HP 13255

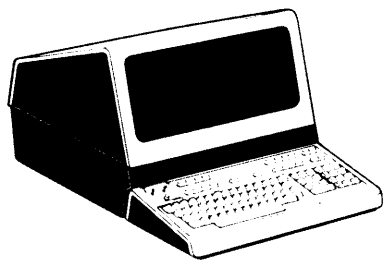
CARTRIDGE TAPE MODULE

Manual Part No. 13255-91032

PRINTED

AUG-01-76

DATA TERMINAL
TECHNICAL INFORMATION



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1.0 INTRODUCTION.

The Cartridge Tape Module consists of a Cartridge Tape Unit (CTU) Interface PCA, a Read/Write PCA, a CTU Top Plane Assembly, two CTU Transport Assemblies, and one or more mini tape cartridges. Each tape cartridge contains 150 feet of single-track 0.150-inch tape with a maximum formatted storage capacity of 110K eight-bit data bytes. The dual cartridge tape units provide full read and write capabilities for phase-encoded data. Data, command, status information, and address interfacing between this subsection and other terminal modules is provided by the Backplane Assembly and CTU Interface PCA. The Read/Write PCA controls recording, reading, and tape motion of the two CTU Transport Assemblies. Interfacing between the two PCA's is provided by the CTU Top Plane Assembly and interfacing between the Read/Write PCA and the two CTU Transport Assemblies is provided by a Motor Cable Assembly and two CTU ribbon cable assemblies.

2.0 OPERATING PARAMETERS.

A summary of operating parameters for the Cartridge Tape Module is contained in tables 1.0 through 5.3.

Table 1.0 Physical Parameters

Part Number	Nomenclature	Size (L x W x D) +/-0.100 Inches	Weight (Pounds)
02640-60021	CTU Top Plane Assembly	4.4 x 1.1 x 0.7	0.10
02640-60032	Read/Write PCA	12.5 x 4.0 x 0.6	0.60
02640-60033	CTU Interface PCA	12.5 x 4.0 x 0.5	0.40
02640-60034	Cartridge Electronics PCA	3.8 x 2.0 x 1.3	0.10
02640-60050	CTU Transport Assembly	5.1 x 3.6 x 3.8	0.80
02640-60054	CTU Base Assembly	N/A	N/A
02640-60055	Motor/Tachometer Assembly	N/A	N/A
02640-60056	Head Bridge Assembly	N/A	N/A
02640-60057	Tachometer Coil Assembly	N/A	N/A
02640-60066	CTU Cable Assembly	N/A	N/A
02640-60067	Head Assembly	N/A	N/A
02640-60074	Magnet Assembly	N/A	N/A
02640-60076	Disc/Capstan Assembly	N/A	N/A
02640-60085	Motor Cable Assembly	N/A	N/A
02640-60102	CTU Bezel Assembly	N/A	N/A
9162-0061	Mini Cartridge	N/A	N/A
Number of Backplane Slots Required: 2			

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NOTE: This document is part of the 264XX DATA TERMINAL product series Technical Information Package (HP 13255).

1.0 INTRODUCTION.

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02640-60034	Cartridge Electronics PCA	3.8 x 2.0 x 1.3	0.10
02640-60050	CTU Transport Assembly	5.1 x 3.6 x 3.8	0.80
02640-60054	CTU Base Assembly	N/A	N/A
02640-60055	Motor/Tachometer Assembly	N/A	N/A
02640-60056	Head Bridge Assembly	N/A	N/A
02640-60057	Tachometer Coil Assembly	N/A	N/A
02640-60066	CTU Cable Assembly	N/A	N/A
02640-60067	Head Assembly	N/A	N/A
02640-60074	Magnet Assembly	N/A	N/A
02640-60076	Disc/Capstan Assembly	N/A	N/A
02640-60085	Motor Cable Assembly	N/A	N/A
02640-60102	CTU Bezel Assembly	N/A	N/A
9162-0061	Mini Cartridge	N/A	N/A
Number of Backplane Slots Required: 2			

Table 2.0 Reliability and Environmental Information

Environmental: (X) HP Class B ( ) Other:

Restrictions: Type tested at product level except the cartridge tape. The cartridge tape limits temperature and humidity conditions as follows.

Free space ambient temperature:

Non-operating:	-10 to + 65 degrees C (-15 to +150 degrees F)
Operating:	+ 5 to + 40 degrees C (+41 to +104 degrees F)

Humidity: 20 to 80% (non-condensing)

Failure Rate (percent per 1000 hours) of Major Assemblies:

CTU Interface PCA	0.82340%
Read/Write PCA	4.04199%
CTU Top Plane Assembly	0.00088%
Motor Cable Assembly	0.00060%
CTU Transport Assembly	4.17800%

Life expectancy for components of the CTU Transport Assembly (the maximum insertion rate = 1 per second. Data for the head, motor, and motor capstan apply to start-stop motion at 10 inches per second):

Eject, Insert Mechanism	20,000 insertions min. (50,000 typical)
Cartridge Insert and File Protect Switches	100,000 insertions min.
Read/Write Head	3,000 hours min. (10,000 hours typical)
Motor	1,000 hours min. (5,000 hours typical)
Motor Capstan	1,000 hours min. (5,000 hours typical)

Table 3.0 Total Module Power Supply and Clock Requirements - Measured While Accelerating to 60 ips (At +/-5% Unless Otherwise Specified)

+5 Volt Supply @ 1350 mA	+12 Volt Supply @ 1630 mA	-12 Volt Supply @ 1580 mA	+42 Volt Supply @ mA NOT APPLICABLE
115 volts ac @ A NOT APPLICABLE		220 volts ac @ A NOT APPLICABLE	
Clock Frequency: 4.915 MHz			

Table 4.0 Connector Information for CTU Interface PCA

Connector and Pin No.	Signal Name	Signal Description
P1, Pin 1	+5V	+5 Volt Power Supply
-2	GND	Ground Common Return (Power and Signal)
-3	SYS CLK	4.915 MHz System Clock
-4	-12V	-12 Volt Power Supply
-5	$\overline{\text{ADDR0}}$	Negative True, Address Bit 0
-6	$\overline{\text{ADDR1}}$	Negative True, Address Bit 1
-7	$\overline{\text{ADDR2}}$	Negative True, Address Bit 2
-8	$\overline{\text{ADDR3}}$	Negative True, Address Bit 3
-9	$\overline{\text{ADDR4}}$	Negative True, Address Bit 4
-10	$\overline{\text{ADDR5}}$	Negative True, Address Bit 5
-11	$\overline{\text{ADDR6}}$	Negative True, Address Bit 6
-12	$\overline{\text{ADDR7}}$	Negative True, Address Bit 7
-13	$\overline{\text{ADDR8}}$	Negative True, Address Bit 8
-14	$\overline{\text{ADDR9}}$	Negative True, Address Bit 9
-15	$\overline{\text{ADDR10}}$	Negative True, Address Bit 10
-16	$\overline{\text{ADDR11}}$	Negative True, Address Bit 11
-17	$\overline{\text{ADDR12}}$	Negative True, Address Bit 12
-18	$\overline{\text{ADDR13}}$	Negative True, Address Bit 13
-19	$\overline{\text{ADDR14}}$	Negative True, Address Bit 14
-20	$\overline{\text{ADDR15}}$	Negative True, Address Bit 15
-21	$\overline{\text{I/O}}$	Negative True, Input Output/Memory
-22	GND	Ground Common Return (Power and Signal)

Table 4.0 Connector Information for CTU Interface PCA (Cont'd.)

Connector and Pin No.	Signal Name	Signal Description
P1, Pin A	GND	Ground Common Return (Power and Signal)
-B	POLL	Negative True, Polled Interrupt Identification Request
-C	+12V	+12 Volt Power Supply
-D	PWR ON	System Power On
-E	BUS0	Negative True, Data Bus Bit 0
-F	BUS1	Negative True, Data Bus Bit 1
-H	BUS2	Negative True, Data Bus Bit 2
-J	BUS3	Negative True, Data Bus Bit 3
-K	BUS4	Negative True, Data Bus Bit 4
-L	BUS5	Negative True, Data Bus Bit 5
-M	BUS6	Negative True, Data Bus Bit 6
-N	BUS7	Negative True, Data Bus Bit 7
-P	WRITE	Negative True, Write/Read Type Cycle
-R	ATN2	Negative True, CTU and Polled Interrupt Request
-S	WAIT	Negative True, Wait Control Line
-T	PRIOR IN	Bus Controller Priority In
-U	PRIOR OUT	Bus Controller Priority Out
-V	PROC ACTIVE	Negative True, Processor Active (Controlling Bus)
-W	BUSY	Negative True, Bus Currently Busy (Not Available)
-X	RUN	Allow Processor to Access Bus
-Y	REQ	Negative True, Request (Bus Data Currently Valid)
-Z	ATN	Negative True, Data Comm Interrupt Request

Table 4.1 Connector Information for CTU Interface PCA

Connector and Pin No.	Signal Name	Signal Description
P3, Pin 1 thru -22		Not Used
P3, Pin A	$\overline{LO}$	Negative True, Lamp Unit 0
-B	$\overline{HOL0}$	Negative True, Hole Unit 0 Detected
-C	$\overline{L1}$	Negative True, Lamp Unit 1
-D	$\overline{HOL1}$	Negative True, Hole Unit 1 Detected
-E	+5V	+5V Supply
-F	$\overline{RE}$	Negative True, Record Enable (Read Enable)
-H	USO	Unit Select 0 (select left unit)
-J	$\overline{DATA}$	Negative True, Write Data (high writes flux in north seeking pole direction)
-K	2XTACH	Two Times Tachometer Frequency
-L	RUNG	Running (>1 ips forward or reverse)
-M	TACH	Tachometer Frequency
-N	DZX	Data Zero Crossing (testing purposes only)
-P	GAP	Gap Detector
-R	CIN0	Cartridge Inserted in Unit 0
-S	CIN1	Cartridge Inserted in Unit 1
-T	RIP	Record In Progress
-U	$\overline{DZX}$	Negative True, Data Zero Crossing
-V	$\overline{STOP}$	Obsolete (tied to +5V thru 4.7 kilohms)
-W	$\overline{FFD}$	Negative True, Fast Forward
-X	$\overline{SFD}$	Negative True, Slow Forward
-Y	$\overline{FREV}$	Negative True, Fast Reverse
-Z	$\overline{SREV}$	Negative True, Slow Reverse

Table 4.2 Connector Information for Read/Write PCA

Connector and Pin No.	Signal Name	Signal Description
J4 & J5 1	TCOM	Tachometer Coil (Common), D.C. Level +2.5V
-2		Not Used
-3	HEAD-	Head (-) AC Signal, Data Dependent
-4	HEAD GND	Head Ground
-5	$\overline{CI}$	Negative True, Cartridge Inserted
-6	$\overline{HOLE}$	Negative True, Hole
-7	+5V	+5V Supply
-8	+5V RET	+5V Return
-9	$\overline{L}$	Negative True, Lamp
-10	HEADCT	Head Center Tap, AC Signal, Data Dependent, Active on Write Only
-11	HEAD+	Head (+) AC Signal, Data Dependent
-12	TGND	Tachometer Ground
-13		Not Used
-14	T	Tachometer Coil, AC Signal, Frequency Depends on Motor Speed
J6 -1	-	Motor 0 (-)
-2	+	Motor 0 (+)
-3	-	Motor 1 (-)
-4	+	Motor 1 (+)

Table 4.3 Connector Information for Read/Write PCA

Connector and Pin No.	Signal Name	Signal Description
P1, Pin 1	+5V	+5 Volt Power Supply
-2	GND	Ground Common Return (Power and Signal)
-3		Not Used
-4	-12V	-12 Volt Power Supply
Pin -5 through Pin -22		Not Used
P1, Pin A through Pin -B		Not Used
-C	+12V	+12 Volt Power Supply
Pin -D through Pin -S		Not Used
-T	PRIOR IN	Bus Controller Priority In
-U	PRIOR OUT	Bus Controller Priority Out
Pin -V through Pin -Z		Not Used

Table 4.4 Connector Information for Read/Write PCA

Connector and Pin No.	Signal Name	Signal Description
P3, Pin 1 through Pin -6		Not Used
-7	GND	Ground
Pin -8 through Pin -22		Not Used

Table 4.4 Connector Information for Read/Write PCA (Cont'd.)

Connector and Pin No.	Signal Name	Signal Description
P3, Pin A	$\overline{LO}$	Negative True, Lamp Unit 0
-B	$\overline{HOL0}$	Negative True, Hole Unit 0 Detected
-C	$\overline{L1}$	Negative True, Lamp Unit 1
-D	$\overline{HOL1}$	Negative True, Hole Unit 1 Detected
-E	+5V	+5V Supply
-F	$\overline{RE}$	Negative True, Record Enable (Read Enable)
-H	US0	Unit Select 0 (select left unit)
-J	$\overline{DATA}$	Negative True, Write Data (high writes flux in north seeking pole direction)
-K	2XTACH	Two Times Tachometer Frequency
-L	RUNG	Running (>1 ips forward or reverse)
-M	TACH	Tachometer Frequency
-N	DZX	Data Zero Crossing (testing purposes only)
-P	GAP	Gap Detector
-R	CIN0	Cartridge Inserted in Unit 0
-S	CIN1	Cartridge Inserted in Unit 1
-T	RIP	Record In Progress
-U	$\overline{DZX}$	Negative True, Data Zero Crossing
-V	$\overline{STOP}$	Obsolete (tied to +5V thru 4.7 kilohms)
-W	$\overline{FFD}$	Negative True, Fast Forward
-X	$\overline{SFD}$	Negative True, Slow Forward
-Y	$\overline{FREV}$	Negative True, Fast Reverse
-Z	$\overline{SREV}$	Negative True, Slow Reverse

Table 4.5 Connector Information for Cartridge Electronics PCA

Connector and Pin No.	Signal Name	Signal Description
J1 1	T	Tachometer Coil, AC Signal, Frequency Depends on Motor Speed
-2	TGND	Tachometer Ground
-3	TCOM	Tachometer Coil (Common), DC Level +2.5V
J2 -1	TCOM	Tachometer Coil (Common), DC Level +2.5V
-2		Not Used
-3	HEAD-	Head (-) AC Signal, Data Dependent
-4	HEAD GND	Head Ground
-5	$\overline{CI}$	Negative True, Cartridge Inserted
-6	$\overline{HOLE}$	Negative True, Hole
-7	+5V	+5V Supply
-8	+5V RET	+5V Return
-9	$\overline{L}$	Negative True, Lamp
-10	HEADCT	Head Center Tap, AC Signal, Data Dependent, Active on Write Only
-11	HEAD+	Head (+) AC Signal, Data Dependent
-12	TGND	Tachometer Ground
-13		Not Used
-14	T	Tachometer Coil, AC Signal, Frequency Depends on Motor Speed

Table 5.0 Module Bus Pin Assignments

Function Performed: Read Data From CTU	Value	Bus Signal
	X	ADDR 15
Poll Bit: Bit 7	X	ADDR 14
	X	ADDR 13
Module Address: (ADDR 11,10,9,4) = (1011)	X	ADDR 12
	1	ADDR 11
	0	ADDR 10
	1	ADDR 9
Function Specifier: ADDR5 = 1	X	ADDR 8
	X	ADDR 7
	X	ADDR 6
Data Bus Bit Interpretation:	1	ADDR 5
	1	ADDR 4
	X	ADDR 3
B7 Data Bit 7	X	ADDR 2
(Most significant bit of data)	X	ADDR 1
	X	ADDR 0
	B7	BUS 7
B6 Data Bit 6	B6	BUS 6
	B5	BUS 5
B5 Data Bit 5	B4	BUS 4
	B3	BUS 3
	B2	BUS 2
B4 Data Bit 4	B1	BUS 1
	B0	BUS 0
B3 Data Bit 3	1=Logical 1=Bus Low	
	0=Logical 0=Bus High	
	X=Don't Care	
B2 Data Bit 2		
B1 Data Bit 1		
B0 Data Bit 0 (Least significant bit of data)		

Table 5.1 Module Bus Pin Assignments

Function Performed: Write Data To CTU	Value	Bus Signal
	X	ADDR 15
Poll Bit: Bit 7	X	ADDR 14
	X	ADDR 13
Module Address: (ADDR 11,10,9,4) = (1011)	X	ADDR 12
	1	ADDR 11
	0	ADDR 10
	1	ADDR 9
Function Specifier: ADDR5 = 1	X	ADDR 8
	X	ADDR 7
	X	ADDR 6
Data Bus Bit Interpretation:	1	ADDR 5
	1	ADDR 4
	X	ADDR 3
B7 Data Bit 7	X	ADDR 2
(Most significant bit of data)	X	ADDR 1
	X	ADDR 0
	B7	BUS 7
B6 Data Bit 6	B6	BUS 6
	B5	BUS 5
B5 Data Bit 5	B4	BUS 4
	B3	BUS 3
	B2	BUS 2
B4 Data Bit 4	B1	BUS 1
	B0	BUS 0
B3 Data Bit 3	1=Logical 1=Bus Low	
	0=Logical 0=Bus High	
	X=Don't Care	
B2 Data Bit 2		
B1 Data Bit 1		
B0 Data Bit 0 (Least significant bit of data)		

Table 5.2 Module Bus Pin Assignments

Function Performed: Input Status From CTU

Poll Bit: Bit 7

Module Address: (ADDR 11,10,9,4) = (1011)

Function Specifier: ADDR5 = 0

Data Bus Bit Interpretation:

B7 - Not Applicable

B6 - BYTE RDY is set to "1" in Read mode when the preamble is detected or a byte is ready to be read from the CTU Module or can be accepted for recording. BYTE RDY is set in Record mode when a byte has been encoded.

B5 - GAP is the output of the gap detector on the Read/Write PCA.

B4 - HOLE is set to "1" whenever a hole is detected on the tape and is cleared when status is read.

B3 - TAK is the frequency of the tachometer divided by 2. There are 58.4 transitions of the TAK status per inch of tape movement.

B2 - RIP indicates the presence of head current while recording a gap. The state of this signal is not defined during read operations or while data is being recorded.
0 = No write current (tape protected)
1 = Write current present while in gap

B1 - CIR indicates that a cartridge is inserted in the right CTU Transport Assembly and is cleared when the cartridge is removed.
0 = No cartridge in right CTU Transport Assembly
1 = Cartridge inserted in right CTU Transport Assembly

B0 - CIL indicates that a cartridge is inserted in the left CTU Transport Assembly and is cleared when the cartridge is removed.
0 = No cartridge in left CTU Transport Assembly
1 = Cartridge inserted in left CTU Transport Assembly

Value	Bus Signal
X	ADDR 15
X	ADDR 14
X	ADDR 13
X	ADDR 12
1	ADDR 11
0	ADDR 10
1	ADDR 9
X	ADDR 8
X	ADDR 7
X	ADDR 6
0	ADDR 5
1	ADDR 4
X	ADDR 3
X	ADDR 2
X	ADDR 1
X	ADDR 0
B7	BUS 7
B6	BUS 6
B5	BUS 5
B4	BUS 4
B3	BUS 3
B2	BUS 2
B1	BUS 1
B0	BUS 0

1=Logical 1=Bus Low
0=Logical 0=Bus High
X=Don't Care

Table 5.3 Module Bus Pin Assignments

Function Performed: Output Command to CTU

Poll Bit: Bit 7

Module Address: (ADDR 11,10,9,4) = (1011)

Function Specifier: ADDR5 = 0

Data Bus Bit Interpretation:

B7 - ANL
- 0 = Turns off left eject button light
- 1 = Turns on left eject button light

B6 - ANR
- 0 = Turns off the right eject button light
- 1 = Turns on the right eject button light

B5 - GEN
- 0 = Disables gap recording
- 1 = Record gap on tape (Bit 3 must also be 1)

B4 - USL
- 0 = Route command to right drive
- 1 = Route command to left drive

B3 - REC
- 0 = Read mode
- 1 = Record mode (enable write circuit)

B2 - FST
- 0 = Run tape at slow speed (10 ips)
- 1 = Run tape at high speed (60 ips)

B1 - FWD
- 0 = Forward
- 1 = Reverse

B0 - RUN
- 0 = Stop tape
- 1 = Move tape according to FST and FWD

Value	Bus Signal
X	ADDR 15
X	ADDR 14
X	ADDR 13
X	ADDR 12
1	ADDR 11
0	ADDR 10
1	ADDR 9
X	ADDR 8
X	ADDR 7
X	ADDR 6
0	ADDR 5
1	ADDR 4
X	ADDR 3
X	ADDR 2
X	ADDR 1
X	ADDR 0
B7	BUS 7
B6	BUS 6
B5	BUS 5
B4	BUS 4
B3	BUS 3
B2	BUS 2
B1	BUS 1
B0	BUS 0

1=Logical 1=Bus Low
0=Logical 0=Bus High
X=Don't Care

3.0 FUNCTIONAL DESCRIPTION - CTU INTERFACE PCA. Refer to the block diagram (figure 1), schematic diagram (figure 2), component location diagram (figure 3), and parts lists (02640-60021 and 02640-60033) located in the appendix.

The terminal processor communicates with the Cartridge Tape Module via the terminal bus (Backplane Assembly). The CTU Interface PCA is responsible for converting processor commands into signals to control tape motion, unit selection, read or write operation, and the state of the eject button lights. The CTU Interface PCA provides status information allowing the processor to determine the present state of the selected CTU Transport Assembly. Finally, the CTU Interface PCA encodes data bytes into serial patterns of bit transitions to be recorded on the tape and vice versa (i.e., decodes bit transitions on the tape into data bytes).

3.0.1 BUS FUNCTION DECODER AND TIMING LOGIC - CTU INTERFACE PCA.

3.0.1.1 The bus function decoder and timing logic generates signals based upon inputs from the terminal bus which control the flow of commands, status, and data bytes to and from the terminal bus.

3.0.1.2 The bus function decoder (U16) generates one of four command signals by decoding $\overline{\text{WRITE}}$ and $\overline{\text{ADDR5}}$. The commands are enabled by $\overline{\text{I/O}}$ (for an $\overline{\text{I/O}}$ module), $\overline{\text{REQ}}$ (bus data is valid), $\overline{\text{ADDR4}}$, $\overline{\text{ADDR11}}$, $\overline{\text{ADDR10}}$, and $\overline{\text{ADDR9}}$. In addition, DATA CLOCK, RD+WRT, RD/WRT SELECT, READ EN, and STATUS EN are generated.

3.0.2 COMMAND LOGIC - CTU INTERFACE PCA.

3.0.2.1 The purpose of the command logic is to acquire command information from the terminal bus when the signals are valid. The command information completely specifies the operation as well as the selection of the CTU Transport Assemblies. In addition, the command logic stops tape motion thus preventing tape runoff when a hole is detected by the hole detect logic.

3.0.2.2 The command signals from the terminal bus are latched into U15, U21 (Pins 5 and 6), and U24 by the CMND CLK signal from the bus function decoder and timing logic.

Two versions of the Run command are contained in the command register (U15). SRUN (Servo Run) is generated at U24, Pin 8 to enable the tape motion decoder (U16). SRUN is cleared if the hole edge detector (U23, Pin 12) detects a transition into a hole. IRUN (Interface Run) is generated at U24, Pin 6 to enable the slow forward tape motion decoder at U36, Pin 8 which generates $\overline{\text{ISF}}$ (used only by the encoder/decoder logic). This prevents a discontinuity in encoded or decoded data when moving across a hole. Both SRUN and IRUN are cleared after a system reset.

The $\overline{\text{SRUN}}$, $\overline{\text{FORWARD}}$, and $\overline{\text{FAST}}$ signals are translated in this block into the signals $\overline{\text{SREV}}$ (slow reverse), $\overline{\text{SFD}}$ (slow forward), $\overline{\text{FREV}}$ (fast reverse), and $\overline{\text{FFD}}$ (fast forward) which are used by the servo electronics on the Read/Write PCA.

The CLRINT signal is generated for the interrupt logic by U27, Pin 8 when the processor performs a status request, enabling the STATUS EN signal. The CLRINT signal is present for one cycle of SYS CLK after STATUS EN goes low.

3.0.3 DATA PATH CONTROL - CTU INTERFACE PCA.

3.0.3.1 The data path control circuitry transfers data to and from the terminal bus. It also converts serial bits from the tape into bytes and converts bytes from the terminal bus into serial bits.

3.0.3.2 The data I/O buffer (U13 and U33) is an 8-bit register with a 2-port input multiplexer. It provides one byte of buffering between the terminal bus and the serial data register.

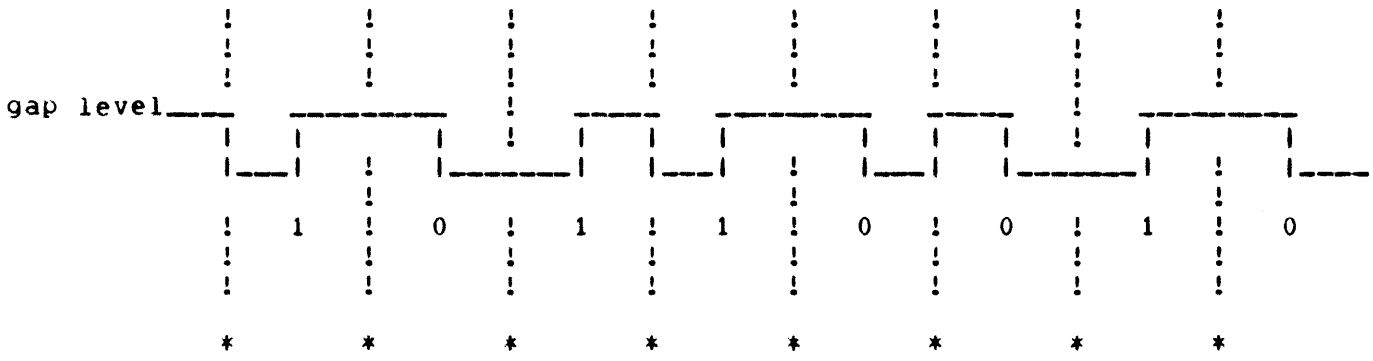
3.0.3.3 In Record mode, the data is loaded into the data I/O buffer from the terminal bus, enabled by RD/WRT SELECT being low. (Note that the data buffer is loaded with complement data since it is loaded from the ground true terminal bus.) The data byte is loaded into the serial data register after the previous byte has been encoded. The serial data register is then shifted right (via $\overline{\text{REC DATA}}$) into the encoder at mid cell point (data transition position) and the encoder is complemented at end cell point (phase position).

3.0.3.4 In Read mode, the serial biphase data is read into the transition detector (U28, Pin 14) of the encoder/decoder logic and shifted into

the serial data register at the appropriate time (corresponding to the zone for data transitions). When the last data bit has been detected at the decoder (there are 7 bits in the serial data register), the data I/O buffer is parallel loaded from the serial data register (shifted right one bit). The data I/O buffer is subsequently output to the terminal bus via drivers U11 and U32, which are enabled by the READ EN signal.

3.0.4 ENCODER/DECODER LOGIC - CTU INTERFACE PCA.

3.0.4.1 This logic provides the timing and control functions for encoding or decoding a data byte. The operation of the encoder/decoder logic is based upon the following theoretical analysis. The code that is recorded on the cartridge tape is Serial Biphase Mark Code (see below). Therefore, the code shown below would be seen at the encoder output (U17, Pin 10) when in Record mode or at the transition detector (U28, Pin 15) in Read mode. The code rules state that there is always a data transition at mid cell, a 1-bit is a transition towards gap level while a 0-bit is a transition away from gap level, and a phase transition occurs at a cell boundary if adjacent data transitions are the same.



*Indicates cell boundaries (125 microseconds)

3.0.4.2 Timing and control for the encode and decode operations is provided by a cell decode counter (U212) and a variable modulus (divide by N) counter (U213, U214, U312, and U313) which are both synchronous with the bus System Clock. The variable modulus counter generates a carry output at time intervals equal to one biphase cell period divided by eight which increments the cell decode counter. By initializing both counters at the beginning of a biphase cell, timing points (for encoding phase and data transitions in Read mode) and timing zones (for decoding phase and data transitions in Read mode) can be decoded from the cell decode counter and variable modulus counter carry output.

The variable modulus counter consists of two counters. One is an 8-bit counter (U213 and U214) which counts from a base state to the overflow state (which generates a carry output); the second is an 8-bit up-down counter which contains the value of the base state. The up-down counter is loaded with the two's complement of the desired modulus. In Record mode, the up-down counter is reset (U311, Pin 11 and U313, Pin 11) to the two's complement of 115 octal (77 decimal) giving a carry output at

$$\frac{N}{4.9150}\ \text{microsecond} = \frac{77}{4.9150}\ \text{microsecond} = \frac{\text{nominal biphase all period}}{8}$$

In Read mode, the up-down counter is initialized to the same value. Then, based on tne actual frequency of the phase/data transitions, the up-down counter is incremented or decremented. (Note that incrementing the up-down counter decrements the modulus of the counter.)

The cell decode counter is decoded as follows when in Record mode.

U212, Pins					
A	B	C	D	CIN	FUNCTION
1	0	0	1	1	Phase Position
1	1	0	1	1	Data Position

When in Read mode, the cell decode counter appears as follows.

	U212, Pins				
	A	B	C	D	FUNCTION
Initialize State	0	1	1	0	Illegal Zone
	0	1	1	1	For Transitions
Decrement	1	0	0	0	
N	1	0	0	1	Zone For Phase
Increment	1	0	1	0	Transitions
N	1	0	1	1	
Decrement	1	1	0	0	
N	1	1	0	1	Zone For Data
Increment	1	1	1	0	Transitions
N	1	1	1	1	

3.0.4.3 The encoder operation can be best explained by considering the recording of a gap and a 2-byte preamble. The preamble consists of a zero byte and a byte with the value 200 octal.

First, the command RUN.FORWARD.RECORD.GAP is output to the command register from the processor. This sets the encoder to record flux in the gap direction. Additionally, the command sets the modulus of the variable modulus counter to 77 and enables the preset signals of the variable modulus, bit, and cell decode counters. While the gap is being recorded, the serial data register is shifted right for each bit time. Since $\overline{DZX}$ is set when in record mode, this results in the serial data register being loaded serially with all 1's. Because the data register contains the complement data, the register is effectively loaded with the first preamble byte (all zeroes).

After the proper gap interval has been recorded, the GAP command is turned off and the last preamble byte is loaded into the data I/O buffer. When $\overline{REC\ GAP}$ is set, the preset signals on the variable modulus, bit, and cell decode counters are removed and the encoder is no longer forced to record in the gap direction.

Each bit is recorded (encoded) as follows:

1) The variable modulus counter counts up and generates a carry output (CIN) every 77 system clocks. The carry output increments the cell decode counter.

2) The cell decode counter is decoded at mid cell setting the encoder to $\overline{DATA}$ (the value of the rightmost bit of the serial data register), and the serial data register is shifted right one bit.

3) At end cell, the bit counter increments, the encoder is complemented, and the cell decode and variable modulus counters are initialized.

The process is repeated for each of the eight data bits. After all eight bits have been encoded, the bit counter, cell decode counter, and the variable modulus counter are initialized. The serial data register is loaded from the data I/O buffer and BYTE RDY is set. If BYTE RDY signal is already set, then data is not loaded from the data I/O buffer and the same byte is recorded, shifted right one bit.

3.0.4.4 The decoder operation can be similarly explained by decoding a record consisting of a gap, a 4-byte preamble and a 1-byte record. First, the command RUN.SLOW.FORWARD is output to the command register from the processor. While the gap is being read, the gap detect circuitry on the Read/Write PCA causes the modulus of the variable modulus counter to be preset to 77, initializes the variable modulus and cell decode counters, and clears READ SYNC (U17, Pin 6).

When the preamble begins to be read, the gap detect circuitry indicates data present. This causes the preset to be removed from the modulus of the variable modulus counter which allows the modulus to be adjusted accordingly. The decoder then proceeds as follows-

The variable modulus counter counts up and generats CIN every N system clocks (N is initially 77). CIN increments the cell decode counter. When a transition is sensed by the $\overline{\text{DZX}}$ transition detector, it is decoded using the cell decode counter and results in one of three possible actions:

1) Transition occurs in the illegal zone- the cell decode and variable modulus counters are initialized. The process continues waiting for the next transition.

2) Transition occurs in the phase zone- the modulus of the variable modulus counter is incremented or decremented (see 3.0.4.2) and the cell decode and variable modulus counters are initialized. The process continues waiting for the next transition.

3) Transition occurs in the data zone- the modulus of the variable modulus counter is incremented or decremented (see 3.0.4.2) and the cell decode and variable modulus counters are initialized. If the data is decoded as a zero ("0"), the process continues waiting for the next transition. Otherwise, a one ("1") indicates the end of the preamble and causes READ SYNC and BYTE RDY to be set.

When READ SYNC is set, the decoder will automatically switch modes to read in data bytes. The initial BYTE RDY indicates that the end of the preamble has been found. BYTE RDY must be cleared by either a $\overline{\text{RD DATA}}$ or $\overline{\text{WR DATA}}$. However, the data byte read will be meaningless.

while reading in data, transitions detected are handled in the same manner as when reading the preamble except for transitions occuring in the data zone. In this case, RD DATA is shifted right into the serial data register and bit counter is incremented. When the last bit is decoded, the data I/O buffer is parallel loaded from the serial data register (shifted right one bit), BYTE RDY is set, and the process is repeated for the next byte. The data in the I/O buffer must be read (which clear BYTE RDY) before the next byte is decoded in order to avoid losing data.

3.0.5 HOLE DETECT LOGIC - CTU INTERFACE PCA.

3.0.5.1 This circuitry detects the presence of a hole in the tape of either CTU Transport Assembly (depending on which transport is selected) and generates the DHOL, DHOL DET, and US0 signals.

3.0.5.2 The Read/Write PCA provides the signals $\overline{\text{HOL0}}$ and $\overline{\text{HOL1}}$ that indicate the presence of a hole on Unit 0 or Unit 1, respectively when the signal is low. When Unit 1 is selected and a hole is detected, U22, Pin 11 will be high. When Unit 0 is selected, US0 at U35, Pin 4 is high, a hole is detected, and U22, Pin 8 is high. Pins 8 and 11 of U22 are wire ORed into U28, Pin 6 where they are synchronized to SYS CLK and provide the DHOL signal at U28, Pin 7. DHOL at U29, Pin 4 is exclusive-ORed with DHOL delayed by one cycle of SYS CLK at U29, Pin 5 and generates the DHOL DET signal which provides a pulse when a hole is initially detected and another pulse when it is no longer detected. It should be noted that DHOL and DHOL DET are ANDed in the command logic to provide a single pulse when a hole is initially detected.

3.0.6 TACH LOGIC - CTU INTERFACE PCA.

3.0.6.1 The tach logic divides the TACH signal from the Read/Write PCA by a factor of two and uses the resulting signal to generate the signals TACH/2 and DTACH/2.

3.0.6.2 The TACH signal is used as the clock input for U26, which is configured as a T flip-flop, and results in one transition of the signal at U26, Pin 6 for every two transitions of the TACH signal. U28 synchronizes the signal from U26, Pin 6 with the SYS CLK and generates the TACH/2

signal for the status drivers. The TACH/2 signal is delayed one cycle of SYS CLK by U28, Pin 5 and is then exclusive-ORed to produce DTACH/2 at U29, Pin 8. DTACH/2 produces a pulse at each transition of TACH/2 with a width equal to one cycle of SYS CLK.

3.0.7 STATUS DRIVERS - CTU INTERFACE PCA.

3.0.7.1 The status drivers present status information for the module to the terminal bus.

3.0.7.2 The CIN0, CIN1, RIP, and INTERRUPT signals are gated onto the terminal bus by U31 which is enabled by STATUS EN. The signals are inverted on the bus to provide ground true logic levels. The TACH, HOLE, GAP, and BYTE RDY signals are gated onto the terminal bus by U12 which is enabled by STATUS EN.

3.0.8 INTERRUPT LOGIC - CTU INTERFACE PCA.

3.0.8.1 The interrupt logic provides an interrupt when a transition occurs in the TACH/2 signal, when a hole is present, or when a byte of data must be received or sent from the processor.

3.0.8.2 The DTACH/2 signal sets flip-flop U25, causing Pin 9 to be low when a transition occurs in TACH/2. The CLRINT signal from the command logic resets U25, causing Pin 9 to go high. The DHOL signal sets flip-flop U25, causing Pin 7 to be low, and indicates the presence of a hole in the tape. The CLRINT signal resets U25, causing Pin 7 to go high.

When U25, Pin 9 is low or U25, Pin 7 is low or $\overline{\text{BYTE RDY}}$ is low, or some combination of these events occurs, then INTERRUPT will be high. This causes $\overline{\text{AIN2}}$ to be low thereby indicating an interrupt condition to the processor. If U25, Pin 7 is high and $\overline{\text{BYTE RDY}}$ is high, then no interrupt condition exists and INTERRUPT will be low.

3.1 FUNCTIONAL DESCRIPTION - READ/WRITE PCA. Refer to the block diagram (figure 4), schematic diagram (figure 5), component location diagram (figure 6), and parts list (02640-60032) located in the appendix.

The Read/Write PCA contains circuitry to record flux transitions onto cartridges in either CTU Transport, to convert flux transitions recorded on the cartridges into TTL signal levels, and to detect the

presence of gap (absence of flux transitions) on the tape. In addition, this PCA contains the servo electronics for controlling tape motion and speed for either CTU Transport. Analysis of the PCA indicates that much of the circuitry is common for servo control and read/write operations. The routing of signals is accomplished for each drive by the read select switch, the unit function decoder, the amplifier select logic, and the tachometer feedback select and conditioning circuits. (Refer to the block diagram in figure 4.)

3.1.1 UNIT FUNCTION DECODER - READ/WRITE PCA.

3.1.1.1 The unit function decoder (U3) is a 1-of-10 decoder which determines whether the Read/Write PCA is in Read or Write mode. It also determines the CTU Transport from which flux transitions are received, or to which flux transitions are sent.

3.1.1.2 When $\overline{RE}$ and line $\overline{US0}$ are low, $\overline{Q0}$ and $\overline{Q1}$ are active outputs and Head 1 is driven by $\overline{DATA}$ as shown in the truth table below. When $\overline{RE}$ is low, and US0 is high, $\overline{Q2}$ and $\overline{Q3}$ are active outputs and Head 0 is drven by $\overline{DATA}$ as shown below.

1 - Of - 10 Decoder (U3)
Truth Table

INPUTS			OUTPUTS							
$\overline{RE}$	US0	$\overline{DATA}$	$\overline{Q0}$	$\overline{Q1}$	$\overline{Q2}$	$\overline{Q3}$	$\overline{Q4}$	$\overline{Q5}$	$\overline{Q6}$	$\overline{Q7}$
L	L	L	L	H	H	H	H	H	H	H
L	L	H	H	L	H	H	H	H	H	H
L	H	L	H	H	L	H	H	H	H	H
L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	H	H	H	L	H	H	H
H	L	H	H	H	H	H	H	L	H	H
H	H	L	H	H	H	H	H	H	L	H
H	H	H	H	H	H	H	H	H	H	L

3.1.2 WRITE CURRENT CIRCUIT - READ/WRITE PCA.

3.1.2.1 The write current circuit provides the current source for either head as selected by the unit function decoder. In addition, the RIP signal is generated allowing the firmware to determine whether a cartridge is protected.

3.1.2.2 When $\overline{RE}$ is low (write) U17, Pin 4 is high and Q15 turns on. This, in turn, drives Q16, the current source, on. When $\overline{RE}$ is high (read), U17, Pin 4 is low and Q15 is cut off which in turn cuts off Q16. The emitter current of Q16 is primarily determined by the +12 volts supply, R42, CR13, and is nominally 9.85 mA. When the current source (Q16) is off, the RIP driver (Q17) is turned on through R42, CR11, CR10, R44.

3.1.2.3 When the current source is on and supplying current to the head, the emitter of Q16 is at approximately +4.6 volts and CR11 isolates the base of Q17 from this voltage. The collector of Q16 is at a low voltage when any one of U3's outputs (Pins 1, 2, 3, or 4) is low, then CR12 removes the drive to the base of Q17 cutting it off. If the current source is on, and not supplying current to the head (i.e., the file protect switch is open, or the head leads are broken), the collector of Q16 is then connected to a high resistance path (CR12, R44, R49) and Q16 saturates causing most of its emitter current to flow out its base into Q15 and CR13 to ground. Then the collector voltage of Q16 which is now about the same as the emitter voltage, drives Q17 on through CR12 and R44. The two paths driving Q17 assure that RIP is true only when head current is actually drawn.

3.1.2.4 When recording data, however, RIP is not at a steady dc level. The head, being inductive, opposes an instantaneous current change. For a brief instant, at each current reversal, the $-L(di/dt)$ is such that Q16 saturates and stays saturated until the rising current through the head reacnes a sufficient value to allow Q16 to come out of saturation. Since, as explained above, Q17 is triggered on and then Q16 is saturated, narrow negative going pulses, approximately 10 microseconds wide, appear at the RIP output. RIP is at a steady high level only when writing gaps.

3.1.3 READ SELECT SWITCH - READ/WRITE PCA.

3.1.3.1 The read select switch (U16) is a FET switch used to connect the head on the selected CTU Transport Assembly with the preamp in the read amplifier circuit when the Read/Write PCA is in the Read mode.

3.1.3.2 Refer to the truth table in section 3.1.1.2 for a summary of the following. When $\overline{RE}$ is high (read) and US0 is low ($\overline{DATA}$ is a don't care), Q4 and Q5 are tied together and go low. This drives U17, Pin 12 high turning switches 1 and 2 on and Head 1 is connected to the preamp.

when $\overline{RE}$ and US0 are high ($\overline{DATA}$ is a don't care), Q6 and Q7 are tied together and go low. This drives U17, Pin 6 high turning switches 3 and 4 on and Head 0 is connected to the preamp.

3.1.4 READ AMPLIFIER CIRCUIT - READ/WRITE PCA.

3.1.4.1 The read amplifier circuit amplifies the input signal from either head, differentiates the signal so that the peaks of the flux transitions become zero crossing, and then detects these zero crossings to produce a TTL signal with transitions at each zero crossings (flux transitions peak).

3.1.4.2 The preamp (U5) is a differential input/differential output op-amp. Its gain is determined by R39 and R40 plus the MOS switch on resistance in one leg, and by R38 and R41 plus the MOS switch on resistance in the other leg. The differential gain is 40dB. R38 and C36 on one side, and R39 and C39 on the other side, roll off the response starting at 30 kHz. C40 resonates the head at approximately 50 kHz, effectively compensating for some loss in the head output.

3.1.4.3 Differentiator (U4) is also a differential input/differential output op-amp. Its differentiating characteristics are determined by C21, R46, C16, and R34 in one leg, and by R47, C22, C19, and R35 in the other leg. Its gain at the two frequencies of interest (4 kHz and 8 kHz) is -2 dB and +4 dB, respectively. C21 with R46, and C22 with R47 stop its gain rise at +20 cB at 80 kHz; and R34 with C16, R34 with C16, R34 with C16, and R35 with C19 start its roll off at 160 kHz. The preamp outputs are connected to this differentiator which translates each amplitude peak of the preamp outputs to zero crossings.

3.1.4.4 The differentiator outputs are ac coupled at Pins 8 and 9 to comparator U1. The two inputs to U1 are lifted off ground and reference to +5V through R101F and R101G. This is necessary because this particular comparator must not have its inputs allowed to go below -0.3 Vdc. This comparator detects the zero crossings of the differentiator outputs and changes state each time, effectively squaring the differentiator output waveform. A small amount of hysteresis is used to assure that

the comparator output is at the correct polarity, i.e., low in the steady state (no data) and also to give it a snap action when a state change occurs. The positive feedback is derived from the output of U13, Pin 4. Since the comparator inputs are referenced to +5 volts, a level shifting is required and is accomplished by CR4, R33 and R32. In the high state, the output of U13, Pin 4 must be kept at a TTL level and CR4, R33 and R32 are also responsible for that. This voltage is +4.4 volts nominally. The +4.4 volts plus the CR4 Zener voltage make the voltage level at the junction of R33, R48, and CR4 equal to +10.6 volts. In the low state, the voltage at this junction is the CR4 voltage plus the low output voltage of U13, Pin 4 (or approximately +6.6 volts). Therefore at this junction, a rectangular wave exists between +6.6 volts and +10.6 volts. The hysteresis voltage is then derived from this through the R48, R101G divider. Nominally, Pin 8 of U1 is 32 millivolts positive with respect to Pin 9.

3.1.5 GAP DETECT CIRCUIT - READ/WRITE PCA.

3.1.5.1 The gap detect circuit provides the GAP signal, which indicates the absence of flux transitions (if GAP is high) or the presence of flux transitions (if GAP is low). Whenever flux transitions begin or terminate, the GAP signal reflects this change after a delay of eight bit times.

3.1.5.2 A single output (U5, Pin 4) is also ac coupled to U1 at Pin 10, used here as a threshold detector. The two inputs of this comparator are referenced to +6 volts through R36 and R37. The threshold level is set by R103E and R37 and is nominally +0.057 volts, which is 15 per cent of the specified 1600 FRPI head output times the gain of the preamp. Pin 11 of U1 is +0.057 volts positive with respect to Pin 10. The output of U1, Pin 13 will change state every time the input to Pin 10 reaches this level, up or down. As a result, the output is not perfectly symmetrical, but has a duty cycle of approximately 45/55 at 1600 FRPI.

3.1.5.3 The output of U1, Pin 13 drives the integrator driver (Q18). R57, R58, and C45 together with U13, Pin 6 form the gap detector. U13, Pin 6 (a Schmitt-Trigger) triggers on at +1.7 volts and off at +0.9 volts. The time constants of the integrator are proportioned so that eight bit times at 1600 FRPI (or 1 millisecond) is required to reach the on level. This delay assures that the gap detect circuitry will not be triggered by random noise. Once U13, Pin 6 is on (output low) and data is received, GAP will be false. When data stops, C45 will begin to discharge through R58 and Q18; when its level reaches +0.9 volts, U13, Pin 6 will trigger off indicating beginning of gap. Nominally, this

time is also 1 millisecond. Therefore, GAP is true 1 millisecond after data stops until 1 millisecond into the next block. The output of U13, Pin 4 is connected to Pin 10 of U12 and the output of U13, Pin 6 is connected to OR gate U12, Pin 9. This serves to quiet the $\overline{DZX}$ output during gap time.

3.1.6 TACHOMETER FEEDBACK SELECT AND CONDITIONING CIRCUITS - READ/WRITE PCA.

3.1.6.1 The tachometer feedback select and conditioning circuits condition the inputs from the tachometers by filtering and by comparison and then select the signal from the tachometer associated with the CTU Transport that is selected.

3.1.6.2 The tachometer on the capstan drive motor is a variable reluctance type which produces a sine wave output of approximately 300 millivolts peak-to-peak at 10 inches per second tape speed. This signal is fed into the Read/Write PCA. The signal has a 0.027 microfarad (C2 and C4) filter capacitor shunting it to roll off the output of the tachometer above the frequencies of interest (4 KHZ). A tach signal then drives a comparator (U1, Pin 6 or U1, Pin 4) with positive hysteresis (33 millivolts). NAND gates U11 select the signal TACH FREQ from the selected CTU Transport. This signal drives a delay circuit producing the DELAYED TACH signal.

3.1.7 AMPLIFIER SELECT LOGIC - READ/WRITE PCA.

3.1.7.1 The amplifier select logic determines which motor is to be driven based upon which CTU Transport is selected.

3.1.7.2 If the RUNG signal is low, then 1SEL and 0SEL are high, inhibiting the motor drive circuitry. If RUNG is high, both gates of U11 in this block are enabled. If Unit 0 is selected (US0 high) and a cartridge is inserted in Unit 0 (CIN0 high), then 0SEL will be low, selecting the CTU drive circuits associated with CTU Transport Unit 0. On the other hand, if Unit 1 is selected (US0 low) and a cartridge is inserted in Unit 1 (CIN1 high), then 1SEL will be low, selecting the CTU drive circuits associated with CTU Transport Unit 1.

3.1.8 COMMAND RAMP AND FEEDBACK CIRCUITS - READ/WRITE PCA.

3.1.8.1 The command ramp circuits translate command signals to move the tape fast forward, slow forward, fast reverse, and slow reverse into ramped voltages used by the CTU drive circuits. The feedback circuit provides a voltage directly proportional to the speed of the motor. The Feedback Voltage (FDBK VOLTAGE) and the Ramp Command Voltage (RAMP VOLTAGE) are summed to provide an error signal for the power amplifiers in the CTU drive circuits.

3.1.8.2 $\overline{\text{FFD}}$, $\overline{\text{SFD}}$, $\overline{\text{FREV}}$ and $\overline{\text{SREV}}$ run command lines drive open-collector TTL inverters which have 10 kilohm pullup resistors to a 10-volt Zener reference. Only one input should be pulled low at any one time. These commands cause the servo to drive at +60, +10, -60 and -10 ips. Fast and slow command voltage values are determined by the relative values of R12 through R15. Reverse commands are inverted before being applied to the ramp circuit by op-amp U6 (all op-amps are dual internally compensated op-amp packages). The two op-amps (U8) make up the ramp circuit which together are analogous to a single inverting op-amp with a slow linear slew rate. The first half of the ramp circuit is a high gain (196K divided by 1 kilohm = 196) voltage driver which supplies bias current to a bidirectional voltage reference composed of CR5 and CR6. This reference voltage (approximately +/-6.9 volts) is supplied to the second op-amp operated as a Miller integrator and has a slew rate of 6.9 volts divided by R23, all divided by C27 (31 volts per second). R22 feeds back the output of the integrator which sets the dc gain of the ramp circuitry. The output for slow commands is +/-1.2 volts and for high speed commands is +/-7.2 volts.

Q3, Q4, U13, and op-amp U6 form a bidirectional threshold detector that indicates the polarity of the command voltage as well as the 1 ips (either forward or reverse) threshold of the ramp command voltage, generating the signals +FDBK EN and -FDBK EN.

3.1.8.3 The TACH FREQ and DELAYED TACH signals go into an exclusive-OR gate made up of U12 and two gates of U15. The output of the exclusive-OR gate is a pulse for every input transition, thus doubling the frequency of the tach signal. This double frequency signal drives a precision one-shot whose output (93 microsecond period) is fed to one of two TTL open-collector buffers (U10), depending on the desired feedback polarity. The feedback polarity is determined by the polarity of the command voltage. The +FDBK EN and -FDBK EN signals gate the one-shot output to the appropriate TTL buffer. One TTL buffer output is inverted by the first half of U7, operated also as a 3 kHz low pass

filter. The filter integrates the pulses of the one-shot to help reduce the ripple on the feedback signal. Both tach feedback polarities are fed to the main 2-pole minimum phase Chebychev filter (2 poles at 200 Hz). This output is the servo Feedback Voltage (FDBK VOLTAGE). The Feedback Voltage waveform looks like the ramp command waveform with extra ripple riding on it. This is risidual digital tach ripple that is not filtered out by the 2-pole filter, but instead is filtered out by the mechanical pole of the motor drive.

3.1.9 CTU DRIVE CIRCUITS - READ/WRITE PCA.

3.1.9.1 The CTU drive circuits use the error voltage generated at the summing junction as an input to the power amplifier determined by the selected CTU Transport driving the motor for that transport.

3.1.9.2 A 2-drive tape system has two dc servo motors which must be selectively driven. The selection of the motor to be driven is done at the low signal level using junction field effect transistors. Each power amp has two FETs associated with it. The first FET (Q6 or Q10) switches a power amp to the power amp summing junction. The R55 speed adjust potentiometer and R25 convert the Ramp Voltages (RAMP VOLTAGE) to command currents into the power amp summing junction. In addition, FDBK VOLTAGE is changed to a feedback current by R24 into the power amp summing junction. The second FET (Q5 or Q9) clamps the unused power amp off so that leakage currents cannot cause the non-selected motor to turn. The power amps are op-amps (U9) with high gain bipolar emitter followers (Q7 and Q8 or Q11 and Q12). The buffer power transistors are mounted on an aluminum heat sink.

The outputs of the power amplifiers are fed to the drive motors. The return side of the motors come through a current sensing resistor (R31). The motor current produces a voltage across this resistor which drives current limit detector transistors Q13 and Q14. They clamp the power amp through diode bridge CR8. C32 and C33 stabilize the current limit feedback loop. The current sense voltage also is used for compensation of the velocity feedback loop by locally characterizing the response of the power amp through R29, R28, C34 and C35 back to the power amp summing junction. This compensation gives the servo velocity loop a 55-hertz bandwidth (with typically 45 degrees phase margin and 12 dB gain margin).

3.1.10 CARTRIDGE DETECT CIRCUIT - READ/WRITE PCA.

3.1.10.1 The cartridge detect circuit delays the $\overline{CI}$ signal from the CTU Transport allowing time for the CTU Transport to mechanically stabilize after a cartridge is inserted.

3.1.10.2 When a cartridge is inserted in Unit 1, the $\overline{CI}$ line is pulled low causing U17, Pin 8 to go high. This allows C3 to charge through R2 and R3. After approximately 1/2 second, Q2 turns on and pulls U13, Pin 1 low causing CIN1 to go high and indicating the presence of a cartridge. U13 is a Schmitt gate used to provide hysteresis so that the slow fall time of the collector Q2 will not cause oscillations at the output of U13.

When the cartridge is ejected from Unit 1, all actions of the signals are inverted with the exception of capacitor C3 which discharges only through R2 (C3 discharges 464 times faster than it charges when a cartridge is inserted). The analysis for Unit 0 cartridge insertion and ejection are similar, except that U17, Pin 10, R1, R50, C1, Q1, and U13, Pin 10 are involved in affecting the state of CIN0.

3.2 FUNCTIONAL DESCRIPTION - CARTRIDGE ELECTRONICS PCA. Refer to the block diagram (figure 7), schematic diagram (figure 8), component location diagram (figure 9), and parts lists (02640-60034 and 02640-60066) located in the appendix.

The Cartridge Electronics PCA is a small PCA (part of the head bridge assembly of the CTU Transport) mounted to the tape mechanism's head mount. This assembly includes a 14-conductor ribbon cable which plugs into the Read/Write PCA. The ribbon cable provides all the electrical connections required by the mechanism, except motor current.

3.2.1 CI SWITCH - CARTRIDGE ELECTRONICS PCA.

3.2.1.1 The Cartridge Inserted (CI) switch (S2) is activated by the presence of a cartridge in the mechanism. The information concerning the presence or absence of a cartridge is transferred to the firmware, which takes the appropriate action.

3.2.1.2 When a cartridge is inserted, contact is made between two pads on the Cartridge Electronics PCA. This action connects the $\overline{CI}$ line to ground.

When a cartridge is not inserted, the $\overline{CI}$ line is pulled to +5 volts by a resistor on the Read/Write PCA. No "debouncing" circuitry is required since a delay is provided by circuitry on the Read/write PCA.

3.2.2 FP SWITCH - CARTRIDGE ELECTRONICS PCA.

3.2.2.1 The File Protect (FP) switch (S1) is activated when the RECORD tab on the cartridge is in the record position. This allows the user to inhibit accidental recording of data.

3.2.2.2 with the RECORD tab in the record position, contact is made between two pads on the Cartridge Electronics PCA. This contact allows current to flow through the center tap of the head which causes recording on the tape. If contact is not made then data may not be recorded on the tape, irrespective of whether or not the Read/Write circuitry is in the Write mode.

3.2.3 LAMP DRIVER - CARTRIDGE ELECTRONICS PCA.

3.2.3.1 The lamp driver accepts the ground true Lamp ($\overline{L}$) signal and drives the lamp used as an indicator for the user. The state of the lamp is controlled by the firmware.

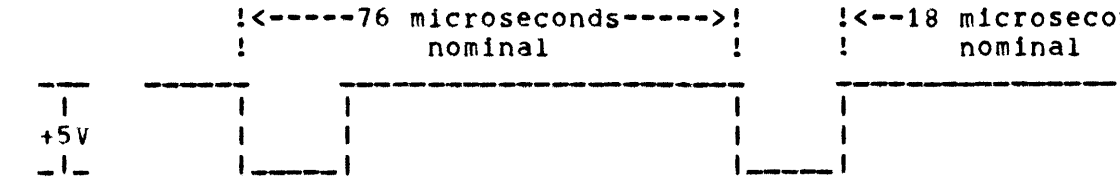
3.2.3.2 The lamp driver circuit consists of DS1, R3, R12, and 1/2 of U1. When the output of U1 is in the high state (lamp off), R3 allows approximately 40 mA to flow through DS1. This current keeps the filament hot so that the lamp turn on surge current (155 mA) is less than twice the nominal current. When J2, Pin 9 is grounded, the output of U1 goes low applying approximately 3.5 volts across the lamp. R12 limits the current through DS1 to achieve longer lamp life.

3.2.4 HOLE DETECT - CARTRIDGE ELECTRONICS PCA.

3.2.4.1 The hole detect circuitry consists of a pulse generator and diode driver and a detection circuit. The hole detect circuit detects the holes in the tape and provides a ground true signal ($\overline{HOLE}$) that is used in the determination of BOT, load point (LP), early warning (EW), and EOT. Holes are detected with an infrared emitting diode and a photo-transistor. Most of the time the irradiance emitted by the diode is blocked by the opaqueness of the tape. When a hole moves in the path, the irradiance travels to the photo-transistor and activates it. The infrared emitting diode in the hole detect circuit is not on continuously, but is pulsed at approximately 13 kHz. By pulsing the diode, more output can be obtained with less average current and power dissipation.

The pulsed diode output is detected, shaped and fed into the monostable multivibrator (one-shot). The one-shot is retriggerable and its time out is slightly longer than the time period of 13 kHz. Therefore, the output of the one-shot will remain true as long as it receives an input of at least a nominal 13 kHz. By measuring the time that the one-shot's output remains true, it can be decided whether the detection circuit has seen a scratch, a normal hole, or the tape has run completely off the end. This technique eliminates ambient light problems.

3.2.4.2 The pulse generator consists of U2, R6, R7 and C2. The resistors and capacitor control the frequency and symmetry of the output. The frequency is 13.125 +/-1.5 kHz. The output of U2, Pin 3 has the following waveform.



3.2.4.3 C1, CR1, R1, R2, and 1/2 of U1 make up the diode driver. During the time that the output of U1 is high (off) C1 charges through R2. When the output of U1 goes low, C1 is discharged through R1 and CR1. R1 limits the current through CR1 and R2 isolates this low impedence path from the +5 volts. The peak current through infrared emitting diode (CR1) is approximately 200 mA, and should provide a beam power output (minimum, peak) of 2.5 milliwatts.

3.2.4.4 The detection circuit consists of Q1, Q2, Q3, CR2, U3, R4, R5, R8, R9, R10, and C4. Irradiance striking its base region causes current to flow through Q1. Most of this current flows through Q3 and into the base of Q2. Q2 saturates, providing a negative transition which initiates the time out of the one-shot multivibrator, U3. R5 and CR2 provide a dc level to the base of Q3 that will allow the collector of Q3 to overcome the V(BE) of Q2. R5 also keeps the capacitance of CR2 and Q3 charged allowing faster circuit response. CR2 and Q3 provide a low impedence load to the photo-transistor Q1, which has a high C(be) thus also increasing response time. R4 sets the threshold of the detector circuit. Q1 must provide enough current to raise the voltage drop across R4 above the V(BE) of Q2 before Q2 will turn on. R9 is the collector load for Q2 and provides current for the inputs of U3 in their high state. R10 provides a high state for the other inputs of U3. R8 and C4 are the timing components for the monostable multivibrator U3. The time out is 110 +/-20 microseconds. R11 provides approximately 5 to 10 per cent positive feedback giving the detection circuit a Schmitt-trigger characteristic. This provides a more definite detection of the hole edges.

3.3 FUNCTIONAL DESCRIPTION - CTU TRANSPORT ASSEMBLY. Refer to the exploded view of the CTU Transport Assembly (figure 10), mounting provisions (figure 11), cartridge outline (figure 12), and the parts lists (02640-60050, 02640-60054, 02640-60055, 02640-60056, 02640-60057, 02640-60067, 02640-60074, 02640-60076, 02640-60085, and 02640-60102) located in the appendix.

The CTU Transport Assembly consists of a single major assembly which fastens to the terminal mainframe with two captive screws. Each drive has a signal cable and a motor cable connecting the drive to the Read/Write PCA. In addition, a special bezel covers the front of the terminal mainframe with openings for each drive. The spring loaded doors on the openings for the cartridges provide finish for the unit and protection for the drives.

Three major sub-assemblies make up the transport assembly--the base assembly, the head-bridge assembly and the motor/tachometer assembly. Each of these sub-assemblies is designed to be seperately replaceable without either special tools or adjustments. Figure 10 shows an exploded view of the CTU Transport.

3.3.1 BASE ASSEMBLY - CTU TRANSPORT ASSEMBLY.

3.3.1.1 The base assembly provides the support structure for the drive.

3.3.1.2 The base assembly is mounted to the terminal using two 5/16 inch well nuts and two number 6-32 screws. The wall thickness at the mounting surface should be >/= 12 gauge for metal or other material. The well nuts with associated screws provide convenient captive fasteners. More importantly, they attenuate mechanical vibrations in the 1 kHz region and above. Without this attenuation, sharp impacts to the terminal could cause read or write errors. A third mounting surface, faced with a rubber pad, is used for location and stabilization of the drive.

In the normal mounting attitude the cartridge is held at 15 degrees to the horizontal. Other mounting positions may be possible but care should be taken to avoid having the head surface facing upwards to collect dirt. Also the eject spring may have to be changed for other mounting attitudes. Provision has been made in the tooling die for the base for an alternate 0 degrees mounting attitude; however, this has not yet been implemented in an optional product. Mounting dimensions and an outline of the mechanism are shown in figure 11. An outline of the cartridge is shown in figure 12.

To prevent loss of intimate tape-head contact due to insufficient wrap and to minimize head and tape wear due to excessive wrap, the base

assembly has registration surfaces which control the fore and aft position of the cartridge. These surfaces are accurate to within +/-0.001 inch with respect to locating pin holes on the base. These holes in turn determine the position of the head bridge assembly. Side-to-side location of the cartridge, a less critical registration, is accomplished by maintaining minimum clearance between the cartridge and the drive.

3.3.1.3 The base assembly also includes a latching and release mechanism which is actuated by a release button. This button is made of green transparent plastic so that it also acts as a light pipe to bring the light from an indicator lamp on a circuit board at the rear of the drive to the surface of the button. This eliminates the cost and complexity of a separate indicator on the bezel. The cartridge is inserted by pushing it in against the spring loaded latch mechanism.

Four rollers provide the locating force. Two rollers press against the corner of the notch in the cartridge base at about 45 degrees resulting in an upward force component. The other two rollers press straight up holding the cartridge against the locating planes in the base. A force of about 4 pounds is required to insert the cartridge. The retention force is over 3 pounds.

Pressing the button releases the latch taking the pressure off the four rollers and allowing the cartridge to pop out to a detent position for easy removal. The cartridge is ejected part way by the motor assembly swinging forward. At this point the ejector rises out of the base and continues the cartridge motion out to the detent position. In this manner, the ejection force does not oppose the latching force when the cartridge is fully inserted. The mechanism resets itself during the ejection and is then ready to accept a cartridge again. The detent action is effected by a pawl which is spring loaded against the cartridge by the same spring that returns the release button.

3.3.2 HEAD BRIDGE ASSEMBLY - CTU TRANSPORT ASSEMBLY.

3.3.2.1 The head bridge assembly provides the critical reference surfaces for head-to-tape positioning and provides mounting for the Cartridge Electronics PCA.

3.3.2.2 The head bridge assembly has three pads which contact three small areas on the reference surface of the cartridge. This defines a reference plane both for the cartridge and the drive. The magnetic head is adjusted for both tilt and azimuth with respect to this plane as part of the manufacturing process. The head itself has a ball socket which engages a spherical "bump" molded into the plastic head bridge. Since the socket is centered on the magnetic gap in the head, the tilt and

azimuth adjustments are independent of one another. The vertical head position is controlled by maintaining close tolerances on the head and head bridge, and thus no height adjustment is required. The spherical bump is also within +/-0.001 inch with respect to the locating pins molded into the head bridge. This accurately controls the fore and aft position of the head to maintain the proper tape-head wrap angle. Once set, the head adjusting screws are sealed in position and no further head adjustment is required either at initial assembly or during field replacement. Thus any head bridge assembly works interchangeably with any base assembly.

3.3.2.3 The head bridge assembly also includes the Cartridge Electronics PCA (detailed in section 3.2) which performs various functions. Circuitry for sensing the position holes in the tape is included on this board. The infrared LED light source for this function is retained and precisely positioned by a molded-in clamp taking advantage of the strength and dimensional stability of the plastic material used in the head bridge to grip the LED without additional parts or machining. Cartridge insertion and the position of the RECORD tab on the cartridge are sensed by the position of two switches. Fixed contact pads for these switches are on the circuit board while the moveable contacts with their plunger actuators are enclosed within the head bridge giving inexpensive, reliable, enclosed switches.

3.3.2.4 The indicator lamp (previously mentioned) is also located on this PCA and is enclosed by a shield molded of titanium-dioxide filled plastic for maximum reflectivity. This part serves the dual functions of blocking stray light from the lamp while concentrating the light entering the light pipe portion of the release button. Since all interconnections are made on the board, no wiring harness is necessary on the mechanism.

3.3.3 MOTOR/TACHOMETER ASSEMBLY - CTU TRANSPORT ASSEMBLY.

3.3.3.1 The third subassembly of the CTU Transport is the motor/tachometer assembly which consists of a motor with drive capstan, a motor mount and a tachometer to provide velocity feedback to the servo.

3.3.3.2 The motor/tachometer assembly is single axis gimballed about its center of gravity to eliminate acceleration effects on the force developed between the motor capstan and the belt capstan in the cartridge. This force is provided by two extension springs which also serve to retain the assembly in the gimbal and to aid in ejecting the cartridge. The force between capstans is 15 +/-1.5 ounces. The gimbal consists simply of two hemispherical ball and socket joints between the motor/tachometer assembly and the base assembly. The assemblies are held together

by two extension springs which also provide the correct capstan force. The right hand ball and socket set prevents translation while the left set has an elongated socket to prevent rotation about two axes without causing binding due to tolerance accumulations.

As well as retaining the motor/tachometer assembly in its gimbal, the two extension springs load the motor capstan against its mating belt capstan within the cartridge. This spring loading takes up an accumulation of dimensional tolerances within both the cartridge and the drive while holding the force between the capstans within specified limits. The motor capstan is a polyurethane elastomer covered aluminum part 0.338 inches in diameter. The elastomer used has the best combination of high coefficient of friction, resistance to compression set and resistance to wear of a selection of potential materials which were tested. The capstan is set-screwed to the motor shaft and its height can be set without special tools or fixtures. A variable reluctance tachometer is mounted to the motor/tachometer assembly. This consists of a 48-tooth disc staked to the motor capstan, a pickup coil and permanent magnetic flux gate assembly screwed to the motor mount. The disc-to-pickup distance is set at 0.012 inches +/-0.002 inches. Motor capstans with disc attached can be field replaced without need for further adjustment.

3.4 FUNCTIONAL DESCRIPTION - TAPE CARTRIDGE. Refer to the tape cartridge diagram (figure 13), hole status format (figure 14), and valid recording area (figure 15) located in the appendix.

The tape cartridge shown in figure 13 provides 120,000 bytes of storage in 256-byte record, single-track 0.130 +/-0.005 inches, 800 BPI (1600 FRPI) +/-60 BPI standard format. At 10 ips, this gives a typical burst rate of 1000 bytes per second and 748 bytes per second average throughput. The cartridge consists of a metal base plate and plastic cover.

The tape contains 140 feet (minimum) of 0.150-inch 8138 computer tape suitable for recording purposes. The tab labeled RECORD is used to enable recording on the cartridge. A cartridge door is used to protect the tape during transport and storage. When the cartridge is inserted into the CTU Transport Assembly, the door is opened automatically. The mirror is used with the hole sense scheme. An infrared emitter located in the CTU Transport Assembly base shines through the base plate onto the mirror. Light is then reflected through the front of the cartridge to a photo-sensor in the CTU Transport Head Bridge Assembly. The light is intercepted by the tape normally indicating no hole. If a hole is present the light will be detected by the photo-sensor. The motor capstan drives the belt capstan which then moves the cartridge tape via the belt. The belt consists of an elastomeric belt which drives the tape by transmitting the belt capstan force to both tape reels. The tape cleaner consists of a scraper which is displaced approximately 1.125 inches in front of the head.

3.4.1 HOLE STATUS FORMAT. The positioning of holes in the cartridge tape and the duration of the signal from the hole detect circuitry on the Cartridge Electronics PCA is shown in figure 14.

3.4.2 INTERCHANGE STANDARDS. The code, format of the encoded data, and the region of valid recording area on the 3M 9585 mini cartridge should be as follows in order to facilitate product interchange.

VALID RECORDING AREA	The portion of the tape where data may be recorded is shown in figure 15.
FILES	There may be 1 to 344 files per cartridge.
BYTES	Recording is bit serial, eight bits to a byte, LSB to MSB.
RECORDS	Records are variable in length and may contain from 12 to 267 bytes. There may be 444 to 517 records of of maximum length per cartridge.
RECORD ORGANIZATION:	
Preamble	(3) bytes octal zero followed by (1) byte octal 200
Header	(2) bytes to define binary length of record (most significant byte first).
Body	1 to 256 data bytes.
Checksum	1 byte binary addition modulo 256.
Postamble	The postamble is (1) byte octal 1 followed by (3) bytes octal zero.
INTER-RECORD GAPS:	
Length	0.805" min., 0.905" max., 0.88 nominal.
Polarity	The IRG shall magnetize so that the beginning of the tape is a north seeking pole. NOTE: There are 0.01712 +/-0.0003" of tape travel for each detected edge.
FILE MARKS	Files shall be separated by a unique length gap and record as follows: 1.61" min., 1.81" max. gap followed by a 1.61" min., 1.81" max. gap. NOTE: The file mark record header is unique insofar as the most significant byte is always a "1".
END OF VALID DATA MARK	A file mark followed by a gap of 11 +/-0.5"

3.4.3 MECHANICAL SPECIFICATIONS.

The mechanical characteristics of the cartridge are summarized in the following table:

Speed	0 to 90 inches per second (maximum)
Drive ratio (tape velocity to the surface of the belt capstan)	0.78 +/-0.02
Average short term tape speed variations at 10 ips (flutter)	+/-4% maximum with head inserted and excluding drive system variations
Maximum acceleration	2000 in./sec^2 from 0 to 90 ips
Tangential driving force of belt capstan to maintain constant operating speed	1.0 to 4.0 ounces
Total equivalent inertial mass of all cartridge moving elements	6×10^{-4} oz. sec^2/in. (in linear units referred to the outer surface of the belt capstan)
Radial load to belt capstan	15 ounces +/-1.5 ounces
Dynamic tape tension (measured at constant drive speed)	0.5 to 2.0 ounces between tape guides exclusive of the effect of tape head

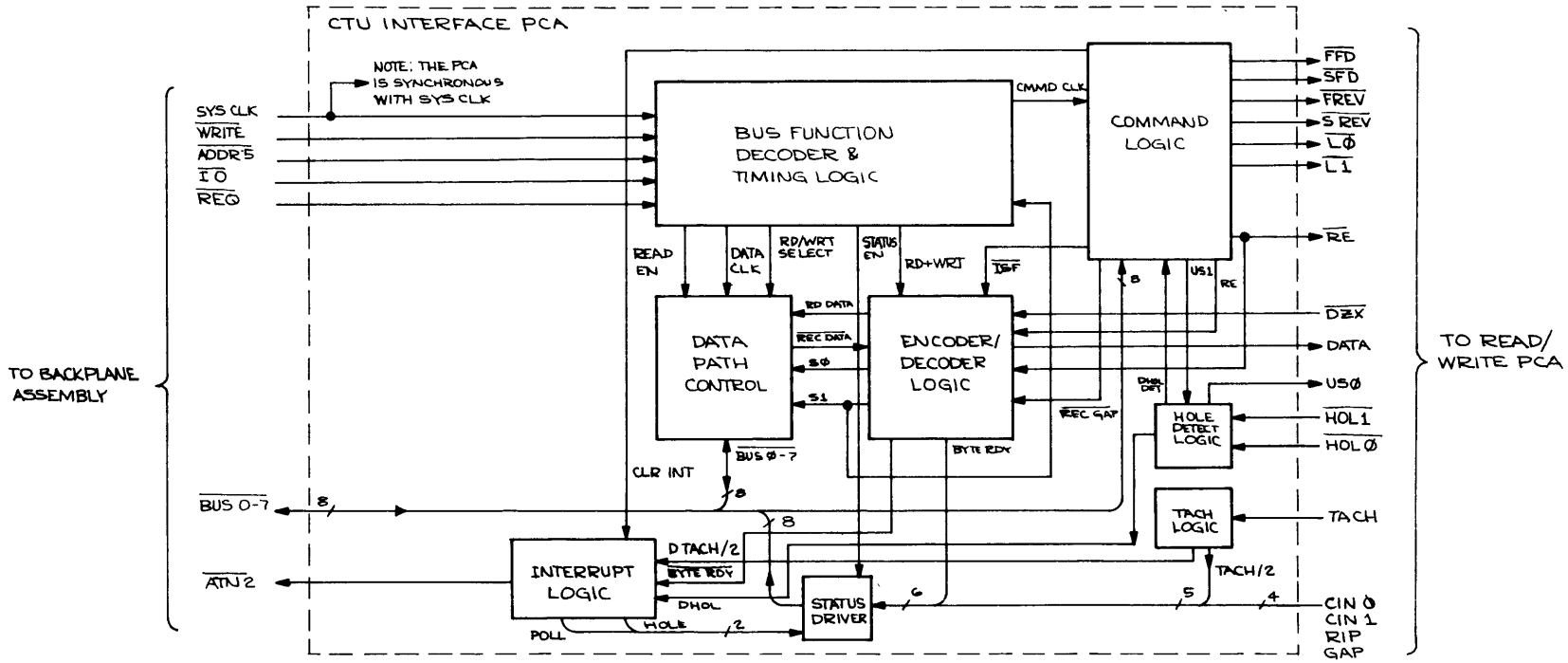


Figure 1
CTU Interface PCA Block Diagram
AUG-01-76 13255-91032

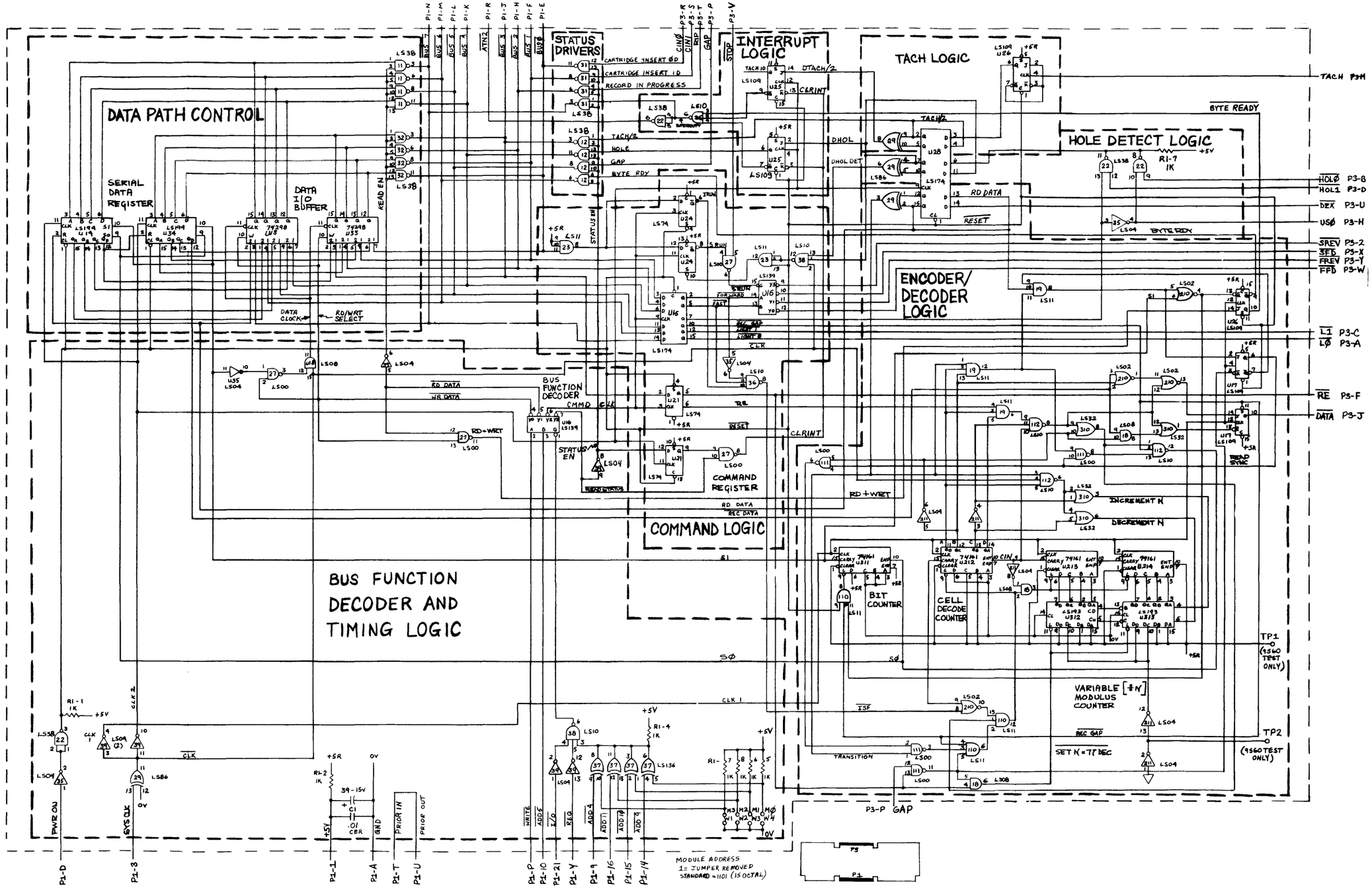


Figure 2
CTU Interface PCA Schematic Diagram
AUG-01-76 13255-91032

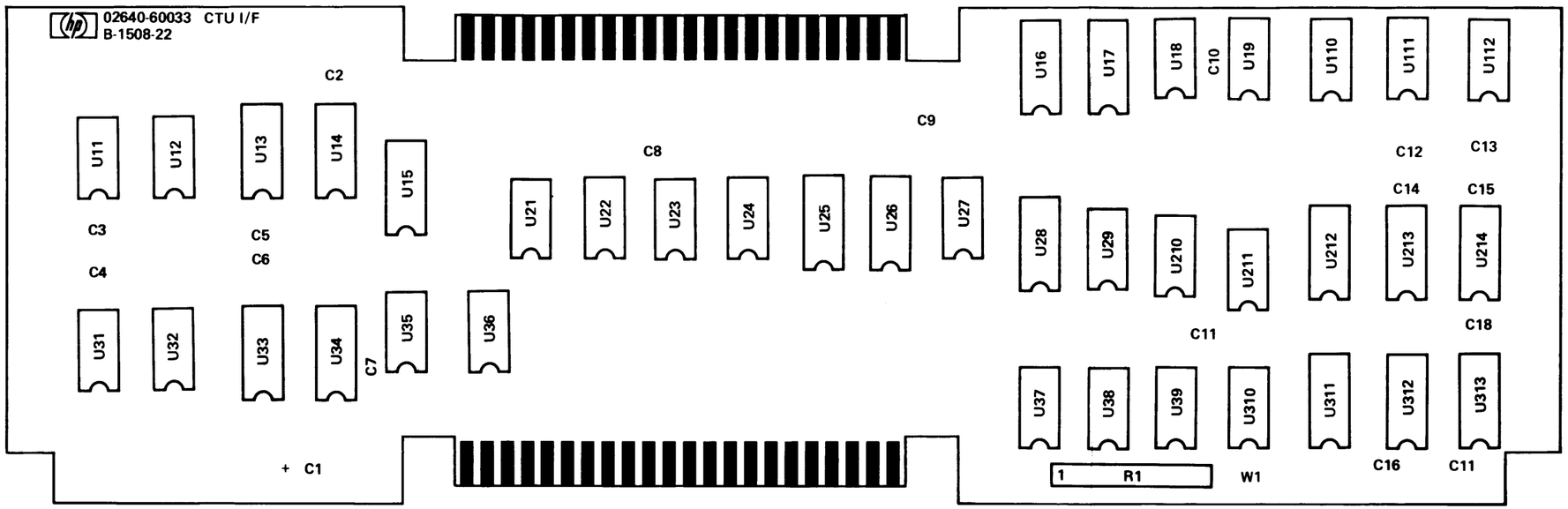


Figure 3
CTU Interface PCA Component Location Diagram
AUG-01-76 13255-91032

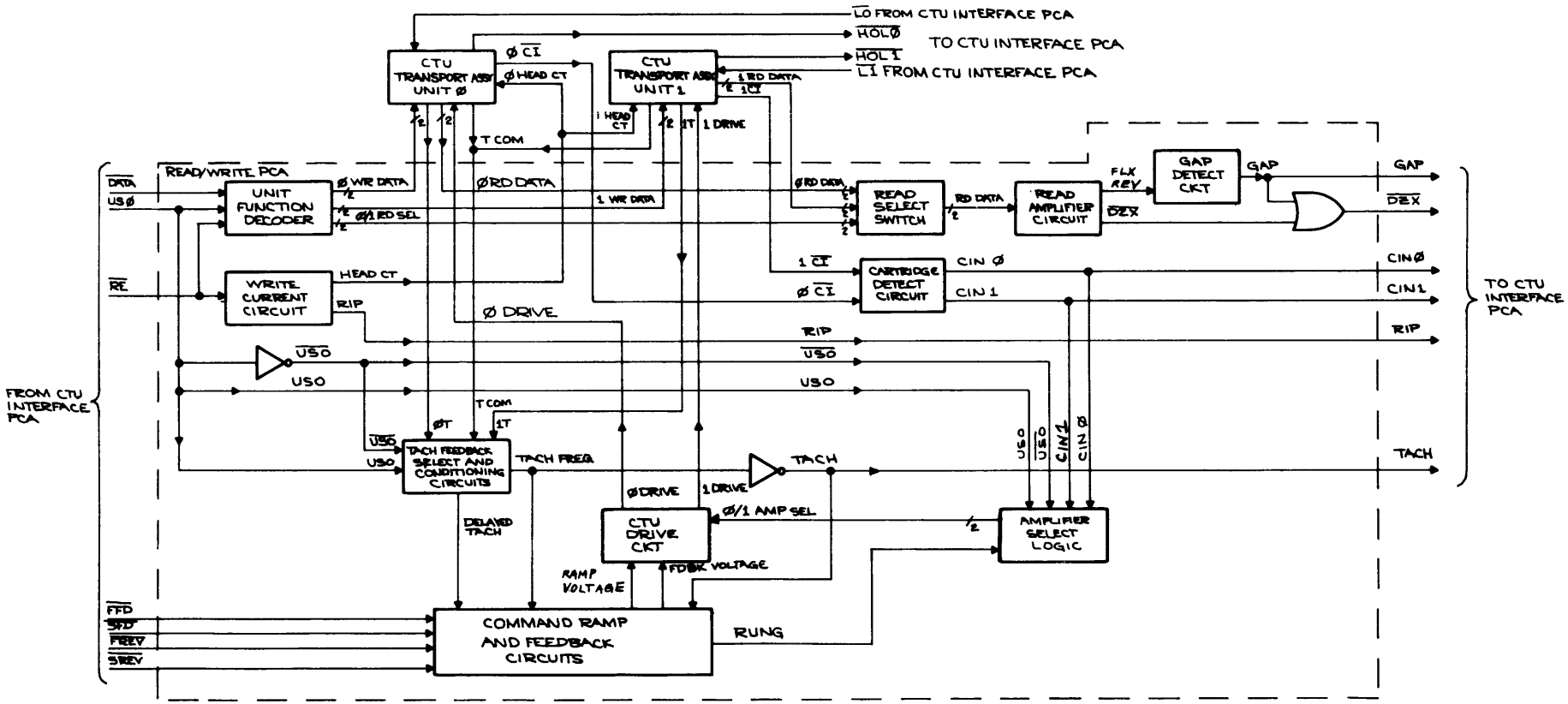


Figure 4
Read/Write PCA Block Diagram
AUG-01-76 13255-91032

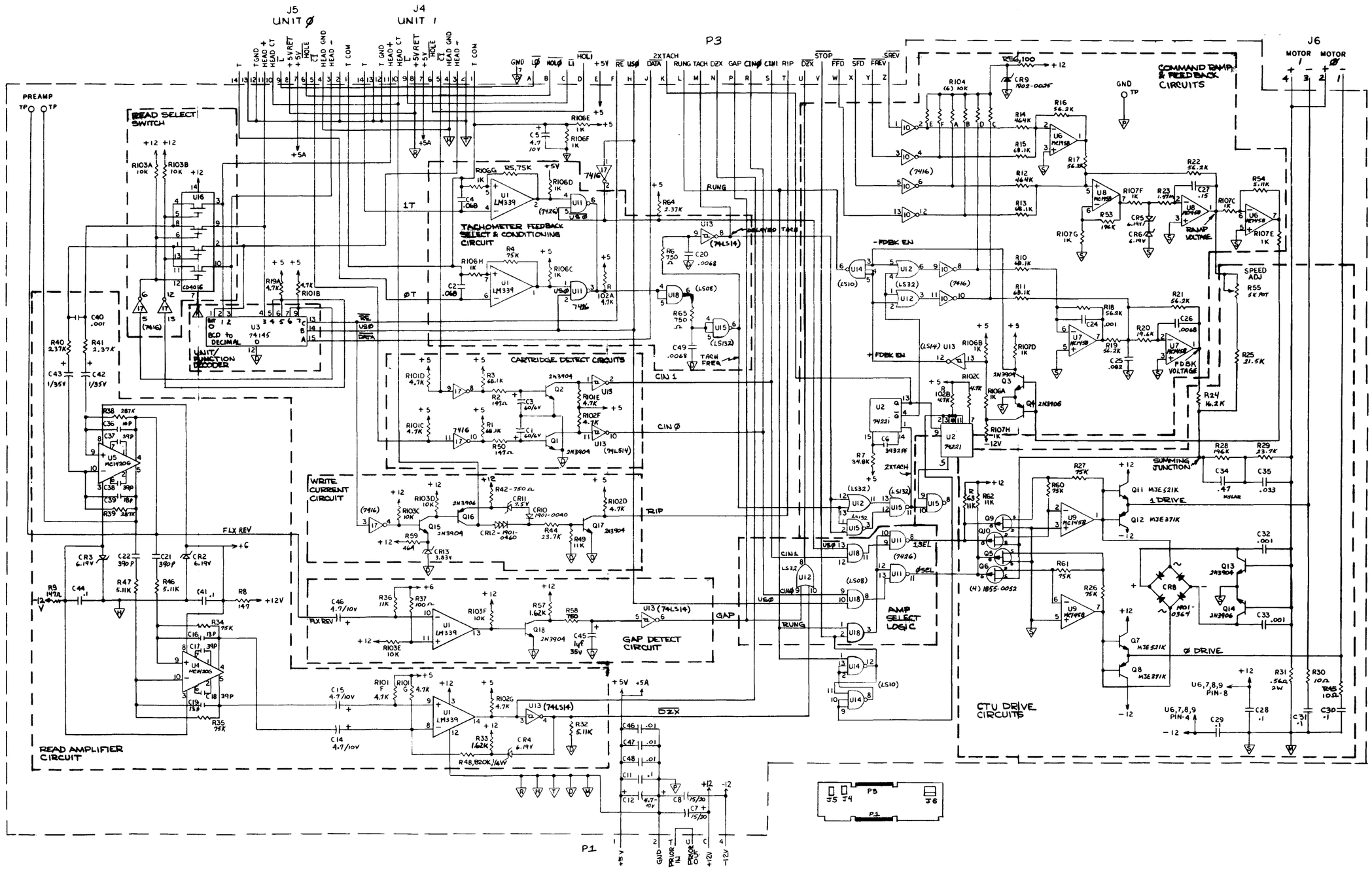


Figure 5
Read/Write PCA Schematic Diagram
AUG-01-76 13255-91032

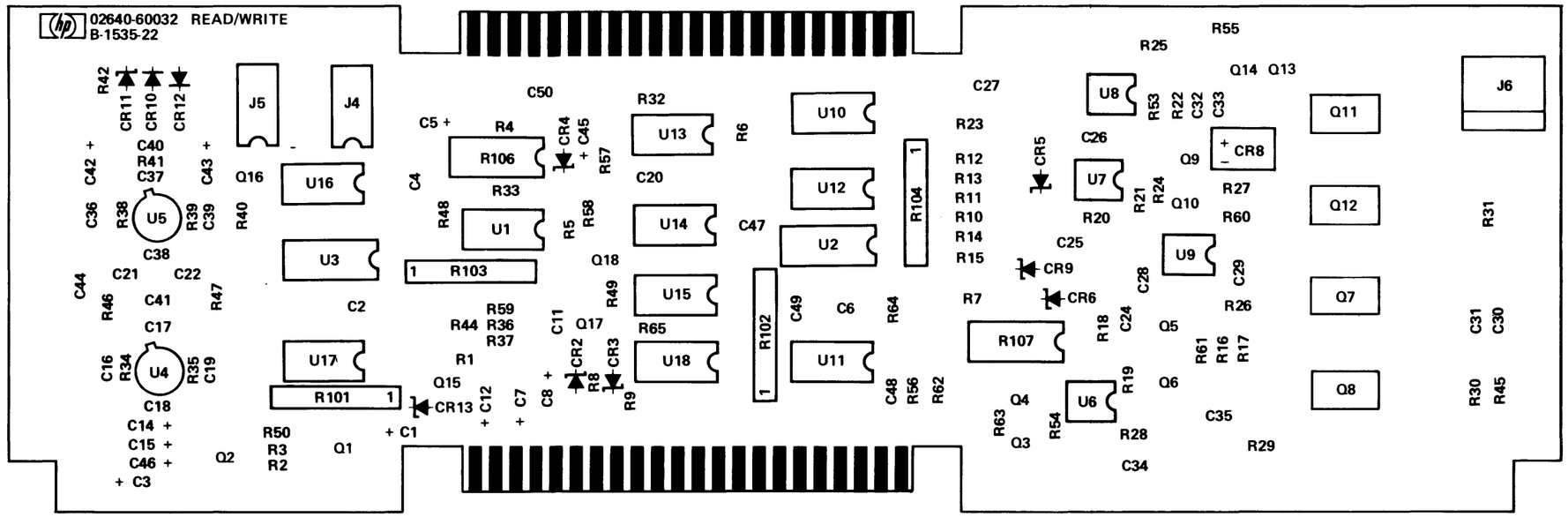


Figure 6
Read/Write PCA Component Location Diagram
AUG-01-76 13255-91032

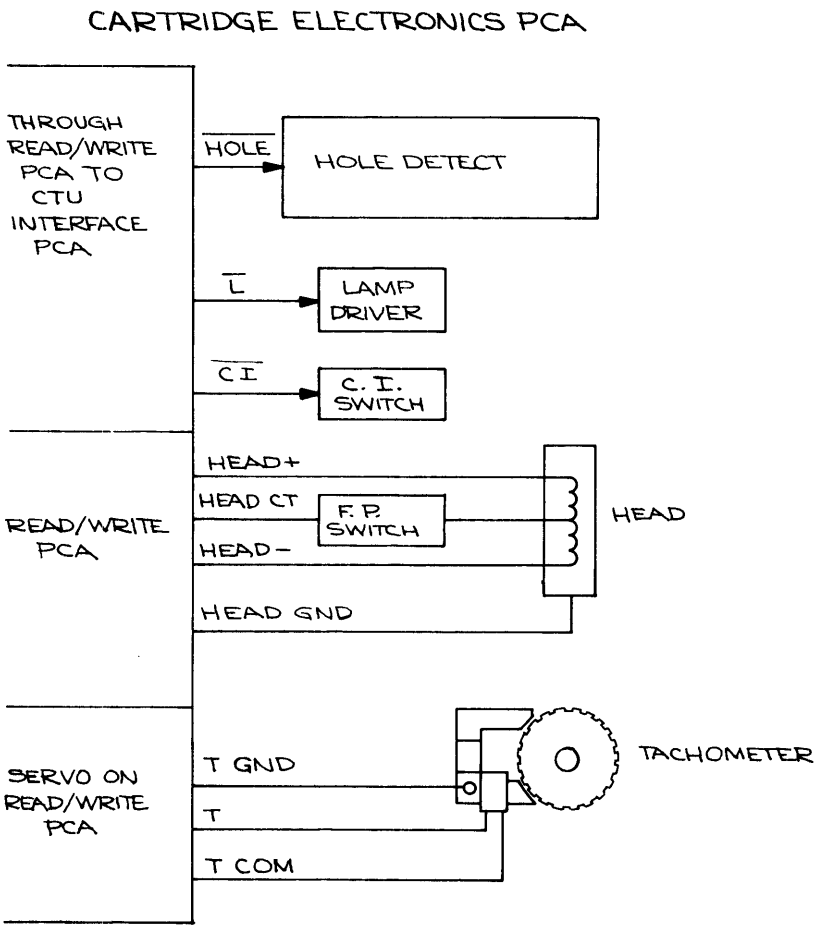


Figure 7
Cartridge Electronics PCA Block Diagram
AUG-01-76 13255-91032

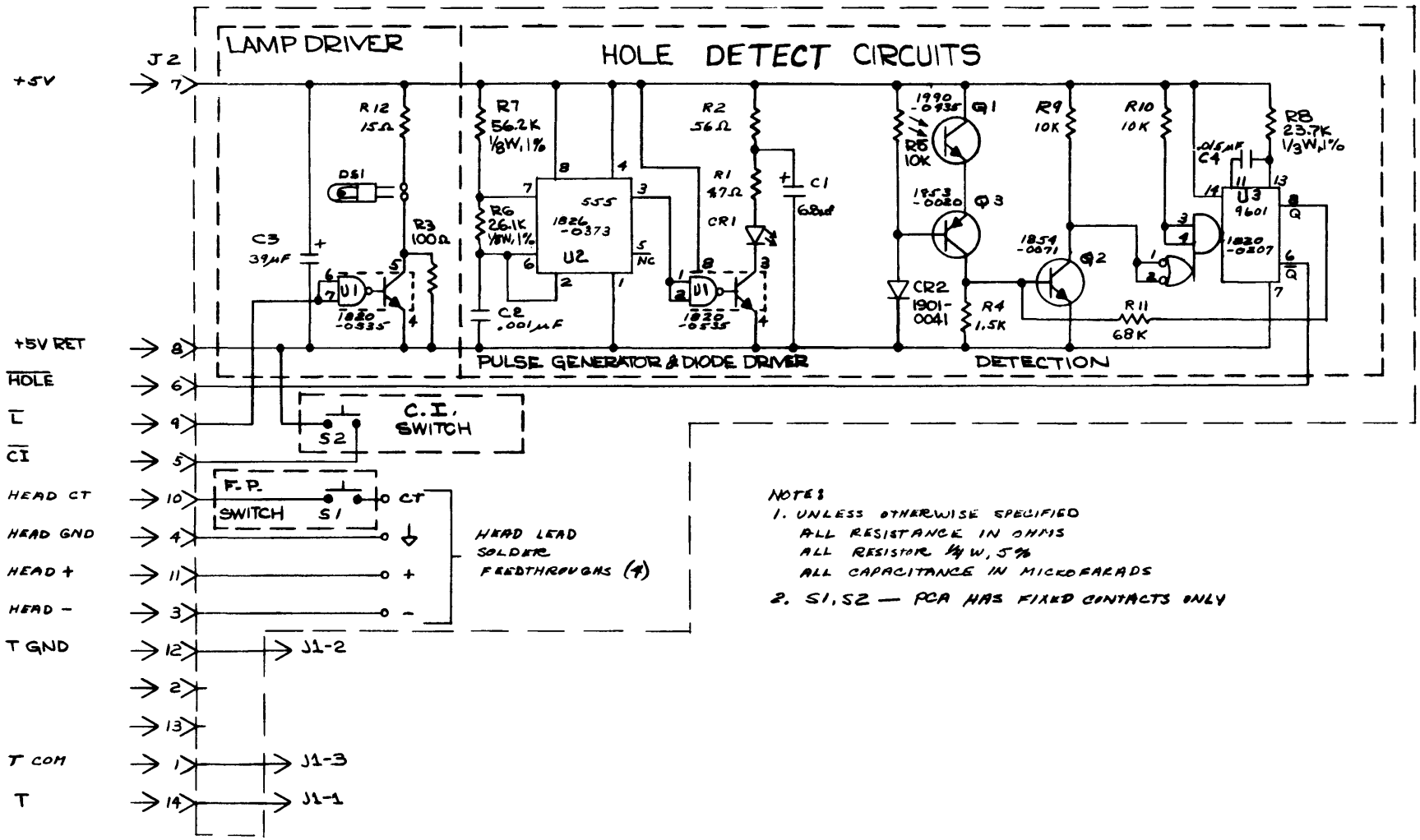


Figure 8
Cartridge Electronics PCA Schematic Diagram
AUG-01-76 13255-91032

02640-60034 CTU ELECTRONICS
B-1632-22

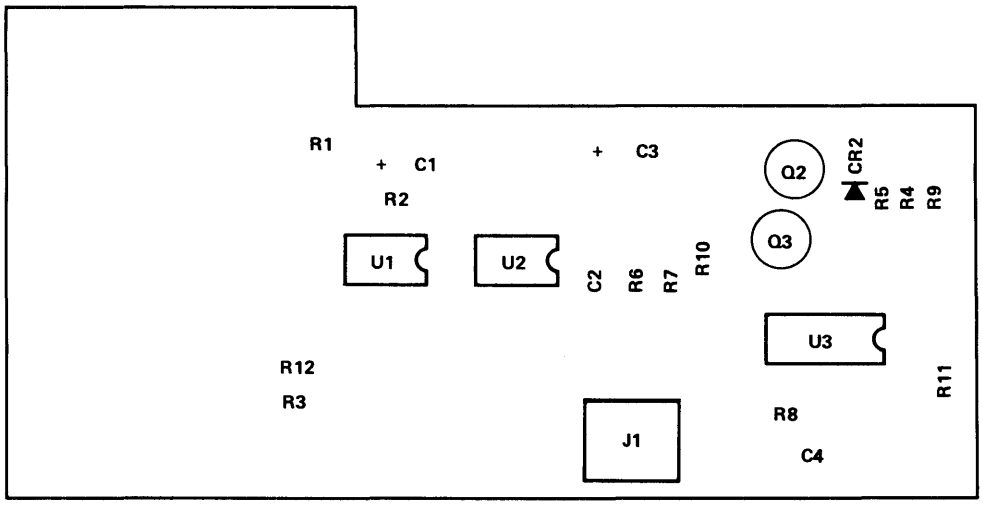


Figure 9
Cartridge Electronics PCA Compnent Location Diagram
AUG-01-76 13255-91032

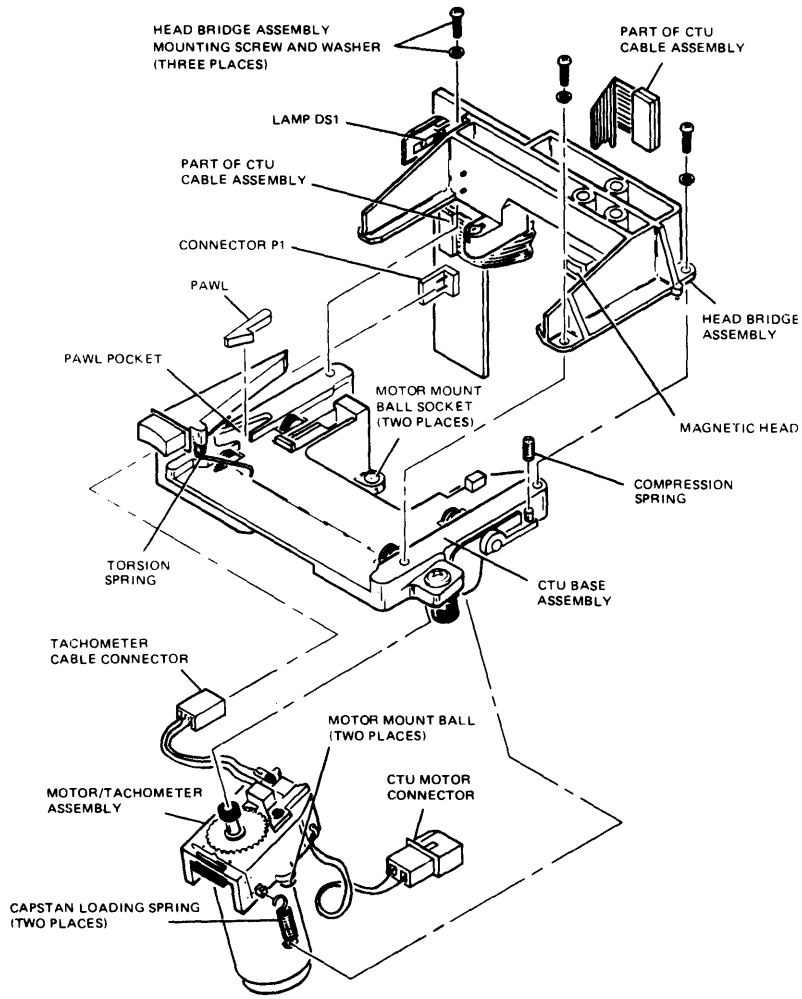
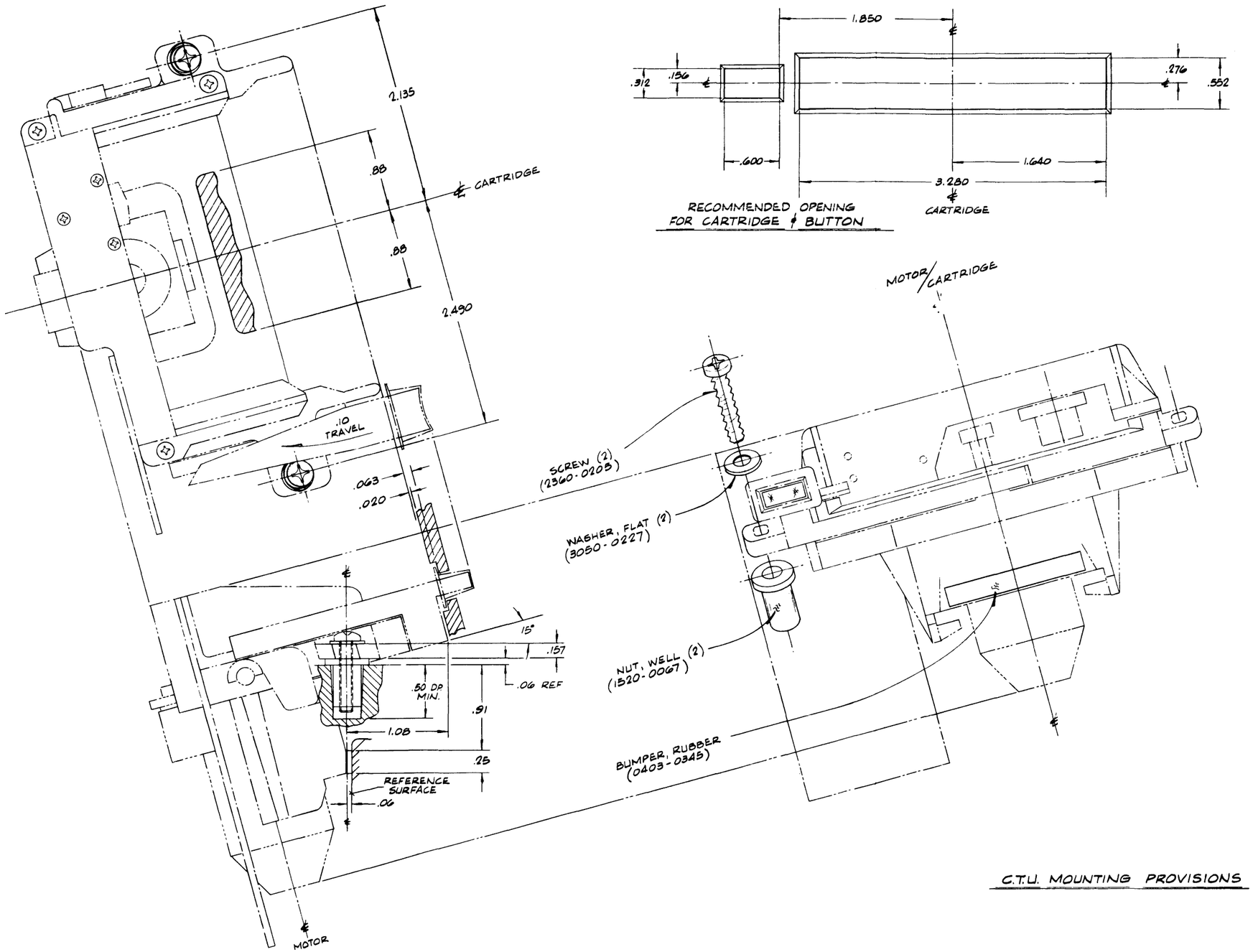


Figure 10
CTU Transport Exploded View Diagram
AUG-01-76 13255-91032



C.T.U. MOUNTING PROVISIONS

Figure 11
CTU Mounting Provisions Diagram
AUG-01-76 13255-91032

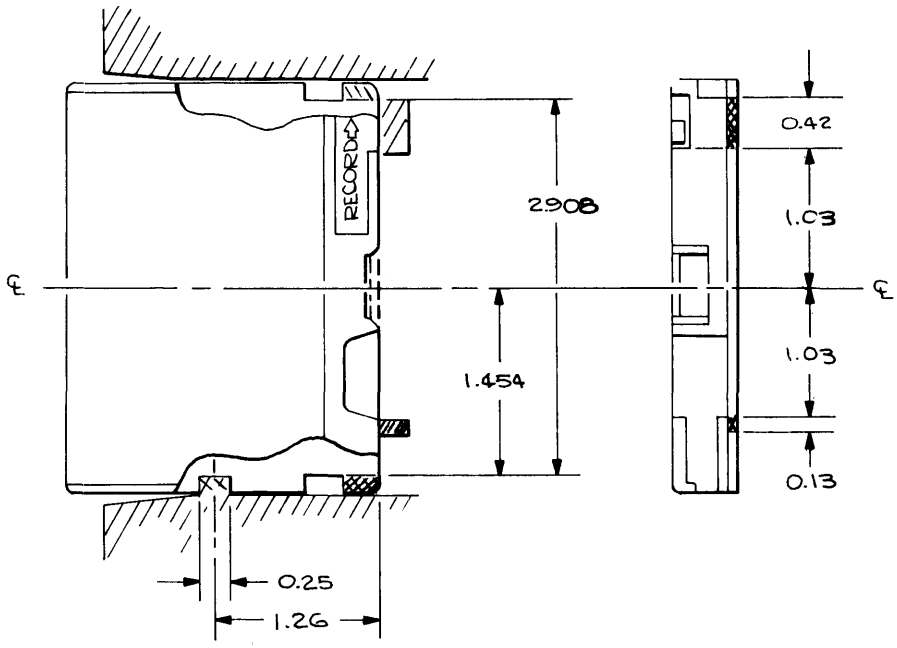


Figure 12
Cartridge Outline Diagram
AUG-01-76 13255-91032

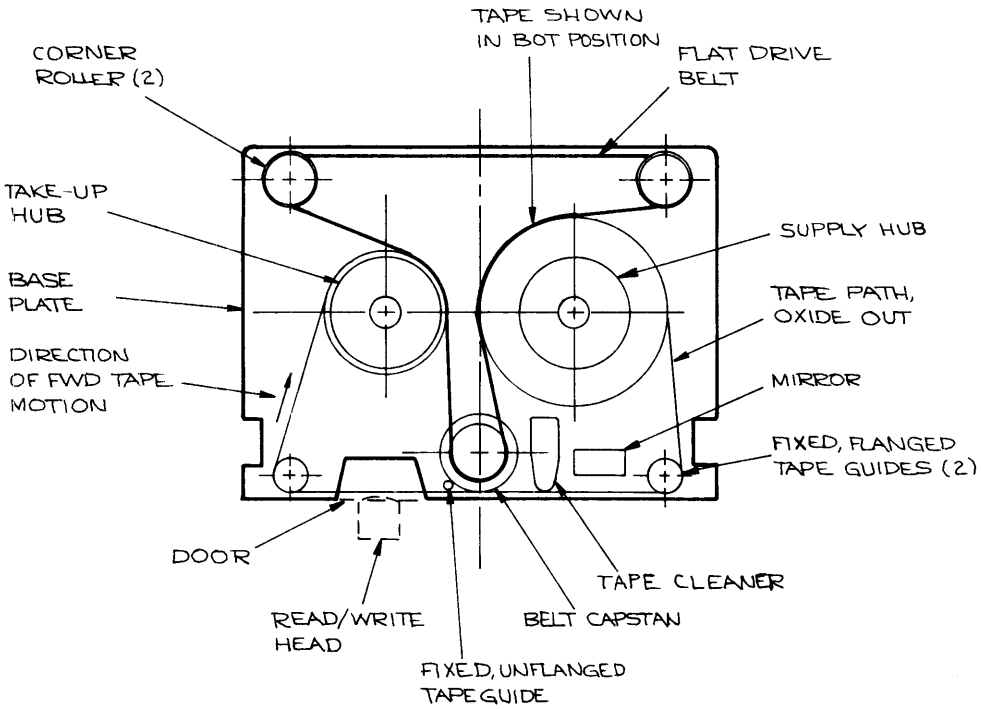
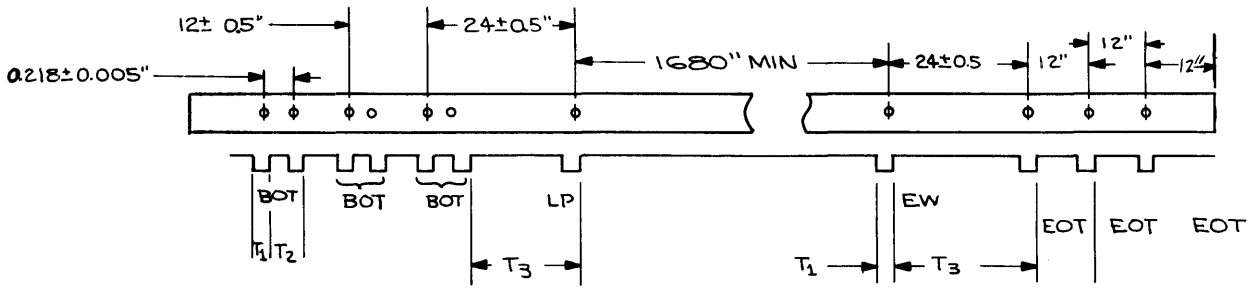


Figure 13
Tape Cartridge Diagram
AUG-01-76 13255-91032



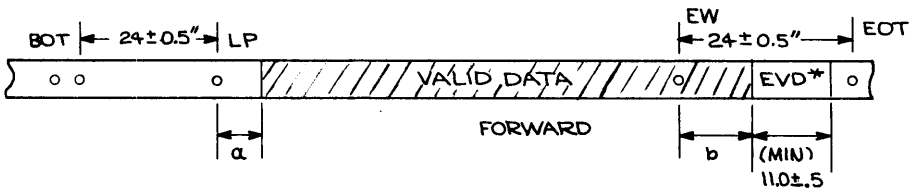
- BOT = BEGINNING OF TAPE (2 CONSECUTIVE HOLES) (3 PAIR BOT HOLES
- LP = LOAD POINT (1 HOLE)
- EW = EARLY WARNING (1 HOLE)
- EOT = END OF TAPE (1 HOLE) (3 EOT HOLES)

USING THE HOLE STATUS FROM THE CTU TRANSPORT ASSEMBLY, THE HOLE TIMING IS AS FOLLOWS;

SPEED	T_1 MIN	T_1 MAX	T_2 MIN	T_2 MAX	T_3 MIN	T_3 MAX
9-11 IPS	2.53 ms	8.57 ms	11.23 ms	25.2 ms	2.12 sec	2.7 sec
56-64 IPS	0.577 ms	1.49 ms	1.92 ms	3.3 ms	353 ms	450 ms

HOLE STATUS FORMAT

Figure 14
Hole Status Format Diagram
AUG-01-76 13255-91032



a) 0.55 INCHES BEHIND LP MIN.
b) 5.50 INCHES BEHIND EW MAX.

* EVD = END OF VALID DATA GAP

NOTE; THE READ/WRITE HEAD IS DISPLACED FROM THE HOLE DETECTOR BY APPROXIMATELY 1.5 INCHES & FROM THE TAPE CLEANER BY APPROXIMATELY 1.125 INCHES

Figure 15
Valid Recording Area Diagram
AUG-01-76 13255-91032

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60021	1	CONNECTOR ASSEMBLY, (2) REVISION DATE: 03-26-76	28480	02640-60021
	0403-0347	2	BUMPER FOOT, 0.25" W	13862	9668
	1251-1887	2	CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	71785	252-22-30-340

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60054	1	CTU BASE ASSEMBLY REVISION DATE: 06-19-76	28480	02640-60054
	0403-0253	1	BUMPER FOOT	00000	OBD
	0510-0052	1	RETAINER-RING .125-DIA STL CD-PL	97464	7100-12-CD
	0624-0333		SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	28480	0624-0337
	1460-1382	2	WIREFORM .16-IN-W 1.42-IN-LG MUW	28480	1460-1382
	1460-1411	1	SPRING-EXT .12-IN-OD .75-IN-LG MUW CD	28480	1460-1411
	1460-1455	1	SPRING-TRSN MUW CD	28480	1460-1455
	4040-0998	1	BUTTON RELEASE	00315	C-4040-0998-1
	4040-1012	1	BASE	28480	4040-1012
	4040-1095	1	LEVER RELEASE	28480	4040-1095
	02640-20006	4	ROLLER, LATCH	28480	02640-20006
	02640-40017	1	CLAMP, BUTTON	28480	02640-40017
	02640-40018	1	EJECTOR	28480	02640-40018
	02640-40019	1	BEZEL, BUTTON	28480	02640-40019

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60057	1	TACHOMETER COIL ASSEMBLY REVISION DATE: 05-19-76	28480	02640-60057
	0362-0505	1	TERMINAL-CRIMP TNG-R #2 26-22-AWG	28480	0362-0505
	1251-0670	3	CONTACT-CONN U/W-POST-TYPE FEM CRP	27264	08-50-0105
	1251-3201	1	CONNECTOR 3-PIN F POST TYPE	27264	09-50-7031
	8150-2353		WIRE 24AWG W 300V PVC 7X32 80C	28480	8150-2353
	9100-0648	1	COIL,TACH 2400+/-100 TURNS	28984	NO. 43 AWG

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60067	1	HEAD ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60067
	0624-0337	3	SCREW-TPG 2-56 .5-IN-LG PAN-HD-TORX STL	93907	235-02020-012
	1400-0249	1	CABLE TIE .062-.625-DIA .091-WD NYL	59730	TYB-23M-8
	1460-1383	2	SPRING-CPRSN .18-IN-OD .312-IN-LG MUW GD	84830	LC-0268-2-MW.
	3050-0675	1	WASHER-FL MTLC NO.-2 .089-IN-ID	86928	5712-156-32
	4040-1013	1	HEAD, MOUNT	28480	4040-1013
	9164-0061	1	HEAD- CART TAPE	28480	9164-0061

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60074	1	MAGNET ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60074
	0470-0515		ADHESIVE, ABLESTIK 293-1T EPOXY 1-PART	21109	293-1T
	1530-1780	2	POLE PIECE	28480	1530-1780
	9160-0240	1	MAGNET	28480	9160-0240

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60076	1	DISC/CAPSTAN ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60076
	1530-1781	1	MOTOR, CAPSTAN	28480	1530-1781
	1600-0491	1	DISC, TACH. .872" DIA	28480	1600-0491
	3030-0142	2	SCREW-SET 2-56 .125-IN-LG SMALL CUP-PT	28480	3030-0142

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60085	1	MOTOR CABLE ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60085
	0850-0006		TUBING-FLEX .204-ID PVC .02-WALL	96906	400/461 FR-1
	1251-0670	4	CONTACT-CONN U/W-POST-TYPE FEM CRP	27264	08-50-0105
	1251-2505	2	CONNECTOR 2-PIN F UTILITY	27264	03-09-1022
	1251-2600	4	CONTACT-CONN FEM CRP .093-IN-CONT-SZ	27264	02-09-1116
	1251-3277	1	CONNECTOR 4-PIN F POST TYPE	27264	09-50-7041
	8150-1540		WIRE 22AWG BK 300V PVC 7X30 80C	28480	8150-1540
	8150-1542		WIRE 22AWG R 300V PVC 7X30 80C	28480	8150-1542
	8150-1550		WIRE 22AWG W/BK 300V PVC 7X30 80C	28480	8150-1550
	8150-1552		WIRE 22AWG W/R 300V PVC 7X30 80C	28480	8150-1552

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60032	1	READ/WRITE ASSEMBLY DATE CODE: 8-1535-22 REVISION DATE: 08-06-76	28480	02640-60032
C1	0180-0106	2	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
C2	0160-0166	2	CAPACITOR-FXD .068UF +-10% 200WVDC POLYE	56289	292P68392
C3	0180-0106		CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
C4	0160-0166		CAPACITOR-FXD .068UF +-10% 200WVDC POLYE	56289	292P68392
C5	0180-0309	5	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C6	0140-0161	1	CAPACITOR-FXD 3932PF +-1% 300WVDC MICA	72136	DM20F3932RF0300WV1CR
C7	0180-1746	2	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
C8	0180-1746		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
C11	0150-0121	7	CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C12	0180-0309		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C14	0180-0309		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C15	0180-0309		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C16	0160-2260	2	CAPACITOR-FXD 13PF +-5% 500WVDC CER	28480	0160-2260
C17	0140-0190	4	CAPACITOR-FXD 39PF +-5% 300WVDC MICA	72136	DM15E390J0300WV1CR
C18	0140-0190		CAPACITOR-FXD 39PF +-5% 300WVDC MICA	72136	DM15E390J0300WV1CR
C19	0160-2260		CAPACITOR-FXD 13PF +-5% 500WVDC CER	28480	0160-2260
C20	0160-0159	3	CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C21	0140-0200	2	CAPACITOR-FXD 390PF +-5% 300WVDC MICA	72136	DM15F391J0300WV1CR
C22	0140-0200		CAPACITOR-FXD 390PF +-5% 300WVDC MICA	72136	DM15F391J0300WV1CR
C24	0160-0153	4	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C25	0160-0167	1	CAPACITOR-FXD .082UF +-10% 200WVDC POLYE	56289	292P82392
C26	0160-0159		CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C27	0160-3238	1	CAPACITOR-FXD .15UF +-5% 200WVDC POLYE	56289	292P15452
C28	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C29	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C30	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C31	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C32	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C33	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C34	0160-0970	1	CAPACITOR-FXD .47UF +-10% 80WVDC POLYE	28480	0160-0970
C35	0160-0163	1	CAPACITOR-FXD .033UF +-10% 200WVDC POLYE	56289	292P33392
C36	0160-2263	2	CAPACITOR-FXD 18PF +-5% 500WVDC CER	28480	0160-2263
C37	0140-0190		CAPACITOR-FXD 39PF +-5% 300WVDC MICA	72136	DM15E390J0300WV1CR
C38	0140-0190		CAPACITOR-FXD 39PF +-5% 300WVDC MICA	72136	DM15E390J0300WV1CR
C39	0160-2263		CAPACITOR-FXD 18PF +-5% 500WVDC CER	28480	0160-2263
C40	0160-0153		CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C41	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C42	0180-0291	3	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C43	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C44	0150-0121		CAPACITOR-FXD .1UF +80-20% 50WVDC CER	28480	0150-0121
C45	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C46	0180-0309		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C47	0160-2055	3	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C48	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C49	0160-0159		CAPACITOR-FXD 6800PF +-10% 200WVDC POLYE	56289	292P68292
C50	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
CR2	1902-0049	5	DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	28480	1902-0049
CR3	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	28480	1902-0049
CR4	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	28480	1902-0049
CR5	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	28480	1902-0049
CR6	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	28480	1902-0049
CR8	1901-0364	1	DIODE-FW BRDG 200V 1A	04713	SDA 10185-4
CR9	1902-0025	1	DIODE-ZNR 10V 5% DO-7 PD=.4W TC=+.06%	28480	1902-0025
CR10	1901-0040	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR11	1902-0064	1	DIODE-ZNR 7.5V 5% DO-7 PD=.4W TC=+.05%	28480	1902-0064
CR12	1901-0460	1	DIODE-STABISTOR 15V 150MA DO-7	28480	1901-0460
CR13	1902-3059	1	DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	15818	CD 35586
E1	0360-0124	3	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
E2	0360-0124		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
E3	0360-0124		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
J4	1200-0474	2	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0474
J5	1200-0474		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0474
J6	1251-3873	1	CONNECTOR 4-PIN M POST TYPE	27264	09-88-2041
Q1	1854-0215	7	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q2	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q3	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q4	1853-0036	3	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q5	1855-0052	4	TRANSISTOR MOSFET P-CHAN D-MODE TO-92 SI	07263	2N4360

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			READ/WRITE ASSEMBLY CONT'D.		
Q6	1855-0052		TRANSISTOR MOSFET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q7	1854-0653	2	TRANSISTOR NPN SI PD=60W	04713	MJE521K
Q8	1853-0369	2	TRANSISTOR PNP SI PD=60W	04713	MJE371K
Q9	1855-0052		TRANSISTOR MOSFET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q10	1855-0052		TRANSISTOR MOSFET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q11	1854-0653		TRANSISTOR NPN SI PD=60W	04713	MJE521K
Q12	1853-0369		TRANSISTOR PNP SI PD=60W	04713	MJE371K
Q13	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q14	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q15	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q16	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q17	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
Q18	1854-0215		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	SPS 3611
R1	0757-0461	6	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R2	0698-3438	4	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-TO-147R-F
R3	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R4	0757-0462	8	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R5	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R6	0757-0420	4	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-TO-751-F
R7	0757-0123	1	RESISTOR 34.8K 1% .125W F TC=0+-100	24546	C4, T-0
R8	0698-3438		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-TO-147R-F
R9	0698-3438		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-TO-147R-F
R10	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R11	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R12	0698-3260	2	RESISTOR 464K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
R13	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R14	0698-3260		RESISTOR 464K 1% .125W F TC=0+-100	91637	CMF-55-1, T-1
R15	0757-0461		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-6812-F
R16	0757-0459	6	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R17	0757-0459		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R18	0757-0459		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R19	0757-0459		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R20	0698-3157	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1962-F
R21	0757-0459		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R22	0757-0459		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R23	0698-3464	1	RESISTOR 1.47M 1% .5W F TC=0+-100	91637	MFF-1/2-10
R24	0757-0447	1	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1622-F
R25	0757-0199	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2152-F
R26	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R27	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R28	0698-3453	2	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1963-F
R29	0698-3158	2	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2372-F
R30	0757-0346	2	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-TO-10R0-F
R31	0811-1552	1	RESISTOR .56 5% 2W PW TC=0+-800	75042	BWH2-9/16-J
R32	0757-0438	4	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5111-F
R33	0757-0428	2	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1621-F
R34	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R35	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R36	0757-0443	4	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1102-F
R37	0757-0401	2	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
R38	0698-3456	2	RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2873-F
R39	0698-3456		RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2873-F
R40	0698-3150	3	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2371-F
R42	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4 -1/8 -TO-751-F
R43	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2371-F
R44	0698-3158		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2372-F
R45	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-TO-10R0-F
R46	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5111-F
R47	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5111-F
R48	0683-8245	1	RESISTOR 820K 5% .25W FC TC=-800/+900	01121	CB8245
R49	0757-0443		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1102-F
R50	0698-3438		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-TO-147R-F
R53	0698-3453		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1963-F
R54	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5111-F
R55	2100-3207	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	73138	72-145-0
R56	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
R57	0757-0428		RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1621-F
R59	0698-0082	1	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-TO-4640-F
R60	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R58	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-TO-751-F
R61	0757-0462		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-TO-7502-F
R62	0757-0443		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1102-F
R63	0757-0443		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1102-F
R64	0698-3150		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2371-F
R65	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-TO-751-F
R101	1810-0125	2	NETWORK-RES 8-PIN-SIP .125-PIN-SPCG	11236	750
R102	1810-0125		NETWORK-RES 8-PIN-SIP .125-PIN-SPCG	11236	750
R103	1810-0151	2	NETWORK-RES 7-PIN-SIP .15-PIN-SPCG	28480	1810-0151
R104	1810-0151		NETWORK-RES 7-PIN-SIP .15-PIN-SPCG	28480	1810-0151
R106	1810-0037	2	NETWORK-RES 16-PIN-DIP .1-PIN-SPCG	11236	760 SERIES/16 PIN

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			READ/WRITE ASSEMBLY CONT'D.		
R107	1810-0037		NETWORK-RES 16-PIN-DIP .1-PIN-SPCG	11236	760 SERIES/16 PIN
U1	1826-0138	1	IC LM 339 COMPARATOR	27014	LM339N
U2	1820-1260	1	IC-DIGITAL SN74221N TTL DUAL	01295	SN74221N
U3	1820-0491	1	IC-DIGITAL SN74145N TTL 4 BCD-TO-DEC	01295	SN74145N
U4	1826-0200	2	IC MC 1420 OP AMP	04713	MC1420G
U5	1826-0200		IC MC 1420 OP AMP	04713	MC1420G
U6	1826-0139	4	IC MC 1458 OP AMP	04713	MC1458P1
U7	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
U8	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
U9	1826-0139		IC MC 1458 OP AMP	04713	MC1458P1
U10	1820-0577	2	IC-DIGITAL SN7416N TTL HEX 1	01295	SN7416N
U11	1820-0514	1	IC-DIGITAL SN7426N TTL QUAD 2 NAND	01295	SN7426N
U12	1820-1208	1	IC-DIGITAL SN74LS32N TTL LS QUAD 2 OR	01295	SN74LS32N
U13	1820-1416	1	IC-DIGITAL SN74LS14N TTL LS HEX 1 INV	01295	SN74LS14N
U14	1820-1202	1	IC-DIGITAL SN74LS10N TTL LS TPL 3 NAND	01295	SN74LS10N
U15	1820-1425	1	IC-DIGITAL SN74LS132N TTL LS QUAD 2 NAND	01295	SN74LS132N
U16	1820-0981	1	IC-DIGITAL CD4016AY CMOS QUAD BILATL	02735	CD4016AY
U17	1820-0577		IC-DIGITAL SN7416N TTL HEX 1	01295	SN7416N
U18	1820-1201		IC-DIGITAL SN74LS08N TTL LS QUAD 2 AND	01295	SN74LS08N
			MISCELLANEOUS		
	0340-0585	1	INSULATOR MICA	28480	0340-0585
	1200-0087	4	INSULATOR-BSHG-FLG NYLON	28480	1200-0087
	2190-0004	4	WASHER-LK INTL T NO.-4 .115-IN-ID	0G791	418-8C EVERLOCK WASHER
	2200-0143	4	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI	28480	2200-0143
	2260-0002	4	NUT-HEX-DBL-CHAM 4-40-THD .062-THK	28480	2260-0005
	6040-0239		GREASE:SILICONE COMPOUND	05820	120-5GM
	02640-20001	1	HEAT SINK	28480	02640-20001

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60033	1	CTU INTERFACE ASSEMBLY DATE CODE: 8-1508-22 REVISION DATE: 04-15-76	28480	02640-60033
C1	0180-0393	1	CAPACITOR-FXD 39UF+-10% 10VDC TA	56289	150D396X901082
C2	0160-2055	17	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C3	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C4	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C5	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C7	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C9	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C10	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C11	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C12	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C13	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C14	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C15	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C16	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C17	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
C18	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
E1	0360-0124	3	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
E2	0360-0124		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
E3	0360-0124		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-0124
R1	1810-0121	1	NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0121
U11	1820-1209	5	IC-DIGITAL SN74LS38N TTL LS QUAD 2 NAND	01295	SN74LS38N
U12	1820-1209		IC-DIGITAL SN74LS38N TTL LS QUAD 2 NAND	01295	SN74LS38N
U13	1820-1100	2	IC-DIGITAL SN74298N TTL QUAD 2	01295	SN74298N
U14	1820-1276	2	IC-DIGITAL SN74LS194AN TTL LS R-S	01295	SN74LS194AN
U15	1820-1196	2	IC-DIGITAL SN74LS174N TTL LS HEX	01295	SN74LS174N
U16	1820-1281	1	IC-DIGITAL SN74LS139N TTL LS DUAL 2	01295	SN74LS139N
U17	1820-1282	3	IC-DIGITAL SN74LS109N TTL LS DUAL	01295	SN74LS109N
U18	1820-1201	1	IC-DIGITAL SN74LS08N TTL LS QUAD 2 AND	01295	SN74LS08N
U19	1820-1203	3	IC-DIGITAL SN74LS11N TTL LS TPL 3 AND	01295	SN74LS11N
U21	1820-1112	2	IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
U22	1820-1209		IC-DIGITAL SN74LS38N TTL LS QUAD 2 NAND	01295	SN74LS38N
U23	1820-1203		IC-DIGITAL SN74LS11N TTL LS TPL 3 AND	01295	SN74LS11N
U24	1820-1112		IC-DIGITAL SN74LS74N TTL LS DUAL	01295	SN74LS74N
U25	1820-1282		IC-DIGITAL SN74LS109N TTL LS DUAL	01295	SN74LS109N
U26	1820-1282		IC-DIGITAL SN74LS109N TTL LS DUAL	01295	SN74LS109N
U27	1820-1197	2	IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
U28	1820-1196		IC-DIGITAL SN74LS174N TTL LS HEX	01295	SN74LS174N
U29	1820-1211	1	IC-DIGITAL SN74LS86N TTL LS QUAD 2	01295	SN74LS86N
U31	1820-1209		IC-DIGITAL SN74LS38N TTL LS QUAD 2 NAND	01295	SN74LS38N
U32	1820-1209		IC-DIGITAL SN74LS38N TTL LS QUAD 2 NAND	01295	SN74LS38N
U33	1820-1100		IC-DIGITAL SN74298N TTL QUAD 2	01295	SN74298N
U34	1820-1276		IC-DIGITAL SN74LS194AN TTL LS R-S	01295	SN74LS194AN
U35	1820-1199	3	IC-DIGITAL SN74LS04N TTL LS HEX 1	01295	SN74LS04N
U36	1820-1202	3	IC-DIGITAL SN74LS10N TTL LS TPL 3 NAND	01295	SN74LS10N
U37	1820-1215	1	IC-DIGITAL SN74LS136N TTL LS QUAD 2	01295	SN74LS136N
U38	1820-1202		IC-DIGITAL SN74LS10N TTL LS TPL 3 NAND	01295	SN74LS10N
U39	1820-1199		IC-DIGITAL SN74LS04N TTL LS HEX 1	01295	SN74LS04N
U110	1820-1203		IC-DIGITAL SN74LS11N TTL LS TPL 3 AND	01295	SN74LS11N
U111	1820-1197		IC-DIGITAL SN74LS00N TTL LS QUAD 2 NAND	01295	SN74LS00N
U112	1820-1202		IC-DIGITAL SN74LS10N TTL LS TPL 3 NAND	01295	SN74LS10N
U210	1820-1144	1	IC-DIGITAL SN74LS02N TTL LS QUAD 2 NOR	01295	SN74LS02N
U211	1820-1199		IC-DIGITAL SN74LS04N TTL LS HEX 1	01295	SN74LS04N
U212	1820-0716	4	IC-DIGITAL SN74161N TTL BIN SYNCHRO	01295	SN74161N
U213	1820-0716		IC-DIGITAL SN74161N TTL BIN SYNCHRO	01295	SN74161N
U214	1820-0716		IC-DIGITAL SN74161N TTL BIN SYNCHRO	01295	SN74161N
U310	1820-1208		IC-DIGITAL SN74LS32N TTL LS QUAD 2 OR	01295	SN74LS32N
U311	1820-0716		IC-DIGITAL SN74161N TTL BIN SYNCHRO	01295	SN74161N
U312	1820-1194	2	IC-DIGITAL SN74LS193N TTL LS BIN	01295	SN74LS193N
U313	1820-1194		IC-DIGITAL SN74LS193N TTL LS BIN	01295	SN74LS193N
W1	8159-0005	1	WIRE 22AWG W PVC 1X22 80C	28480	8159-0005

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60034	1	CTU ELECTRONICS ASSEMBLY DATE CODE: B-1632-22 REVISION DATE: 08-04-76	28480	02640-60034
C1	0180-1701	1	CAPACITOR-FXD 6.8UF+-20% 6VDC TA	56289	1500685X0006A2
C2	0160-0153	1	CAPACITOR-FXD 1000PF +-10% 200WVDC POLYE	56289	292P10292
C3	0180-0393	1	CAPACITOR-FXD 39UF+-10% 10VDC TA	56289	1500396X9010B2
C4	0160-0194	1	CAPACITOR-FXD .015UF +-10% 200WVDC POLYE	56289	292P15392
CR2	1901-0040	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
DS1	2140-0450	1	LAMP-INCAND 7362 5VDC 115MA T-1-3/4-BULB	71744	CM7-7362-AS25%
	4040-1017	1	SHIELD, LIGHT	28480	4040-1017
J1	1251-3192	1	CONNECTOR 3-PIN M POST TYPE	27264	09-60-1031(2403-03A)
Q2	1854-0071	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q3	1853-0020	1	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
R1	0683-0475	1	RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB47G5
R2	0683-5605	1	RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
R3	0683-1015	1	RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
R4	0683-1525	1	RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
R5	0683-1035	3	RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
R6	0698-3159	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2612-F
R7	0757-0459	1	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5622-F
R8	0698-3158	1	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-TO-2372-F
R9	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
R10	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
R11	0683-6835	1	RESISTOR 68K 5% .25W FC TC=-400/+800	01121	CB6835
R12	0683-1505	1	RESISTOR 15 5% .25W FC TC=-400/+500	01121	CB1505
U1	1820-0535	1	IC-DIGITAL SN754518P TTL DUAL 2 AND	01295	SN754518P
U2	1826-0373	1	IC LINEAR		
U3	1820-0207	1	IC-DIGITAL 9601PC TTL MONOSTBL	07263	9601PC
	1251-4099	2	CONN - SC		

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60050	1	CTU TRANSPORT ASSEMBLY REVISION DATE: 06-30-76	28480	02640-60050
	0624-0314	3	SCREW-IPG 4-20 .375-IN-LG PAN-HD-POZI	28480	0624-0315
	1460-1381	2	SPRING-EXT .187-IN-OD .75-IN-LG MUW CD	84830	LE-022B-00-MW
	1460-1440	1	SPRING-CPRSN .12-IN-OD .25-IN-LG MUW CD	84830	LC-014A-1MW
	1520-0067	2	SHOCK MOUNT .44-EFF-WGT .31" OD	61957	WELL-NUT E-632
	2190-0020	3	WASHER-LK HLCL NO.-5 .128-IN-ID	28480	2190-0020
	2360-0205	2	SCREW-MACH 6-32 .75-IN-LG PAN-HD-POZI	28480	2360-0205
	3050-0227	2	WASHER-FL MTLC NO.-6 .149-IN-ID	80120	AN960C-6
	7124-5066	1	LABEL		
	02640-40016	1	PANL	28480	02640-40016
	02640-60054	1	ASSY, CTU BASE	28480	02640-60054
	02640-60055	1	ASSY, MOTOR/TACH	28480	02640-60055
	02640-60056	1	ASSY, HEAD BRIDGE	28480	02640-60056

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60055	2	MOTOR/TACHOMETER ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60055
	0050-1831	1	CASTING	28480	0050-1831
	0403-0333	1	BUMPER FOOT, RUBBER 0.312" W	13862	459
	0470-0443		ADHESIVE BONDING:#224-1	00000	OBD
	0515-0029	3	SCREW-MACH M2 X 0.40 6-MM-LG 90 DEG	28480	0515-0029
	0624-0296	2	SCREW-TPG 2-56 .375-IN-LG PAN-HD-POZI	28480	0624-0300
	1251-2510	1	CONNECTOR 2-PIN M UTILITY	27264	03-09-2022
	1251-2599	2	CONTACT-CONN MALE CRP .093-IN-CONT-SZ	27264	02-09-2116
	1400-0249	1	CABLE TIE .062-.625-DIA .091-WD NYL	59730	TYB-23M-8
	1460-1412	1	WIREFORM .699-IN-W 1.032-IN-LG MUW CD	28480	1460-1412
	2190-0889	2	WASHER-SPR BLVL NO.-2 .093-IN-ID	70472	B0187-007
	3140-0544	1	MOTOR-DC PERM MAG 6V 5000-RPM	28480	3140-0544
	02640-60057	1	ASSY, TACH COIL	28480	02640-60057
	02640-60076	1	ASSY, DSC/CAPSTAN	28480	02640-60076
	02640-60074	1	ASSY, MAGNET	28480	02640-60074

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60056	1	HEAD BRIDGE ASSEMBLY REVISION DATE: 03-13-76	28480	02640-60056
	0624-0307	2	SCREW-TPG 2-28 .25-IN-LG PAN-HD-PHL STL	28480	0624-0309
	0624-0333	2	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	28480	0624-0337
	1950-0435	1	PHOTOTRANSISTOR VAX=20V BVECO=5V	07263	FPT120
	1950-0492	1	LED-INFRARED IF=100MA-MAX BVR=2V VF=1.8V	28480	1990-0492
	02640-00012	2	SWITCH, CONTACT	28480	02640-00012
	02640-40015	2	PLUNGER	28480	02640-40015
	02640-60034	1	ASSY, CTU ELECTRONICS	28480	02640-60034
	02640-60066	1	ASSY, CABLE CTU	28480	02640-60066
	02640-60067	1	ASSY, HEAD	28480	02640-60067

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60066	1	CTU CABLE ASSEMBLY REVISION DATE: 05-15-76	28480	02640-60066
	0400-0191	1	GROMMET, CHANNEL 0.125" W	06915	DSC-1DUROSTRIP SPEC
	1251-2499	2	CONNECTOR 14-PIN M RECTANGULAR	76381	3406-0000
	8120-1458		CA RBN 14 x 28 GA UL	76381	3365-14

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	02640-60102	1	CTU BEZEL ASSEMBLY REVISION DATE: 09-18-76	28480	02640-60102
	0905-0126	4	"O" RING, .114"-ID	5E440	03.006
	1460-1448	2	SPRING-TRSN MUW CD	28480	1460-1448
	2190-0006	4	WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0006
	2360-0219	4	SCREW-MACH 6-32 1.375-IN-LG PAN-HD-POZI	28480	2360-0219
	4040-1014	2	DOOR, BEZEL	28480	4040-1014
	4040-1015	1	BEZEL	28480	4040-1015
	02644-00003	1	STIFFENER, BEZEL	28480	02644-00003
	0460-1062		TAPE - INDL .375W		
	3050-0247	4	WASHER - #6 FIBER		