

**Digital Equipment Corporation  
Maynard, Massachusetts**



**PDP-10  
TU30 Tape Transport  
Maintenance Manual  
Volume I Logic Package**



**PDP-10**  
**TU30 TAPE TRANSPORT**  
**MAINTENANCE MANUAL**  
**VOLUME I LOGIC PACKAGE**

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## INTRODUCTION

This manual, together with referenced documents, provides the detailed information necessary to operate, maintain, adjust, and repair the TU30 Series DEC Logic Packages manufactured by Digital Equipment Corporation (DEC) of Maynard, Massachusetts. The manual is a replacement for paragraph 4.7 of Section 4, and an addendum to Section 5 of the Datamec manual.

The series nomenclature is as follows:

- TU30-AA 9-channel, 60 Hz
- TU30-AB 9-channel, 50 Hz
- TU30-BA 7-channel, 60 Hz
- TU30-BB 7-channel, 50 Hz

These logic packages are subsystems of the DEC Type TU30 7- and 9-channel Magnetic Tape Transports; and are designed to interface with either the TC58 Magnetic Tape Control for the PDP-8 computer system, the TC59 of the PDP-9 computer, or the TM10 Magnetic Tape Control of the PDP-10 system.

The seven chapters comprising this manual are structured in such a way that the reader has available all necessary details and references as the physical, logical and electrical characteristics of the DEC logic package are developed. The information contained in each chapter is summarized below.

Chapter 1 provides a brief introductory description of the logic packages, a general discussion of equipment applications, detailed equipment specifications and a complete reference listing.

Chapter 2 outlines the procedures to be followed during on-site installation. This discussion supplements the 3030 Series Datamec Manual which describes on-site installation in detail.

All operating controls and related functions are described and discussed in Chapter 3.

Chapter 4 provides an in-depth discussion of the TU30 DEC Logic Package's operation. All implementing logic levels are described in terms of polarity and terminal designation. Also, all SET, CLEAR, enabling and disabling actions are detailed in exact sequence and in relation to module identity, terminal designation and rack location.

Chapter 5 covers adjustment, maintenance, and repair. Trouble shooting procedures are outlined, along with step-by-step instructions for all necessary adjustments.

Chapter 6 contains circuit diagrams for the DEC logic modules used in the DEC Logic Package. The parts list for the TU30 Magnetic Tape Transport is contained in Section 7 of the Datamec manual.



## CHAPTER 1

### GENERAL INFORMATION

This chapter presents an overall description of the TU30 Series DEC Logic Packages in terms of physical description, equipment purpose, and performance specifications. Also included is a module listing showing the quantity and rack location of each module type used.

All documents referenced in this manual are listed at the end of this chapter.

#### 1.1 PHYSICAL DESCRIPTION

The TU30 Magnetic Tape Transport (Figure 1-1) consists of a Datamec D3030 Tape Unit, a DEC Type 844 Power Control, a DEC Type 783 Power Supply and one of the TU30 Series Logic Packages described in the Introduction. A complete physical description of the Datamec D3030 Tape Unit is presented in Sections 1 and 4 of the Datamec manual.

Each TU30 Series DEC Logic Package consists of 91 single height 18-pin FLIP CHIP modules mounted in a standard DEC Type 1943 Mounting Panel. Table 5-2 lists all modules by type, number and quantity. The panel includes receptacles for 128 modules, provisions for mounting a standard DEC triple-fan module cooling unit below the module array and mounting holes for a DEC Type 844 Power Control. The mounting panel assembly mounts inside the Datamec rear-access door on a hinge bracket which is bolted to the transport frame. When in the operating position, the rack is secured by a knurl-handled turn-latch to the Datamec frame. For easy access, hinge mounting of the panel rack allows the DEC Logic Package to swing out perpendicular to the tape transport.

Power requirements (+10V and -15V) are furnished by a DEC Type 783 Power Supply. The electrical mechanical characteristics of this supply are described

on page 306 of the 1968 edition of the Digital Logic Handbook.

The DEC Type 783 Power Supply, viewed from the transport's rear-access door, is attached to the left-hand interior panel just below the capstan motor.

Four machine screws and nuts secure the supply to two transverse channels on the interior panel. The DEC Type 844 Power Control is standard for all PDP-10 peripheral equipment and is described in detail in the PDP-10 Module Reference Manual.

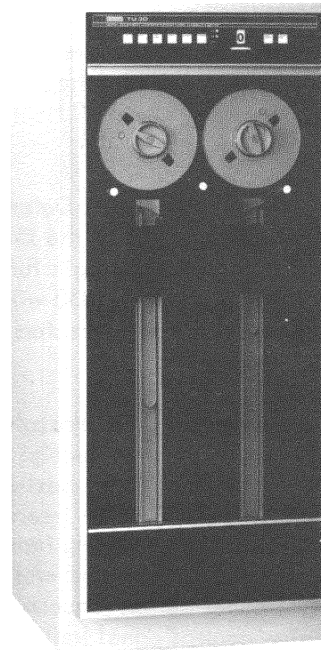


Figure 1-1 TU30 Magnetic Tape Transport

## 1.2 EQUIPMENT PURPOSE

The TU30 Series Magnetic Tape Transport is designed to record and read either seven or nine channels of binary data on 1/2-in. tape, using IBM compatible reels, at rates up to 60 kHz. In addition to recording at a maximum tape density of 800 bpi (based on a 60 kHz rate), the TU30 series can also record at 200 and 556 bpi. File security is assured by a file protection ring, when installed on the file reel prior to mounting.

Recording is performed using the Non-Return-to-Zero (NRZ) format with one channel reserved for parity bits.

The unit can be operated manually under central processor direction by depressing the appropriate control panel pushbutton (LOCAL or AUTO). In local mode a file reel when loaded can, through pushbutton action, be positioned at the tape load point. Also through pushbutton action, tape reels can be rewind, or moved in forward or reverse direction. In auto mode, the transport is placed under complete direction of the computer system through an associated magnetic tape control. When placing the tape unit in auto mode, an appropriate address must be placed in the address selector on the TU30 control panel prior to pressing the AUTO button. This action provides for selection by the computer.

Unit status for both auto and local modes is displayed by indicator lamps on the control panel.

The TU30 Series is available in two line frequency versions; the TU30AA/BA for use in areas where 60 Hz 115/230 Vac is the standard line voltage, and the TU30AB/BB for use in areas where 50 Hz 115/230 Vac is the standard line voltage.

The DEC Logic Package replaces all Datamec data electronics (see paragraph 4.7.3 of the Datamec Manual) and thereby performs all logic functions necessary to interface the Datamec D3030 with the computer system, to perform data transfers, and to control tape logistics.

Interfacing to the computer system through an associated magnetic tape control includes receipt and processing of motion and data recording/acquisition commands, and transmission of transport status. Interfacing with the Datamec D3030 involves enabling tape motion commands, operating read, write and erase heads, interpreting control panel button requests and tape markers, and driving control panel indicators.

The design of the DEC Logic Package is such that all conceivable contingencies have been logically pro-

vided for (i.e., catastrophic failure, continuous parity error, security of recorded data, and spurious-data detection).

## 1.3 SPECIFICATIONS

The following listing provides a summary of physical, electrical, and performance specifications for the TU30 Series. Detailed electrical and mechanical specifications for the D3030 are presented in Section 1 of the Datamec Manual.

### Physical

Width = 29-5/8 in., Height = 69 in., Depth = 25 in.

### Mechanical

Service Clearance (front and rear): 28 in.

Transport Mechanism: pinch roller drive, vacuum column tension

Read/Write Head Gap: see Section 1, paragraph 1.2.5 of the Datamec manual

Static and Dynamic Skew: see Section 1, paragraph 1.3.2 of the Datamec manual.

### Electrical

TU30AA/BA Power Requirements: 60 Hz, 115/230 Vac

TU30AB/BB Power Requirements: 50 Hz, 115/230 Vac

Line Regulation:  $\pm 10\%$

Line Frequency Tolerance:  $\pm 2\%$

### Performance

Character Transfer Rates: 60 kHz at 800 bpi, 41.6 kHz at 556 bpi, 15 kHz at 200 bpi

Tape Speed: 75 ips forward or reverse, high speed rewind 225 ips

Rewind Time: 3 min (2400 ft)

Tape Speed Variation:  $\pm 3.0\%$  forward or reverse

**Tape Characteristics:**  
 Width - 0.5 in.  
 Length - 2400 ft  
 Reels - 10.5-in. IBM compatible with write enable ring  
 Brand - Any recognized brand certified for all specified recording densities

**Tape Format:**  
 Recording method - Non-Return-to-Zero  
 Number of Channels - 9, with 8-data channels and 1-parity channel (TU30AA/AB); 7, with 6-data channels and 1-parity channel (TU30BA/BB) End of Tape (EOT) and Beginning of Tape (BOT) sensing is compatible with IBM 729-I-VI

Environmental

Relative Humidity: 40 to 80%

Altitude: 0 to 10,000 ft

Temperature: 40° to 60°F

Controls and Indicators

**LOCAL** Switches the tape unit control to the control panel; clears all tape unit typical functions. Lights when in local mode.

**AUTO** Disables the front control panel and puts the unit under direction of the associated magnetic tape control. Lights when in auto mode.

**LOAD POINT** Initiates a (LP) search in the forward direction. If no LP is found after 25 ft, it reverses the tape until the LP is found. Lights when at LP.

**REWIND** Rewinds the tape to LP. Lights while rewinding.

**REVERSE** Moves the tape in the reverse direction until LP is reached, or either LOCAL or AUTO is depressed. Lights when tape moves in reverse direction.

**FORWARD**

Moves the tape in the forward direction until the EOT marker is sensed, or when either LOCAL or AUTO is depressed. Does not stop for LP. Lights when tape moves in forward direction.

200,556,800

Indicates the bit density selected by the associated magnetic tape control when the transport is in auto mode.

**ADDRESS SELECTOR**

Specifies the transport address to the associated magnetic tape control, (0-7).

**WRITE ENABLED**

Lights when the file-protect ring is on the reel.

**EOT**

Lights if the EOT marker has passed under the photosense head, and goes out when the tape is rewound.

**Start/Brakes**

'Start' loads the tape into the vacuum columns. 'Brakes' releases the reel brakes for manual loading of the tape.

**Cleaning Switch**

Used for cleaning pinch rollers and capstans. It will spin the rollers in either direction.

**844 Power Control**

**LOCAL/OFF/REMOTE**

Places power at all points in the transport with actual turn-on at the transport (LOCAL) or at the computer console (REMOTE).

**844 Power Control Indicator**

When illuminated it indicates that the transport is powered up.

#### 1.4 REFERENCE DOCUMENTS

The following documents are used as references in this manual:

- a. Hewlett Packard 3030 Series Computer Magnetic Tape Unit (Datamec), Instruction Manual
- b. TM10 Magnetic Tape Control, Maintenance Manual
- c. TC59 Magnetic Tape Control, Instruction Manual
- d. TC58 Magnetic Tape Control, Instruction Manual
- e. PDP-10 Module Reference Manual
- f. C105 DIGITAL Logic Handbook, 1968 Edition
- g. PDP-10 KA10 Central Processor, Maintenance Manual, Vol. I.

## CHAPTER 2 INSTALLATION

The purpose of this chapter is to present a guide for installing the TU30 Magnetic Tape Transport at a permanent site. Information such as site preparation, unpacking and set-up, cabling hook-up, and initial check out are provided. Section 2 of the Datamec manual should also be referred to during TU30 installation.

### 2.1 SITE PREPARATION

The TU30 Magnetic Tape Transport is designed for operation in areas which are vibration and shock free and which have a closely maintained ambient temperature. Any selected site should be clean and dustless without curtains, drapes, rugs or other lint and dust producing decoration. This site should also be free of corrosive fumes or vapors and strong magnetic fields. Each TU30 installed at a given site requires approximately one ton of air-conditioning capacity in order to maintain the required operating temperature and humidity. The specific air conditioning requirements

are determined through detailed analysis of site variables.

Space requirements for each TU30 transport are shown in Figure 2-1.

### 2.2 CABLING HOOK-UP

TU30 cable requirements involve connection of six cable assemblies to the DEC Logic Package and to the associated magnetic tape control (MTC). The remaining cables have been installed prior to shipment. The cable complement for the TU30 is shown in Table 2-1.

#### 2.2.1 Connection to the MTC

Connection from the DEC Logic Package to the associated MTC is accomplished with single-height W841 Cable Terminators and associated cables. These cables are coiled and taped to the bottom of the transport for shipment. After unpacking, these cables should be installed according to module location, shown in Table 2-1.

Table 2-1  
Cabling Types and Locations

Cable Type	Function	TU30 Location	TM10 Location	TC58 Location	TC59 Location	Datamec Location
W841/W021	WRITE DATA	D01	B01	B01	B01	NA
W841/W021	STATUS	D02	A02	A02	A02	NA
W841/W021	COMMAND	D03	B02	B02	B02	NA
W841/W021	READ	D04	A01	A01	A01	NA
W841/W021	DENSITY	D05	A03	A03	A03	NA
W025	WRITE HEADS	A01, B01				See
W025	READ HEADS	C23, D23				Figure
W025	CTRL/DATAMEC	C08, D08				2-2

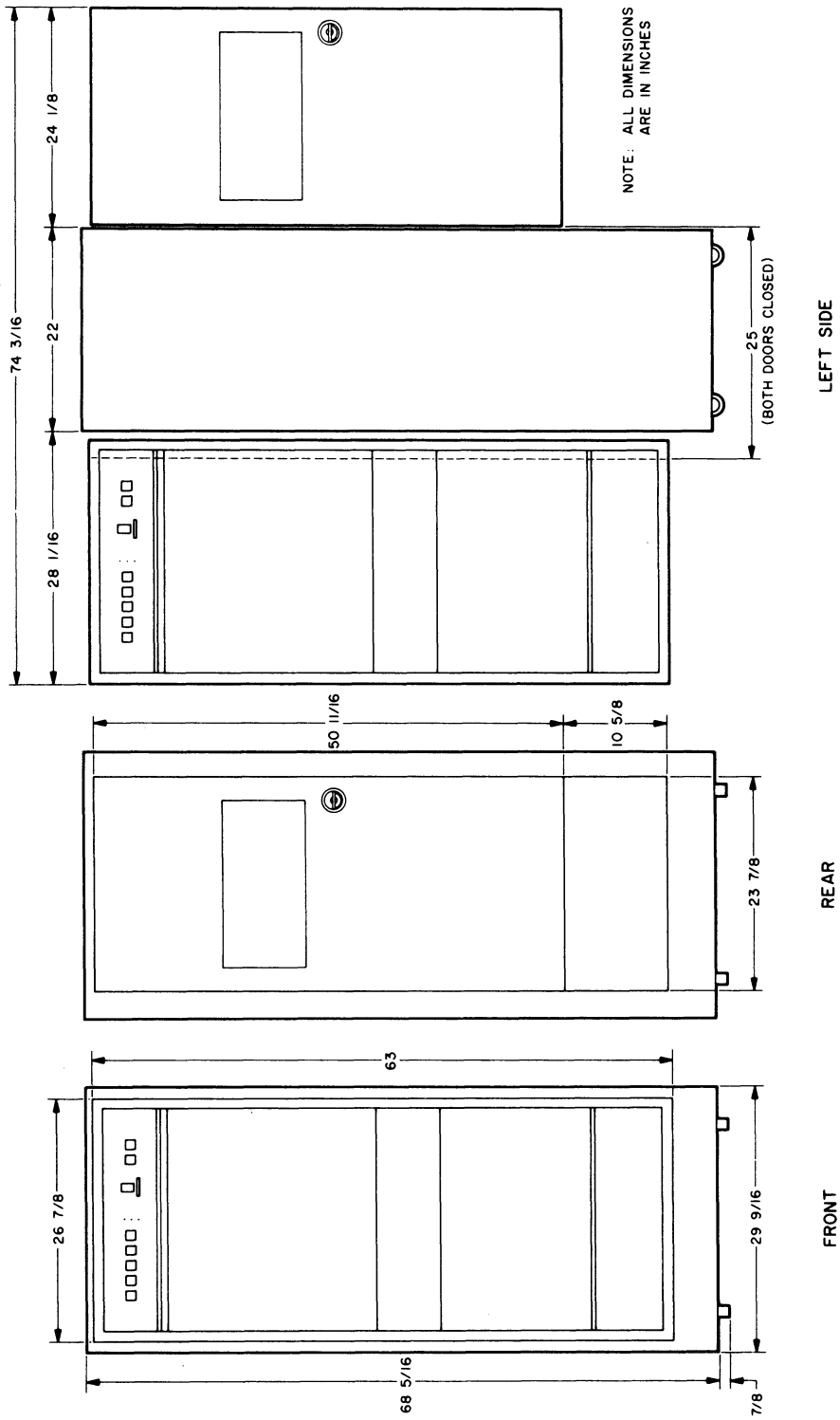


Figure 2-1 TU30 Tape Transport, Cabinet Dimensions



### 2.2.2 Connections to Datamec

Double-height W025 Connector Boards and associated cables connect the DEC Logic Package with the read/write/erase heads. Although these cables are connected to the heads at the factory, the connection schemes are shown, for reference and maintenance purposes, in Figures 2-2a for 7-channel and 2-2b for 9-channel equipments.

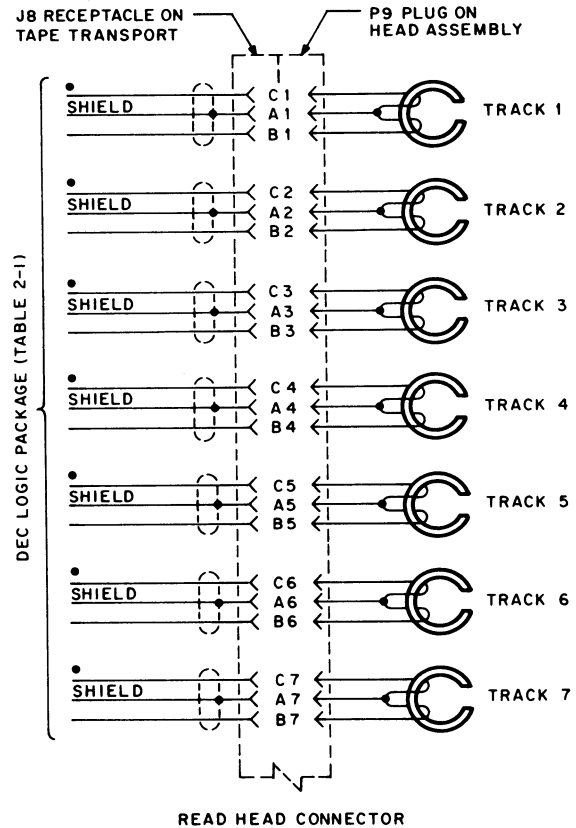
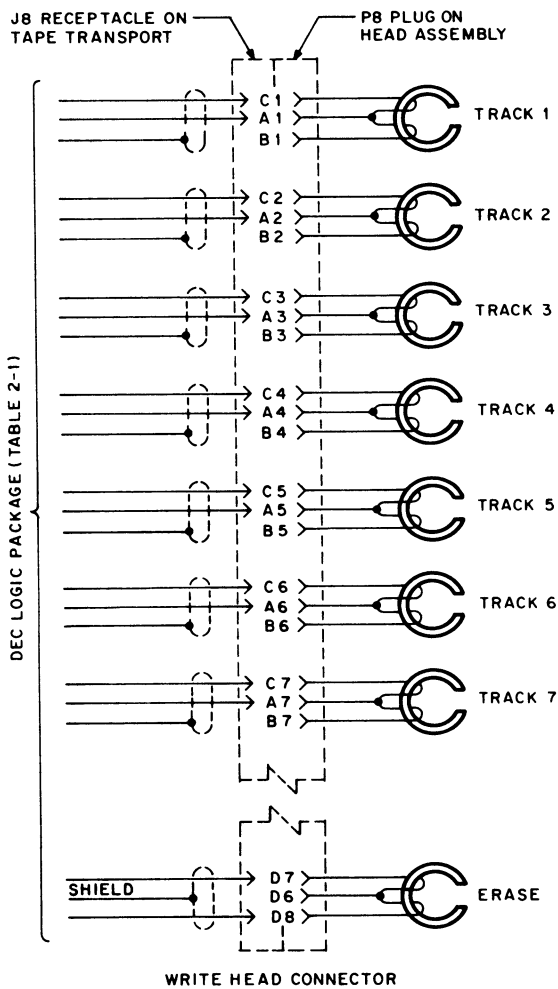
### 2.2.3 Power Cabling

The main power cable to an outside voltage source is

installed at the factory. It is coiled and stored at the bottom of the transport cabinet for shipment.

### CAUTION

When connecting the TU30 to a local power source, make sure that the line voltage and frequency matches the input requirements for the TU30 power supply.



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Figure 2-2a Seven Channel Write/Read Head Connector Wiring

### 2.3 TRANSPORT CHECKOUT

Place the transport in operation according to Chapter 3, Section 3.2. Also refer to Section 3.2.1 and load a reel of scratch tape to check control panel functions according to procedures outlined in Section 3.2.3. Carefully observe tape motion, while tape is being moved forward and reverse and at standard and rewind speeds. Check for uneven or wobbly reel motion, loose or excessive tape tension at the reel guides, im-

proper tape positioning in the vacuum columns or other maladjustments resulting from possible rough handling during shipment.

Check also that the transport responds properly to LP and EOT markers by moving the tape forward, and then rewinding. Chapter 5 of this manual and Section 5 of the Datamec manual provide adjustment procedures for any malfunctions detected during this checkout.

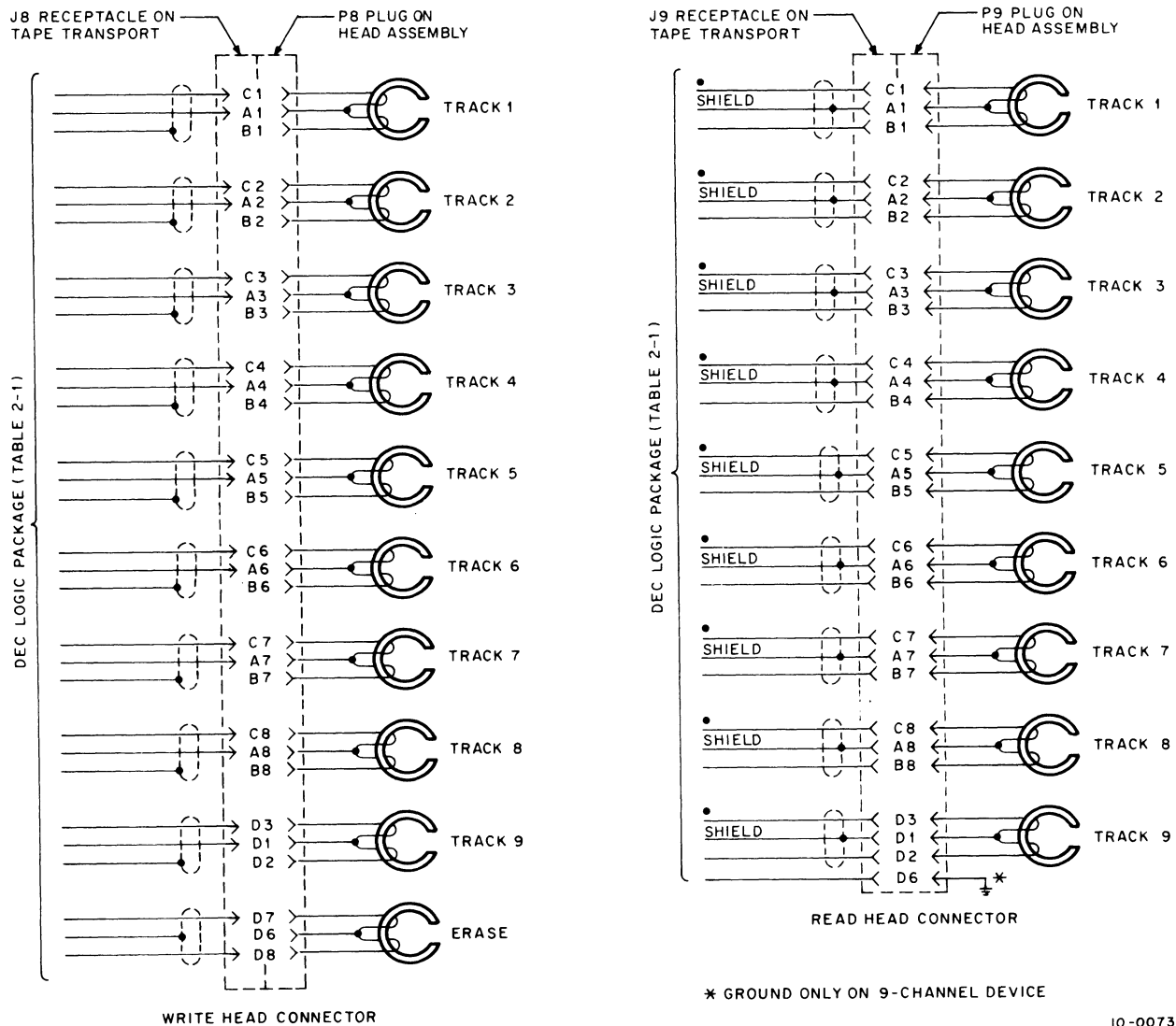


Figure 2-2b Nine Channel Write/Read Head Connector Wiring

# CHAPTER 3

## OPERATION AND PROGRAMMING

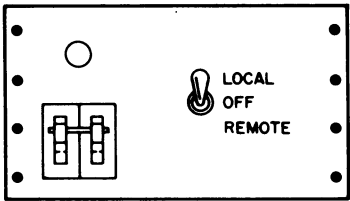
The TU30 Tape Transport, when augmented by one of four interface logic packages, can operate with either the PDP-8, PDP-9, or PDP-10 computer systems. Although, for purposes of brevity, this discussion describes its operation with the PDP-10 system; operation with the other systems is similar, provided it is interfaced with the proper Magnetic Tape Control for that system.

In all PDP-10 system configurations, the TU30 Tape Transport is operated in conjunction with the DEC TM10 Magnetic Tape Control. As a consequence, the TU30 when under PDP-10 program control performs data recording and reading as directed by the program and as implemented by the TM10 Magnetic Tape Control. For further information on PDP-10 Magnetic Tape Transport programming refer to Section 2.12 of the PDP-10 System Reference Manual. Implementation of I/O commands and tape transport direction is discussed in the TM10 Magnetic Tape Control manual.

### 3.1 CONTROLS

The TU30 control panel (see Figure 3-1) is conveniently located on the topmost section of the front panel assembly, above the reel section. All control pushbuttons are grouped on the left side of the control panel, and all indicators are located on the right side. Controls and indicators are summarized in Table 3-1 and 3-2, respectively.

Power to the TU30 Magnetic Tape Transport is controlled through the three position LOCAL/OFF/REMOTE toggle switch on the DEC Type 844 Power Control (PC) panel (see Figure 3-2). The 844 Power Control is located on the lower section of the DEC Logic Package. Power is applied to the power control by placing the PC LOCAL/OFF/REMOTE switch in the LOCAL position. The red light on the panel indicates that input power is present. With the LOCAL/OFF/REMOTE switch in the REMOTE position, power is applied to the TU30 Tape Transport when the PDP-10 system is activated. In the LOCAL position, operating power is applied to the transport until the switch is turned OFF.



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Figure 3-2 844 Power Control Panel

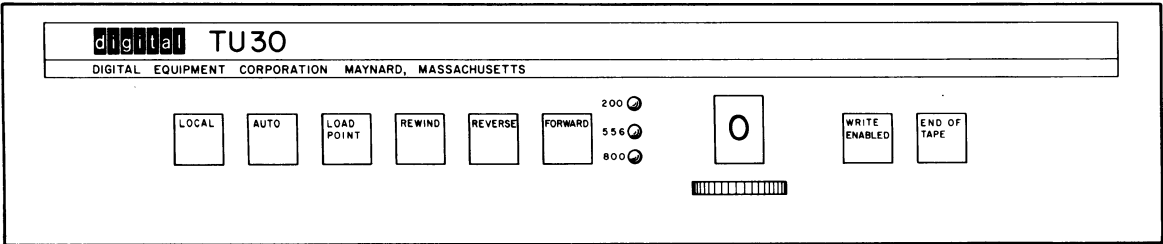


Figure 3-1 TU30 Control Panel

Table 3-1  
Control Panel Switches

Switch	Function
LOCAL	Places transport under operator control through control panel. Clears and initializes all transport logic. Serves as a HALT button. At start-up this button lights to indicate application of power to the transport.
AUTO	Places transport under PDP-10 Central Processor control through an associated magnetic tape control. Button lights to designate AUTO status.
LOAD POINT	Initiates a load point (LP) search by causing tape to move in the forward direction until the LP marker is photoelectrically sensed. If the LP is not sensed after 25 ft of forward movement, the tape is reversed until the LP is sensed. When the LP is located, the LOAD POINT button will light.
REWIND	Starts a high speed rewind to tape LP, with tape being pulled from the vacuum columns. This button lights during the rewind operation and goes out when the operation has been completed.
FORWARD	Starts the tape moving in the forward direction at operating speed until the end-of-tape (EOT) marker is photoelectrically sensed. Forward motion can be arbitrarily halted by pressing either the LOCAL or AUTO button. An LP is ignored in this operation. The FORWARD button will light during tape movement and go out when forward motion is halted or when an EOT is sensed. The tape is not removed from the vacuum columns during this operation.
REVERSE	Starts the tape moving in a reverse direction at operating speed until a LP is photoelectrically sensed. Reverse motion can be arbitrarily halted by pressing either the LOCAL or AUTO button. The REVERSE button will light during tape movement and go out when reverse motion is halted or when the LP is sensed. The tape is not removed from the vacuum columns during this operation.
ADDRESS SELECTOR	This 10-position manually-actuated rotary switch specifies the transport address. Any address from 0 to 7 may be selected, with numbers 8 and 9 un-addressable. This switch illuminates when transport power is turned on.

### 3.2 OPERATION

Assuming a start-up condition, the tape transport must be turned on at the PC panel; this action provides power to all points in the transport and clears all logic in the DEC Logic Package. As previously noted, power-up to the PC is indicated by a red indicator light. For start-up purposes the LOCAL/OFF/REMOTE switch on the PC panel should be in the LOCAL position.

#### 3.2.1 Tape Loading and Start-Up

Tape loading involves installation of a file reel and a take-up reel and positioning of tape in the vacuum wells. Section 3, paragraph 3.2.1 of the Datamec manual presents the required tape loading procedure in complete detail.

Table 3-2  
Control Panel Indicators

Indicator	Purpose
Density Lights 200 bpi (white) 556 bpi (yellow) 800 bpi (green)	These indicators designate, when lit, the read/write bit density selected by the PDP-10 Central Processor through the associated magnetic tape control. These indicators operate only when the transport is in auto mode.
WRITE ENABLE (red)	This indicator will light when a file protect ring is installed on the file reel.
END-OF-TAPE (orange)	This indicator, when lit, designates that the end-of-tape marker has been photoelectrically sensed by the transport. Once sensed, the END-OF-TAPE indicator will remain lit, until a tape rewind operation is started.

Table 3-3  
DEC 844 Power Control Panel Switches/Indicator

Switch/Indicator	Function
REMOTE/OFF/LOCAL	This 3-position switch allows the power turn-on/off function to be performed at the transport (LOCAL) or at the PDP-10 Central Processor (REMOTE). In the OFF position, line power is disconnected.
Power Indicator Light (red)	This indicator lights when the REMOTE/OFF/LOCAL switch is placed in either the REMOTE or LOCAL position.
30 AMP (Circuit Breaker)	Protects the power control from line surges exceeding 30 amperes.

### 3.2.2 Control Panel Operation

The TU30 Magnetic Tape Transport is placed under control panel direction by activating the LOCAL button. Conversely, activating the AUTO button disables the control panel and places the TU30 under direction of the PDP-10 Central Processor through the associated magnetic tape control. When the transport is turned on at the PC during start-up time, it is automatically placed in local mode. In addition, when in auto mode the LOCAL button serves a halt mechanism, if for some reason an operator wishes to remove the transport from PDP-10 control. In both cases, illumination of the pertinent button designates mode status.

During start-up, the next action after tape loading is placement of the tape load (LP) marker at the proper start position. This LP placement is performed automatically when the LOAD POINT button is pressed. The first action is forward movement of the tape. If the tape LP is not detected after 25 ft of tape movement, tape movement is reversed until the LP is detected. This technique precludes any effect of tape reels winding past the LP during tape loading. When LP is finally detected, the LOAD POINT button is illuminated.

Selection of a logical address is the final action required to prepare the transport for PDP-10 control. This is done by turning the ADDRESS SELECTOR to the appropriate address (a number from 0 to 7). This number must match the I/O selection address designated in the pertinent object program being executed. At this point, pressing the AUTO button will place the transport under PDP-10 control and ready it for object program selection.

### 3.2.3 On-Line Operation

When under PDP-10 control, the TU30 Magnetic Tape Transport requires no operator action except when specific circumstances dictate that the transport be halted. In this case, as previously noted, the transport can quickly be removed from central processor

control, halted, and placed under operator control by pressing the LOCAL button.

While in auto mode, several indicator lights on the control panel provide a quick visual indication of transport operation status. For instance, the tape writing or reading density selected by the control is designated by one of three indicator lights; the 200 bpi light, the 556 bpi light, or the 800 bpi light. Presence of a write enable ring on the file reel is designated when the WRITE ENABLE indicator is illuminated. The EOT button (end of tape) will light when the EOT marker is photoelectrically sensed by the transport. Tape motion will stop in conjunction with the EOT indicator being lit.

### 3.2.4 Off-Line Operation

In local mode the operator has three tape motion prerogatives implemented by the control panel buttons; FORWARD, REVERSE, and REWIND. Both the FORWARD and REVERSE buttons, when pressed, will move the tape in the pertinent direction at standard operating speed. In both cases the tape will maintain operating position in the transport vacuum wells. Aside from aiding in operations which might require positioning the tape at certain predetermined points, the forward and reverse motion options are included primarily for transport maintenance activities. Both buttons, when activated, will be illuminated. Pressing the LOCAL or AUTO button will halt both forward and reverse tape motion.

The REWIND button allows an operator to rewind tape onto the file reel prior to its removal at the end of on-line operation. The rewind operation is performed at high speed with tape removed from the vacuum wells and is terminated when the tape LP is detected. The REWIND button is illuminated during the rewinding operation and goes out when terminated by the LP.

Procedures for removing tape reels are presented in Section 3, paragraph 3.2.7 of the Datamec Manual.

## CHAPTER 4

### THEORY OF OPERATION

This chapter presents an in-depth discussion covering all aspects of the DEC Logic Package's operation. Organization and function are discussed apart from the complex logic sequences which implement tape transport operations. This structure makes it possible for the detailed description of each operation to be related to the logic package organization and the functions performed. The discussion that follows assumes a working knowledge of digital logic operation and familiarity with DEC logic symbology.

#### 4.1 FUNCTIONAL DESCRIPTION

The TU30 Logic Package is designed to perform all the logic and electrical functions necessary to interface the TU30 Magnetic Tape Transport with all compatible DEC magnetic tape controls (MTC). Consequently, the TU30 DEC Logic Package completely replaces the Datamec Data Electronics.

In the discussions that follow, the descriptions of DEC Logic Package organization are followed by descriptions of the specific functions performed and how they interrelate.

##### 4.1.1 Organization

The TU30 DEC Logic Package consists of a complement of FLIP CHIP modules mounted in two back-wired panel racks. The total module complement is interconnected functional blocks corresponding to the engineering drawings for the package. These functional blocks are discussed in the order listed: transport bus, control, command, timing, and read/write.

**4.1.1.1 Transport Bus (TB)** - The basic function of the transport bus (Figure 4-1, Part 1 and 2) is to interface the tape transport with the MTC. This means

that all status, command, and control communication between the two units passes through the TB. A number of logic operations associated with the MTC interface function are performed at the TB. These mainly concern the logic levels necessary to trigger command and control pulses. It should be noted at this point that four of the lines incoming from the MTC to the TB are bifunctional, meaning that each line carries two independent signals on a time-sharing basis. The specific lines are on connector W841, D02 pins E, H, K, and M.

In addition to handling command and control pulses, the TB inverts specific incoming command levels and status levels making both polarities available to the DEC Logic Package.

Clock frequencies necessary to control writing densities are also produced at the TB. Two clock frequencies are generated to time three writing densities. A 60 kHz clock times the 800 bpi writing density and a 41.7 kHz clock times the 556 bpi density. The 200 bpi density is timed by a clock which is derived at the MTC by dividing the 60 kHz clock by four.

**4.1.1.2 Control (CTRL)** - The control (Figure 4-2) interfaces the DEC Logic Package with the Datamec motion-control logic and circuits and all control panel circuitry. All Datamec logic levels (-10V, +10V) enabled by pushbutton action at the TU30 control panel are converted to DEC logic levels by Schmitt triggers. Where both polarities are required, Schmitt trigger output is inverted.

Tape unit selection, which occurs when a logical address sent by the MTC matches the address physically selected at the transport control panel, is also processed by CTRL. A logical address is received as a binary number 0 through 7 and converted to a one-out-of-eight bit code by a binary-to-octal decoder. The





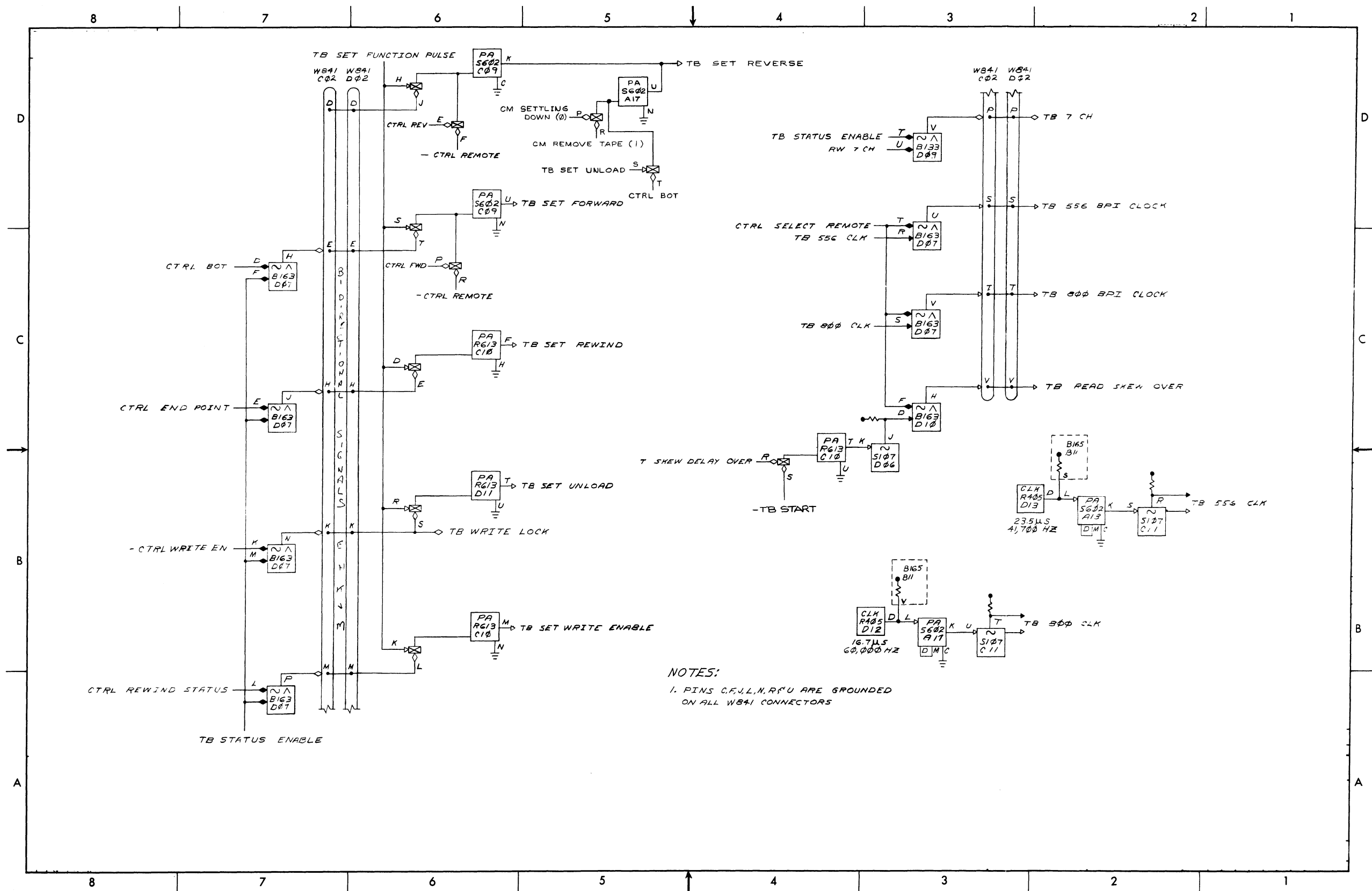


Figure 4-1 Transport Bus Logic Block Diagram, Part 1



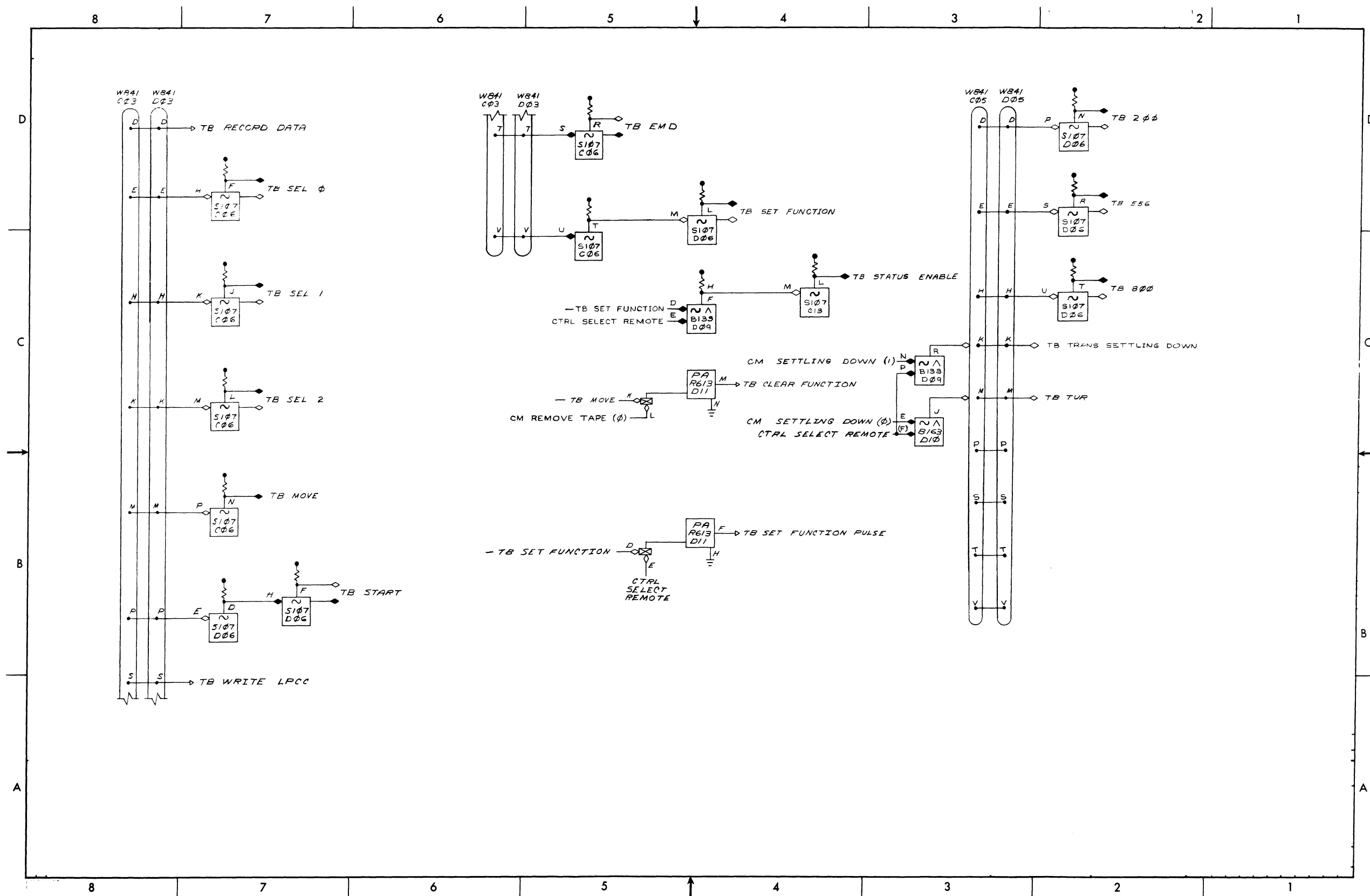


Figure 4-1 Transport Bus Logic Block Diagram, Part 2



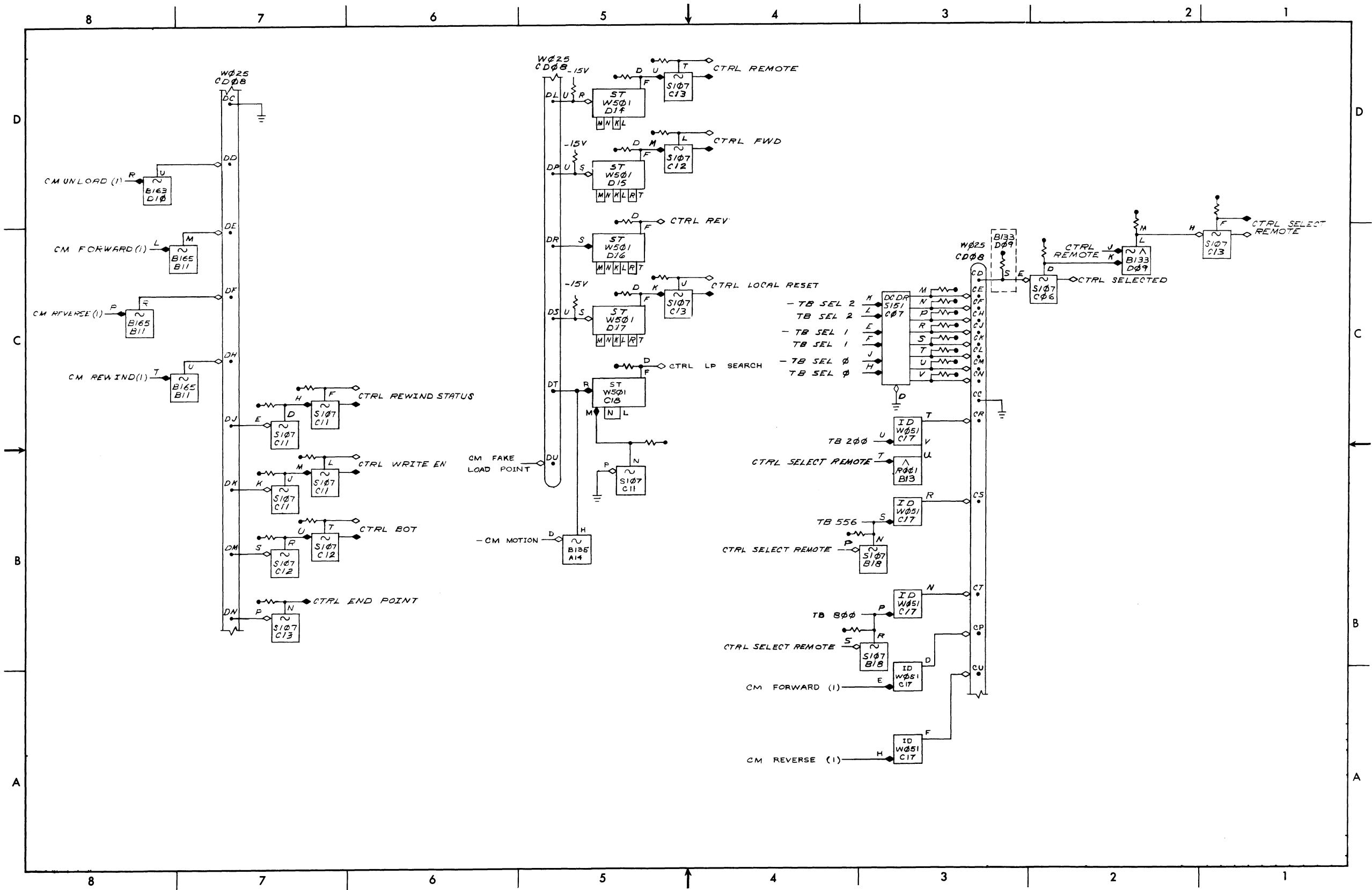


Figure 4-2 Control Logic Block Diagram



eight output lines from the decoder, in turn, connect the address selection switch.

Density selection lamps on the tape transport control panel are also driven from CTRL. The selected writing density is enabled by a specific command level from the TB. This level also enables lamp drivers at CTRL to light appropriate density selection indicators at the tape unit control panel.

As part of the CTRL Datamec interface function, forward and reverse motion commands are transmitted to the Datamec control circuitry to activate the pertinent pinch roller actuator.

A level simulating LP detection is also sent over the CTRL Datamec interface. This level initiates a reversal of tape motion in the direction of the LP for those cases where the LP was inadvertently passed over during tape loading.

A logic level indicating the presence or absence of a write enable ring on a file reel is also received by CTRL. Depending on the polarity of this level, a file reel can be either written on, or not written on.

**4.1.1.3 Command (CM) -** This functional block (Figure 4-3) contains all motion control flip-flops and delays, the write enable flip-flop, and all start up and crobar circuitry.

Flip-flops controlling forward and reverse tape motion, enable when set, relay drivers at the CTRL and activate one of the pinch roller actuators controlling the direction of tape motion. (See paragraph 4.2.5 of the Datamec manual.)

The rewind delay is a one-shot multivibrator which provides a positive-going enabling pulse long enough (12  $\mu$ s) to be compatible with Datamec control logic. This pulse sets a rewind control flip-flop in the Datamec logic to initiate rewinding. A rewind operation is automatically terminated by Datamec logic when an LP marker is sensed.

Another one-shot provides a 5-ms delay to insure that all tape motion has been halted prior to enabling additional motion commands. At the end of this delay, a tape-unit-ready signal is enabled at the TB.

A rewind and unload operation, which results in the file tape being completely unwound from the take-up reel, is initiated by a one-shot and a flip-flop operating in conjunction. A 12- $\mu$ s positive-going pulse

sets the Datamec rewind flip-flop to start a high-speed rewind. The rewinding is then terminated by the Datamec logic when the LP is sensed. At that point the 5-ms settling-down delay is started, and at the end of the delay the unload flip-flop is cleared. This action triggers a pulse generator at the TB which sets the flip-flop controlling reverse tape motion. As soon as the tape is pulled out of the vacuum wells, the Datamec logic automatically places the tape unit in local mode which, in turn, initiates the clearing of all flip-flops in the DEC Logic Package.

The CM functional block also performs the logic steps necessary to perform a load point (LP) search. In this operation, a control panel pushbutton triggers a 4s delay and initiates tape motion in a forward direction. If an LP marker is detected during the 4s delay, the forward motion flip-flop in the Datamec logic is cleared and the Datamec reverse motion flip-flop is set, as the marker moves by, to reverse the tape and halt it when the LP is again sensed. This action causes tape to halt at the inside end of the LP marker. If, after 4s, an LP is not sensed, the DEC Logic Package generates a false load point signal. This in turn causes the Datamec reverse motion flip-flop to be set, initiating the same sequence used to compensate for tape deacceleration. However, in this case the slow reverse motion continues until the real LP is sensed. The need for a false load point signal occurs when, during tape loading, the reel is inadvertently wound past the LP by an operator.

The flip-flop which initiates a write operation is also part of the CM functional block. This flip-flop, is set as a result of an MTC command and a logic level indicating that the transport is in auto mode and that the file reel is not write protected.

The purpose of the start-up and crobar logic is three fold. First, that portion of the CM functional block protects the DEC Logic Package from any line transients which might occur when the transport power control is activated. Second, this logic clears all motion flip-flops and terminates all read or write operations when a power shutoff occurs at the transport. And third, the DEC Logic Package master-clearing function is associated with the start up and crobar circuitry. This function, in addition to preparing all logic at start-up and disabling all logic during failure, automatically prepares all logic at the end of any read or write operation for the next upcoming operation.

**4.1.1.4 Timing (T) -** The Timing functional block (Figure 4-4), as the name implies, performs all timing





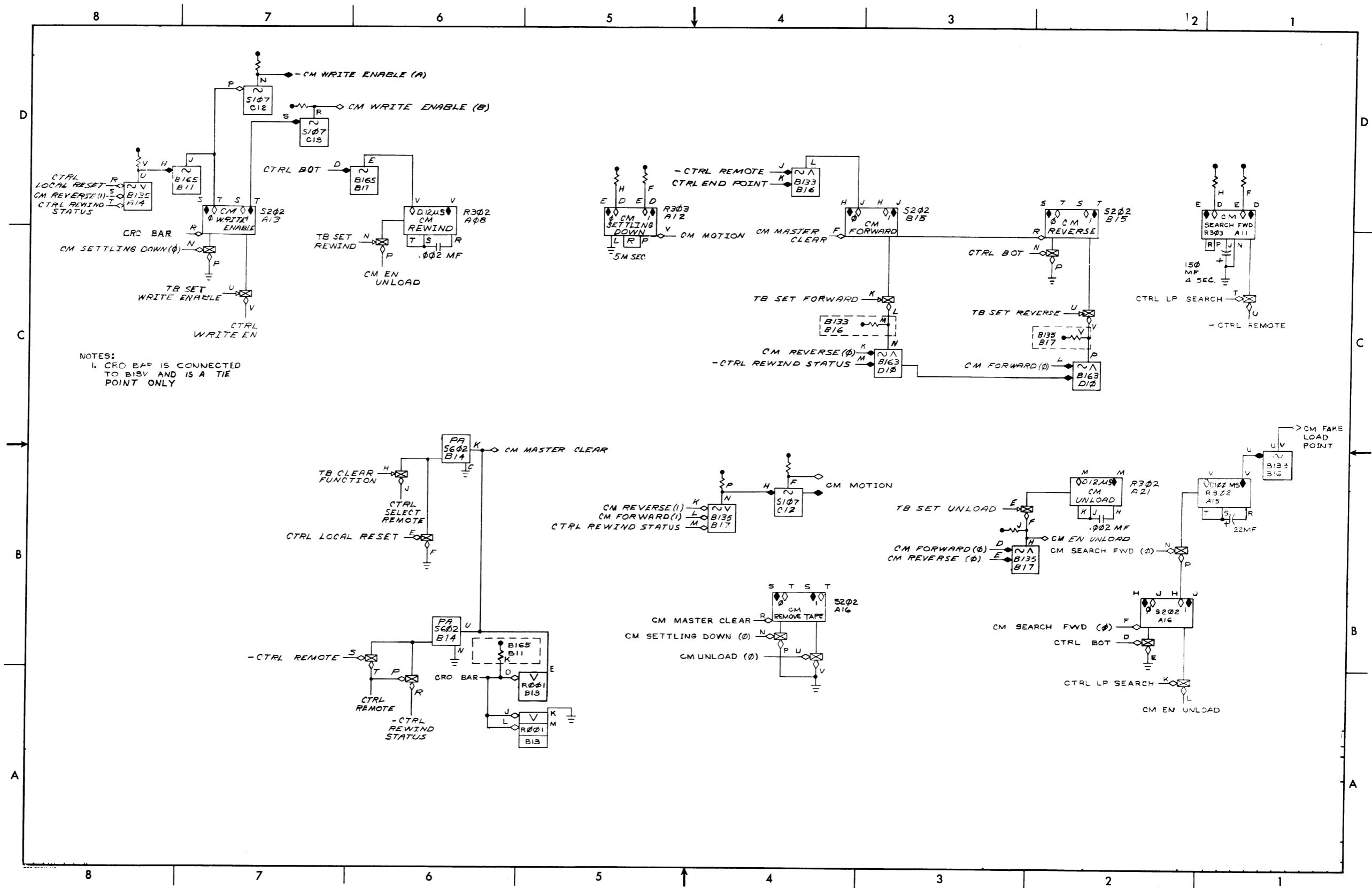


Figure 4-3 Command Logic Block Diagram



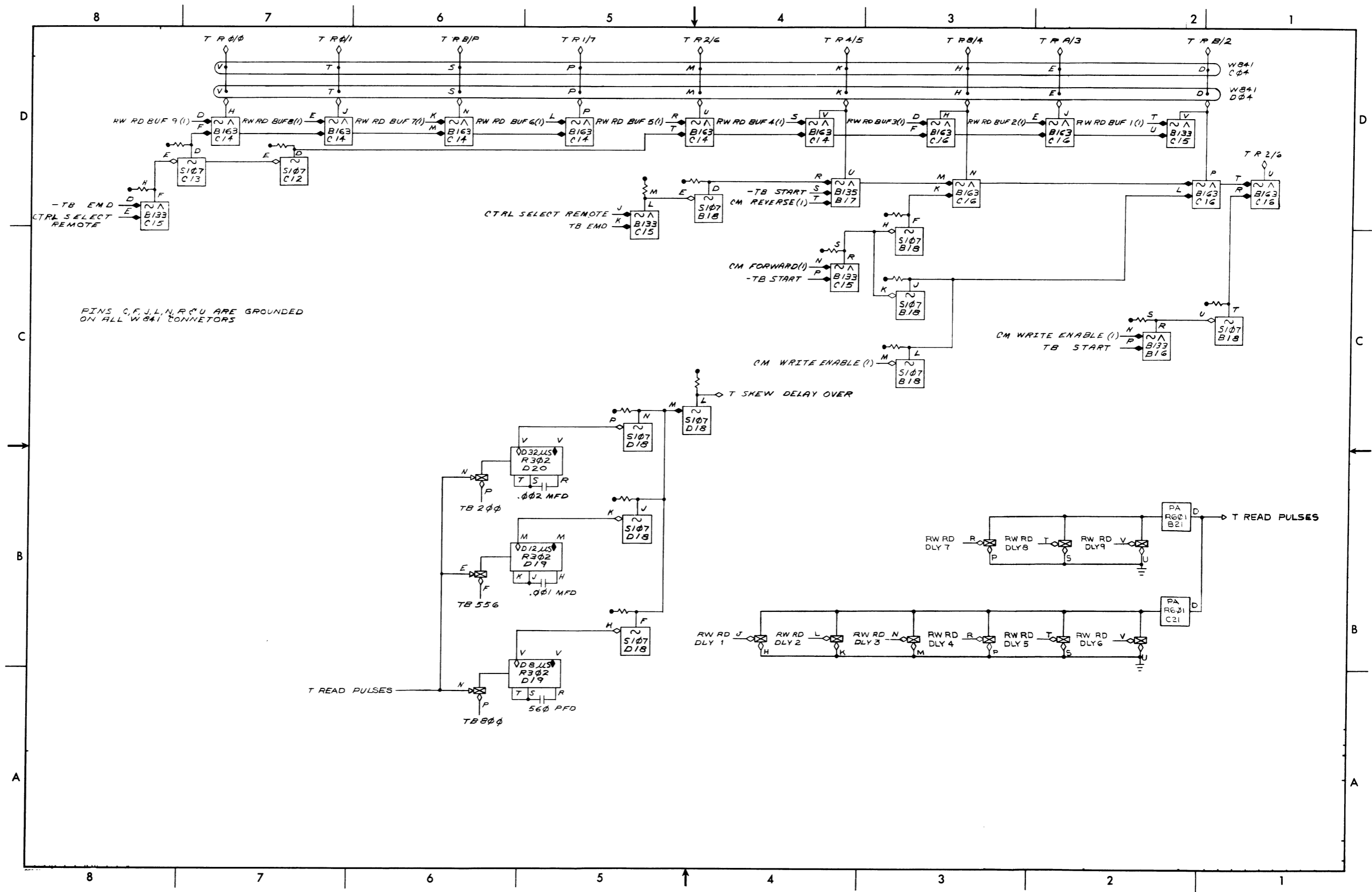


Figure 4-4 Timing Logic Block Diagram



necessary for data transfer operations, start and stop-motion delays, and read/write skew compensation.

Each data character, after being read from tape, is transferred to a bus receiver at the MTC. Because of normal tape skew conditions (see paragraph 5.2.4.6 of the Datamec manual), the bits constituting a given word are received at the MTC during a delay period which is determined by the density at which the tape was written. The MTC transmits one of three enabling levels to the transport according to the density at which the tape is to be read. The specific enabling level, in turn, triggers the appropriate one-shot delay in the timing logic to implement the pertinent skew delay period. This selected skew delay is triggered by the first logic 1 read from a given character. This action allows enough time for all the bits in a given character to be transferred to the MTC bus receivers, regardless of bit-to-bit skew. At the end of this skew delay, a pulse is sent to the MTC to strobe the transferred word out of the bus receivers.

The TU30 writes data on tape using a record format with each record separated by a minimum standard interrecord gap of 0.75 in. for the TU30 and 0.6 in. for the TU30A which by definition, consists of completely erased tape.

Interrecord gap (IRG) length is a function of tape acceleration and deceleration. Consequently, at the end of a read/write operation or any forward or reverse tape motion, the read/write heads must be positioned with respect to the IRG so that the tape can be accelerated to speed before the next record can be written or read. To do this the CTRL must provide a start delay during which data transfers are disabled until the tape has accelerated to operating speed, or a stop delay so that the read/write heads are in a start-up position with respect to the next record to be written on or read from tape. The required delay (write start, write stop, read stop or reverse stop) is initiated by the logic sequence which enables and/or disables the specified operation. For example, at the start of a write operation, the required delay is implemented when the MTC enables forward tape motion as a result, the transport transmits the octal number 20 over the read lines. This octal number is then counted down to 0 by the MTC. At the end of this countdown, the MTC initiates the enabling of the write logic and the writing of a record begins. Conversely, when a write operation is completed, the MTC disables the write logic and enables transmission of octal 500 over the read lines. This octal number is counted down by the MTC to initiate a write stop delay in the same manner as a write start delay. At the end of a write

stop delay, the MTC either enables a write start delay to continue writing records, or disables forward tape motion so that the read/write heads are properly positioned in the IRG.

Read stop and reverse stop are performed in essentially the same manner as a write stop except that the logic enabling and disabling conditions are different.

Facility for tape skew adjustment is also part of the timing functional block. To provide for this adjustment, the outputs from all read lines are logically ORed to form the level T READ PULSES. This level is used only for skew adjustment. Actual skew adjustment involves calibration of read/write delays with an oscilloscope. (Procedures for performing skew adjustment are presented in Chapter 5 of this manual.)

4.1.1.5 Read/Write (RW) - The read/write functional block (see Figure 4-5, Part 1 and 2), from an operations standpoint, constitutes two separate, but interrelated, logic functions. Each function is operationally independent; that is, each has separate data lines to the MTC, and separate buffers, delays and bus receivers. However, since writing operations are performed in the read-after-write mode, the two functions are highly interrelated. For example, in the read-after-write mode, all data written on tape is automatically read, immediately after writing and transferred back to the control for error checking.

A write operation is enabled by an MTC command, and the presence of a write enable ring on the file reel, in conjunction with the tape unit being placed in auto mode (see Section 3.1).

The write logic records data on tape in the Non-Return-to-Zero mode. (This method, referred to as NRZ recording, is fully described in Section 3.2 of the TM10 Magnetic Tape Control manual.) Data to be recorded appears at the bus receivers as logic levels where logic 0 = -3V, and logic 1 = ground. To accomplish NRZ recording, only the logic 1s in a given word are actually recorded on tape. As a result, only a ground level at a given bus receiver will trigger the related write delay when enabled by the data strobe pulse. At the end of this delay (which is calibrated to compensate for skew), the output complements an associated flip-flop in the write buffer. Whenever a write buffer flip-flop is complemented, it drives a write amplifier to record a logic 1 on tape, by virtue of a reversal of magnetic flux in the tape area allotted to the information bit. Conversely, if, during a specific data strobing, this same write buffer flip-flop



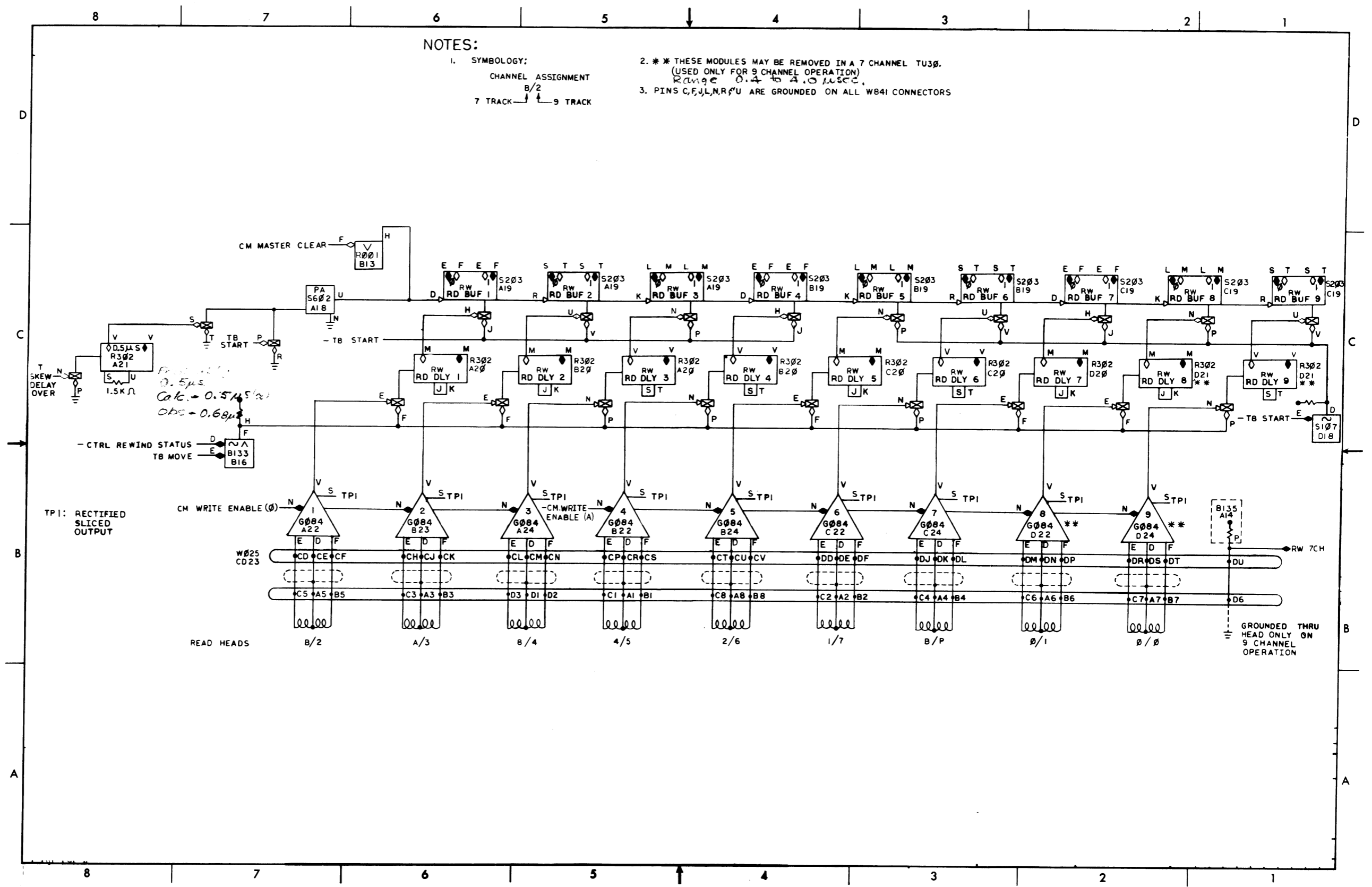


Figure 4-5 Read/Write Logic Block Diagram, Part 1





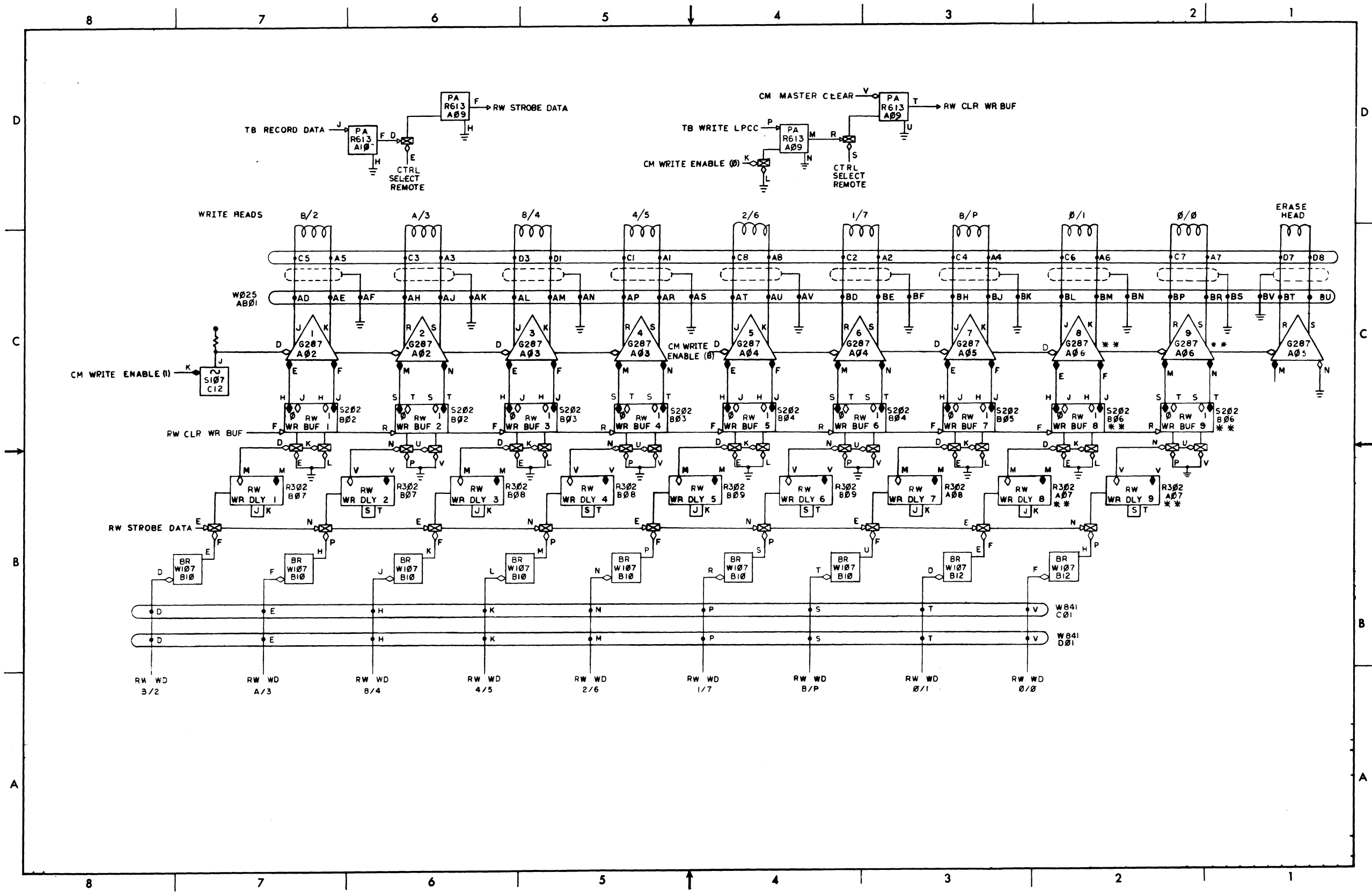


Figure 4-5 Read/Write Logic Block Diagram, Part 2



is not complemented (the result of a logic 0 at the related bus receiver) the flux in the tape area allotted to the information bit remains unchanged.

A write operation is terminated by an MTC command which initiates the DEC Logic Package master clearing pulse. This pulse, when initiated, results in the clearing of the forward motion flip-flop, the write enable flip-flop, and all the flip-flops in the write buffer. However, just prior to the master clear pulse, the MTC transmits the longitudinal parity check character (LPCC) which clears all write buffer flip-flops. As a result, those write buffer flip-flops in the set state will drive the associated write amplifiers to record a logic 1 in the related channels. The consequence of an MTC WRITE LPCC command is the binary sum of all logic 1s recorded in a given channel of a given record.

Any write operation can involve recording from one to n records on tape. In the case where one record is written, the IRG is defined by a write stop delay and the stop/start distance specific to the transport. When n records are written in a continuous manner, forward tape motion is maintained and recording is stopped by the MTC at the end of each record after the LPCC is written. A write stop and a write start delay are then enabled by the control with the writing of the next record beginning at the end of the write start delay.

TU30 write logic also contains a full-width erase head which is enabled only during a write operation. The erase head is driven by unidirectional output from a write amplifier and is positioned upstream from the write heads so that tape magnetic flux is always aligned in a standard direction prior to recording any data. This standard direction is defined as a magnetic flux with the north pole pointing toward the LP.

As previously indicated, the TU30 Magnetic Tape Transport is designed to read all data immediately after it is written, for error checking purposes. To do this, the read heads are positioned downstream close to the write heads and are enabled during all write operations. Information is read from tape in NRZ form. Each logic 1 read is amplified by an associated read amplifier which enables the triggering of a related skew delay. At the end of the delay, the pertinent flip-flop in the read buffer is set, sending a logic 1 (-3V) over the read lines to the control. At the end of the skew delay period, a pulse is generated by the timing logic (see Section 4.1.1.4) which clears all read buffer flip-flops. Thus it can be seen that, during a skew delay period, a word is read from tape

and transferred to the MTC. At the end of that period, the read buffer is cleared for the receipt of the next word read. Further, data in NRZ form read from tape is transmitted to the MTC in logic form; i.e., logic 0 = -3V, logic 1 = ground level.

During a read-only operation, there is no need for interrecord delays, since the IRG is established during recording. Also during read only operation, write operations are disabled by the control, and a read stop delay is enabled at read termination to properly position the tape IRG with respect to the read/write heads.

## 4.2 LOGIC ANALYSIS

A logic analysis of a digital subsystem entails detailed description of logic levels and timing pulses with respect to point or origin or circumstances of generation and the subsequent logical events enabled and/or disabled. When studied in the context of the related functional description, the logic analysis will provide a user with principal information needed to properly maintain this digital subsystem. The discussions comprising the DEC Logic Package logic analysis is organized on the basis of operating functions and all logic designations are referenced by the specific functional block identity prefix (TB, CTRL, CM, T, and RW refer to Figure 4-1 through 4-5). The discussion that follows provides a thorough analysis of all logic events contributing to operation of the DEC Logic Package as it relates to TU30 Magnetic Tape Transport performance.

### 4.2.1 Tape Unit Selection

Selection of a given tape transport requires that power be turned on, that the unit be placed in auto mode, and that a physical address be specified by the address selection switch (see Section 3.1, TU30 Control Panel).

Tape unit identification occurs when the logical address sent by the MTC matches the number (0-7) designated by the address selector switch on the control panel. The address of the selected tape unit, in the form of 3-digit binary number, is sent from the MTC to pins H, K, and M of the S107 Inverter at C06 at the TB. A true and inverted output for each input is presented to drive the S151 Binary-to-Octal Decoder at C07 at CTRL which produces a ground level on one of eight lines connecting to the address selector rotary switch. The logical address from the MTC will match the address selected at the control panel when the armature of the address selector rotary switch connects a ground level from the decoder called CTRL SELECTED.

This level together with CTRL REMOTE, a result of the transport AUTO button being activated, produces the logic level CTRL SELECT REMOTE. This level, when true, designates to the MTC that all conditions for selection are satisfied.

When a read or write operation is to be performed, the MTC always selects one of two clocks frequencies generated at the transport bus to time the specified writing density. The TU30 has two clock generators; one which produces a 60 kHz frequency, and one which produces a 41.7 kHz frequency. The output of both clocks trigger pulse amplifiers to produce 400-ns pulse widths. The 60 kHz pulse amplifier output is inverted to generate both positive- and negative-going TB 800 CLK levels. The 41.7 kHz pulse amplifier output is also inverted to generate both positive- and negative-going TB 556 CLK. The positive-going clock frequencies are transmitted as 400-ns pulses over the TB to the MTC when enabled by CTRL SELECT REMOTE being true. At the MTC, TB 800 CLK is divided by four to produce a clock rate for the 200 bpi writing density.

Depending on the density selected, the MTC uses one of the clock rates to determine the TB RECORD DATA pulse rate. In addition, the selected density is sent to the TB as TB200, TB556, or TB800. When enabled by CTRL SELECT REMOTE, the selected density energizes a lamp driver at the transport bus to light the related density indicator on the TU30 control panel. The selected density is also used to enable the T SKEW DELAY OVER logic (see Section 4.2.2.4).

#### 4.2.2 Read/Write Operation

The primary purpose of the TU30 Magnetic Tape Transport is to record binary information on magnetic tape for storage and subsequent acquisition. Operationally, this involves writing on tape in the prescribed format, providing for error checking, allowing for acceleration and deceleration spacing between information blocks, and providing for reliable storage and subsequent acquisition regardless of any interim operations. Simplified block diagrams of the read/write operation are shown in Figure 4-6 and 4-7. The following discussion analyzes the logic implementation of the DEC Logic Package read/write operation.

**4.2.2.1 Write Enabling** - The first step in a write operation involves setting the write enable flip-flop. This action requires three conditions be satisfied: that the AUTO button on the transport control panel be activated, that the transport be properly selected by

the MTC, and that a write enable ring be installed on the file reel. When the first two conditions are satisfied, CTRL SELECT REMOTE is a ground level, and the third condition is satisfied by CTRL WRITE ENABLE being at ground. To start actual recording, the MTC places D02, pin M on the TB at ground and sends the command TB SET FUNCTION over the bus. This command, along with CTRL SELECT REMOTE, triggers the positive-going pulse TB SET FUNCTION PULSE. This pulse, together with the ground level on D02 pin M, triggers the pulse TB SET WRITE ENABLE. This positive-going pulse, in conjunction with the level CTRL WRITE ENABLE, serves to set the CM WRITE ENABLE flip-flop.

Placing the CM WRITE ENABLE flip-flop in the set state, serves to enable all the G287 Dual Write Drivers in the write logic to complete the logic set-up for actual recording.

The CM FORWARD flip-flop is set coincident with setting the CM WRITE ENABLE flip-flop. This set level is enabled by the positive-going TB SET FORWARD pulse and a ground level designating that the transport is neither in reverse nor rewinding. The TB SET FORWARD pulse is triggered in turn by a ground level forward motion command from the MTC and the same positive-going TB SET FUNCTION pulse which triggered the TB SET WRITE ENABLE pulse.

When set, the output level, from the CM FORWARD flip-flop is transmitted to the Datamec logic to energize the transport forward pinch roller actuator, causing forward tape motion.

**4.2.2.2 Write Start Delay** - The principle function of the write start delay is to impose, through a timed acceleration duration, a standard distance or gap between the start of a subsequent write operation, and the end of a previous write operation. This total space, called the interrecord gap (IRG) is determined for one-half the total gap by the write start delay with the remaining half determined by the write stop delay. The write start delay is initiated by an enable motion delay command, TB EMD, sent by the MTC coincident with the forward motion commands. This command, TB EMD, along with TB START, in the true state from the MTC, enables the transmission of a logic 1 over read line TR 2/6 to be interpreted by the MTC as the octal number 20. This number is then counted down to 0 by the MTC to determine the write start delay. When the count reaches 0, the MTC places the first data character to be recorded on the write bus receivers.

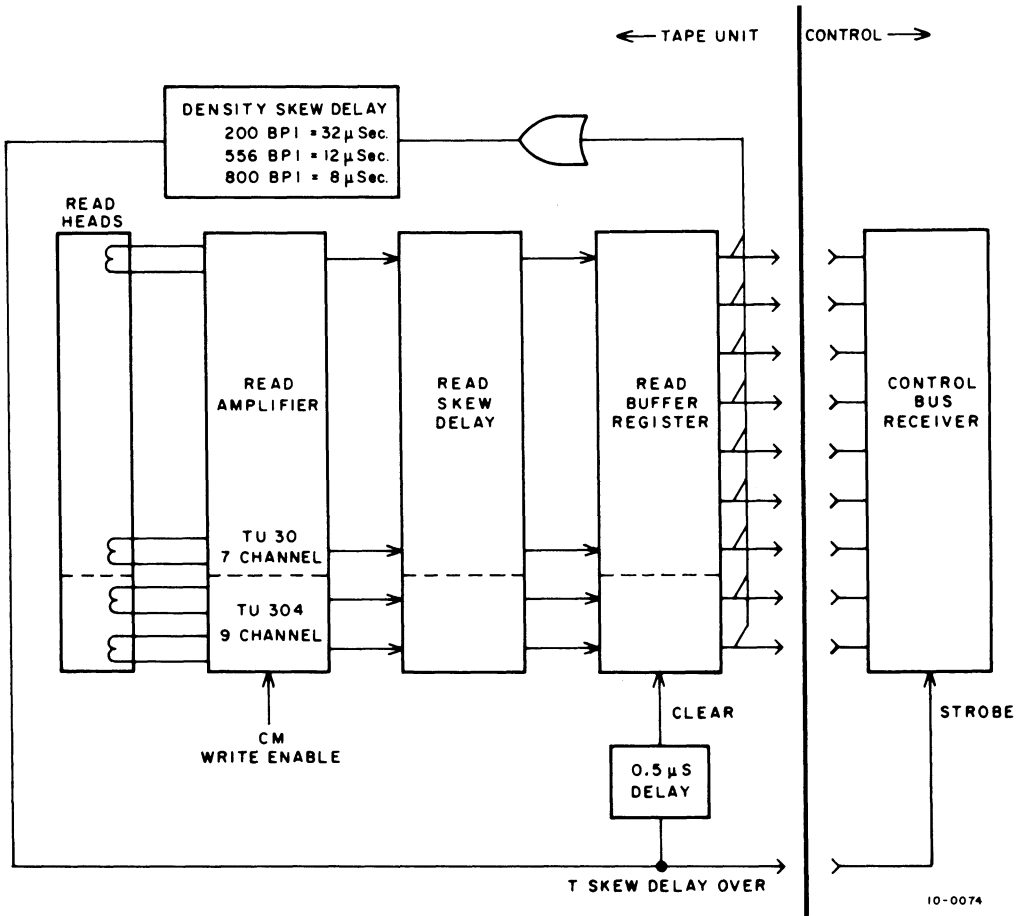


Figure 4-6 Simplified Block Diagram of Read Operation

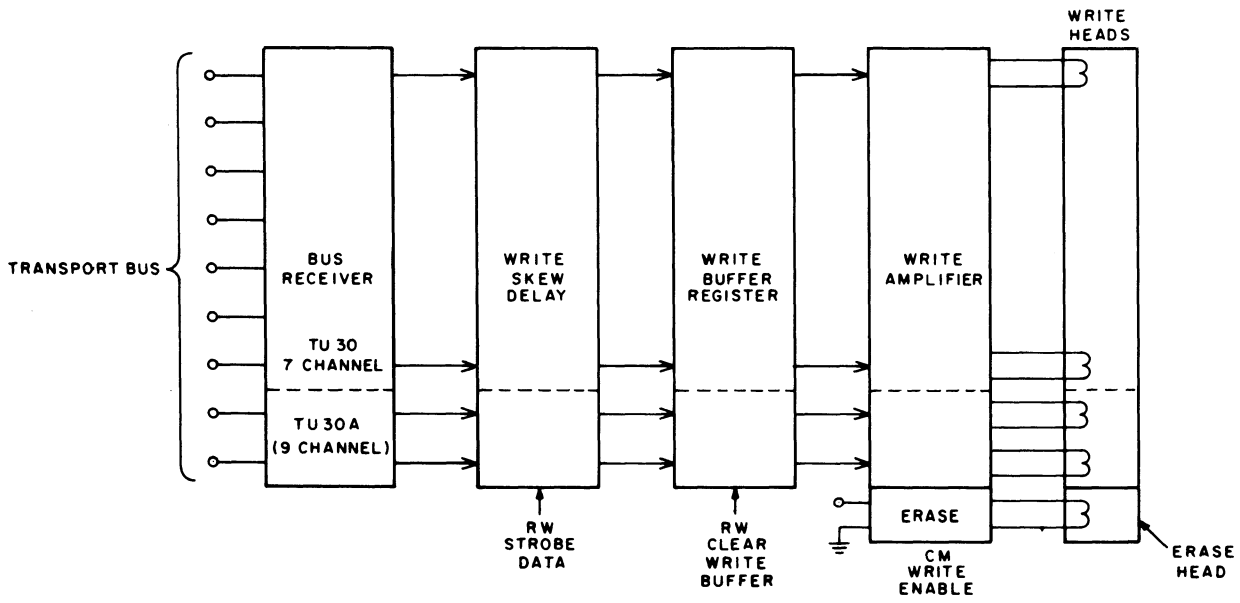


Figure 4-7 Simplified Block Diagram of Write Operation

4.2.2.3 Record Data - At the end of the write start delay, a positive-going TB RECORD DATA pulse is sent from the MTC, through the transport bus, to pin J of the R163 Pulse Amplifier at A10. This positive-going output pulse, along with CTRL SELECT REMOTE at ground level, enables (at pins D and E) a ground level input to Pulse Amplifier R613 at A09. The resulting output is a positive-going pulse RW STROBE DATA.

Each data word transferred from the MTC to the transport bus receiver register is preceded by a TB RECORD DATA pulse which, in turn, generates the TB STROBE DATA pulse necessary to record that word on tape. To maintain clarity, the following discussion will describe the writing of data on a single tape channel. Since the TU30 records on parallel channels, this description will apply to all channels.

Data transferred from the control to each bit position in the bus receiver register is defined as follows:

- a. Logic 1 = a positive going level or ground, and
- b. Logic 0 = a -3V level

On this basis and with reference to Figure 4-8, consider writing a 1 on the given tape channel, B/2. At word-time 1, bit position B/2 in bus receiver #1 is at ground level. Upon generation, RW STROBE DATA pulse #1, along with the logic 1 level, enables triggering of write delay #1. The purpose of the write delay register is to provide a time lapse compensation for static positional differences (or skew) between channel write heads. The write delay modules are adjustable for skew through a potentiometer (see Chapter 5 for Skew Adjustment Procedure). When triggered, the output from write delay #1 is a positive-going pulse which complements write buffer register flip-flop #1. The state of this flip-flop, as a result of this input pulse, depends on the previous state. A transition of this write buffer register flip-flop terminates current in one direction to the enabled write amplifier #1 and applies it in the opposite direction. The effect of this current direction change is a flux reversal at the write head and the writing of a logic 1. Thus it can be seen that, at each word time a transition of a write buffer flip-flop writes a logic 1 on tape and that at a given word time the absence of a write buffer flip-flop transition causes the writing of a logic 0.

In order to insure errorless transcription, the TU30 tape transport is equipped with an erase head which is positioned in front of the write heads. This erase head is controlled by Write Driver G287 at A05 connected so that pin N is always at ground level and

pin M is floating. When enabled, the result is uni-directional current to the erase head, thereby aligning tape flux in a constant direction and wiping out any previously written extraneous or stray data.

4.2.2.4 Read After Write - The TU30 tape transport automatically operates in the read-after-write mode; that is, each word, after being written, is read 2 ms later and transmitted to the MTC for parity checking. As part of the sequence for initiating a write operation, a ground level (-CM WRITE ENABLE) is placed at pin N of all read amplifiers. This action, a result of the CM WRITE flip-flop being set, amounts to a partial enabling of the read amplifiers. This partial enabling is necessary since newly recorded data has not yet been exposed to the normal 15% erasure which occurs during subsequent read operations and is due to the residual magnetism of the write and erase heads. A ground level on the write amplifiers results in a read sensitivity which is about 80% of normal to compensate for the strength of an initial recording.

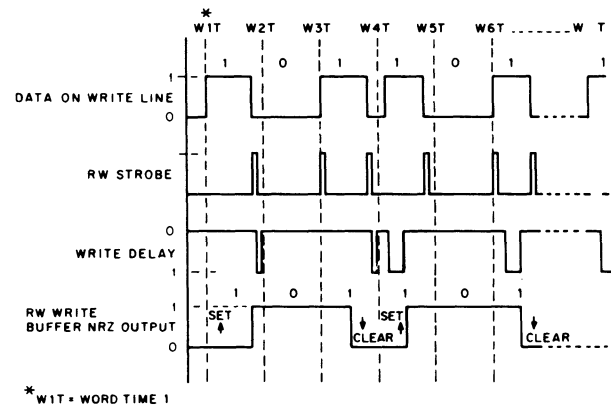


Figure 4-8 Record Data Timing

At the same time, the read delay register gates are enabled by two 3V levels, namely CTRL REWIND STATUS, not true, indicating that the Transport is not rewinding, and the TB MOVE command initiated by the MTC. At the beginning of the write operation enable motion delay (EMD) time, the read buffer flip-flops are in the clear state. This is a result of TB START being true which in turn triggers a positive-going pulse output from a pulse amplifier to clear the read data output from the read delays into the read buffer flip-flops. At this point the read logic is ready to read data from the file tape being written.

The output from each read delay, in addition to enabling an associated read buffer flip-flop, is connected to a logic structure which generates a skew delay sufficient to complete the reading of a character at the density the character was written. Consider, for example, read delay #1 as being typical with respect to read logic interaction with the skew delay over logic. When triggered by the reading of a logic 1, the output is a ground level called RW RD DLY 1. This level enables an associated gate in a 7- or 9-gate AND structure to produce the positive-going pulse T READ PULSES. The first of the T READ PULSES produced serves to trigger one of three delays. The delay triggered is that which is enabled by one of three selected density levels from the MTC (TB200, TB556, or TB800). The resulting output is the ground level T SKEW DELAY OVER which occurs after a given delay whose duration is directly related to the density at which the character being read, was written; i.e., 32  $\mu$ s for 200 bpi, 12  $\mu$ s for 556 bpi, 8  $\mu$ s for 800 bpi. Density selection by the MTC is a normal step in a read or write operation. And, since tape velocity is a constant, a given recording density is a function of TB RECORD DATA pulse frequency, which in turn is determined by the density clock rate selected by the MTC.

It can be seen that the T SKEW DELAY OVER goes to ground level only after a delay occurs which is sufficient to read a given word at its recorded density and place that word in the read buffer. Two actions result from T SKEW DELAY OVER going to ground level; a strobe data pulse to the MTC, and clearing of the read buffer.

The strobe data pulse to the MTC TB READ SKEW OVER, is initiated by a pulse amplifier called at the transport bus. This pulse amplifier output is inverted to form a negative-going pulse input to TB, gate B163 at D10. Pin F of this gate has been placed at -3V by CTRL SELECT REMOTE. The resulting positive-going pulse is sent over the transport bus to the MTC to strobe the data word read and transmitted during the skew delay.

After each data word is read, and transmitted, the read buffer must be cleared in order to receive the next data word to be read. With T SKEW DELAY OVER at ground level, delay R302 in the read logic is enabled to initiate a 5  $\mu$ s delay. This delay allows time for the MTC to strobe the data word just read out of the MTC bus receiver register into the MTC read buffer. After 5  $\mu$ s, a positive-going pulse generated by delay R302 triggers a pulse amplifier to clear each flip-flop in the read buffer. With the read buffer cleared, the read logic is ready to read and transmit the next word written, to the MTC.

4.2.2.5 Write LPCC - After all data has been written, the TU30 automatically generates a longitudinal parity check character (LPCC). The LPCC is actually the final word written during any given write operation and represents the last state of each flip-flop in the write buffer, logically the exclusive OR of all digits (1 and 0) written on tape in each channel.

TB LPCC is a positive-going pulse generated by the MTC after the last data word has been written. The control initiates a TB LPCC at the termination of all write operations.

TB LPCC triggers a pulse amplifier in the write logic whose output together with CTRL SELECT REMOTE at ground triggers another write logic pulse amplifier to produce the positive-going output pulse RW CLR WR BUF which clears each flip-flop in the write buffer. Since the write amplifiers are still enabled, a logic 1 is written only in those channels where the related write buffer flip-flop changed state.

4.2.2.6 Write Stop Delay - As indicated in the discussion of the write start delay, the principle function of the write stop delay is to impose, through a timed deceleration duration, a standard distance or gap between the end of a current data recording and the start of the next data recording. Also, as previously stated, the gap on tape defined by the write stop delay is equal to one-half the total IRG. A write stop delay is initiated by the MTC when the LPCC is read after being written. To do this, the MTC places TB EMD and TB START at -3V. TB EMD is asserted at -3V; whereas, TB START is asserted at ground, so that for this operation TB START is not true. With all other logic conditions present, namely the forward and write enable flip-flops set, and CTRL SELECT REMOTE asserted, TB EMD and -TB START will enable transmission of a logic 1 over read line TR B/2. Transmission of logic 1 over this read line is interpreted by the MTC as an octal 5, and is counted down to determine the duration of the write stop delay.

4.2.2.7 Master Clear and Tape Unit Ready - At the completion of the write stop delay countdown, the MTC changes TB MOVE to not true (from ground to -3V) to initiate clearing of the write logic, the write enable flip-flop, and the forward flip-flop. To accomplish this, -TB MOVE at ground, together with CM REMOVE TAPE at ground (indicating that the tape path is intact), triggers a pulse amplifier in the transport bus to produce the positive-going pulse TB CLEAR FUNCTION. This pulse, together with CTRL SELECT REMOTE at ground (true), serves to trigger a pulse am-

plifier in the command logic generating the positive-going CM MASTER CLEAR pulse. The CM MASTER CLEAR pulse, in addition to clearing all write buffer flip-flops, also clears the CM FORWARD flip-flop. With the CM FORWARD flip-flop in the clear state, a diode gate structure in the command logic is enabled to place CM MOTION at ground level. When CM MOTION is at ground, the 5 ms delay CM SETTLING DOWN is triggered. At the end of 5 ms, which permits the transport logic to stabilize before the next operation, CM SETTLING DOWN reverts to a ground, thereby clearing the CM WRITE ENABLE flip-flop, and placing TB TUR (tape unit ready) at ground. Placing TB TUR at ground serves to notify the MTC that the transport is ready for the next operation.

4.2.2.8 Read - A read operation is performed in exactly the same manner as the read after write operation (see Section 4.2.2.4) except for the enabling level on the read amplifiers. For a read-only operation, the CM WRITE ENABLE flip-flop is in the clear state as a result of the last CM MASTER CLEAR generated. This action places CM WRITE ENABLE at -3V which, in turn, places all read amplifiers at maximum input sensitivity. Maximum read amplifier input sensitivity is necessary during read-only operation to insure data pickup regardless of any time influenced flux decay.

4.2.2.9 Read Stop Delay - As in the write operation, a delay must be enabled so that after a read operation, the read/write heads are properly positioned in a tape IRG to allow enough space for tape acceleration at the onset of the next read/write operation. A read stop delay is initiated when the MTC reads the last word (LPCC) in the last record to be read. At that point the MTC places TB START and TB EMD at -3V. This action enables the same logic structure used to initiate a write stop delay, except that gate B163 at C16 in the timing logic is enabled at pin K instead of at pin L. Since the read buffer flip-flops were cleared by the final T SKEW DELAY OVER pulse, all the read lines are at -3V. This leaves only the output of B163 at C16, pin N at ground level which is sent to the MTC across read line T R8/4. The MTC interprets a ground level on this line, after making TB START not true and asserting TB EMD, as the octal number 4 which is counted down to 0. At the end of the delay, the MTC initiates the same logic clearing sequence initiated during a write stop delay.

### 4.3 REWIND OPERATION

The rewind operation can be performed in two ways;

automatically under the direction of the MTC, or manually by pushbutton action at the tape transport control panel (see Section 3.1, TU30 Control Panel). When done automatically, the MTC can direct a rewind to beginning of tape (BOT) or a rewind unload. In the latter case, the BOT marker is ignored and the tape unwound completely from the file reel. All rewind operations are performed at high speed with the tape removed from the vacuum columns.

#### 4.3.1 Automatic Rewind to BOT

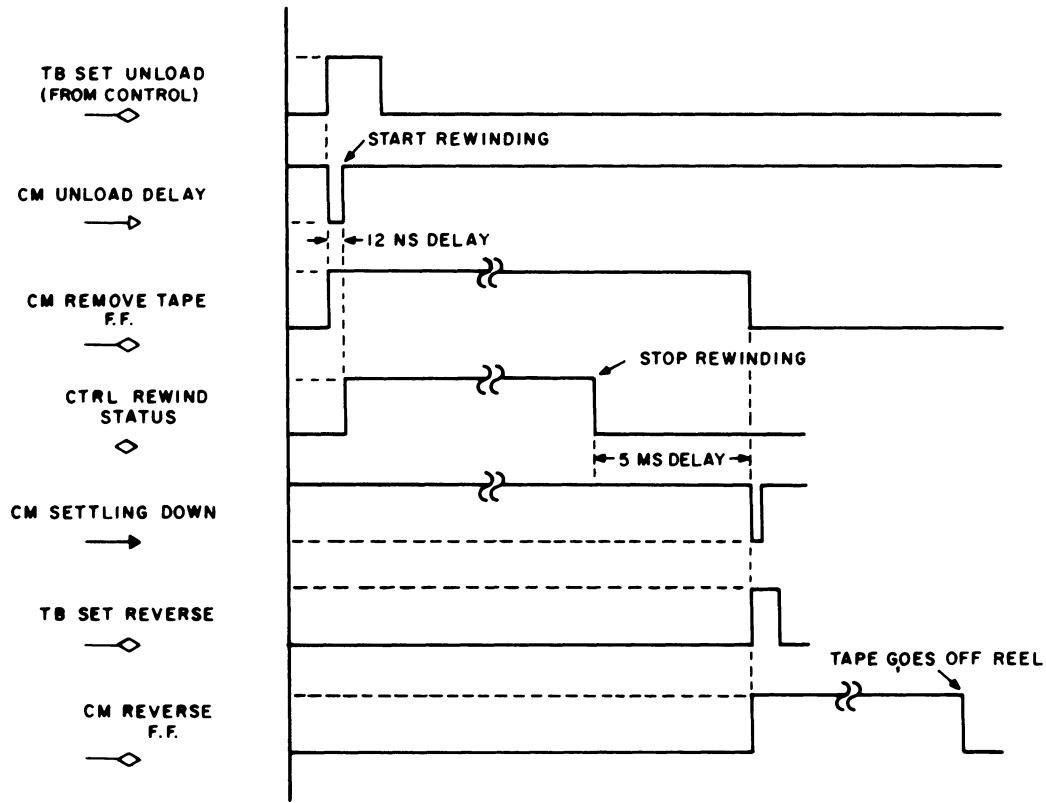
A rewind to BOT (see Figure 4-9) is initiated by the MTC with a positive-going ground level on the TB SET REWIND line, and a positive-going TB SET FUNCTION pulse. The TB SET FUNCTION pulse along with TB SET REWIND triggers a pulse amplifier at the transport bus. The output is a TB SET REWIND pulse which together with a ground level CM ENABLE UNLOAD triggers the 12  $\mu$ s, negative-going CM REWIND delay in the command logic. CM ENABLE UNLOAD is at ground when the CM FORWARD and CM REVERSE flip-flops are both in the clear state, indicating that the tape reels are not moving. The 12  $\mu$ s negative-going pulse from the CM REWIND delay is connected to the Datamec logic and serves to initiate the rewind operation.

Once initiated, the rewind operation is under complete Datamec control and requires no further action by the DEC Logic Package. The rewind operation is terminated when the Datamec senses the BOT marker. At that point, the Datamec logic transmits the command CTRL BOT a positive-going level which is inverted by the control logic to furnish both polarities. CTRL BOT at -3V serves to disable the CM REWIND delay to eliminate the possibility of spurious signals rewinding the tape beyond the LP. At the same time, the Datamec logic places CTRL REWIND STATUS at ground causing CM MOTION to become true. When CM MOTION becomes true, the CM SETTLING DOWN 5 ms negative-going delay pulse is triggered to allow all logic to stabilize. At the end of 5 ms, CM SETTLING DOWN is automatically cleared, placing TB TUR at ground. This action notifies the MTC that the tape transport is ready for the next operation.

#### 4.3.2 Automatic Rewind Unload

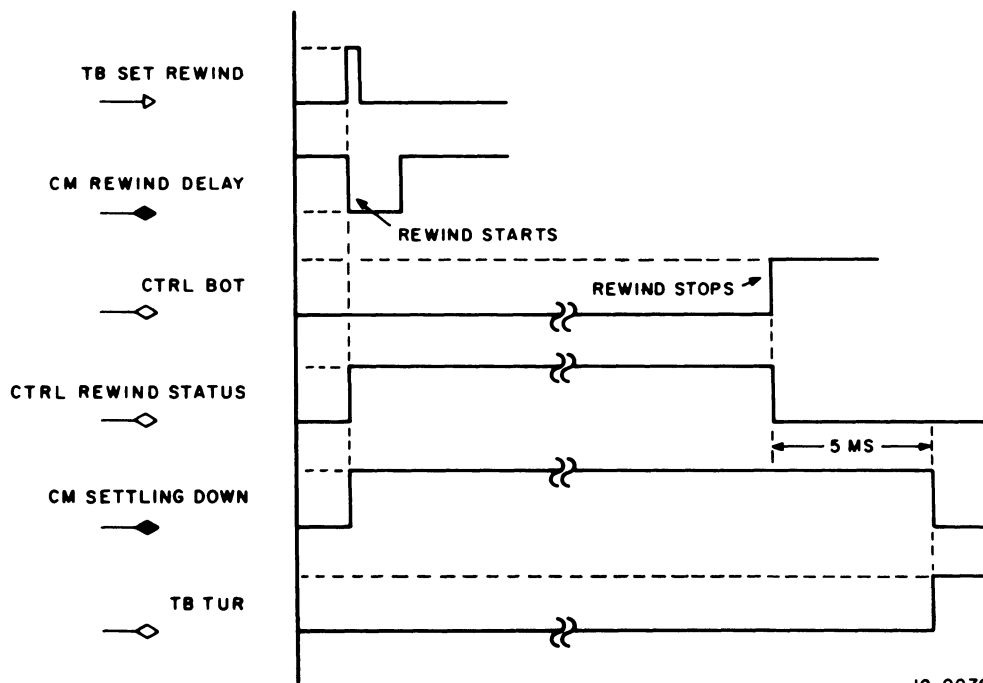
The MTC initiates an automatic rewind unload (see Figure 4-10) by a TB SET FUNCTION command and a positive-going TB SET UNLOAD pulse. This pulse is triggered by a ground level SET UNLOAD command





10-0077

Figure 4-9 Rewind to BOT, Timing Diagram



10-0076

Figure 4-10 Rewind-Unload, Timing Diagram

from the MTC and the positive-going TB SET FUNCTION pulse. The TB SET UNLOAD pulse then triggers CM UNLOAD delay. The CM UNLOAD can be triggered only when both the CM FORWARD and CM REVERSE flip-flops are in the cleared state indicating absence of tape motion. Triggering the CM UNLOAD delay generates a 12  $\mu$ s negative-going delay pulse. This pulse initiates two actions; the first is the command CM REWIND over the TB to the Datamec logic to start a high-speed rewind (see paragraph 4.7.2.4 Datamec Manual), and the second is setting the CM REMOVE TAPE flip-flop.

When the BOT is reached, rewinding stops, and the CTRL REWIND STATUS line is placed at -3V by the Datamec logic. As a result, CM MOTION becomes a ground level which triggers the CM SETTling DOWN delay. After 5 ms all tape reel motion has ceased and the delay is cleared so that CM SETTling DOWN is a ground level. CM SETTling DOWN along with the CM REMOVE TAPE flip-flop in the set state triggers a pulse amplifier at the transport bus to generate the positive-going TB SET REVERSE pulse which in turn sets the CM REVERSE flip-flop. Setting the CM REVERSE flip-flop sends the command CM REVERSE over the TB to activate the reverse punch roller actuators pulling the tape past BOT, off the file reel and out of the vacuum columns.

When the tape is removed from the vacuum columns, the TU30 Magnetic Tape Transport senses a loss of vacuum and reverts automatically to local mode. This action has the same effect as manually activating the LOCAL button; that is, to remove the TU30 from AUTO control. During the transition from auto to local mode a pulse amplifier in the command logic is triggered when CTRL REMOTE changes from -3V to ground as a result of the transition from auto to local mode. During this -3V to ground transition, the capacitor memory feature typical of DEC DCD-gates places both pins simultaneously at ground level long enough to trigger the pulse amplifier and produce a positive-going output pulse. This output pulse, CM MASTER CLEAR places the motion control and the write enable flip-flops in the DEC Logic Package in the clear state, thereby disabling all logic.

#### 4.4 REVERSE

A reverse operation (see Figure 4-11) is initiated by the MTC as a result of a computer generated command to backspace *n* records. At the start of a reverse, the transport read/write heads are positioned on an inter-record gap as a result of the last stop motion command from the MTC. Further, the read heads are enabled

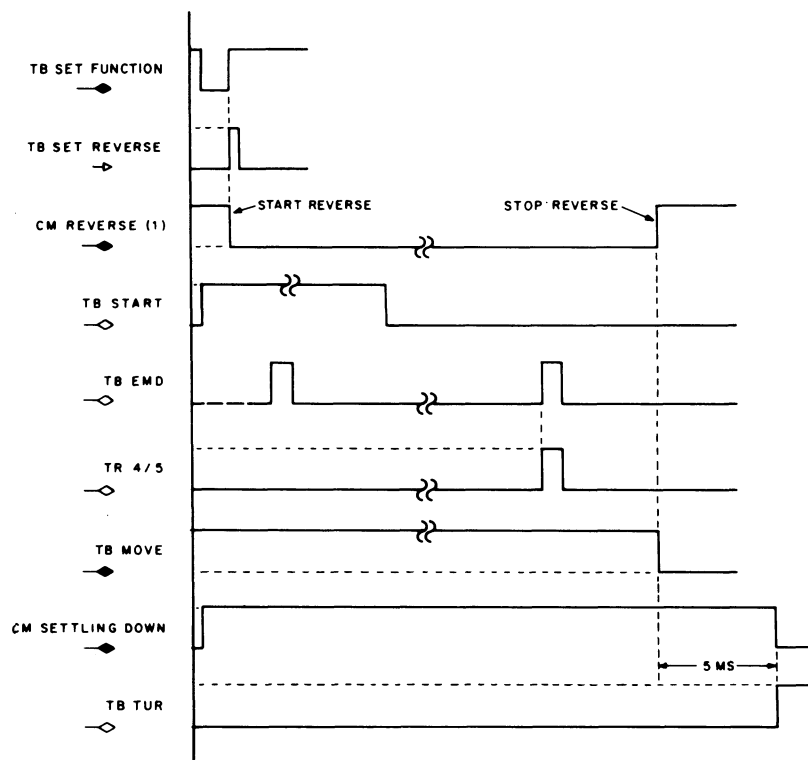
as a result of the write enable flip-flop being cleared. Reverse motion is started by a positive-going TB SET FUNCTION pulse and a TB SET REVERSE ground level from the MTC. This action triggers a pulse amplifier at the TB to generate a TB SET REVERSE pulse, thereby setting the CM REVERSE flip-flop. A set of the CM REVERSE flip-flop is enabled by the TB SET REVERSE pulse only when the CM FORWARD flip-flop is in the clear state and CTRL REWIND STATUS is not true. Setting the CM REVERSE flip-flop sends the command CM REVERSE over the TB which causes the transport actuators to backspace the tape and enables a lamp driver at the control/Datamec interface to light the control panel reverse indicator. After backspacing *n* records, the MTC determines that, since data is no longer present, the next interrecord gap is being entered. At that point the MTC asserts TB EMD which enables transmission of a logic 1 from the transport to the MTC over read line TR 4/5. A 1 on this line is interpreted as the octal number 20 by the MTC. This number is then counted down by the MTC to define the necessary delay prior to stopping the tape so that, when the tape is halted, the read/write heads are properly positioned with respect to the IRG. At the end of the delay, the MTC stops tape motion by placing TB MOVE at -3V. This level is inverted and, in conjunction with CM REMOVE TAPE (0), triggers a pulse amplifier at the transport bus to generate a positive-going TB CLEAR FUNCTION pulse. The TB CLEAR FUNCTION pulse together with a ground level CTRL SELECT REMOTE triggers a pulse amplifier in the command logic to generate CM MASTER CLEAR. In turn, CM MASTER CLEAR places the CM REVERSE flip-flop in the clear state, and releases the reverse pinch roller actuator. Clearing the CM REVERSE flip-flop causes CM MOTION to become true which triggers the CM SETTling DOWN delay. At the end of 5 ms, CM SETTling DOWN is cleared, thereby placing TB TUR at ground. This action notifies the MTC that the tape transport is ready for the next operation.

#### 4.5 MANUAL CONTROLS

As indicated in Section 4.1.1.2 of this chapter, the DEC Logic Package control function implements the interface between DEC logic and the manual controls on the transport control panel. In the discussions that follow, each of these controls is analyzed with respect to the function performed and the logic sequence enabled by the specific control.

##### 4.5.1 LOCAL Button

The transport LOCAL button, when activated, places the TU30 under operator direction and ready for ex-



10-0075

Figure 4-11 Reverse, Timing Diagram

ecution of a manual option as elected by the operator. With power to the transport ON, pressing the LOCAL button directly enables a Schmitt trigger at the control/Datamec interface to produce the logic level CTRL LOCAL RESET. This level is asserted at ground and serves to completely disable all write logic and clear all motion flip-flops.

The write logic is disabled by CTRL LOCAL RESET which clears the CM WRITE ENABLE flip-flop, thereby turning the write amplifiers off. CM MASTER CLEAR, a positive-going pulse triggered when CTRL LOCAL RESET becomes true, completes the disabling of the write logic by clearing all flip-flops in the write buffer. Also, the CM MASTER CLEAR pulse clears the CM FORWARD and CM REVERSE flip-flops as well as the CM REMOVE TAPE flip-flop.

The action of the transport LOCAL button is twofold; in addition to initializing transport logic for a start-up situation, this button, because of the manner in which initialization is performed also serves as a transport halt button when activated during remote operation, or during manually initiated forward or reverse tape motion. In addition, activation of any of the manual controls described herein must be preceded by pressing

the LOCAL button, unless the transport is already in the local mode.

#### 4.5.2 AUTO Button

The principle function of the transport control panel AUTO button is to enable selection of the transport by the MTC.

Pressing the AUTO button activates a Schmitt trigger at the control/Datamec interface to produce the level CTRL REMOTE. This level together with CTRL SELECTED, which is asserted when the MTC successfully selects the pertinent transport, causes the logic level CTRL SELECT REMOTE to be asserted. CTRL SELECT REMOTE, in turn, is the key level in the enabling of all transport operations conducted under MTC direction.

#### 4.5.3 LOAD POINT Button

In a typical start-up situation, the operator first loads the file tape, then presses the LOCAL button, and finally activates the LOAD POINT button to start an LP search to position the tape on the LP marker. Activating the LOAD POINT button energizes a Schmitt

trigger at the control/Datamec interface to produce the level CTRL LP SEARCH. Asserting this level triggers the 4s integrating one-shot delay CM SEARCH FORWARD, and sets the fake load-point flip-flop (S202 at A16) in the command logic. Since pressing the LOAD POINT button also directly activates the transport forward pinch roller actuator, forward tape motion will begin at the same time CM LP SEARCH is asserted.

After activating the LOAD POINT button, forward tape motion continues for 4s. If the LP is detected during this period, appropriate Datamec circuits halt the tape so that the LP marker is positioned correctly with respect to the read/write heads. If the LP marker is not detected after 4s (or 25 ft of tape movement) the CM SEARCH FORWARD delay reverts to the clear state. The resulting ground level, together with the set level from the fake load-point flip-flop, serves to trigger a one-shot in the command logic to assert the level CM FAKE LOAD POINT. This level, when transmitted to the Datamec logic, simulates LP marker detection and activates the transport reverse pinch roller actuator causing reverse tape motion. This action is part of a normal LP search since detection of the LP marker will reverse tape motion so that the marker, which was just passed over, will be backed up a short distance until detected again and stopped in the correct position with respect to the read/write heads. However, in this case, when the level CM FAKE POINT is asserted, reverse tape motion continues until the real LP marker is detected. The need for this corrective mechanism arises because of the possibility that a file reel could be wound past the LP marker during tape loading.

#### 4.5.4 REWIND Button

A rewind operation, whether initiated manually or through the MTC, involves removing the tape from the vacuum wells, rewinding at high speed, then slowing down and stopping at the LP marker, and finally reinserting the tape into the vacuum wells. The complete manually-initiated rewind operation is conducted under Datamec control and is described in Section 4, paragraph 4.7.2.4 of the Datamec manual. When a tape rewind begins, the Datamec asserts the level CTRL REWIND STATUS at the control/Datamec interface. This level, when asserted, disables all motion flip-flops and the CM WRITE ENABLE flip-flop to effectively prevent all other transport operation during

the rewind period.

#### 4.5.5 REVERSE Button

The REVERSE button, when activated, will initiate reverse tape motion only if the transport is under LOCAL control. In this mode, pressing the REVERSE button activates a Schmitt trigger at the control/Datamec interface to assert the CTRL REV level. When asserted this level, in conjunction with CTRL REMOTE not true (indicating that the transport is not in auto mode), triggers a pulse amplifier at the transport bus to produce the positive going TB SET REVERSE pulse. This pulse enables setting of the CM REVERSE flip-flop to cause reverse tape motion only if the CM FORWARD flip-flop is in the clear state and CTRL REWIND STATUS from the Datamec is not asserted. Reverse tape motion continues until the LP is detected or until halted by pressing the LOCAL button. When the LP is detected, the CTRL BOT level is asserted at the control/Datamec interface. When asserted this level clears the CM REVERSE flip-flop to halt tape motion. Pressing the LOCAL button stops reverse tape motion by initializing all logic as indicated in Section 4.5.1.

#### 4.5.6 FORWARD Button

The FORWARD button, when activated, initiates forward tape motion only if the transport is under LOCAL control. In this mode, pressing the FORWARD button activates a Schmitt trigger at the control/Datamec interface to assert the CTRL FWD level. When asserted, this level, together with CTRL REMOTE not true, triggers a pulse amplifier at the transport bus to produce the positive going TB SET FORWARD pulse. This pulse enables setting of the CM FORWARD flip-flop to cause forward tape motion only when the CM REVERSE flip-flop is in the clear state and CTRL REWIND STATUS from the Datamec is not asserted. Forward tape motion continues until the end-of-tape (EOT) marker is detected or until it is halted by activation of the LOCAL button. When the EOT is detected, the CTRL END POINT level is asserted at the control/Datamec interface. When asserted, this level, together with CTRL REMOTE not true, clears the CM FORWARD flip-flop to halt forward tape motion. Pressing the LOCAL button stops forward tape motion by initializing all logic as indicated in Section 4.5.1.

## CHAPTER 5 MAINTENANCE

This chapter presents all instructions necessary to check out, adjust, troubleshoot, and repair the DEC Logic Package. Maintenance information for the remaining subsystems of the TU30 Magnetic Tape Transport is contained in Section 5 of the Datamec manual.

Many of the maintenance and adjustment procedures described require the use of a DEC TU30 Off-Line Tester. The control panel for this tester is shown in Figure 5-1. The purpose of this tester is to simulate the actions of an associated magnetic tape control (MTC). Design of the off-line tester is such that the five attached cable assemblies correspond to the five cable assemblies connecting the transport to the MTC.

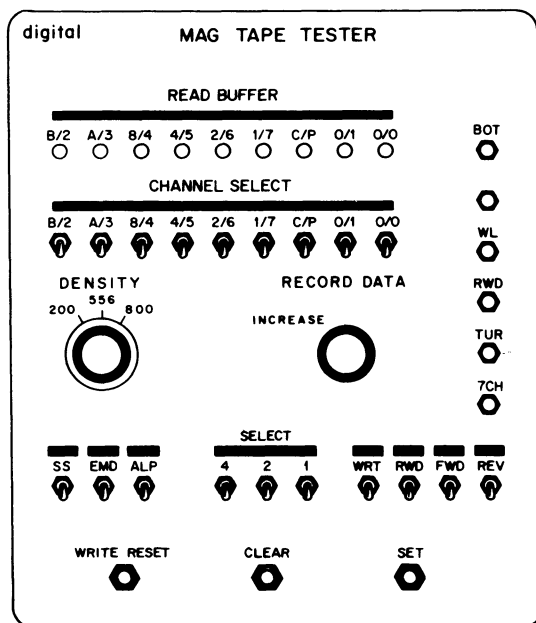


Figure 5-1 Control Panel DEC TU30 Off-Line Tester

Connection of the off-line tester to the transport requires that these cable assemblies be substituted for the MTC cable assemblies as designated in Table 2-1. Table 5-1 lists the equipment recommended for servicing the TU30 Tape Transport, in addition to the standard hand tools normally required.

Table 5-1  
TU30 Maintenance Equipment

Equipment	Manufacturer	Model Number
Off-Line Tester	DEC	
Multimeter	Triplet or Simpson	630 MA or 260
Oscilloscope	Tektronix	Series 540 or 580, with Type CA Differential Amplifier
Head Cleaner Kit (8705)	Potter	P/N A-425-484

### 5.1 DEC MODULES

The module types, descriptions and the quantity required for the DEC Logic Package are listed in Table 5-2. Any standard modules used are described in the DEC Logic Handbook (C105), and special PDP-10 system modules are detailed in the PDP-10 Module Reference Manual. A spares schedule of one of each module type per tape transport is recommended for any TU30 maintenance program.

Table 5-2  
TU30 Module Utilization

Module Description	Type Number	Quantity Used
Diode Gate	B133	3
Diode Gate	B135	2
Diode Gate	B163	4
Inverter	B165	1
Magtape Read Amplifier	G084	9
Write Driver	G287	5
Diode Network	R001	1
Diode Network	R002	1
Dual Delay	R302	13
1-Shot Multi-vibrator	R303	2
Clock	R405	2
Pulse Amplifier	R603	2
Pulse Amplifier	R613	4
Inverter	S107	7
Binary-to-Octal Decoder	S151	1
Dual Flip-Flop	S202	8
Triple Flip-Flop	S203	3
Pulse Amplifier	S602	4
Cable	W025	3
Indicator Driver	W051	1
I/O Bus Receiver	W107	2
Schmitt Trigger	W501	5
Cable	W841	5

Module position within the mounting panel, viewed from the wiring side, is shown in Figure 5-2. Each module in Figure 5-2 is identified by the name of the logic level(s) asserted at the circuit output. Figure 5-3 is a photograph of the modules on the mounting panel.

## 5.2 PRELIMINARY CHECKOUT

The following procedure is recommended for determining the operating status of a TU30 Magnetic Tape Transport during initial installation or during installation following a move within or without a facility.

- a. Connect the transport input-power cable to the specified external power source.
- b. Place REMOTE/OFF/LOCAL switch on power control to LOCAL position.
- c. With power control (PC) switch in LOCAL position, power is applied to the transport.
- d. If power is not present, check that the Datamec power supply switch, at the righthand floor section, is ON; also check that circuit breakers on the power control are set.
- e. With power applied to the transport, check that the DEC Logic Package cooling fans are operating.
- f. Check for presence of logic supply voltage with a multimeter; +10V on pin A and -15V at pin B of both connector panels.
- g. Connect off-line tester cables by removing the MTC and read/write cable and connector assemblies and replacing them with the appropriate Tester cables. Table 2-1 locates cable connector positions in the module panel.
- h. Place all off-line tester switches in the down position.
- i. Place any address from 1 to 7 (not 0) in the ADDRESS SELECTOR switch on the TU30 control panel.
- j. With this action all lights on the off-line tester should be out.

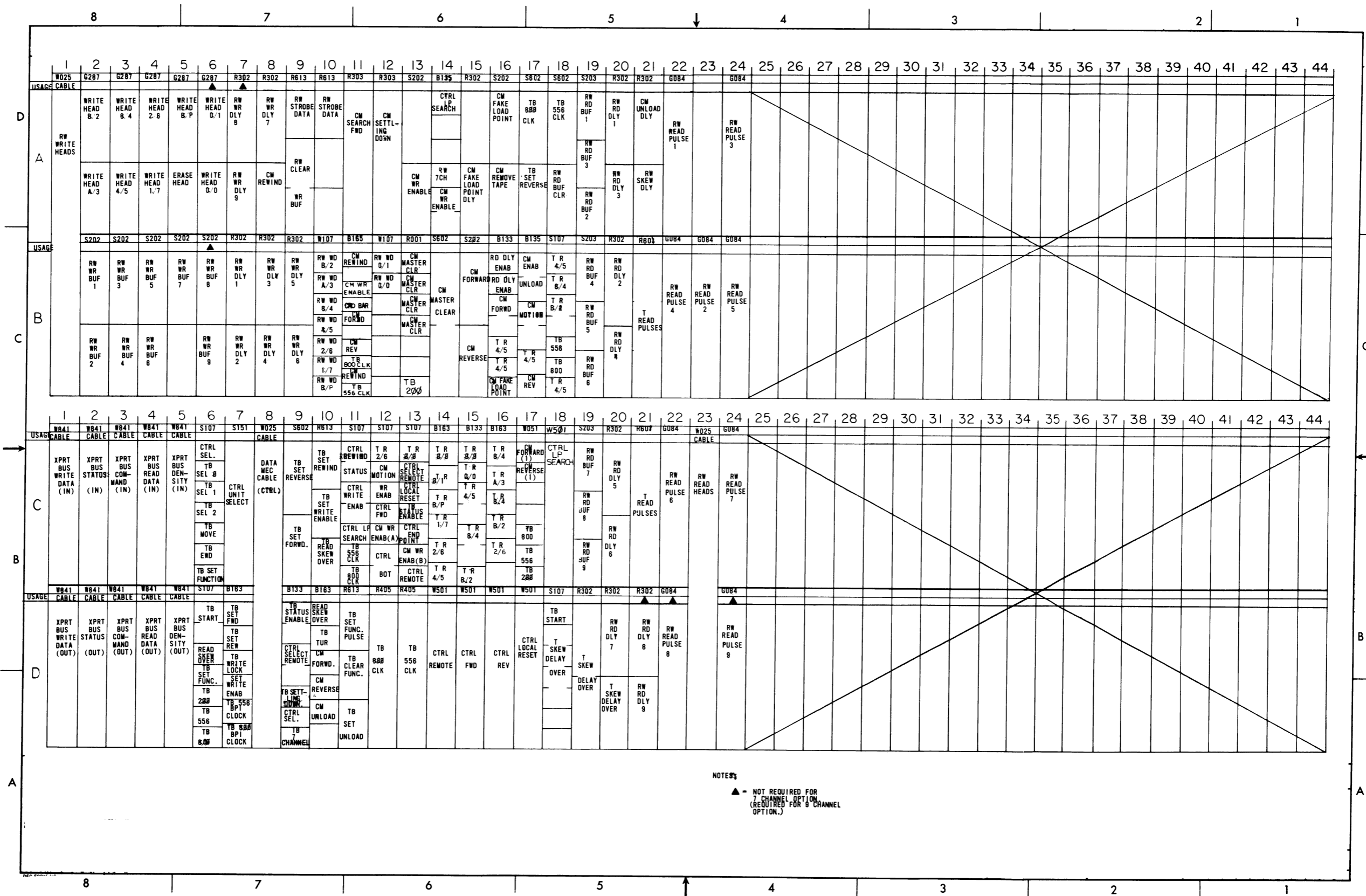


Figure 5-2 Module Position Within Mounting Panel





#### NOTE

If the TUR indicator lights, this indicates a malfunction in the transport selection logic. Refer to Section 4.2.1 and Figures 4-1 and 4-2. Also check the functioning of the S107 inverter module at C06, pins HF, KJ, MC, or ED, S151 Binary-to-Octal Decoder module at D07, gate module B133 at D09, pins K, J, L, M, and S107 Inverter module at C13, pins H, F.

k. Change address in transport control panel ADDRESS SELECTOR switch to 0.

l. With this action, the TUR indicator on the off-line tester control panel will light.

#### NOTE

If a tape has been installed on the transport and if that tape has been positioned to the load point (LP), the LOAD POINT indicator on the off-line tester control panel will also light at this time.

m. Pressing the LOCAL button on the transport control panel will cause the off-line tester TUR indicator (and the LOAD POINT indicator when applicable) to go out.

n. Refer to paragraph 5.2.2.3 of the Datamec manual and check pinch roller actuator adjustment and tape path linearity. If necessary, perform these adjustments according to steps 1 through 10 of paragraph 5.2.2.3 of the Datamec manual.

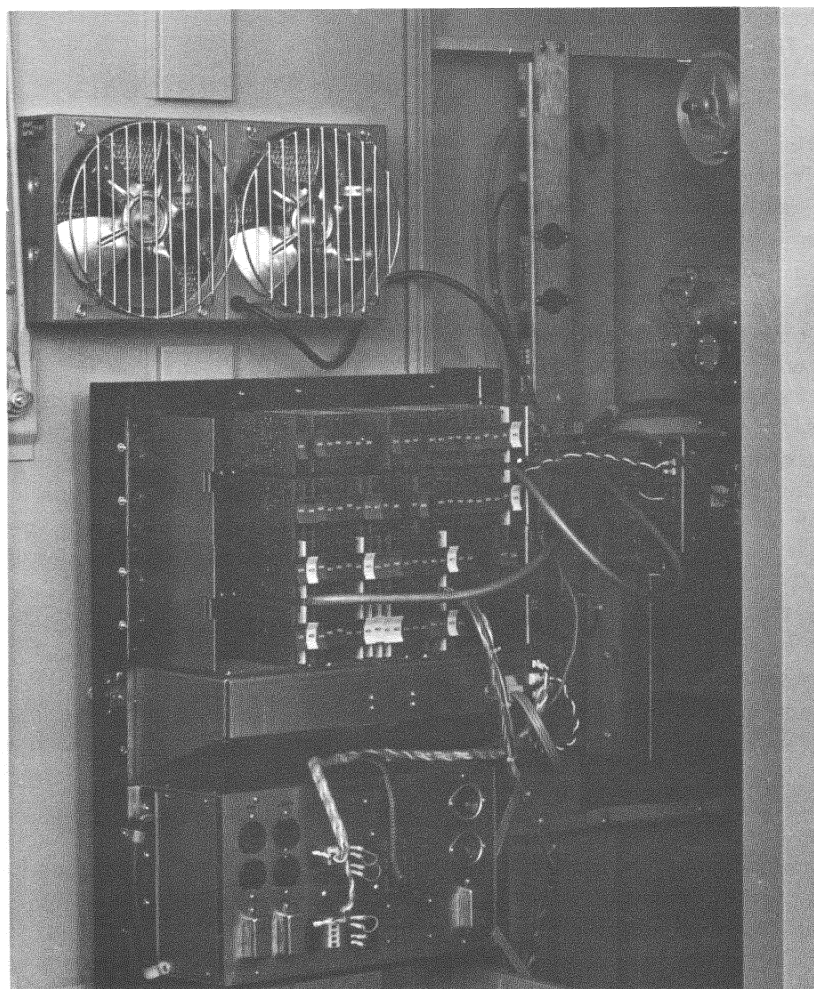


Figure 5-3 Modules on Mounting Panel

### 5.3 CONTROL PANEL CHECKOUT

The procedures described below define correct TU30 control panel operation. Such definition is imperative to post-installation checkout and troubleshooting activity. The following instructions provide a precise definition of TU30 control panel operation and are based on the TU30 Off-Line Tester being connected to the TU30 as delineated in Section 5.2, step g.

- a. Install a "scratch" tape on the transport according to the procedures outlined in paragraph 3.2.1 of the Datamec manual, and advance the tape to the LP marker by pressing the LOAD POINT button.
- b. Press the FORWARD button. This action will cause the FORWARD indicator to light, and the tape to move forward and stop at the tape End Point (EP) marker. When the EP is reached, and the tape stops, the panel EOT (end of tape) indicator will light and the FORWARD indicator light will go out.

#### NOTE

During forward motion of the tape, all transport control panel pushbuttons will be disabled with the exception of the LOCAL and AUTO buttons. Pushing either of these buttons will stop tape motion.

- c. With the tape positioned at the EP, adjust the on-marker voltage, according to steps 5 and 6 of paragraph 5.3.2 of the Datamec manual.
- d. With the tape still positioned at the EP, press the transport AUTO button. This action will cause the EOT indicator on the off-line tester to light.
- e. Press the transport LOCAL button, then the REVERSE button. This action will cause the REVERSE indicator light to on and the tape to move in reverse at standard speed and stop at the tape BOT marker. At that point the REVERSE indicator light will go out and the LOAD POINT indicator will light.
- f. With the transport control panel still in LOCAL, press the FORWARD button to place the tape at EOT.
- g. Press the REWIND button. This action will cause the REWIND indicator to light and the reels to move in reverse at standard speed, pulling the tape out of the vacuum wells. When out of the wells, the tape will rewind at high speed until the LP is near. The tape speed then slows down to standard, the tape is pulled back into the vacuum wells and

stops at the LP. The transport control panel LOAD POINT indicator will light and the REWIND indicator will go out.

- h. While the tape is rewinding, press the FORWARD and REVERSE buttons. Both buttons should be disabled.
- i. Press the LOCAL button. This action will halt the rewind operation.
- j. Press the REWIND button to start the operation again. This time, press the AUTO button; the tape should continue rewinding until the LP is reached and the LOAD POINT indicator lights. At this point the LOAD POINT indicator on the off-line tester panel should be lit.

### 5.4 DELAY ADJUSTMENTS

The delay adjustments described herein are critical to peak efficiency of the transport and are normally subject to periodic checks with the prescribed diagnostic (see Table 5-3). When adjusting any of the delays described in this chapter, it is important that the pertinent procedure be followed precisely in the manner delineated.

#### 5.4.1 Rewind Delay

The purpose of the .2- $\mu$ s rewind delay is to provide a negative-going level with a period long enough to insure receipt by the Datamec rewind logic. The detailed procedures for performing this adjustment are presented below.

- a. If tape has been loaded on the transport, make sure that the tape is not positioned at the LP.
- b. Place CM EN UNLOAD at ground level by connecting a jumper wire from pin H of B135 at B17 to ground.
- c. Place one end of a ground jumper at pin N of R302 at A08.
- d. Place the oscilloscope probe on pin V of R302 at A08.
- e. Momentarily touch the jumper designated in step c to ground and note the length of the resulting pulse on the oscilloscope.

f. If the negative-going delay pulse is greater or less than 20 $\mu$ s, adjust the related potentiometer on R302 at A08 and recheck the delay pulse length.

g. Repeat steps e and f until the delay is 20 $\mu$ s.

#### 5.4.2 Unload Delay

The unload delay is a negative-going 20 $\mu$ s pulse which triggers the Datamec rewind logic to perform a rewind and unload operation. The 20 $\mu$ s period insures receipt by the Datamec logic. The detailed procedures for performing this adjustment are listed below:

- a. Place the oscilloscope probe on pin M of R302 at A21.
- b. Connect one end of a jumper to pin E of R302 at A21.
- c. Momentarily touch the jumper designated by step b to ground and note the length of the resulting pulse on the oscilloscope.
- d. If the negative-going delay pulse is greater or less than 20  $\mu$ s, adjust the related potentiometer on R302 at A21 and recheck the delay pulse length.
- e. Repeat steps c and d until the delay is 20 $\mu$ s.

#### 5.4.3 Search Forward Delay

This 4s delay initiates forward tape movement for the purpose of an LP search. At the end of 4s, if the LP is not located, forward tape motion stops. The de-

tailed procedures for performing this adjustment are listed below.

- a. Place the oscilloscope probe on pin D of R303 at A11.
- b. Connect one end of a jumper wire to pin T of R303 at A11.
- c. Momentarily touch the jumper designated in step b to ground and note the length of the resulting pulse on the oscilloscope.
- d. If the negative-going delay pulse is greater or less than 4s, adjust the potentiometer on R303 at A11 and recheck the delay pulse length.
- e. Repeat steps c and d until the search forward delay is 4s.

#### 5.4.4 Fake Load-Point Delay

A fake load-point delay pulse is generated only after the search forward delay is over and no LP found. This 100-ms delay simulates the sensing of an actual LP marker and initiates the normal reverse tape motion to correctly position the marker after location. However, in this case, the LP marker is not present and reverse tape motion continues until the real LP marker is located. The detailed procedures for performing this adjustment are listed below.

- a. Place the oscilloscope probe on pin V of R302 at A15.
- b. Connect one end of a jumper wire to pin T of R303 at A11.

Table 5-3  
Summary of TU30/PDP-10 Diagnostics

Name	Number	Function
Transport Timing Test	MAINDEC-10-D4GB	Check transport timing and length of all logic delays
TM10A Magnetic Tape Control Test	MAINDEC-10-D4AB	Checks all status and control channels concerned with tape motion.
TM10A Magnetic Tape Control Test	MAINDEC-10-D4BB	Checks all status and control channels concerned with data transfer.
Magnetic Tape Reliability Test	MAINDEC-10-D4HA	A comprehensive test which exercises nearly all aspects of TU30 operation.

c. Momentarily touch the jumper wire designated in step b to ground producing the 4s search-forward delay.

d. At the end of the 4s delay pulse, a negative-going pulse will appear at pin V of R302 at A15.

e. If the length of the pulse at pin V of R302 at A15 is greater or less than 100 ms, adjust the associated potentiometer and recheck the delay pulse length.

f. Repeat steps c, d, and e until the fake load-point delay is 100 ms.

j. Place the oscilloscope probe on pin M of R302 at D19.

k. If the pulse at pin M is greater or less than 12  $\mu$ s, adjust the related potentiometer on R302 at D19 and recheck until the delay pulse length is exactly 12  $\mu$ s.

l. Turn the off-line tester DENSITY switch to 800.

m. Place the oscilloscope probe on pin V of R302 at D19.

n. If the pulse at pin V is greater or less than 8  $\mu$ s, adjust the related potentiometer on R302 at D19 and recheck until the delay pulse length is 8  $\mu$ s.

#### 5.4.5 Read Skew Over Delay

Normal tape skew conditions require a prescribed delay to allow reading of the bits constituting a data word. The purpose of the read skew over delay is to establish the time period during which a given word must be read. In addition, the length of this delay depends on the density at which data is being read. Since the TU30 Magnetic Tape Transport will record and read at three densities (200, 556, and 800 bpi), three separate read skew over delays are required. The detailed procedures for performing these adjustments are listed below.

a. Connect the off-line tester to the TU30 Magnetic Tape Transport according to step g of Section 5.2.

b. Turn transport power ON and press control panel AUTO button.

c. Turn the off-line tester DENSITY switch to 200.

d. Adjust TB-RECORD DATA pulses (C03, pin D) to 64  $\mu$ s intervals by turning the RECORD DATA dial on the off-line tester to 64.

e. Place the WRT and FWD switches on the off-line tester in the UP position.

f. Place CHANNEL SELECT switch A/3 on the off-line tester in the UP position.

g. Place the oscilloscope probe on pin V of R302 at D20.

h. If the pulse at pin V is greater or less than 32  $\mu$ s, adjust the related potentiometer on R302 at D20 and recheck until the delay pulse length is exactly 32  $\mu$ s.

i. Turn the off-line tester DENSITY switch to 556.

#### 5.5 READ/WRITE SKEW ADJUSTMENTS

Read skew is defined as the difference in time between a data pulse reproduced from one channel of a given tape and a data pulse reproduced from another channel of the same tape. Write skew, in turn, is defined as the positional difference between the first bit recorded of a given character and the last bit recorded of the same character. Although skew is both static and dynamic, only static skew is adjustable. Static skew is the consequence of slight positional differences between the side-by-side recording elements and side-by-side reading elements comprising the read/write heads and any angular displacement inherent in the tape path. The adjustment procedures described serve to compensate for these positional differences to the extent that skew will not be a limiting factor in any tape exchange between various TU30 Magnetic Tape Transports.

##### 5.5.1 Read Skew

The read skew adjustment serves to minimize azimuth and angular read head scatter. This adjustment involves determining the required delay for each read channel as compared to a reference, and adjusting each related delay circuit for the required time. These adjustments are detailed in the following procedure:

a. Connect the off-line tester to the TU30 Magnetic Tape Transport according to step g of Section 5.2.

b. Load a Master Skew Tape on the transport according to the tape loading procedure outlined in paragraph 3.2.1 of the Datamec manual, and position this tape at the LP.

### NOTE

Master Skew Tapes are recorded at a density of 800 bpi.

- c. Remove the write head cable connector (W025 at A01) from the DEC Logic Package.

### CAUTION

Failure to remove the write head cable connector can result in damage to the Master Skew Tape.

- d. Place all off-line tester switches in the down position.
- e. Press the AUTO button on the transport control panel.
- f. Connect a 1:1 oscilloscope probe to pin S of the G084 Read Amplifier at A22.
- g. Place FWD switch on off-line tester panel in up position and press SET button. At this point the transport should be reading the Master Skew Tape.
- h. Adjust the potentiometer on G084 at A22 so that the output at pin S is +1.8V. *BULL*
- i. At the same time, check the read amplifier output waveform for regularity. Replace the module if the output waveform is not symmetrical and square.
- j. Repeat steps f, h, and i for adjustment of G084 Read Amplifiers at B23, A24, B22, B24, C22, C24, ~~D22~~, and ~~D24~~.

### CAUTION

When the Master Skew Tape reaches EOT during any of the adjustment procedures described herein, do not rewind. Instead, place the REV switch on the off-line tester panel in the up position to move the tape in reverse to the LP. This is necessary because a high speed rewind will damage the Master Skew Tape.

- k. Connect the A-probe of a dual trace oscilloscope to pin ~~F~~ *D* of ~~R603~~ *R601* at C21. The resulting signal is the

logical OR of all data pulses from the Master Skew Tape.

- l. Synchronize the oscilloscope on the positive-going edge of the signal. This edge is the first or leading data signal and is used in the adjustment as the reference.
- m. Connect the oscilloscope B-probe to pin V of the G084 Read Amplifier at A22, and compare the positive-going edge of this signal to the reference. The average time displacement must not exceed 3  $\mu$ s.
- n. Repeat step m for G084 at B23, A24, B22, B24, C22, C24, ~~D22~~ and ~~D24~~.

### NOTE

If any signal does exceed 3  $\mu$ s, check pinch roller adjustment and tape path linearity according to the procedures outlined in paragraph 5.2.2.3 of the Datamec manual. If these adjustments are within specification, then an incorrect manufactured read/write head is indicated. *BULL*

- o. Connect B-probe to pin M of R302 at A20 and adjust the associated potentiometer for a 1  $\mu$ s negative-going delay pulse length.
- p. Repeat step o for R302 at A20, pin V; R302 at B20, pins M and V; R302 at C20, pins M and V; R302 at D20, pin M and R302 at D21, pins M and V.
- q. While performing step p, take note of the specific read delay with an output signal having the greatest time displacement from the reference. Connect the oscilloscope A-probe to the output of this delay (pin M or V) to establish a reference signal for read skew adjustment.
- r. Place the oscilloscope in the add algebraically mode.
- s. Connect the oscilloscope B-probe to the output pin (M or V) of any read delay other than the reference.
- t. Adjust the potentiometer associated with the specific read delay so that the average trailing edge coincides with the trailing edge of the reference signal.
- u. Repeat steps s and t for all read delays other than the one used for a reference.

### 5.5.2 Write Skew

The purpose of the write skew adjustment is to minimize any inherent azimuth or angular write head scatter. In this adjustment, write delays are calibrated on a channel by channel basis against a reference which is the logical OR of all data written. In all cases the write skew must be done after adjustment of read skew. The steps for performing this adjustment are listed below.

- a. Remove Master Skew Tape and replace with a "scratch" tape.
- b. Place all CHANNEL SELECT switches on off-line tester panel in UP position. This action provides for recording all 1s on the "scratch" tape. All other switches should be down.
- c. Press AUTO button on transport control panel.
- d. Place FWD and WRT switch on the off-line tester panel in the UP position and press SET. At this point the transport should be recording on the "scratch" tape.
- e. Turn the DENSITY switch to the 800 bpi position.
- f. Connect the oscilloscope A-probe to pin V or Read Amplifier G084 at A24.
- g. Adjust the RECORD DATA dial on the off-line tester panel so that the leading-edge-to-leading-edge period of the output pulse equals  $16.6 \mu\text{s}$ .
- h. Place the oscilloscope A-probe on the logical OR reference C21, ~~pin F~~<sub>pin D</sub>.
- i. Place the oscilloscope in the alternate mode.
- j. Connect the oscilloscope B-probe to pin M of Read Delay R302 at A20.
- k. Determine the time displacement between the B-probe signal and the reference signal.
- l. Repeat step j for each read delay and determine which read channel demonstrates the greatest time displacement from the reference.

m. Connect the oscilloscope A-probe to the output pin (M or V) of the specific read delay determined by step k.

n. Place the oscilloscope in the add algebraically mode.

p. Connect the oscilloscope B-probe to the output pin (M or V) of any read delay other than the one determined as a reference by step k.

q. Adjust the potentiometer on the corresponding write delay so that the average trailing edge of the signal on the B-probe coincides with the reference signal.

### CAUTION

Any adjustment of read skew delay during this procedure will completely invalidate previous read de-skew adjustments.

r. Repeat steps n and p until the write delay for each channel, with the exception of the reference channel, has been adjusted to the reference.

s. At this point, if all skew adjustments have been made correctly and accurately, the transport can produce a reference skew tape for use in future periodic skew checks.

### 5.6 TROUBLESHOOTING PROCEDURE

The primary tools for troubleshooting the DEC Logic Package are the various MAINDEC diagnostic programs which are designed specifically to exercise transport logic in a manner conducive to fault isolation. In all cases the specific diagnostic will designate the fault or error through whatever output media is being used.

In some error situations a fault which occurs during execution of a specific user routine cannot be isolated through use of a diagnostic. In these cases it is recommended that the user routine which originally exposed the error be used to repeat the error. Then by studying the error in respect to the specific logic function or functions and using an oscilloscope to signal trace the logic path involved, the fault can be isolated to a specific module.

In all cases, when a TU30 Magnetic Tape Transport is not performing in a normal manner, the condition of the reel of magnetic tape mounted on the transport should be inspected for the following abnormalities:

- a. Wrinkles or fold marks
- b. Pin holes
- c. Tears or rips
- d. Stretching

Also, prior to initiating any lengthy troubleshooting procedure, the transport read/write/erase head should be cleaned using the Head Cleaning Kit furnished with the transport.

### 5.6.1 TU30 Diagnostics

Diagnostic routines for use with the TU30 Magnetic Tape Transport fall into three main program groups; timing routines, MTC checkout routines, and magnetic tape reliability test routines. These programs are summarized in Table 5-3 by name, number and function.

Descriptions of the purpose and function of each program group and definitions of the type of transport malfunction each program group is designed to isolate follow.

**5.6.1.1 Transport Timing Test Program** - This program is designated as MAINDEC-10-D4GB, and is designed to give definitive indication of machine timing efficiency. Through its various routines, this program provides a record of the length of the various transport logic delays, the state of punch roller adjustments and the mechanical condition of the tape handling mechanism. This diagnostic is particularly useful in determining that transport start and stop times, which are a function of pinch roller response, are within tolerance. The procedure for start and stop time adjustment are described in detail in Section 5, paragraph 5.2.2.3 of the Datamec manual.

Conducting monthly runs of this program will provide a user with a cumulative record of transport timing. Comparison of the results of a current program run with records of previous runs will serve to flag possible ad-

justment deterioration. Program output is a listing of the measure of logic and mechanical adjustments. The form of this listing depends on the particular output media being used.

**5.6.1.2 MTC Diagnostic Programs** - MTC diagnostics are designed primarily to exercise the TM10 Magnetic Tape Control. However, in this process these programs can provide valuable TU30 troubleshooting data. In this group there are two basic programs; MAINDEC-10-D4AB and MAINDEC-10-D4BB. A description of each of these programs follows.

**5.6.1.2.1 MAINDEC-10-D4AB** - The purpose of this diagnostic is to verify that the TM10/TU30 status and control channels concerned with transport selection and movement of tape are operating properly. After the diagnostic completes an operating cycle, any malfunctioning status or control channel is designated by name in the error listing produced. If the pertinent transport cannot be selected, the program will designate this condition.

**5.6.1.2.2 MAINDEC-10-D4BB** - This diagnostic is designed to verify that the TM10/TU30 status and control channels concerned with information transfer as well as the actual data channels are operating properly. The program transfers predictable data at all recording densities and verifies that the data is correctly recorded and read off.

The program designates information transfer errors by listing the octal equivalent of the character in error, along with the correct octal form of the character in question.

**5.6.1.3 Magnetic Tape Reliability Test** - This diagnostic, identified as MAINDEC-10-D4HA, is the most powerful of all the diagnostics discussed in this chapter. In addition to providing error indication at the individual transport level, this program will verify inter-compatibility of a specific TU30 transport in a given PDP-10 system and with the PDP-10 Central Processor itself.

## NOTE

The following procedure defines the method for verifying IBM compatibility:

- a. Record a tape on the transport in question using the diagnostic MAINDEC-10-D4HA.
- b. Copy the tape just recorded using another IBM compatible transport.
- c. Verify the tape just copied by reading it using the transport in question.

This procedure can be expanded to include any number of IBM compatible transports.

At the individual transport level, the program will record and read at random densities, with random data patterns and at random record lengths. All errors detected under this type of testing are listed as octal characters in both correct and error form. The diagnostic also verifies the correspondence of the position of characters in a record with the originating memory address. The program designates addressing discrepancies.

This diagnostic program is designed to be executed under control of the Dynamic Debugging Test program (DDT). Running under DDT control allows isolated execution of the specific routine within DDT which located the failure. In this manner, the failure condition can be caused repetitively so that any troubleshooting can be done under the specific conditions of failure. Further, with this technique of isolated execution of a specific routine, any character which previously was randomly recorded and in the process was designated as in error, can be repetitively recorded in the same character position in which the original error occurred. In all cases where required, specific errors, along with conditions causing the error, will be designated by the program.

### 5.6.2 Marginal Checking

The operation of the logic modules comprising the TU30 DEC Logic Package at voltages close to non-operating levels at both polarities provides a valuable method for locating those modules on the verge of failure. By performing periodic marginal checks, the bias voltage levels at which modules fail can be plot-

ted and analyzed for signs of progressive deterioration. On this basis, expected failure rates can be predicted and a program for planned module replacement can be established.

5.6.2.1 Marginal Checking Procedure - The following instructions outline the methods recommended for performing marginal checks on the TU30 DEC Logic Package. The marginal checking switches on the DEC Logic Package are shown in Figure 5-4.

- a. Load the diagnostic MAINDEC-10-D4HA, Magnetic Tape Reliability Test, in the PDP-10 Central Processor according to Sections 3.0 and 4.0 of the MAINDEC-10-D4HA write-up and the operation and programming procedures outlined in Chapter 3 of the KA10 Central Processor manual.
- b. Install a "scratch" tape on the TU30 transport according to the tape loading procedure delineated in Section 3, paragraph 3.2.1 of the Datamec manual.
- c. Place the proper transport address in the control panel ADDRESS SELECTOR switch, and press the AUTO button to put the transport under PDP-10 system control.
- d. Execute the diagnostic according to Section 4.0 and 5.0 of the MAINDEC-10-D4HA write up and Chapter 3 of the KA10 Central Processor manual.
- e. With reference to Figure 5-4, place the +10V margin switch (the upper toggle switch) on panel rack A in the ON position.
- f. With reference to Chapter 3, Operation and Programming, of the KA10 manual, operate the margin potentiometer on the KA10 Central Processor so the voltage excursion ranges from +2.5V to +17.5V.
- g. Take note of all errors listed by the diagnostic during the margin checks.
- h. Repeat steps e, f, and g separately for panel racks B, C, and D.
- i. Place the -15V margin switch (the lower toggle switch) on panel racks A in the ON position.
- j. Repeat step f but vary the voltage excursion range from -12V to -18V.



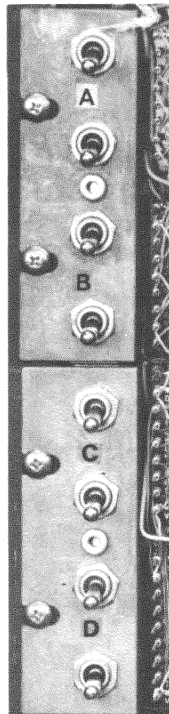


Figure 5-4 Marginal Check Switches on DEC Logic Package

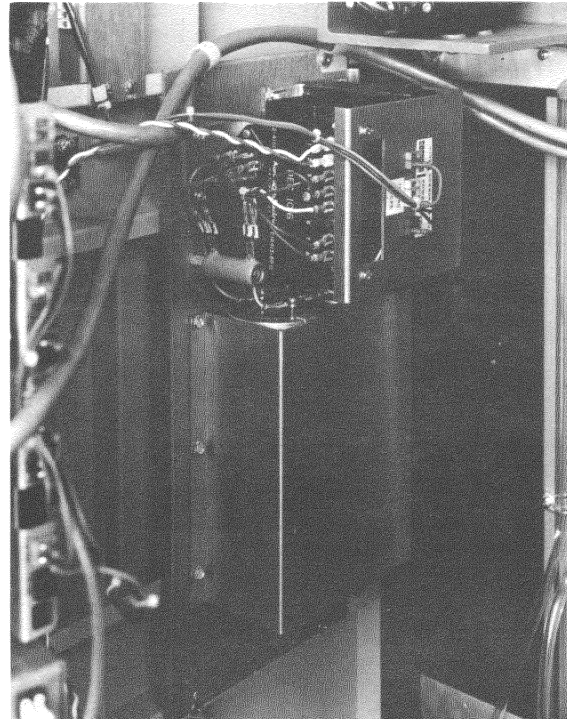


Figure 5-5 Type 728 Power Supply

#### CAUTION

To avoid damage to logic modules, do not vary negative margin voltage to a value more negative than  $-18V$ .

- k. Repeat step g for negative margin checks.
- l. Repeat steps i, j, and k for panel racks B, C, and D.

#### 5.7 POWER SUPPLY AND POWER CONTROL

The TU30 Magnetic Tape Transport uses one Type 728 or 728A Power Supply depending on line frequency (Figure 5-5) and one Type 844 Power Control (Figure 5-6). The 728 supply provides 60 Hz power and the 728A provides 50 Hz power. Various jumper options in the 728A supply allow the supply to be adjusted to various local line voltages. Noise filtering and protection against line surge conditions are provided by the Type 844 Power Control.

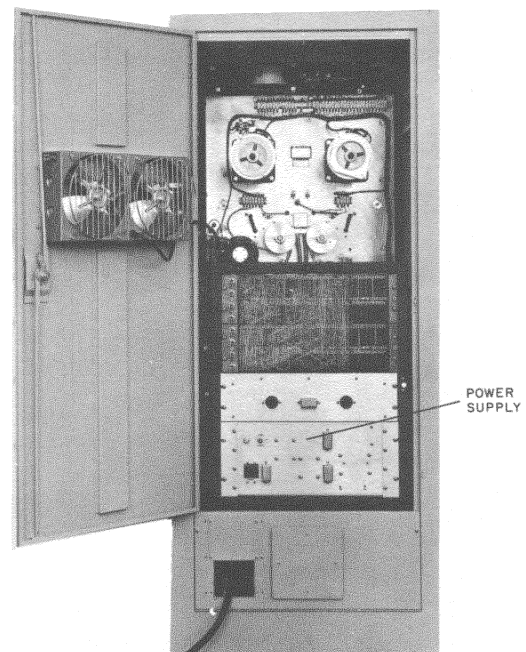


Figure 5-6 Type 844 Power Control

Operational details and specifications for the Type 728 and 728A Supplies are presented in the DIGITAL Logic Handbook (C105). Similar information for the Type 844 Power Control can be found in the PDP-10 Module Reference Manual.

### 5.7.1 Power Supply Checks

A multimeter of the type listed in Table 5-1 can be used to measure Type 728 and 728A Power Control out-

put voltage without disconnecting the supply from the transport. An oscilloscope of a type listed in Table 5-1 can be used to measure the peak-to-peak ripple of each dc output voltage. Acceptable ranges for output voltage and current and limits for output ripple are summarized in Table 5-4.

Since the Type 728 and 728A Power Supplies are not adjustable, any supply that does not meet the tolerances listed in Table 5-4 should be replaced.

Table 5-4  
Type 728 Power Supply Output Parameters

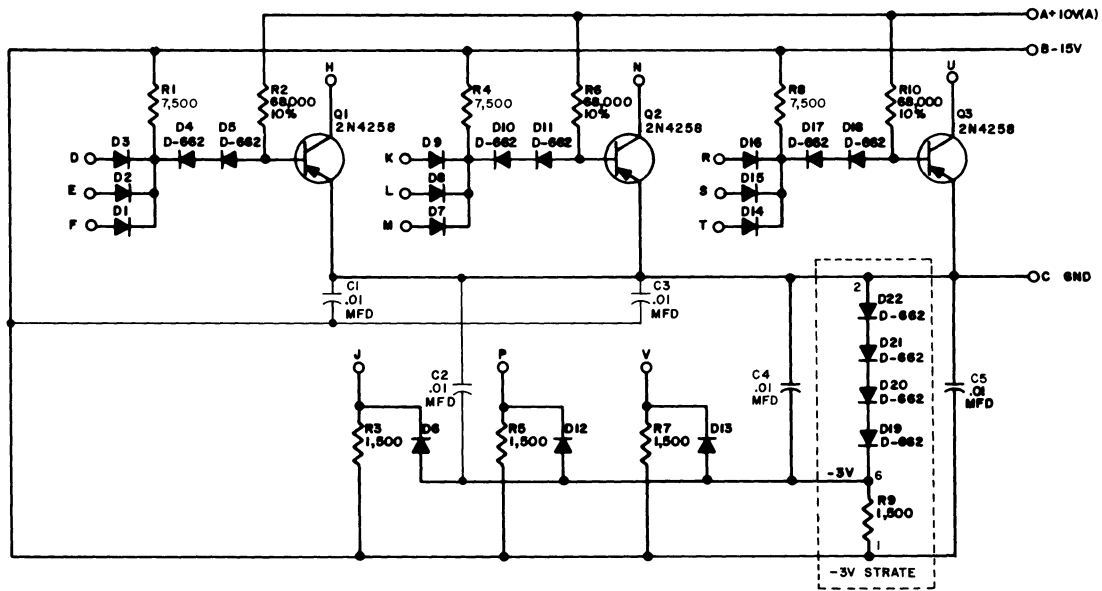
Power Supply Output Measurement Terminals	Nominal Output (Vdc)	Acceptable Output Range (Volts)	Maximum Output Current (Amps)	Maximum Peak-to-Peak Output Ripple (Volts)
Red (+) to Yellow (-)	+10	+9.5 to 11.5	7.5	0.7
Yellow (+) to Blue (-)	-15	-14.5 to 16.5	8.5	0.4

## CHAPTER 6

### CIRCUIT SCHEMATICS

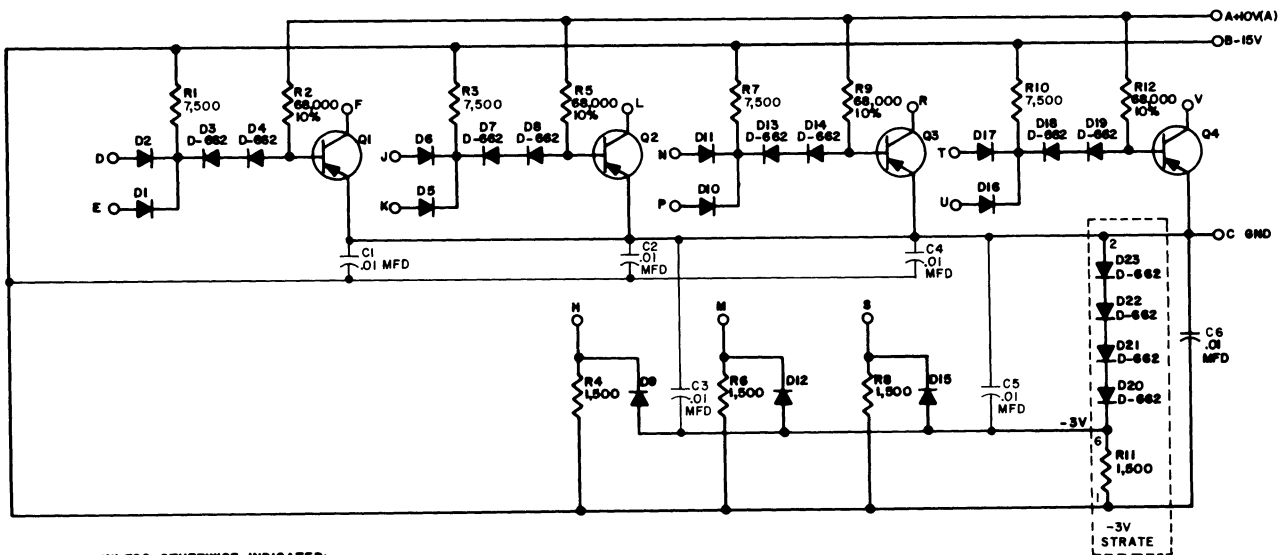
The following circuit schematics pertaining to the TU30 Systems appear in this chapter.

<u>Drawing No.</u>	<u>Title</u>	<u>Rev.</u>	<u>Drawing No.</u>	<u>Title</u>	<u>Rev.</u>
B-CS-B133-0-1	Diode Gate	B	B-CS-R603	Pulse Amplifier	C
B-CS-B135-0-1	Diode Gate	B	B-CS-R613-0-1	Pulse Amplifier	B
B-CS-B163-0-1	Diode Gate	D	B-CS-S107-0-1	Inverter	D
B-CS-B165-0-1	Diode Inverter	A	B-CS-S151-0-1	Binary to Octal Decoder	C
B-CS-G084-0-1	Magnetic Tape Read Amplifier	C	B-CS-S202-0-1	Dual Flip-Flop	D
B-CS-G287-0-1	Write Driver	B	B-CS-S203-0-1	Triple Flip-Flop	C
B-CS-R001	Diode Network	-	B-CS-S602-0-1	Pulse Amplifier	H
B-CS-R002-0-1	Diode Cluster	A	B-CS-W051-0-1	100 mA Indicator and Relay Driver	E
B-CS-R302-0-1	Delay R302	T	B-CS-W107-0-1	I/O Bus Receiver Circuit	A
B-CS-R303-0-1	Integrating One Shot	K	B-CS-W501-0-1	Schmitt Trigger	F
B-CS-R405-0-1	Crystal Clock	J	B-CS-W841-0-1	Cable Terminator	B



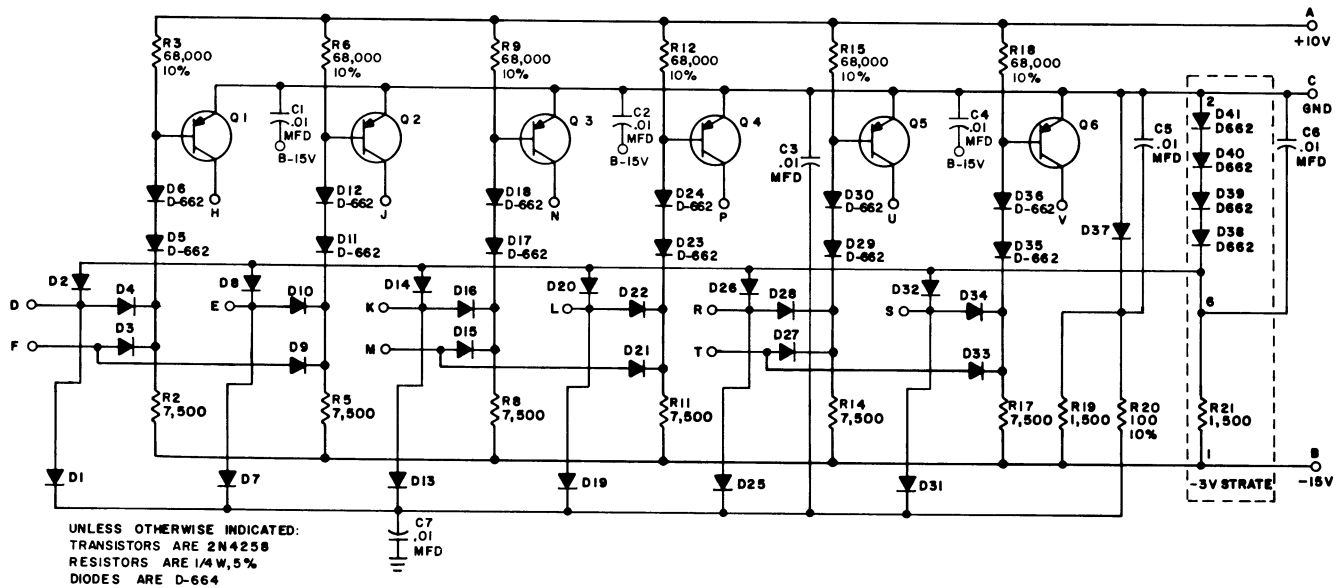
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 DIODES ARE D-664

B-CS-B133-0-1 Diode Gate B133

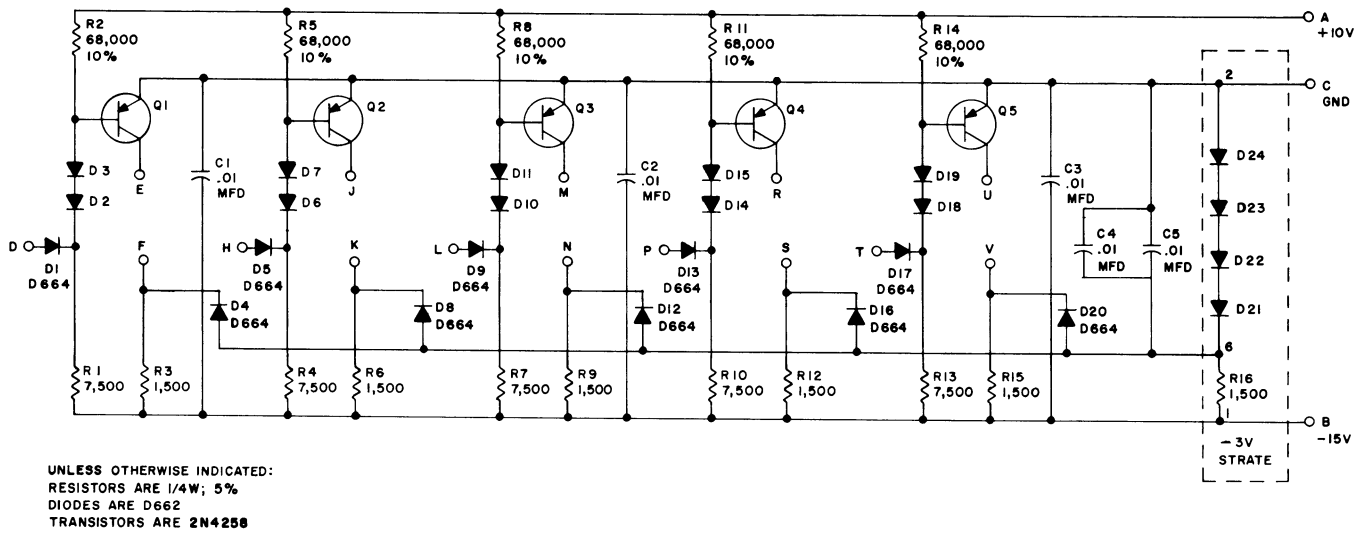


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 TRANSISTORS ARE 2N4258  
 DIODES ARE D-664

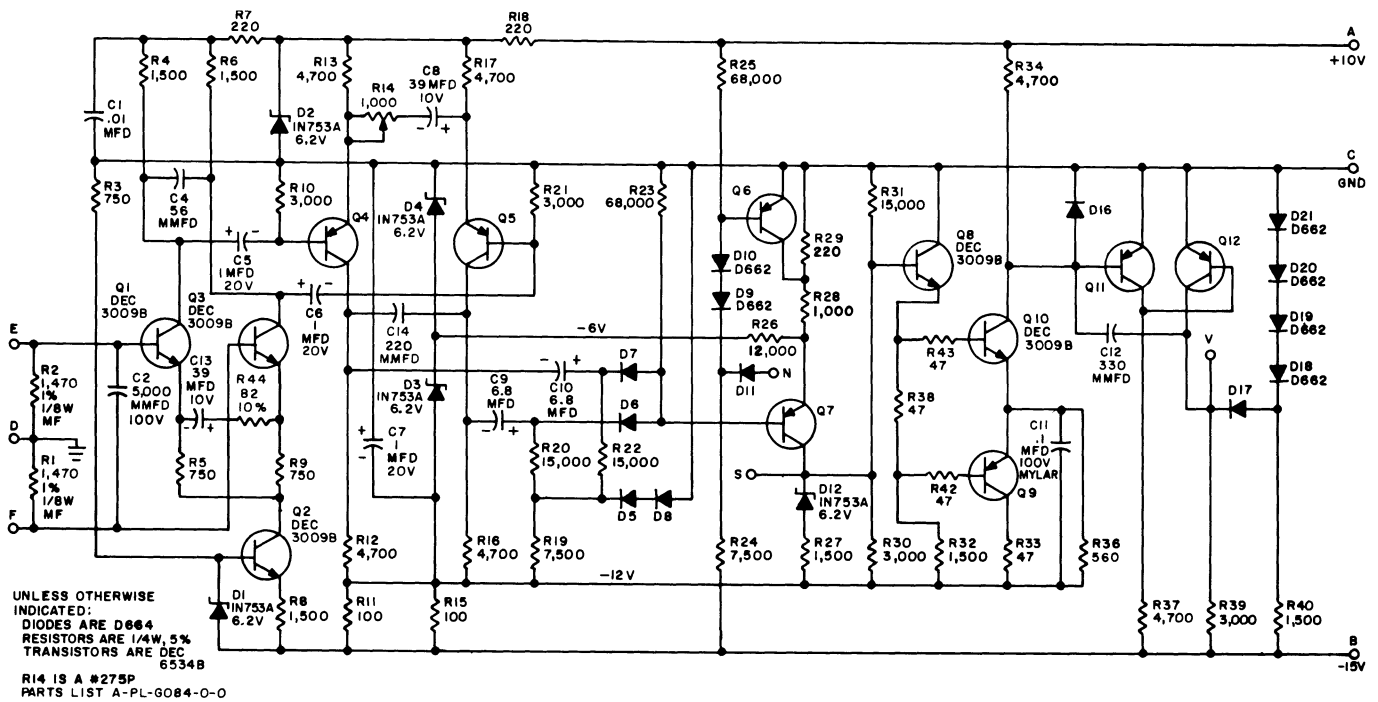
B-CS-B135-0-1 Diode Gate B135



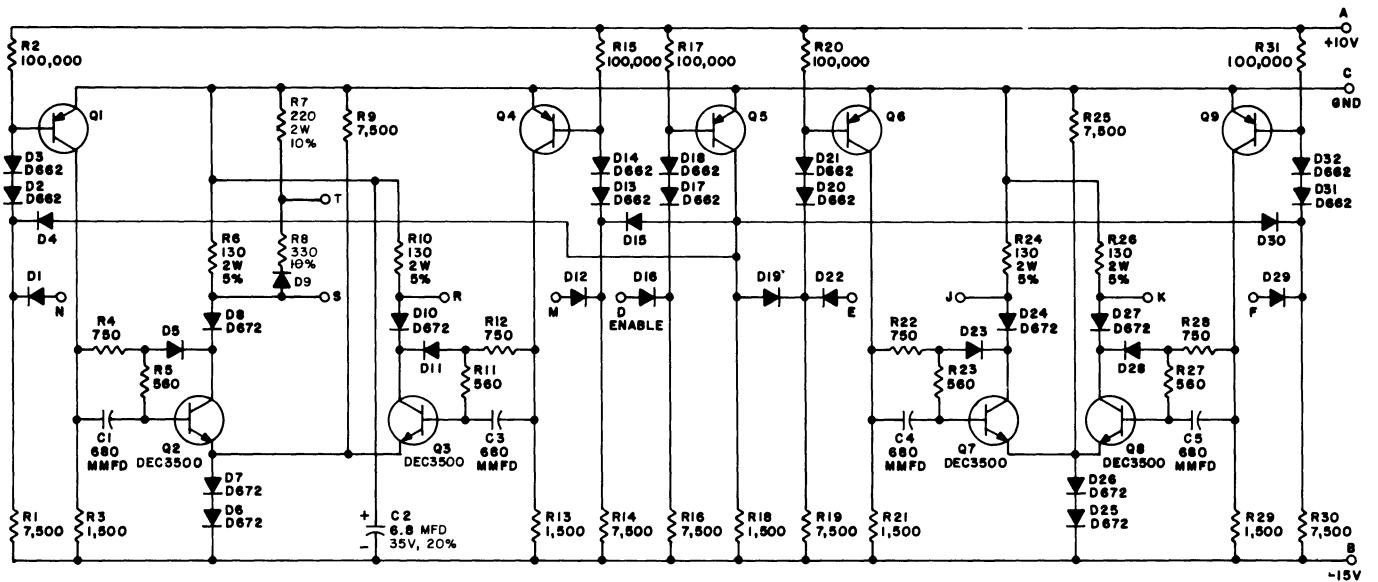
B-CS-B163-0-1 Diode Gate B163



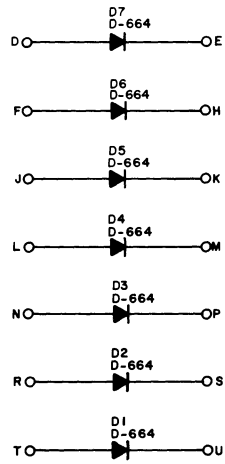
B-CS-B165-0-1 Diode Inverter B165



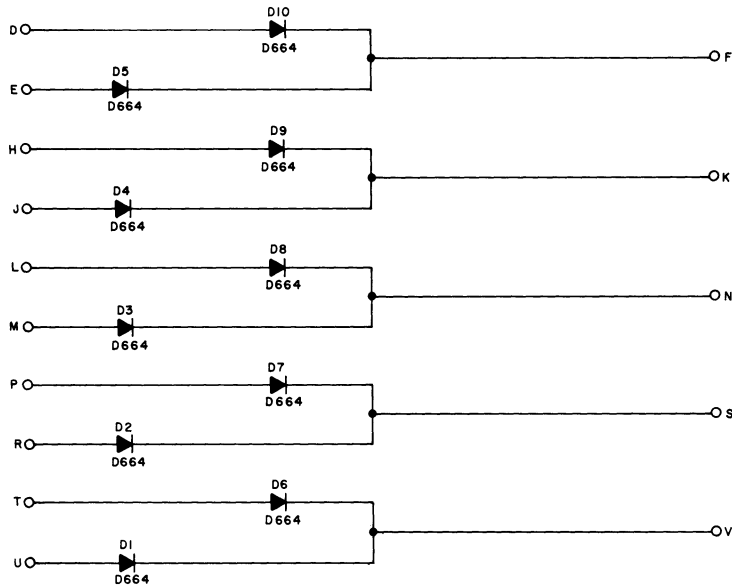
B-CS-G084-0-1 Magnetic Tape Read Amplifier G084



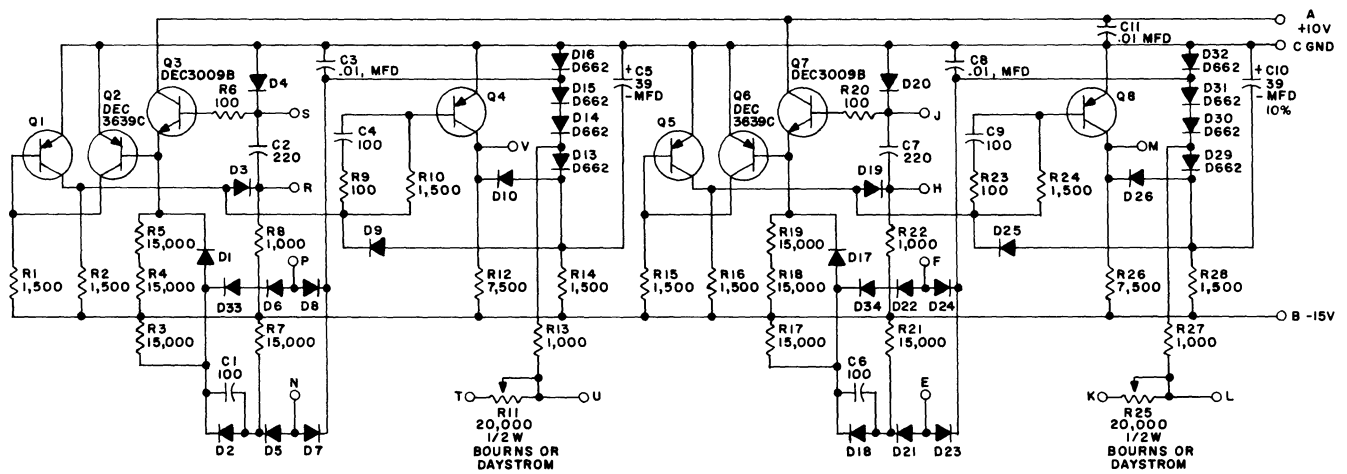
B-CS-G287-0-1 Write Driver G287



B-CS-R001 Diode Network R001

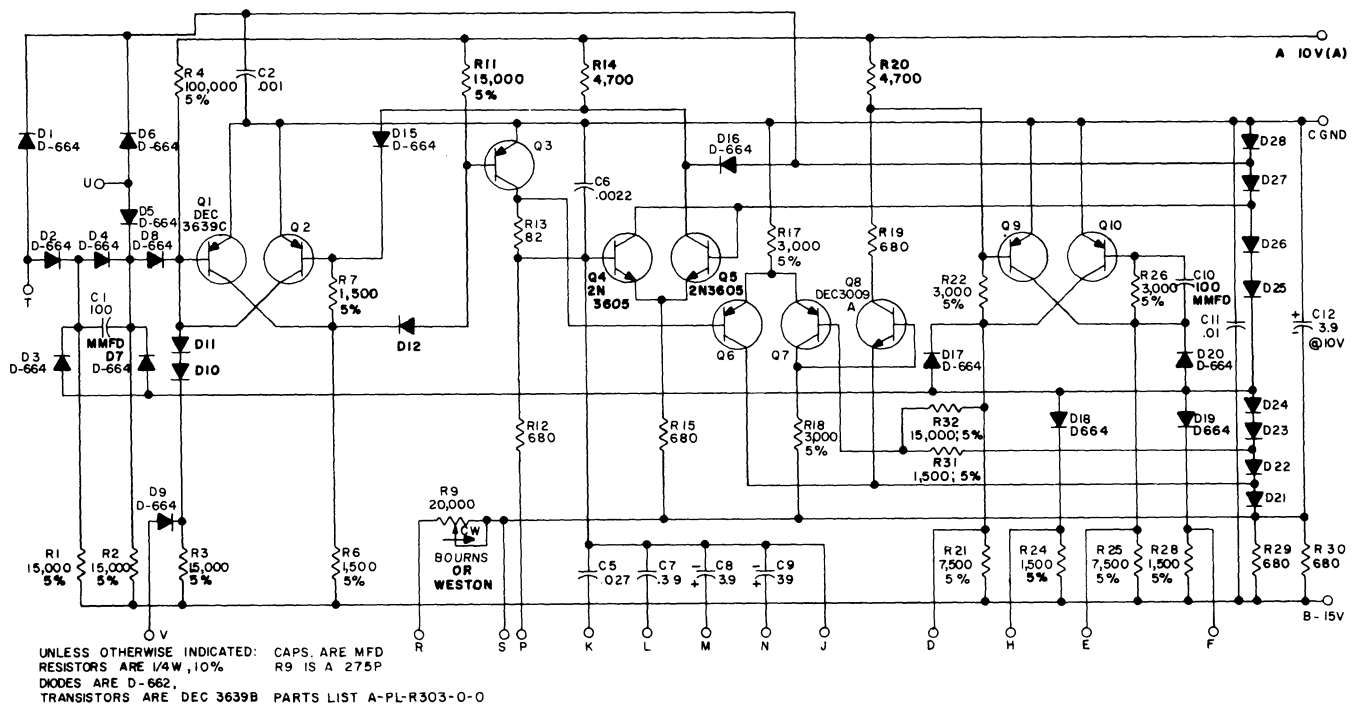


B-CS-R002-0-1 Diode Cluster R002



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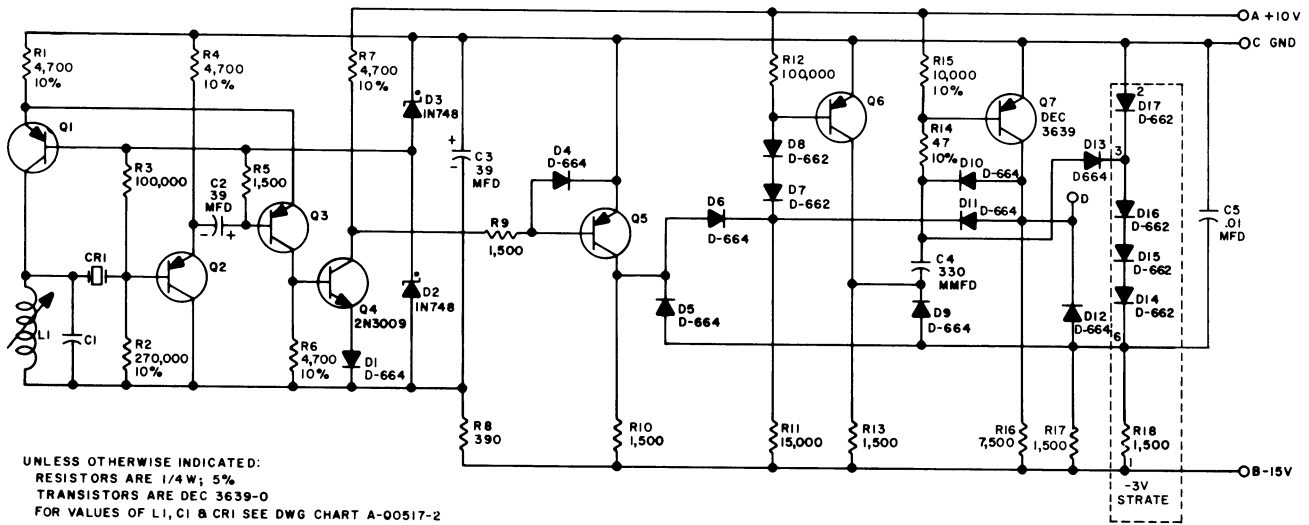
B-CS-R302-0-1 Delay R302



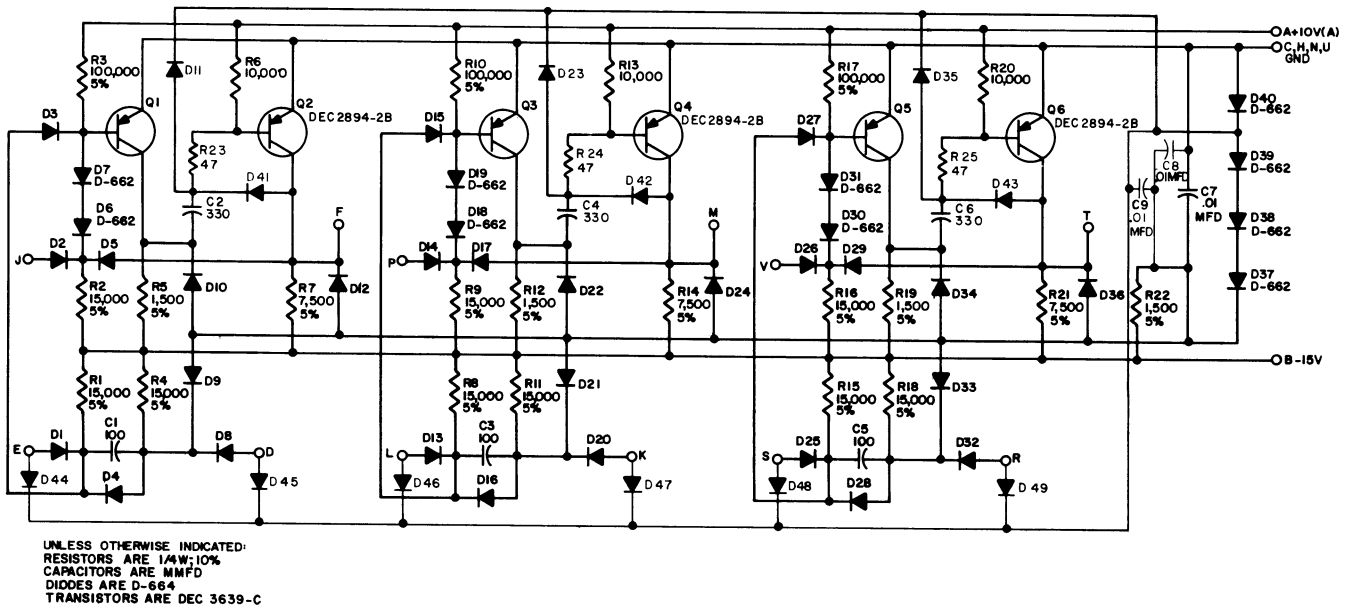
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B-CS-R303-0-1 Integrating One Shot R303

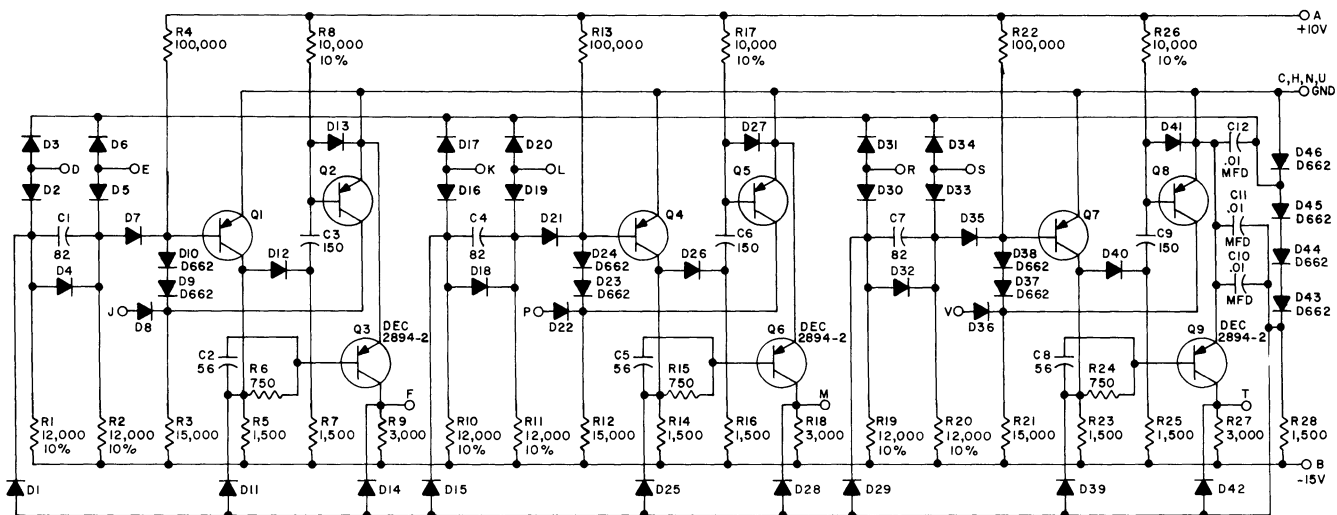




B-CS-R405-0-1 Crystal Clock R405

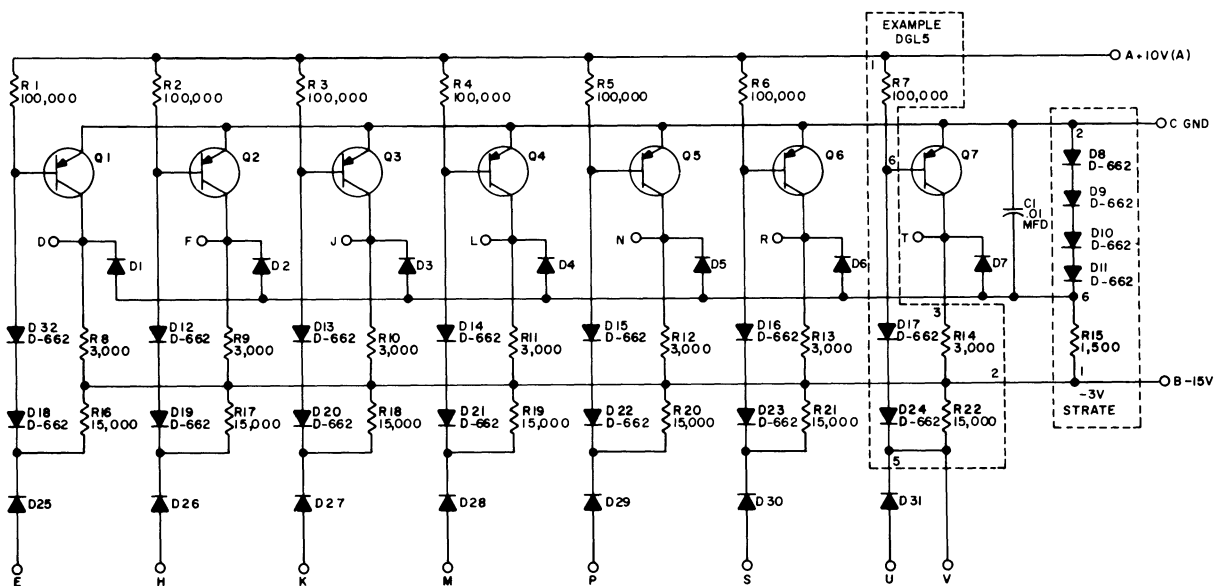


B-CS-R603 Pulse Amplifier R603



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 TRANSISTORS ARE DEC 3639-0

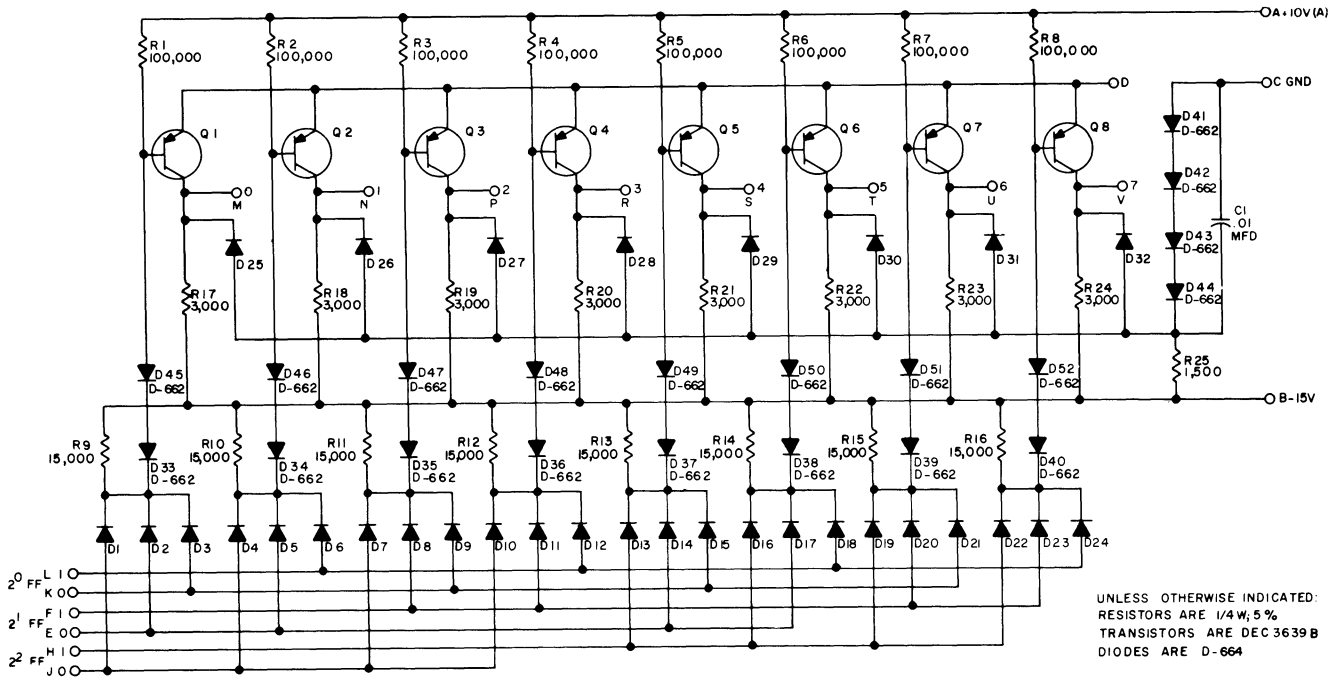
B-CS-R613-0-1 Pulse Amplifier R613



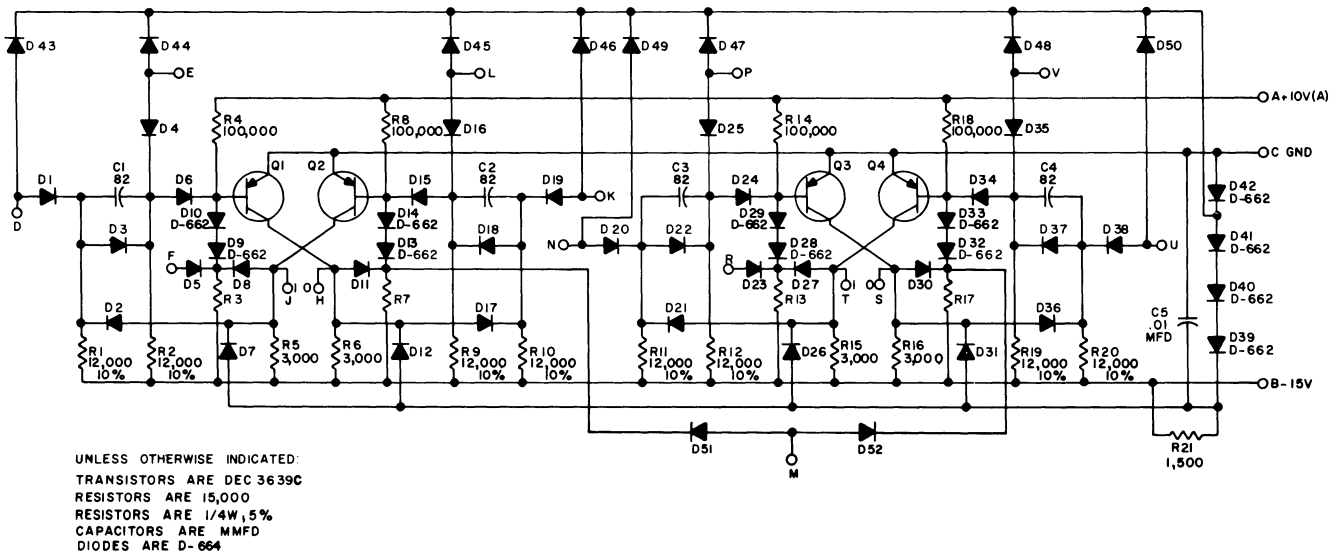
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 DGL BOARD IS SIA

PARTS LIST A-PL-S107-0-0

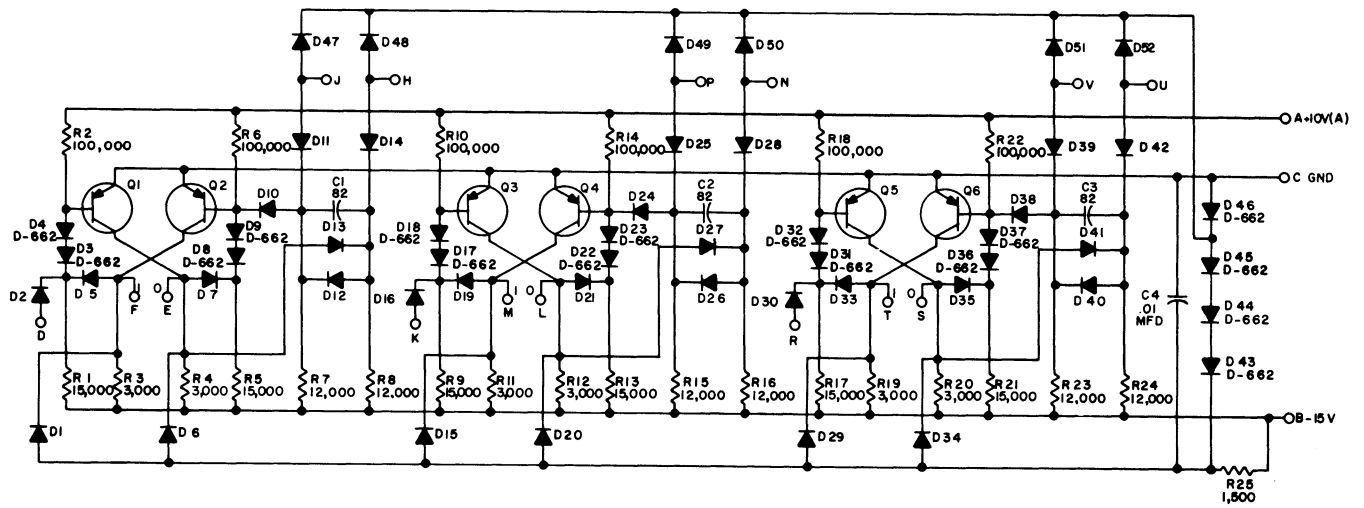
B-CS-S107-0-1 Inverter S107



B-CS-S151-0-1 Binary to Octal Decoder S151

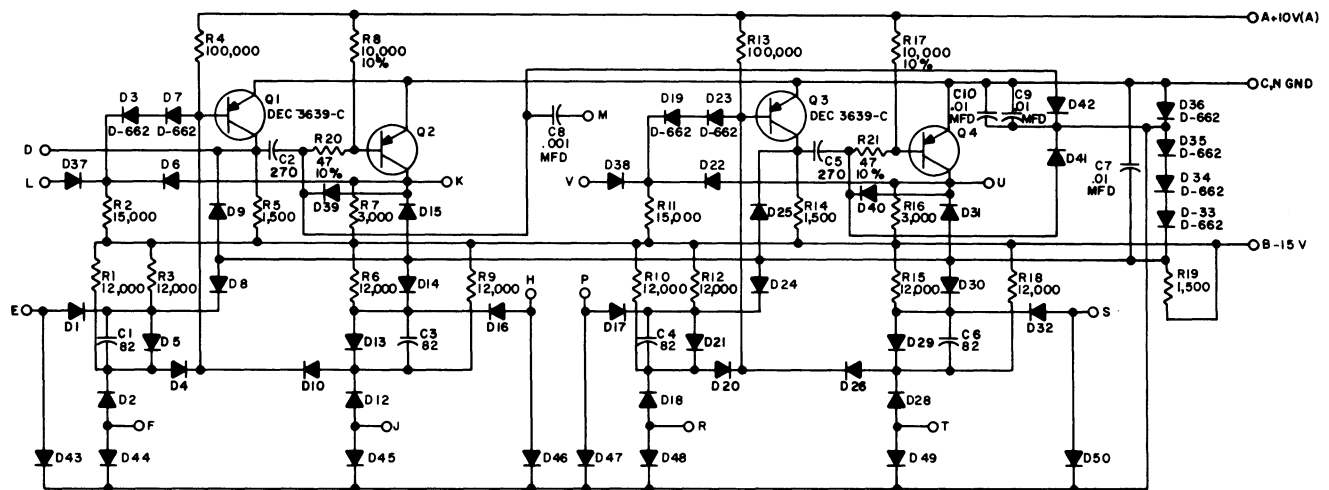


B-CS-S202-0-1 Dual Flip-Flop S202



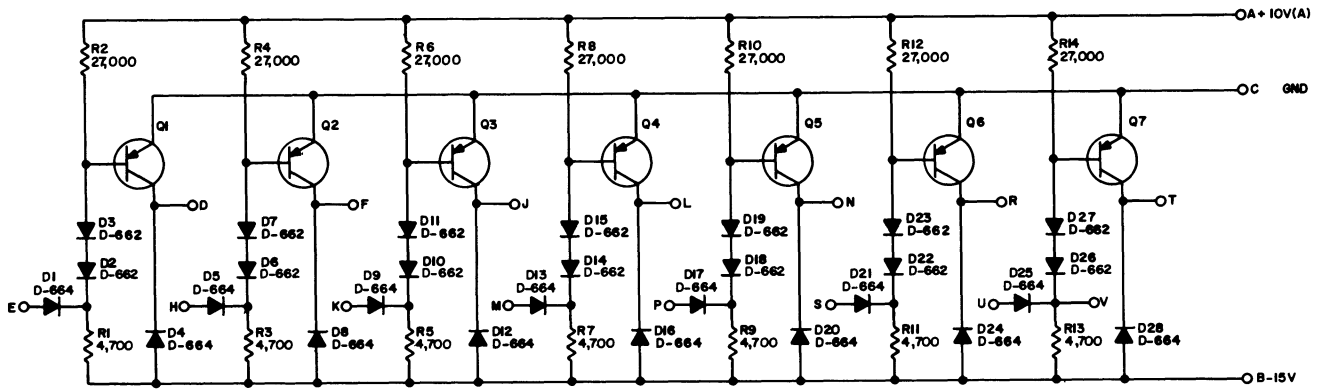
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 TRANSISTORS ARE DEC 3639C

B-CS-S203-0-1 Triple Flip-Flop S203



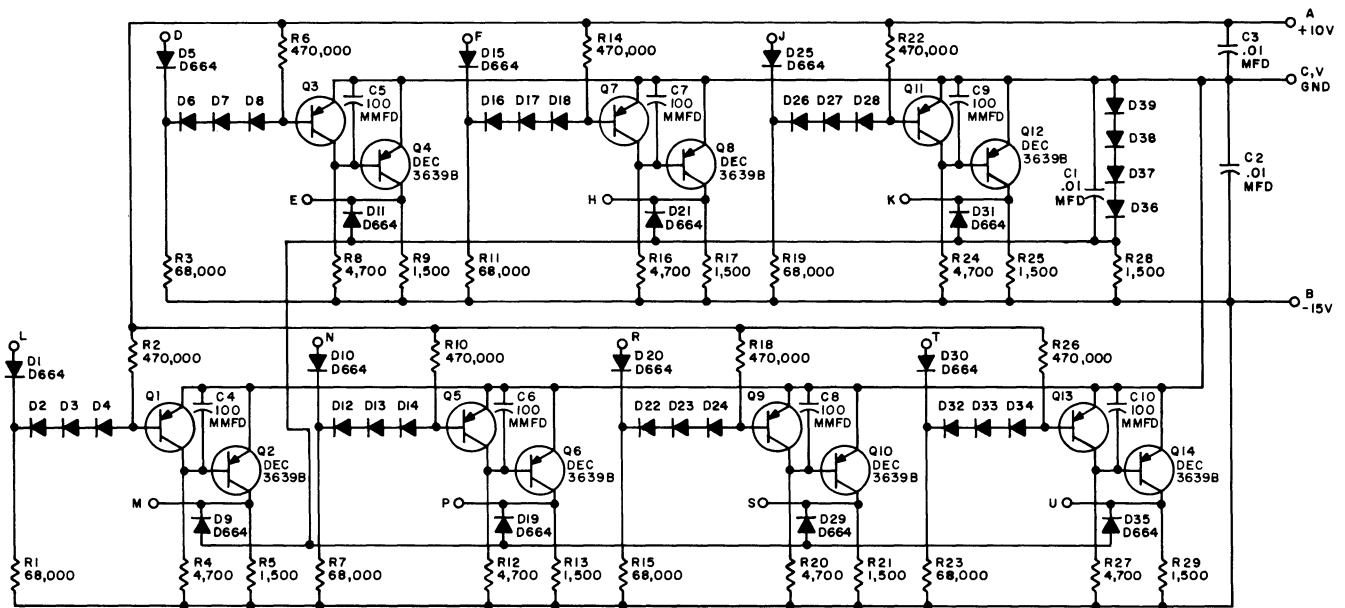
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B-CS-S602-0-1 Pulse Amplifier S602



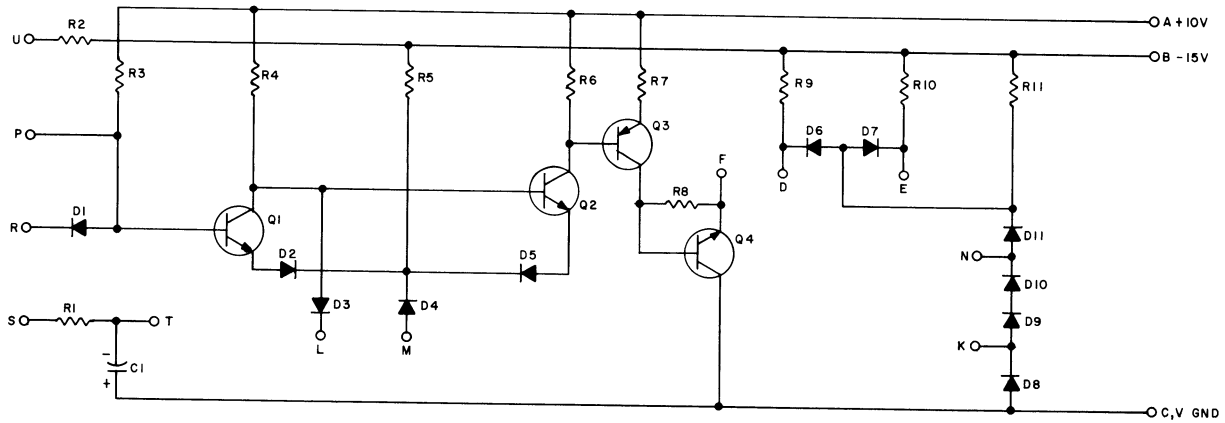
UNLESS OTHERWISE INDICATED:  
RESISTORS ARE 1/4W; 10%  
TRANSISTORS ARE DEC 6534B

B-CS-W051-0-1 100 mA Indicator and  
Relay Driver W051



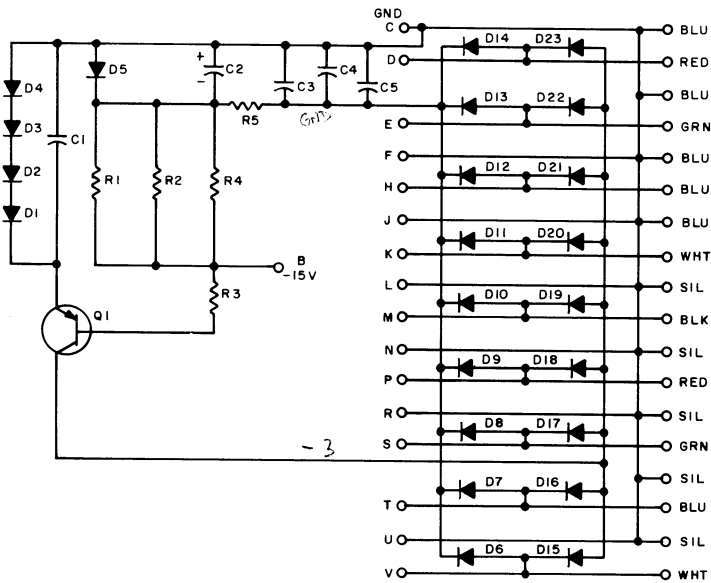
UNLESS OTHERWISE INDICATED:  
RESISTORS ARE 1/4W; 5%  
DIODES ARE D662  
TRANSISTORS ARE DEC3639C

B-CS-W107-0-1 I/O Bus Receiver Circuit



Q1, Q2, Q4	TRANSISTOR DEC3009B	1503100
Q3	TRANSISTOR DEC999	1501836
R6, R7, R8, R10, R11	RES. 1.5K 1/4W 5% CC	1300391
R3, R4, R9	RES. 7.5K 1/4W 5% CC	1301422
R2, R5	RES. 4.7K 1/4W 10% CC	1300448
R1	RES. 330 1/4W 10% CC	1300293
D8-D11	DIODE D662	1100113
D1-D7	DIODE D664	1100114
C1	CAP. 6.8MFD 35V 20% S.TANT	1000067
	PARTS LIST	A-PL-W501-0-0
REFERENCE DESIGNATION	DESCRIPTION	PART NO.

B-CS-W501-0-1 Schmitt Trigger W501



Q1	TSTR. DEC6534B OR TSTR. DEC3638B	15-03409-01 15-02979
R5	RES. 22 1/4W 5% CC	13-01969
R1 THRU R4	RES. 1.5K 1/4W 5% CC	13-00391
D6 THRU D23	DIO. D664	11-00114
D1 THRU D5	DIO. D662	11-00113
C1, C3, C4, C5	CAP. .01MFD 100V 20% DISC	10-01610
C2	CAP. 3.9MFD 10V 10% S. TANT	10-00064
	PARTS LIST	A-PL-W841-0-0
REFERENCE DESIGNATION	DESCRIPTION	PART NO.

B-CS-W841-0-1 Cable Terminator W841









**Digital Equipment Corporation  
Maynard, Massachusetts**

