluid and cotton-tipped wooden swabs, clean any accumulated oxide from the read/write head, erase head, tape cleaner, and fixed guides. (Pay particular attention to removing oxide buildup from ceramic surfaces of fixed guides.)

NOTE

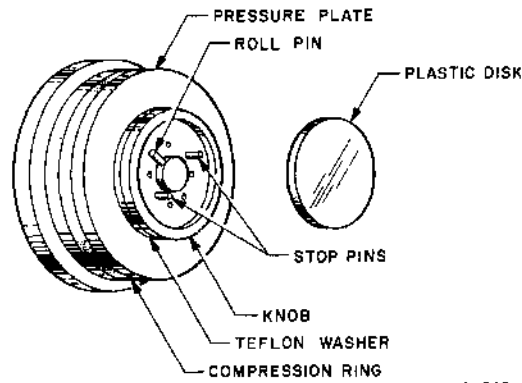
Ensure that the inner (spring-loaded) guides move freely after cleaning and that they are not jammed under the fixed guides.

- Clean vacuum columns and vacuum column doors with DECmagtape cleaning fluid and Kimwipes. Clean roller guides with cotton swabs and DECmagtape cleaning fluid.

5.3.6 Reel Hubs

Inspect reel hubs as follows. (Refer to Figure 5-6.)

- Place the take-up reel on the lower hub. Turn the hub lock until it hits the stop pin. Hold the hub with one hand and attempt to turn the reel counterclockwise with the other hand.



10-1303

Figure 5-6 Hub Composition

2. If the hub lock does not hit the stop when tightened or if the reel turns while the hub is being held stationary, readjust the hub pin and replace the compression ring according to the following procedure.
 - a. Remove power from the TU10 and remove the tape reel.
 - b. Carefully snap out the plastic disk from the reel hub.
 - c. Mark the position of the center roll pin in the hub guide.
 - d. Using a pair of heavy duty diagonal pliers, carefully remove the center roll pin.
 - e. Grasp the reel hub and unscrew the knob from the hub.
 - f. Remove (in order) the Teflon washer, pressure plate, and rubber compression ring.
 - g. Install (in order) the new compression ring, (P/N 12-10021) pressure plate, and Teflon washer.
 - h. Lightly tighten the knob on the hub until the compression ring is compressed and fully seated.
 - i. Loosen the knob until it is free of the Teflon washer. Then gently screw it in until it just touches the washer.
 - j. Reinstall the roll pin in the same hole from which it was removed (step d, above).

- k. Turn the knob counterclockwise until the roll pin makes contact with one of the two hub stop pins.
 - l. Try to install a tape reel on the hub. If the tape reel does not easily slip on the hub, move the stop pin back one hole at a time until the knob can be released far enough to permit the tape reel to slip on the hub.
 - m. With a tape reel installed, tighten the knob (clockwise) until the roll pin contacts the other hub stop pin. If the tape reel is not secure, move the stop pin ahead until the knob can be tightened correctly.
3. Place the take-up reel on the upper hub. Repeat the procedure followed for the lower hub take-up reel in step 2, above.

5.4 QUARTERLY (500-HOUR) PREVENTIVE MAINTENANCE PROCEDURES

The following procedures should be performed quarterly, in addition to the daily (8-hour) and monthly (160-hour) procedures. A summary appears in Table 5-1.

5.4.1 Vacuum Motor Brushes

NOTE

This procedure should be followed only for TU10s with serial numbers up to 10320, which use vacuum systems that are DEC P/N 12-05944. For later models, which use vacuum systems that are P/N 7012052, skip this procedure, as these TU10s do not use brushes. Because of the long running-time interval required to seat brushes properly, it is not regarded as advisable. If one of these motors needs brushes, the motor should be replaced.

With power OFF, replace the vacuum motor brushes as follows:

1. Disconnect the vacuum motor electrical connector by unplugging P9 from J9 (wires from plenum cover on vacuum motor).
2. Loosen three large Phillips head screws that fasten plenum chamber cover to the casting and remove plenum chamber cover.
3. Remove the brush assembly by removing the screws that hold the U-shaped bracket over the brush assembly, then pull out the connector that holds the coil wire of the brush assembly.
4. Using a cotton-tipped wooden swab, carefully clean the commutator. Apply a drop of light oil at the rear sleeve bearing, taking care not to get any oil on the commutator.
5. Install and connect the new brush assembly.
6. Reinstall cover and reconnect P9 to J9.

NOTE

If a semiannual PM procedure is scheduled, proceed to the first step of that procedure; if not, continue with the procedure described in Section 5.4.3, below.

5.4.2 Diagnostic Checks

Perform the appropriate diagnostic check as follows:

1. Position the tape at BOT; place the TU10 on-line.
2. Run the appropriate data reliability diagnostic for 10 minutes.

NOTE

If possible, the recently-released Multidrive Random Data Exerciser Programs should be used to make this check. (MAINDEC-11-DZTMH is the PDP-11 diagnostic; MAINDEC-08-DHTSD is designed for use with the TS03 tape drive, but can be used with the TU10.) These diagnostics are extremely sophisticated and versatile tools for checking TU10 performance. They feature:

- Switch-selectable option for automatic retries, allowing the user to differentiate between drive-induced and tape-induced Read Errors.
- Switch-selectable randomization of data, record size, and block size.
- Switch-selectable choice of write-only, read-only, or write-backspace-read modes.
- Switch-selectable "rock-back-and-forth-on-a-single-record" option to aid in debugging operations.

3. If any read errors occur, it will be necessary to run a complete pass to determine whether the frequency of soft errors is within specifications. Acceptable soft error rates for one 2400-ft reel of tape are:
 - a. Two Forward Read Errors that are not accompanied by Write Errors.
 - b. Two Write Errors.

5.5 SEMIANNUAL (1000-HOUR) PREVENTIVE MAINTENANCE PROCEDURES

The following procedures should be performed semiannually, in addition to the daily (8-hour), monthly (160-hour), and quarterly (500-hour) procedures. They are summarized in Table 5-1.

5.5.1 Capstan Speed and DC Balance

The potentiometers on the G932 Module (slot A/B04) are used for adjusting dc balance and the FWD, REV, and REW speeds. Each potentiometer is identified on side 2 of the module.

CAUTION

The master skew tape must not be rewound at 150 ips; doing so may result in microstretching of the tape.

NOTE

The REW potentiometer is not provided on early versions of the TU10.

To check capstan speed and dc balance, proceed as follows:

1. Load Master Skew Tape (800 bpi).
2. Connect scope to pin B31D2 (G060 compressor output).
3. Initiate FWD tape motion and measure the compressor waveform for a double-period of 55–57 μ s (Figure 5-7).
4. If necessary, adjust FWD (middle) potentiometer on G932 module for 56 μ s.
5. Initiate REV tape motion and measure the compressor waveform for a double-period of 55–57 μ s (Figure 5-7).
6. If necessary, adjust REV (top) potentiometer on G932 module for 56 μ s.
7. Remove the Master Skew Tape (800 bpi); mount a good tape with write ring in place.
8. Write all 1s for at least 400 feet of tape.
9. Initiate rewind tape motion and measure the compressor waveform for a double-period of 16–18 μ s (Figure 5-8).
10. If necessary, adjust REW (bottom) potentiometer on G932 module for 16 μ s.

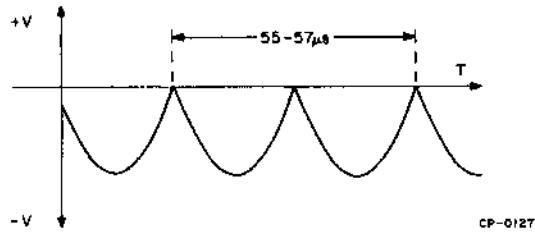


Figure 5-7 Compressor Waveform for FWD and REV

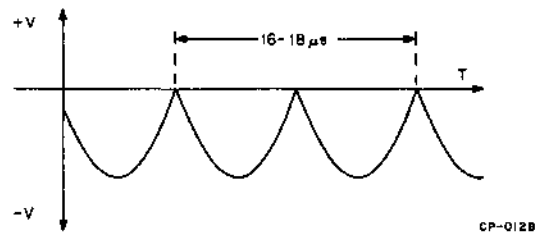


Figure 5-8 Compressor Waveform for REW

11. Stop tape.
12. Measure voltage at pin A04P2 for ± 20 mV. If necessary, adjust dc balance potentiometer on G932 module to obtain minimum of test voltage.

5.5.2 Capstan Acceleration and Deceleration Times

To check capstan acceleration and deceleration, perform the following steps:

1. Connect the scope probe to A04J2.
2. Connect SYNC + to A04E2.
3. Set scope to 5 ms/cm horizontal and 0.2 V/cm vertical.

4. Load the Data Reliability Diagnostic and answer the questions as follows:

TMA-11 tape drive test (DZTMH-C)

Enter conditions in octal

Register start = 172520

Vector address = 224

Unit number = 0 9 CHAN

Density = 3

Parity = 1

Unit number =

Record count = 1

Character count = 10

Pattern number = 6

Tape mark = 0

Single pass = 0

Enter stalls

Read = 1

Write = 1

Turn around = 1

5. Place switch 5 to the up position. This causes the program to yozzel on one record, thereby creating the forward and reverse motion required to generate forward and reverse acceleration ramps.
6. Check the forward and reverse acceleration and deceleration times on the scope. The waveforms should be as shown in Figure 5-10.

Figure 5-9 Deleted

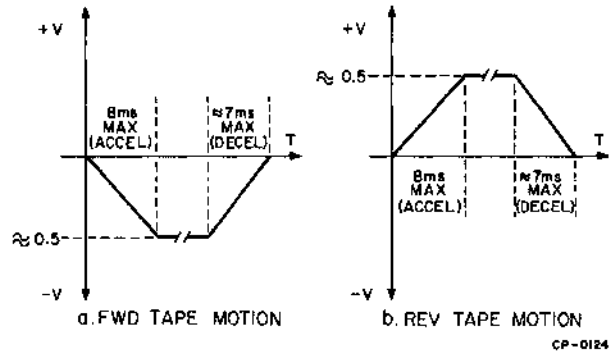


Figure 5-10 Acceleration and Deceleration Waveforms

7. If necessary, adjust the forward and reverse acceleration times with the two potentiometers on the H603 module. The potentiometer nearest the casting adjusts the forward acceleration (negative waveform), while the other adjusts the reverse acceleration (positive waveform).

NOTE

The deceleration times are not adjustable.

Figure 5-11 Deleted

Figure 5-12 Deleted

5.5.3 Capstan Jitter

To check capstan jitter, proceed as follows:

1. Set oscilloscope sweep rate to 20 $\mu\text{s}/\text{cm}$.
2. Set oscilloscope gain to 0.5 V/cm.
3. Connect channel A probe to pin A32L1.
4. Mount a skew tape and initiate FWD tape motion. Check that about 6-1/2 pulses appear on the screen. (See Figure 5-13.)

5. Position the fourth leading edge of this waveform in the center of the screen. Use the horizontal 10X magnifier to increase the horizontal display rate to 2 $\mu\text{s}/\text{cm}$.
6. Raise the vertical gain to 50 or 100 mV/cm, so that a trace similar to that shown in Figure 5-14 is obtained.
7. Check that the waveform jitter is less than 3 cm wide (6 μs). If jitter exceeds 6 μs , replace or clean the capstan motor. (Refer to Section 5 of this manual.)

NOTE

If it is necessary to replace the capstan motor, tape path alignment must be performed at the same time.

8. Remove the 10X horizontal magnification on the oscilloscope.
9. Initiate REV tape motion and repeat steps 1 through 8, above.

5.5.4 Static and Dynamic Skew

Mechanical skew is checked by measuring the lead or lag time of each track relative to a reference track. In 9-channel units, track 5 is used as the reference track; in 7-channel units, track 1 is used as the reference track. The lead or lag times are then plotted to determine the mechanical skew. If the skew exceeds 2.0 μs , the tape attitude with respect to the head assembly can be changed by rotating the upper and lower tape guides in opposite directions.

CAUTION

Mechanical deskewing on a head assembly should not be attempted again once it has been mechanically deskewed at the time of installation. If the mechanical skew is out of specification, a new head assembly should be installed and then electrically deskewed following the mechanical deskewing procedures. It should be understood that there is a physical limit to the amount of mechanical skew that can be removed (see text) and this limit must not be violated or tape damage and instability will result.

5.5.4.1 Mechanical Skew Measurement – Proceed as follows to measure mechanical skew:

1. Load Master Skew Tape (800 bpi) and initiate FWD tape motion.
2. Set time base on scope to 5 $\mu\text{s}/\text{div}$ and connect channel 1 to pin B32L1 (read amplifier output, track 5).
3. Invert channel 2 and sync on B32L1. Waveforms should appear as shown in Figure 5-15.

NOTE

For 7-channel units, connect scope to track 1 (pin B32R1).

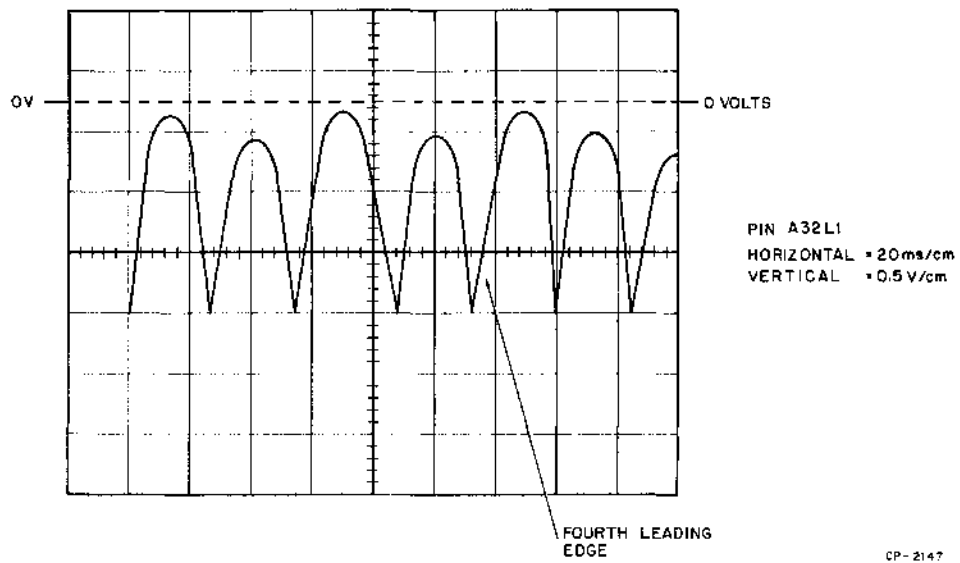


Figure 5-13 Capstan Waveform Showing 6-1/2 Pulses

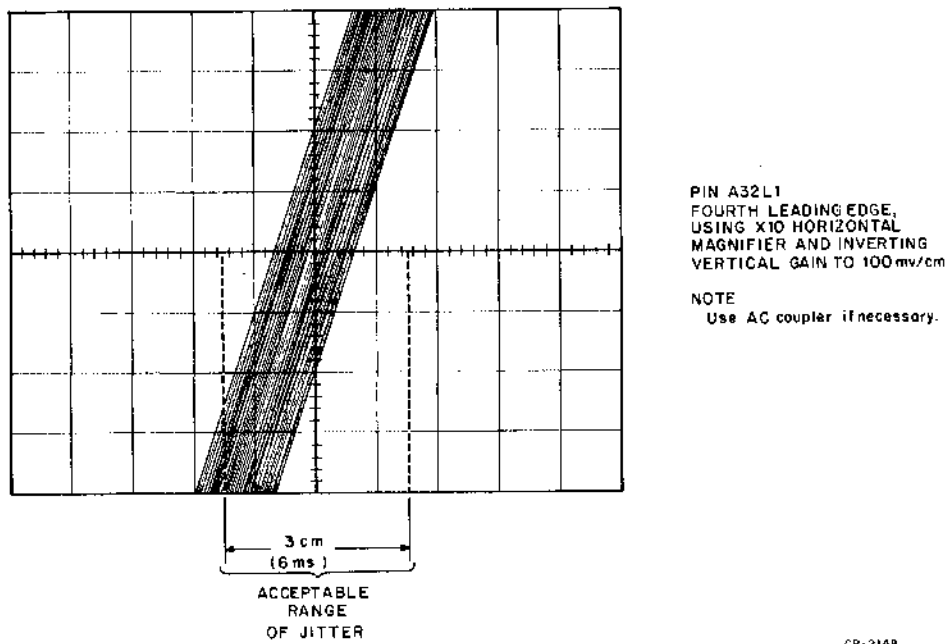


Figure 5-14 Capstan Jitter Waveform Magnified

4. Leave channel 1 connected to the reference track and connect channel 2 to track 7 (pin B32R1).
5. Measure lead or lag time between track 7 and reference track (see Figure 5-16). Plot lead/lag time on graph paper as shown in Figure 5-17.
6. Compare each of the remaining tracks to the reference track and plot the corresponding lead or lag time (see Figure 5-17). Refer to Table 5-2 for read amplifier pins.
7. Examine the graph and draw a straight line as shown in Figure 5-17. The line should originate at the reference track and should be equally spaced between the points farthest to the left and right.
8. The intersection of the "mean line" drawn in Step 7 with the horizontal line for track 4 represents the mechanical skew (for example, in Figure 5-17 this skew value is $-4.4 \mu\text{s}$). If the measured skew exceeds $2 \mu\text{s}$, refer to the deskewing procedure that follows. (The tape guide system allows approximately $3 \mu\text{s}$ of mechanical deskewing.)

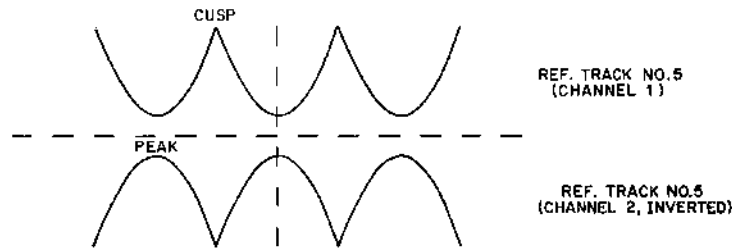


Figure 5-15 Sync Pattern for Reference Track

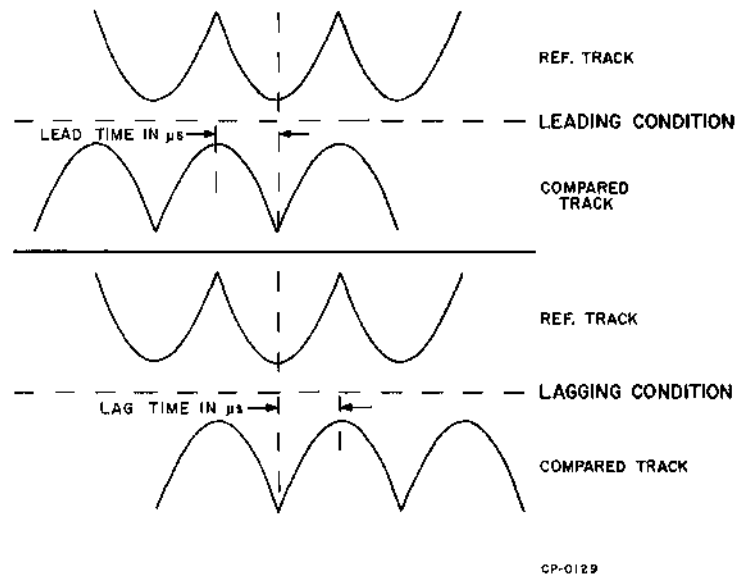


Figure 5-16 Lead/Lag Patterns

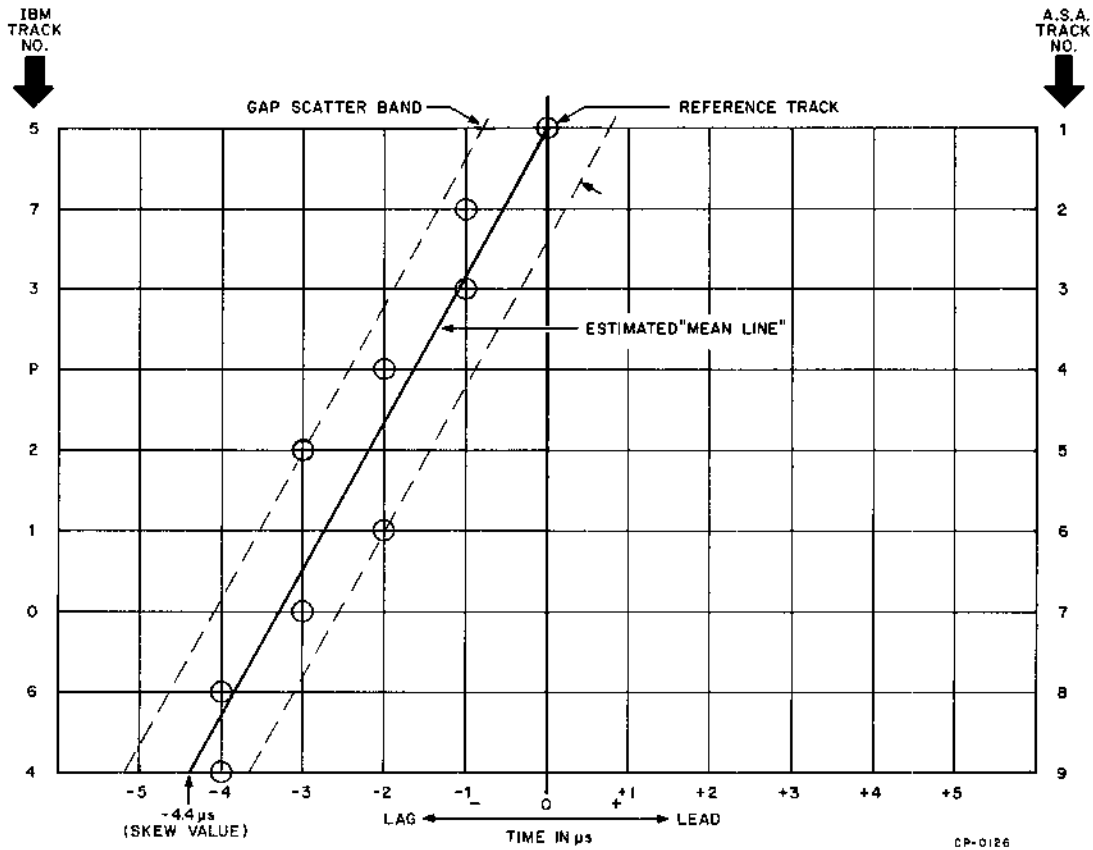


Figure 5-17 9-Channel Skew Plot

Table 5-2
Read Amplifier Pin Numbers

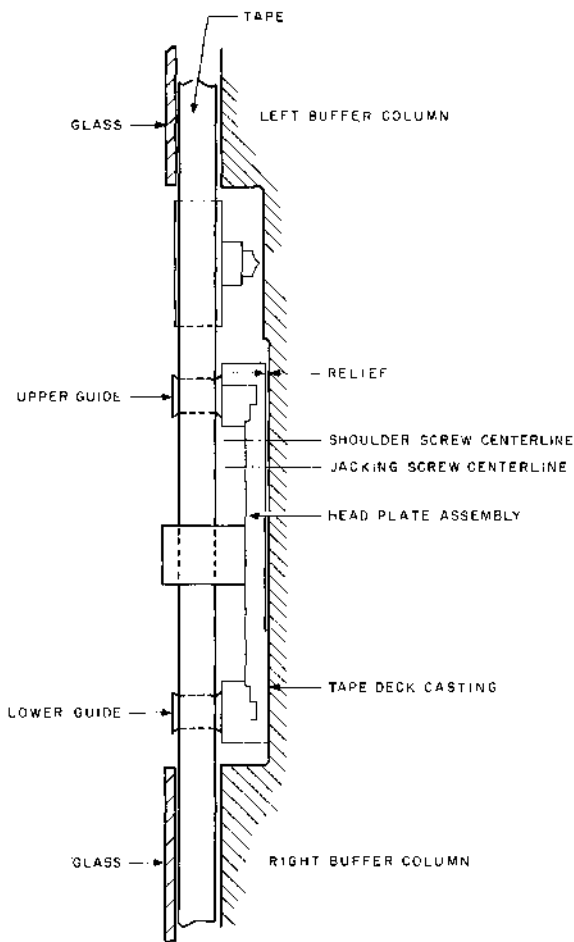
Track No.	9 Ch	5	7	3	P	2	1	0	6	4
	7 Ch	4	1	A	C	B	*	*	2	8
Slot Pin No.	B32 L1	B32 R1	B32 F1	A32 L1	B32 D1	A32 R1	A32 N1	B32 N1	B32 J1	

* Not used in 7-track.

5.5.4.2 Mechanical Skew Adjustment

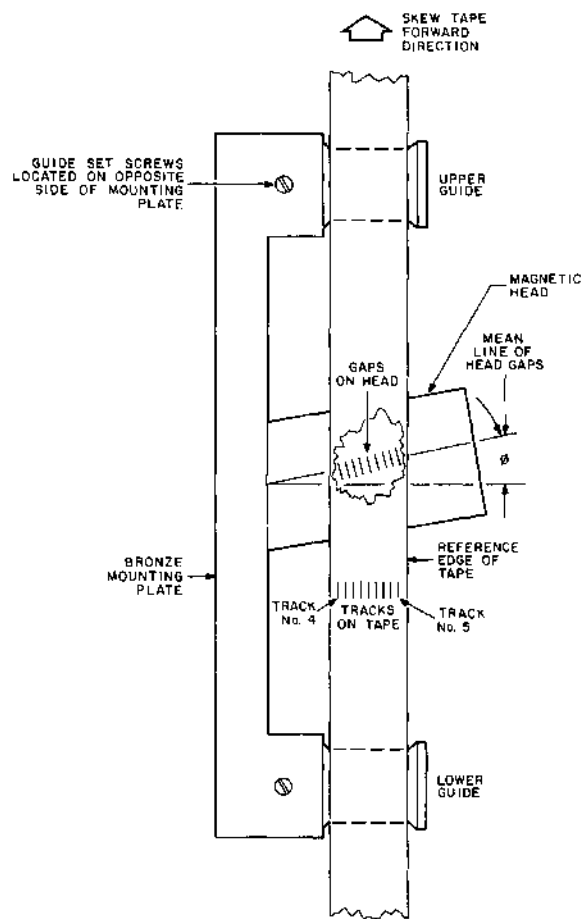
NOTE

There are three different versions of the head plate assembly. The early version had no jacking screws, and used movable tape guides to adjust skew. The second version has jacking screws incorporated into the front plate (Figure 5-18) and a stepped machined relief in the rear surface (Figure 5-19). The most recent version has a spring-loaded, cantilevered head-mounting surface, a single Phillips head skew adjustment screw, and fixed guides.



CP-135B

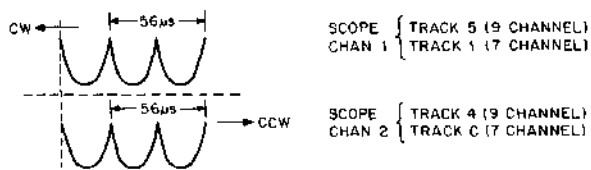
Figure 5-18 Head Plate Assembly (Right View)



NOTE: Azimuth error (θ) is exaggerated for purpose of this illustration.

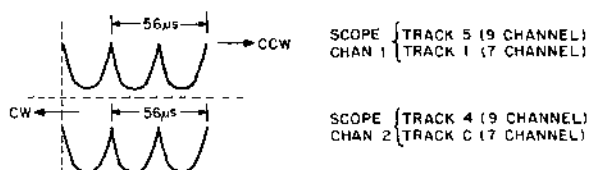
CP 0125

Figure 5-19 Azimuth Error (θ) Static View (Head Assembly, Left View)



CP-1350

Figure 5-20 Mechanical Skew Waveforms



CP-1351

Figure 5-21 Mechanical Skew Waveforms

Early TU10 Head Plates

To reduce mechanical skew on the earliest version of the head plate, proceed as follows:

1. Remove the two plugs from the buffer column door to expose the tape guide adjustment slots (Figure 5-2).

CAUTION

Do not attempt to force the guides. Loosen the set screw slightly to relieve the binding. If the guide is too loose, tighten the set screw slightly or the adjustments become unstable.

2. Load Master Skew Tape (800 bpi) and initiate FWD tape motion.
3. Carefully rotate the upper and lower tape guides in opposite directions to reduce skew. For example, in Figure 5-19, the skew can be reduced by tightening the upper guide (CW rotation) and loosening the lower guide (CCW rotation).
4. Set time base on scope to 5 μ s/div and connect channel 1 probe to the Read Amplifier output at pin B32L1 (track 5 of 9 channel unit) or B32R1 (track 1 of 7 channel unit).
5. Connect channel 2 probe to pin B32J1 (track 4 of 9 channel unit) or pin A32L1 (outside track of 7 channel unit); observe two waveforms (Figure 5-20). If the waveforms are incorrect, mechanical skew must be adjusted as described in the following steps.
6. Mechanical skew can be adjusted and reduced by turning the upper tape guide (CW or CCW) and turning the lower tape guide (CCW or CW).

NOTE

When one tape guide is rotated CW, the other must be rotated CCW an equal amount. Turn the tape guides only a very small amount at any one time.

7. CW rotation of the upper tape guide and CCW rotation of the lower tape guide will move the waveforms as shown in Figure 5-20.
8. CCW rotation of the upper tape guide and CW rotation of the lower tape guide will move the waveforms as shown in Figure 5-21.
9. If mechanical skew is correct, the waveforms should overlay and appear as one waveform. Another check would be to invert and algebraically add both channels; a straight line (minute ripples only) should appear if mechanical skew has been adjusted correctly.
10. Retighten the two guide set screws; replace the head cover and install the guide plug in the buffer column door.

NOTE

The capstan should be checked and, if necessary, replaced if one or more of the following conditions occur:

- The waveforms display a left-to-right jitter that exceeds 5 μ s.
- The static skew in the reverse direction is not within 2 μ s of the value measured in the forward direction.
- The track patterns become totally unstable in the reverse direction with erratic jumps (sideways).

Second Version Head Plates

To reduce mechanical skew on the second version head plate assembly, proceed as follows:

1. Load a scratch tape and initiate FWD tape motion. Wind about half the tape onto the take-up reel then initiate REV tape motion. Use a flashlight to check for gross mechanical misalignment as follows:
 - a. Shine the flashlight to create a reflection off the tape at the upper tape guide (Figure 5-22).
 - b. Check to see if the tape is puckering against the outer fixed edge of the upper guide, or depressing the spring loaded inner edge of the upper guide.
 - c. If either condition exists, adjust the head plate mechanical alignment as described in Step 2, below.
2. If the tape is puckering against the outer fixed edge of the upper guide (head plate assembly in too far in the casting) continue REV tape motion and adjust the head plate assembly as follows.
 - a. Slightly loosen the upper shoulder screw (Figure 5-23) and slowly turn in the upper jacking screw until the pucker is eliminated.
 - b. Lightly retighten the upper shoulder screw.
 - c. Operate the tape in both the FWD and REV direction and ensure that the tape travels smoothly, without damage, through both tape guides.

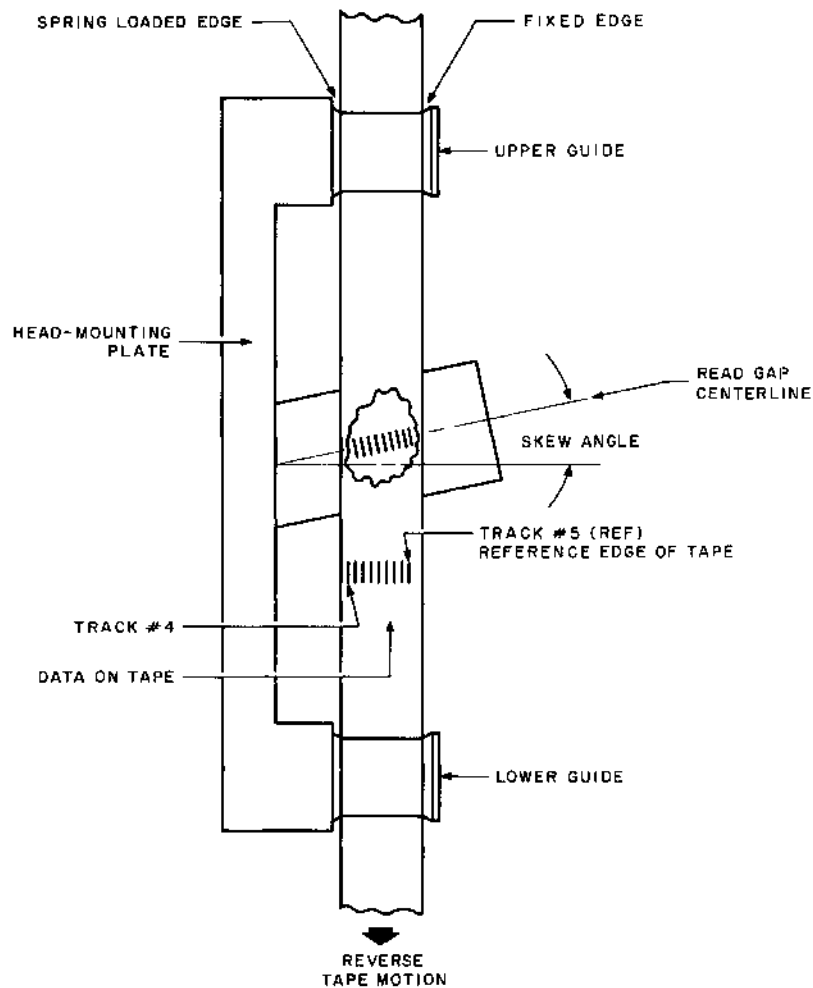
If the tape is depressing the spring loaded inner edge of the upper guide (head plate assembly out too far from the casting) continue REV tape motion and adjust the head plate assembly as follows.

- a. Back off the upper jacking screw (Figure 5-23) about one-half turn then slowly tighten the upper shoulder screw until the tape no longer depresses the inner tape guide edge.
 - b. Operate the tape in both the FWD and REV direction and ensure that the tape travels smoothly, without damage, through both tape guides.
3. Set the scope time base to 5 μ s/div and connect the channel 1 probe to pin B32L1 (track 5 read amplifier output). Synchronize the scope on channel 1 and connect the channel 2 probe to B32J1 (track 4 read amplifier output).

NOTE

For 7-track units, connect the scope probes to pins B32R1 (track 1) and A32L1 (track c).

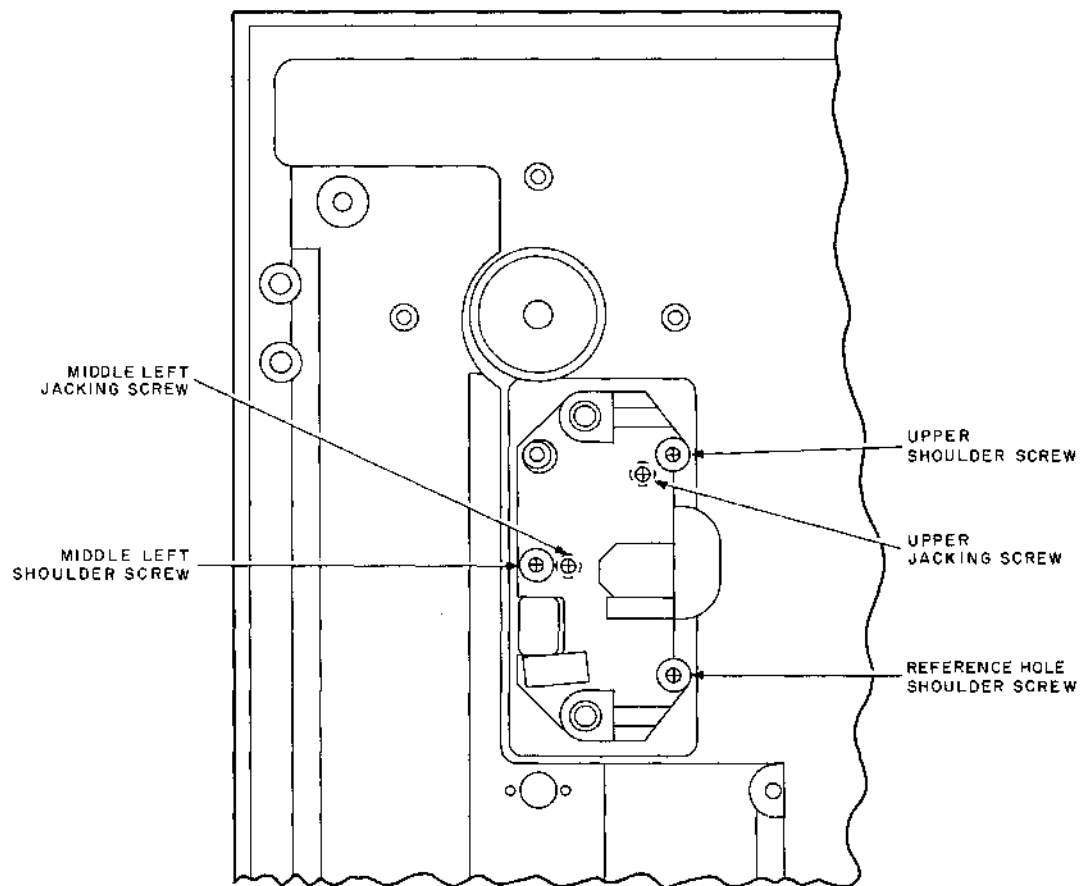
4. Load a Master Skew Tape (800 bpi).
5. Check for minor mechanical misalignment by initiating FWD then REV tape motion while checking that the forward and reverse skews are approximately equal (within about $2 \mu\text{s}$ of each other). If not, further adjust the upper jacking screws as described in Step 2 until both skews are approximately equal.
6. Gently snug down the upper jacking and shoulder screws.
7. With the skew tape running in REV, monitor the outside tape channels as described in Step 3 and tighten the head plate assembly in the following sequence.
 - a. Gently turn in the middle left jacking screw until it touches the tape deck casting.



CP - 0639

Figure 5-22 Head Plate Assembly Mechanical Alignment

- b. Lightly tighten the middle left shoulder screw with just enough force to keep the head plate assembly from twisting when the upper shoulder and jacking screws are tightened.
 - c. Ensure that the upper jacking screw is in contact with the casting then, starting with the upper shoulder screw, alternately tighten both the upper shoulder and upper jacking screws, being careful not to disturb the displayed skew pattern during the tightening sequence.
 - d. Starting with the middle left shoulder screw, alternately tighten the middle left shoulder and middle left jacking screws, again being careful not to disturb the displayed skew pattern during the tightening sequence.
 - e. Snug down the reference hole shoulder screw.
8. REV the skew tape, remove the upper reel and tighten the tape guide set screws with an Allen wrench.
 9. Replace the head cover.



CP - 0637

Figure 5-23 Head Plate Assembly (Front View)

Recent Version Head Plate Assemblies

For TU10s with the most recent version of the head plate, proceed as follows:

1. Remove the head plate cover by removing the 2 Allen head screws.
2. Load a skew tape.
3. Place probe 1 at B32L1 (7-channel B32R1). Sync the scope with this input.
4. Place probe 2 on B32R1. (7-channel B32N1).
5. Run skew tape forward. Adjust the azimuth screw for minimum peak deflection (Figure 5-24).
6. Place probe 2 on B32J1 (7-channel A32L1).
7. Adjust the azimuth screw for minimum peak deflection.

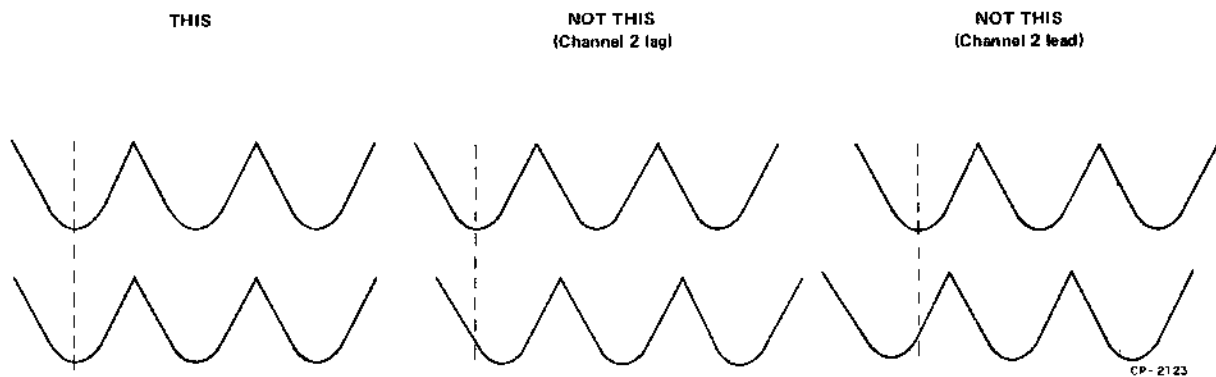


Figure 5-24 Example of Peak Deflection

NOTE

This version is factory-aligned; the single skew adjustment described above is the only adjustment necessary.

5.5.5 Electrical Read Skew

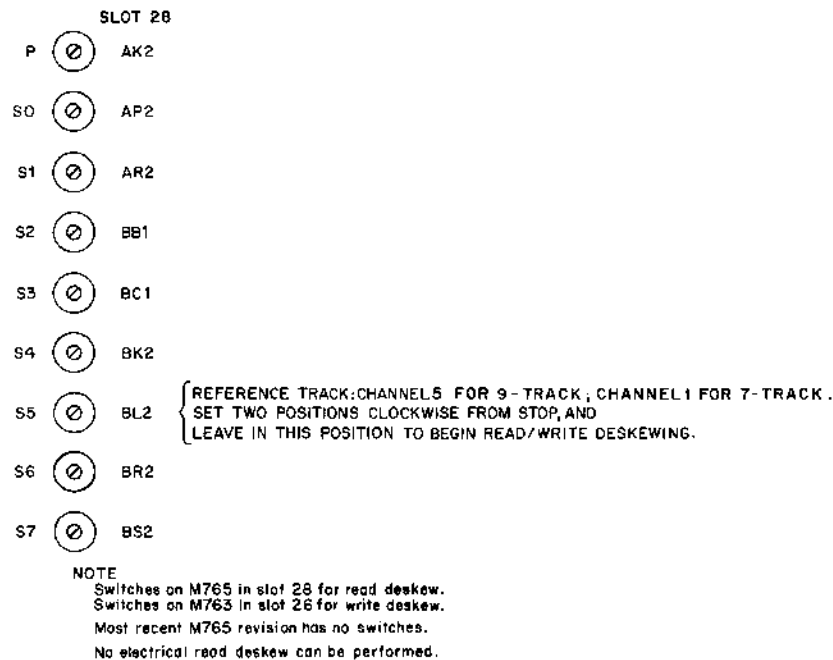
Proceed as follows to check and adjust electrical read skew:

1. Mount M765 Read Buffer Module (slot A/B 28) on a double-height extender board. Set all module switches two positions clockwise from Stop.

2. Set the scope to 2 VOLTS/CM, 10 μ SEC/CM, and sync to channel 1 only-positive slope. Invert channel 2 and add the two channels together.
3. Connect channel 1 of the scope to pin B28L2 (track 5) for 9-track; connect to pin B28S2 (track 1) for 7-track.
4. Connect channel 2 to the remaining tracks and check the read skew with respect to track 5 (refer to Table 5-3 for pin numbers). When necessary, adjust the switches on the Read Buffer Module (Figure 5-25) so the scope shows minimum skew in the positive and negative direction of the waveform. Maximum allowable skew in either direction is 1.8 μ s. Figure 5-26 illustrates the acceptable waveforms. If it is not possible to achieve skew less than 1.8 μ s, it will be necessary to perform a tape path alignment (Section 5.5.13).
5. After read skew is set up, remove the Master Skew Tape from the transport. The Read Head can now be used as a standard to set the Electrical Write Skew.

Table 5-3
Read Buffer Pin Numbers

IBM Track No.	9 Ch	5	7	3	P	2	1	0	6	4
	7 Ch	4	1	A	C	B	-	-	2	8
Slot Pin No.	B28 L2	B28 S2	B28 C1	A28 K2	B28 B1	A28 R2	A28 P2	B28 R2	B28 K2	



CP-0281

Figure 5-25 Switch Location Guide

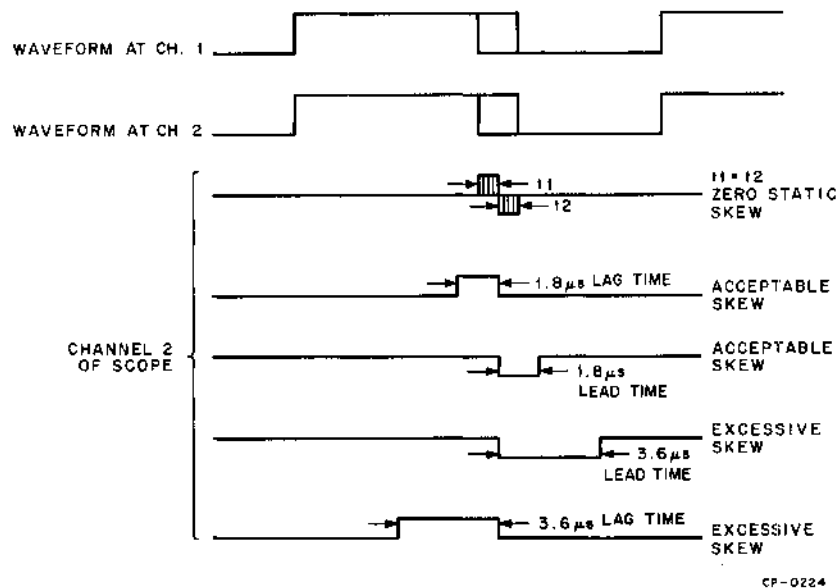


Figure 5-26 Examples of Electrical Skew, Read and Write

5.5.6 Electrical Write Skew

Proceed as follows to check the electrical write skew:

1. Mount a good quality scratch tape with write ring.
2. Mount the M763 Write Buffer Module (slot A/B 26) on the extender boards.
3. Put the TU10 online.
4. Write an all-1 data pattern. (Table 5-4 shows cable connections when using a magtape tester.)
5. Set all of the switches on the Write Buffer Module to the center position.
6. Set scope to 2 VOLTS/CM, 10 μSEC/CM, and sync to channel 1 only-positive slope. Invert channel 2 and add the two channels together.
7. Connect channel 1 of scope to pin B28L2 (track 5); for 7-track connect to pin B28S2 (track 1).
8. Select the transport by means of the UNIT SELECT switches on the tester and initiate a write FWD command.
9. Connect channel 2 of scope to the remaining tracks and check the write skew with respect to track 5 (refer to Table 5-3 for pin numbers). When necessary, adjust the switches on the M763 Write Buffer Module for minimum skew. (Each turn of a Write Buffer switch produces a time change of 1.8 μs.) Refer to Figure 5-26 for examples of electrical skew.

Table 5-4
Magtape Tester Connections

Tester	TU10
AA01	A17/B17, Side 1
AA02	A18/B18, Side 2
AA03	A17/B17, Side 2
AA04	A18/B18, Side 1
AB01	A19/B19, Side 2

5.5.7 Read and Write Slice Levels

5.5.7.1 Units Up to No. 10320 – Proceed as follows to check and adjust the slice levels:

1. Put the TU10 online.
2. Set scope to 1 VOLT/CM, 10 μ SEC/CM, and sync to channel 1 only-negative slope.
3. Connect channel 1 to pin B31L2 (track 5).
4. Initiate a series of WRITE FORWARD commands.
5. Measure the compressor waveform as shown in Figure 5-27 and, if necessary, adjust the upper potentiometer on the G060 Module.
6. Initiate READ FWD commands.
7. Measure the compressor waveform as shown in Figure 5-28 and, if necessary, adjust the lower potentiometer on the G060 Module.

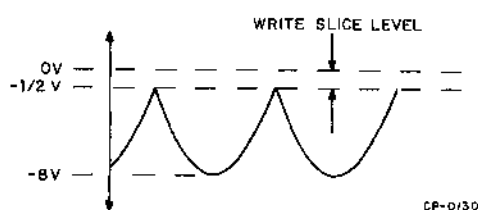


Figure 5-27 Write Slice Level Measurement

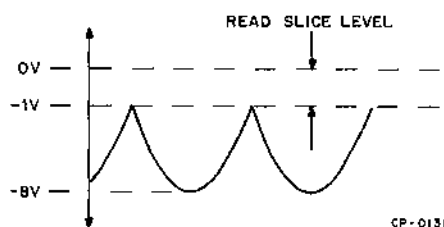


Figure 5-28 Read Slice Level Measurement

5.5.7.2 Units Above No. 10320 – Proceed as follows to check and adjust the slice levels for those TU10s with a G093 (slot 30), G094 (slot 29), G060-YA (slot 31), and M765-YA (slot 28).

1. Ensure that the potentiometers on the G060-YA are fully clockwise. Verify that test points AE1 and AB1 are at minimum levels (i.e., as close to 0V as possible).

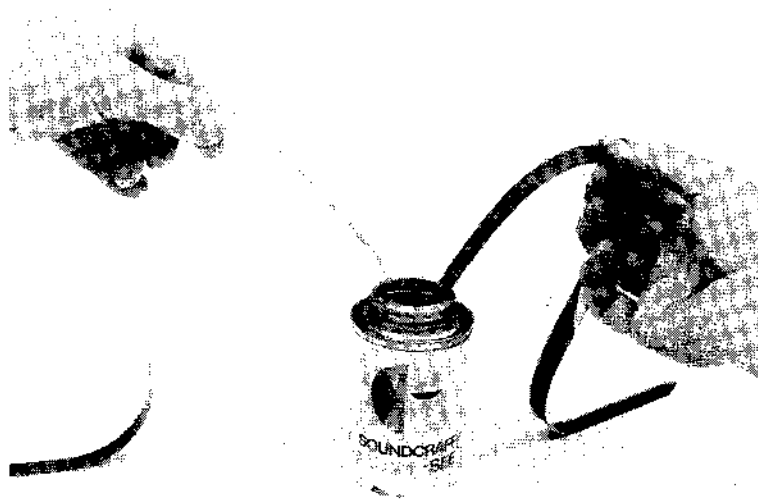
2. Power down the drive, and mount the G094 on a double extender. (G094s at Rev B and subsequent need not be put out on an extender.)
3. Power up the drive.
4. To adjust write threshold:
 - a. Ground A29E1, using a jumper wire. (It is possible to ground this point without causing damage to the circuit generating the WRITE L signal.)
 - b. Place scope probe on the junction between L15, R23, and R22 pins. (For G094s at Rev B and subsequent, place scope probe on BV2.)
 - c. Adjust the bottom potentiometer (R22) for -5.0V.
5. To adjust read threshold:
 - a. Remove ground from A29E1.
 - b. Leave probe in place. Adjust the top potentiometer (R23) for -4.0V.
6. Stop the tape and remove the jumper from A29E1.
7. Run the Data Reliability diagnostic (MAINDEC-11-DZTMB for 9-track; MAINDEC-11-DZTMC for 7-track) to verify correct read/write operation.
8. Return the transport to operational status.

5.5.8 Industry-Compatible Tape Tracking

Check industry-compatible tape tracking as follows:

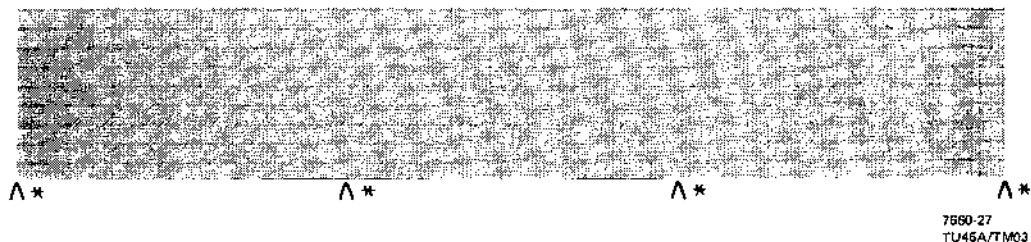
1. Position a scratch tape at BOT; using the appropriate diagnostic, write about 10 feet of tape with an all-1s pattern. Make records as long as possible.
2. Stop the diagnostic, and rewind the tape.
3. Remove the tape from the drive, take it to a work area, and proceed as follows:
 - a. Unwind tape until you reach the BOT marker; cut the tape with scissors.
 - b. Unwind 3 feet of tape beyond the BOT marker; cut the tape again.
 - c. Shake Magna-see solution vigorously.
 - d. Dip the 3-foot section of tape in Magna-see solution. (Refer to Figure 5-29.) Try to keep a loop of tape at the bottom of the can.

- e. Work the tape back and forth until the entire 3-foot section (except for the ends being held) has been dipped into the solution.
 - f. Allow the tape to dry. Data written on the tape should appear as the solution dries. (See Figure 5-30.) If necessary, dip the tape again.
4. When the tape has been developed, proceed as follows:
- a. Place the developed tape flat on a white background (e.g., white sheet of paper).
 - b. Make sure that the tape is flat, then place a weight on each end.
 - c. Check four points along the reference edge (edge with BOT marker) 1-1/2 inches apart. (See Figure 5-30.)
 - d. Set up microscope according to Figure 5-31; lay the penlight flat on the table, positioned so that it shines on the reflector.



7660-24

Figure 5-29 Dipping Tape Section in Magna-sec



7660-27
TU46A/TM03

Figure 5-30 Developed Tape Segment

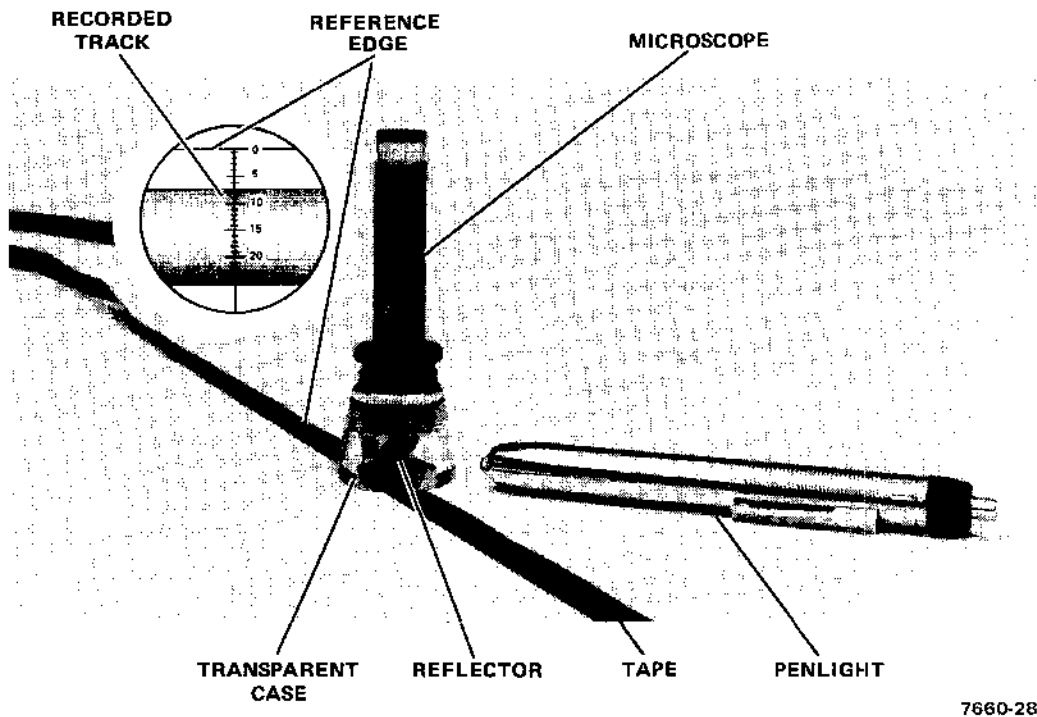


Figure 5-31 Track No. 1 to Reference Edge Measurement

- e. Ensure a distance of 0.007 ± 0.003 inch for 9-track operation and 0.016 ± 0.006 inch for 7-track operation from the reference edge to track 1 at each of the four points mentioned in Step c, above.

NOTE

If the tracking check described above fails, tape path alignment must be performed at this time.

5. Install a new BOT marker 15 feet from the front of the tape on the non-oxide side, against the reference edge. (The reference edge faces the operator when the tape is installed on the transport.)

5.5.9 Power Supply Voltages (docs not apply to early master units)

Proceed as follows to check the power supply voltages:

1. Connect voltmeter to +5V and GND terminals at the side of the logic rack facing the casting.
2. Voltage should measure $+5V \pm 0.25V$.
3. Connect voltmeter to -15V and GND terminals.
4. Voltage should measure $-15V \pm 0.5V$.

5. If necessary, adjust potentiometer on voltage regulator board.

CAUTION

Be sure to slide the regulator board partially out so that there are no wires in the way that could be shorted.

5.5.10 Read/Write Interlock Assembly

To perform the following adjustment, refer to Figure 5-32:

1. Loosen the two screws securing the switch to the bracket just enough to allow the switch to be moved.
2. Loosen the locknut and adjusting screw several turns (see detail B, Figure 5-32).
3. Insert the small end of the setting gauge (No. 29-18610) in front of the roll pin through the bottom of the bracket so that it fits between pin and bracket body edge. Tighten the adjusting screw until the switch just actuates.
4. Tighten the two screws securing the switch to the bracket and lock adjusting screw using the locknut.
5. Loosen the two solenoid mounting screws on the left of the interlock assembly (see detail A, Figure 5-32).
6. Insert the large end of the setting gauge in front of the roll pin as described in Step 3. Push solenoid body forward until plunger bottoms out, then tighten the solenoid mounting screws, keeping solenoid body parallel to upper edge of bracket.
7. Loosen bottom screws securing the interlock assembly to mounting bracket (see detail C, Figure 5-32).
8. Insert ring gauge (No. 29-18608) on reel, lock it, and spin reel to check for even rotation.
9. Push interlock assembly forward until the shaft bottoms in the solenoid and the small spring is fully depressed.
10. Tighten screws securing assembly to bracket, remove ring gauge, and check for free movement of solenoid shaft in casting.

5.5.11 Tape Guide Rollers

Proceed as follows to adjust the tape guide rollers:

1. Release service locks and pull transport forward approximately 8 to 10 inches.
2. Loosen the clamp lock screw (see Figure 5-33).
3. Use gauge No. 29-18607 to adjust the tape guide roller as shown in Figure 5-33.
4. Tighten the clamp lock screw.
5. Repeat the same procedure for the second tape guide roller.

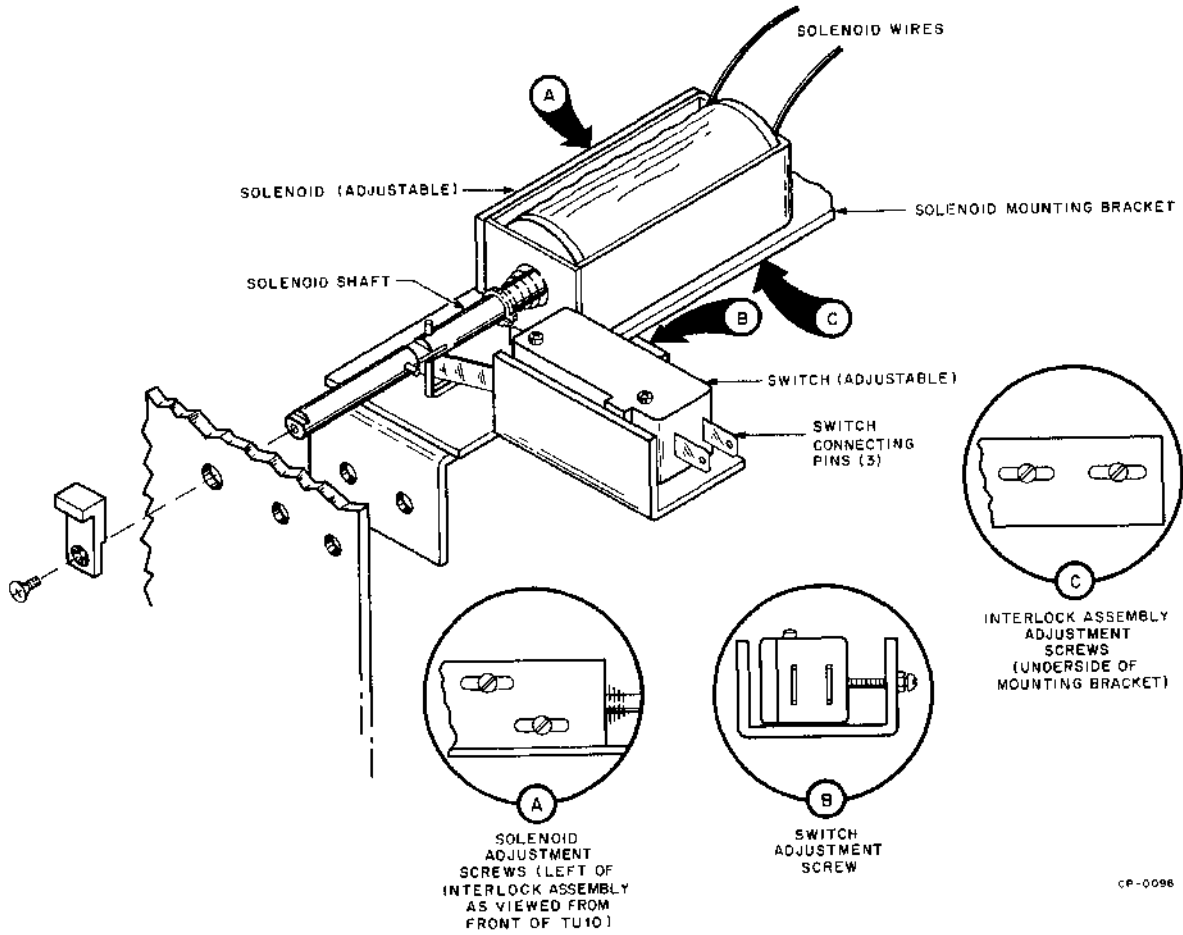


Figure 5-32 Read/Write Interlock Assembly

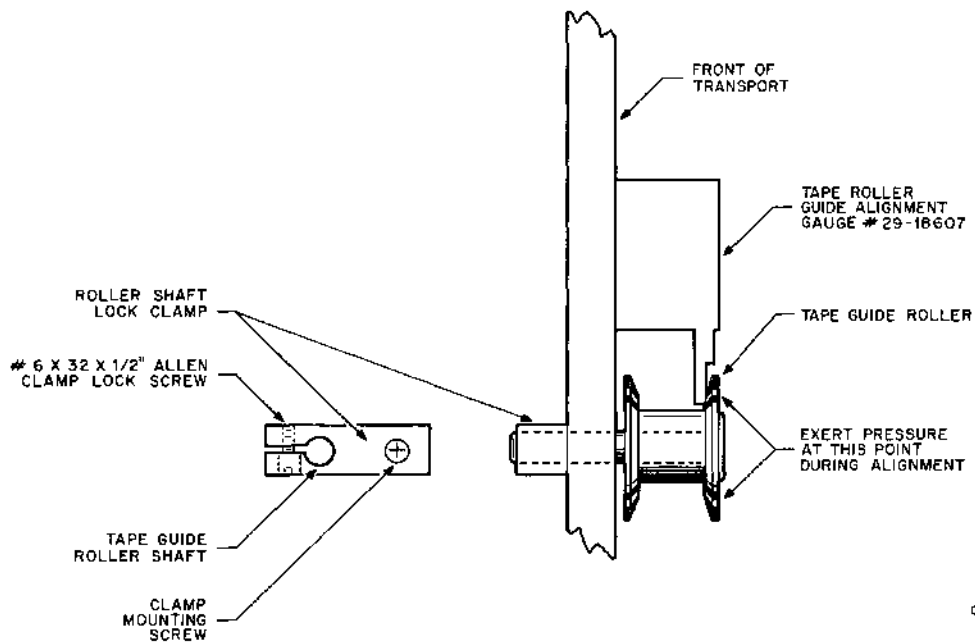


Figure 5-33 Tape Guide Roller Adjustment

5.5.12 Delay Diode Check

Set the magtape tester to EMD. Check the status of each of the delay diodes (M768 Module, Figure 5-34) by setting the following commands and pushing CLEAR and SET: (If no magtape tester is available, use the appropriate DRIVE FUNCTION TIMER diagnostic to make this check.)

Write	Alpha	Forward	Reverse	Channel Lights Octal Reading	
				9-Track	7-Track
0	0	0	1	200	700
1	1	1	0	240	340
1	0	1	0	200 (600)*	200 (600)*
0	1	1	0	400	400
0	0	1	0	200	200
0	1	0	1	400	400

* Later units have an additional write shutdown count, hence the octal code 600.

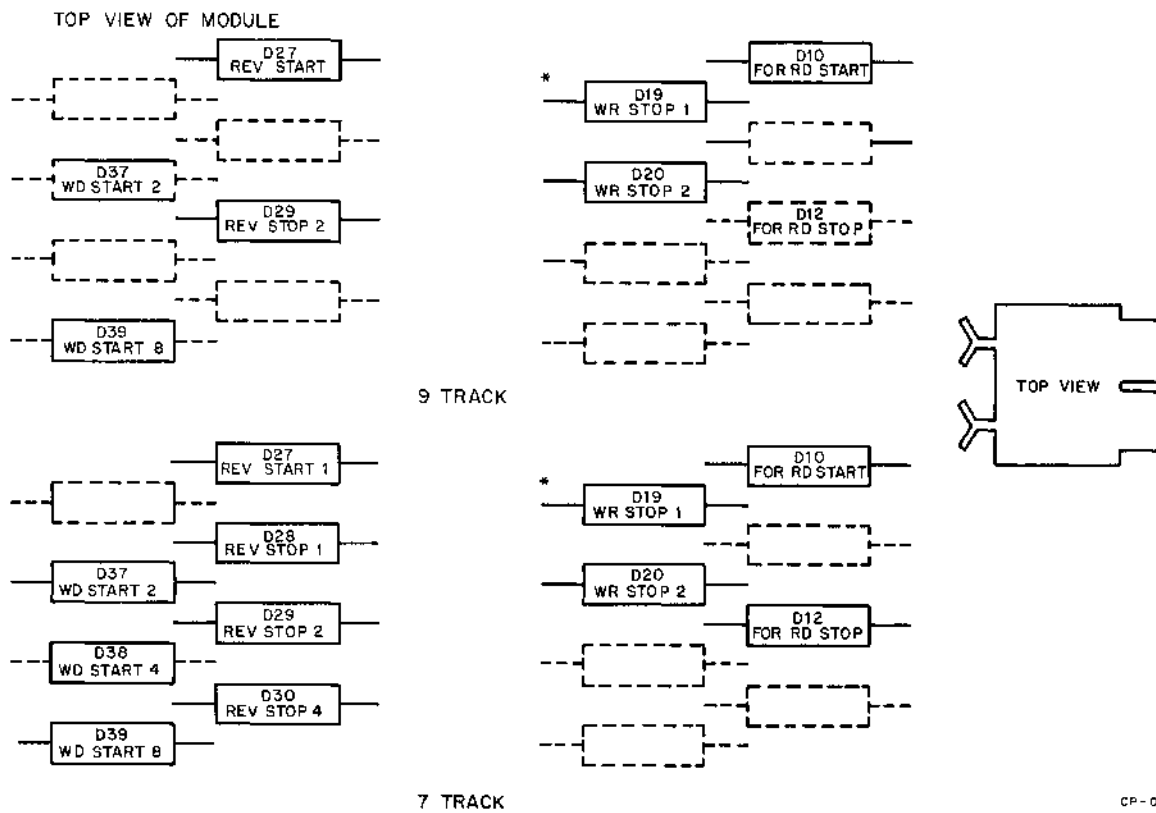


Figure 5-34 M768 Diode Locations

5.5.13 Tape Path Alignment

5.5.13.1 Tools Required -- The following tools are required to perform a tape path alignment:

Tool	DEC Part No.
Skew Tape (800 bpi)	
1200 ft	29-19224
600 ft	29-22020
Reel Hub Tool	29-18611
Roller Guide Tool	29-18607
Microscope	29-20273
Magna-see	29-16871
Penlight	--
Alignment Doors	74-13969
Depth Micrometer	29-22039
Shim Stock	
0.001 inch	48-50023-01
0.002 inch (red)	48-50023-03
0.003 inch (green)	48-50023-04
0.004 inch (tan)	48-50023-05
0.005 inch (blue)	48-50023-06
0.0075 inch (transparent)	48-50023-07
0.010 inch (brown)	48-50023-08

5.5.13.2 When to Perform - A tape path alignment should be performed:

1. When a capstan, capstan motor, roller guide, or head plate is replaced.
2. When forward and/or reverse skew is found to exceed specifications.
3. When an amplitude difference of more than 10 percent is seen between forward and reverse read amp output.
4. When a visible change in the tape's path across the capstan is apparent when changing from forward to reverse tape motion.
5. When measurement of reference edge to Track 1 of the developed (with Magna-see solution) tape shows a result different from 0.007 inch (± 0.003).
6. When, after tape speed adjustment, mechanical skew adjustment, capstan ramp adjustment, and read amplitude adjustment have all been performed, and all of the applicable diagnostics have been run, the unit is still incompatible with other tape transports.

5.5.13.3 Objectives -- The objectives of tape path alignment are:

1. To establish a single plane for tape to travel from supply reel to take-up reel, independent of the capstan and fixed guides (part of the head plate assembly). This is accomplished by aligning reel hubs and roller guides.

2. To mount the head plate in the plane established in 1, above. This is accomplished by establishing the relationship between the reference surfaces used in 1, above, and the surface onto which the head plate is to be mounted. If this relationship is not nominal, appropriate shims are placed underneath the head plate so as to bring the reference edges of the fixed guides into the proper plane.
3. To minimize the amount of distortion to the tape as it travels through the plane established in 1 and 2, above. This is accomplished by shimming the capstan motor in such a way that the capstan motor shaft becomes perpendicular to the tape path.

NOTE

The effect of accomplishing 1, 2, and 3, above, is to minimize static skew, dynamic skew, and tracking error in both forward and reverse directions. Skew is the total amount of non-perpendicularity of characters written on tape. Tracking is defined by ANSI standard as the measurements from the reference edge to each track center line. Improper tracking takes two forms:

- **Read** – A tape transport that is tracking incorrectly will not have its read head elements centered over tracks correctly written by another tape transport.
- **Write** – A tape transport tracking incorrectly will write tracks of data that are not correctly spaced from the reference edge of the tape. Therefore, a transport with proper tracking alignment would not have its read head elements centered on the incorrectly written tracks.

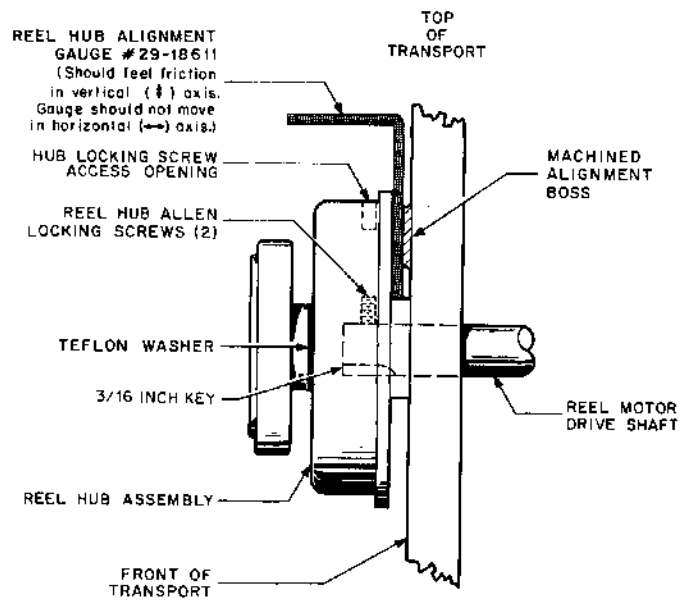
5.5.13.4 Tape Path Alignment Procedure – To establish a basic plane for the tape path, proceed as follows:

1. Remove supply reel and take-up reel.
2. Use reel hub alignment tool to check alignment of both reel hubs. A small amount of friction should be felt when sliding the tool in and out between alignment boss and reel hub. It should not be possible to move the tool back and forth between the hub and the alignment boss; if it is possible, loosen the Allen screws and adjust the hub as necessary (Figure 5-35).
3. Rotate hub, checking fit of alignment tool at several intervals. Some high and low spots will probably be found, but tool should not bind hard or become loose when moving toward and away from the casting. Replace hub and/or motor if either of these conditions exist.
4. Remove upper roller guide ramp. (See Figure 5-36.)
5. Slide roller guide alignment tool underneath upper roller guide. A small amount of friction should be felt as the tool is slid back and forth under roller guide. Loosen clamp on back side of casting and adjust roller guide if necessary. (See Figure 5-37.)



7660-3

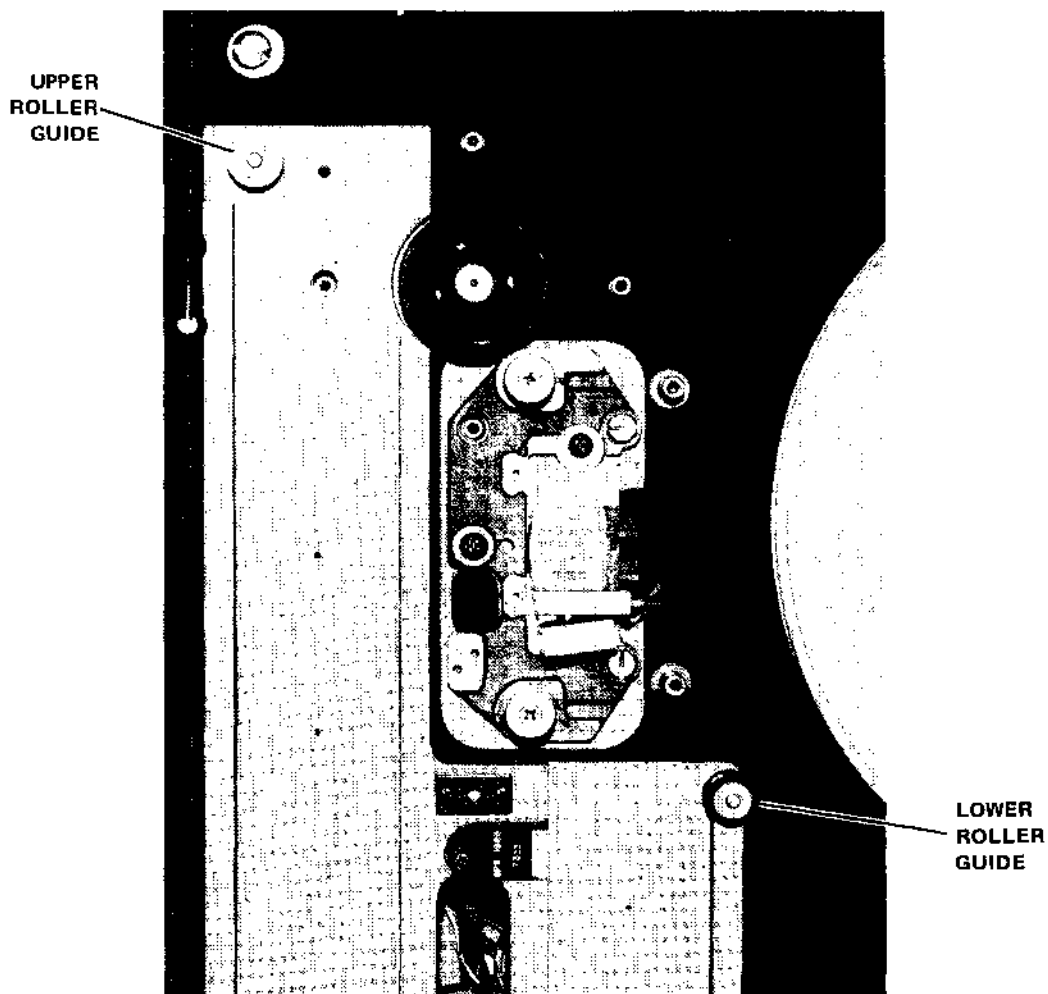
a. Front View



CP-0104

b. Side View

Figure 5-35 Reel Hub Adjustment



7660-12

Figure 5-36 Location of Upper and Lower Roller Guides

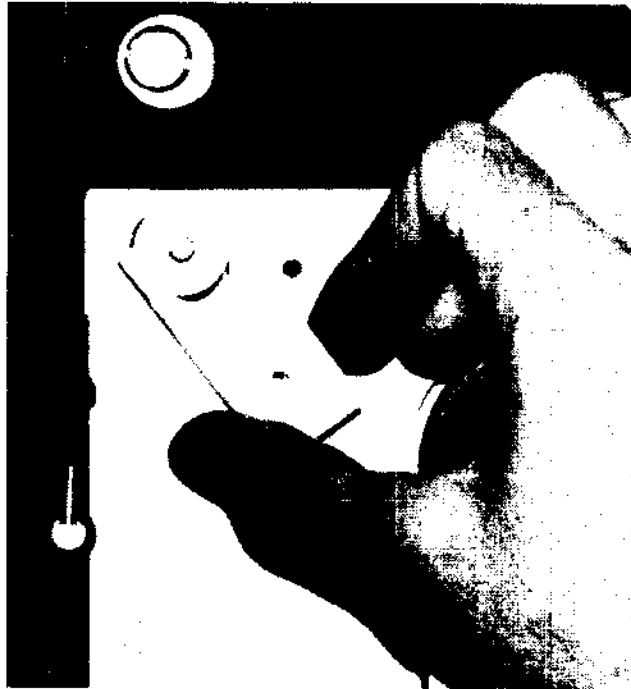
6. Slide one side of roller guide alignment tool under lower roller guide. You should feel slight amount of friction as you move tool back and forth. Adjust if necessary. (See Figure 5-37.)
7. Load a scratch tape. Run tape forward for 5 seconds.
 - a. Ensure that tape is not touching either side of supply or take-up reel while tape is moving.
 - b. Look for tape puckering against either column floor or door glass at both upper and lower roller guides.

If either of these conditions exist, recheck the associated roller guide and reel hub adjustments.

8. Dismount tape. Reinstall upper-roller guide ramp.

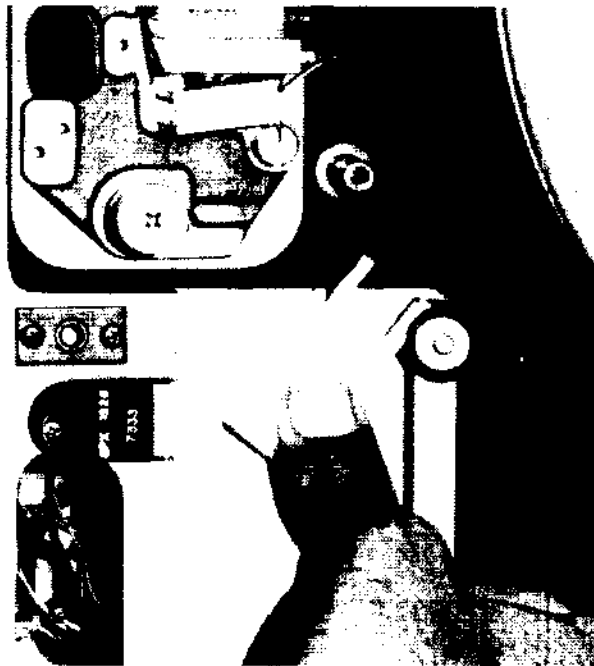
CAUTION

When installing ramp, it is necessary to push down on right side of ramp while tightening screw. Otherwise, it is possible that the ramp will be touching tape.



7660-1

a. Upper Roller Guide Adjustment



7660-5

b. Lower Roller Guide Adjustment

Figure 5-37 Roller Guide Adjustment (Sheet 1 of 2)

9. The reel hubs and roller guides are now set in the same plane as the vacuum columns. (See Figure 5-38.)

To mount the head plate in the plane of the tape path, proceed as follows:

1. Remove head plate cover.
2. Disconnect Write, Read, and Erase head cables from head.
3. Loosen the three shoulder screws and remove head assembly.

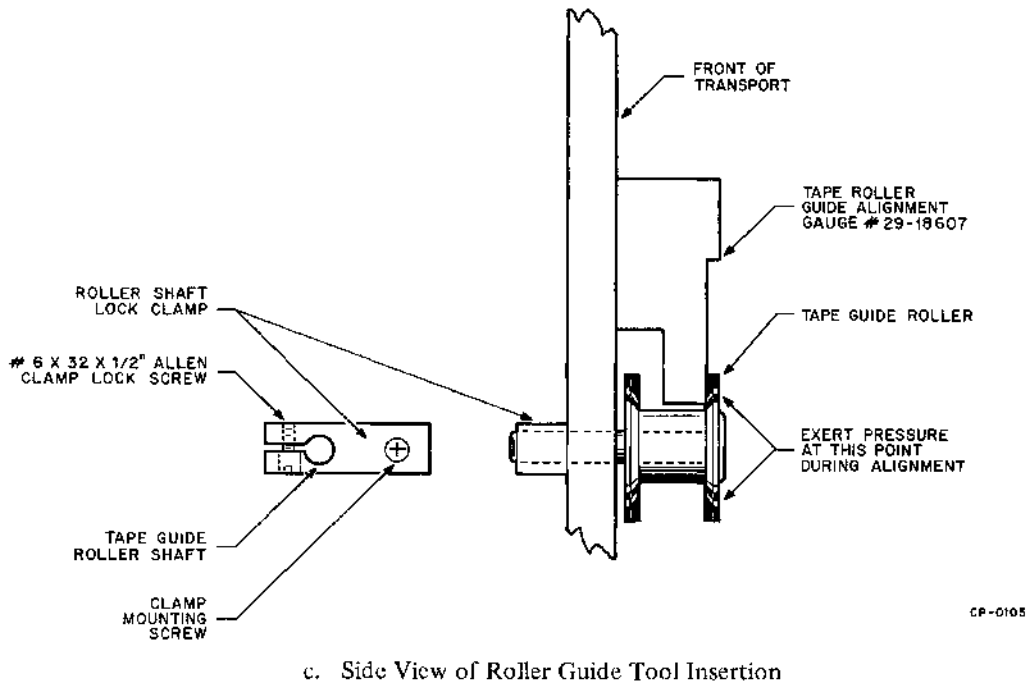


Figure 5-37 Roller Guide Adjustments (Sheet 2 of 2)

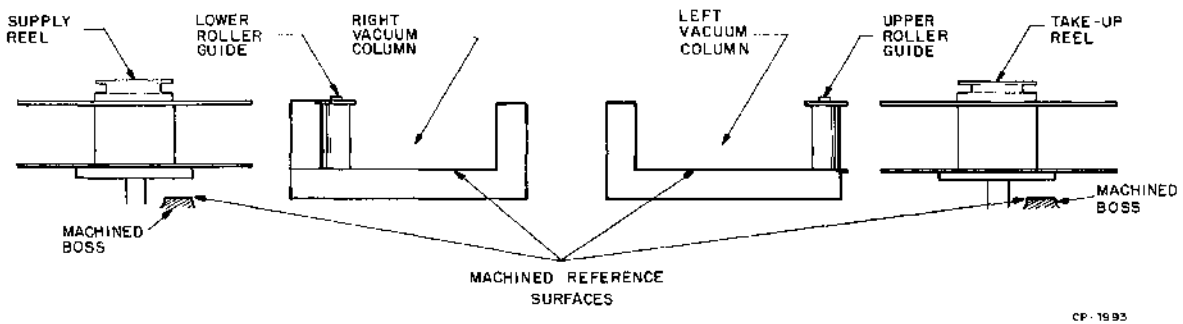


Figure 5-38 Machined Reference Surfaces Used to Establish Tape Path Plane

4. Measure depth from outer surface of left vacuum column to surface onto which head plate was mounted. Nominal value is 1.120 inches. Call this value "HMS". (See Figure 5-39.)

NOTE

This measurement may prove difficult to make since only one side of the micrometer can be seated on the vacuum column surface. Therefore, proceed as follows:

- Place the micrometer base at 45-degree angle with the vacuum column surface (to give greater seating area).
 - Make the measurement with the micrometer shaft as close as possible to vacuum column wall. (Permits more leverage to keep the micrometer base seated and less distance to project error.)
 - Repeat the measurement several times to verify results.
5. Subtract 1.120 from HMS (HMS-1.120).
 - 6.* If result obtained in Step 5 is zero or negative, mount head plate without shims.

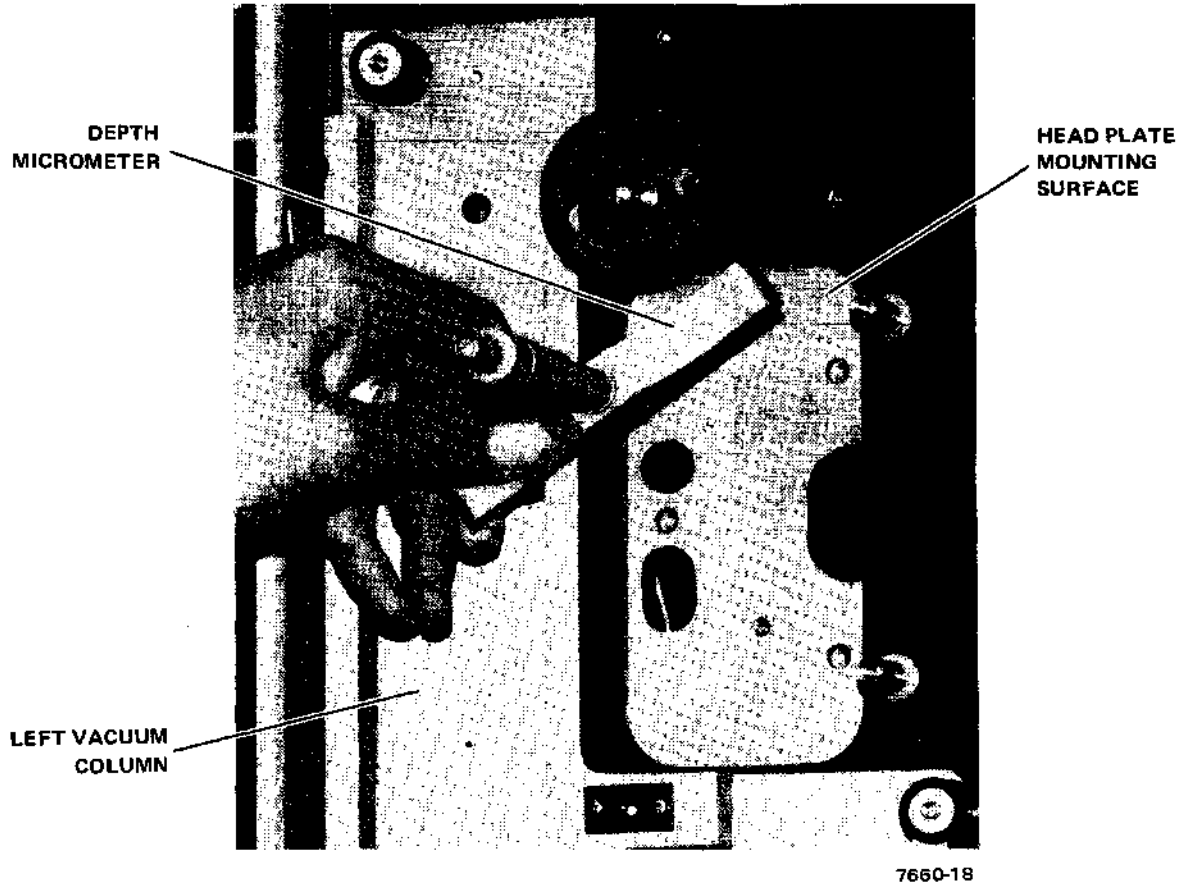
If result obtained in Step 5 is positive, cut three horseshoe-shaped shims of the value obtained in Step 5 and place one under each of the three shoulder screws when mounting head plate. (Shims go between head plate and mounting surface.) See Paragraph 3 for shim color codes. Also cut shim of same value to surround vacuum port which goes to tape cleaner (prevents air leakage). (See Figure 5-40.)

Making Capstan Motor Shaft Perpendicular to Tape Path

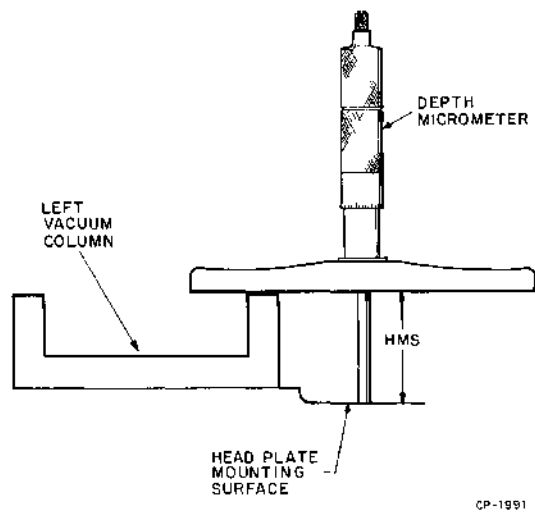
Steps 1 through 21 below, will ensure that the capstan motor shaft is perpendicular to the tape path. There are two conditions that can cause non-perpendicularity of the motor shaft to the tape path. One is the capstan motor shaft not being perpendicular to the mounting face of the motor. Figures 5-41a and 5-41c are examples of this condition. (Specifications allow 0.005 inch of non-perpendicularity of the motor shaft.) The other condition is non-parallelism between the motor mounting surface on the back of the casting and the front surface of the casting. Figure 5-41b illustrates this situation. (Specifications allow 0.004 inch of non-parallelism between the machined surfaces on the front and back of the casting.)

The effect of the capstan motor shaft not being perpendicular to the tape path will depend on the direction of the non-perpendicularity (i.e., whether the motor shaft is pointing up, down, toward the left, or toward the right). When the shaft is pointing down (Figure 5-41a), the top of the capstan is away from the casting, causing the tape to track away from the casting. Hard guiding will occur on the vacuum door glass and the fixed guides in both forward and reverse directions. When the shaft is pointing up (Figure 5-41b), the bottom of the capstan is away from the casting, causing the tape to track toward the casting. Hard guiding will occur on the vacuum column floor and the spring-loaded guides in both forward and reverse directions. When the shaft is pointing toward the left (Figure 5-41c), the tape will track away from the casting in the forward direction and toward the casting in the reverse direction. If the shaft were pointing toward the right, the opposite would be true (i.e., the tape would track toward the casting in the forward direction and away from the casting in the reverse direction).

*If a new head assembly is mounted, electrical write deskew will have to be performed. This should be done after the read mechanical skew adjustment.



a. Placement of Depth Micrometer



b. Bottom View of HMS Measurement

Figure 5-39 Measurement of Head Plate Mounting Surface (HMS)

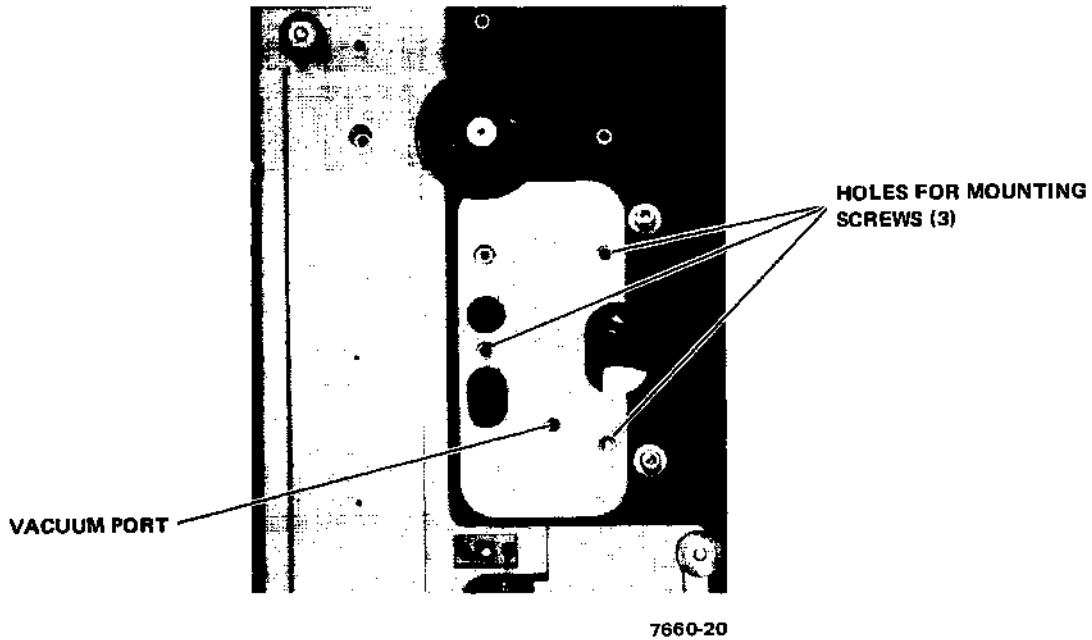


Figure 5-40 Location of Shims under Head Plate Assembly

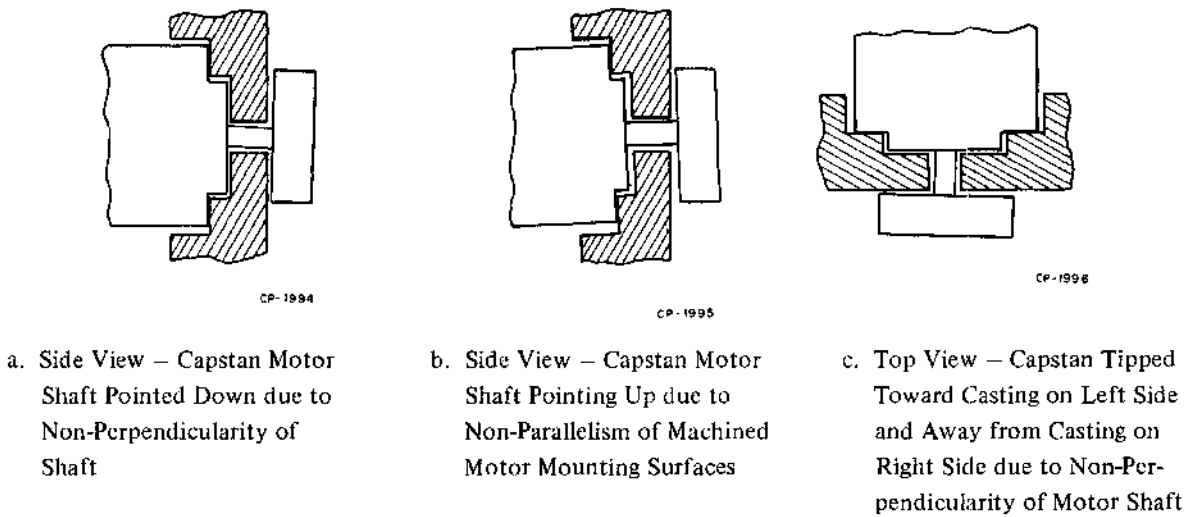


Figure 5-41 Examples of Capstan Non-Perpendicularity

1. Remove the capstan by loosening the capstan locking clamp with an Allen wrench and remove the capstan and clamp.

NOTE

If the capstan is hard to remove, it may be bent, and should be replaced. The inside of the capstan should be checked for burrs in the area of the slots. The end of the capstan motor shaft should be checked for burrs also. (See Figure 5-42.)

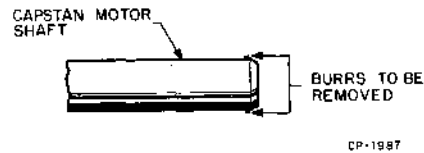


Figure 5-42 Location of Possible Capstan Burrs

2. Remove the capstan motor by unplugging P1 from the II606 Power Board and removing the four bolts holding the capstan motor on the casting.

CAUTION

Because the bolt heads are in front of the casting and the motor is on the rear, caution should be used that the motor does not fall when the screws are removed.

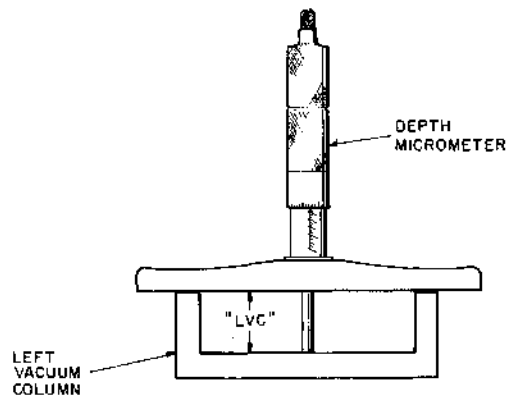
DO NOT ATTEMPT to remove the tachometer portion of the motor; the two are replaced as an assembly.

3. Check the capstan motor and casting for the following:
 - a. The capstan motor specification template does not interfere with the motor mounting on the casting. If there is interference, remove the template.
 - b. The motor does not have any burrs on the mounting surface that would prevent it from mounting squarely on the casting.
 - c. Ensure the mounting surface of both the motor and casting are free of dirt, gummy substances, and burrs pushed up by machining operations.
4. Lift up and remove the vacuum column door.
5. Measure depth from the outer surface of left vacuum column to floor of left vacuum column. Nominal depth = 0.502. Call this value LVC. (See Figure 5-43.)



7660-11

a. Placement of Depth Micrometer



CP-19 90

b. Top View of LVC Measurement

Figure 5-43 Measuring Depth of Left Vacuum Column (LVC)

6. Subtract 0.500 from LVC; call the resulting value X ($LVC - 0.500 = X$). Record value X as it will be used in Step 16.

NOTE

X is the distance that the inside edge of the tape should be from the floor of the left vacuum column when the outside edge is 0.002 inch from the outer surface of left vacuum column. If our capstan motor shaft is perpendicular to the tape path and the operations described above have been performed correctly, X will be equal to this distance.

7. Remount the capstan motor on the casting (four bolts). Tighten the mounting bolts.
8. Clean the capstan with a water-dampened Kimwipe or lint-free cloth. Do not use any cleaner other than water on capstan.
9. Reposition the capstan on the capstan motor shaft. Tighten the clamp.
10. The reference edge of the fixed guides is now set into the plane of the tape coming out of the vacuum columns. (See Figure 5-44.)
11. Load a good quality tape using the alignment glass (Figure 5-45). It will be necessary to hold glass doors with one hand while pressing "load" with other. (See Figure 5-46.)
12. Ensure that the tape rides in the center of the capstan. This can be done by running the tape forward several feet and eyeballing the tape position on the capstan. The capstan can be moved in or out to ensure that the tape is in the middle of the capstan. The capstan alignment tool (29-18609) can be used for coarse adjustment. Ensure that the capstan is clamped securely to the capstan motor shaft.

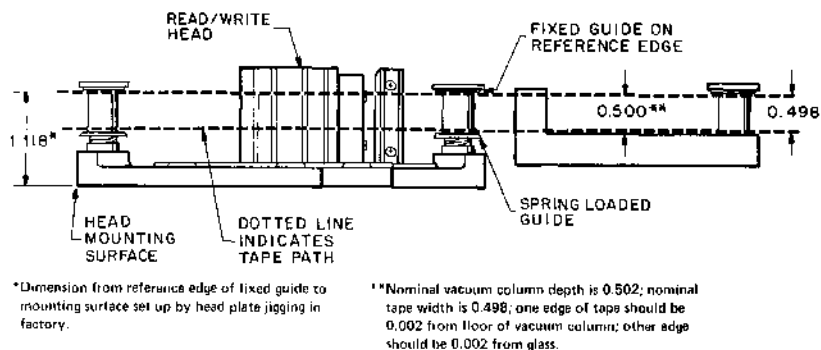


Figure 5-44 Head Plate Assembly Mounted in the Plane of the Tape Path

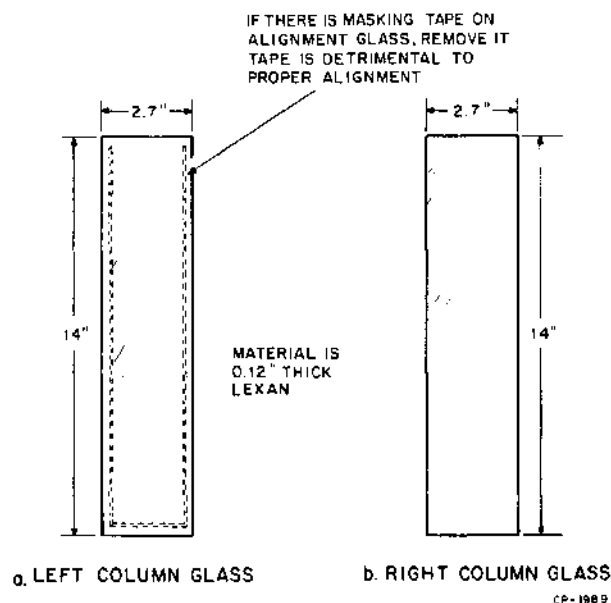


Figure 5-45 Alignment Glass

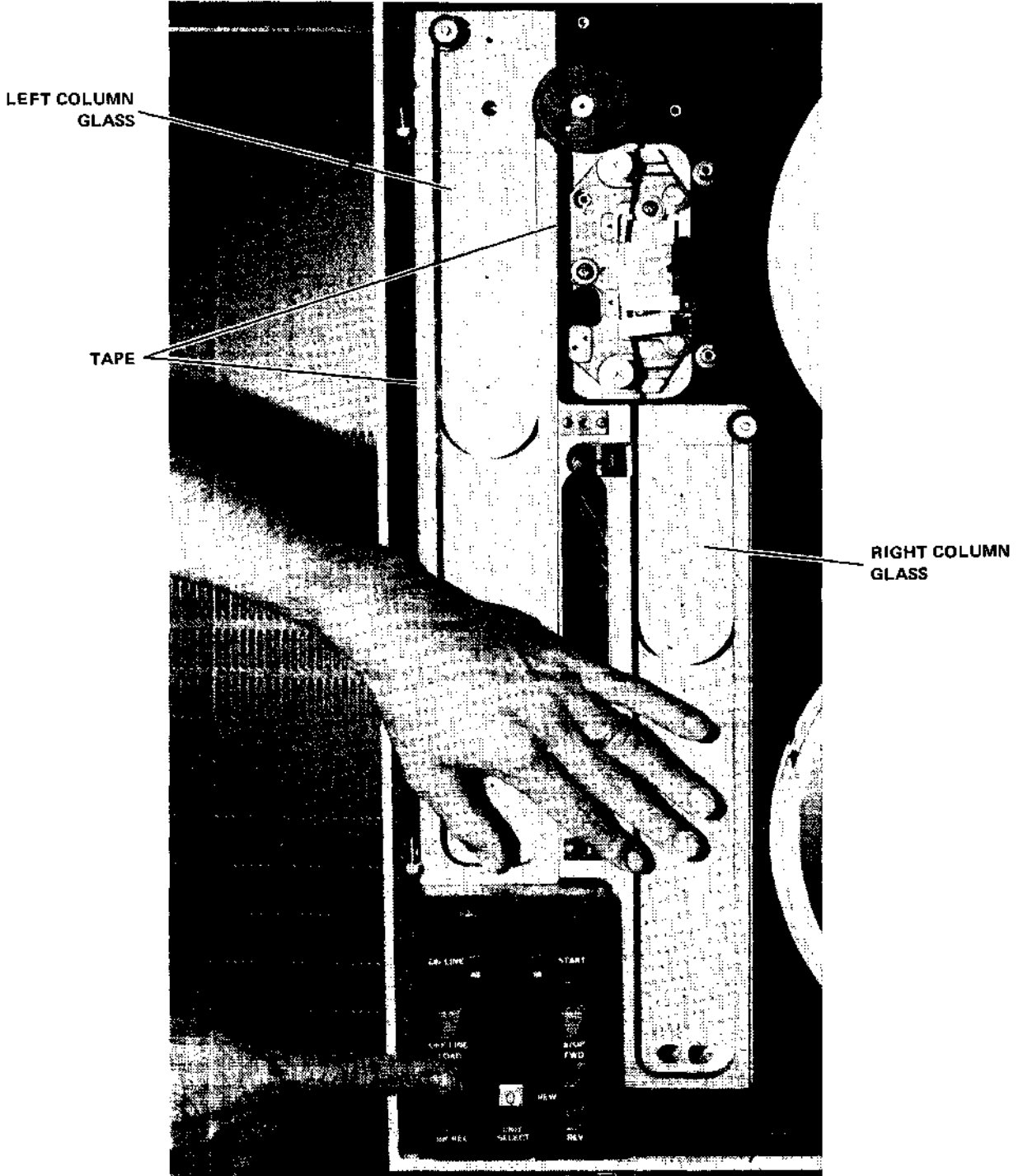
13. You are now ready to begin aligning the capstan motor shaft (making it perpendicular to tape path). This will be done by placing shims between the capstan motor mounting face and the casting surface onto which the capstan motor is mounted. Shims will be placed in the vertical axis to correct for capstan steering when both forward and reverse tape motion produces the same steering characteristic (i.e., tape steers toward the deck plate or toward the vacuum column glass in both directions). Shims will be placed in the horizontal axis if forward and reverse tape motion show opposite steering characteristics. (See Figure 5-47.)

NOTE

To facilitate this step, note the following:

- The sequence of tightening the bolts on the capstan motor is important. Each time the bolts are tightened in a particular procedure, they must be tightened in the same order. This allows the procedure to be repeated while keeping the motor in the exact same position.
- The use of sharp scissors on the plastic shim stock is necessary to keep the edges from curling up. The plastic shim stock sizes are identifiable by the color coding as follows:

Amber	0.001 inch
Red	0.002 inch
Green	0.003 inch
Tan	0.004 inch
Blue	0.005 inch
Transparent	0.0075 inch
Brown	0.010 inch

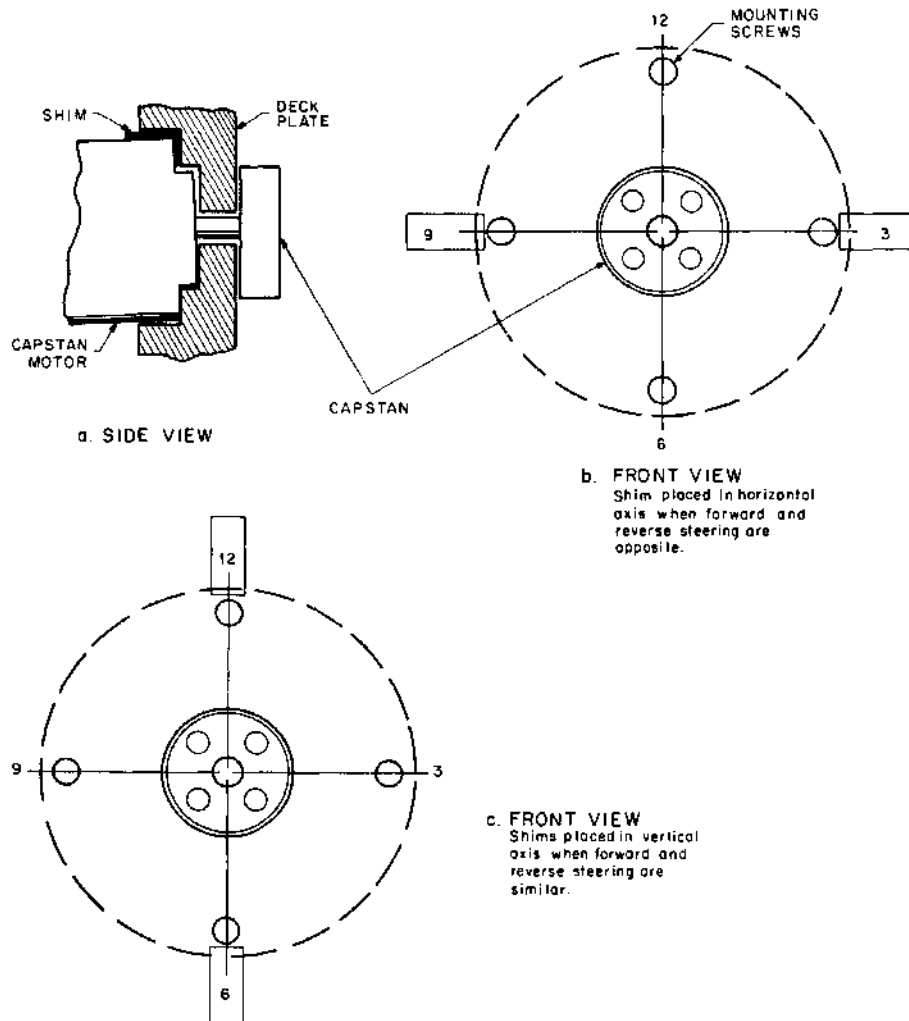


7660-17

Figure 5-46 Using Alignment Glass to Load Tape

- The use of a good quality tape is necessary for correct capstan alignment. A used or abused tape will not run true over the capstan, causing false readings during the capstan alignment procedure.

14. Cut one piece of each type of shim stock as indicated in Figure 5-48. Exact dimensions of shim stock are not critical; main thing is to have a manageable size to use as a feeler gauge. The blunt point shown in Figure 5-48 also minimizes curling of the end which will be used.
15. Run tape forward from BOT for 5 seconds.



CP 2121

Figure 5-47 Capstan Motor Shim Placement

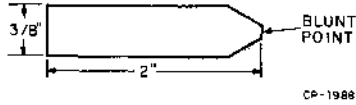


Figure 5-48 Capstan Motor Shim

16. Using shim stock and penlight determine the spacing (Y) between the inside edge of the tape and the floor of the left vacuum column. (See Figure 5-49.) The method of measuring space Y is shown in Figure 5-50 and is as follows:
 - a. Slide shim stock underneath inside edge of tape at slot between top of left column and capstan.
 - b. Shine light onto full width of tape while moving shim stock back and forth; look for puckering.
 - c. Measurement has been obtained when you select a piece of shim stock which causes small amount of friction when sliding back and forth, yet no visible pucker.

NOTE

Value Y (obtained in Step 16) must be equal to value X (obtained in Step 6). The tolerance for value Y is ± 0.002 inch. In no case shall value Y be less than 0.001 inch. Continue with procedure to determine corrective action.

17. Run tape reverse for 5 seconds. Measure tape to column spacing to obtain value Y.
Value Y obtained in Step 16 must equal value Y obtained in Step 17, ± 0.001 inch.
- 17A. In other words, it will be necessary to continue shimming the capstan motor as described in Step 13 until value Y is:
 - a. No greater than value X plus 0.002 inch in forward or reverse.
 - b. No less than value X minus 0.002 inch in forward or reverse (no less than 0.001 inch in any case).
 - c. The difference between forward and reverse does not exceed 0.001 inch.

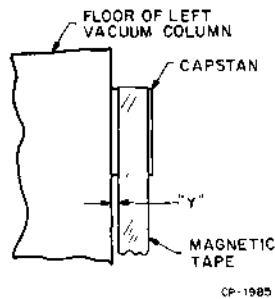
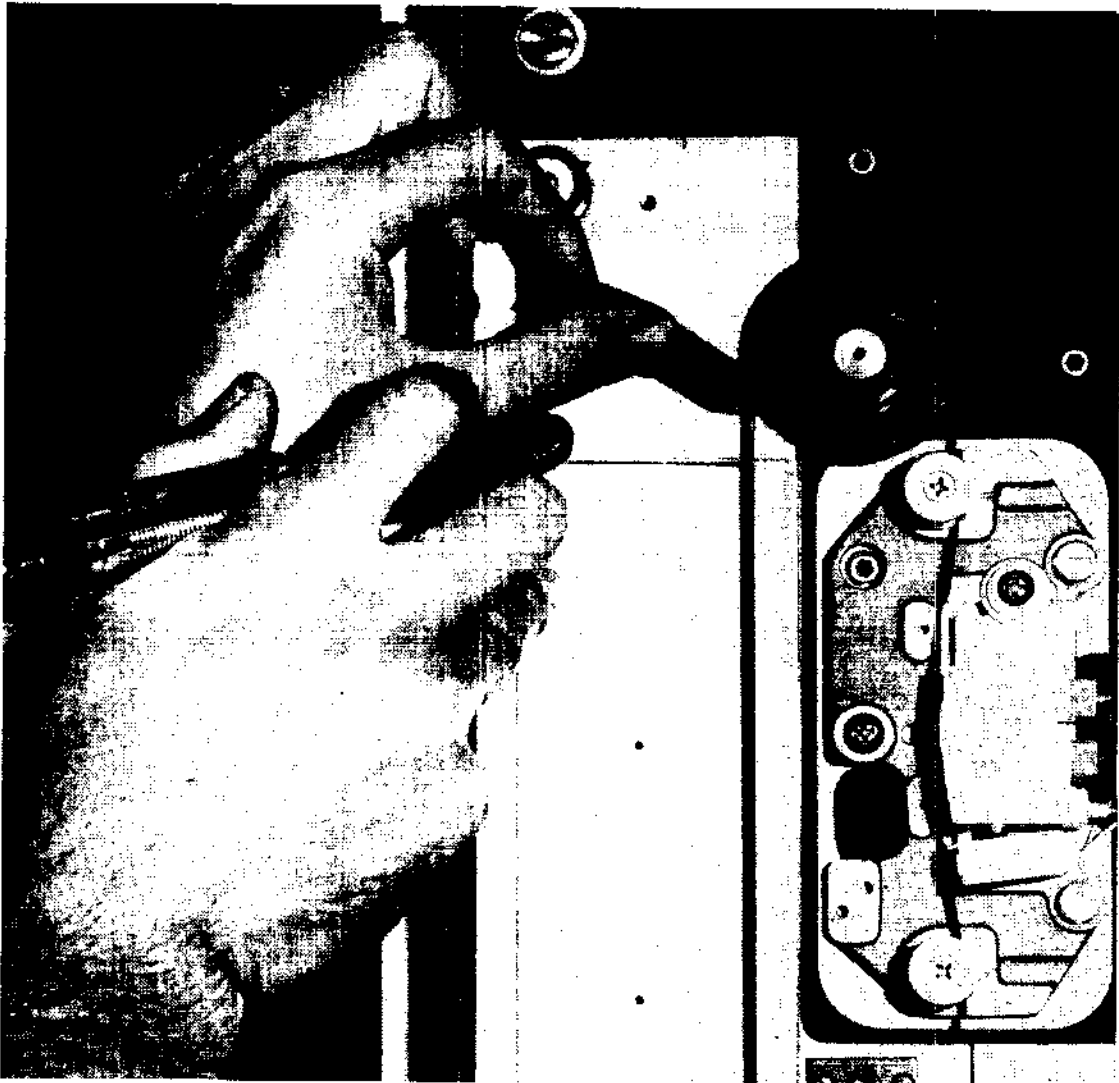


Figure 5-49 Gap (Y) from Tape to Floor of Left Column



7660-15

Figure 5-50 Measurement of Tape Gap (Y) with Penlight and Shim

17B. Shimming will be accomplished as follows:

- a. If tape is too close to casting in forward and reverse: loosen motor mounting bolts, place a shim under the motor adjacent to the bolt at 6 o'clock, tighten bolts, and repeat Steps 15, 16 and 17.
- b. If tape is too far away from casting in both forward and reverse: loosen motor mounting bolts, place a shim under the motor adjacent to the bolt at 12 o'clock, tighten bolts, and repeat Steps 15, 16 and 17.
- c. If tape is too close to casting in forward and too far away from casting in reverse: loosen motor mounting bolts, place a shim under the motor adjacent to the bolt at 3 o'clock, tighten bolts, and repeat Steps 15, 16 and 17.
- d. If tape is too far away from casting in forward and too close to casting in reverse: loosen motor mounting bolts, place a shim under the motor adjacent to the bolt at 9 o'clock, tighten bolts, and repeat Steps 15, 16 and 17.
- e. If measurements meet the criteria stated in Step 17A, go to Step 18.

17C. Following guidelines should be adhered to:

- a. A 0.005 inch shim is usually a good starting point, but almost any size shim (up to 0.010 inch) may be necessary to accomplish the criteria stated in 17A.
- b. If a shim size greater than 0.010 inch is called for, it is advisable to rotate the motor mounting 90 degrees and try again, or change the motor.
- c. In no case should there be a shim at the two ends of the same axis (e.g., 3 and 9 o'clock, or 6 and 12 o'clock). In other words, if the formula in Step 17B says to place a shim at 6 o'clock and there is already a shim at 12 o'clock, decrease the shim size at 12 o'clock instead.
- d. It is quite normal to have one shim in each of the two axes. In fact, it is desirable, as this will make the procedure less subject to irregularities due to variations in bolt tightening sequences. (A shim in the vertical axis will allow the motor to rock in the horizontal axis.) For this reason, at the start of a shimming session, place a shim of half the value in the horizontal axis, if a shim is placed in the vertical axis due to the formula in Step 17A (or vice versa). This is only a time-saving starting point; both shims may need adjustment on re-runs through Steps 16 and 17.
- e. It is acceptable to use multiple shims under a given bolt to obtain the desired value (e.g., placing a 0.005 inch and 0.004 inch together to obtain 0.009 inch).
- f. If Steps 16 and 17 seem impossible to accomplish, or if measurements taken in these steps are inconsistent, see Step 20 for explanation of capstan and tape phenomena.
- g. It should be noted that, while a guiding surface exists on the right side of the capstan (the head plate guides), none exists on the left side (left vacuum column). This will tend to make forward capstan steering look less severe than reverse. Therefore, small differences between forward and reverse are sometimes better corrected by shims in the vertical axis.

18. Mount a skew tape; adjust mechanical skew per quarterly P.M. schedule.
19. With skew tape mounted, scoping tracks 1 and 9 (9-track) or 0 and 6 (7-track), evaluate capstan alignment as follows:
 - a. Run tape forward looking at skew signal on scope. Skew jitter must be less than $2 \mu\text{s}$.
 - b. While tape is running forward, move upper spring-loaded guide (Figure 5-51) away from tape. Skew jitter must not increase more than $2 \mu\text{s}$ (take care not to touch tape).
 - c. While tape is running forward, look at tape interface to upper fixed guide (use a penlight to reflect light off the tape surface); ensure that no puckering exists.
 - d. Run tape reverse, looking at skew signal on scope. Basic skew must not change more than $0.5 \mu\text{s}$, and jitter must remain less than $2 \mu\text{s}$.
 - e. While tape is running reverse, move upper spring-loaded guide away from the tape. Skew must not increase more than $2 \mu\text{s}$.
 - f. While tape is running reverse, look at tape interface to upper fixed guide; ensure that no puckering exists.

Corrective Action:

- a. If skew increases by more than $2 \mu\text{s}$ in either forward or reverse when the spring guide is depressed, it should be assumed that the tape is running too close to the casting in that direction of tape travel.
- b. If tape is puckering on the guide in either forward or reverse, or if the skew or jitter is excessive in forward or reverse yet does not increase when the upper spring guide is depressed, it should be assumed that the tape is running too far away from the casting in that direction of tape motion.

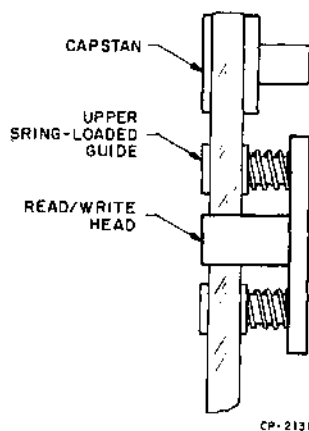


Figure 5-51 Location of Upper Spring-Loaded Guide on Capstan

- c. If neither condition exists, go to Step 20.
- d. If a or b exists, make final shimming corrections according to procedure in Step 17B.

NOTE

After all shimming is done in this step, it will be necessary to verify that the criteria in Step 17A (tape to column spacing) are still met.

- 20. Run tape forward. Look in the slot between the inside tape edge and the left vacuum column floor while the tape is moving forward. If room light is not adequate, shine penlight through from inside of vacuum column. (See Figure 5-52.)

A constant space (width of light) should be seen in this slot as the tape moves forward. Periodic width change at a very low frequency (less than one per second) is probably due to tape defects; these changes may be disregarded unless they are very repetitive and cause wide excursions. Higher frequency width changes (5 to 10 times per second) are usually caused by a bent capstan. If this occurs, it will be necessary to replace the capstan and recheck tape-to-column spacing with slim stock feeler gauges.

- 21. Run tape in reverse. Check slot width to same criteria as Step 20.
- 22. Replace vacuum column door. Run skew tape forward; ensure that skew does not exceed $2 \mu\text{s}$. Run tape reverse; ensure that packet width does not exceed $2.5 \mu\text{s}$. If either criteria fails, suspect roller guide adjustment problem.

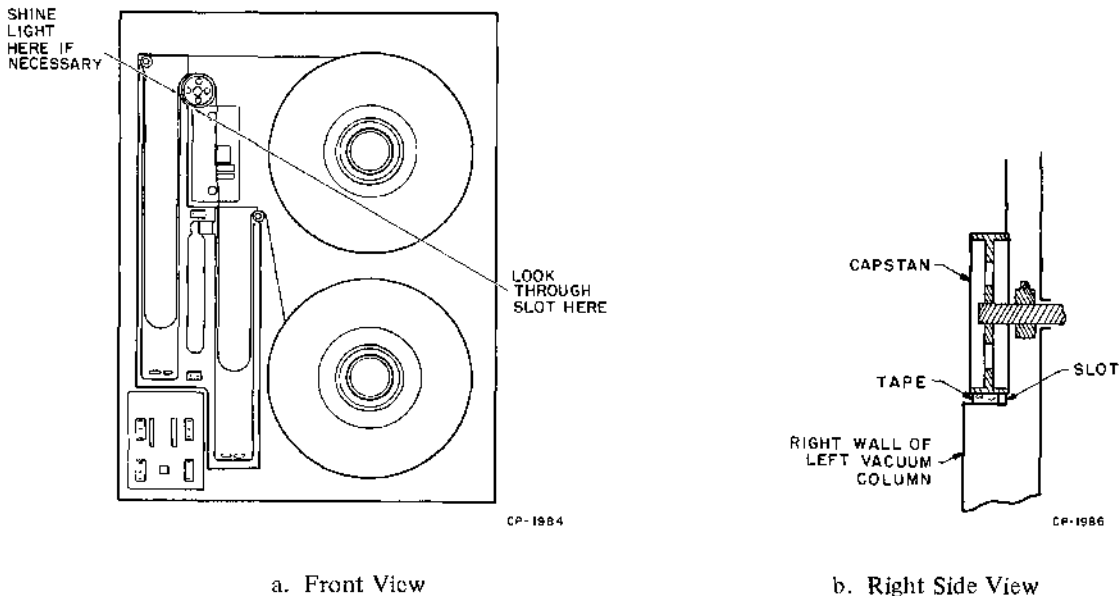


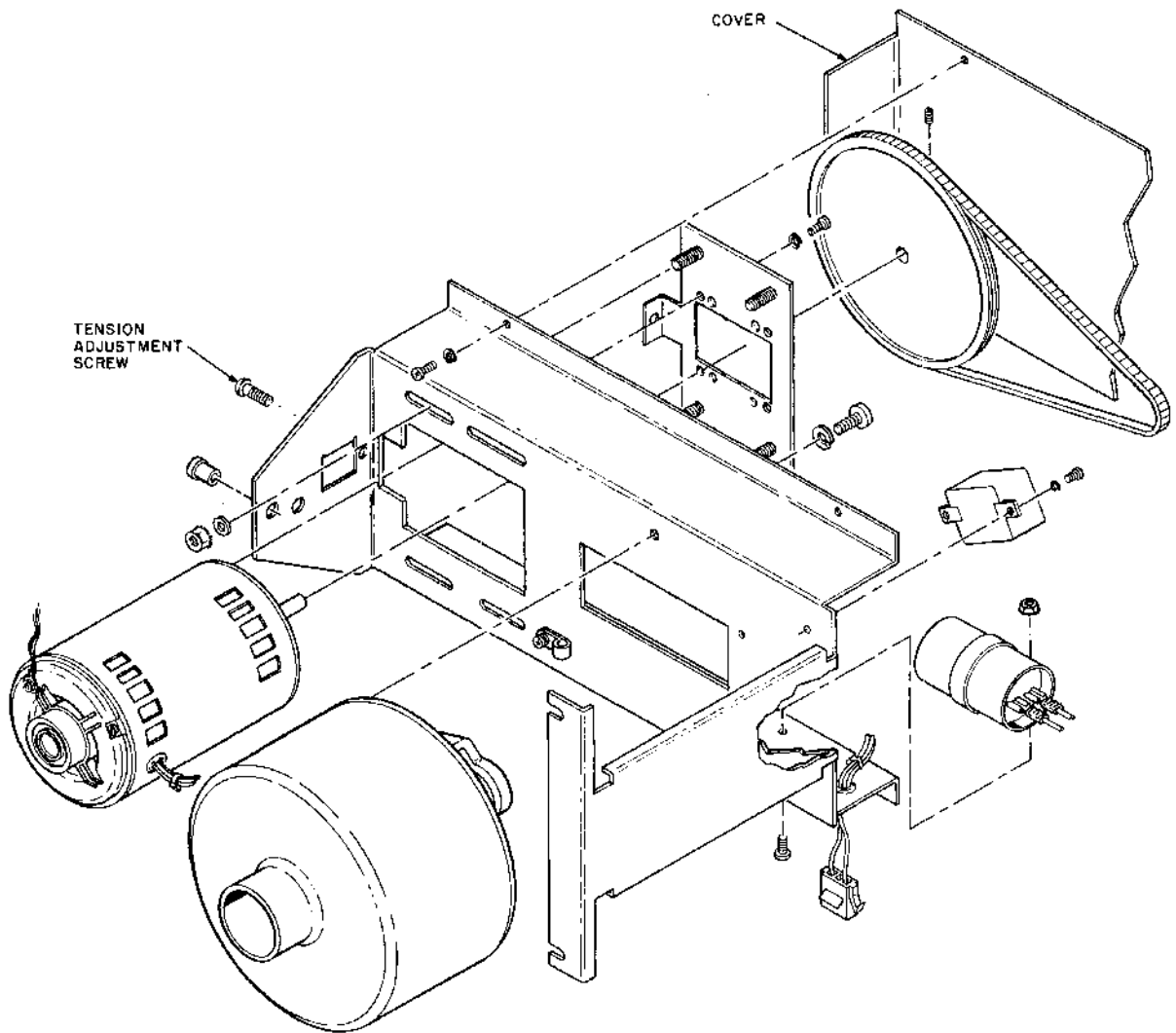
Figure 5-52 Capstan Wobble Check

5.5.14 Vacuum System Adjustments (Units above No. 10320)

TU10s above approximately no. 10320 contain a vacuum blower driven by an induction motor through a pulley and belt. This system may require adjustment either to change the operating frequency, which necessitates a pulley readjustment as described below, or to change the belt. (Refer to Section 5.6.14.)

To make any adjustments on this assembly, proceed as follows:

1. Remove the four Phillips head screws holding the cover in place, and remove the cover (Figure 5-53).



CP - 2126

Figure 5-53 TU10 Cover Assembly

2. Remove the long 10/32-inch Phillips head screw that passes through the left member of the TU10 cruciform to secure the left side of the vacuum assembly.
3. Loosen, but do not remove, the Phillips head screws that hold the right side of the assembly to the casting.
4. Loosen all of the nuts (four) that secure the motor mounting plate to the vacuum system chassis.
5. Lift the left (motor) side of the vacuum assembly high enough to expose the belt tension adjusting screw (Figure 5-53). If possible, place a small block between the protruding tab of the vacuum assembly and the TU10 cruciform so that the adjusting screw remains exposed.
6. Back off on the tension adjusting screw until the belt is loose enough to be removed easily. Remove belt.

5.5.14.1 Changing Operating Frequency – To change operating frequency, proceed as follows:

1. Remove the black anodized pulley from the motor shaft by removing the set screw holding it in place. (This set screw will be either a 10/32-inch or a 1/4-20 screw; DEC part numbers 9009174-10 or 9007722-10, respectively).
2. Inspect the set screw for stripped threads or a damaged tip; replace it, if it appears damaged.
3. Inspect the motor mounting plate, which should have an open set of four motor-mount holes. Remove the four socket-head screws holding the motor in place and remount them in the open set of holes, as shown in Figure 5-54.
4. Replace the pulley; use the pulley height gauge (DEC part number 7416187) to set the pulley height (0.820 inch for 50 Hz; 0.520 inch for 60 Hz).
5. Ensure that the set screw rests on the flat part of the motor shaft. Retighten the set screw.

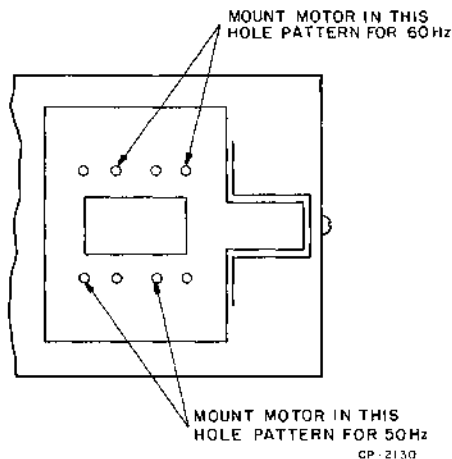


Figure 5-54 Motor-Mounting Holes for 50/60 Hz Operation

5.6 REPLACEMENT PROCEDURES

5.6.1 Reel Motor Filter Elements

Proceed as follows to replace the reel motor filter elements (see Figure 5-55):

1. Remove the filters from reel motors
2. Unscrew the two 4/40 Kep-nuts that secure the filter body together.
3. Remove the old filter element and replace with a new one.
4. Reassemble filter body.
5. Wrap Teflon tape (90-093583) on threads of filter body and hand tighten onto reel motor.

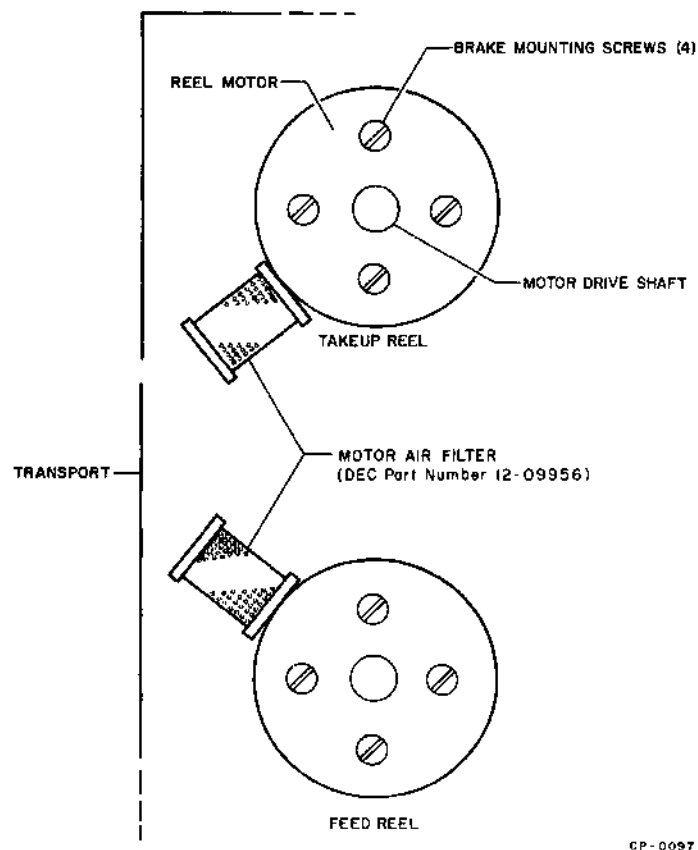


Figure 5-55 Reel and Motors, Rear View

5.6.2 Foam Stripping (Casting Perimeter)

Proceed as follows to replace the foam stripping along the perimeter of the casting:

1. Remove defective stripping from casting.
2. Cut new stripping to proper length before removing the protective backing.
3. Carefully install foam stripping on casting.

5.6.3 Vacuum Motor or Vacuum Motor Brushes

Proceed as follows to replace vacuum motor brushes:

1. Disconnect vacuum motor electrical connector.
2. Remove the three 4-40 × 1/4 screws from plenum cover and then remove cover.
3. Disconnect brushes, then remove brush retainers and brushes.
4. Carefully clean commutator with a small brush.
5. Apply a drop or two of light oil at rear sleeve bearing taking care not to get any oil on the commutator.
6. Install and connect new brushes.
7. Re-install plenum cover and reconnect vacuum motor electrical connector.

Proceed as follows to replace the vacuum motor (see Figure 5-56):

1. Remove both reel motor air filters.
2. Disconnect vacuum motor electrical connector.
3. Remove the two 10-32 screws located on the filter side of the plenum chamber.
4. Remove the third 10-32 screw while supporting the chamber with your free hand; move the chamber to a work area.
5. Remove the two 6-32 screws from the cleat; remove cleat, motor, and rubber ring after removing connector from wires.
6. Clean and inspect the rubber ring and replace if necessary.
7. Drop rubber ring into casting (concave side up); insert motor feeding wires through grommet and secure motor cleat to casting with the two 6-32 screws.
8. Connect new sockets to wires of new motor and insert them into holes 1 and 3 of the connector housing.
9. Re-install the plenum assembly by starting the first screw in the position adjacent to the vacuum channel cover and continuing with the two remaining screws near the filters. Insert a new piece of foam tape, then align housing and tighten all three screws.

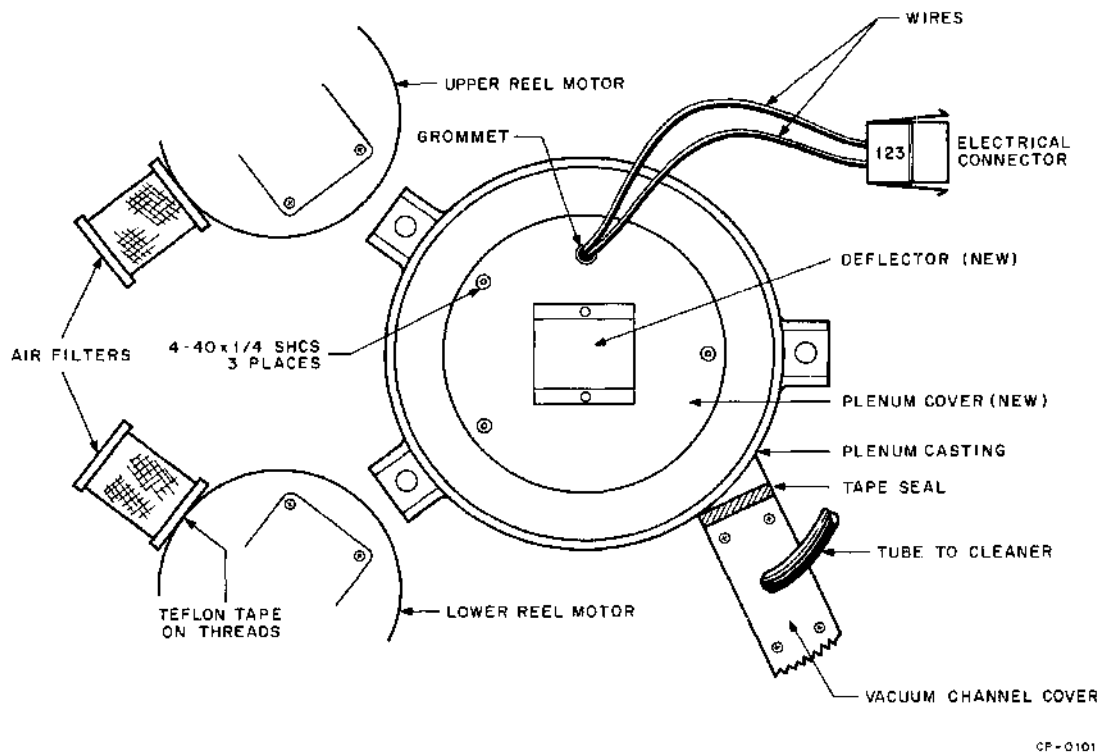


Figure 5-56 Vacuum Motor, Rear View

10. Wrap Teflon tape around filter threads and re-install filters. Reconnect the vacuum motor electrical connector.

5.6.4 Reel Hubs

Proceed as follows to inspect the reel hub knob threads or to replace the compression ring and Teflon washer:

1. Snap out plastic disk from reel hub.
2. Use a pair of heavy-duty diagonal pliers to carefully remove the center roll pin from the hub guide, noting its position for reassembly purposes.
3. Unscrew knob and remove Teflon washer, pressure plate, and rubber compression ring. Apply a small amount of silicon grease to finger tips, rub finger tips together, and lightly lubricate the surfaces of a *new* compression ring. Use a lint-free cloth to wipe all excess grease from the ring.
4. Install the compression ring, pressure plate, and a *new* Teflon washer. Apply a very light coat of silicon grease to hub guide threads and wipe off any excess grease.
5. Screw on knob and tighten to compress rubber ring. This ensures proper seating of the assembly. Loosen the knob so that it is free from the Teflon washer, then gently retighten the knob to meet the washer.
6. Reinstall the roll pin in the same hole from which it was removed.

The following checks must be performed to ensure proper alignment of the hub guide pins:

1. With the knob turned fully CCW (released position), the knob should have about 8 to 15 degrees of freedom in the CW direction before it begins to compress the assembly. If necessary, *shift the positions of the two pins* in the hub to obtain the required clearance and hub tightness.
2. If the hub pins have been shifted and the reel hubs are still loose, install a new compression ring and washer (Paragraph 5.6.4).
3. Load a tape reel on the hub and check for proper engagement and release or possible binding.

Proceed as follows to replace the reel hub assembly:

1. Loosen the two Allen locking screws that secure the reel hub to the shaft and remove hub (access holes for the screws are located on the side of the hub). Remove any burrs on the shaft.
2. Install a new reel hub on the shaft. Use a 0.125 inch gauge to achieve the necessary clearance between the back surface of the reel hub and the machined boss on the casting (see Figure 5-57).

5.6.5 Vacuum Switches and Rubber Sleeves

Proceed as follows to replace the vacuum switches or the rubber sleeves on the switches (see Figure 5-58):

1. Remove the two 8-32 screws securing the switch brackets to the casting. Pull the brackets rearward to disengage the assembly.
2. Carefully detach the pair of fast-on connectors from each switch and note their positions for reassembly purposes.

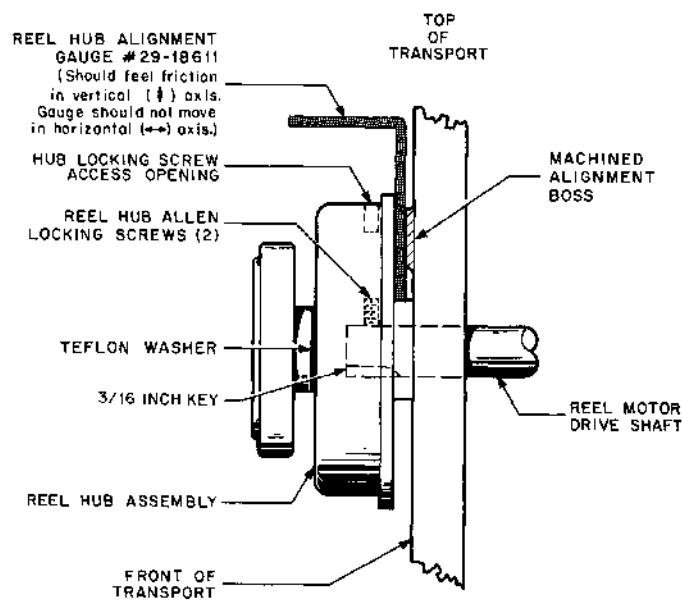
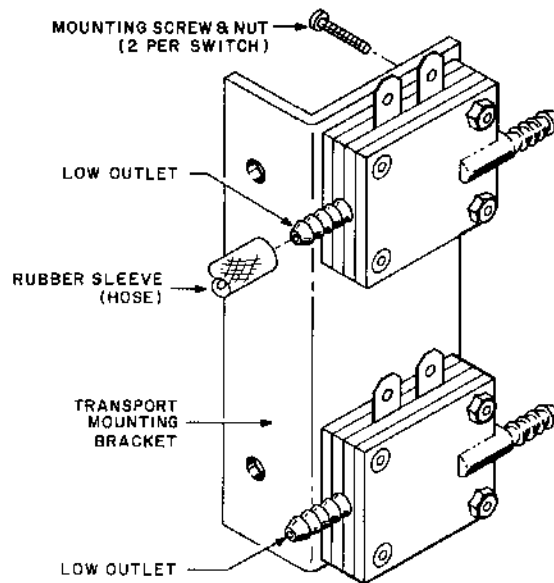


Figure 5-57 Reel Hub



CP-0103

Figure 5-58 Vacuum Switches

3. Remove the switch from the bracket by removing the two 2-56 screws.
4. Replace the rubber sleeve on each switch with a 7/8-inch length of tubing. Replace the switch, when necessary.
5. If a switch is replaced, it should be left slightly loose until the bracket is secured to the casting. This allows for any misalignment present in the mechanics.

CAUTION

Never overtighten the screws securing the vacuum switches to the bracket. This can damage the switches.

6. Reconnect the fast-on connectors to all switches.
7. Guide the switch assemblies so that each switch sleeve fits snugly into its respective hole in the casting without any lateral strain.
8. Insert and tighten bracket screws.
9. Operate transport off-line to check switch functions.

5.6.6 Reel Motors and Brushes

Recent investigations indicate that reel motor brushes have a normal operating life of 10,000 hours. Brushes are matched to the motor's commutator by a burnishing process, new unburnished brushes may generate unacceptable levels of electrical noise.

If a motor exhibits symptoms indicating a need for brush replacement, the motor should be changed as a unit, as follows:

1. Remove the reel hub assembly by loosening the two Allen locking screws that secure the reel hub to the shaft.
2. Remove the air filter.
3. Remove the brake assembly (refer to Paragraph 5.6.7).
4. Remove the four captivating screws that secure the motor to the deck casting.
5. Replace the reel motor and tighten the four captivating screws to a torque value of 19 inch-pounds.
6. Install the brake assembly (Paragraph 5.6.7), air filter, and reel hub assembly. Use a 0.125-inch reel hub gauge (part number 29-18611) to achieve the necessary clearance between the back surface of the reel hub and the machined boss on the casting.

5.6.7 Reel Motor Brakes

If the stator slot is worn away, proceed as outlined in 5.3.3 to remove and replace the reel motor brakes.

5.6.8 Capstan

Proceed as follows to remove and replace the capstan:

1. Use a pair of tru-arc pliers* to loosen the capstan lock-ring and slide the capstan from the motor shaft. Check that there are no burrs on the end of the shaft or in the slots cut in the shaft of the capstan (Figure 5-59).

*Old style only (see Figure 5-59).

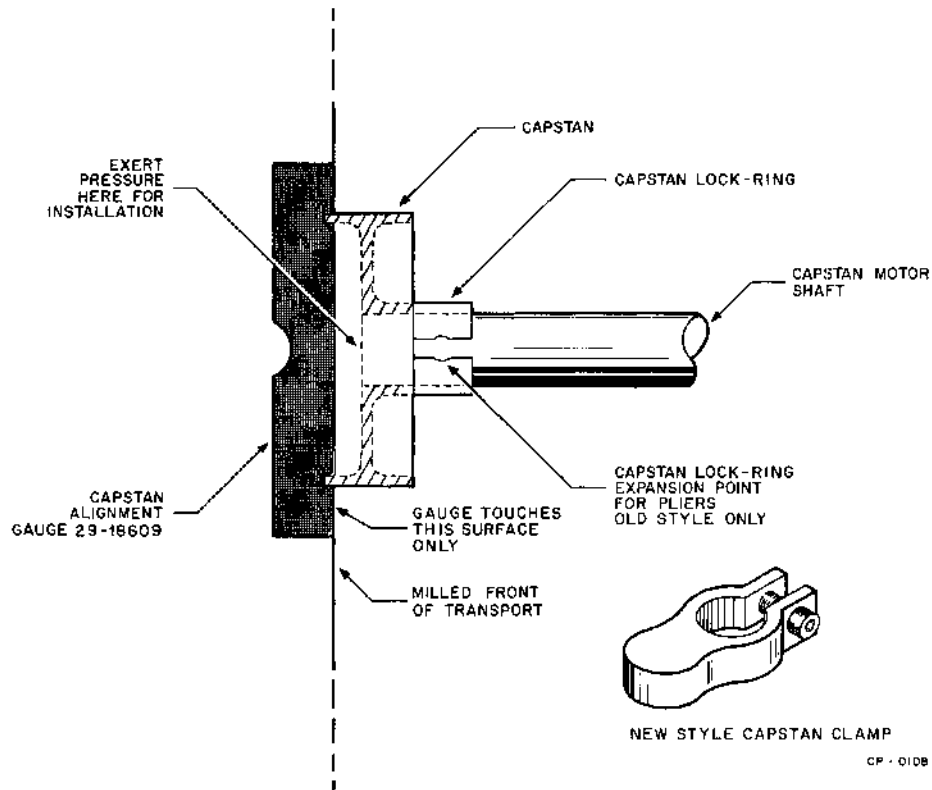


Figure 5-59 Capstan Adjustment

2. Place a new capstan on the motor shaft and use the tru-arc pliers* to carefully install the lock-ring flush with the end of the capstan. Ensure that the lock-ring slot is in the center of a section of the capstan.
3. Mount the capstan to the motor shaft, using the capstan gauge to push the capstan on the capstan motor shaft. (If new style clamp is used, tighten it.)
4. Power up the drive. Mount a good-quality tape.
5. Run the tape forward and reverse to ensure that the tape is centered on the capstan.
6. Align tape path. (Refer to Paragraph 5.5.14.)

5.6.9 Control Box

Proceed as follows to replace the bulbs in the control box:

1. Loosen the screw at the bottom-center of the control box and remove panel.
2. Use a bulb extracting tool to remove and replace defective bulbs.
3. Mount panel on control box and tighten screw.

*Old style only (see Figure 5-59).

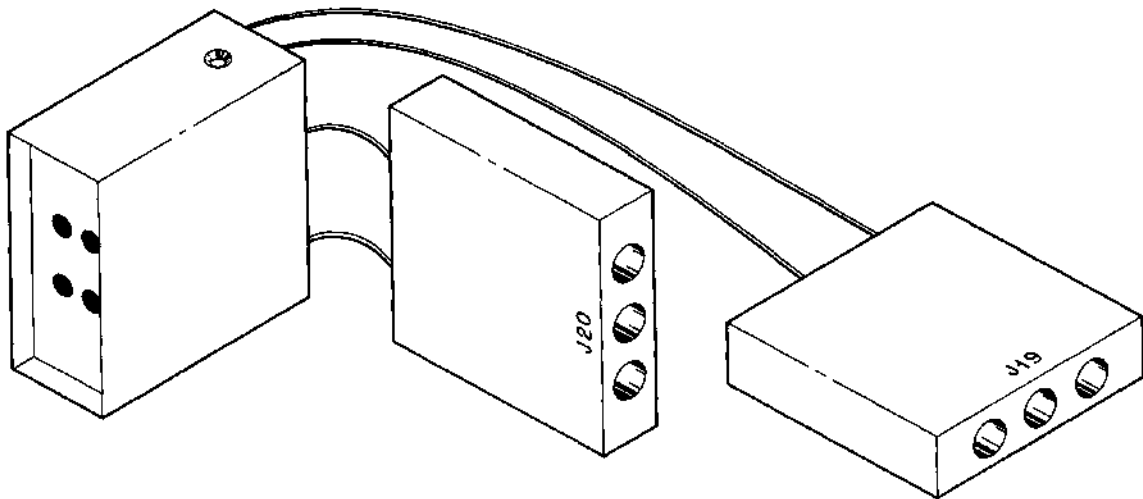
Proceed as follows to remove the control box:

1. Disconnect cable at the logic rack.
2. Disconnect plugs from the EOT/BOT sensor assembly.
3. Loosen and remove the four nuts securing the control box to the casting.
4. Carefully remove the control box to ensure the connecting cable is not damaged.
5. Repeat Steps 1 through 4 in the reverse order to install the control box.

5.6.10 EOT/BOT Assembly

The EOT/BOT assembly is mounted on the head plate. Proceed as follows to remove and replace this assembly (see Figure 5-60):

1. Use a small screwdriver to loosen the mounting screw.
2. Disconnect the plugs at the rear of the casting.
3. Carefully remove the assembly to ensure the head or head cables are not damaged while pulling the connectors through the hole.
4. Replace faulty assembly and install by repeating Steps 1 through 3 in the reverse order.
5. Check for proper alignment by ensuring that the EOT and BOT markers are sensed and adjust the assembly if necessary.



CP-0225

Figure 5-60 EOT/BOT Assembly

5.6.11 Head Plate

The head plate assembly consists of the tape cleaner, tape guides, heads, and the EOT/BOT assembly. Since the heads and the tape cleaner are factory-adjustable only, **DO NOT ATTEMPT TO ADJUST EITHER OF THESE ITEMS IN THE FIELD.** All new head plate assemblies are now manufactured with a stepped machined relief in the rear surface (Figure 5-18) and two jacking screws incorporated in the plate front (Figure 5-23). These new head plate assemblies are directly interchangeable with the older assemblies (no jacking screws or stepped relief) and are shipped with the jacking screws withdrawn from the rear surface of the plate. The jacking screws are to be used to mechanically align the head plate and should not be screwed down before the plate assembly is installed and ready to be aligned.

Proceed as follows to replace a head plate assembly and properly set the initial mechanical alignment:

1. Remove the head cover.
2. Remove the EOT/BOT assembly (Paragraph 5.6.10).
3. Before disconnecting the erase head cables, note the color code of the cable connections to ensure proper reinstallation. Disconnect the read/write head cables.
4. Remove the three shoulder screws (Figure 5-23) that secure the head plate assembly to the tape deck casting and remove the head plate assembly.
5. Position the new head plate assembly on the casting and insert the first shoulder screw through the lower right reference hole. Tighten this screw finger tight.
6. Insert the two remaining shoulder screws and finger tighten them until they are not quite touching the head plate assembly.

NOTE

The head plate assembly can now be slightly rotated from side-to-side around the lower reference hole shoulder screw.

7. Position the head plate assembly approximately half-way between this side-to-side arc and gently tighten the reference shoulder screw with a screwdriver.
8. Reinstall the EOT/BOT assembly (Paragraph 5.6.10) and connect the read/write head cables, observing the erase cable polarity. (Ensure that the black wire is connected to the erase terminal closest to the operator.)
9. Using a handled 3/32 Allen wrench, turn in the upper jacking screw until it touches the tape deck casting and then lightly tighten the upper shoulder screw with a screwdriver. Ensure that the remaining shoulder screw is not tight and that the middle left jacking screw is not touching the casting.
10. Perform the mechanical skew adjustment for the new head plate assembly (Paragraph 5.4.4.1).

5.6.12 Power Supply

Proceed as follows to remove the power supply:

1. Disconnect the power cable and fan cable at the rear of the power supply.
2. Disconnect plugs P3, P4, and P6 on the front of the power supply. Remove ground strap.
3. Remove the four screws securing the power supply to the frame and lift out power supply.
4. To install the power supply, repeat Steps 1 through 3, in reverse order.

5.6.13 Capstan Motor

NOTE

No repair must be attempted on a faulty capstan motor; return the faulty unit to DEC.

To remove the capstan motor proceed as follows:

1. Remove the capstan as described in Paragraph 5.6.8.
2. Unplug the capstan motor connectors located at the rear of the casting.
3. Use a 3/16-inch Allen wrench to remove the four screws that hold the capstan motor to the casting. (It is not necessary to remove the tachometer portion of the motor; these two are replaced as an assembly.)
4. Replace the motor with a new one, taking care to apply a thin coat of Wakefield Thermal Compound to the face of the motor that touches the casting.
5. Replace the four screws and retighten to 10 inch-pounds.
6. Replace the capstan as described in Paragraph 5.6.8.

5.6.14 Vacuum System Belt Replacement

The procedure for replacing the belt is as follows:

1. Determine which motor pulley is to be used (the larger diameter for 50-Hz operation; the smaller diameter for 60-Hz operation).
2. Place the belt over the appropriate pulley; loop the belt over the blower pulley.
3. Tighten the belt tension adjustment screw until the belt has about 1/2 inch of play when pressed.
4. Position the belt tension gauge as shown in Figure 5-61; push against the knob at the end of the spring until the third tab on the gauge just touches the belt.
5. Read the tension from the scale just under the spring; adjust the belt tension adjustment screw for between 14 and 16 lb of belt tension.

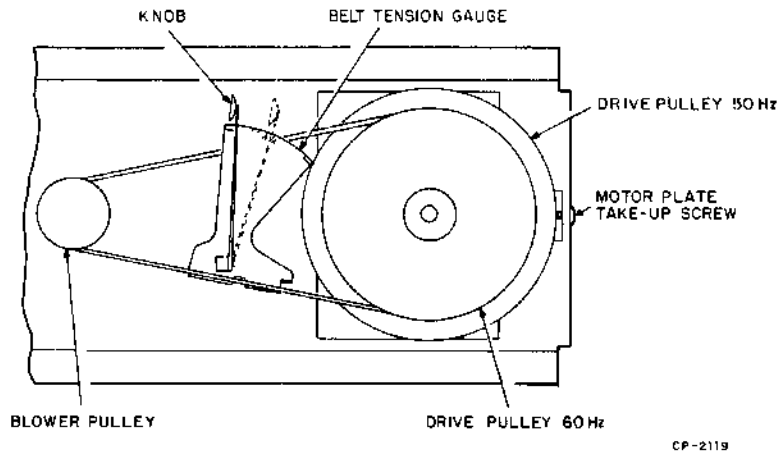


Figure 5-61 Belt Tension Gauge

NOTE

New belts must be run in for 1/2 hour, and then retensioned. Failure to perform this run-in and retensioning process will result in excessive pulley wear and possible breakage.

6. Replace and retighten all mounting hardware.

5.7 BRAKE ADJUSTMENT PROCEDURE

To ensure proper operation of the TU10, an adjustment to the brake circuit may be necessary after normal wear or long periods of inactivity. In addition, brake operation must be checked after cleaning the brake armature. The TU10 brake circuit has two adjustments that affect brake operation during REWIND. Both adjustments affect only the upper brake and upper vacuum column. Vacuum failures caused by excessive tape loop travel in the lower vacuum column are indicative of a defect in the circuit, the brake, or the associated connectors.

Proceed as follows to perform a visual check of the REWIND operation.

1. Place the TU10 in the off-line mode and move tape to EOT.
2. Initiate the REWIND operation from EOT several times. Allow the operation to continue approximately 10 seconds before returning to EOT.
3. Initiate the REWIND operation and continue to the BOT marker.
4. Check for an improperly adjusted brake circuit by watching for any of the following symptoms during the REWIND operation.
 - a. Any vacuum column failure.
 - b. More than 2 or 3 tape loop excursions exceeding approximately 1/3 of the distance into the brake zone. During acceleration from EOT, 2 or 3 large excursions are normal.

- c. Normal tape loop excursions during acceleration, but a sluggish return of the tape loop from the reel motor zone to the brake zone.
- d. Erratic tape loop excursions during continuous REWIND operation exceeding 1-1/4 inches above the UPPER VAC SW. Tape motion will always be somewhat erratic, but the magnitude of the loop "jumps" should be below 1-1/4 inches.

In almost every case a tape loop failure can be diagnosed as an extreme example of symptoms b, c, or d. Continuous large tape loop excursions are probably due to one of the following causes:

1. High current REWIND time is too short. The high current REWIND time is measured as a positive pulse at B05V2. Typical pulse length is 20–25 ms. It is adjusted using the potentiometer (R61) on the G9340 Module. Adjustment should be made in intervals not exceeding 3 ms.
2. Low current REWIND amplitude is too low. The amplitude is adjusted using the potentiometer on the G9341 Module. Clockwise rotation of the potentiometer increases the current to the brake. Adjustment should be made at intervals not greater than 2 turns of the potentiometer.

Symptom c is an indication that the low current REWIND amplitude is too high. Counterclockwise adjustment of the potentiometer (R79) on the G9341 Module will decrease the amplitude. The effects of the adjustment should be observed at intervals of 2 turns on the potentiometer.

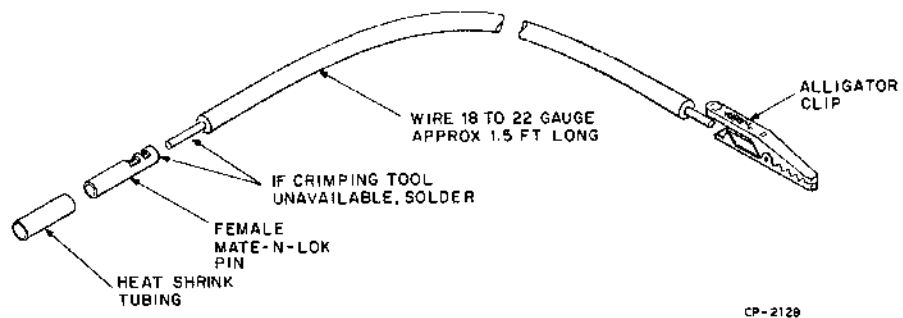
Symptom d is an indication that the high current REWIND time is either above or below the ideal operating range. The 20–25 ms range is a helpful guideline, but is not absolute, and will depend on the operation of the brakes.

5.8 CAPSTAN MOTOR TACHOMETER CHECKING PROCEDURES

5.8.1 Equipment Required

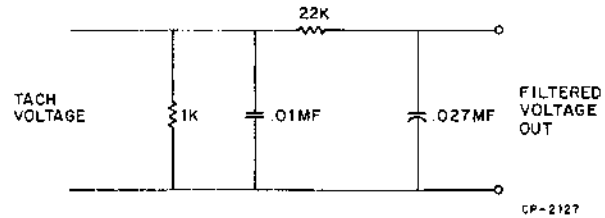
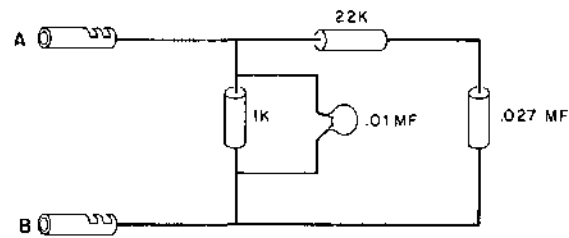
The following equipment is required for the procedures described below:

1. Jumper wires (Figure 5-62) (Two required).
2. Tachometer filter circuit (Figure 5-63).
3. Oscilloscope.



CP-2126

Figure 5-62 Jumper Wires – 2 Required



CP-2127

Figure 5-63 Tachometer Filter Circuit

4. Plastic shim, 0.015 inch. (Two pieces of 0.075-inch plastic shim can be used; DEC part number 48-50023-07 is a 10-inch × 20-inch piece of 0.075-inch shim.)

5.8.2 Checking Tachometer Voltage

The procedure for checking tachometer voltage is as follows:

1. Turn power OFF; dismount tape.
2. Unplug the capstan motor Mate-N-Lok connector from the II603 Driver Module.
3. Use jumpers (Figure 5-62) to connect motor leads to the 5-volt supply. To prevent blowing the 5-volt fuse (F6, 6 Amps, fast-blow), disconnect the red 5-volt supply wires from the Jones strip just beneath the vacuum motor assembly and clip one of the jumper wires to it. Clip the other jumper wire to the ground lead. Disconnect the 15-volt supply wires also, and push them out of the way.

NOTE

Motor leads originate at studs closest to casting. Tachometer leads originate at studs farthest from casting.

4. Connect the +5 jumper to the red motor lead, the GND jumper to the black motor lead. Connect filter lead A (Figure 5-63) to red tachometer lead, and filter lead B to black lead. Connect scope probe and ground strap across the 0.027 mF capacitor (Figure 5-63).
5. Turn power ON.
6. Tachometer voltage should read +1.0V, -1.1V. Plus or minus voltage reading depends on the scope probe location. Tachometer ripple should be no more than 30 mV peak-to-peak.
7. Reverse motor jumper (+5 to black and GND to red).
8. Tachometer voltage should reverse; ripple must remain less than 30 mV peak-to-peak.

NOTE

On PMI motors with model numbers beginning with 4J and earlier, tachometer leads are reversed from above.

5.9 RECOMMENDED TEST EQUIPMENT AND SPARE PARTS

The following tables provide a recommended test equipment list and a spare parts list for the TU10. Table 5-5 lists the test equipment and alignment tools recommended for maintenance purposes. Tables 5-6 through 5-9 contain spare parts requirements for the modules, control box, power supply, and miscellaneous categories.

**Table 5-5
Recommended Test Equipment and Alignment Tools**

Description	Model or Part Number
Dual Beam Oscilloscope with Two X10 Probes and Two X1 Probes	Tektronix Model 453 or equivalent
Multimeter	Triplett 630 or equivalent
Capstan Gauge	29-18609
Roller Guide Gauge	29-18607
Reel Hub Gauge	29-18611
Write Interlock Gauge Set	29-18608 and 29-18610
10 in./lb Torque Driver*	29-18360
19 in./lb Torque Driver*	29-18361
* Torque Driver Blades	
8/32 Allen Tip	29-18504
10/32 Allen Tip	29-18505
5/16 Screwdriver Blade	29-18509

**Table 5-6
Control Box Spare Parts**

Part Number	Description
12-11239	Lamp Control Box*
12-10078	Switch (Digitran)
12-05941	Switch (Rocker #RS-50-FB-PC)
12-09614	Switch (Rocker)

*This is a new part number, it designates a lamp with a significantly longer life than the old lamp.

**Table 5-7
Module Spare Parts**

Type	Name	Quantity
G9340	Brake Actuator	1
G9341	Brake Actuator	1
H1603	Servo Amplifier	1
M050	Lamp Driver	1
M514	Bus Transceiver	1
M763	Write Buffer	1
M765	Read Buffer	1
M765-YA	Read Buffer	1
M767	Clock Skew Delay	1
M768	Delay Transmitter	1
M769	Function Control	1
M890	Motion Control	1
M7670	Forward BOT Timer	1
W726	Switch Filter	1
G050	Read Amplifier	1
G060	Compressor	1
G060-YA	Compressor	1
G062	Peak Detector	1
G093	Peak Detector	1
G064	Slicer	1
G094	Slicer	1
G350	Head Driver	1
G741	Terminator	2
G741-YA	Terminator	1
G932	Servo Preamplifier	1
G933	Reel Motor Amplifier	2

**Table 5-8
Power Supply Spare Parts**

Part Number	Description
11-10051	Diode (MDA990-3)
90-08838	Fuse (#3AG, 10 amp)
90-07221	Fuse (#3AG, 5 amp)
90-07999	Fuse (#3AG, 6 amp)
90-07225	Fuse (#3AG, 10 amp, SB)
90-07222	Fuse (#3AG, 5 amp, SB)
54-08924	Power Control Board
12-10102	Relay
15-03068	Transistor (2N3715)
54-08928	Voltage Regulator Board

**Table 5-9
Miscellaneous Spare Parts**

Part Number	Description
12-11581	Belt, Vacuum System
12-11582	Blower, 3-Stage, for Vacuum System
29-22265	Gauge, Belt Tension
29-12291	Brushes, Vacuum Motor
70-10316*	Cables
74-07957	Capstan
74-07958	Clamp (Lock-Ring), Capstan
74-07960	Clamp, Roller Guide Shaft
12-10721	Elapsed Time Indicator Assembly
12-10336	EOT/BOT Sensor Assembly
12-09956	Filter, Reel Motor (Atomuffler)
70-09885-4	Head Assembly, 9-Track
70-09885-3	Head Assembly, 7-Track
91-07716	Hose, Vinyl 3814-1
12-09786	Motor, Capstan
12-11639	Motor, Induction, for Vacuum System
12-09677	Motor, Reel
12-05944	Motor, Vacuum
74-07996	Plug, Air
12-11659	Relay, Motor Starting, for Vacuum System
12-10145	Roller Guide Assembly
12-10021	Ring, Compression
91-07717	Rubber Tubing #192
90-09397	Screw Set Knurled Cup PT #8-32 X 1/4 lg.
12-09378-01	Socket Housing (Mate-N-Lok)
12-09868	Solenoid (Deltrol Controls)
12-09870	Switch, Read/Write Interlock
12-10477	Switch, Vacuum (Fairchild)
90-07834	Tape, Stock Mount (3M #4032)

*The following table lists the variations of cable 7010316 that apply to specific vendors. The head assembly includes cables.

Cable Vendor	9-Track Read	9-Track Write/Erase	7-Track Read	7-Track Write/Erase
Hamilton Digital with cables having blue male connectors (up to October, 1974)	-1	-3	-2	-4
DEC and Hamilton Digital heads with cables having black female connectors	-19	-17	-18	-20

APPENDIX A

VOLTAGE, FREQUENCY, AND 7 TO 9 CHANNEL CONVERSIONS

A.1 GENERAL

This appendix provides all information necessary to perform the various conversions possible on TU10 DEC magtape drives.

Because there are currently 16 different voltage, frequency, and 7/9 track options of TU10 available, 240 different conversions are possible. Rather than list all conversions and the steps required to effect them, this appendix lists the various types of conversions together with part numbers and specific procedures for carrying them out.

Whenever the operating voltage, frequency, or 7/9 track status of a TU10 is altered, the configuration tag located just above the serial number tag behind the lower right hand corner of the machine must be changed to reflect that alteration.

Consult Table A-1 for proper TU10 configuration designations.

Table A-1
TU10 Configuration Designations

	115V, 60 Hz	115V, 50 Hz	230V, 60 Hz	230V, 50 Hz
9-track Master Transport	TU10-EA	TU10-EB	TU10-EC	TU10-ED
9-track Slave Transport	TU10-EE	TU10-EF	TU10-EH	TU10-EJ
7-track Master Transport	TU10-FA	TU10-FB	TU10-FC	TU10-FD
7-track Slave Transport	TU10-FE	TU10-FF	TU10-FH	TU10-FJ

A.2 APPLICABLE DOCUMENTS

TU10 Maintenance Manual - EK-TU10-MM-005
 TU10 Engineering Drawings – specifically, D-MU-TU10-0-18
 Vacuum Assembly Drawing – E-AD-7012052-0-0

A.3 VOLTAGE CONVERSION

A.3.1 115 VAC-to-230 VAC Conversion

To change from 115 VAC operation, to 230 VAC operation, proceed as follows:

- a. Delete these items:

Male AC Receptacle, 115 VAC

Male plug-on power cord

Female plug-on power cord

On jumper plug J-1:

delete connection pin 1 – pin 2

delete connection pin 4 – pin 5

delete connection pin 8 – pin 7

delete connection pin 11 – pin 12

Power Control 861C (TU10 Master only)

- b. Add these items:

Male AC Receptacle, 9008854

Male plug-on power cord, 9008853

Female plug-on power cord, 9008855

On jumper plug J-1:

add connection pin 2 – pin 3

add connection pin 4 – pin 5

add connection pin 10 – pin 11

Power Control 861B (TU10 Master only)

A.3.2 230 VAC-to-115 VAC Conversion

To change from 230 VAC operation to 115 VAC operation, proceed as follows:

- a. Delete these items:

Male AC Receptacle, 230 VAC

Male plug-on power cord

Female plug-on power cord

On jumper plug J-1:

delete connection pin 2 – pin 3

delete connection pin 4 – pin 5

delete connection pin 10 – pin 11

Power Control 861B (TU10 Master only)

- b. Add these items:

Male AC Receptacle, 1201252
Male plug to power cord, 9008938
Female plug to power cord, 9008939
On jumper plug J-1:

- add connection pin 1 – pin 2
- add connection pin 4 – pin 5
- add connection pin 8 – pin 7
- add connection pin 11 – pin 12

Power Control 861C (TU10 Master only)

A.4 FREQUENCY CONVERSION

A.4.1 60 Hz-to-50 Hz Conversion

To change from 60 Hz to 50 Hz operation, proceed as follows:

- a. Remove leads from hour meter and insulate, using shrink tubing (9107685).
- b. Remove hour meter and replace with blank cover plate (7414614) per ECO H730-14.
- c. On TU10's having belt driven vacuum blowers, remove the cover plate and perform the following steps:
 - c.1 Loosen motor plate, back off belt tension adjusting screw, and remove belt and motor pulley.
 - c.2 Move motor to other (unused) set of mounting holes. (see E-AD-7012052)
 - c.3 Remount pulley.
- d. Set pulley 0.820 in. up from assembly chassis using gauge block 7416187. Tighten set screw.
- e. Adjust belt tension as described in E-AD-7012052.

A.4.2 50 Hz-to-60 Hz Conversion

To change from 50 Hz to 60 Hz operation, proceed as follows:

- a. Perform steps a, b, and c.
- b. Set pulley 0.520 in. up from assembly chassis using low side of gauge block 7416187. Tighten set screw.
- c. Adjust belt tension as described in E-AD-7012052.

A.5 SEVEN/NINE CHANNEL CONVERSION

A.5.1 7-Channel-to-9-Channel Conversion

To convert from 7-channel to 9-channel operation, proceed as follows:

- a. Remove 7-channel head plate with cables and replace with 9-channel head plate with cables. (7009885-04)
- b. Remove 7-channel logo and add 9-channel logo. (7409373)
- c. Add jumper from A21J1 to ground (A21C2).
- d. Modify M768 per paragraph 5.5.12 of this manual.
- e. Deskew unit.

A.5.2 9-Channel-to-7-Channel Conversion

To convert from 9-channel to 7-channel operation, proceed as follows:

- a. Remove 9-channel head plate with cables and replace with 7-channel head plate with cables. (70-09885-03)
- b. Remove 9-channel logo and add 7-channel logo. (7409294)
- c. Remove jumper A21J1 to ground.
- d. Modify M768 per paragraph 5.5.12 of this manual.
- e. Deskew unit.

A.6 MASTER/SLAVE CONVERSION

A.6.1 Master-to-Slave Conversion

To convert from a TU10 Master to a TU10 Slave, remove all modules indicated on D-MU-TU10-0-18, slots 6 through 15 inclusive.

A.6.2 Slave-to-Master Conversion

To convert from a TU10 Slave to a TU10 Master, add all modules indicated on D-MU-TU10-0-18, slots 6 through 15, inclusive.

A.7 OVER/UNDER-VOLTAGE RANGE CONVERSION

Later units with the T9147D Transformer have extra primary taps to cover extreme voltage ranges. Simply resolder the wires going to terminals 2 and 4 to 2L or 2H and 4L or 4H respectively:

95-115 Vac,	190-230 Vac	2L, 4L
105-125 Vac,	210-250 Vac	2, 4
115-135 Vac,	230-270 Vac	2H, 4H.

Your comments and suggestions will help us in our continuous effort to improve the quality and usefulness of our publications.

What is your general reaction to this manual? In your judgment is it complete, accurate, well organized, well written, etc.? Is it easy to use? _____

What features are most useful? _____

What faults do you find with the manual? _____

Does this manual satisfy the need you think it was intended to satisfy? _____

Does it satisfy *your* needs? _____ Why? _____

Would you please indicate any factual errors you have found. _____

Please describe your position. _____

Name _____ Organization _____

Street _____ Department _____

City _____ State _____ Zip or Country _____

Fold Here

Do Not Tear - Fold Here and Staple

FIRST CLASS
PERMIT NO. 33
MAYNARD, MASS.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

Postage will be paid by:

digital

Digital Equipment Corporation
Technical Documentation Department
146 Main Street
Maynard, Massachusetts 01754

