HP 13255

CARTRIDGE TAPE MODULE

Manual Part No. 13255-91032

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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 pro -vided by the Backplane Assembly and CTU Interface PCA. Information on CTU Interface is contained in a seperate module. 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. The CTU is supplied with a thin stainless steel grounding strap attached to the drive motor.

During installation of the CTUs the ground strap attaches to the CTU shield located in the mainframe. This improved grounding and shielding of the CTU decreases susceptibility of CTU failure from electrostatic discharge (ESD).

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
02640-60242	Cartridge Electronics PCA	3.8 x 2.0 x 1.3	0.10
02640-60254	CTU Transport Assembly	5.1 x 3.6 x 3.8	0.80
02640-60255	Motor/Tachometer Assembly	N/A	N/A
02640-60066	CTU Cable Assembly	N/A	N/A
02640-60067	Head Assembly	N/A	N/A
02640-60085	Motor Cable Assembly	N/A	N/A
02640-60177	CTU Bezel Assembly	N/A	N/A
98200A	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:

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

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	+5V RET	+5V Return
-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	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	+5V RET	+5V Return
-13	+5V RET	+5V Return
-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 ($\overline{\text{Read Enable}}$)
-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	+5V RET	+5V Return
-3	TCOM	Tachometer Coil (Common), DC Level +2.5V
J2 -1	TCOM	Tachometer Coil (Common), DC Level +2.5V
-2	+5V RET	+5V Return
-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	+5V RET	+5V Return
-13	+5V RET	+5V Return
-14	T	Tachometer Coil, AC Signal, Frequency Depends on Motor Speed

Table 5.0 Module Bus Pin Assignments

Function Performed: Read Data From CTU

Poll Bit: Bit 7

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

Function Specifier: ADDR5 = 1

Data Bus Bit Interpretation:

B7 Data Bit 7
(Most significant bit of data)

B6 Data Bit 6

B5 Data Bit 5

B4 Data Bit 4

B3 Data Bit 3

B2 Data Bit 2

B1 Data Bit 1

B0 Data Bit 0
(Least significant bit of data)

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
1	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 5.1 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	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 = 0	X	ADDR 8
	X	ADDR 7
	X	ADDR 6
Data Bus Bit Interpretation:	0	ADDR 5
	1	ADDR 4
B7 - Not Applicable	X	ADDR 3
	X	ADDR 2
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.	X	ADDR 1
	X	ADDR 0
	B7	BUS 7
	B6	BUS 6
	B5	BUS 5
B5 - GAP is the output of the gap detector on the Read/Write PCA.	B4	BUS 4
	B3	BUS 3
	B2	BUS 2
B4 - HOLE is set to "1" whenever a hole is detected on the tape and is cleared when status is read.	B1	BUS 1
	B0	BUS 0
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.	1=Logical 1=Bus Low 0=Logical 0=Bus High X=Don't Care	

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

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

3.1 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.)

3.0.1 UNIT FUNCTION DECODER - READ/WRITE PCA.

3.0.1.1 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.

3.0.1.2 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 driven by $\overline{DATA}$ as shown below.

1 - Of - 10 Decoder (U3)
Truth Table

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

3.0.2 WRITE CURRENT CIRCUIT - READ/WRITE PCA.

3.0.2.1 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.

3.0.2.2 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.

3.0.2.3 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.

3.0.2.4 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 reaches 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.

3.0.3 READ SELECT SWITCH - READ/WRITE PCA.

3.0.3.1 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.

3.0.3.2 Refer to the truth table in section 3.0.1.2 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.

3.0.4 READ AMPLIFIER CIRCUIT - READ/WRITE PCA.

3.0.4.1 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).

3.0.4.2 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.

3.0.4.3 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.

3.0.4.4 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.

3.0.5 GAP DETECT CIRCUIT - READ/WRITE PCA.

3.0.5.1 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.

3.0.5.2 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.

3.0.5.3 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.

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

3.0.6.1 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.

3.0.6.2 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.

3.0.7 AMPLIFIER SELECT LOGIC - READ/WRITE PCA.

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

3.0.7.2 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.

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

3.0.8.1 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.

3.0.8.2 $\overline{FFD}$, $\overline{SFD}$, $\overline{FREV}$ and $\overline{SREV}$ 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.

3.0.8.3 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.

3.0.9 CTU DRIVE CIRCUITS - READ/WRITE PCA.

3.0.9.1 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.

3.0.9.2 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).

3.0.10 CARTRIDGE DETECT CIRCUIT - READ/WRITE PCA.

3.0.10.1 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.

3.0.10.2 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.

3.1 FUNCTIONAL DESCRIPTION - CARTRIDGE ELECTRONICS PCA. Refer to the block diagram (figure 7), schematic diagram (figure 8), component location diagram (figure 9), and parts lists (02640-60242 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.

3.1.1 CI SWITCH - CARTRIDGE ELECTRONICS PCA.

3.1.1.1 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.

3.1.1.2 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.

3.1.2 FP SWITCH - CARTRIDGE ELECTRONICS PCA.

3.1.2.1 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.

3.1.2.2 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.

3.1.3 LAMP DRIVER - CARTRIDGE ELECTRONICS PCA.

3.1.3.1 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.

3.1.3.2 The lamp driver circuit consists of DS1, R10, R11, and 1/2 of U1. When the output of U1 is in the high state (lamp off), R10 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. R11 limits the current through DS1 to achieve longer lamp life.

3.1.4 HOLE DETECT - CARTRIDGE ELECTRONICS PCA.

3.1.4.1 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 13.6Khz. 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 pulse stretcher. The time out of the pulse stretcher is slightly longer than the time period of 12Khz. Therefore, the output of the stretcher will remain true as long as it receives an input of at least 12Khz. By measuring the time that the stretcher 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.

3.1.4.2 The pulse generator consists of U2, R3, R4 and C2. The resistors and capacitor control the frequency and symmetry of the output. The frequency is 13.6 +/-1.5 kHz. The output of U2, Pin 3 has the foll owing waveform.

3.1.4.3 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.

3.1.4.4 The detection circuit consists of Q1, Q2, Q3, CR2, U3, R5, R6, R7, R8, R9, 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, discharging C4 through R 8. U3 is a dual schmitt input gate to detect the state of charge on C4. 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 fo 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. R6 sets the threshold of the detector circuit. Q1 must provide enough current to raise the voltage drop across R6 above the V(BE) of Q2 before Q2 will turn on. R9 is the collector load for Q2 and provides current for the input of U3 and charging current for C4. R7 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.

3.2 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 (02640-60254, 02640-60057, 02640-60067, 02640-60085,02640-60177 and 02640-60247) located in the appendix.

The CTU Transport Assembly consists of a single major assembly which fastens to the terminal mainframe with two captive screws and the CTU ground strap, (for electrostatic discharge (ESD) protection) attaches to the CTU shield located in the mainframe. 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.

3.2.1 BASE ASSEMBLY - CTU TRANSPORT ASSEMBLY.

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

3.2.1.2 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.

3.2.1.3 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.

3.2.2 HEAD BRIDGE ASSEMBLY - CTU TRANSPORT ASSEMBLY.

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

3.2.2.2 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.

3.2.2.3 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.

3.2.2.4 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.

3.2.3 MOTOR/TACHOMETER ASSEMBLY - CTU TRANSPORT ASSEMBLY.

3.2.3.1 The third subassembly of the CTU Transport is the motor/tachometer assembly which consists of a motor with drive capstan, a motor mount, a tachometer to provide velocity feedback to the servo and a ground strap for electrostatic discharge (ESD) protection.

3.2.3.2 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.

3.3 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.

3.3.1 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.

3.3.2 INTERCHANGE STANDARDS. The code, format of the encoded data, and the region of valid recording area on the H-P 98200A mini cartridige 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 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"

3.3.3 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

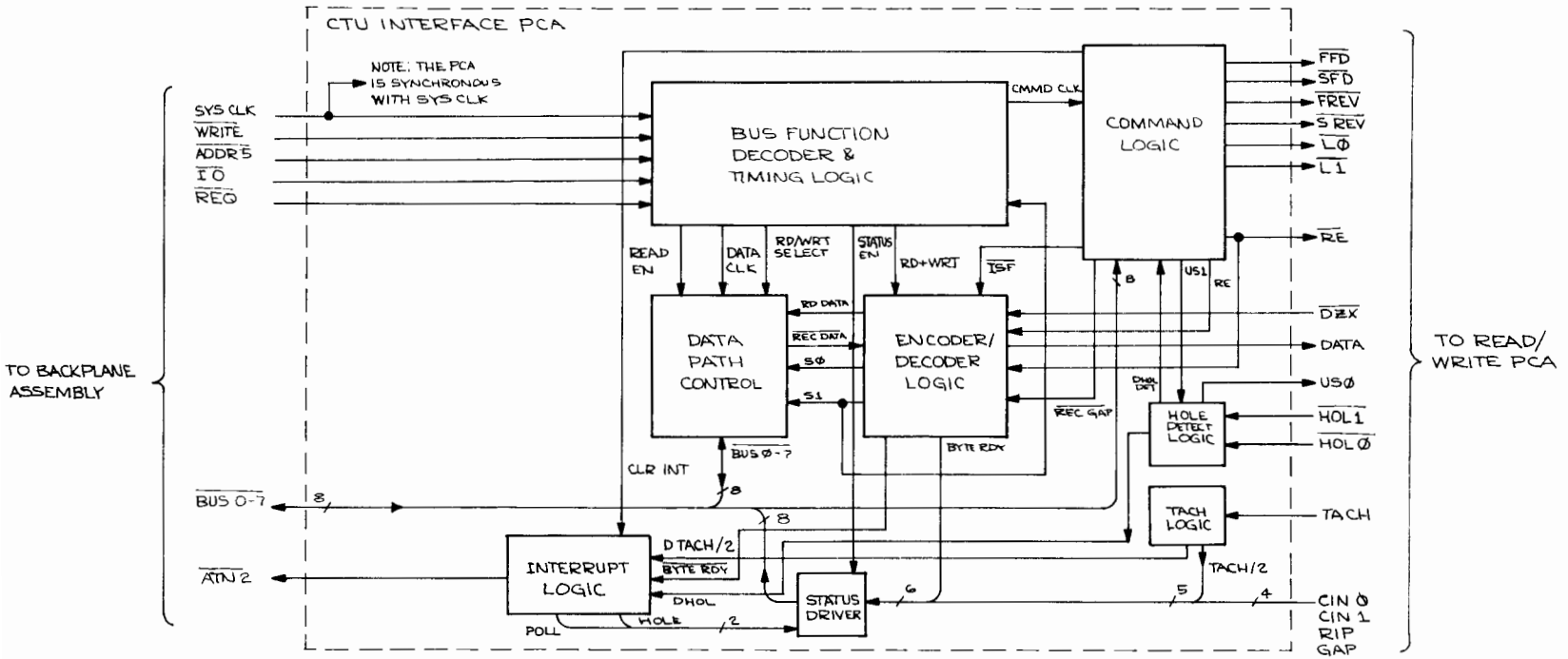


Figure 1
CTU Interface PCA Block Diagram
SEP-26-80 13255-91032

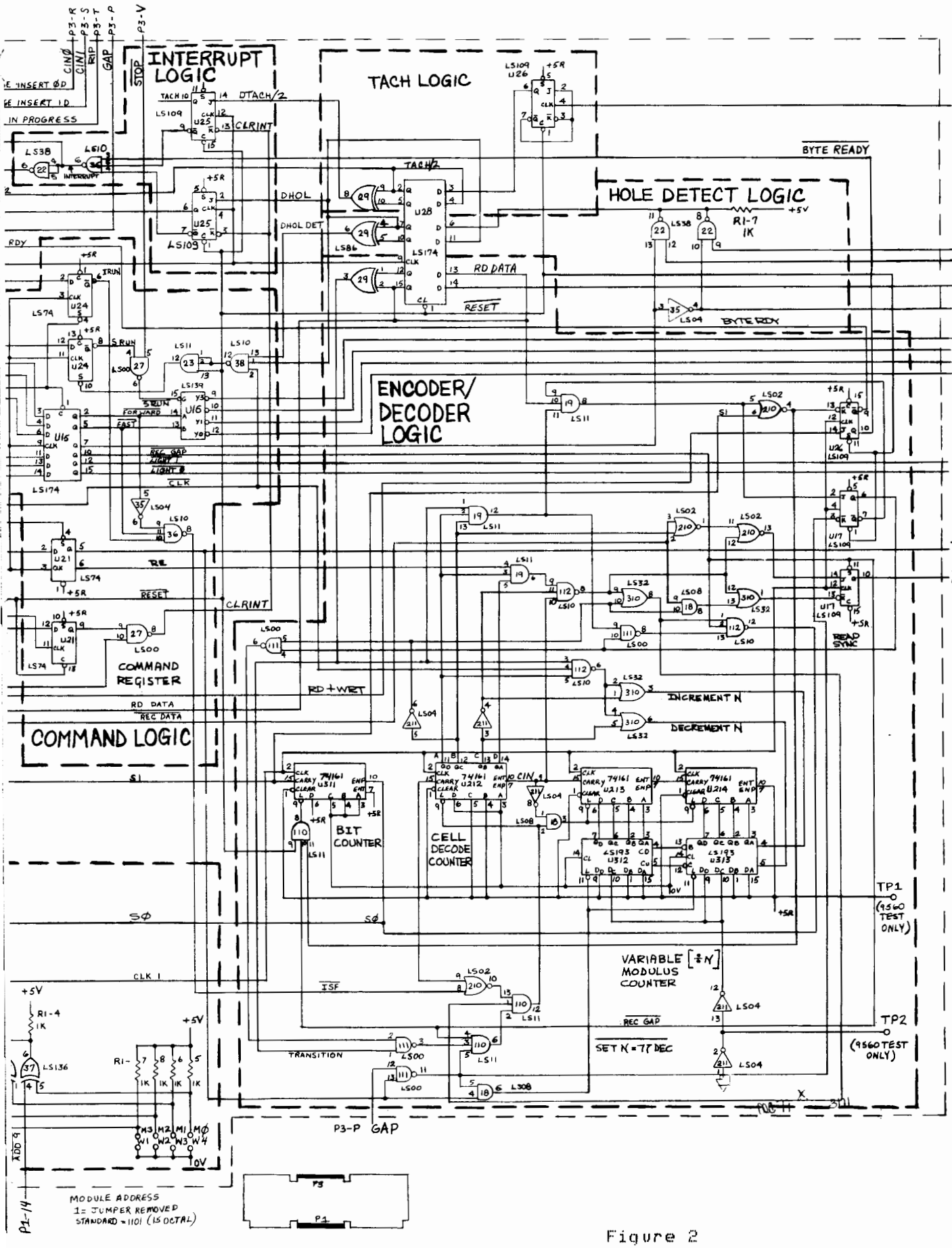
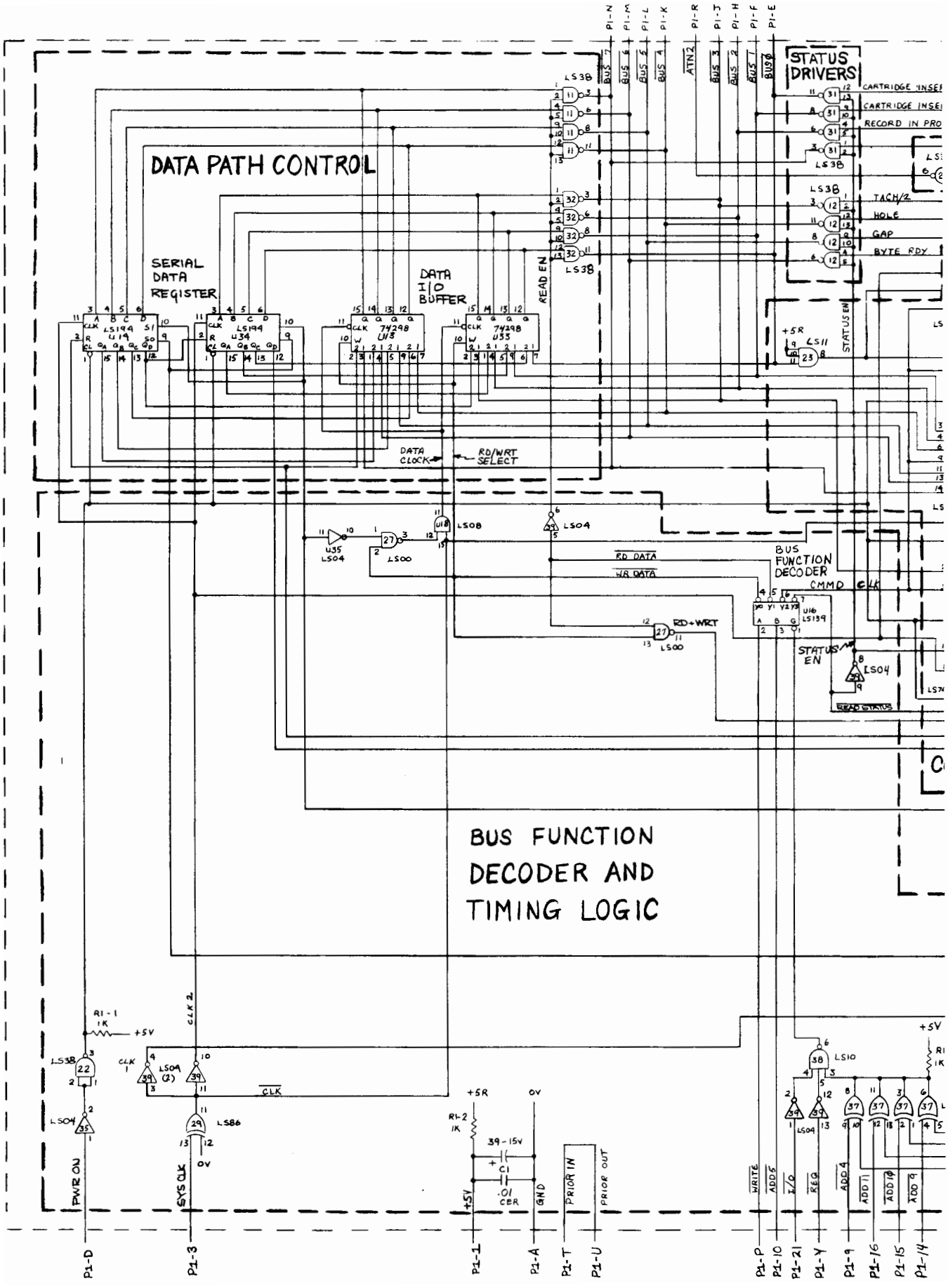


Figure 2
CTU Interface PCA Schematic Diagram
SEP-26-80 13255-91032


DATA PATH CONTROL
SERIAL DATA REGISTER
DATA I/O BUFFER
STATUS DRIVERS
BUS FUNCTION DECODER AND TIMING LOGIC
BUS FUNCTION DECODER
DATA CLOCK
RD/WRT SELECT
READ EN
STATUS EN
RD DATA
WR DATA
RD+WRT
CMMD CLK
CARTRIDGE INSERT
CARTRIDGE INSERT
RECORD IN PROG
TACH/2
HOLE
GAP
BYTE RDY
READ STATUS
PWR ON
SYS CLK
CLK 2
CLK
PRIOR IN
PRIOR OUT
WRITE
ADD 5
E/O
REG
ADD 4
ADD 11
ADD 10
ADD 9
P1-D
P1-3
P1-1
P1-A
P1-T
P1-U
P1-P
P1-10
P1-21
P1-Y
P1-9
P1-16
P1-15
P1-14

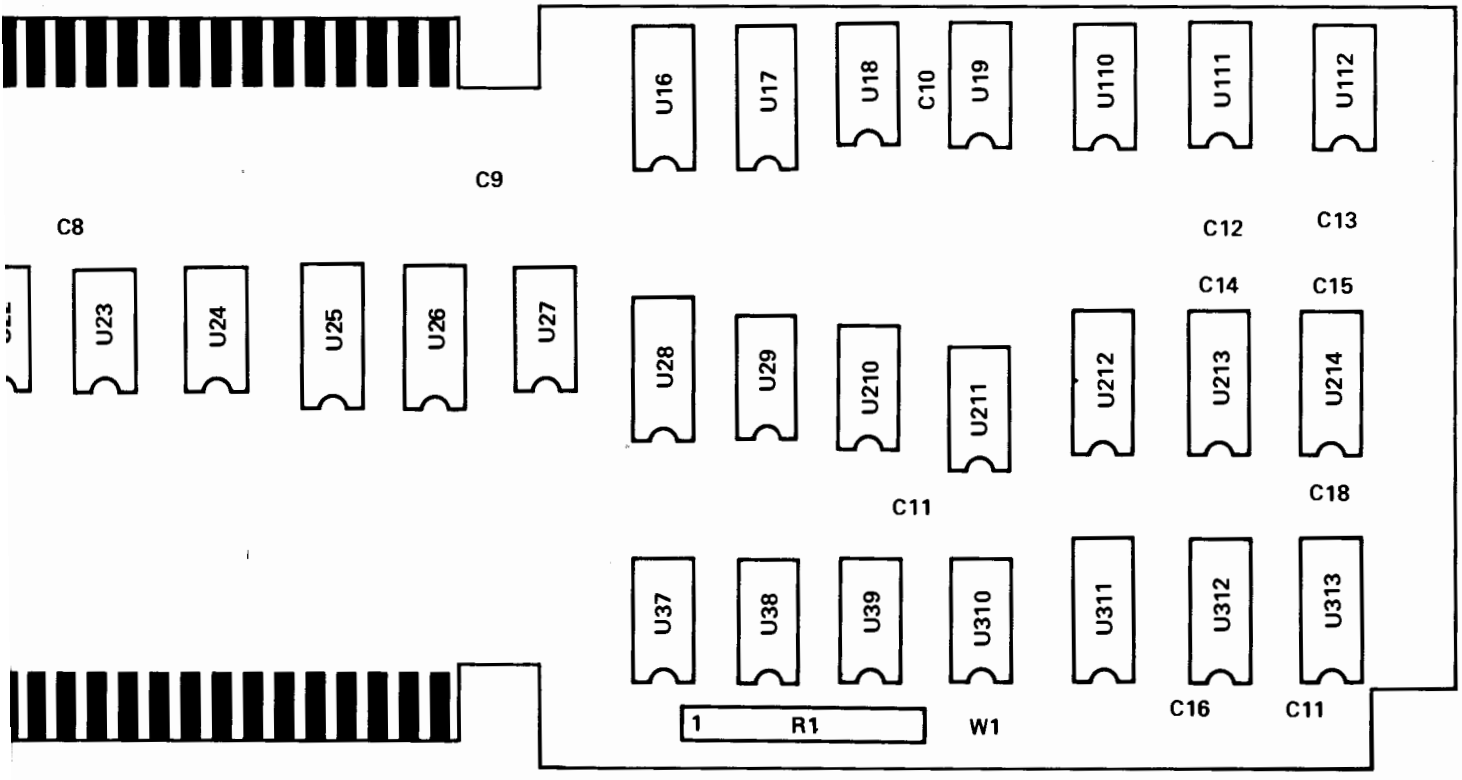
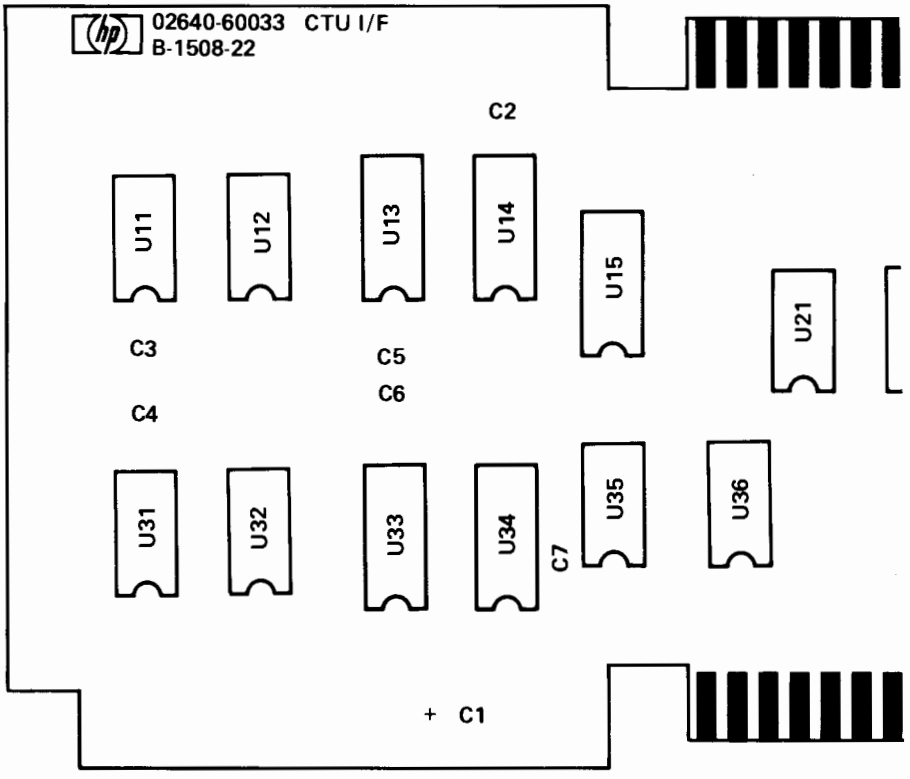


Figure 3
CTU Interface PCA Component Location Diagram
SEP-26-80 13255-91032


02640-60033 CTU I/F
B-1508-22
C2
U11
U12
U13
U14
U15
U21
C3
C5
C6
C4
U31
U32
U33
U34
C7
U35
U36
+ C1

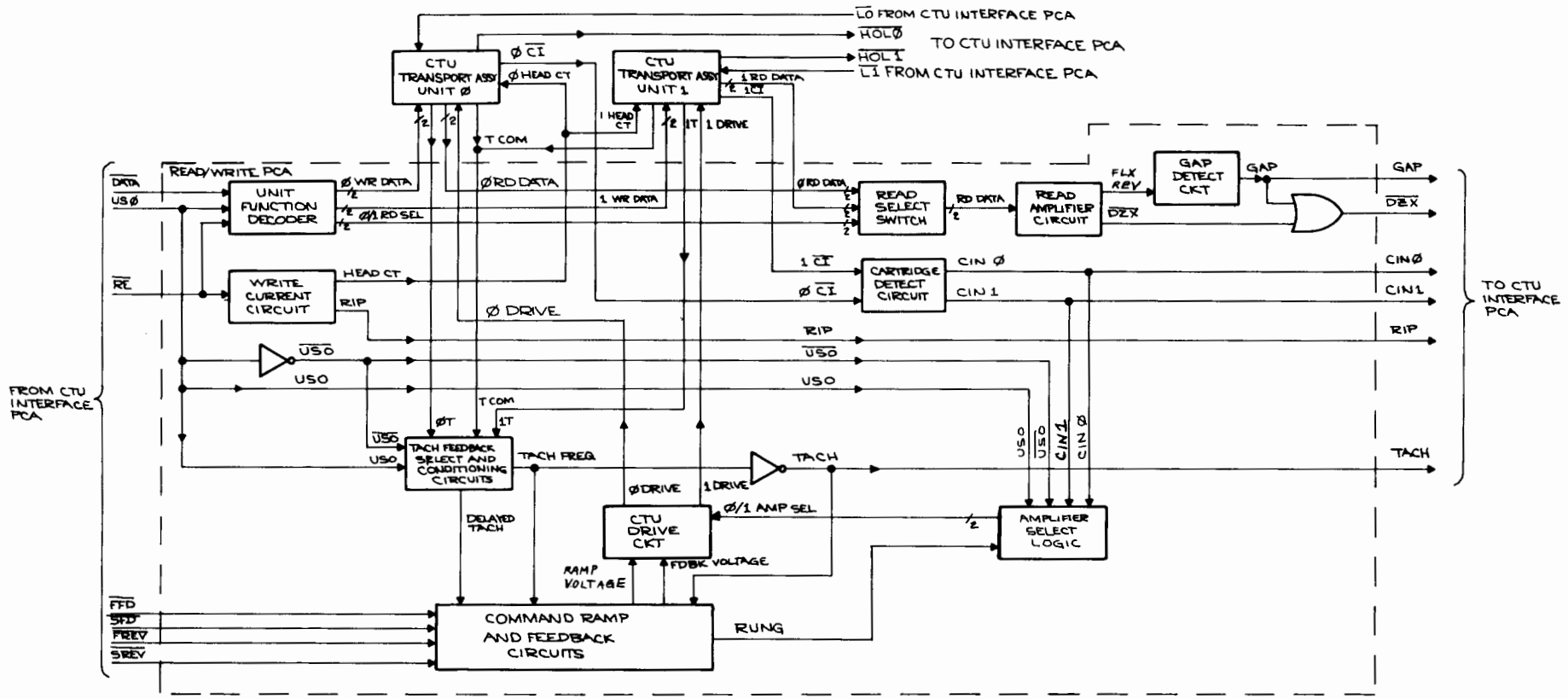


Figure 4
Read/Write PCA Block Diagram
SEP-26-80 13255-91032

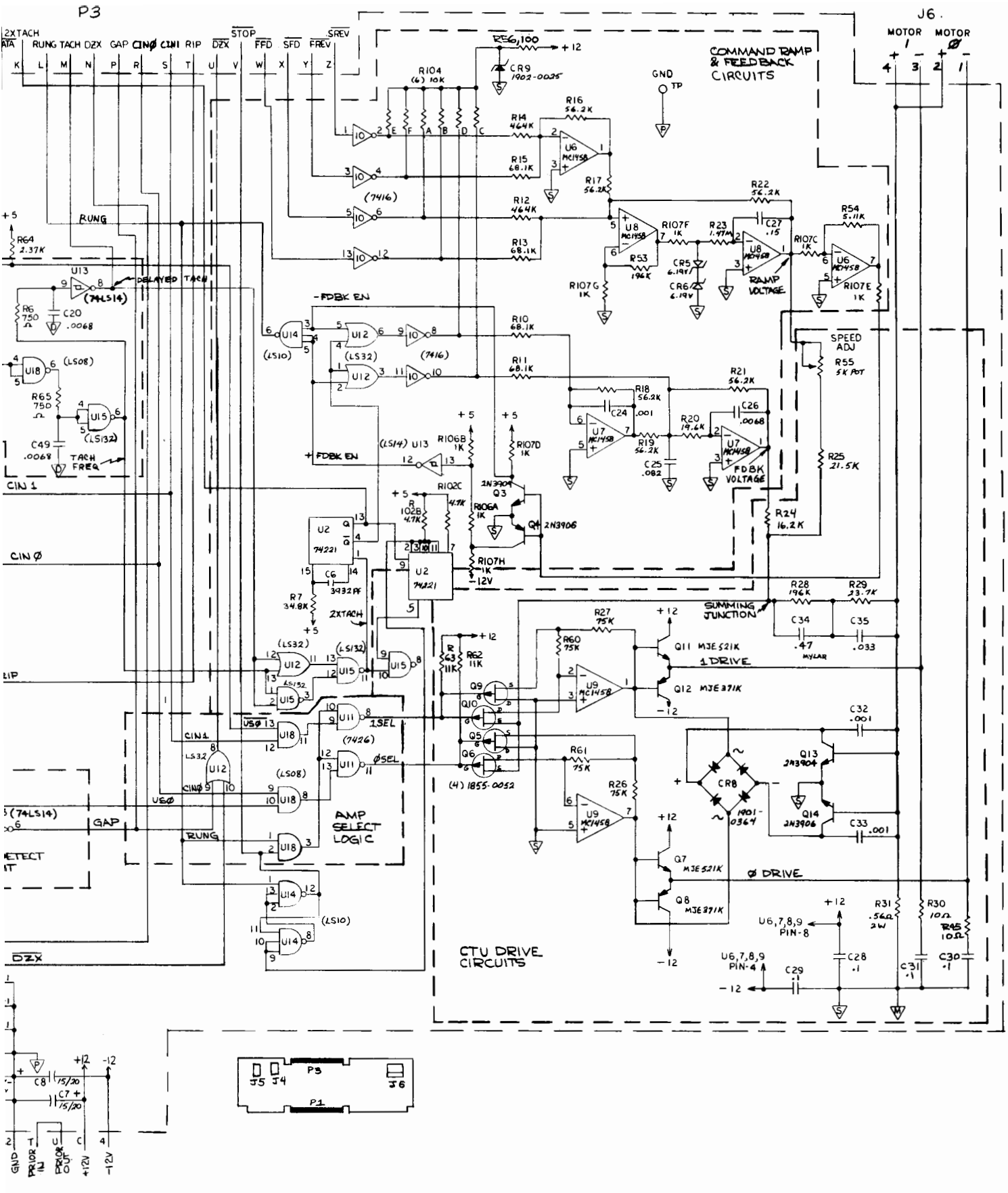
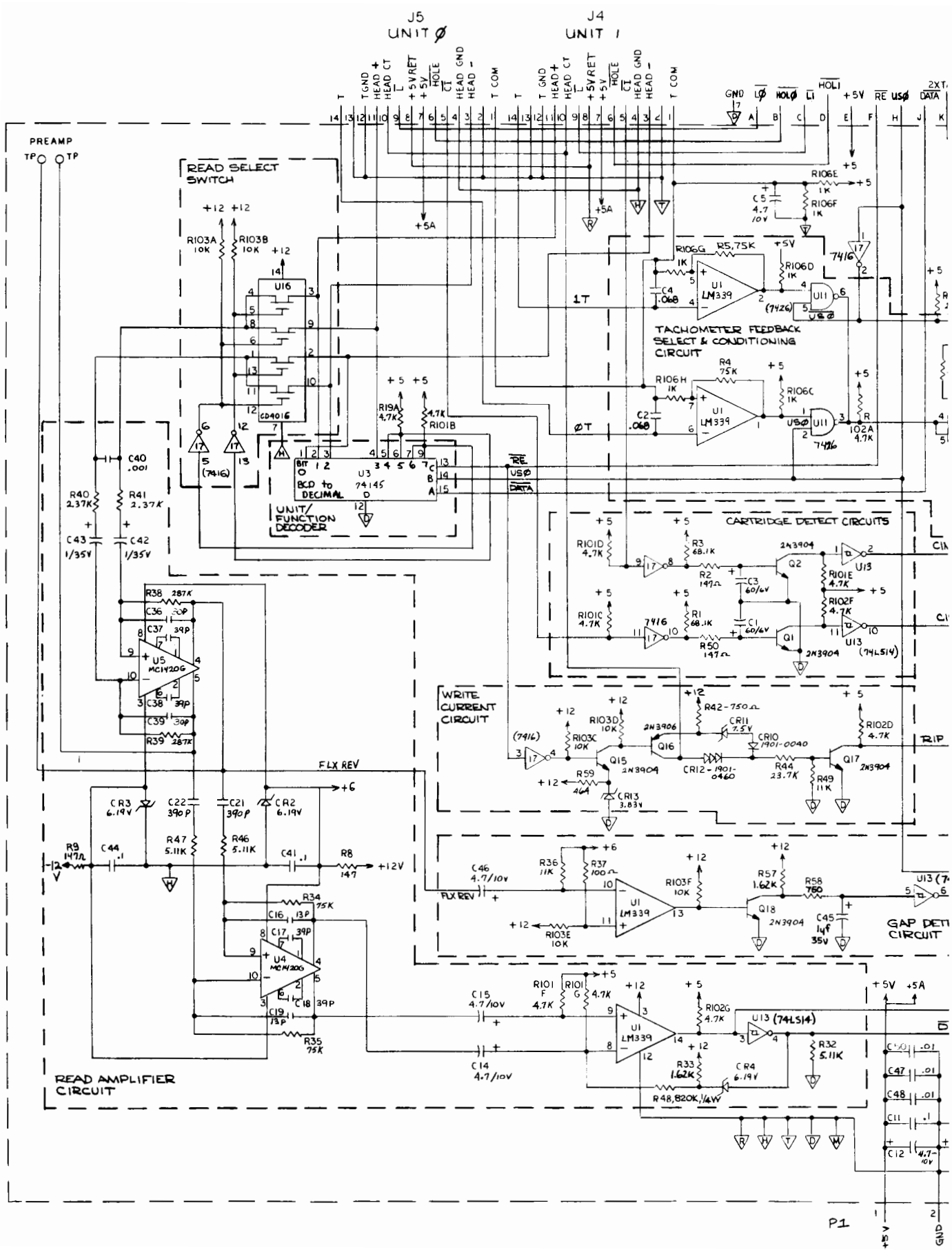


Figure 5
Read/Write PCA Schematic Diagram
SEP-26-80 13255-91032


J5
UNIT Ø
J4
UNIT 1
PREAMP
TP
TP
READ SELECT SWITCH
+12 +12
R103A 10K
R103B 10K
U16
CD4016
UNIT/ FUNCTION DECODER
BCD to DECIMAL
U3 74145
R19A 4.7K
R101B 4.7K
C40 .001
R40 2.37K
R41 2.37K
C43 1/35V
C42 1/35V
R38 287K
C36 30P
C37 39P
U5 MC1420G
C38 39P
C39 30P
R39 287K
FLX REV
+6
CR3 6.19V
CR2 6.19V
C22 390P
C21 390P
R47 5.11K
R46 5.11K
R9 147Ω
C44 .1
C41 .1
R8 147
+12V
-12V
R34 75K
C16 13P
C17 39P
U4 MC1420G
C18 39P
C19 13P
R35 75K
READ AMPLIFIER CIRCUIT
C15 4.7/10V
C14 4.7/10V
R101F 4.7K
R101G 4.7K
U1 LM339
R102G 4.7K
U13 (74LS14)
R33 1.62K
CR4 6.19V
R48, 820K, 1/4W
R32 5.11K
C50 .01
C47 .01
C48 .01
C11 .1
C12 4.7-10V
P1
+5V
GND
WRITE CURRENT CIRCUIT
R42 750Ω
CR11 7.5V
CR10 1901-0040
CR12 1901-0460
CR13 3.83V
R103C 10K
R103D 10K
Q15 2N3904
Q16 2N3906
Q17 2N3904
R59 464
R44 23.7K
R49 11K
R102D 4.7K
R103E 10K
R103F 10K
R36 11K
R37 100Ω
C46 4.7/10V
R57 1.62K
R58 750
Q18 2N3904
C45 1μF 35V
GAP DETECT CIRCUIT
CARTRIDGE DETECT CIRCUITS
R101D 4.7K
R101C 4.7K
R3 68.1K
R2 149Ω
R1 68.1K
R50 149Ω
C3 60/6V
C1 60/6V
Q2 2N3904
Q1 2N3904
R101E 4.7K
R102F 4.7K
U13 (74LS14)
R106E 1K
R106F 1K
C5 4.7 10V
R106G 1K
R5, 75K
R106D 1K
U1 LM339
C4 .068
1T
TACHOMETER FEEDBACK SELECT & CONDITIONING CIRCUIT
R106H 1K
R4 75K
R106C 1K
C2 .068
ØT
R102A 4.7K
7416
(7426)
(7416)
5 (7416)
13
RE
USØ
DATA
BIT 1 2 3 4 5 6 7
A B C D
T GND HEAD + HEAD CT L +5V RET +5V HOLE CT HEAD GND HEAD - T COM
GND LØ HOLØ LI HOLI +5V RE USØ 2XT DATA

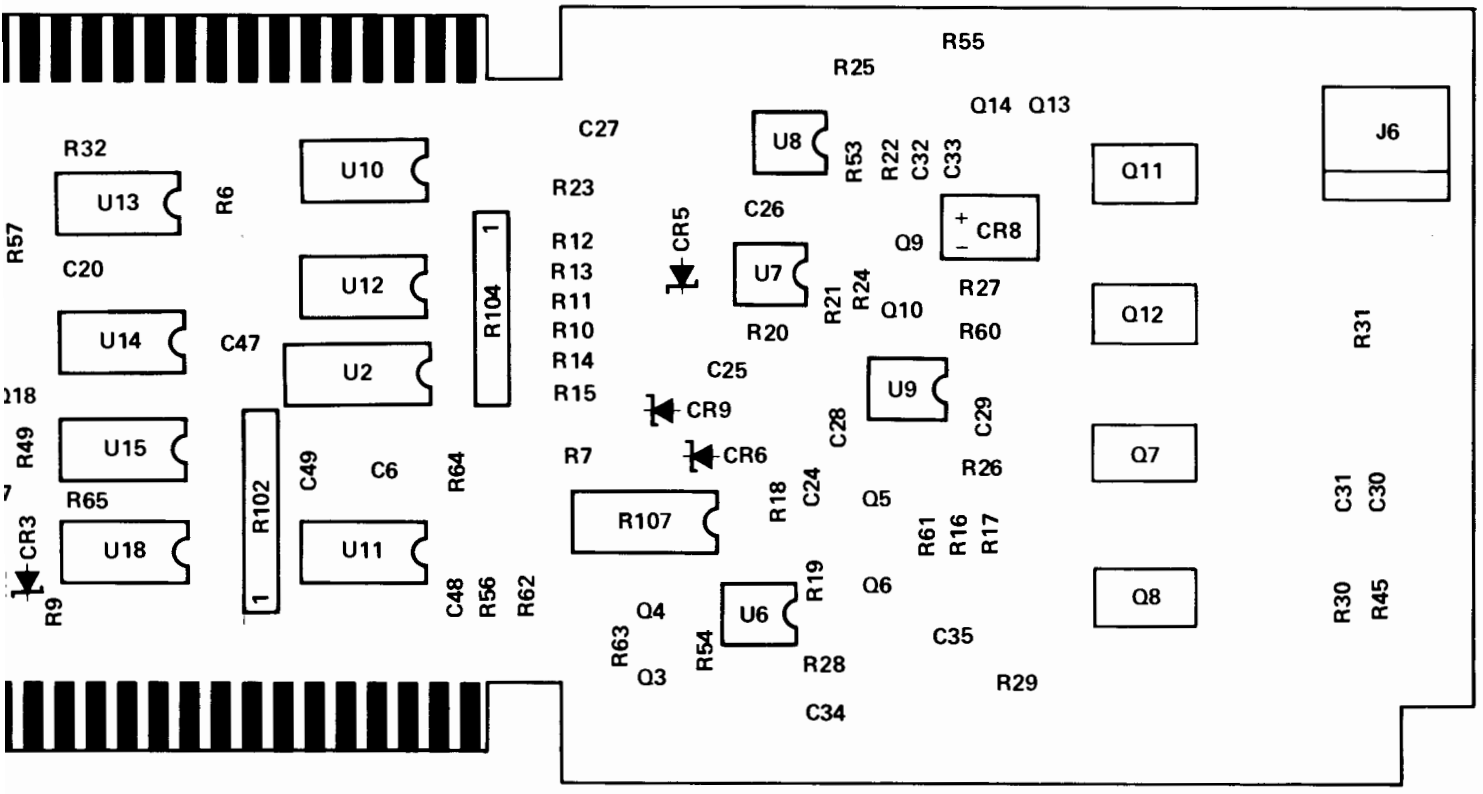
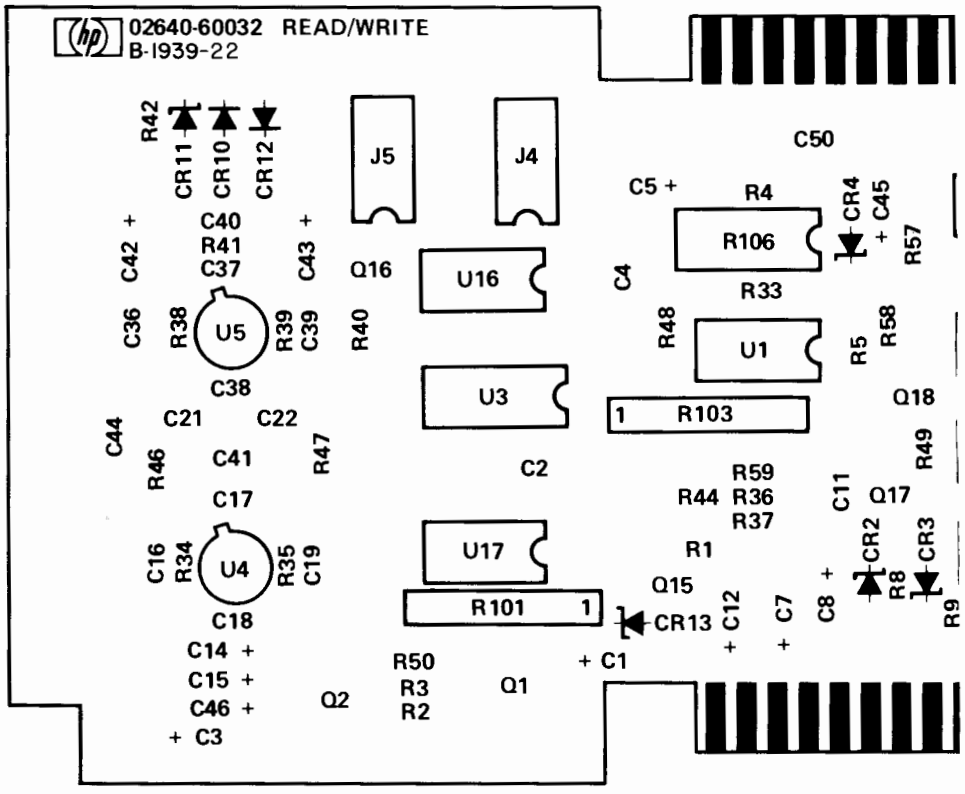


Figure 6
Read/Write PCA Component Location Diagram
SEP-26-80 13255-91032


02640-60032 READ/WRITE
B-1939-22
R42
CR11
CR10
CR12
J5
J4
C50
C5 +
R4
CR4
C45
C40
R41
C37
C42 +
C43 +
Q16
U16
R106
R57
C4
R33
C36
R38
U5
R39
C39
R40
R48
U1
R5
R58
C38
U3
Q18
C21
C22
1 R103
C44
C41
R47
C2
R49
R46
R59
C17
R44 R36
C11
Q17
R37
C16
R34
U4
R35
C19
U17
R1
CR2
CR3
Q15
R8
C18
R101 1
CR13
C12
C7
C8 +
R9
C14 +
R50
+ C1
C15 +
R3
Q1
C46 +
Q2
R2
+ C3

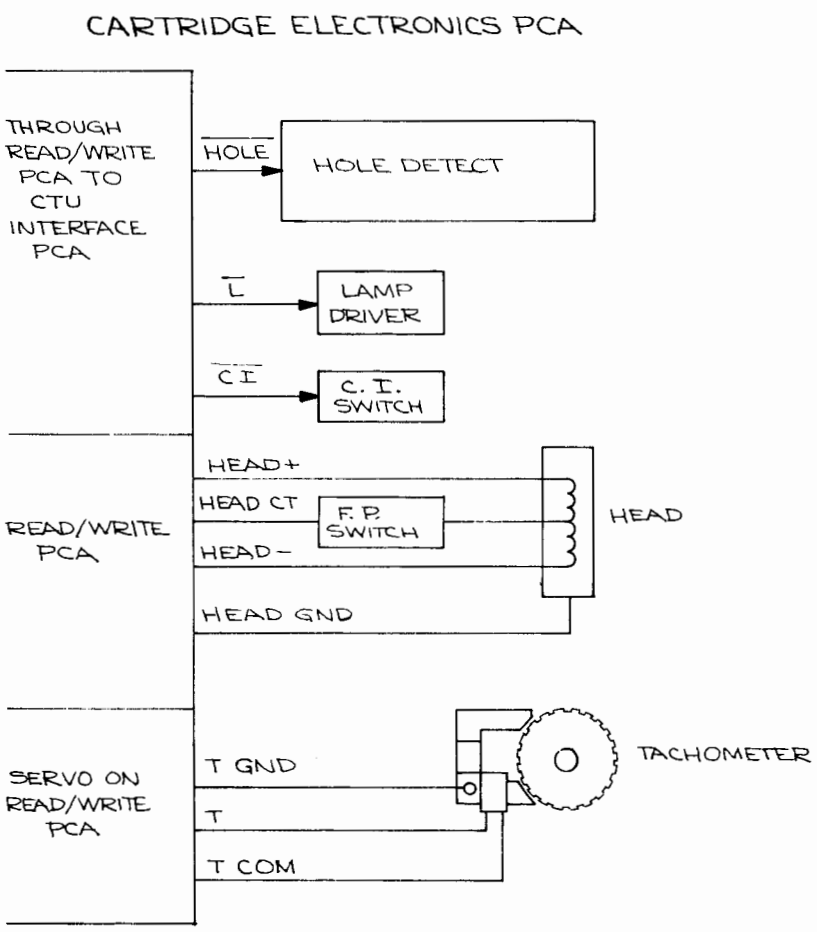


Figure 7
Cartridge Electronics PCA Block Diagram
SEP-26-80 13255-91032

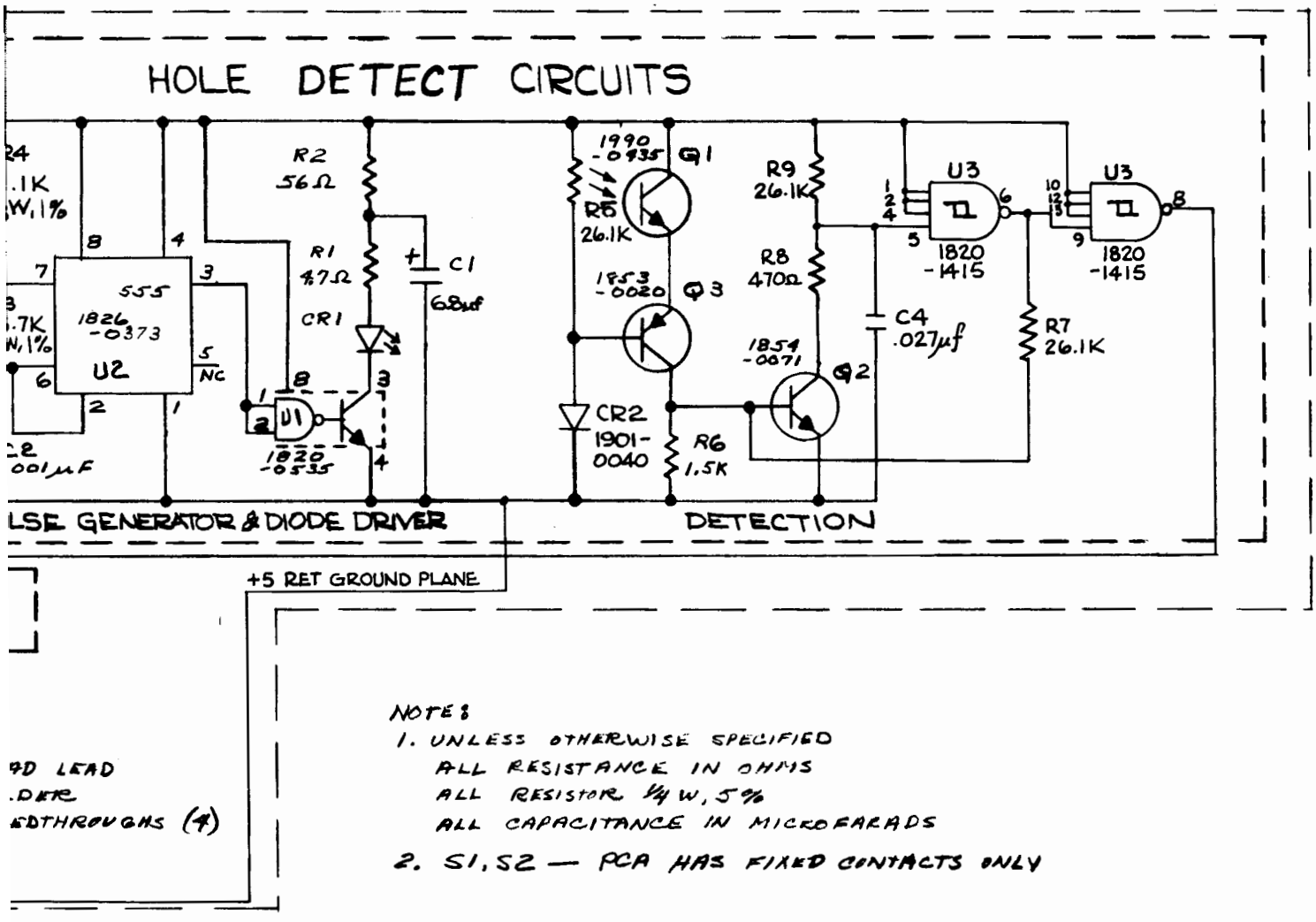
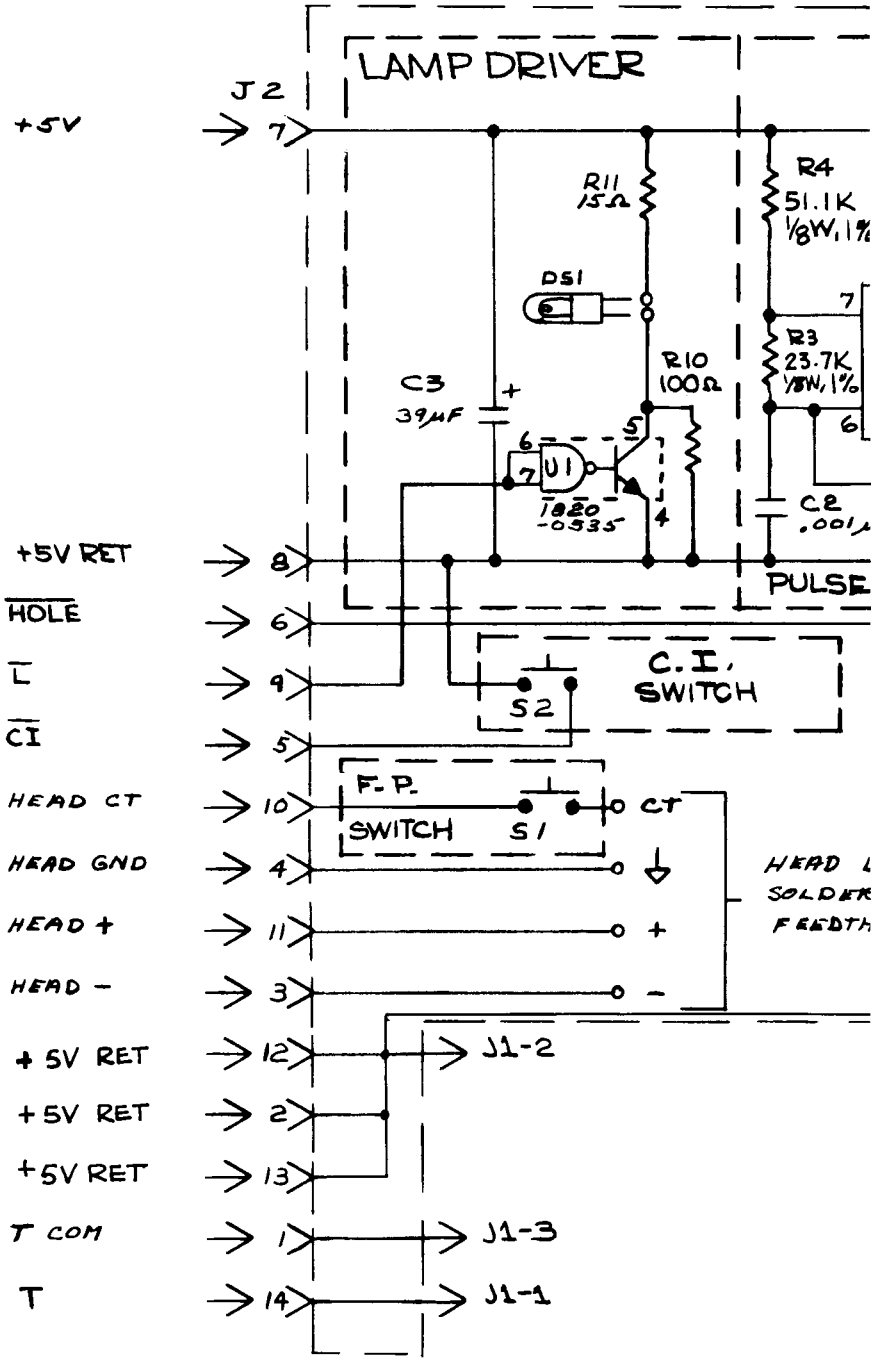


Figure 8
Cartridge Electronics PCA Schematic Diagram
SEP-26-80 13255-91032


LAMP DRIVER
J2
+5V
7
R11
15Ω
R4
51.1K
1/8W, 1%
DS1
R3
23.7K
1/8W, 1%
R10
100Ω
C3
39μF
U1
1820
-0535
C2
.001μ
+5V RET
8
HOLE
6
L
9
CI
5
PULSE
C.I.
SWITCH
S2
F-P.
SWITCH
S1
CT
HEAD CT
10
HEAD GND
4
HEAD +
11
HEAD -
3
+5V RET
12
+5V RET
2
+5V RET
13
T COM
1
T
14
J1-2
J1-3
J1-1

02640-60242 CTU ELECTRONICS
A-2042-42

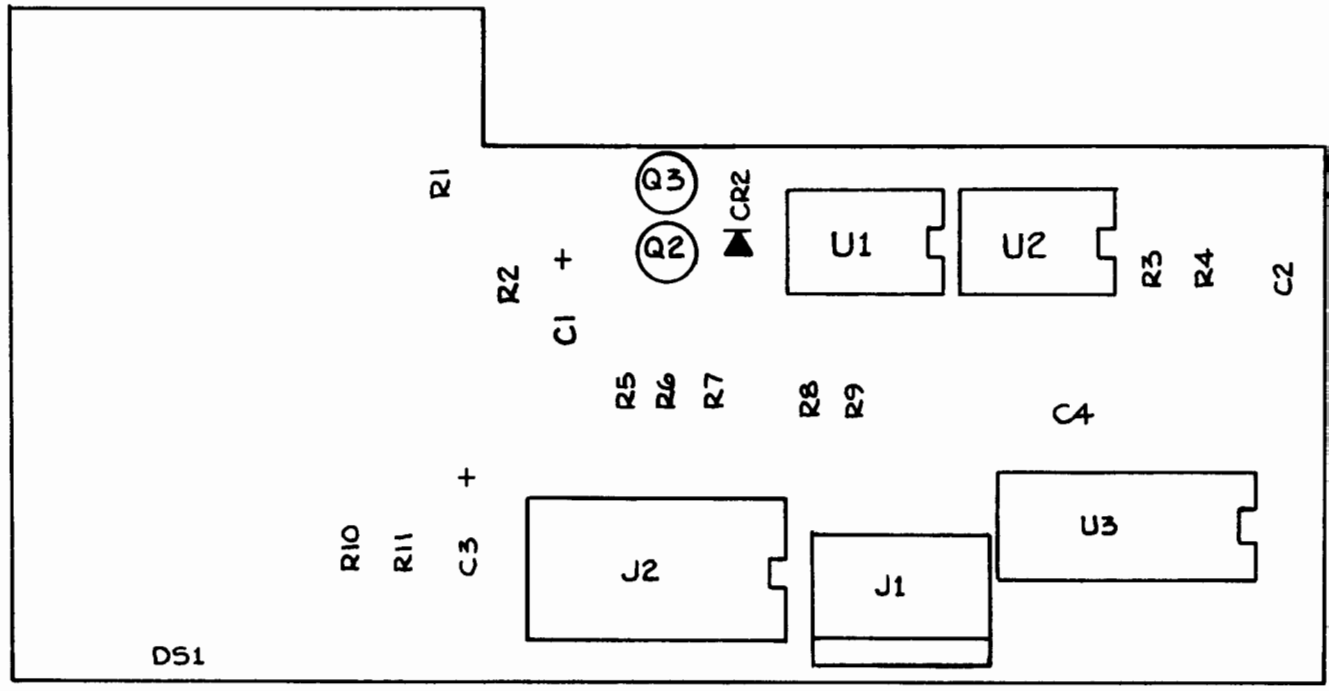


Figure 9
Cartridge Electronics PCA Compnent Location Diagram
SEP-26-80 13255-91032

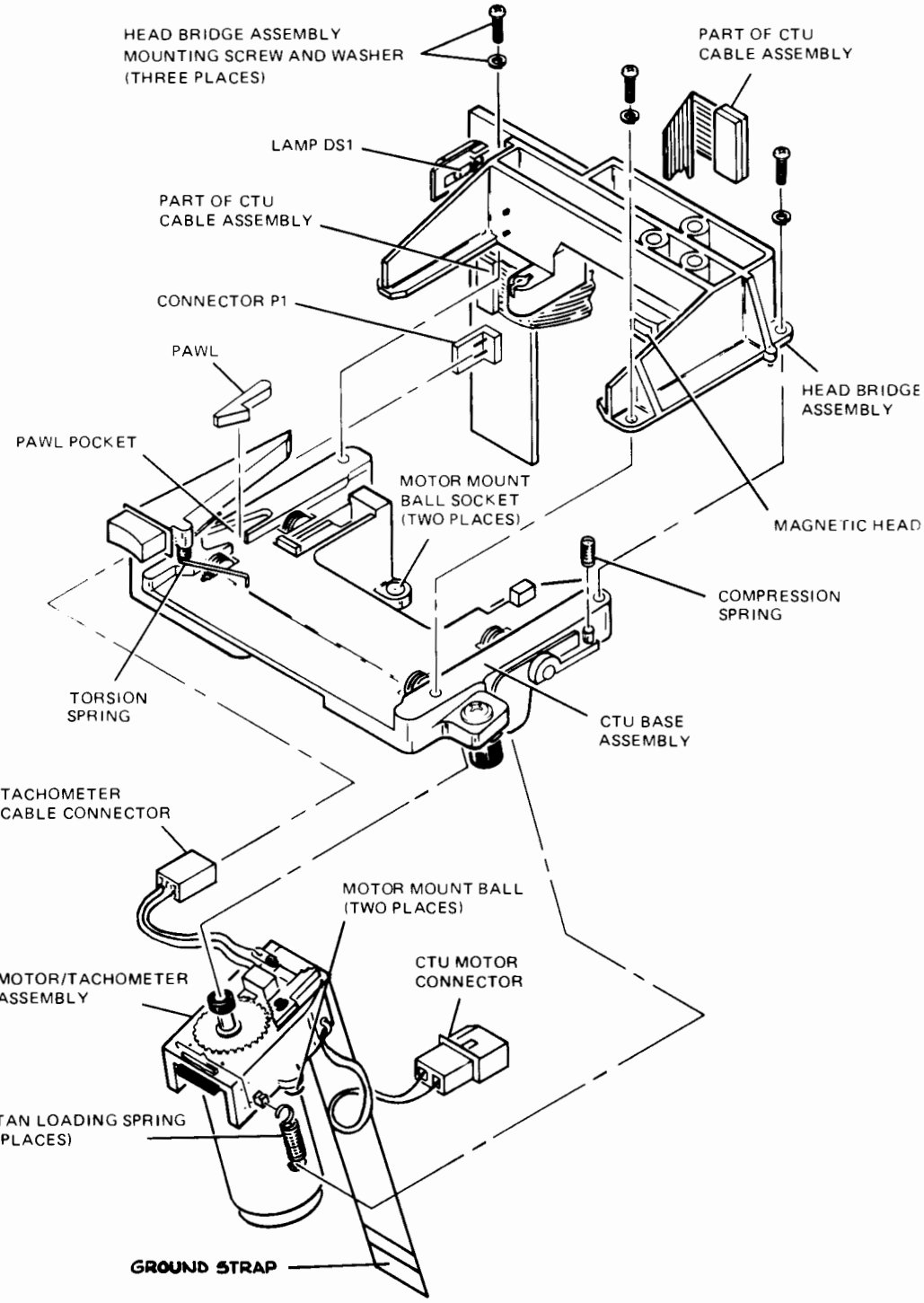
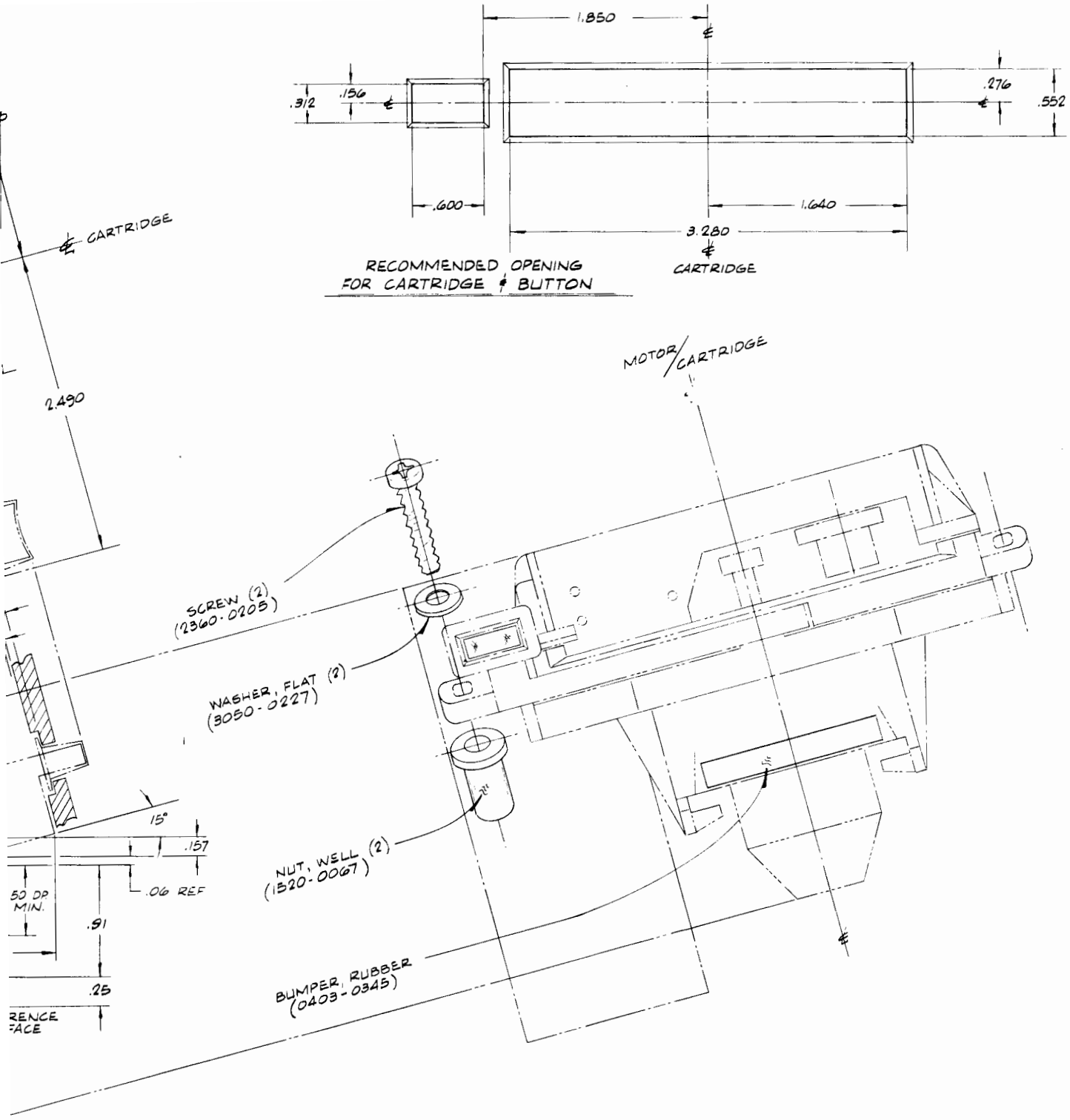
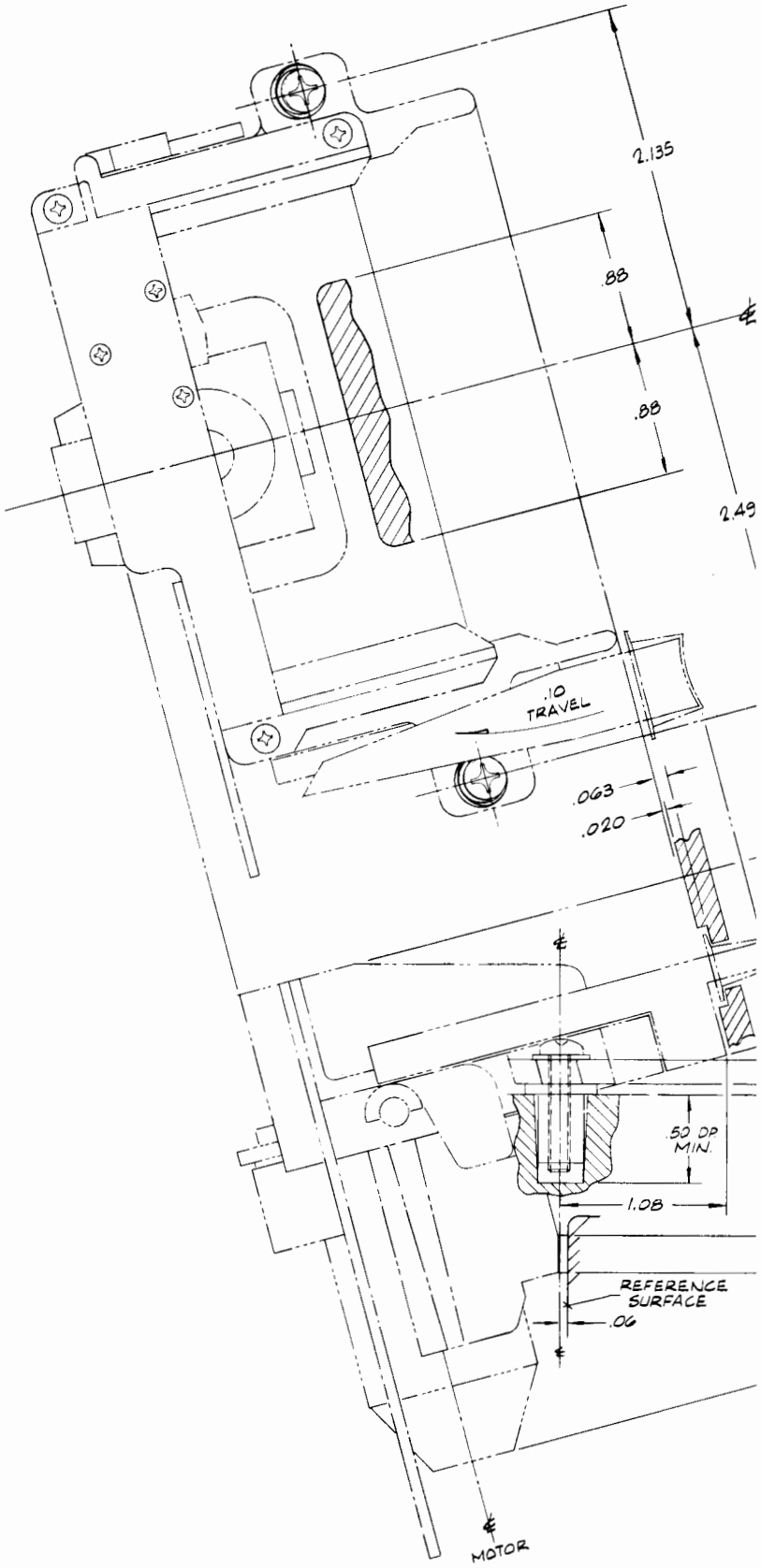


Figure 10
CTU Transport Exploded View Diagram
SEP-26-80 13255-91032



C.T.U. MOUNTING PROVISIONS

Figure 11
CTU Mounting Provisions Diagram
SEP-26-80 13255-91032


2.135
.88
.88
2.49
.10
TRAVEL
.063
.020
.50 DP
MIN.
1.08
REFERENCE
SURFACE
.06
MOTOR

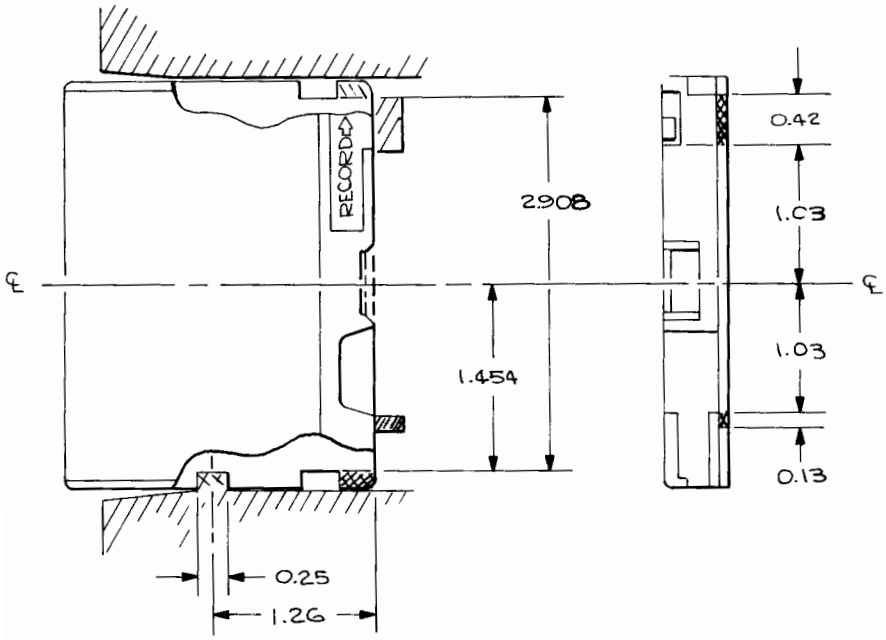


Figure 12
Cartridge Outline Diagram
SEP-26-80 13255-91032

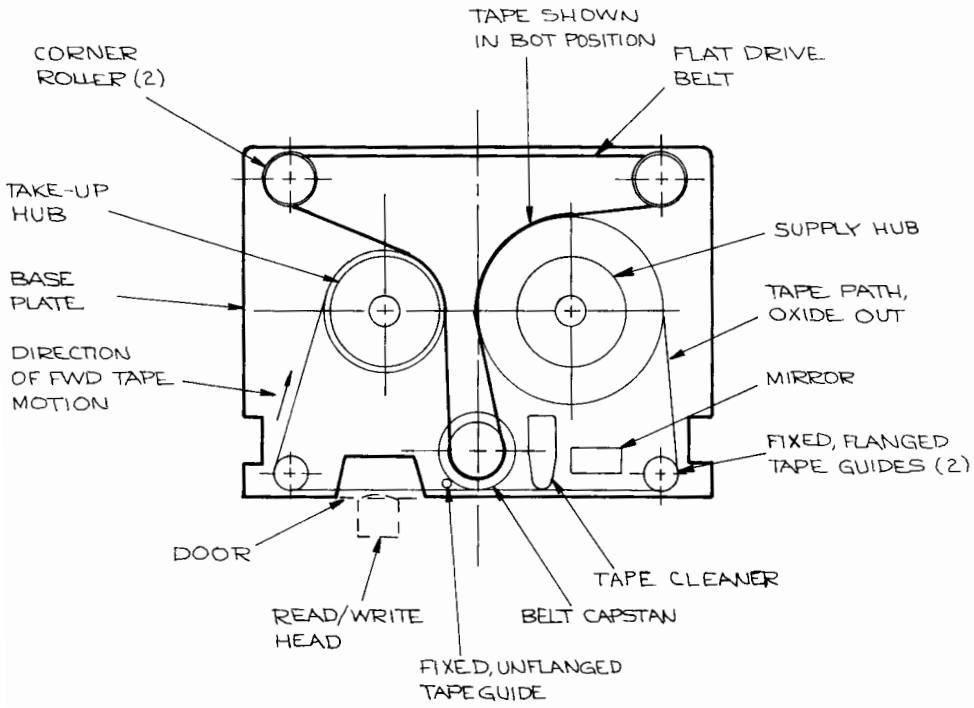
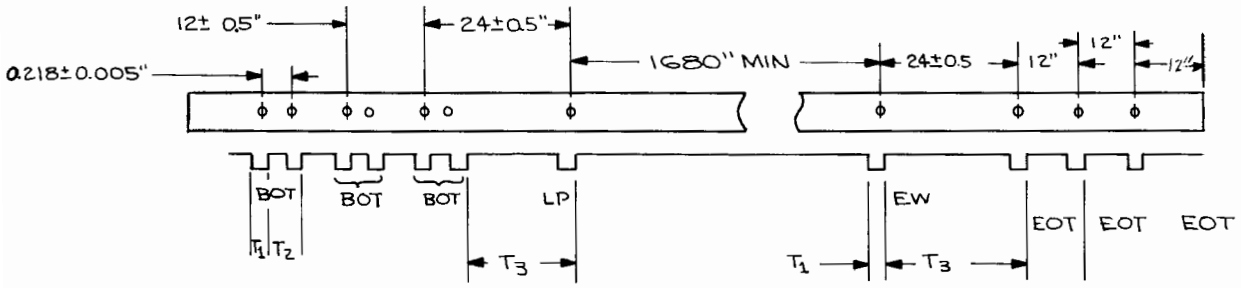


Figure 13
Tape Cartridge Diagram
SEP-26-80 13255-91032



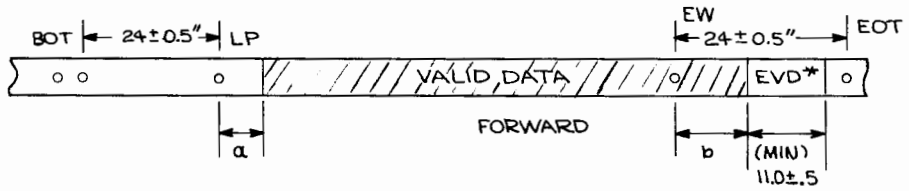
- BOT = BEGINNING OF TAPE (2 CONSECUTIVE HOLES) (3 PAIR BOT HOLES
- LP = LOAD POINT (1 HOLE)
- EW = EARLY WARNING (1 HOLE)
- EOT = END OF TAPE (1 HOLE) (3 EOT HOLES)

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	3.9 ms	353 ms	450 ms

HOLE STATUS FORMAT

Figure 14
Hole Status Format Diagram
SEP-26-80 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
SEP-26-80 13255-91032

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60021	5		ASSEMBLY-CONNECTOR (2)	28480	02640-60021
	0403-0243	9		BUMPER FOOT-ADH MTG .38-IN-WD .25-IN-THK	28480	0403-0243
	1251-5564	5		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-5564

Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60032	8	1	ASSEMBLY-READ/WRITE	28480	02640-60032
C1	0180-0106	9	2	CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
C2	0160-0166	9	2	CAPACITOR-FXD .068UF +-10% 200VDC POLYE	28480	0160-0166
C3	0180-0106	9		CAPACITOR-FXD 60UF+-20% 6VDC TA	56289	150D606X0006B2
C4	0160-0166	9		CAPACITOR-FXD .068UF +-10% 200VDC POLYE	28480	0160-0166
C5	0180-0309	4	5	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C6	0140-0161	2	1	CAPACITOR-FXD 3932PF +-1% 300VDC MICA	72136	DM20F3932RF0300WV1CR
C7	0180-1746	5	2	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
C8	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
C11	0150-0121	5	7	CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C12	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C14	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C15	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C16	0160-2260	8	2	CAPACITOR-FXD 13PF +-5% 500VDC CER 0+-30	28480	0160-2260
C17	0140-0190	7	4	CAPACITOR-FXD 39PF +-5% 300VDC MICA	72136	DM15E390J0300WV1CR
C18	0140-0190	7		CAPACITOR-FXD 39PF +-5% 300VDC MICA	72136	DM15E390J0300WV1CR
C19	0160-2260	8		CAPACITOR-FXD 13PF +-5% 500VDC CER 0+-30	28480	0160-2260
C20	0160-0159	0	3	CAPACITOR-FXD 6800PF +-10% 200VDC POLYE	28480	0160-0159
C21	0140-0200	0	2	CAPACITOR-FXD 390PF +-5% 300VDC MICA	72136	DM15F391J0300WV1CR
C22	0140-0200	0		CAPACITOR-FXD 390PF +-5% 300VDC MICA	72136	DM15F391J0300WV1CR
C24	0160-0153	4	4	CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	28480	0160-0153
C25	0160-0167	0	1	CAPACITOR-FXD .082UF +-10% 200VDC POLYE	28480	0160-0167
C26	0160-0159	0		CAPACITOR-FXD 6800PF +-10% 200VDC POLYE	28480	0160-0159
C27	0160-3238	2	1	CAPACITOR-FXD .15UF +-5% 200VDC POLYE	28480	0160-3238
C28	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C29	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C30	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C31	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C32	0160-0153	4		CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	28480	0160-0153
C33	0160-0153	4		CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	28480	0160-0153
C34	0160-0970	3	1	CAPACITOR-FXD .47UF +-10% 80VDC POLYE	28480	0160-0970
C35	0160-0163	6	1	CAPACITOR-FXD .033UF +-10% 200VDC POLYE	28480	0160-0163
C36	0160-2199	2	2	CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
C37	0140-0190	7		CAPACITOR-FXD 39PF +-5% 300VDC MICA	72136	DM15E390J0300WV1CR
C38	0140-0190	7		CAPACITOR-FXD 39PF +-5% 300VDC MICA	72136	DM15E390J0300WV1CR
C39	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
C40	0160-0153	4		CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	28480	0160-0153
C41	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C42	0180-0291	3	3	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C43	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C44	0150-0121	5		CAPACITOR-FXD .1UF +80-20% 50VDC CER	28480	0150-0121
C45	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C46	0180-0309	4		CAPACITOR-FXD 4.7UF+-20% 10VDC TA	56289	150D475X0010A2
C47	0160-2055	9	3	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C48	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
C49	0160-0159	0		CAPACITOR-FXD 6800PF +-10% 200VDC POLYE	28480	0160-0159
C50	0160-2055	9		CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
CR2	1902-0049	2	5	DIODE-ZNR 6.19V 5% DO-35 PD=.4W	28480	1902-0049
CR3	1902-0049	2		DIODE-ZNR 6.19V 5% DO-35 PD=.4W	28480	1902-0049
CR4	1902-0049	2		DIODE-ZNR 6.19V 5% DO-35 PD=.4W	28480	1902-0049
CR5	1902-0049	2		DIODE-ZNR 6.19V 5% DO-35 PD=.4W	28480	1902-0049
CR6	1902-0049	2		DIODE-ZNR 6.19V 5% DO-35 PD=.4W	28480	1902-0049
CR8	1901-0364	2	1	DIODE-FW BRDG 200V 1A	28480	1901-0364
CR9	1902-0025	4	1	DIODE-ZNR 10V 5% DO-35 PD=.4W TC=+.06%	28480	1902-0025
CR10	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR11	1902-0064	1	1	DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.05%	28480	1902-0064
CR12	1901-0460	9	1	DIODE-STABISTOR 30V 150MA DO-7	28480	1901-0460
CR13	1902-3059	0	1	DIODE-ZNR 3.83V 5% DO-35 PD=.4W	28480	1902-3059
E1	0360-0124	3	3	CONNECTOR-SGL CONT PIN .04-IN-BSC-SZ RND	28480	0360-0124
E2	0360-0124	3		CONNECTOR-SGL CONT PIN .04-IN-BSC-SZ RND	28480	0360-0124
E3	0360-0124	3		CONNECTOR-SGL CONT PIN .04-IN-BSC-SZ RND	28480	0360-0124
J4	1200-0474	9	2	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0474
J5	1200-0474	9		SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0474
J6	1251-3873	5	1	CONNECTOR 4-PIN M POST TYPE	28480	1251-3873
Q1	1854-0215	1	7	TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q2	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q3	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q4	1853-0036	2	3	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q5	1855-0052	6	4	TRANSISTOR J-FET P-CHAN D-MODE TO-92 SI	07263	2N4360

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
Q6	1855-0052	6		TRANSISTOR J-FET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q7	1854-0653	1	2	TRANSISTOR NPN SI PD=60W	04713	MJE521K
Q8	1853-0369	4	2	TRANSISTOR PNP SI PD=60W	04713	MJE371K
Q9	1855-0052	6		TRANSISTOR J-FET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q10	1855-0052	6		TRANSISTOR J-FET P-CHAN D-MODE TO-92 SI	07263	2N4360
Q11	1854-0653	1		TRANSISTOR NPN SI PD=60W	04713	MJE521K
Q12	1853-0369	4		TRANSISTOR PNP SI PD=60W	04713	MJE371K
Q13	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q14	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q15	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q16	1853-0036	2		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
Q17	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
Q18	1854-0215	1		TRANSISTOR NPN SI PD=350MW FT=300MHZ	04713	2N3904
R1	0757-0461	2	6	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R2	0698-3438	3	4	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
R3	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R4	0757-0462	3	8	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R5	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R6	0757-0420	3	4	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R7	0757-0123	3	1	RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
R8	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
R9	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
R10	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R11	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R12	0698-3260	9	2	RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260
R13	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R14	0698-3260	9		RESISTOR 464K 1% .125W F TC=0+-100	28480	0698-3260
R15	0757-0461	2		RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
R16	0757-0447	4	2	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
R17	0757-0459	8	5	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
R18	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
R19	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
R20	0698-3157	3	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
R21	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
R22	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
R23	0698-3464	5	1	RESISTOR 1.47M 1% .5W F TC=0+-100	20480	0698-3464
R24	0757-0447	4		RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
R25	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
R26	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R27	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R28	0698-3453	2	2	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
R29	0698-3158	4	2	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
R30	0757-0346	2	2	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
R31	0811-1552	0	1	RESISTOR .56 5% 2W PW TC=0+-800	75042	BWH2-9/16-J
R32	0757-0438	3	4	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R33	0757-0428	1	2	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F
R34	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R35	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R36	0757-0443	0	4	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
R37	0757-0401	0	2	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R38	0698-3456	5	2	RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2873-F
R39	0698-3456	5		RESISTOR 287K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2873-F
R40	0698-3150	6	3	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
R41	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
R42	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R44	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
R45	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
R46	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R47	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R48	0683-8245	9	1	RESISTOR 820K 5% .25W FC TC=-800/+900	01121	CB8245
R49	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
R50	0698-3438	3		RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
R53	0698-3453	2		RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
R54	0757-0438	3		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
R55	2100-3207	1	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN	28480	2100-3207
R56	0757-0401	0		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
R57	0757-0428	1		RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1621-F
R58	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R59	0698-0082	7	1	RESISTOR 464 1% .125W F TC=0+-100	24546	C4-1/8-T0-4640-F
R60	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R61	0757-0462	3		RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
R62	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
R63	0757-0443	0		RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
R64	0698-3150	6		RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
R65	0757-0420	3		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
R101	1810-0125	0	2	NETWORK-RES 8-SIP4.7K OHM X 7	28480	1810-0125
R102	1810-0125	0		NETWORK-RES 8-SIP4.7K OHM X 7	28480	1810-0125
R103	1810-0151	2	2	NETWORK-RES 7-SIP10.0K OHM X 6	91637	CSP07C07-103J

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
R104	1810-0151	2		NETWORK-RES 7-SIP10.0K OHM X 6	91637	CSP07C07-103J
R106	1810-0037	3	2	NETWORK-RES 16-DIP1.0K OHM X 8	11236	761-3-R1K
R107	1810-0037	3		NETWORK-RES 16-DIP1.0K OHM X 8	11236	761-3-R1K
U1	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
U2	1820-1260	7	1	IC MV TTL MONOSTBL DUAL	01295	SN74221N
U3	1820-0491	4	1	IC DCDR TTL BCD-TO-DEC 4-TO-10-LINE	01295	SN74145N
U4	1826-0200	5	2	IC OP AMP GP TO-100 PKG	04713	MC1420G
U5	1826-0200	5		IC OP AMP GP TO-100 PKG	04713	MC1420G
U6	1826-0139	9	4	IC OP AMP GP DUAL 8-DIP-P PKG	0192B	CA1458G
U7	1826-0139	9		IC OP AMP GP DUAL 8-DIP-P PKG	0192B	CA1458G
U8	1826-0139	9		IC OP AMP GP DUAL 8-DIP-P PKG	0192B	CA1458G
U9	1826-0139	9		IC OP AMP GP DUAL 8-DIP-P PKG	0192B	CA1458G
U10	1820-0577	7	2	IC INV TTL HEX 1-INP	01295	SN7416N
U11	1820-0514	2	1	IC GATE TTL NAND QUAD 2-INP	01295	SN7426N
U12	1820-1208	3	1	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
U13	1820-1416	5	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N
U14	1820-1202	7	1	IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
U15	1820-1425	6	1	IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP	01295	SN74LS132N
U16	1820-0981	7	1	IC SWITCH ANLG QUAD 14-DIP-P PKG	0192B	CD4016AE
U17	1820-0577	7		IC INV TTL HEX 1-INP	01295	SN7416N
U18	1820-1201	6	1	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
	0340-0585	8	1	INSULATOR MICA	28480	0340-0585
	1200-0081	4	4	INSULATOR-FLG-BSHG NYLON	28480	1200-0081
	2190-0004	9	4	WASHER-LK INTL T NO. 4 .115-IN-ID	28480	2190-0004
	2200-0145	2	4	SCREW-MACH 4-40 .438-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2260-0002	6	4	NUT-HEX-DBL-CHAM 4-40-THD .062-IN-THK	00000	ORDER BY DESCRIPTION
	6040-0239	9		LUBRICANT-GREASE SIL	05820	120
	8150-2333	3		WIRE 30AWG W 42V TEFZEL 1X30 105C	28480	8150-2333
	02640-20001	7	1	HEAT SINK	28480	02640-20001

Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
	02640-60242	2	1	ASSEMBLY-CTU ELECTRODE	28480	02640-60242
C1	0180-1701	2	1	CAPACITOR-FXD 6.8UF+-20% 6VDC TA	56289	150D685X0006A2
C2	0160-0153	4	1	CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	28480	0160-0153
C3	0180-0393	6	1	CAPACITOR-FXD 39UF+-10% 10VDC TA	56289	150D396X9010B2
C4	0170-0066	9	1	CAPACITOR-FXD .027UF +-10% 200VDC POLYE	28480	0170-0066
CR2	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
DS1	2140-0450	4	1	LAMP-INCAND 7362 5VDC 115MA T-1-3/4-BULB	1F556	7362
J1	1251-3192	1	1	CONNECTOR 3-PIN M POST TYPE	28480	1251-3192
J2	1200-0474	9	1	SOCKET-IC 14-CONT DIP-SLDR	28480	1200-0474
Q2	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
Q3	1853-0020	4	1	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
R1	0683-0475	1	1	RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB47G5
R2	0683-5605	9	1	RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
R3	0698-3158	4	1	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
R4	0757-0458	7	1	RESISTOR 51.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5112-F
R5	0698-3159	5	3	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
R6	0683-1525	4	1	RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
R7	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
R8	0683-4715	0	1	RESISTOR 470 5% .25W FC TC=-400/+600	01121	CB4715
R9	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
R10	0683-1015	7	1	RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
R11	0683-1505	0	1	RESISTOR 15 5% .25W FC TC=-400/+500	01121	CB1505
U1	1820-0535	7	1	IC DRVR TTL AND DUAL 2-INP	01295	SN75451BP
U2	1826-0373	3	1	IC TIMER TTL MONO/ASTBL	27014	LM555CN
U3	1820-1415	4	1	IC SCHMITT-TRIG TTL LS NAND DUAL 4-INP	01295	SN74LS13N
	1251-4099	9	2	CONNECTOR-SGL CONT SKT .022-IN-BSC-SZ	28480	1251-4099
	4040-1017	1	1	SHIELD-LIGHT	28480	4040-1017

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60254	6	1	ASSEMBLY-CTU TRANS	28480	02640-60254
	0050-1953	1	1	CASTING	28480	0050-1953
	0403-0253	1	1	BUMPER FOOT	28480	0403-0253
	0403-0333	8	1	BUMPER RUBBER	28480	0403-0333
	0470-0010	9		ADHESIVE-CYANOACRYL	05972	404
	0470-0231	6		COMPOUND-NUT LOCK	05972	242
	0510-0052	5	1	RETAINER-RING GRPR EXT .125-IN-DIA STL	28480	0510-0052
	0515-0029	6	3	SCREW-MACH M2 X 0.4 6MM-LG 90-DEG-FLH-HD	00000	ORDER BY DESCRIPTION
	0624-0296	0	3	SCREW-TPG 2-56 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	0624-0307	4	2	SCREW-TPG 2-28 .25-IN-LG PAN-HD-PHL STL	28480	0624-0307
	0624-0314	3	3	SCREW-TPG 4-20 .375-IN-LG PAN-HD-POZI	28480	0624-0314
	0624-0333	6	4	SCREW-TPG 4-20 .25-IN-LG PAN-HD-POZI STL	28480	0624-0333
	1400-0249	0	1	CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	1400-1381	3	2	SPRING-EXTENSION	28480	1400-1381
	1400-1382	4	2	WIREFORM .036 DIA.	28480	1400-1382
	1400-1411	0	1	SPRING-EXTENSION	28480	1400-1411
	1400-1455	2	1	SPRING-TORSION	28480	1400-1455
	1400-1610	1	1	WIREFORM	28480	1400-1610
	1400-1751	1	1	SPRING-COMPRESSION .12 DIA. .25 LG.	28480	1400-1751
	1520-0067	4	2	SHOCK MOUNT	28480	1520-0067
	1530-1780	1	2	POLE PIECE	28480	1530-1780
	1530-1781	2	1	MOTOR-CAPSTAN	28480	1530-1781
	1600-0491	8	1	DISC-TACH. .872 DIA.	28480	1600-0491
	1600-1015	4	1	CTU GROUND STRAP	28480	1600-1015
	1990-0435	5	1	PHOTOTRANSISTOR ID=100NA-MAX	28480	1990-0435
	1990-0492	4	1	LED-INFRARED IF=100MA-MAX BVR=2V	28480	1990-0492
	2190-0020	9	3	WASHER-LK HLCL NO. 5 .128-IN-ID	28480	2190-0020
	2190-0889	8	5	WASHER-SPR BLVL NO. 2 .093-IN-ID	28480	2190-0889
	2360-0235	9	2	SCREW-MACH 6-32 .688-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	3030-0142	9	2	SCREW-SET 2-56 .125-IN-LG SMALL CUP-PT	00000	ORDER BY DESCRIPTION
	3050-0227	3	2	WASHER-FL MTLC NO. 6 .149-IN-ID	28480	3050-0227
	4040-0998	5	1	BUTTON-RELEASE	0031F	C-4040-0998-1
	4040-1012	6	1	BASE	28480	4040-1012
	4040-1095	5	1	LEVER RELEASE	28480	4040-1095
	6040-0353	8		LUBE WAX MTL CUT	28480	6040-0353
	7120-5066	1	1	LABEL-INFO	28480	7120-5066
	9160-0240	9	1	MAGNET	28480	9160-0240
	02640-00012	8	2	SWITCH-CONTACT	28480	02640-00012
	02640-20006	2	4	ROLLER-LATCH	28480	02640-20006
	02640-40015	5	2	PLUNGER	28480	02640-40015
	02640-40016	6	1	PAWL	28480	02640-40016
	02640-40017	7	1	CLAMP-BUTTON	28480	02640-40017
	02640-40018	8	1	EJECTOR	28480	02640-40018
	02640-60057	7	1	ASSY-TACH COIL	28480	02640-60057
	02640-60066	8	1	ASSY-CABLE CTU	28480	02640-60066
	02640-60067	9	1	ASSY-HEAD	28480	02640-60067
	02640-60242	2	1	ASSY-CTU ELECTRODE	28480	02640-60242
	02640-60247	7	1	ASSY-MOTOR WIRE	28480	02640-60247

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60255	7	1	ASSY-MOTOR/TACH	28480	02640-60255
	0050-1953	1	1	CASTING	28480	0050-1953
	0403-0333	8	1	BUMPER-RUBBER	28480	0403-0333
	0470-0010	9		ADHESIVE-CYANOACRYL	05972	404
	0470-0231	6		COMPOUND-NUT LOCK	05972	242
	0515-0029	6	3	SCREW-MACH M2 X 0.4 6MM-LG 90-DEG-FLH-HD	00000	ORDER BY DESCRIPTION
	0624-0296	0	3	SCREW-TPG 2-56 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	1400-0249	0	1	CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	1460-1610	7	1	WIREFORM	28480	1460-1610
	1530-1780	1	2	POLE PIECE	28480	1530-1780
	1530-1781	2	1	MOTOR-CAPSTAN	28480	1530-1781
	1600-0491	8	1	DISC-TACH .872 DIA.	28480	1600-0491
	1600-1015	4	1	CTU GROUND STRAP	28480	1600-1015
	2190-0889	8	3	WASHER-SPR BLVL	28480	2190-0889
	3030-0142	9	2	SCREW-SET 2-56 .125-IN-LG SMALL CUP-PT	00000	ORDER BY DESCRIPTION
	6040-0353	8		LUBE WAX MTL CUT	28480	6040-0353
	9160-0240	9	1	MAGNET	28480	9160-0240
	02640-60057	7	1	ASSY-TACH COIL	28480	02640-60057
	02640-60247	7	1	ASSY-MOTOR WIRE	28480	02640-60247

Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
	02640-60066	8	1	ASSEMBLY-CABLE CTU	28480	02640-60066
	0400-0191	0	1	CLIP-PLASTIC	28480	0400-0191
	1251-2499	9	2	CONNECTOR 14-PIN M RECTANGULAR	28480	1251-2499
	8120-1458	8	1	CABLE-FL-RBN 28AWG 14-CNDCT GRA-INSUL	28480	8120-1458

Replaceable Parts

Reference Designation	HP Part Number	CD	Qty	Description	Mfr Code	Mfr Part Number
	02640-60067	9	1	ASSEMBLY-HEAD	28480	02640-60067
	0624-0337	0	3	SCREW-TPG 2-56 .5-IN-LG PAN-HD-TORX STL	00000	ORDER BY DESCRIPTION
	0890-0006	3	1	TUBING-FLEX .204-ID PVC .02-WALL	28480	0890-0006
	1400-0249	0	1	CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	1460-1383	1	2	SPRING-CPRSN .18-IN-OD .312-IN-OA-LG MUW	28480	1460-1383
	3050-0675	5	1	WASHER-FL MTLC NO. 1 .089-IN-ID	28480	3050-0675
	4040-1013	7	1	HEAD MOUNT	28480	4040-1013
	9164-0061	0	1	HEAD-CART TAPE	28480	9164-0061

Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60085	1	1	ASSEMBLY-MOTOR CABLE	28480	02640-60085
	0890-0006	3	1	TUBING-FLEX .204-ID PVC .02-WALL	28480	0890-0006
	1251-2505	8	2	CONNECTOR 2-PIN F UTILITY	28480	1251-2505
	1251-2600	4	4	CONTACT-CONN U/W-UTIL FEM CRP	28480	1251-2600
	1251-3073	7	4	CONTACT-CONN U/W-POST-TYPE FEM CRP	28480	1251-3073
	1251-3277	3	1	CONNECTOR 4-PIN F POST TYPE	28480	1251-3277
	8150-1540	2	1	WIRE 22AWG BK 300V PVC 7X30 80C	28480	8150-1540
	8150-1542	4	1	WIRE 22AWG R 300V PVC 7X30 80C	28480	8150-1542
	8150-1550	4	1	WIRE 22AWG W/BK 300V PVC 7X30 80C	28480	8150-1550
	8150-1552	6	1	WIRE 22AWG W/R 300V PVC 7X30 80C	28480	8150-1552

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02640-60177	2	1	ASSEMBLY-CTU BEZEL	28480	02640-60177
	0460-0924	3		TAPE-POLYU FOAM	28480	0460-0924
	0905-0126	1	4	O-RING .114-IN-ID .07-IN-XSECT-DIA FLCBN	28480	0905-0126
	1460-1448	9	2	SPRING-TRSN .124-IN-OD MUW CD	28480	1460-1448
	2190-0918	4	4	WASHER-LK HLCL NO. 6 .141-IN-ID	28480	2190-0918
	2360-0219	9	4	SCREW-MACH 6-32 1.375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	3050-0247	7	4	WASHER-FL NM NO. 6 .141-IN-ID .375-IN-OD	28480	3050-0247
	4040-1247	9	2	DOOR-BEZEL	28480	4040-1247
	4040-1248	0	1	BEZEL	28480	4040-1248
	02644-00007	5	1	STIFFENER-BEZEL	28480	02644-00007

MFR NO.	MANUFACTURER NAME	ADDRESS		ZIP CODE
00000	ANY SATISFACTORY SUPPLIER			
0031F	OSTERRATH KG	SASSMANNSHAUSEN	GM	
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
01928	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	08876
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85062
05820	WAKEFIELD ENGINEERING INC	WAKEFIELD	MA	01880
05972	LOCTITE CORP	NEWINGTON	CT	06111
06383	PANDUIT CORP	TINLEY PARK	IL	60477
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
1F556	PRECISION LAMP INC	MOUNTAIN VIEW	CA	94040
11236	CTS OF BERNE INC	BERNE	IN	46711
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
72136	ELECTRO MOTIVE CORP SUB IEC	WILLIMANTIC	CT	06226
75042	TRW INC PHILADELPHIA DIV	PHILADELPHIA	PA	19108
91637	DALE ELECTRONICS INC	COLUMBUS	NE	68601