

ST406/412 /419



Service Manual

SEAGATE TECHNOLOGY

**ST406/412/419 MICROWINCHESTER
SERVICE MANUAL
OCTOBER 17, 1983**

920 Disc Drive • Scotts Valley, CA 95066 • Phone: (408) 438-6550

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1.0 INTRODUCTION

1.1 General Description

The ST406/412/419 are second generation 5.25 inch Microwinchester disc drives from SEAGATE. Based on the world's first MicroWinchester, the ST506, this series features higher capacity and performance.

Manganese-Zinc heads and an advanced stepper motor design enable higher track density. The new head design allows increased bit packing; utilizing more of the disc surface and twice the number of cylinders. High reliability is assured through the use of a metal band actuator, open-loop stepper head positioner and a direct-drive brushless DC motor. The spindle motor assembly is dynamically balanced and the Head Disc Assembly (HDA) is shock mounted to reduce vibration.

The low mass/load force of the Winchester heads and the lubricated oxide coated media provide reliable start/stop operation. Each disc surface is read by a dedicated Read/Write head. The HDA, which includes the Read/Write heads, disc and band-actuator assembly is completely sealed and protected by a air-recirculation system employing a 0.3 micron absolute filter. A filtered port permits ambient air pressure equalization.

Thermal stabilization delays are unnecessary with the ST400 series. The spindle pump assures adequate air flow and uniform temperature distribution throughout the sealed HDA. This allows significantly greater off-track margin and immediate read/write ability after power-up.

Only DC voltages (+5 and +12 V DC) are required. All electronics are packaged on two printed circuit boards (PCB). The boards are mounted outside the sealed media area allowing easy field access without risking media integrity. Simplification of mechanical and electrical design provides a projected service life of more than 11,000 hour Mean Time Between Failures (MTBF).

The ST400 drives have the same interface, power supply and controller requirements as the Industry Standard SEAGATE ST506. SEAGATE provides controllers that are compatible with Small Computer Interface (SCSI) Standard. Controllers are also available from several other sources.

1.2 SPECIFICATION SUMMARY

1.2.1 Physical Specifications

Environmental Limits

Ambient Temperature Limits

Operating: 40° to 122°F (4° to 50°C)
Non-Operating: -40° to 140°F (-40° to 60°C)

Maximum Temperature Gradient

Operating: 18°F/hour or 10°C/hour
Non-Operating: Below Condensation

Relative Humidity: 8 to 80% non-condensing

Maximum Wet Bulb: 78.8°F (26°C)

Maximum Elevation

Operating: 10,000 feet
Non-Operating: -1,000 to 30,000 feet

Maximum Shock Without Incurring Physical Damage

Operating: 10 G's
Non-Operating: 20 G's*

*No mechanical damage will occur within these limits.

DC Power Requirements

+12 Volts $\pm 5\%$, 1.6 A typical, 3.5 A (At Power-on)
+5 Volts $\pm 5\%$, 1.1 A typical, 1.7 A (Maximum)
Maximum Ripple: 50 mV peak to peak (12 V, 5 V)

Mechanical Dimensions

Height: 3.25 inches
Width: 5.75 inches
Depth: 8.00 inches
Weight: 4.6 pounds (2.1 Kg)
Shipping Weight: 9.0 pounds (4.1 Kg)

Heat Dissipation

Typical: 25 Watts
Maximum: 32 Watts

1.2.2 Reliability Specifications

MTBF: 11,000 POH, typical usage
MTTR: 30 minutes
PM: Not required
The component design life is 5 years.

Error Rates

Soft Read Errors*: 1 per 10^{10} bits read
Hard Read Errors**: 1 per 10^{12} bits read
Seek Errors: 1 per 10^6 seeks

* Recoverable within 16 retries

** Not recoverable within 16 retries

1.2.3 Performance Specifications

CAPACITY	ST406	MODEL	ST419
Unformatted		ST412	
Per Drive:	6.38 MB	12.76 MB	19.14 MB
Per Surface:	3.19 MB	3.19 MB	3.19 MB
Per Track:	10,416 Bytes	10,416 Bytes	10,416 Bytes
Formatted			
Per Drive:	5.0 MB	10.0 MB	15.0 MB
Per Surface:	2.5 MB	2.5 MB	2.5 MB
Per Track:	8,192 Bytes	8,192 Bytes	8,192 Bytes
Per Sector:	256 Bytes	256 Bytes	256 Bytes
Sectors Per Track:	32	32	32
Access Time			
Average*:	85 mSec	85 mSec	85 mSec
Maximum*:	205 mSec	205 mSec	205 mSec
Settling Time/Single Track:	<16.67 mSec		
*Using buffered seek (includes settling)			
Transfer Rate:	5.0 M Bits/sec		
Average Latency:	8.33 mSec		

1.2.4 Functional Specifications

Rotational Speed: 3,600 RPM $\pm 1\%$
Recording Density: 9,074 Bits per inch (Maximum)
Flux Density: 9,074 Flux changes per inch (Maximum)
Track Density: 345 Tracks per inch
Cylinders: 306
Tracks: 612 1,224 1,836
Read/Write Heads: 2 4 6
Discs: 1 2 3

2.0 THEORY OF OPERATIONS

2.1 General Interface Description

The ST400 family supports the Industry Standard ST506 Interface, developed by SEAGATE. This interface provides many floppy-disc similarities in addition to supporting the increased performance requirements of the 5.25 inch Winchester products.

The interface consists of a 34 pin Control connector, a 20 pin Read/Write connector and a 4 pin DC connector. The 34 pin connector provides 10 control signals to the drive and returns 5 status signals to the controller. The 20 pin connector handles the Modified Frequency Modulation (MFM) data to/from the drive and supplies the Drive-Selected status to the controller. The 4 pin connector provides +5 and +12 Volts DC.

In general, the Control connector is "daisy-chain" terminated throughout the user system, while the Read/Write connector is terminated radially. The following tables illustrate the ST400 interface requirements.

J1/P1 - CONNECTOR PIN ASSIGNMENTS

PIN	PIN	DIRECTION	DESCRIPTION
1	2		Reserved
3	4	In	Reserved (Head 22)
5	6	In	-Write Gate
7	8	Out	-Seek Complete
9	10	Out	-Track 0
11	12	Out	-Write Fault
13	14	In	-Head Select 20
15	16		Reserved (To J2 Pin 7)
17	18	In	-Head Select 21
19	20	Out	-Index
21	22	Out	-Ready
23	24	In	-Step
25	26	In	-Drive Select 1
27	28	In	-Drive Select 2
29	30	In	-Drive Select 3
31	32	In	-Drive Select 4
33	34	In	-Direction In

J2/P2 - CONNECTOR PIN ASSIGNMENTS

GROUND RTN. PIN	SIGNAL PIN	SIGNAL DIRECTION	DESCRIPTION
2	1	Out	-Drive Selected
4	3		Reserved
6	5		Reserved
8	7		Reserved (To J1 Pin 16)
10	9		Reserved
12	11		Ground
	13	In	+MFM Write Data
	14	In	-MFM Write Data
16	15		Ground
	17	Out	+MFM Read Data
	18	Out	-MFM Read Data
20	19		Ground

J3/P3 - CONNECTOR PIN ASSIGNMENTS

GROUND RTN. PIN	SIGNAL PIN	SIGNAL DIRECTION	DESCRIPTION
2	1		+12 Volts DC
3	4		+5 Volts DC

2.1.1 Recording Format

The ST400 series uses Modified Frequency Modulation (MFM) as the encoding method to record data. This double-density encoding scheme increases disc capacity by replacing clock bits with data bits. Clock bits are written only when data bits are not present in both the preceding and current bit cell. Clock bits are written at the beginning of the bit cell, while data bits are written in the middle.

Due to predictable bit-shift phenomena, the ST400 series requires pre-compensation of write data on cylinders 128 through 305. This function must be provided by the controller to ensure data integrity at the specified error rate. The data pattern determines which bits must be pre-compensated. The recommended amount of pre-compensation is 12 nSec for both early and late written bits. All other data patterns are written on time.

2.1.2 Track Format

The ST400 series uses a slightly modified version of the IBM System 34 double-density format. This format is common to many Industry Standard floppy-disc drives.

As formatted, each sector is identified by a unique identification field containing, cylinder, head and sector information, address mark and error checking polynomials. The SEAGATE format uses Cyclic Redundancy Checking (CRC) for error evaluation. This format also allows for a plus or minus speed variation of approximately 3%. The specification for spindle speed variation is 1% over the specified environmental and power limits.

2.1.3 Winchester Heads

The ST400 family uses Manganese/Zinc Ferrite Winchester head technology. The head/flexure (supporting arm) assembly is designed for contact start/stop operation. When operational, the Read/Write heads fly on an air bearing created by the rotating disc. There is no dedicated landing zone.

The Winchester heads are loaded toward the disc surface at 9.5 grams. This is a typical value to allow the required stability in all operating conditions. The flying height at the innermost cylinder is 19 microinches with a tolerance of ± 3 microinches. At the outermost cylinder the height is 24 microinches, ± 3 microinches.

The 9.5 gram loading is sufficient such that various mounting orientations of the drive will not affect the flying height of the Winchester heads to any significant degree. The head/flexure assembly incorporates an extremely low mass design that is resistive to head and/or media damage during shipping.

2.1.4 Discs

The ST400 drives employ nonremovable double-sided 5.25 inch discs. The discs are designed using current iron oxide technology. Disc dimensions are 40 mm inside diameter by 130 mm outside diameter. The thickness of the magnetic coating is 20 microinches at the ID and increases linearly to 40 microinches at the OD.

The disc surface is coated with a Teflon lubricant 40 to 60 angstroms in thickness. This value is equivalent to a uniform monomolecular film. The lubricant has sufficient abrasion resistance to withstand a minimum of 10,000 start/stop cycles. The magnetic discs have a life expectancy of 5 years.

2.1.5 Air Filtration System

The ST400 series incorporates an integral air filtration system. The 0.3 micron filter maintains Class 100 standards within the sealed HDA and requires no maintenance during the life of the drive. A filtered port allows ambient pressure equalization. During normal operation there is no measurable air flow between the HDA and the outside environment.

2.2 Mechanical Theory

2.2.1 Track 0 Sensor

The Track 0 optical interrupter provides an output whenever the Winchester heads are positioned over Cylinder Zero. This signal is used by the internal drive control electronics during the power-on/auto-recalibrate routine. The Track 0 signal is also output to the drive interface for use by the controller. Note that the signal at the interface is really Track 0/Phase "A."

The Track 0 optical interrupter incorporates an infrared LED and an infrared sensitive photo-transistor. When the heads are positioned at Cylinder Zero, an interrupter arm attached to the stepper motor shaft breaks the light beam between the two components of the sensor. The sensor will put out a valid Track 0 signal as long as the beam remains broken.

2.2.2 Index Sensor

Once each revolution the Index Sensor provides an index pulse to the microprocessor for recalibration. This pulse width depends upon the specific Main Control PCB in use (See Sec 2.4). The ST400 Index Sensor is of the reluctance transducer type. This cylindrical sensor incorporates a built-in preamplifier. The case of the sensor is grounded, which ties the drive DC returns to the drive casting.

The hub of the spindle motor has two metal tabs attached. One is ferrous and the other, which is mounted 180° is non-magnetic. Each revolution of the spindle motor causes the ferrous tab to rotate past the Index Sensor, thereby inducing a pulse.

Note: The dimension between the spindle motor tab and the Index Sensor is factory set to 0.030 inch.

2.2.3 Ground Spring

The ST400 incorporates a grounding contact between the spindle motor hub and the drive casting. The Ground Spring removes all unwanted static electrical charges from the spindle motor hub.

2.2.4 Spindle Brake

Note: Newer ST400 disc drives do not use a Spindle Brake. A revised Motor Control PCB incorporates dynamic braking. In these units, the Motor Board uses the reverse EMF generated by the spindle motor to slow the discs (See Sec. 2.3.2).

Earlier drives use an electromechanical brake to slow the spindle motor when DC power is removed. The Spindle Brake is energized directly from the +12 Volt supply. When +12 V is removed, a brake pad engages directly against the spindle motor hub.

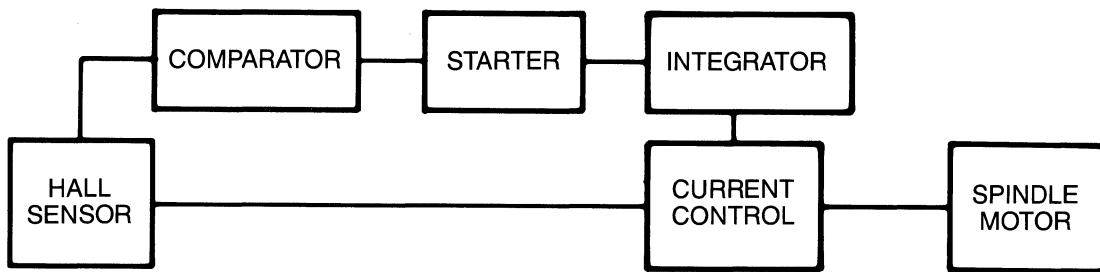
The pad contact material is of a rubber-cork composition with wear life designed to exceed 20,000 cycles. When energized, the brake will draw a maximum current of 267 milliAmps.

If the Spindle Brake is serviced or adjusted, the contour of the pad contact must match the spindle motor hub. When disengaged, the clearance between the pad and the hub should be set at .010 inch.

2.3 ELECTRICAL THEORY

2.3.1 Motor Speed Control PCB - Part No. 20099

Block Diagram-



Functional description - (Refer to schematic on page 44)

Initially, when power is first applied, the disc is stationary and the Hall Effect transistor (located inside the spindle motor) will output a high or low level, depending on the physical position of the motor. This DC level will keep Q1 turned off, allowing C5 to charge up. Pin 1 of Comparator 2A will output a low level travels through R12 and forces Pin 7 of 2A high. As a result, 1A will be off and maximum current will flow into the coil selected by the Hall Effect sensor.

As the motor speeds up, the Hall Effect becomes a square wave responsible for both selecting the motor coil to receive current and controlling the amount of current applied. Current is applied alternately to coils A and B as the Hall device senses the motor's physical position. Depending on the time between high going edges of the Hall sensor, Q1 will be turned off long enough for C5 to charge to more than 4 Volts and force Pin 1 of Comparator 2A low. This low pulse will turn on Pin 7 of 1A whose resulting 6 volt output pulse will direct Pin 7 of Integrator 2A to allow more current to enter the motor coils.

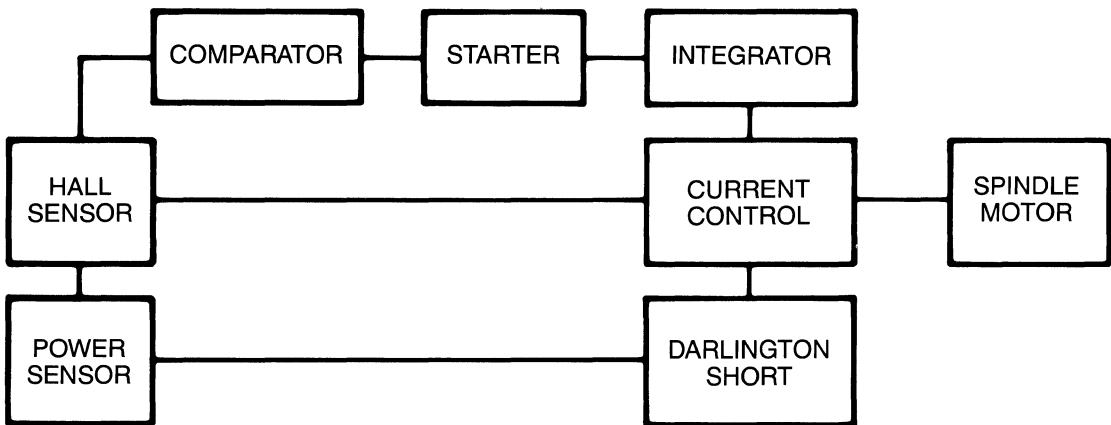
The sequence of normal operation is as follows:

1. The Hall Effect sensor relays speed and position information to the Speed-Error Comparator and to the Current Controller.

2. The Speed-Error Comparator, Pin 1 of 2A, generates a low spike whose duration is dependent on the speed error. A slow speed will result in the low pulse being longer.
3. The speed error information enters the starting circuit, which passes a low frequency signal directly to the Integrator, indicating maximum error during start-up.
4. Pin 7 of Integrator 2A translates the error information into a level appropriate for biasing both halves of IC 1A, which functions to control the current source.
5. The Current Control, IC 3A, supplies the correct current level for attaining speed as directed by IC 1A.

2.3.2 Motor Speed Control PCB - Part No. 20136
Dynamic Brake

Block Diagram -



Functional Description - (Refer to schematic of page 45)

Initially, when power is first applied, the disc is stationary and the Hall Effect transistor (located inside the spindle motor) will output a high or low level, depending on the physical position of the motor. This DC level will keep Q1 turned off, allowing C5 to charge up. Pin 1 of Comparator 2A will output a low level that travels through R12 and forces Pin 7 of 2A high. As a result, 1A will be off and maximum current will flow into the coil selected by the Hall Effect sensor. Q2 acts as a limiter to keep the starting current down to 3.5 Amps maximum.

As the motor speeds up, the Hall Effect becomes a square wave responsible for both selecting the motor coil to receive current and controlling the amount of current applied. Current is applied alternately to coils A and B as the Hall device senses the motor position. Depending on the time between high going edges of the Hall Effect sensor, Q1 will be turned off long enough for C5 to charge to more than 4 Volts and force Pin 1 of Comparator 2A low. This low pulse will turn on Pin 7 of 1A, whose resulting 6 Volt output pulse will direct Pin 7 of Integrator 2A to allow more current to enter the motor coils.

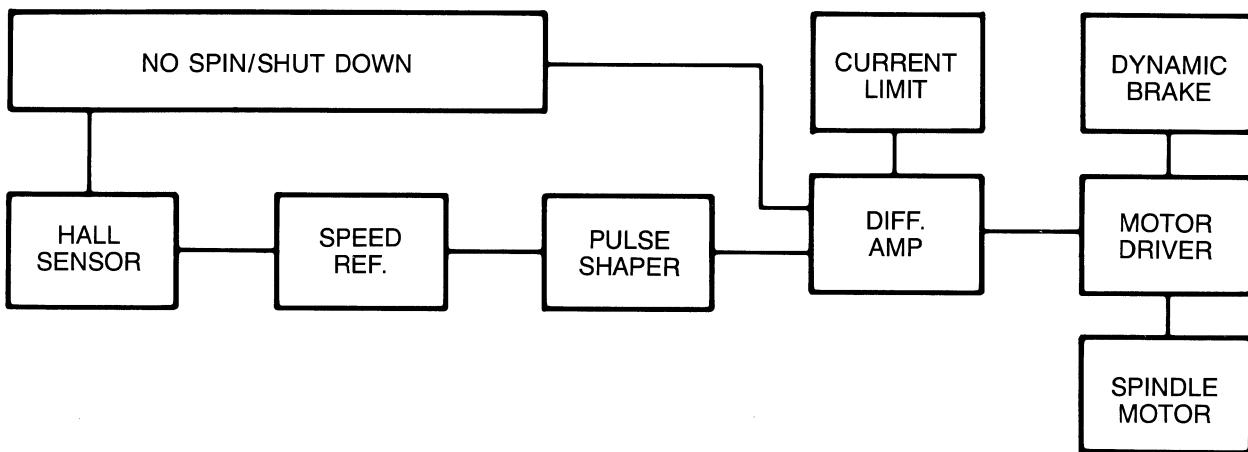
The sequence of normal operations is as follows:

1. The Hall Effect sensor relays speed and position information to the speed-error Comparator and to the Current Controller.

2. The speed-error Comparator, Pin 1 of 2A, generates a low spike whose duration is independent of the speed error. A slow speed will result in the low pulse being longer.
3. The speed-error information enters the starting circuit, which, during start-up passes a low frequency signal directly to the Integrator, indicating maximum error. The starting circuit also inverts the speed-error information and combines it with a carrier that properly biases the Integrator during normal operation.
4. Pin 7, of Integrator 2A, translates the error information into a level appropriate for biasing both halves of IC 1A, which functions to control the current source.
5. The Current Control, Q3 and Q4, supplies the proper amount of current for attaining proper speed as directed by IC 1A.
6. On power-up, C13 is charged to just below 12 Volts and Q7 remains off. When the power is shut off or drops below 12 Volts for a period, C13 discharges through Q7 turning on the Dynamic Brake. These components energize both phases of the spindle motor in opposite directions, bringing the motor to a rapid stop.

2.3.3 Motor Speed Control PCB - Part No. 20217
Dynamic Brake

Block Diagram -



Functional Description - (Refer to schematic on page 46)

The operation of this PCB is very similar to the previously described PCB 20136. The No-Spin/Shut-Down components are the only functional changes.

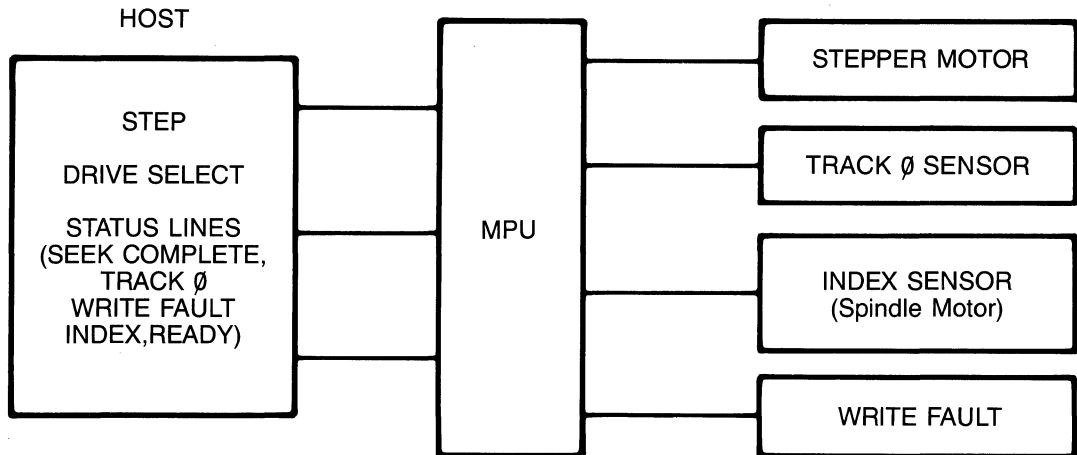
The sequence of normal operations is as follows:

1. The Hall Effect transducer, located inside the spindle hub, provides feedback proportional to the speed of the motor. The sensor supplies two complete square wave transitions for each motor revolution. These transitions are inverted at 1A, Pin 2, and are also used to inversely bias final drivers Q3 and Q4.
2. The Hall sensor transitions are compared against a voltage reference at 2A, Pin 2. This provides the motor control logic with speed-servo information.
3. At power-on, a time constant of .875 second is developed at Comparator 2A, Pin 5. The No-Spin/Shut-Down device compares the two voltages developed and shuts down the spindle motor if the Hall signal exceeds the time constant.
4. Pulse Shaper - The output of transistor 1A, Pin 7, smooths out the incoming Hall Effect waveform.
5. The Differential Amplifier at Pin 13 intergates and compares the Hall Effect signal. The output of this component establishes the "on time" for each phase of the spindle motor.

6. The spindle motor drive current is supplied by transistors Q3 and Q4. These transistors are biased "on" alternately with respect to the Hall signal and the output from the Differential Amplifier.
7. The starting current is limited to a maximum of 3.5 Amps by transistor Q2 decreasing the available bias from the output of the Differential Amplifier.
8. The circuitry that includes transistors Q5, Q6 and Q7 is charged up during power-on. At power-down, or whenever the voltage drops below 12 Volts for a period, these components energize both phases of the spindle motor in opposite directions, bringing the motor to a rapid stop.

2.3.4 Microprocessor Operation

Block Diagram -



Functional Description -

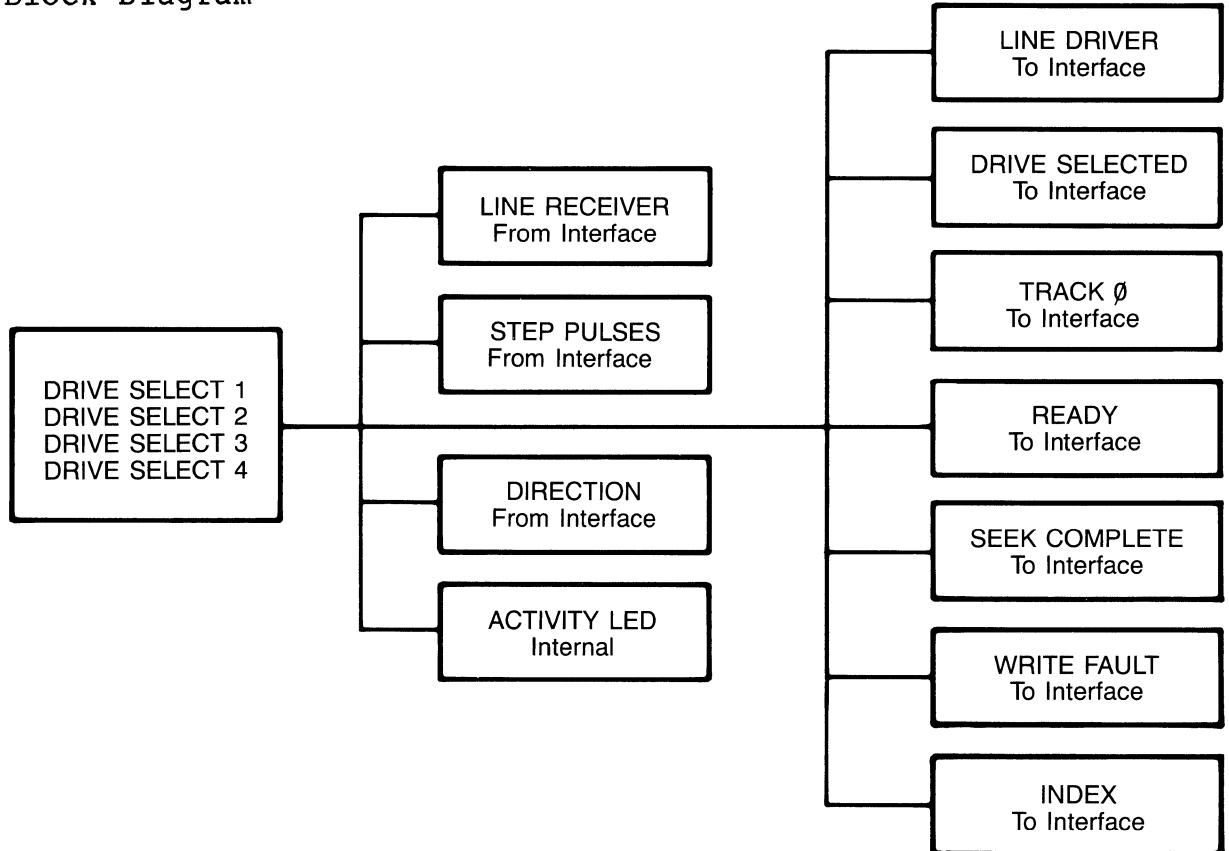
The ST400 family uses a microprocessor to monitor most of the drive functions, and to interface with the host controller.

Primary Processor duties are as follows:

1. It counts the required 660 revolutions after power-up for the "up-to-speed" function.
2. The processor monitors the Track Ø sensor and automatically recalibrates the drive to Track Ø.
3. It accepts step pulses, performs the necessary buffering of the pulses and then determines the necessary algorithm to perform the required stepping.
4. When the DRIVE SELECT line is active, the processor receives control signals from the host controller and gates status signals in return.

2.3.5 Drive Selection

Block Diagram -

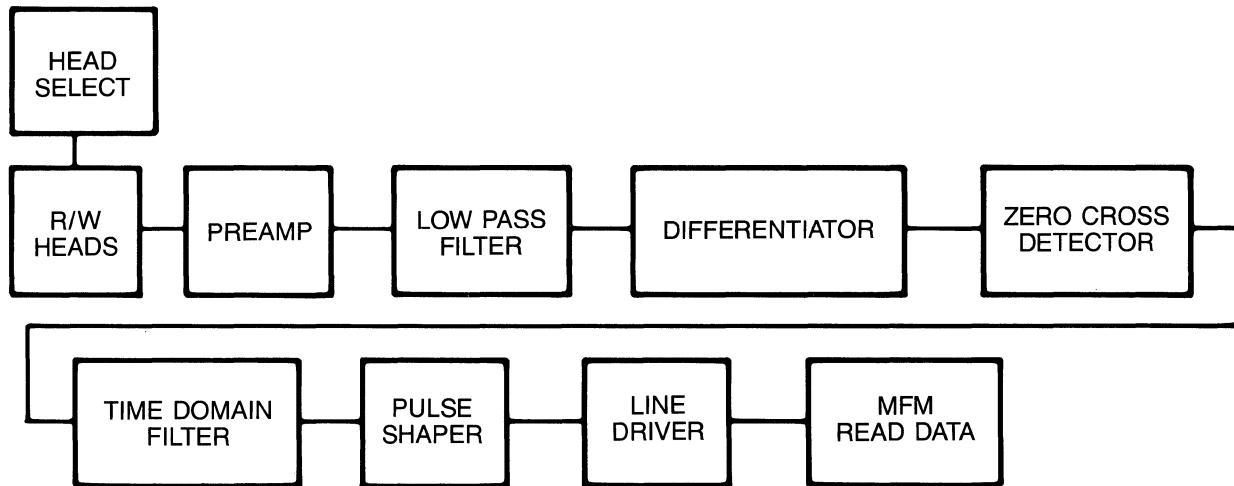


Functional Description -

DRIVE SELECT serves only to gate other signals to or from the drive interface. Without DRIVE SELECT, the drive cannot Read, Write or Seek.

2.3.6 Read Operation

Block Diagram -



Functional Description -

In order to READ, the following conditions must be true:

1. Write Gate inactive.
2. Write Fault inactive.
3. Drive Select active.
4. Head Select active.

The binary decoder decodes the two Head Select lines, the Write Gate line and the Write Fault line. Assuming Write Gate is inactive and there is no Write Fault, the inactive state of both Head Select lines will select head 0. The center tap of the selected head is set to approximately +5 Volts by the use of series resistors. By changing the reference to +5 Volts, 0 Volts appears as -5 Volts and the use of an actual negative voltage is precluded. Raw data riding on the +5 Volt signal is amplified by the Differential Two-Stage Amplifier before entering the Low Pass Filter, which attenuates the higher unused frequencies.

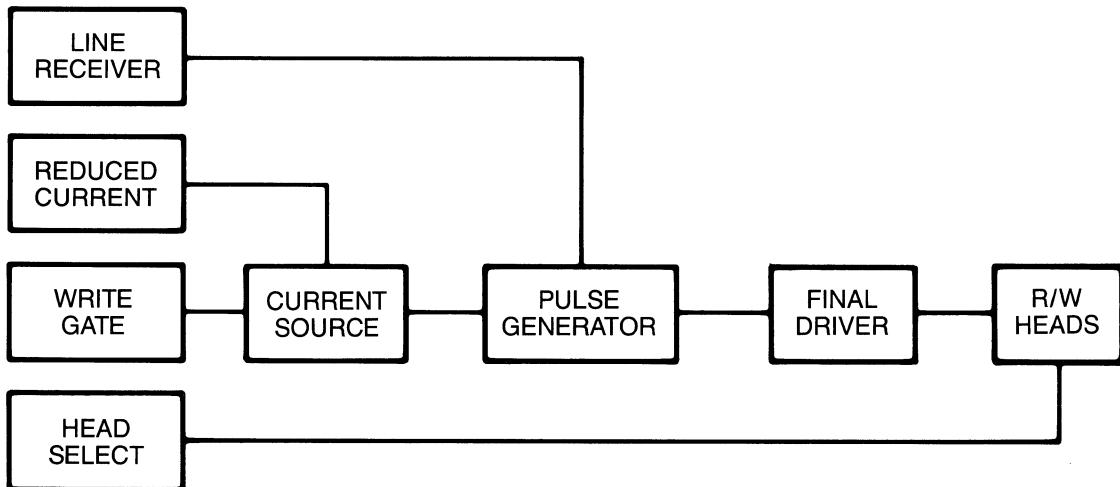
The Differentiator shifts the data by 90° causing the data peaks to become zero crossings. The zero crossing detector senses this and converts the analog input to TTL levels. The Time Domain Filter inhibits any false zero crossings that may be found on the outer edge of the disc surface. These false crossings are primarily caused by excessive third harmonics in the analog signal.

The Differential receiver and 2-input Exclusive-OR gate form a bidirectional monostable multivibrator. The output of this device is delayed 60 nsec by the four Hex Schmidt triggers. This delay is used to clock the output of the Zero Cross Detector into the D-type flip-flop. Any false clocks caused by a false zero crossing does not change the state of the flip-flop.

The last Differential receiver and 2-input Exclusive-OR gate form a bidirectional monostable multivibrator that establishes the width of the data pulse output from the drive. The line driver converts the data pulse to differential RS-422 levels.

2.3.7 Write Operation

Block Diagram -



Functional Description -

In order to WRITE, the following conditions must be true:

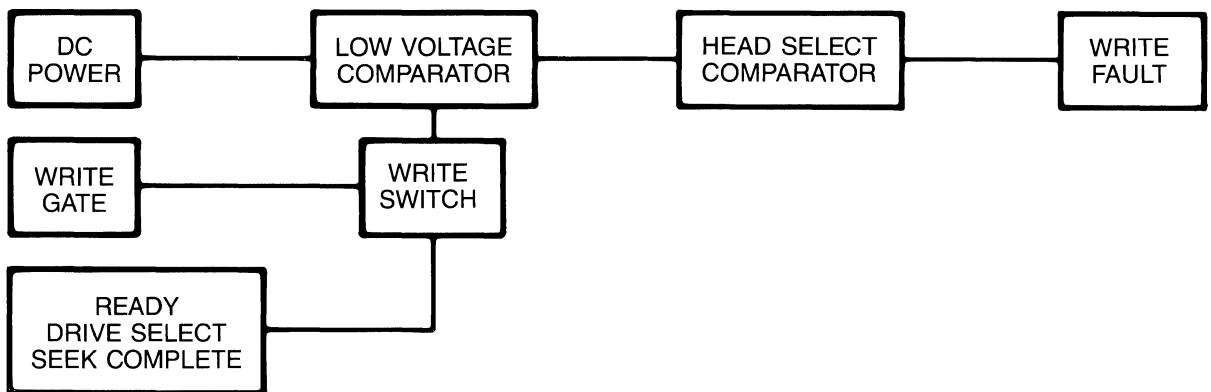
1. Write Fault inactive.
2. Drive Select active.
3. Drive Ready active.
4. Seek Complete active.
5. Write Gate active.

With Write Gate active and all the above conditions true, +12 Volts is supplied to Write circuit Current Source (IC 4K), which provides a constant current to the pulsing circuit. When active, the reduced Write current will reduce the Write current by approximately 10%, peak to peak.

When MFM Write data is received by the Line Receiver, it clocks the D-type flip-flop causing the driver transistors to alternate Write current between the windings of the selected head. The center tap of the selected head is at ground potential when Write Gate is active. When Write Gate goes false, the D-type flip-flop is both reset and preset. Both driver transistors are biased off and +12 Volts is removed from the Write circuit.

2.3.8 Fault Detection

Block Diagram -



Functional Description -

Any combination of the following events will cause a Write Fault condition and will prevent the drive from writing:

1. Multiple heads selected.
2. DC voltages greater than 20% low.
3. Write Gate active with no Write current
4. Write Gate inactive with no Write current.
5. Seek Complete inactive, with Write Gate active.

The Head-Unsafe circuit monitors the Head Select output for the following conditions:

1. No head selected.
2. Multiple heads selected.
3. Head selected for Read during Write.
4. Head selected for Write during Read.

The Head-Unsafe circuit constantly sums the head center tap voltage. If the voltage exceeds the upper or lower threshold established by the resistor divider, the circuit provides a Head-Unsafe output. The upper and lower thresholds shift correspondingly when Write Gate is active. A capacitor delays this change to allow for the change from Read to Write. If any unsafe condition

is sensed, the Write Fault line is activated and +12 Volts is removed from the Write Circuit.

If the DC power degrades by more than 20%, the Power-Unsafe detector circuit will de-select the head, activate Write Fault, turn off Write current and apply a re-set to the microprocessor. After the re-set is removed, the processor counts 660 index pulses and then executes a recalibration routine. If the +5 Volt line drops below 4 Volts, the +5 Volt Comparator will go high. The +12 Volt Comparator will go high if the +12 Volt line drops below 10 Volts. When either Comparator turns on, the resulting low level is gated through the Head-Select decoder and output to the drive interface as an active Write Fault signal. A low-voltage fault condition will also turn off the Write current source.

Write Gate and Write current to the heads are continuously tested. If one is ever active, while the other is not, a fault condition will occur. The signal is gated to the drive interface and the Head-Select decoder. In addition to the three listed fault conditions, Write Gate is compared with Drive Select, Seek Complete and Ready. If an improper condition exists with any of these signals, Write current will be shut off.

2.4 Test Point Descriptions

2.4.1 Test Point Description PCB 20096

Test Points 1 and 2 (Differential Read Filter):

Test Points 1 and 2 may be used to observe the Differential Read Data. The typical amplitude of the signal resulting from adding the two channels is 300 mVolts. TP 8 should be used as ground to reduce noise.

A full track record of high frequency data (0000 or 1111) should resemble Figure 1.1.

Test Points 3 and 4 (Read Data):

Test Points 3 and 4 may be used to observe the Read Data from the operation of the Time Domain Filter. Trigger off TP 3 and monitor the delay at TP 4. Typically, the delay observed should be 50 nsec. A full track record of high frequency data (0000 or 1111) should resemble Figure 1.2.

Test Point 5 (Track 0 Sensor):

Test Point 5 may be used to monitor the Track 0 Sensor. A high logic level is a valid Track 0 indication.

Test Point 6 (Index Sensor):

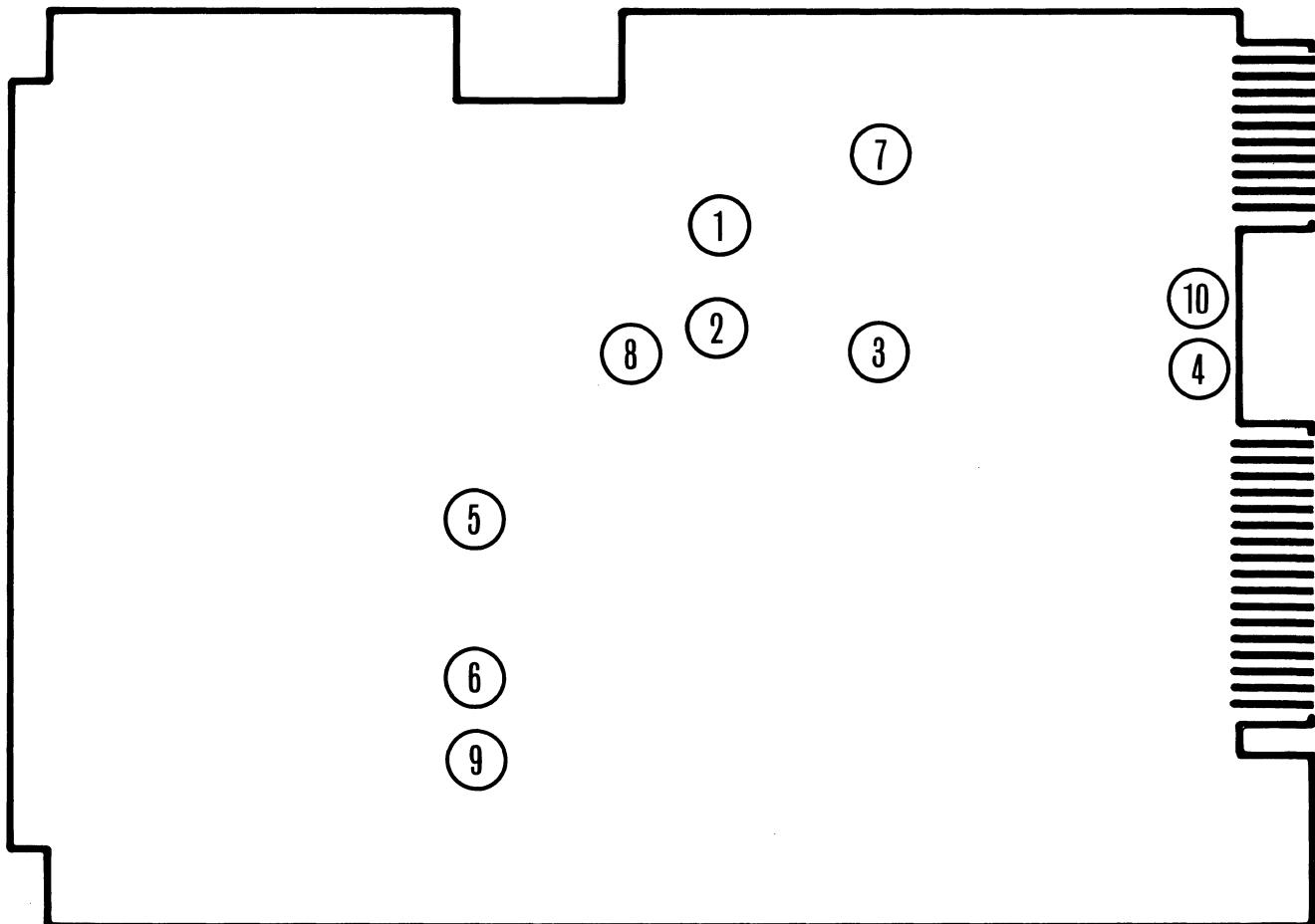
Test Point 6 may be used to monitor the Index Sensor. A high logic level is a valid Index indication. Only the leading edge of the pulse may be considered valid. The typical signal at TP 6 should resemble Figure 1.3.

Test Point 6 is used to adjust the spindle motor speed. Monitor TP 6 and adjust R3 on the Motor Control PCB (accessible through the side frame) for a period of 16.67 msec,+1%.

Test Points 7,8,9 and 10 are convenience grounds.

For any of the above functions, use the ground point nearest the active TP.

FIGURE 1.0
TEST POINT LAYOUT PCB 20096



TEST POINT **DESCRIPTION**

1 & 2	Differential Read Filter
3 & 4	Read Data
5	Track 0 Sensor
6	Index Sensor
7,8,9,10	Convenience Grounds

TEST POINT TIMING PCB 20096

FIGURE 1.1
DIFFERENTIAL READ FILTER

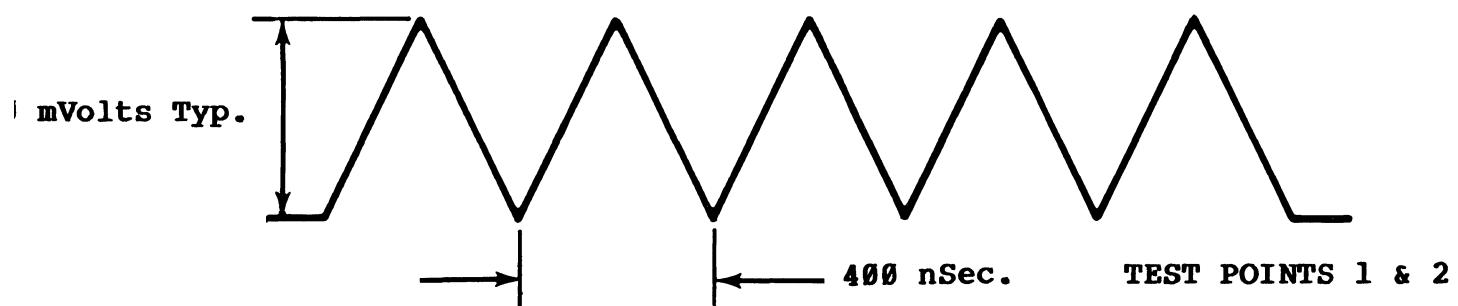


FIGURE 1.2
READ DATA

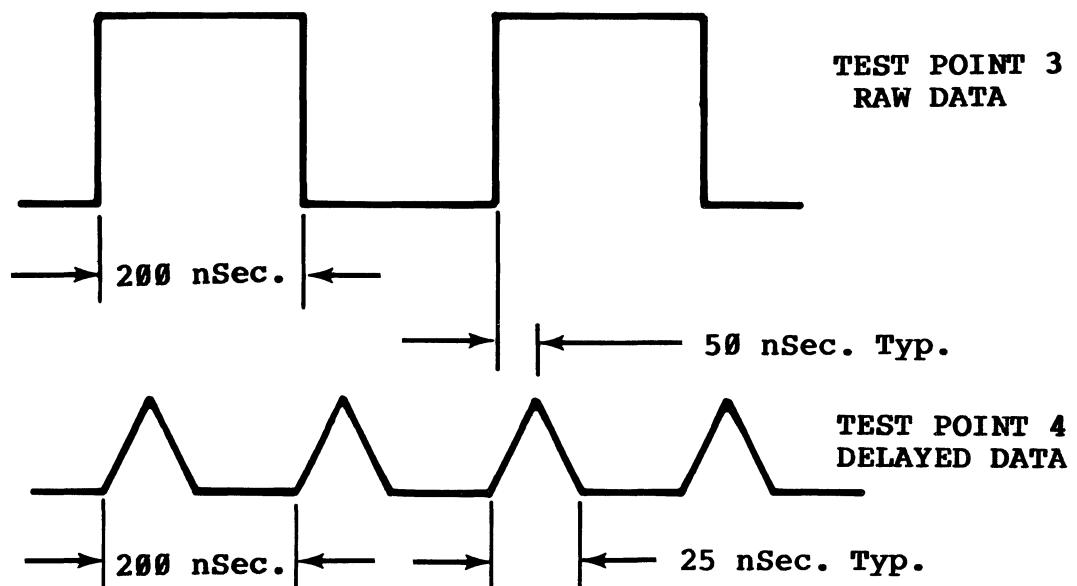
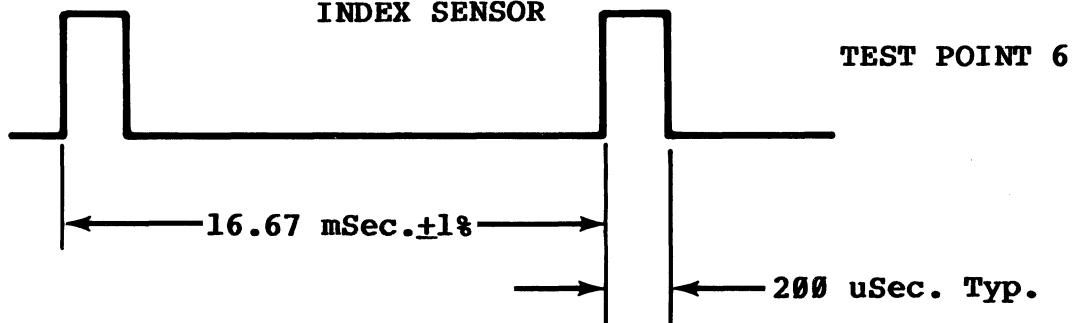


FIGURE 1.3
INDEX SENSOR



2.4.2 Test Point Description PCB 20110

Test Point 3 (Track 0 Sensor):

Test Point 3 may be used to monitor the condition of the Track 0 Sensor. A high logic level is a valid Track 0 indication.

Test Point 4 (Index Sensor):

Test Point 4 may be used to monitor the Index Sensor. A high logic level is a valid Index indication. Only the leading edge of the pulse may be considered valid. The typical signal at TP 4 should resemble Figure 2.1.

Test Point 5 (Seek Complete):

Test Point 5 may be used to monitor the Seek Complete line. A high logic level is a valid Seek Complete indication.

Test Points 11 and 13 (Read Data):

Test Points 11 and 13 may be used to observe the Read Data from the Time Domain Filter. Trigger on TP 11 and monitor the delay at TP 13. The delay observed should be typically 50 nanoseconds. A full track record of high frequency data (0000 or 1111) should resemble Figure 2.2.

Test Points 7 and 8 (Differential Read Filter):

Test Points 7 and 8 may be used to observe the Differential Read Data. The typical amplitude of the signal resulting from adding the two channels is 300 mVolts. TP 9 should be used as a ground to reduce noise.

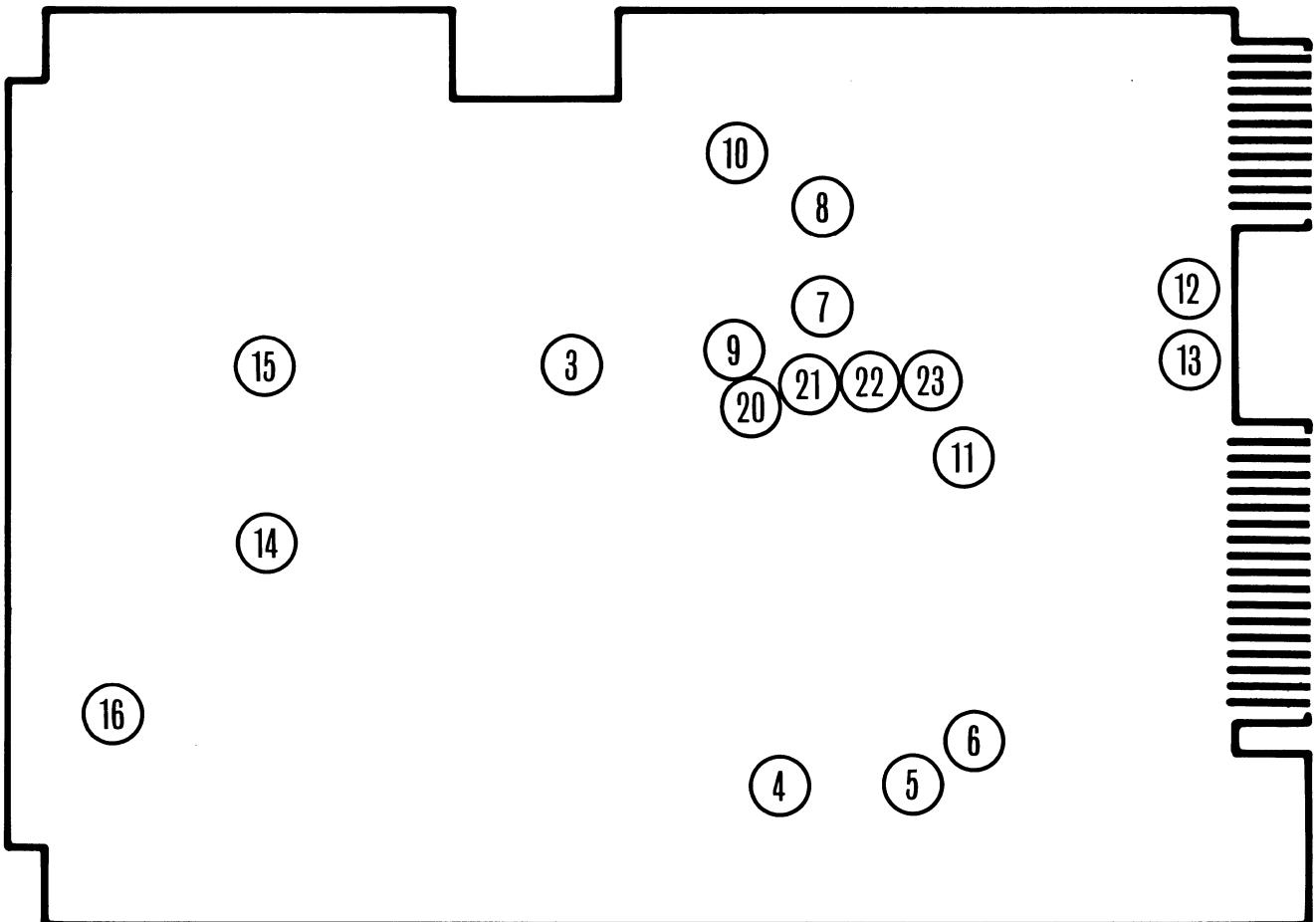
A full track record of high frequency data (0000 or 1111) should resemble Figure 2.3.

Test Point 20 (5 Volt Pullup):

Test Point 20 is a 5 Volt pullup. To use this pullup, the line at J01 must be cut.

Test Points 9,10,12,14,15,16,21,22,23 are convenience grounds.

FIGURE 2.0
TEST POINT LAYOUT PCB 20110



TEST POINT	DESCRIPTION
3	Track 0 Sensor
4	Index Sensor
5	Seek Complete
7 & 8	Differential Read Filter
11 & 13	Read Filter
20	5 Volt Pullup
9,10,12,14,15, 16,21,22,23	Convenience Grounds

TEST POINT TIMING PCB 20110

FIGURE 2.1
INDEX SENSOR

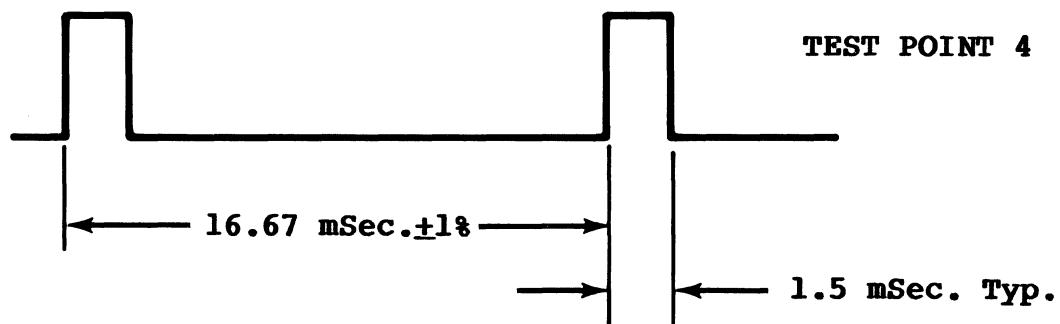


FIGURE 2.2
READ DATA

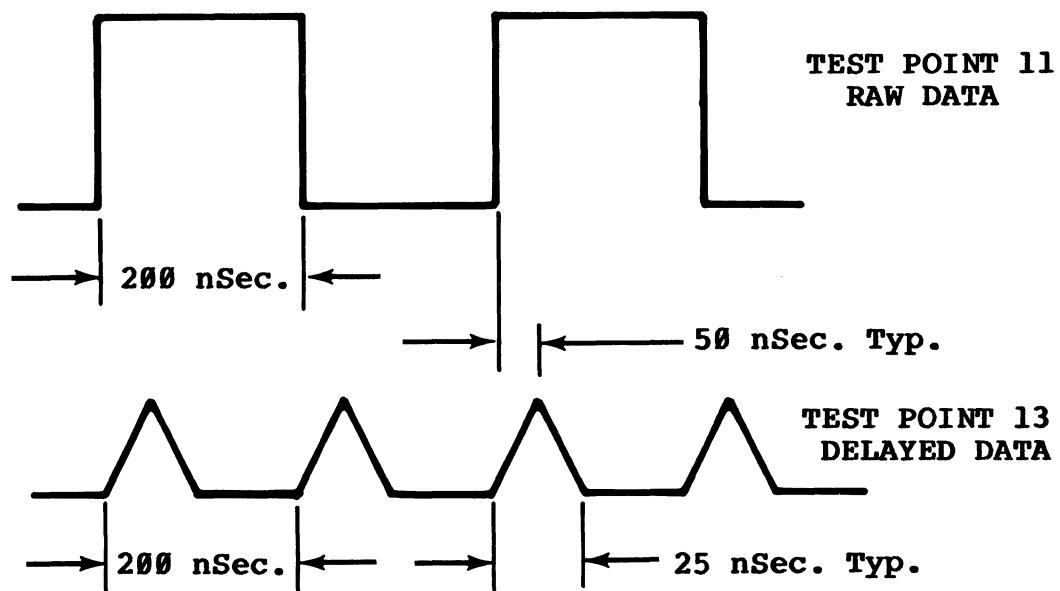
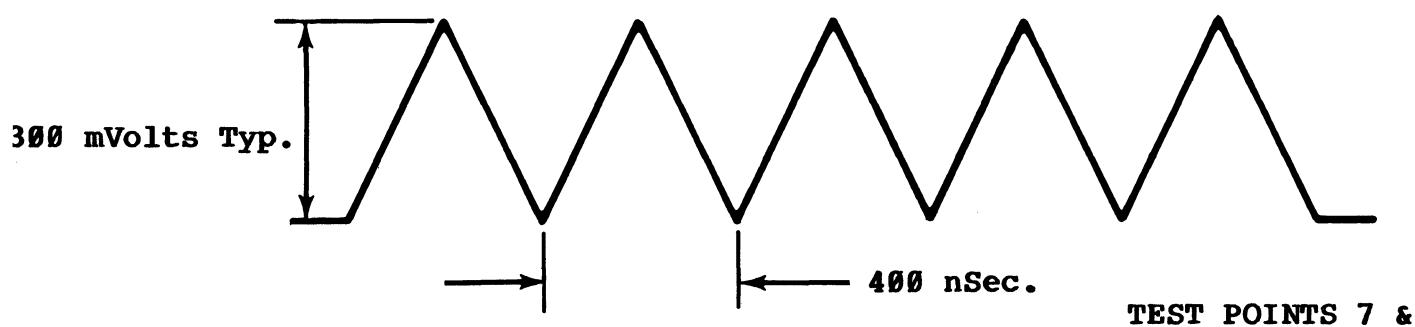


FIGURE 2.3
DIFFERENTIAL READ FILTER



2.4.3 Test Point Description PCB 20118

Test Points 1 and 2 (Differential Read Filter):

Test Points 1 and 2 may be used to observe the Differential Read Data. The typical amplitude of the signal resulting from adding the two channels is 300 mVolts. A full track record of high frequency data (0000 or 1111) should resemble Figure 3.1.

Test Points 3 and 4 (Read Data):

Test Points 3 and 4 may be used to monitor the Read Data from the Time Domain Filter. Trigger off TP 3 and observe the delay at TP 4. Typically, the delay observed should be 50 nanoseconds. A full track record of high frequency data (0000 or 1111) should resemble Figure 3.2.

Test Point 5 (Track 0):

Test Point 5 may be used to monitor Track 0. A high logic level is a valid Track 0 indication.

Test Point 6 (Index Sensor):

Test Point 6 may be used to monitor the Index Sensor. A high logic level is a valid Index indication. Only the leading edge of the pulse may be considered valid. A typical signal at TP 6 should resemble Figure 3.3.

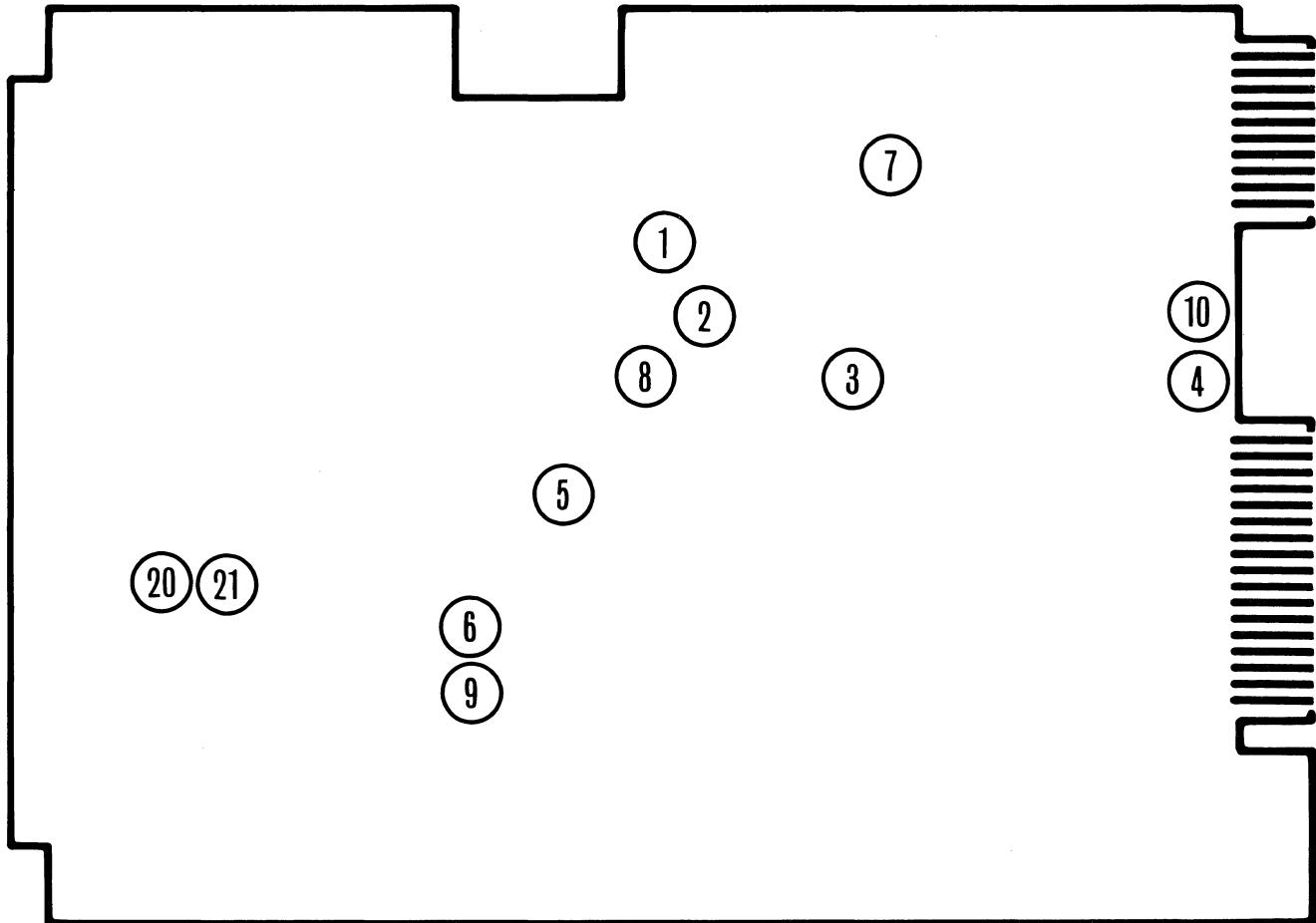
Test Point 6 is used to adjust the spindle motor speed. Monitor TP 6 and adjust R3 on the Motor Control PCB (accessible through the side-frame) for a period of 16.67 ms, $\pm 1\%$.

Test Point 21 (5 Volt Pull-Up):

Test Point 21 is a 5 Volt pull-up.

Test Points 7-10, 20 are convenience grounds.

FIGURE 3.0
TEST POINT LAYOUT PCB 20118



TEST POINT	DESCRIPTION
1 & 2	Differential Read Filter
3 & 4	Read Data
5	Track Ø Sensor
6	Index Sensor
7,8,9,10,20	Convenience Grounds
21	5 Volt Pullup

TEST POINT TIMING PCB 20118

FIGURE 3.1
DIFFERENTIAL READ FILTER

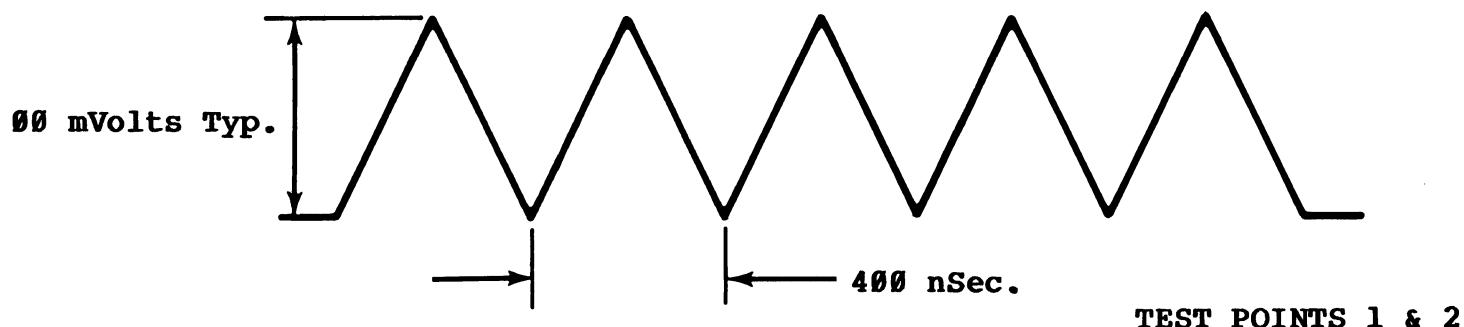


FIGURE 3.2
READ DATA

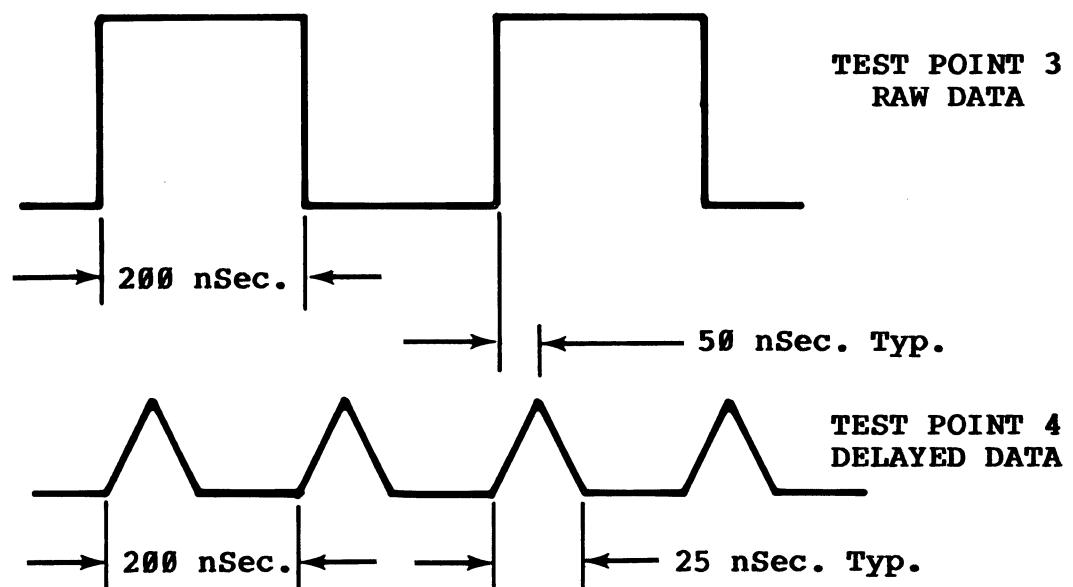
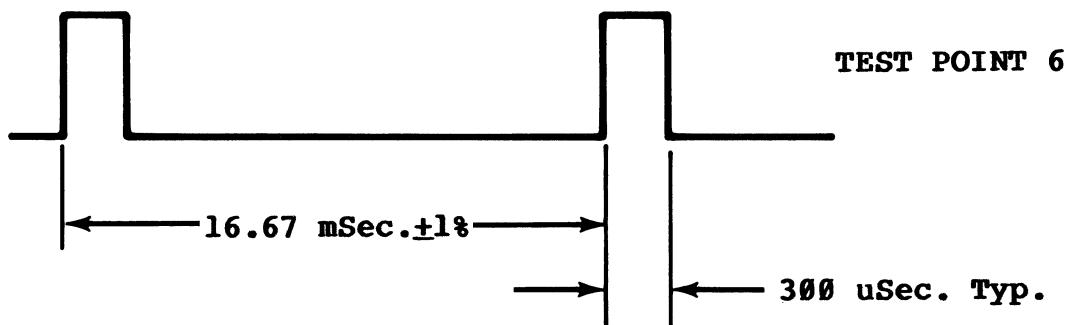


FIGURE 3.3
INDEX SENSOR



2.4.4 Test Point Description PCB 20221

Test Points 1 and 2 (Differential Read Filter):

Test Points 1 and 2 may be used to observe the Differential Read Data. The typical amplitude of the signal resulting from adding the two channels is 300 mVolts. Trigger on TP 8. A full track record (0000 or 1111) should resemble Figure 4.1.

Test Points 3 and 4 (Read Data):

Test Points 3 and 4 may be used to observe the Read Data. Trigger off TP 3 and monitor the delay at TP 4. Typically, the delay observed should be 80 nanoseconds. A full track record of high frequency data (0000 or 1111) should resemble Figure 4.2.

Test Point 7 (Track 0 Sensor):

Test Point 7 may be used to monitor the Track 0 Sensor. A high logic level is a valid Track 0 indication.

Test Point 8 (Index Sensor):

Test Point 8 may be used to monitor the Index Sensor. A high logic level is a valid Index indication. Only the leading edge of the pulse may be considered valid. The typical signal at TP 8 should resemble Figure 4.3.

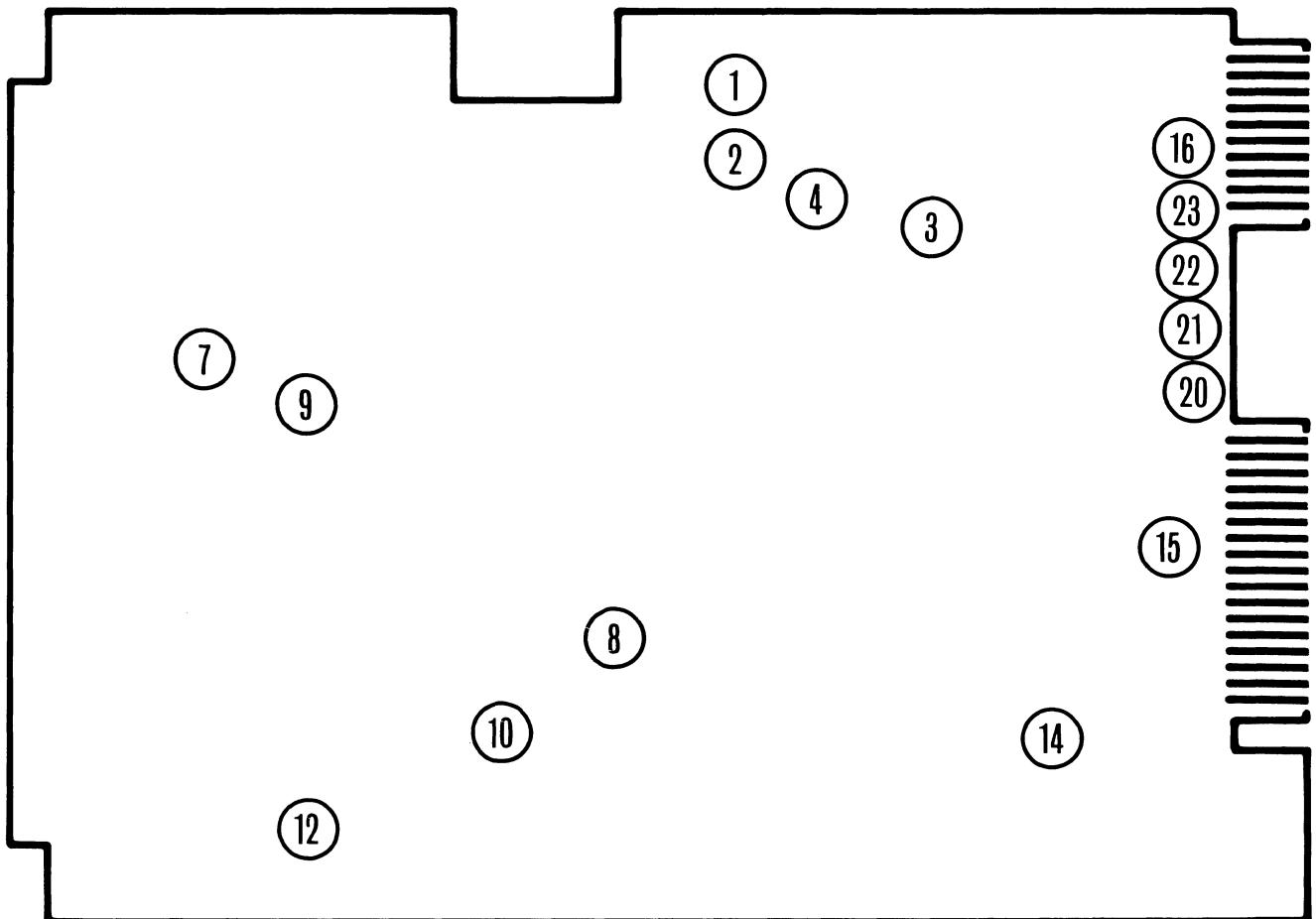
Test Point 8 is used to adjust the spindle motor speed. Monitor at TP 6 and adjust at R3 (accessible through the side-frame) for a period of 16.76 msec,±1%.

Test Point 20 (5 Volt Pull-Up)

Test Point 20 is a 5 Volt pull-up. To use this pull-up, cut the jumper at J01.

Test Points 9,10,12,14-16,21-23 are convenience grounds.

FIGURE 4.0
TEST POINT LAYOUT PCB 20221

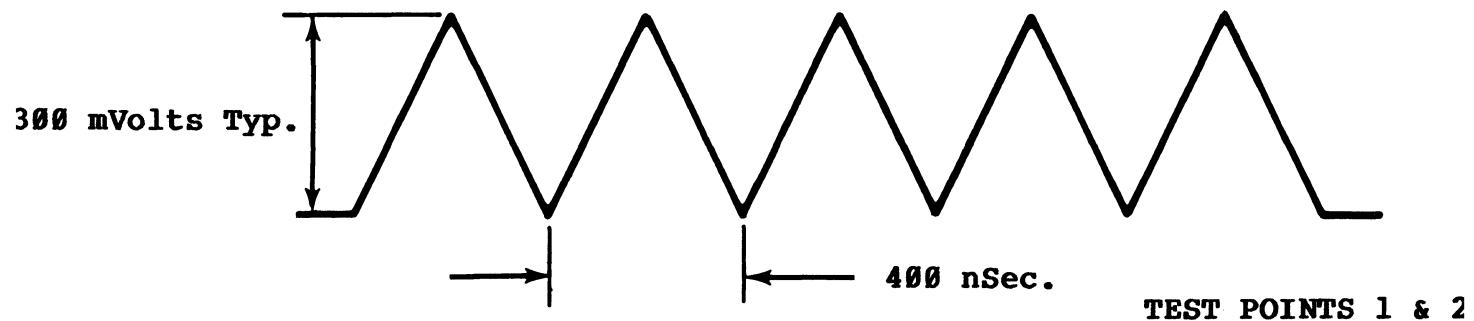


TEST POINT **DESCRIPTION**

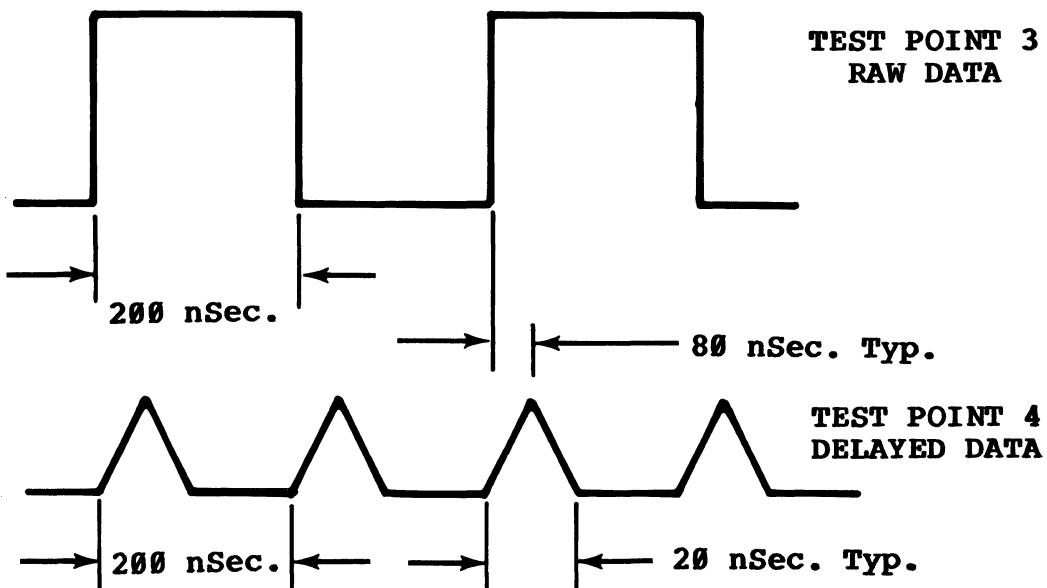
1 & 2	Differential Read Filter
3 & 4	Read Data
7	Track 0
20	5 Volt Pull-up
8	Index Sensor
9,10,12,14-16	Convenience Grounds
22,23	

TEST POINT TIMING PCB 20221

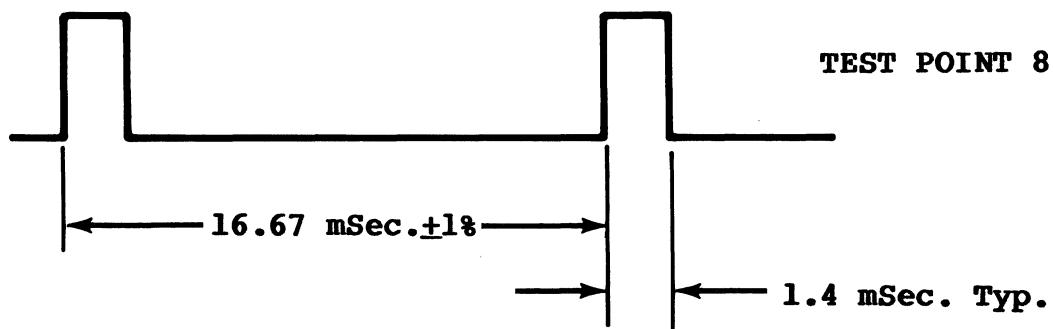
**FIGURE 4.1
DIFFERENTIAL READ FILTER**



**FIGURE 4.2
READ DATA**



**FIGURE 4.3
INDEX SENSOR**



2.4.5 Test Point Description PCB 20225

Test Points 1 and 2 (Differential Read Filter):

Test Points 1 and 2 may be used to observe the Differential Read Data. The typical amplitude of the signal resulting from adding the two channels is 250 mVolts. A full track record of high frequency data (0000 or 1111) should resemble Figure 5.1.

Test Points 3 and 4 (Read Data):

Test Points 3 and 4 may be used to observe the Read Data. Trigger off TP 3 and monitor the delay at TP 4. Typically, the delay observed should be 80 nanoseconds. A full track record of high frequency data (0000 or 1111) should resemble Figure 5.2.

Test Point 6 (Track 0 Sensor):

Test Point 6 may be used to monitor the Track 0 Sensor. A high logic level is a valid Track 0 indication.

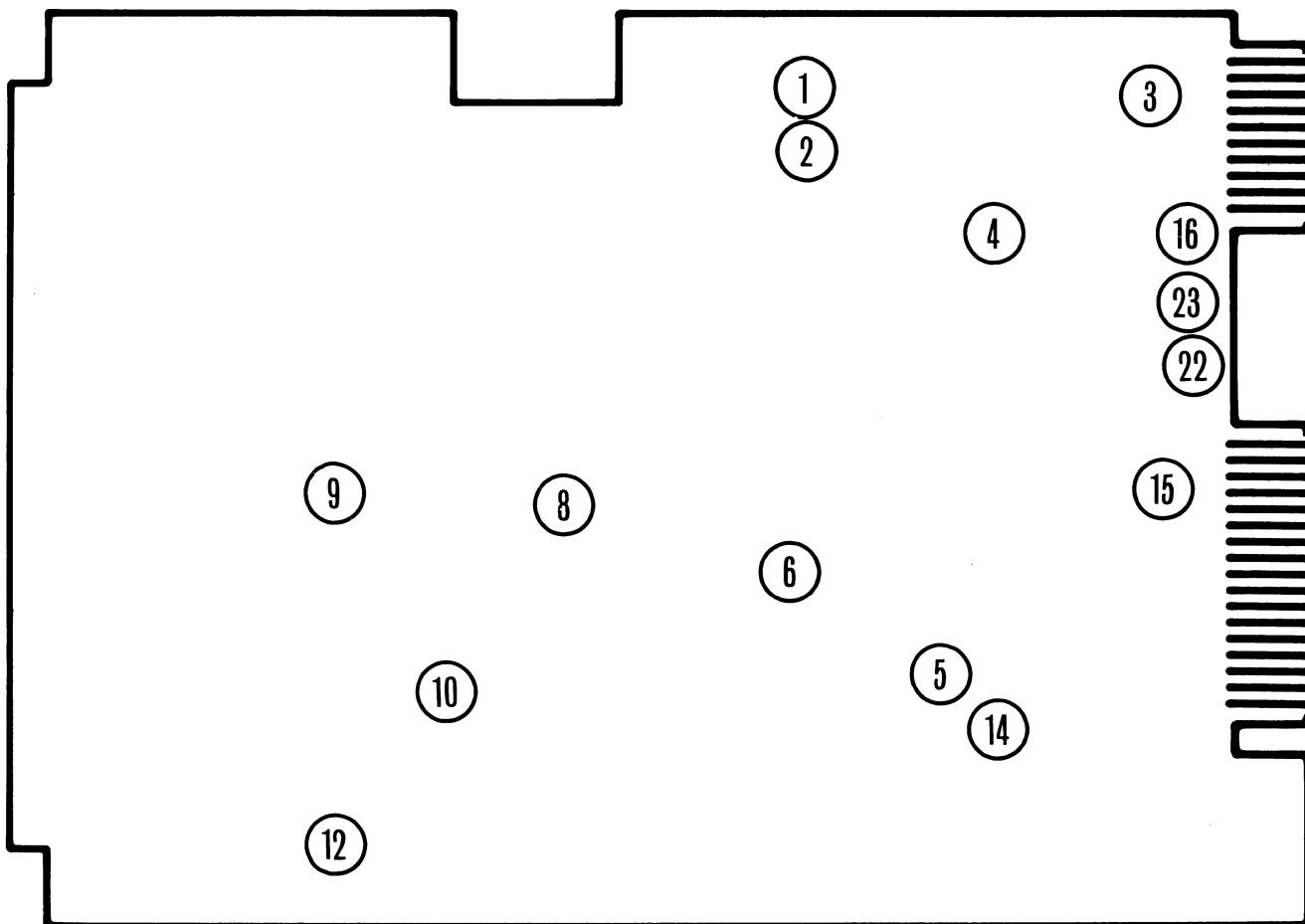
Test Point 8 (Index Sensor):

Test Point 8 may be used to monitor the Index Sensor. A high logic level is a valid Index Indication. Only the leading edge of the pulse may be considered valid. The typical signal at TP 8 should resemble Figure 5.3.

Test Point 8 is used to adjust the spindle motor speed. Monitor TP 8 and adjust R3 (accessible through the side-frame) for a period of 16.67 msec, $\pm 1\%$.

Test Points 9,10,12,14-16,22,23 are convenience grounds.

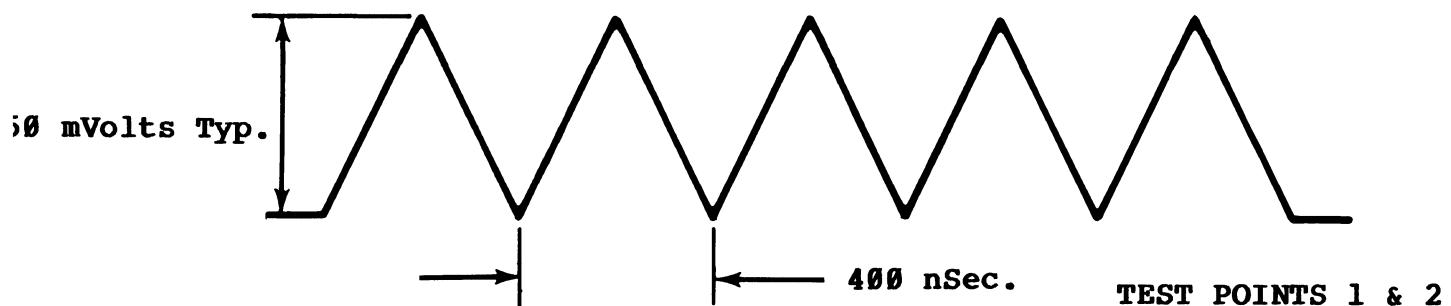
FIGURE 5.0
TEST POINT LAYOUT PCB 20225



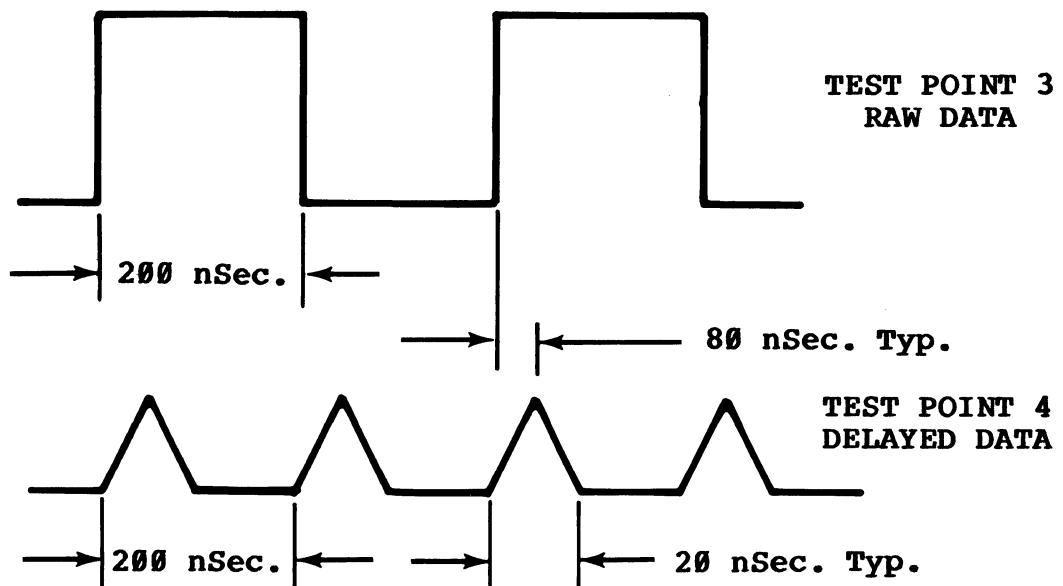
TEST POINT	DESCRIPTION
1 & 2	Differential Read Filter
3 & 4	Read Data
6	Track 0
8	Index Sensor
20	5 Volt Pull-up
9,10,12,14-16	Convenience Grounds
22,23	

TEST POINT TIMING PCB 20225

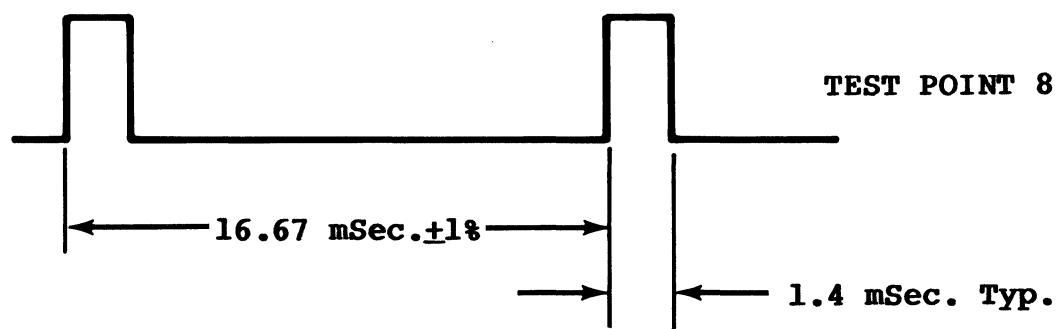
**FIGURE 5.1
DIFFERENTIAL READ FILTER**



**FIGURE 5.2
READ DATA**



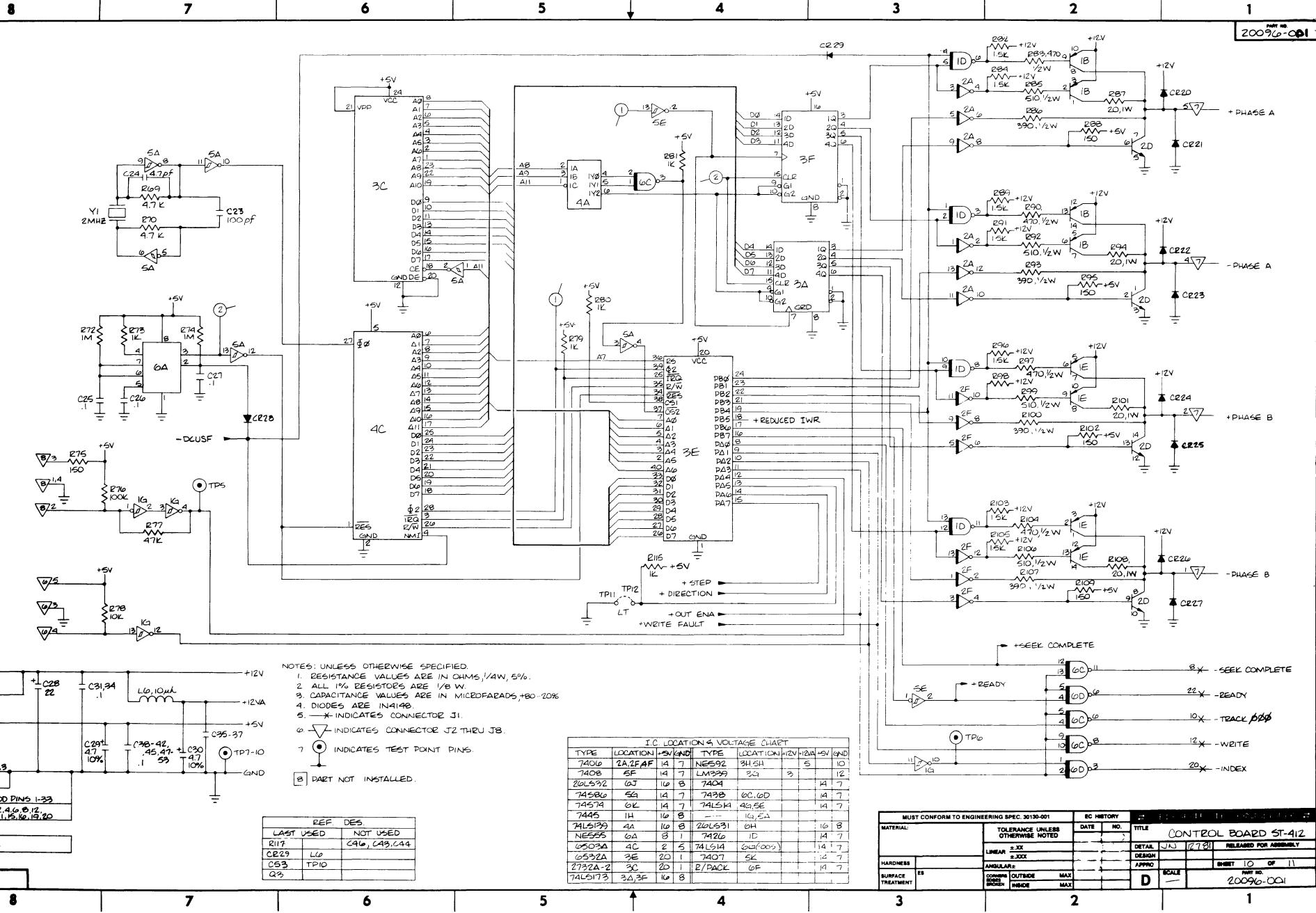
**FIGURE 5.3
INDEX SENSOR**

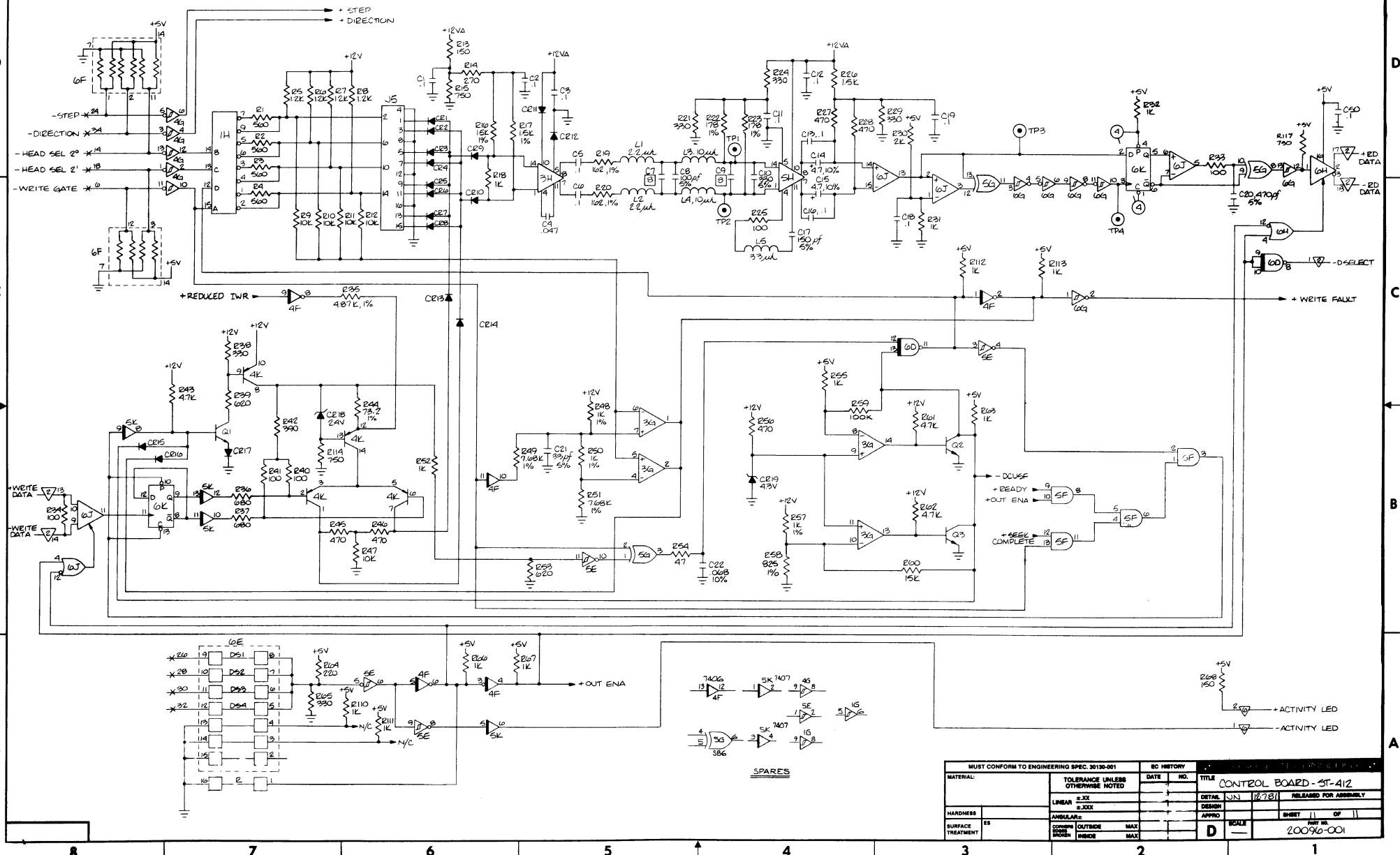


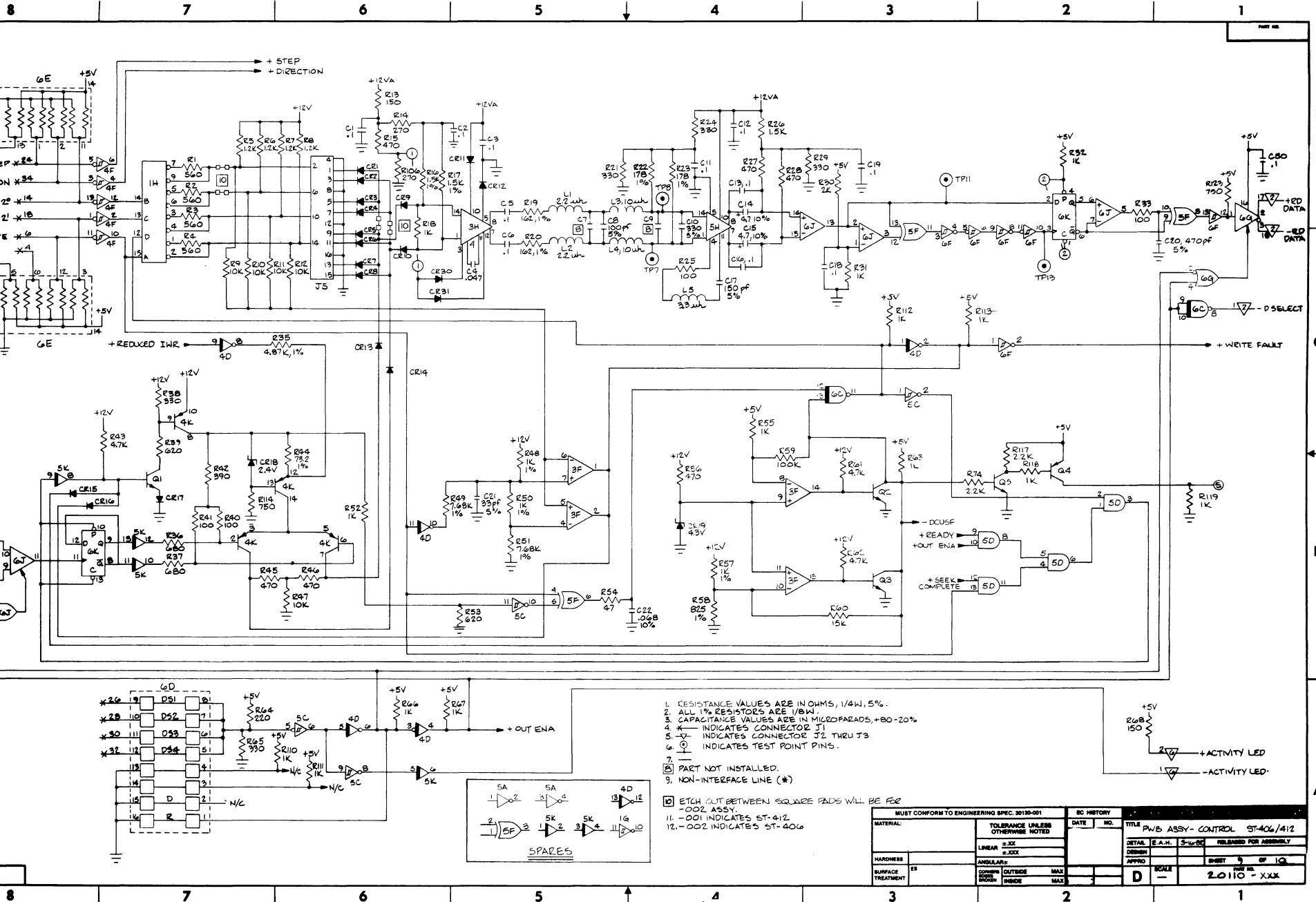
2.5 ST400 SERIES SCHEMATICS

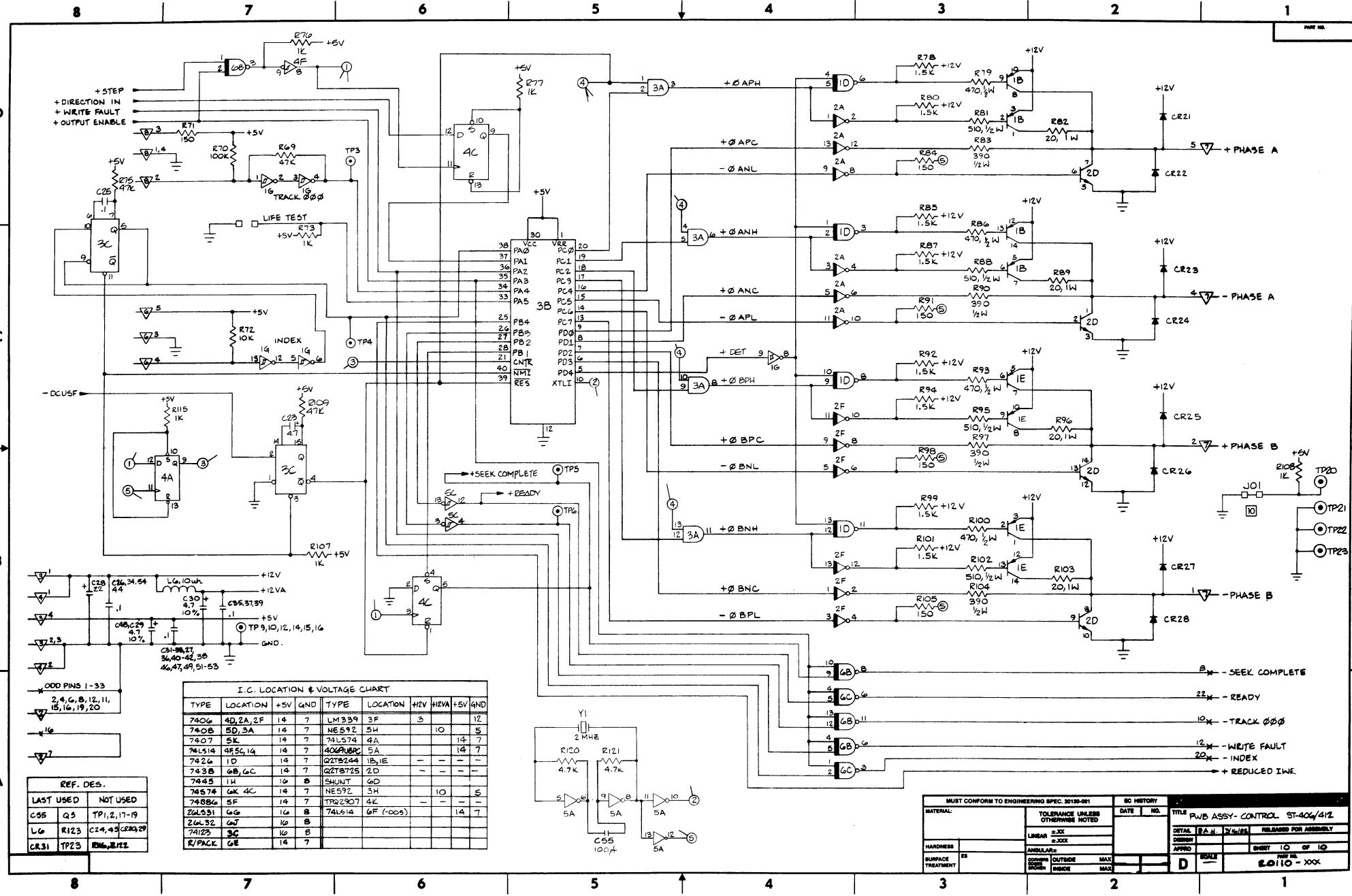
INDEX

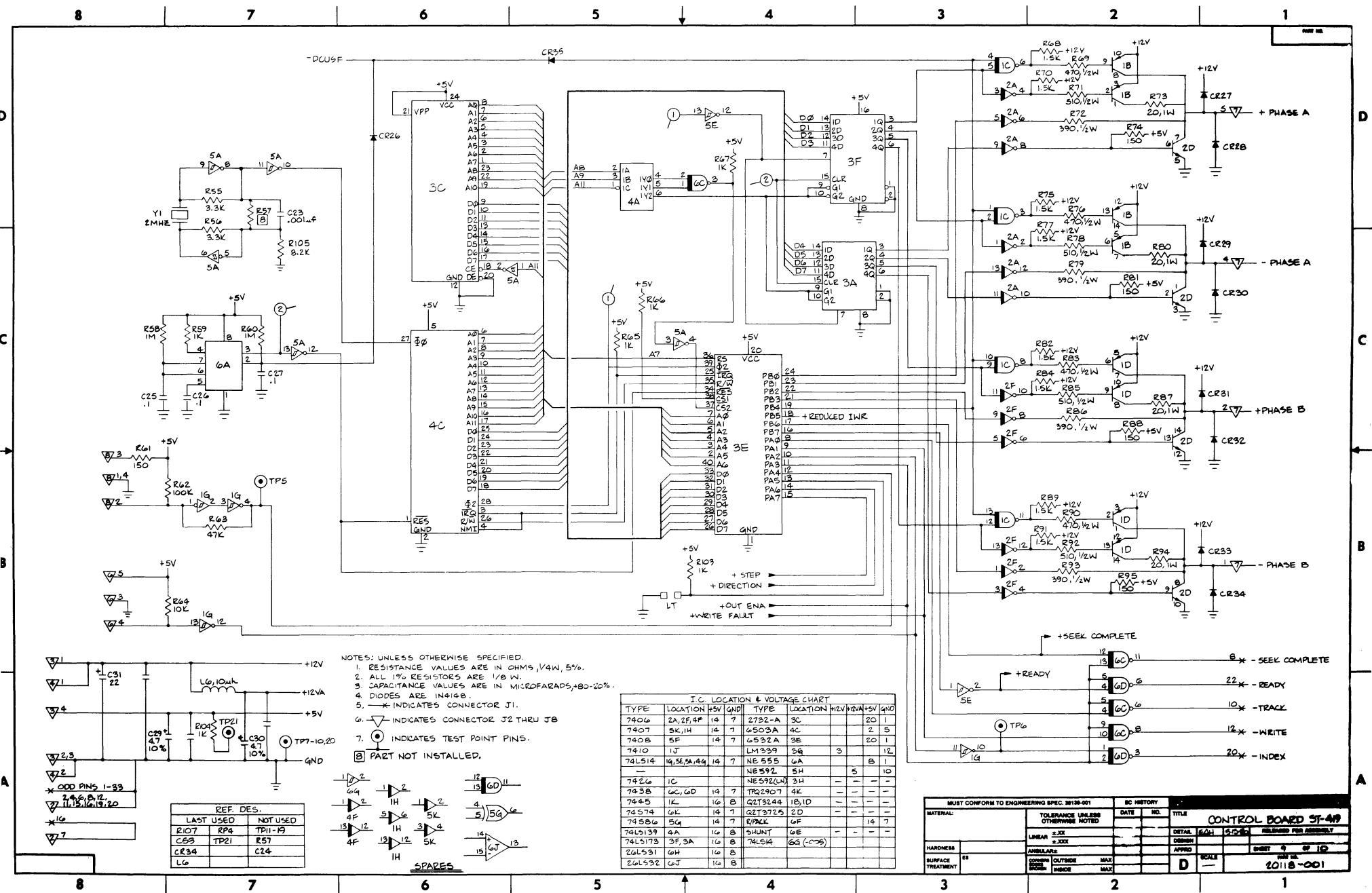
SECTION	PAGE
2.5.1 Main Control PCB - 20096.....	39-40
2.5.2 Main Control PCB - 20110.....	41-42
2.5.3 Main Control PCB - 20118.....	43-44
2.5.4 Main Control PCB - 20221.....	45-46
2.5.5 Main Control PCB - 20225.....	47-48
2.5.6 Motor Control PCB - 20099.....	49
2.5.7 Motor Control PCB - 20136.....	50
2.5.8 Motor Control PCB - 20217.....	51

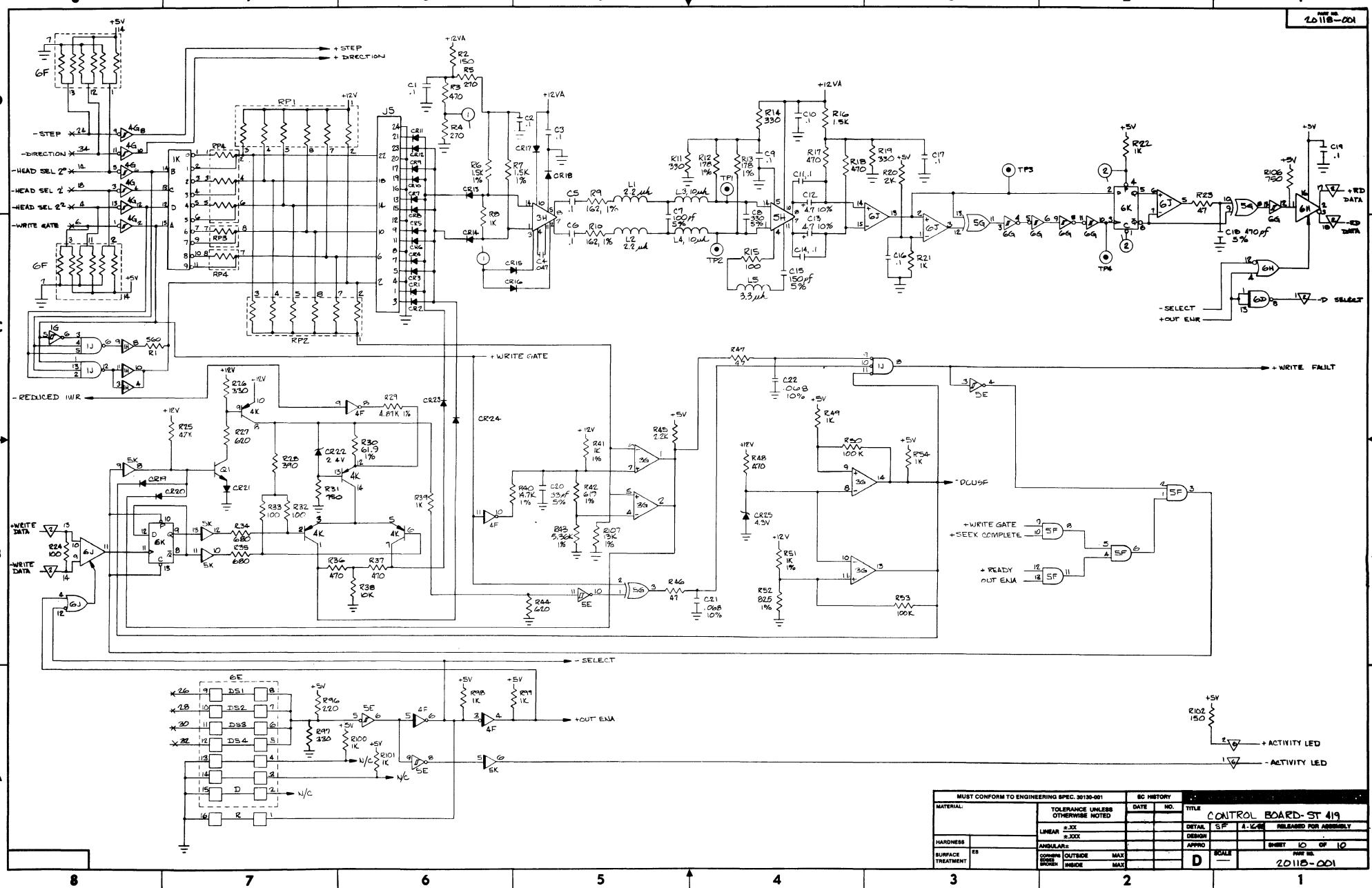




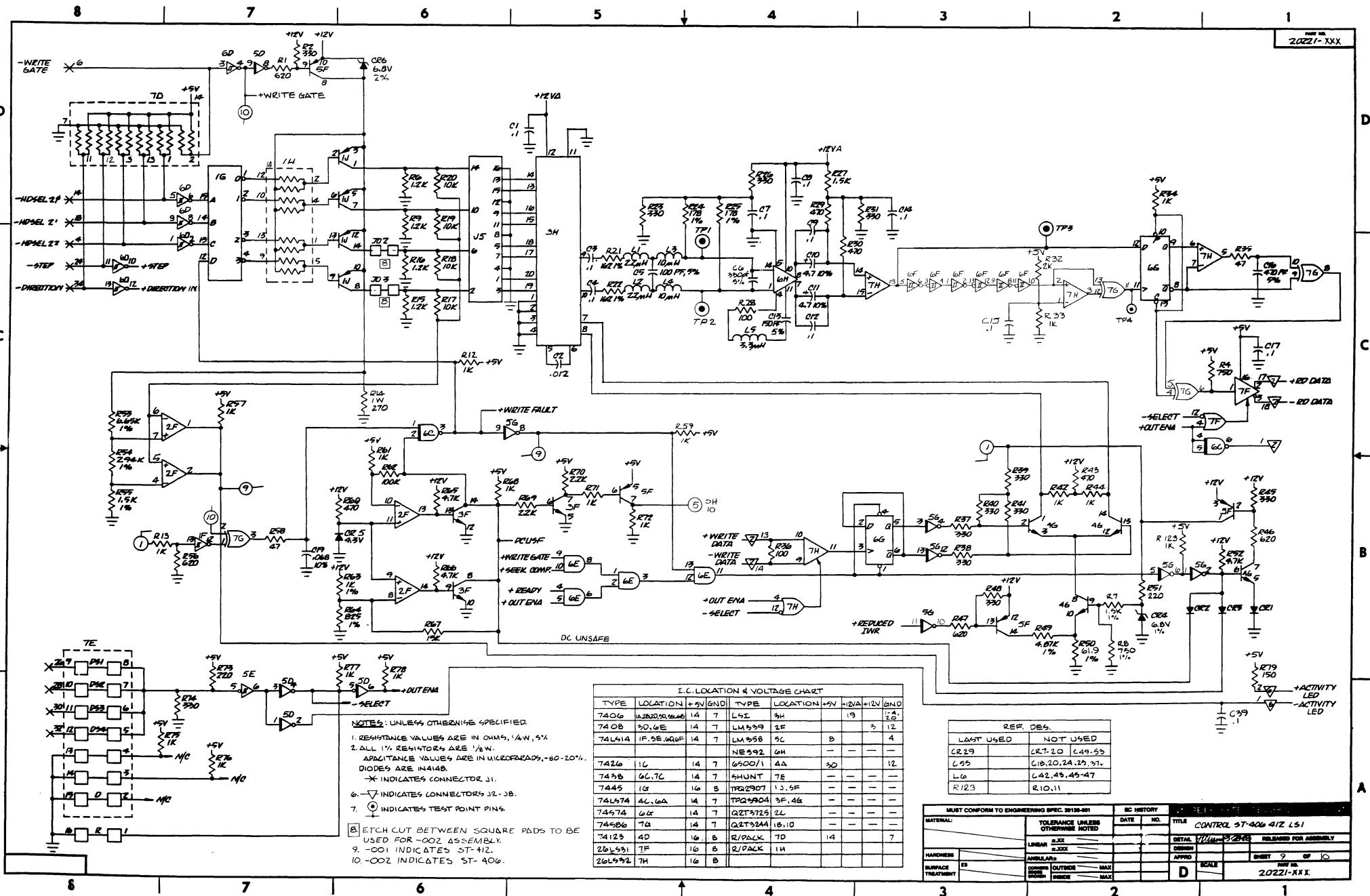


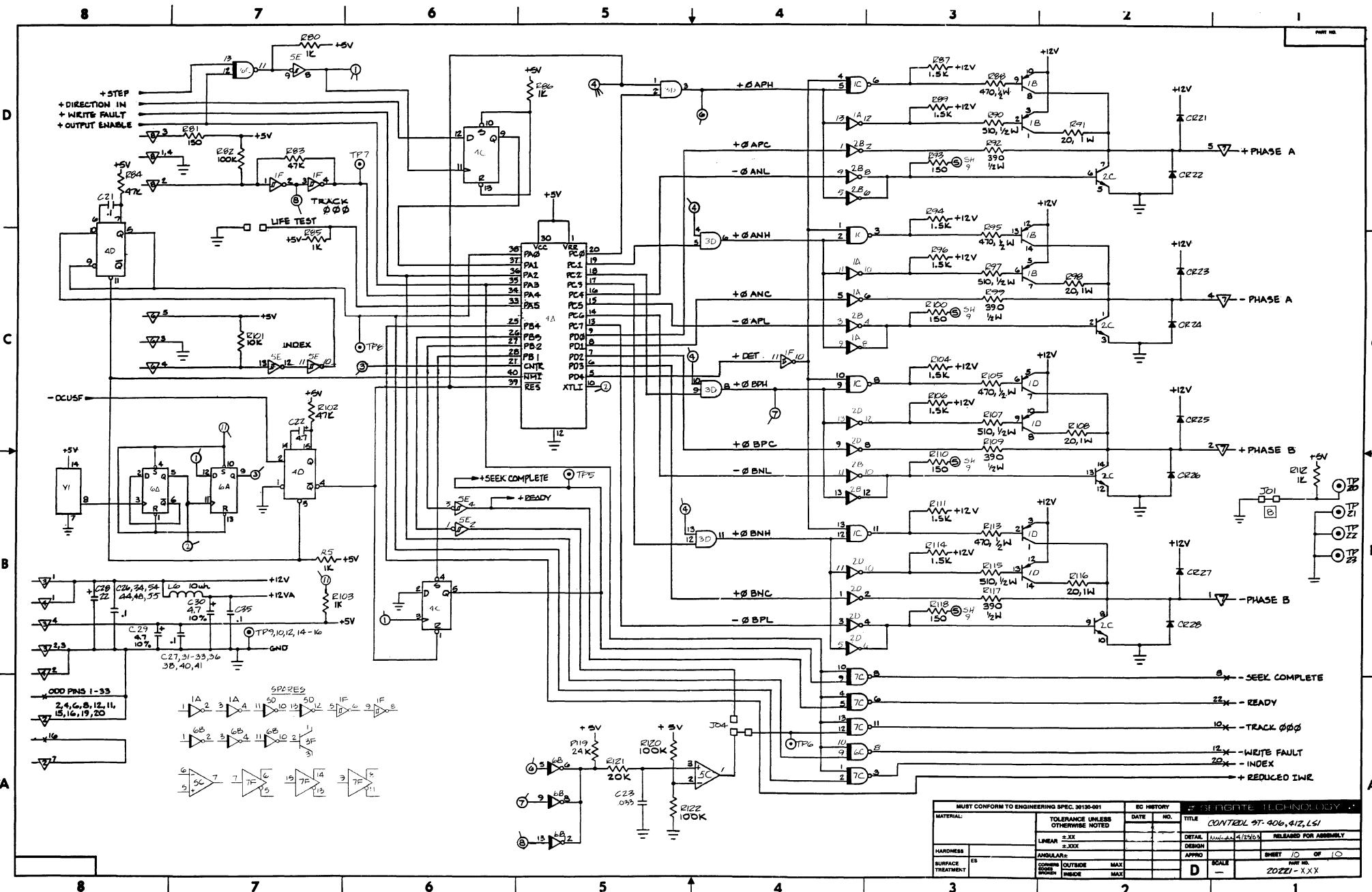


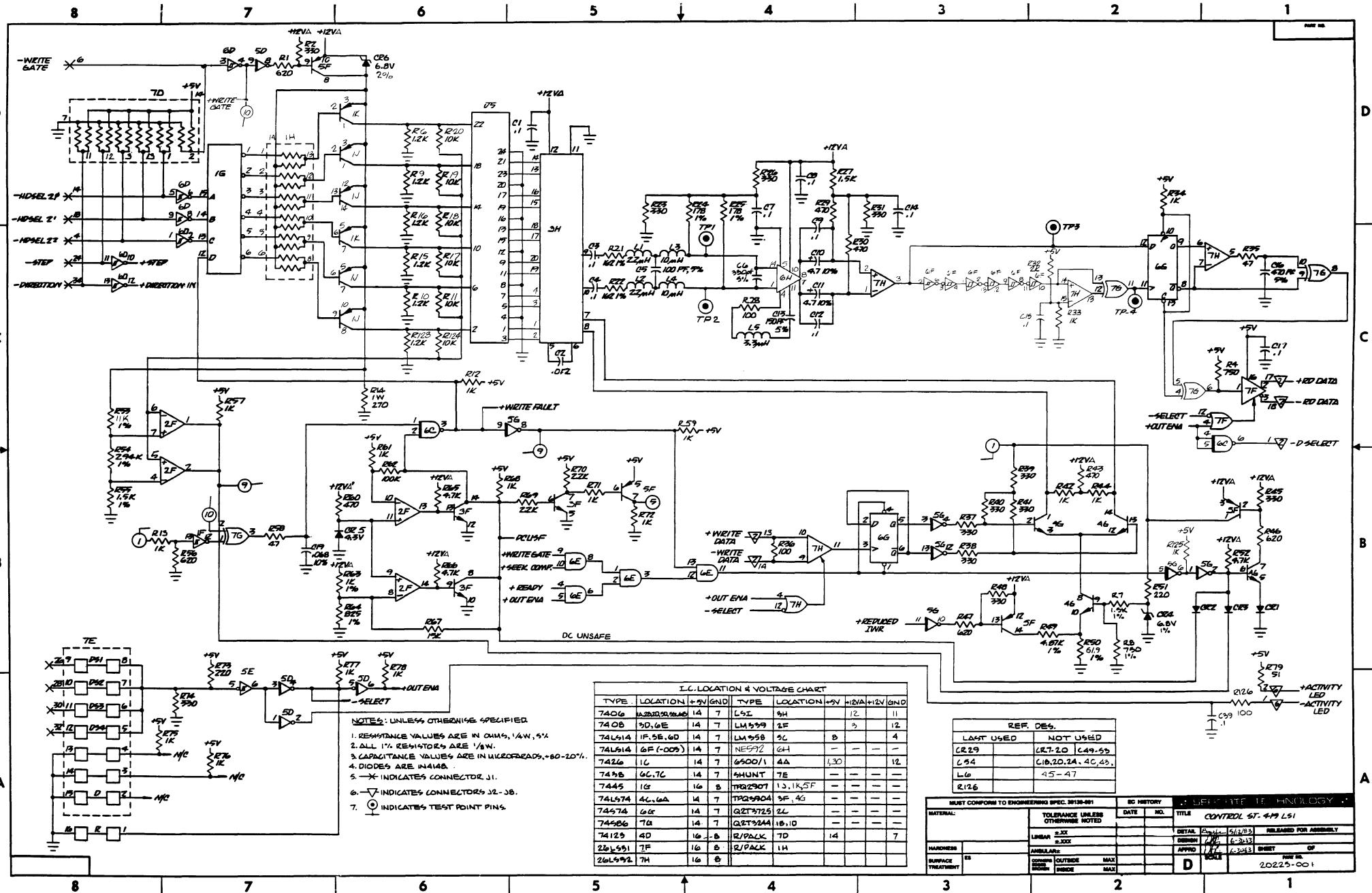


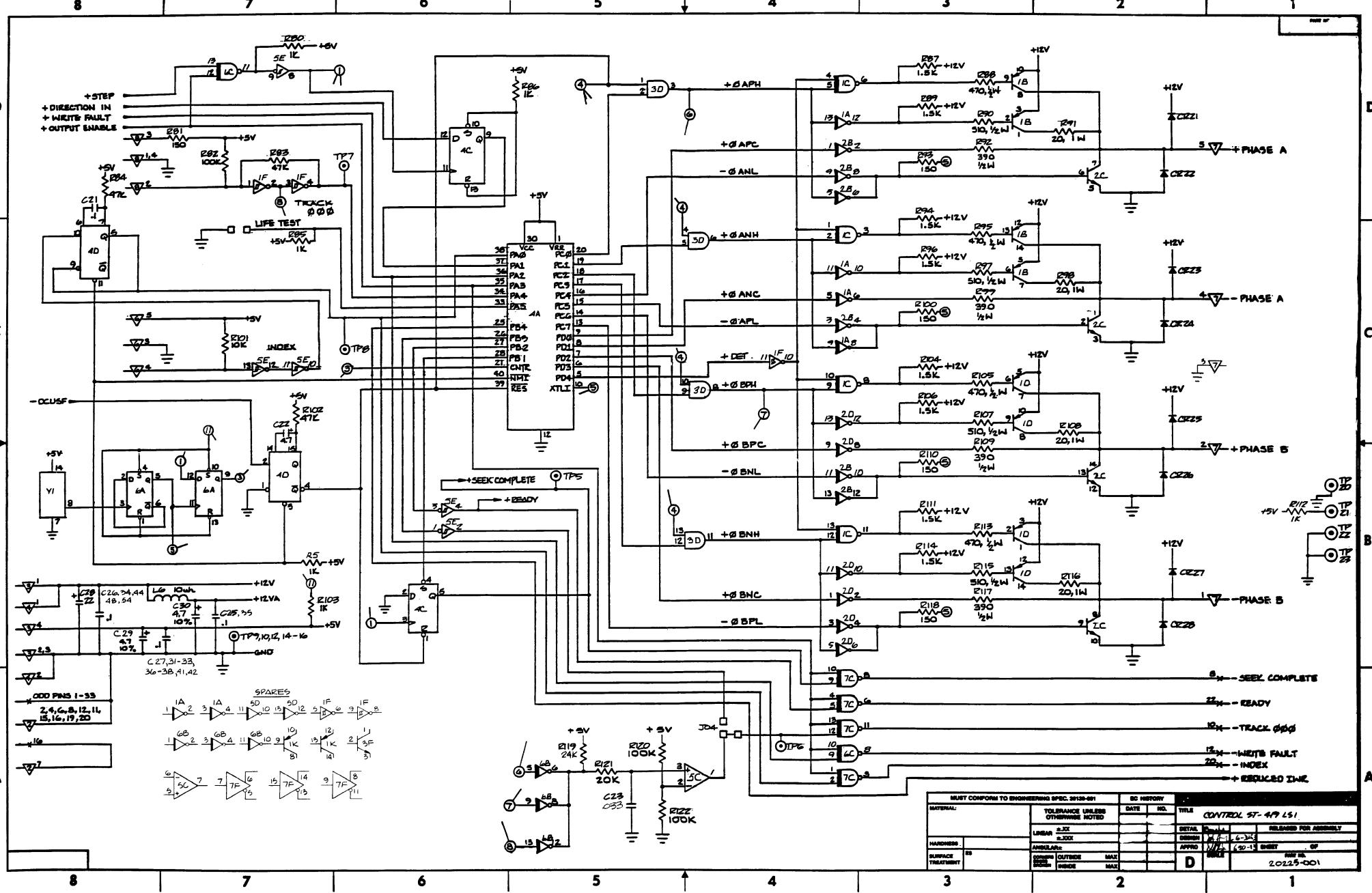


MATERIAL:		SC HISTORY		TITLE	
	TOLERANCE UNLESS OTHERWISE NOTED			DETAIL SP	A-148 RELEASED FOR ASSEMBLY
	LINEAR ±.XX			DESIGN	
HARDNESS	±.300			APPRO	SHEET ID OF 10
SURFACE TREATMENT	ES			PART NO.	2011B-001
				D	SCALE

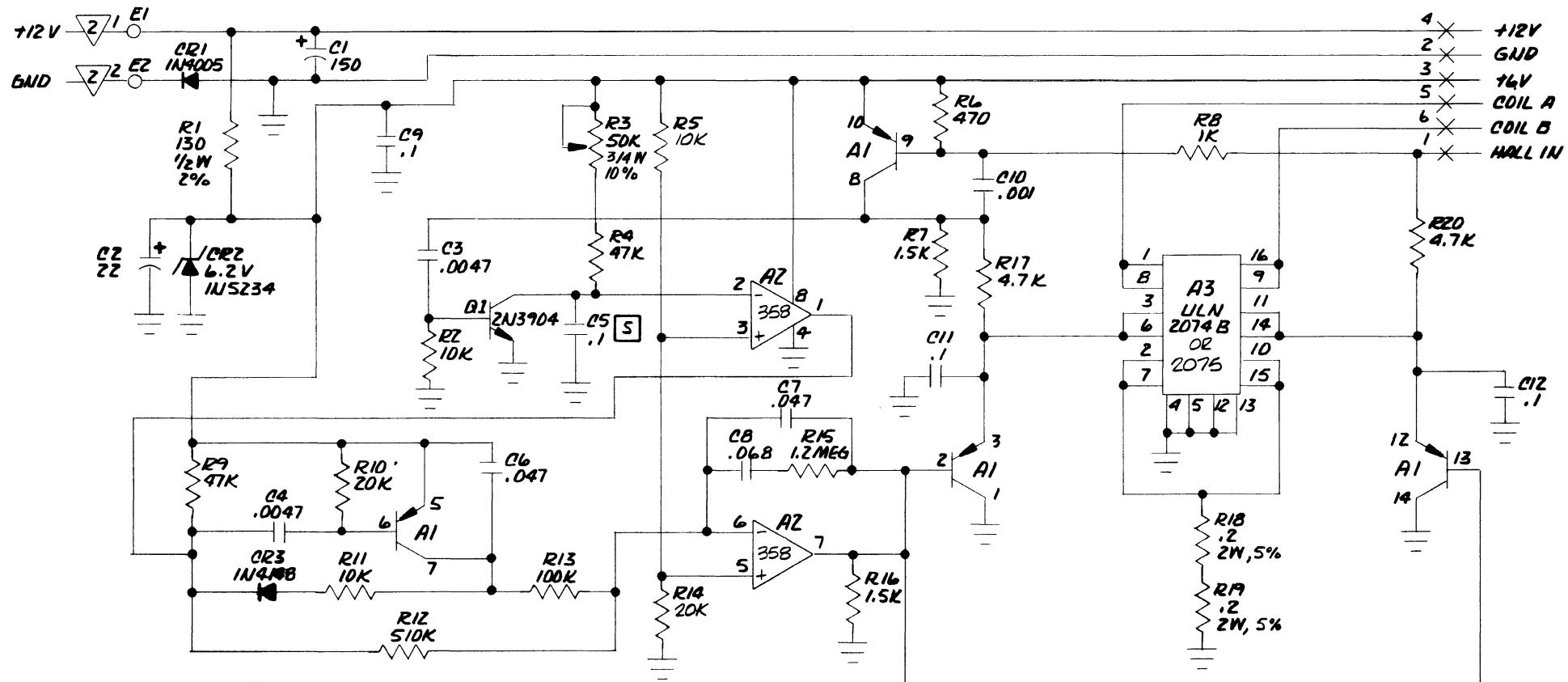








PART NO.
20099-001



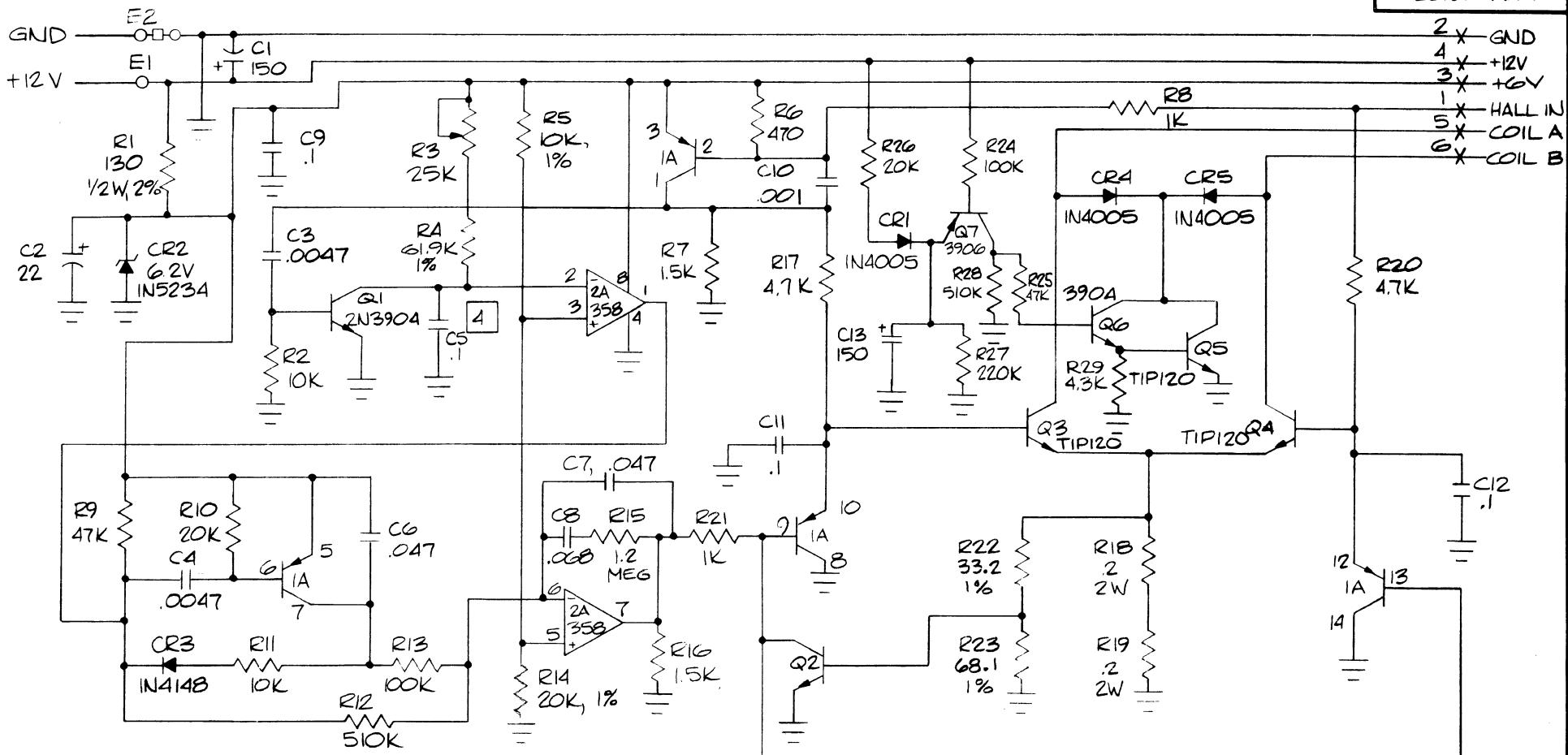
NOTES UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS ARE IN OHMS 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS, 10%.
3. INDICATES JT1.
4. INDICATES JT2.
5. CS, POLYCARBONATE 50V, ±10%.

MATERIAL:		TOLERANCE UNLESS OTHERWISE NOTED		DATE	NO.	SEAGATE TECHNOLOGY	
		LINEAR	±.XX ±.XXX			DETAIL	RELEASED FOR ASSEMBLY
HARDNESS		ANGULAR: ±		DESIGN		APPRO	SHEET 6 OF 6
SURFACE TREATMENT	ES	CORNERS EDGES BROKEN	OUTSIDE INSIDE	MAX		SCALE	PART NO.
						B	20099-001

PART NO.
20136-XXX

2 X GND
4 X +12V
3 X +6V
1 X HALL IN
5 X COIL A
6 X COIL B



NOTES UNLESS OTHERWISE NOTED

1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS,
10%

3. X INDICATES J1.

4. C5 - POLYCARBONATE, 50V ± 10%

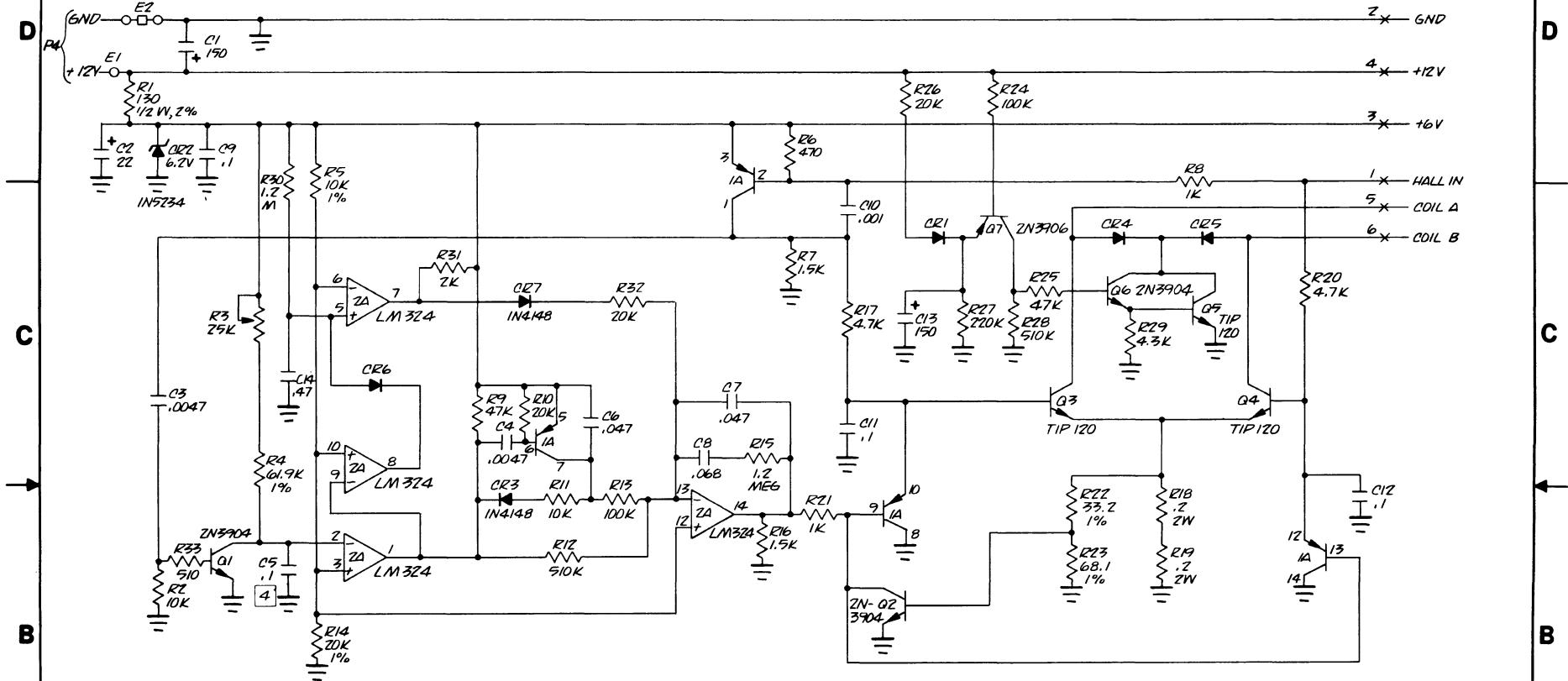
MUST CONFORM TO ENGINEERING SPEC. 30130-001		EC HISTORY		SEAGATE TECHNOLOGY	
MATERIAL:		TOLERANCE UNLESS OTHERWISE NOTED		DATE	NO.
		LINEAR	±.XX		
			±.XXX		
HARDNESS		ANGULAR	±		
SURFACE TREATMENT	ES	CORNERS EDGES BROKEN	OUTSIDE MAX		
		INSIDE	MAX		
DETAIL		SF	6 28 82	RELEASED FOR ASSEMBLY	
DESIGN					
APPRO				SHEET 7 OF 7	
B		SCALE	—	PART NO. 20136-001	

4

3

2

1

PART NO.
20217-001

NOTES! UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS, $\frac{1}{4}$ WATT, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS 10%.
3. —X— INDICATES J1.
4. C5 - POLYCARBONATE 50V $\pm 10\%$.
5. ALL DIODES ARE IN4005.
6. ALL 1% RESISTORS ARE $\frac{1}{8}$ WATT.

REF DES	
LAST USED	NOT USED
R33	
CR7	
C14	
Q7	

TPQ2907	1A	—	—
LM324	2A	4	11
TYPE	LOCATION	+6V	GND

IC VOLTAGE AND LOCATION

MUST CONFORM TO ENGINEERING SPEC. 30130-001		EC HISTORY	
MATERIAL:	TOLERANCE UNLESS OTHERWISE NOTED	DATE	NO.
LINEAR	$\pm .XX$		
ANGULAR	$\pm .XXX$		
SURFACE TREATMENT	ES		
CORNERS BROKEN	OUTSIDE MAX INSIDE MAX		

SERGATE TECHNOLOGY

DETAIL: 20217-001 RELEASED FOR ASSEMBLY

DESIGN APPRO SHEET 7 OF PART NO. 20217-001

4

3

2

1

3.0 FIELD SERVICE AND ADJUSTMENTS

SEAGATE disc drives do not require preventative maintenance. All units shipped are covered by a one year factory warranty. Should field service or adjustment become necessary, certain restrictions apply. Primarily, the sealed Head Disc Assembly (HDA) must not be opened. SEAGATE considers a drive to be out of warranty if the HDA has been tampered with. Any special tools or additional cautions will be treated under the appropriate sections.

This section of the ST400 Service Manual covers adjustments and procedures concerning field-accessible components. Any questions not treated in this document should be referred to your Regional SEAGATE Technical Support Office. These offices and their phone numbers are listed on page 88.

Should it become necessary to return a drive to SEAGATE, please ensure that the drive is shipped in the original SEAGATE container. If that is not possible, your Regional Technical Support Office will assist you in obtaining an approved container. Please note: Shipping a drive in a unapproved container could cause damage and may void your warranty.

3.1 Removals and Adjustments

Note: Removal of any assembly not covered in this section is not possible without special tools and clean-room facilities.

3.1.1 Main Control PCB

Tools Required: T-10/T15 Torx Driver

1. Remove (4) 6-32 x 1/4" Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Slide the PCB toward the rear of the drive and remove.
4. To reinstall, reverse the above procedure.

Note: It is recommended that the replacement PCB be powered-up with the head cable, P5, disconnected. This will ensure that a damaged replacement does not alter data on the disc. To determine if the PCB is good, the Write Fault signal can be monitored at the junction of the inverter and R113. If a high logic level exists at junction R113, then a No-Write-Fault condition exists and the PCB can be powered down and P5 connected. Avoid creasing the Printed Circuit Cable when removing P5. Inspect the cable after this operation.

3.1.2 Motor Control PCB

Tools Required: T-10/T15 Torx Driver

1. Remove (4) 6-32 x 1/4" Main Control PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Slide the Main PCB toward the rear of the drive and remove.
4. Disconnect Motor Control PCB P1 and P2, noting their positions.
5. Remove (2) 6-32 x 1/4" Motor Control PCB mounting screws.
6. Remove the Motor PCB.
7. To reinstall, reverse the above procedure.

Note: If the Motor PCB is replaced or if any components are changed, the spindle speed must be adjusted.

Spindle Speed Adjustment: Warm the drive up for approximately 5 minutes. Connect a frequency counter to the Index Test Point and adjust the Motor Control trimpot (accessible through the side frame) for a period of 16.67 mSec $\pm 1\%$. The counter must average 100 samples per minutes, minimum.

3.1.3 Spindle Brake (Drives with Motor Control PCB 20099)

Tools Required: T-10/T15 Torx Driver,
Loctite #242, Flexible .010" shim

1. Remove (4) 6-32 x 1/4" Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Slide the Main PCB toward the rear of the drive and remove.
4. Disconnect P2 at the Motor Control PCB and free the Brake wires from the retaining clip.
5. Remove (1) 6-32 x 1" Brake mounting screw, washer and spacer.
6. Remove the Brake.
7. To reinstall, apply Loctite to the first three threads of the Brake mounting screw. Replace the Brake, spacer, washer and mounting screw, but do not tighten.
8. Insert the flexible shim between the Brake pad and the spindle motor housing.
9. Move the Brake toward the spindle hub until the spring is compressed and a slight resistance is felt on the shim.
10. Tighten the 6-32 Brake mounting screw and verify that the contour of the Brake pad aligns with the spindle motor housing.
11. Route the Brake wires through the retaining clip and connect P2 to the Motor Control PCB.
12. Reverse steps 1 through 3 to replace the Main PCB.

3.1.4 Index Sensor

Tools Required: T-10/T15 Torx Driver,
Loctite #242, .030" shim

Note: This procedure may result in a loss of recorded data.

1. Remove (4) 6-32 x 1/4" Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Remove the Main PCB.
4. Remove the connector from the front panel LED, noting the orientation of the connector.
5. Free the Index Sensor wires from the retaining clip.
6. Remove (2) 6-32 x 1/8" Index Sensor mounting screws and clamp.
7. Remove the Index Sensor.
8. To Reinstall, apply Loctite to the first three threads of the Index Sensor screws. Replace the Sensor, clamp and screws, but do not tighten.
9. Rotate the spindle motor until the silver index tab aligns with the Index Sensor.

10. Using the .030" shim, adjust the gap between the Index Sensor and the index tab.
11. Tighten the 2 mounting clamp screws and verify that the gap is .030 inch.
12. Route the Index Sensor wires through the retaining clip and reconnect the LED.
13. Reverse steps 1 through 3 and replace the Main PCB.

3.1.5 Ground Spring

Tools Required: T-10/T15 Torx Driver
Loctite #242

1. Remove the 4 Main Control PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Remove the Main PCB.
4. Remove (1) 6-32 x 1/8" Ground Spring mounting screw.
5. Remove the Ground Spring.
6. When reinstalling, apply Loctite to the first 3 threads of the mounting screw.
7. Verify that the Ground Spring contact button and the spindle motor ball are clean and making positive contact.

3.1.6 Front Cover

Tools Required: T10/T15 Torx Driver

Note: On Drives employing a 3-point suspension system, the Front Cover mounting screws are accessible (side mount) without removing the Main PCB. A water base hot melt glue may be used to secure the LED/grommet assembly.

1. Remove the Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Remove the Main PCB.
4. Remove the connector from the Front Cover LED, noting the orientation.
5. Remove (2) 6-32 x 1/8" Front Cover mounting screws.
6. Remove the LED and grommet from the cover, noting the orientation of the LED.
7. Remove the Front Cover.

3.1.7 Front Cover LED

Tools Required: T-10/T-15 Torx Driver

Note: On Drives employing a 3-point suspension system, the Front Cover mounting screws are accessible (side mount) without removing the Main PCB. A water base hot melt glue may be used to secure the LED/grommet assembly.

1. Remove the Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Remove the Main PCB.
4. Remove the connector from the Front Cover LED, noting the orientation of the connector (black wire to single dot).
5. Remove the LED and grommet from the Front Cover, noting the orientation of the LED.

3.1.8 Box Frame/Side Frames

Tools Required:T-10/T15 Torx Driver
Loctite #242

Four Point Suspension:

1. Remove the Main PCB mounting screws.
2. Disconnect P1 through P8, noting their positions.
3. Remove the Main PCB.
4. Remove the 2 Front Cover mounting screws. It is not necessary to remove the LED connector.
5. Remove the (4) 6-32 x 5/16" Side Frame mounting screws. Retain the spacers, washers and grommets.
6. To reinstall, apply Loctite on the first three threads of all 6-32 screws.

Three Point Suspension:

The 3-point Box Frame requires a similar procedure with one additional step required. Before Step 5, free the ground strap, which mounts with (1) 6-32 x 1/4" screw.

3.1.9 Track Ø Sensor

Tools Required: T-7/T-10/T-15 Torx Driver
.050" Allen Wrench
Loctite #242

Models that have a single mounting screw in the center of the Track Ø assembly are not field serviceable.

Proper positioning of the Sensor is essential. The adjusting set screw is set at the factory and should not be tampered with.

Three Point Suspension

1. Remove the Front Cover.
2. Disconnect P8.
3. Remove the Track Ø Sensor mounting screws, using the Torx Driver or Allen Wrench.
4. Remove Sensor.
5. When reinstalling, apply Loctite to the first three threads of the mounting screws.

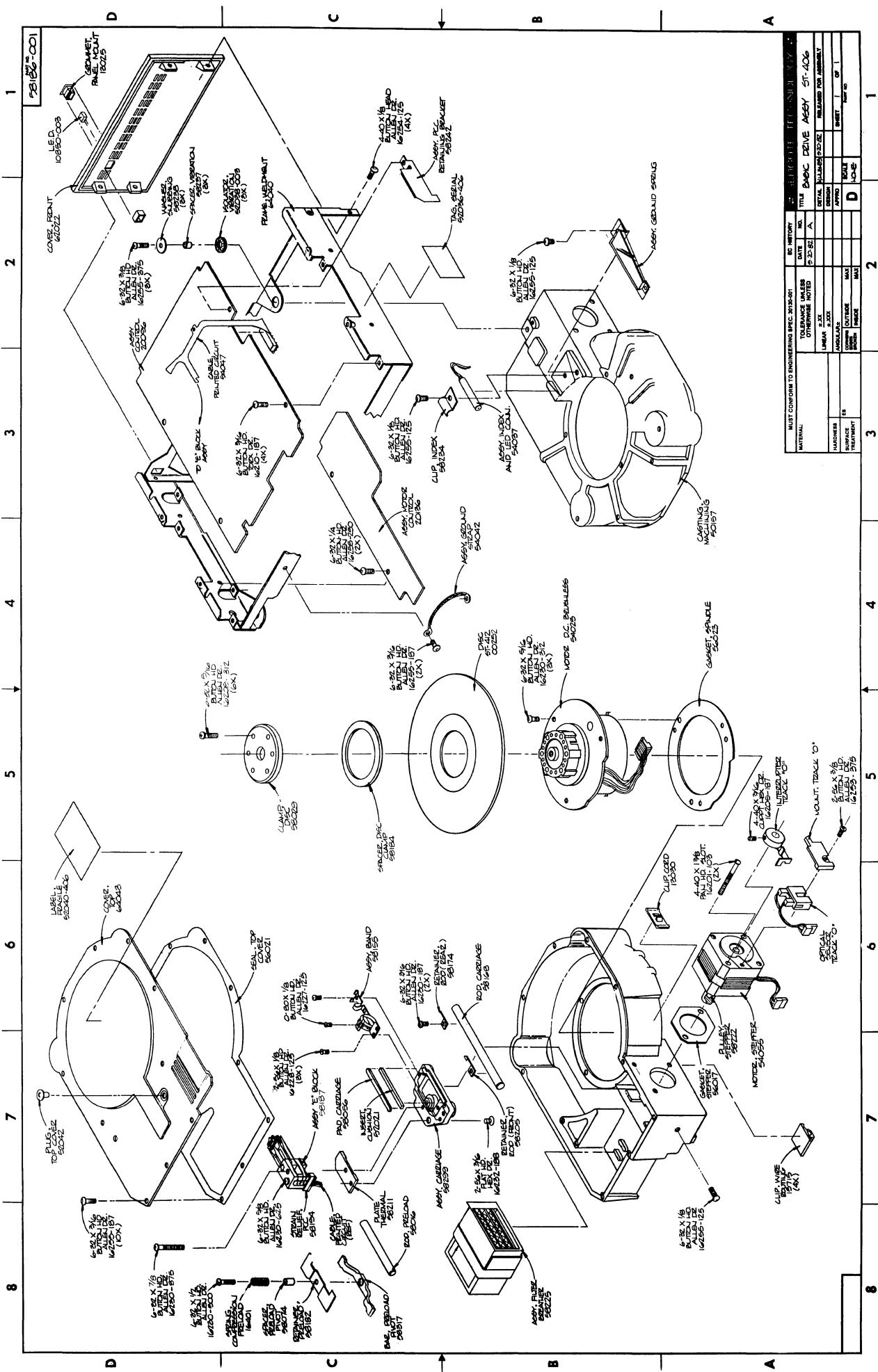
Four Point Suspension

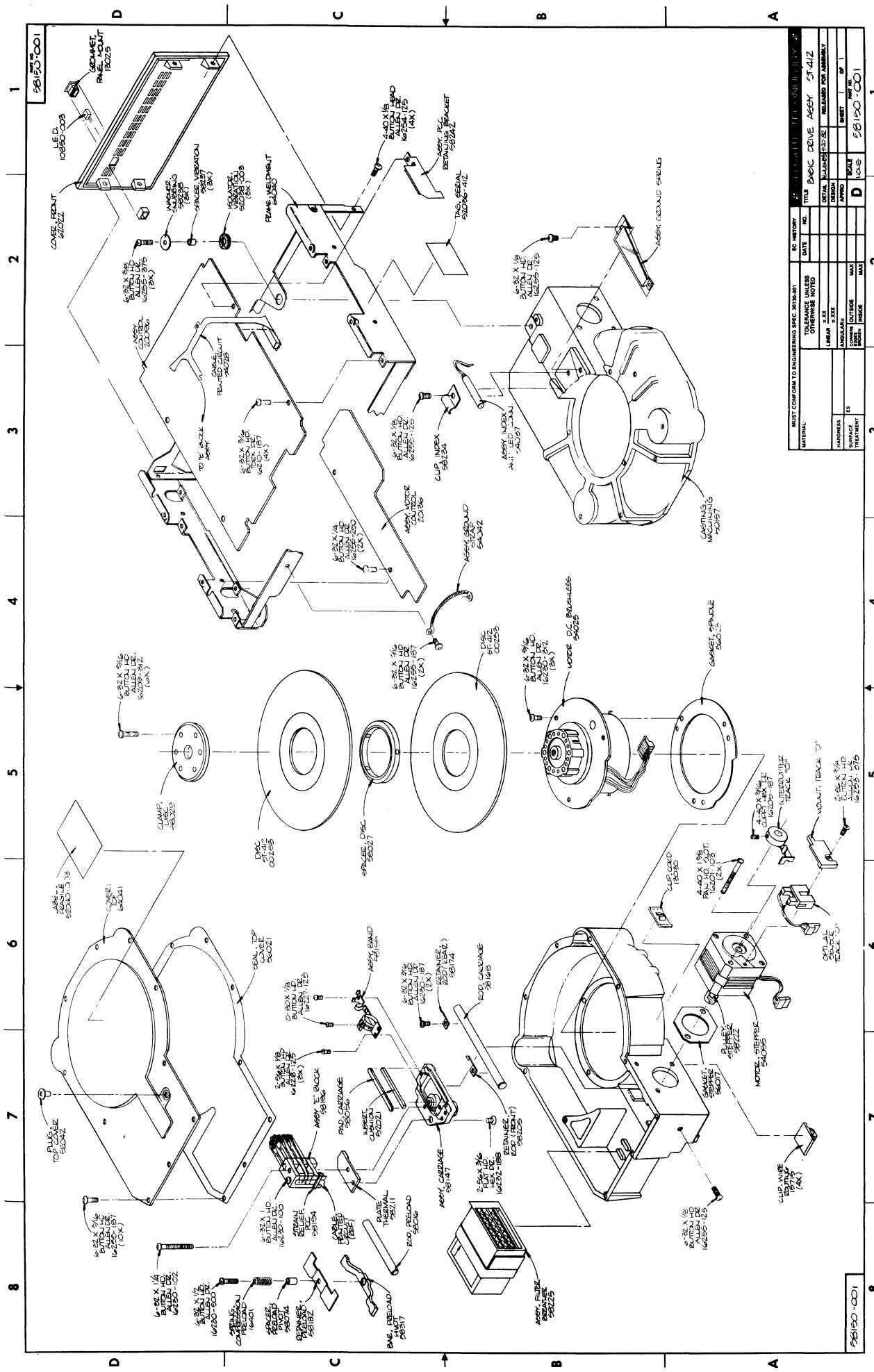
1. Remove the Main PCB mounting screws.
2. Slide the PCB to the rear of the drive.
3. Disconnect P8.
4. Remove the Track Ø Sensor mounting screws.
5. Remove Sensor.
6. When reinstalling, apply Loctite to the first three threads of the mounting screws.

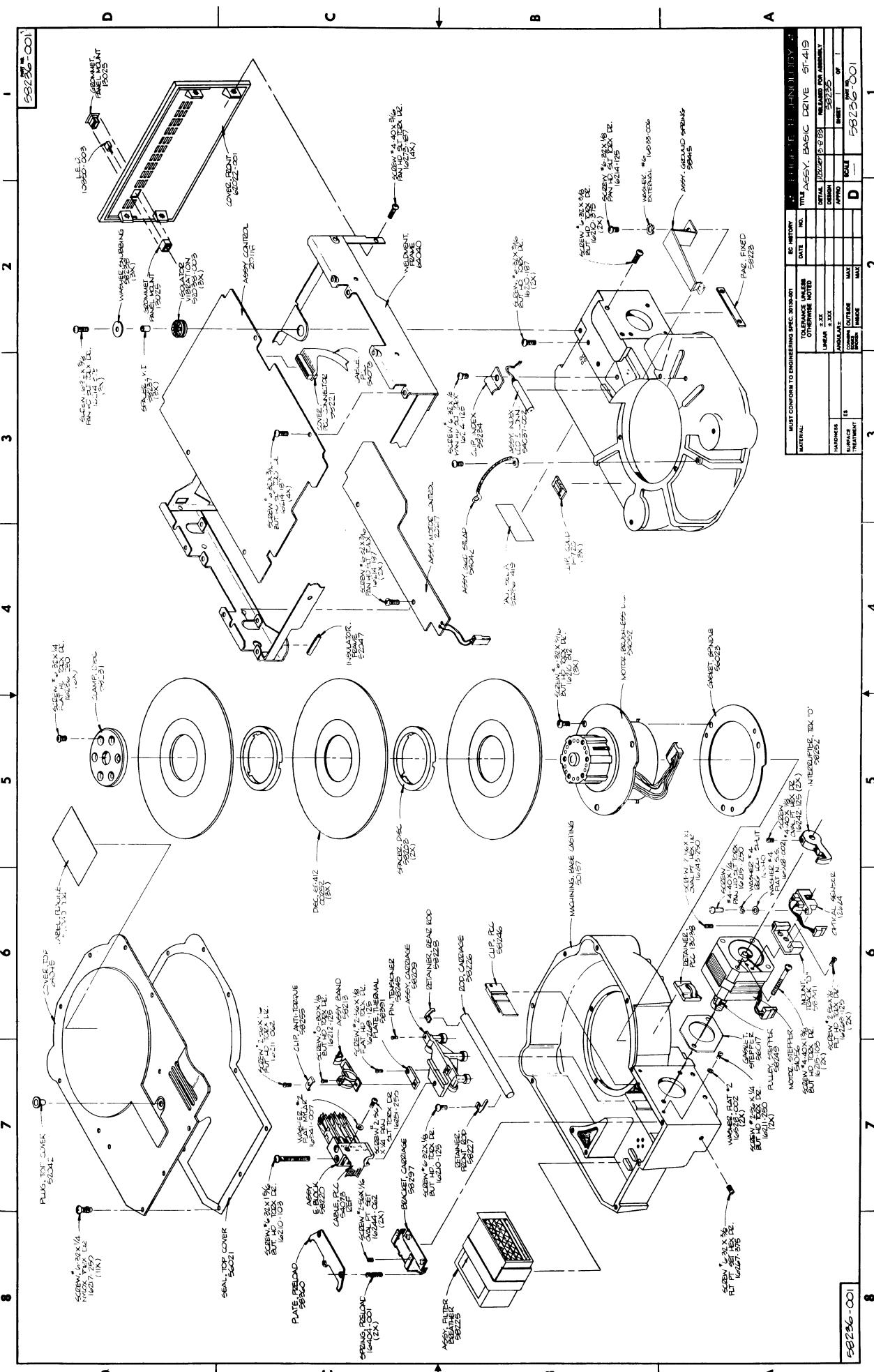
4.0 ILLUSTRATED PARTS CATALOG

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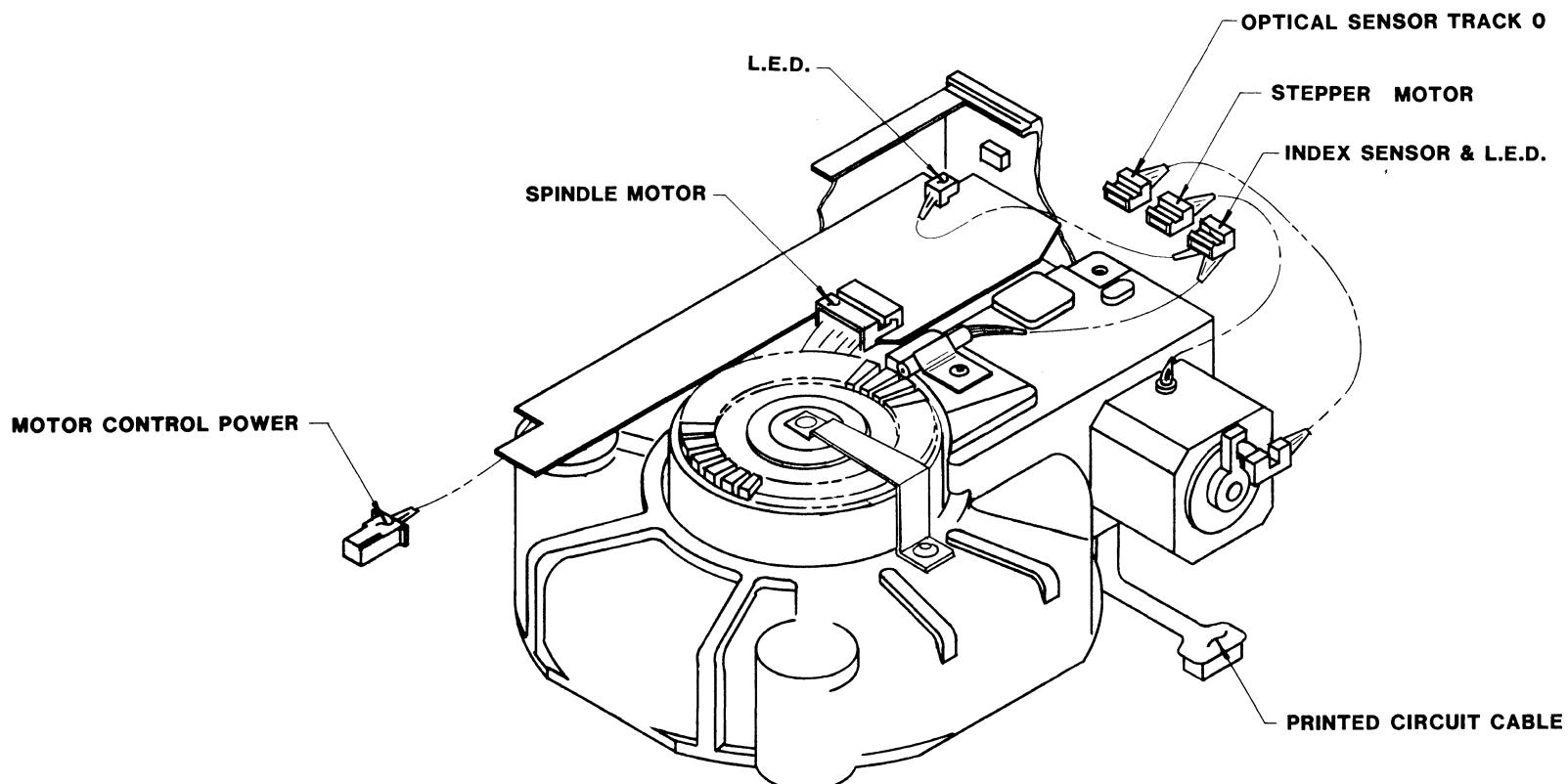
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PART NO.



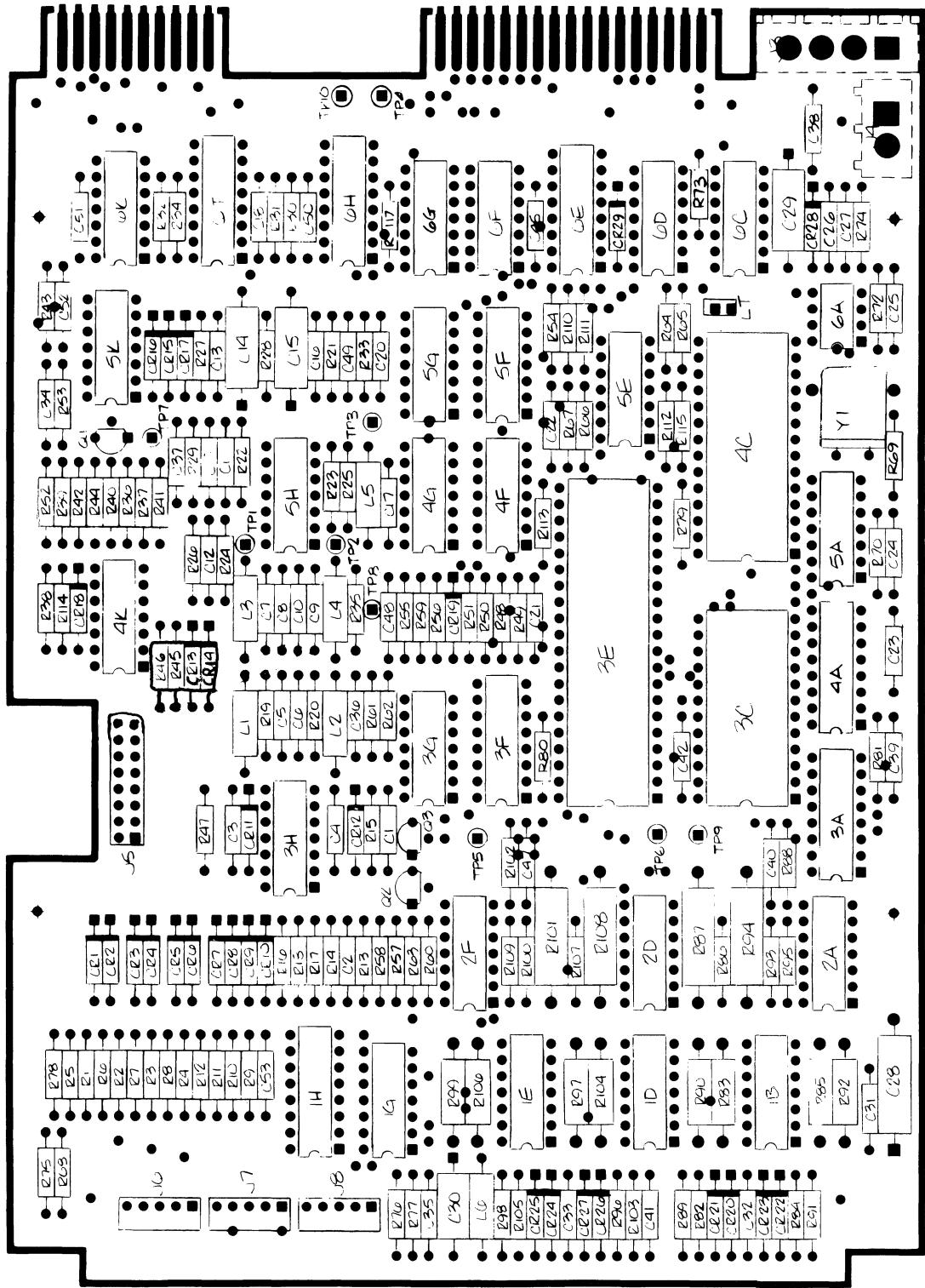
MUST CONFORM TO ENGINEERING SPEC. 30130-001				EC HISTORY		SEAGATE TECHNOLOGY			
MATERIAL:		TOLERANCE UNLESS OTHERWISE NOTED		DATE	NO.	TITLE		CONNECTORS	
		LINEAR	$\pm .XX$			DETAIL	11/3/82	RELEASED FOR ASSEMBLY	
			$\pm .XXX$			DESIGN			
HARDNESS		ANGULAR	\pm			APPRO		SHEET	OF
SURFACE TREATMENT	ES	CORNERS EDGES BROKEN	OUTSIDE MAX			B	SCALE	PART NO.	
		INSIDE	MAX						

4.5 Component Locations

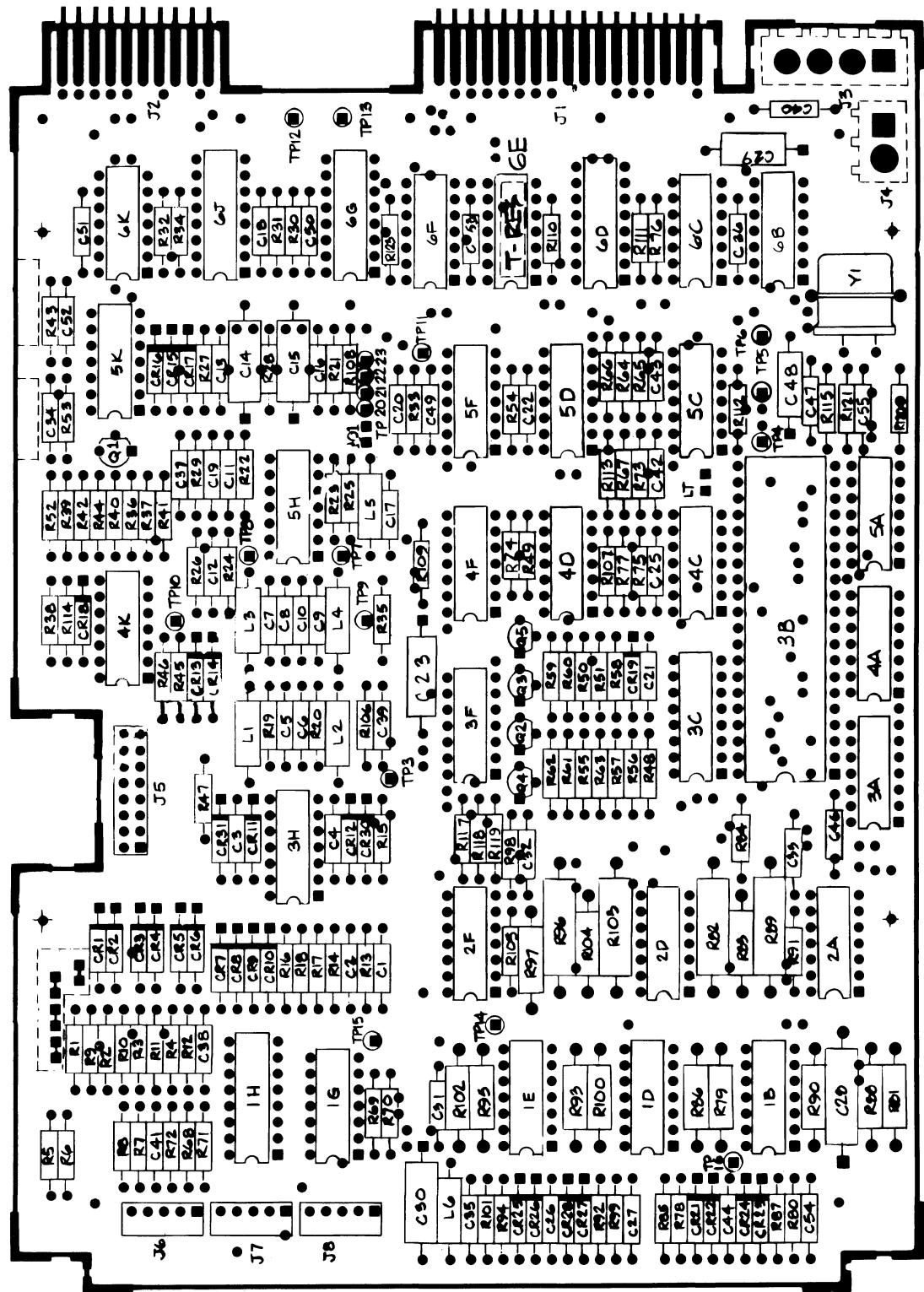
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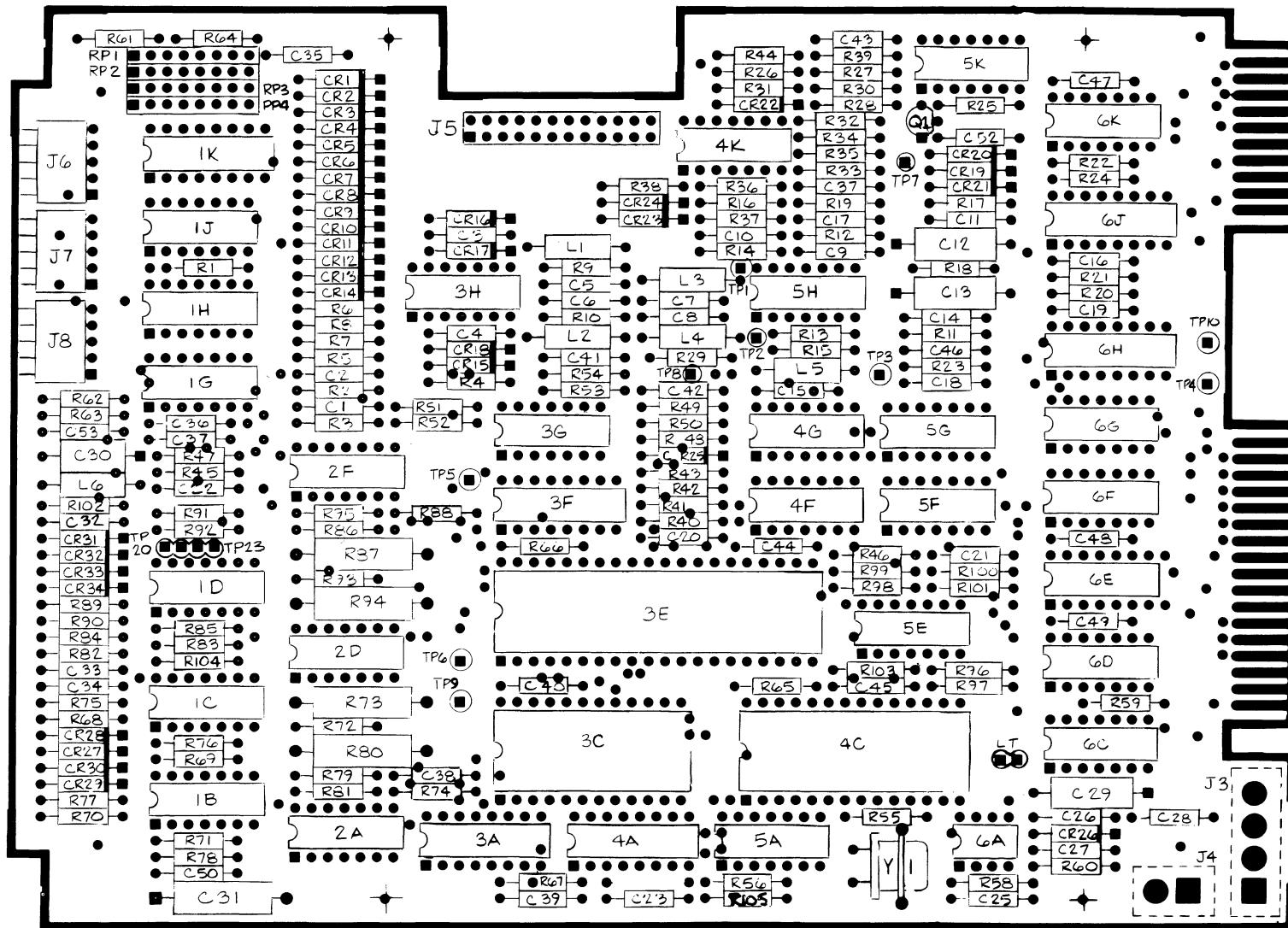
MAIN CONTROL PCB 20096



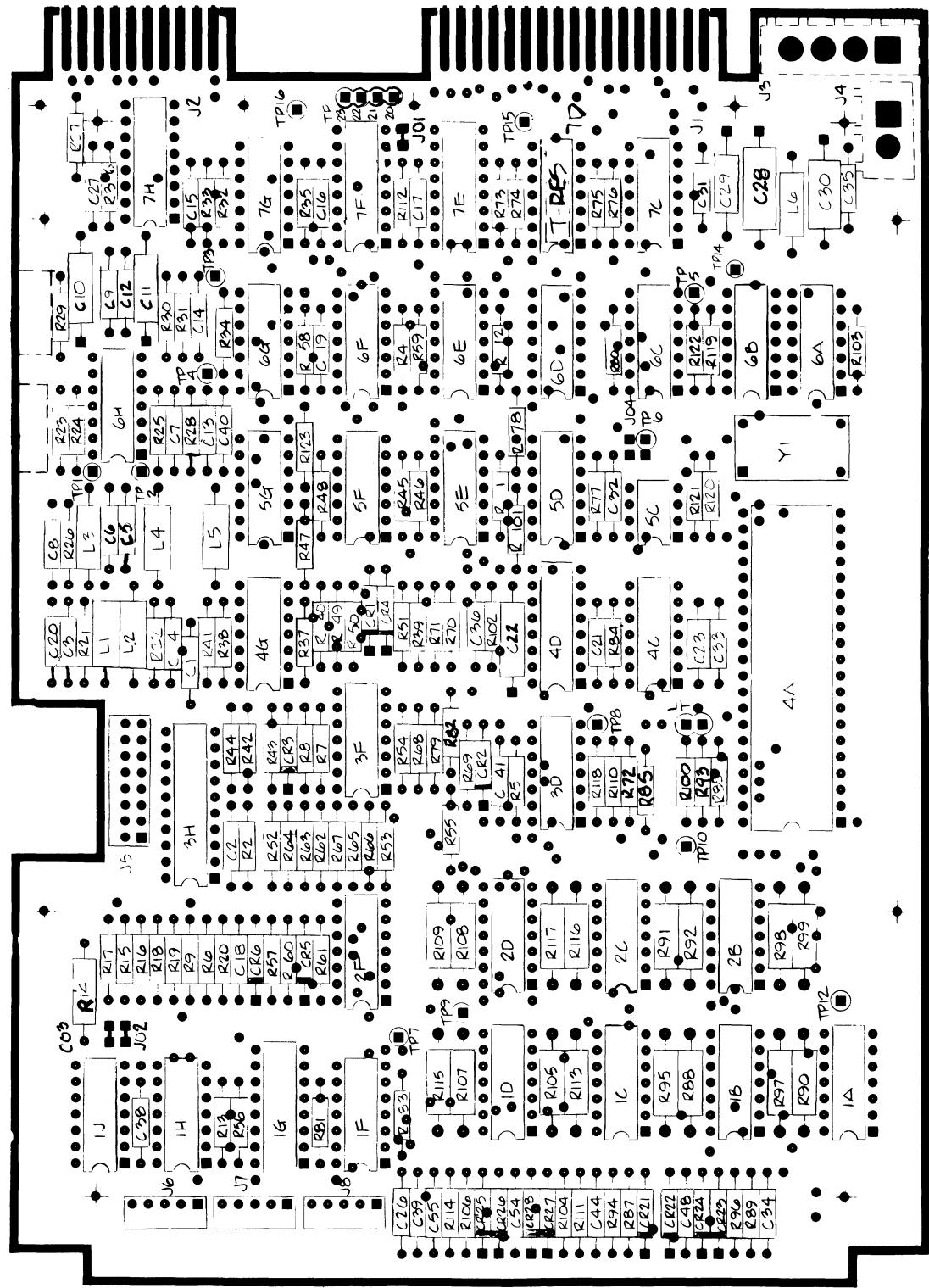
MAIN CONTROL PCB 20110



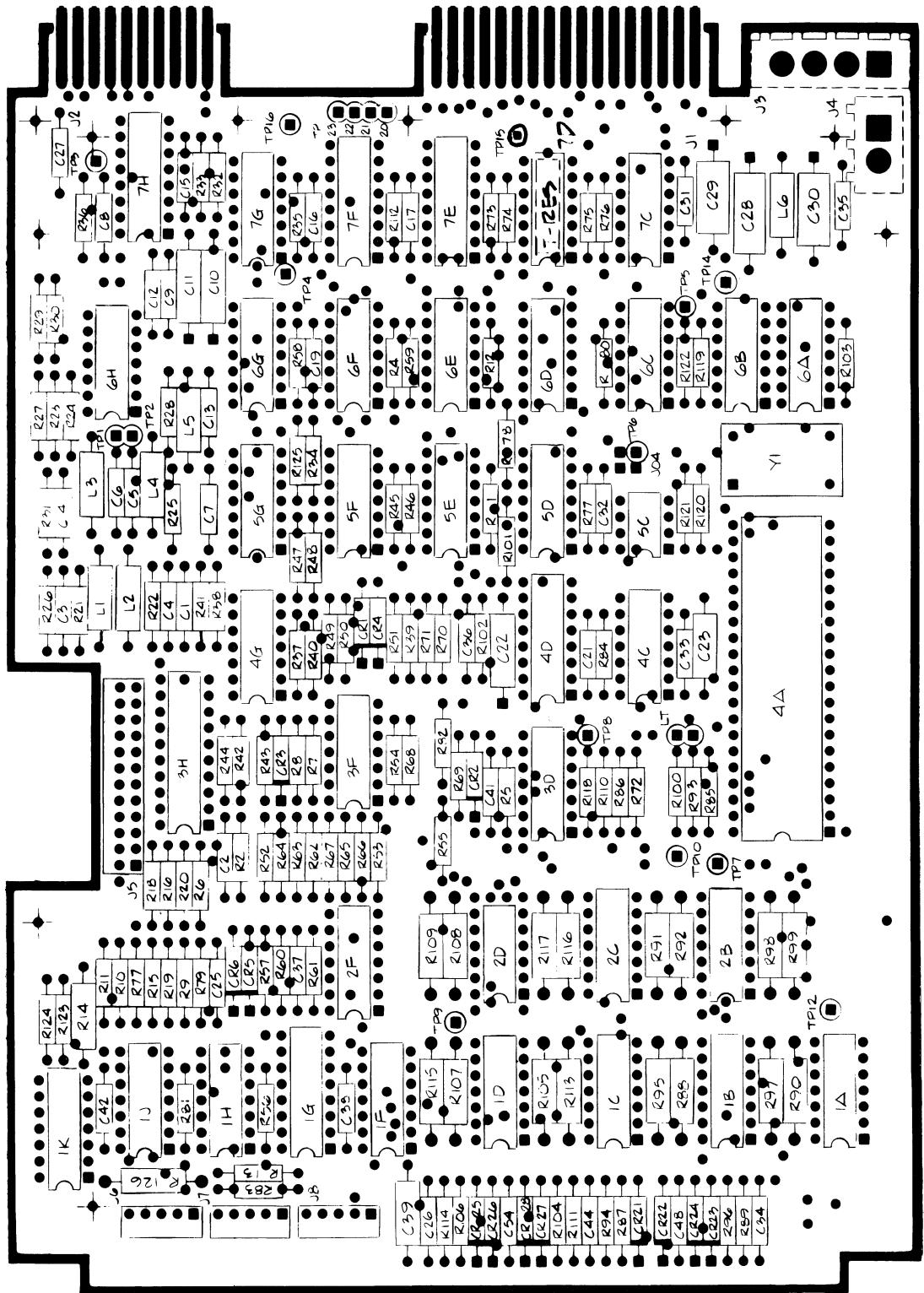
MAIN CONTROL PCB 20118



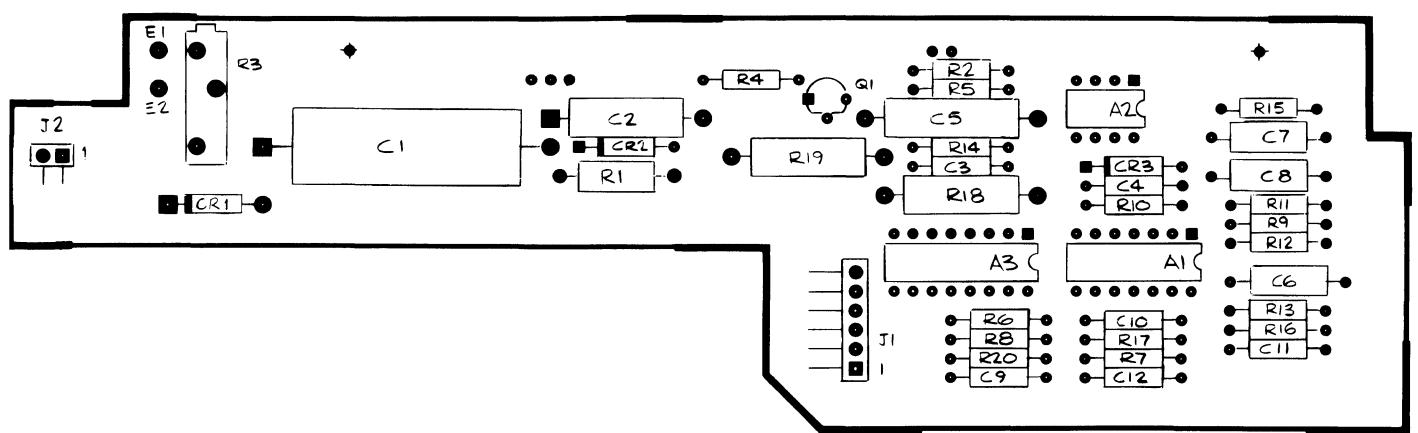
MAIN CONTROL PCB 20221



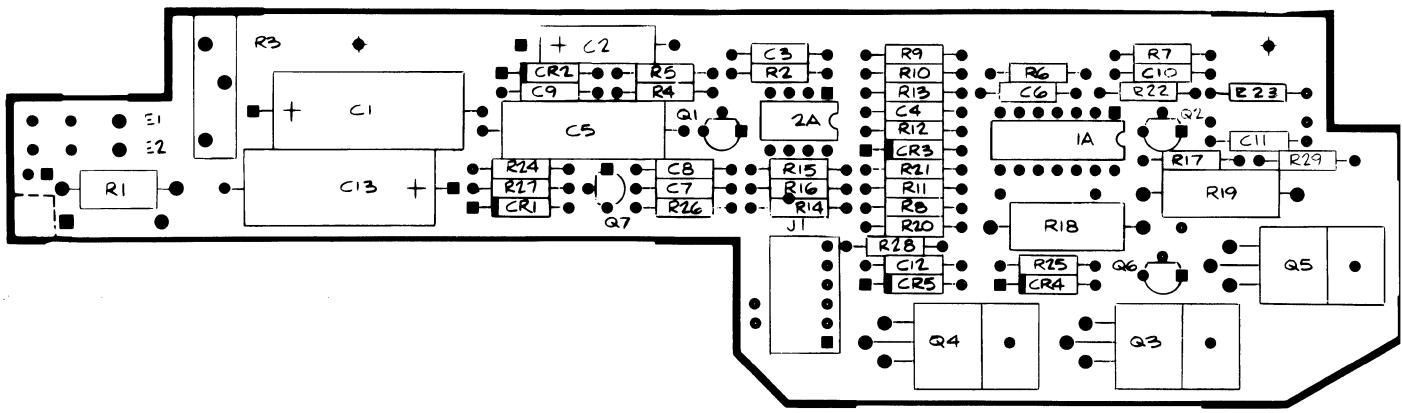
MAIN CONTROL PCB 20225



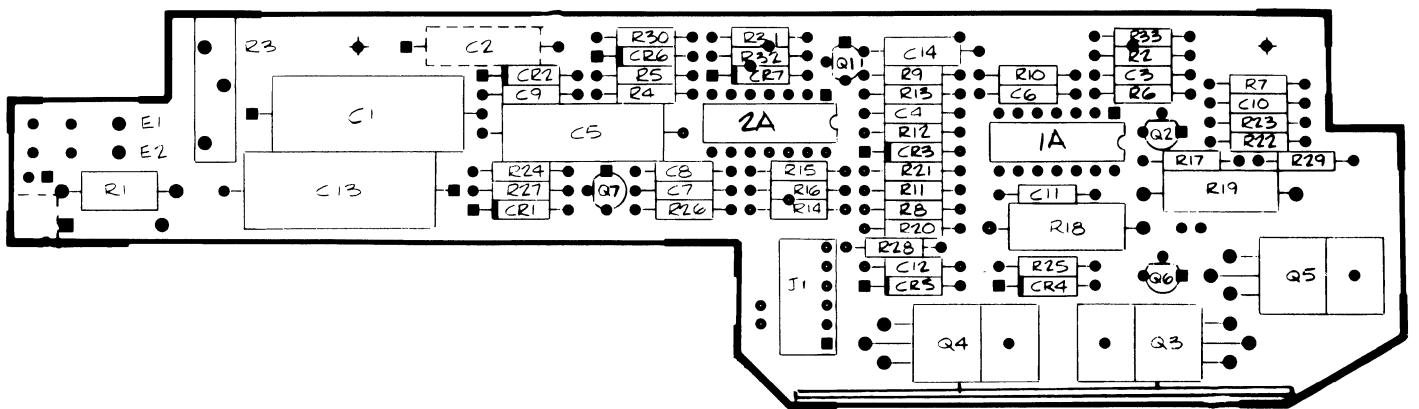
MOTOR CONTROL PCB 20099



MOTOR CONTROL PCB 20136



MOTOR CONTROL PCB 20217



4.6 Component Parts Lists

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4.6.1 MAIN CONTROL PCB - 20096

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	3	IC 7406	4F, 2A, 2F
2.	1	IC 7407	5K
3.	1	74LS14 [T.I./SIGNETICS ONLY]	6G
4.	3	74LS14	4G, 5E, 1G
5.	1	IC MC74HCU04	5A
6.	1	IC 7426	1D
7.	2	IC 7438	6C, 6D
8.	1	IC 7445	1H
9.	1	IC 74S74	6K
10.	1	IC 74S86	5G
11.	1	IC 74LS139	4A
12.	2	IC 74LS173	3F, 3A
13.	1	IC 26LS31	6H
14.	1	IC 26LS32	6J
15.	1	IC 2732A-2	3C
16.	1	IC 6503A (MICROPROCESSOR)	4C
17.	1	IC 6532A	3E
18.	1	IC LM339	3G
19.	1	IC NE555	6A
20.	1	IC NE592	5H
21.	1	IC NE592 (LOW NOISE) [T.I. or MOTOROLA ONLY]	3H
22.	1	IC 7408	5F
23.	1	RESISTOR PACK, 220/330 OHM	6F
24.	1	SHUNT, 7 POSITION, AMP-435704-7	6E
25.	2	RESISTOR, 1/8W, 1%, 7.68K	R49, 51
26.	3	RESISTOR, 1/8W, 1%, 1K	R48, 50, 57
27.	2	RESISTOR, 1/8W, 1%, 1.5K	R16, 17
28.	2	RESISTOR, 1/8W, 1%, 162 OHM	R19, 20
29.	2	RESISTOR, 1/8W, 1%, 178 OHM	R22, 23
30.	1	RESISTOR, 1/8W, 1%, 4.87K	R35
31.	1	RESISTOR, 1/8W, 1%, 73.2 OHM	R44
32.	1	RESISTOR, 1/8W, 1%, 825 OHM	R58
33.	4	RESISTOR, 1/4W, 5%, 560 OHM	R1-4
34.	1	RESISTOR, 1/4W, 5%, 390 OHM	R42
35.	1	RESISTOR, 1/4W, 5%, 47K	R77
36.	1	RESISTOR, 1/4W, 5%, 47 OHM	R54
37.	5	RESISTOR, 1/4W, 5%, 100 OHM	R25, 34, 40, 41, 33
38.	6	RESISTOR, 1/4W, 5%, 150 OHM	R13, 68, 75, 88, 95, 102, 109
40.	3	RESISTOR, 1/4W, 5%, 750 OHM	R15, 114, 117
41.	1	RESISTOR, 1/4W, 5%, 270 OHM	R14
42.	2	RESISTOR, 1/4W, 5%, 1M	R72, 74
43.	5	RESISTOR, 1/4W, 5%, 470 OHM	R27, 28, 45, 46, 56
44.	2	RESISTOR, 1/4W, 5%, 620 OHM	R39, 53
45.	16	RESISTOR, 1/4W, 5%, 1K	R18, 31, 32, 52, 55, 63, 66, 67, 110-112,

ITEM	QUANTITY	DESCRIPTION	LOCATION
46.	1	RESISTOR, 1/4W, 5%, 2K	R30
47.	5	RESISTOR, 1/4W, 5%, 4.7K	R43,61,62,69,70
48.	7	RESISTOR, 1/4W, 5%, 10K	R9-12,47,78
49.	2	RESISTOR, 1/4W, 5%, 15K	R60
50.	2	RESISTOR, 1/4W, 5%, 100K	R59,76
51.	4	RESISTOR, 1/4W, 5%, 1.2K	R5,6,7,8
52.	1	RESISTOR, 1/4W, 5%, 220 OHM	R64
53.	2	RESISTOR, 1/4W, 5%, 680 OHM	R36,37
54.	9	RESISTOR, 1/4W, 5%, 1.5K	R26,82,84,89,91, 96,98,103,105
55.	5	RESISTOR, 1/4W, 5%, 330 OHM	R21,24,29,38,65
56.	4	RESISTOR, 1/2W, 5%, 390 OHM	R86,93,100,107
57.	27	DIODE, 1N4148	CR1-17,20-29
58.	1	DIODE,ZENER, 4.3V,5%,1N5229B	CR19
59.	1	DIODE,ZENER, 2.4V,2%,1N5221	CR18
60.	3	TRANSISTOR, 2N3904	Q1,2,3
61.	1	CAP,CERAMIC, 47pf,NPO,5%	C24
62.	1	CAP,CERAMIC, 33pf,NPO,5%	C21
63.	1	CAP,CERAMIC, 150pf,NPO,5%	C17
64.	2	CAP,CERAMIC, 100pf,NPO,5%	C8,23
65.	1	CAP,CERAMIC, 470pf,NPO,5%	C20
66.	1	CAP,CERAMIC, 330pf,NPO,5%	C10
67.	1	CAP,CERAMIC, .047uf,X7R,10%	C4
68.	1	CAP,CERAMIC, .068uf, X7R,10%	C22
69.	34	CAP,CERAMIC,.1uf,Z5U,+80%-20%	C1,2,3,5,6,11-13, 16,18,19,25-27,31- 42,45,47-53
70.	4	CAP,TANT, 4.7uf, 35V, 10%	C14,15,29,30
71.	1	CAP,ELECTROLYTIC, 22uf, 16V	C28
72.	1	TRANS ARRAY, TPQ2907	4K
73.	2	TRANS ARRAY, Q2T3244 (MAY SUB. MPQ3467)	1B,1E
74.	1	TRANS ARRAY, Q2T3725 (MAY SUB. MPQ3725)	2D
75.	1	CRYSTAL, 2MHZ, \pm .1%, B200HC-18/U	Y1
76.	2	INDUCTOR, 2.2uh	L1,2
77.	3	INDUCTOR, 10uh	L3,4,6
78.	1	INDUCTOR, 3.3uh	L5
79.	4	RESISTOR, 1/2W, 2%, 470 OHM (MAY SUB 1/2W, 1%, 475 OHM)	R83,90,97,104
80.	4	RESISTOR, 1/2W, 2%, 510 OHM (MAY SUB. 1/2W, 1%, 511 OHM)	R85,92,99,106
81.	4	RESISTOR, 1W, 2%, 20 OHM	R87,94,101,108
82.	1	HEADER, 16 PIN, AMP-86479-2	J5
83.	3	HEADER, 5 PIN, AMP-640457-5	J6,7,8
84.	1	HEADER, 2 PIN, AMP-350209-1	J4
85.	1	HEADER, 4 PIN, AMP-350211-1	J3

4.6.2 MAIN CONTROL PCB - 20110

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	1	IC 74LS74	4A
2.	1	IC 6500/1	3B
3.	3	IC 7406	4D, 2A, 2F
4.	1	IC 7407	5K
5.	3	IC 74LS14	4F, 5C, 1G
6.	1	IC 7426	1D
7.	2	IC 7438	6B, 6C
8.	1	IC 7445	1H
9.	2	IC 74S74	6K, 4C
10.	2	IC 7408	5D, 3A
11.	1	IC 74S86	5F
12.	1	IC 26LS31	6G
13.	1	IC 26LS32	6J
14.	1	IC LM339	3F
15.	1	IC 4069UBPC [FAIRCHILD]	5A
16.	1	IC NE592	5H
17.	1	IC NE592 (LOW NOISE) [T.I. OR MOTOROLA ONLY]	3H
18.	1	IC 74123	3C
19.	1	RESISTOR PACK, 220/330 OHM	6E
20.	1	IC 74LS14	6F
21.	1	SHUNT, 7 POSITION	6D
22.	1	SHUNT, DIP, PROGRAM. 7 POS.	6D
23.	2	RESISTOR, 1/8W, 1%, 7.68K	R49, 51
24.	3	RESISTOR, 1/8W, 1%, 1K	R48, 50, 57
25.	2	RESISTOR, 1/8W, 1%, 1.5K	R16, 17
26.	2	RESISTOR, 1/8W, 1%, 162 OHM	R19, 20
27.	2	RESISTOR, 1/8W, 1%, 178 OHM	R22, 23
28.	1	RESISTOR, 1/8W, 1%, 4.87K	R35
29.	1	RESISTOR, 1/8W, 1%, 73.2 OHM	R44
30.	1	RESISTOR, 1/8W, 1%, 825 OHM	R58
31.	2	RESISTOR, 1/4W, 5%, 2.2K	R74, 117
32.	4	RESISTOR, 1/4W, 5%, 560 OHM	R1-4
33.	1	RESISTOR, 1/4W, 5%, 390 OHM	R42
34.	3	RESISTOR, 1/4W, 5%, 47K	R69, 75, 109
35.	1	RESISTOR, 1/4W, 5%, 47 OHM	R54
36.	5	RESISTOR, 1/4W, 5%, 100 OHM	R25, 33, 34, 40, 41
37.	7	RESISTOR, 1/4W, 5%, 150 OHM	R13, 68, 71, 84, 91, 98, 105
38.	2	RESISTOR, 1/4W, 5%, 750 OHM	R114, 123
39.	2	RESISTOR, 1/4W, 5%, 270 OHM	R14, 106
40.	6	RESISTOR, 1/4W, 5%, 470 OHM	R15, 27, 28, 45, 46, 56
41.	2	RESISTOR, 1/4W, 5%, 620 OHM	R39, 53
42.	20	RESISTOR, 1/4W, 5%, 1K	R18, 31, 32, 52, 53, 63, 66, 67, 73, 76, 77, 107, 108, 110-113, 115, 118, 119,
43.	1	RESISTOR, 1/4W, 5%, 2K	R30

ITEM	QUANTITY	DESCRIPTION	LOCATION
44.	5	RESISTOR, 1/4W, 5%, 4.7K	R43,61,62,120,121
45.	6	RESISTOR, 1/4W, 5%, 10K	R9-12,47,72
46.	1	RESISTOR, 1/4W, 5%, 15K	R60
47.	2	RESISTOR, 1/4W, 5%, 100K	R59,70
48.	4	RESISTOR, 1/4W, 5%, 1.2K	R5,6,7,8
49.	1	RESISTOR, 1/4W, 5%, 220 OHM	R64
50.	2	RESISTOR, 1/4W, 5%, 680 OHM	R36,37
51.	9	RESISTOR, 1/4W, 5%, 1.5K	R26,78,80,85,87, 92,94,99,101
52.	5	RESISTOR, 1/4W, 5%, 330 OHM	R21,24,29,38,65
53.	4	RESISTOR, 1/2W, 5%, 390 OHM	R90,97,83,104
54.	15	DIODE, 1N148	CR9-12,15-17,21-28
55.	12	DIODE, UNITRODE NDP 767	CR1-8,13,14,30,31
56.	1	DIODE, ZENER, 4.3V, 5%, 1N5229B	CR19
57.	1	DIODE, ZENER, 2.4V, 2%, 1N5221	CR18
58.	4	TRANSISTOR, 2N3904	Q1,2,3,5
59.	1	TRANSISTOR, 2N3906	Q4
60.	1	CAP,CERAMIC, 33pf, NPO, 5%	C21
61.	1	CAP,CERAMIC, 150pf, NPO, 5%	C17
62.	2	CAP,CERAMIC, 100pf, NPO, 5%	C8,55
63.	1	CAP,CERAMIC, 330pf, NPO, 5%	C10
64.	1	CAP,CERAMIC, 470pf, NPO, 5%	C20
65.	2	CAP,CERAMIC, .047uf, X7R, 10%	C4
66.	1	CAP,CERAMIC, .068uf, X7R, 10%	C22
67.	36	CAP,CERAMIC,.1uf,Z5U,+80%-20%	C1-3,5,6,11-13,16 18,19,25-27,31-39, 40-44,46,47,49-54
68.	6	CAP, TANT, 4.7uf, 35V, 10%	C14,15,23,29,30,48
69.	1	CAP, ELECTROLYTIC, 22uf, 16V	C28
70.	1	TRANS ARRAY, TPQ2907	4K
71.	2	TRANS ARRAY, MPQ3467	1B,1E
72.	1	TRANS ARRAY, MPQ3725	2D
73.	1	CRYSTAL, 2 MHZ, ± .1%, B200HC-18/U	Y1
74.	2	INDUCTOR, 2.2uh	L1,2
75.	3	INDUCTOR, 10uh	L3,4,6
76.	1	INDUCTOR, 3.3uh	L5
77.	4	RESISTOR, 1/2W, 2%, 470 OHM	R79,86,100
78.	4	RESISTOR, 1/2W, 2%, 510 OHM	R81,88,95,102
79.	4	RESISTOR, 1/2W, 2%, 20 OHM	R82,89,96,103
80.	1	HEADER, 16 PIN, AMP-86479-2	J5
81.	3	HEADER, 5 PIN, AMP-640457-5	J6,7,8
82.	1	HEADER, 2 PIN, AMP-350209-1	J4
83.	1	HEADER, 4 PIN, AMP-350211-1	J3

4.6.3 MAIN CONTROL PCB - 20118

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	1	IC 74LSI4 [SIGNETICS OR T.I. ONLY]	6G
2.	3	IC 7406	2A,2F,4F
3.	2	IC 7407	5K,1H
4.	1	IC 7408	5F
5.	1	IC 7410	1J
6.	4	IC 74LS14	1G,5E,5A,4G
7.	1	IC 7426	1C
8.	2	IC 7438	6C,6D
9.	1	IC 7445	1K
10.	1	IC 74LS74	6K
11.	1	IC 74S86	5G
12.	1	IC 74LS139	4A
13.	2	IC 74LS173	3F,3A
14.	1	IC 26LS31	6H
15.	1	IC 26LS32	6J
16.	1	IC 2732A-2	3C
17.	1	IC 6503A (MICROPROCESSOR)	4C
18.	1	IC 6532A	3E
19.	1	IC LM339	3G
20.	1	IC LM555	6A
21.	1	IC NE592	5H
22.	1	IC NE592	3H
23.	1	RESISTOR PACK 220/330 OHM DIP	6F
24.	1	SHUNT, 7 POS.,AMP-435704-7	6E
25.	1	RESISTOR, 1/8W, 1%, 619 OHM	R42
26.	1	RESISTOR, 1/8W, 1%, 14.7k	R40
27.	2	RESISTOR, 1/8W, 1%, 1K	R41,51
28.	2	RESISTOR, 1/8W, 1%, 1.5K	R6,7
29.	2	RESISTOR, 1/8W, 1%, 162 OHM	R9,10
30.	2	RESISTOR, 1/8W, 1%, 178 OHM	R12,13
31.	1	RESISTOR, 1/8W, 1%, 4.87K	R29
32.	1	RESISTOR, 1/8W, 1%, 61.9 OHM	R30
33.	1	RESISTOR, 1/8W, 1%, 825 OHM	R52
34.	1	RESISTOR, 1/8W, 1%, 5.36K	R43
35.	1	RESISTOR, 1/4W, 5%, 390 OHM	R28
36.	1	RESISTOR, 1/4W, 5%, 47K	R63
37.	3	RESISTOR, 1/4W, 5%, 47 OHM	R23,46,47
38.	4	RESISTOR, 1/4W, 5%, 100 OHM	R15,24,32,33
39.	7	RESISTOR, 1/4W, 5%, 150 OHM	R2,102,61,74,81,88,95
40.	2	RESISTOR, 1/4W, 5%, 750 OHM	R31,106
41.	2	RESISTOR, 1/4W, 5%, 270 OHM	R4,5
42.	2	RESISTOR, 1/4W, 5%, 1M	R58,60
43.	6	RESISTOR, 1/4W, 5%, 470 OHM	R3,17,18,36,37,48
44.	2	RESISTOR, 1/4W, 5%, 620 OHM	R27,44
45.	16	RESISTOR, 1/4W, 5%, 1K	R8,21,22,39,49,54 59,65-67,98-101,104

ITEM	QUANTITY	DESCRIPTION	LOCATION
46.	1	RESISTOR, 1/4W, 5%, 2K	R20
47.	1	RESISTOR, 1/4W, 5%, 4.7K	R25
48.	2	RESISTOR, 1/4W, 5%, 10K	R38,64
49.	3	RESISTOR, 1/4W, 5%, 100K	R50,53,62
50.	1	RESISTOR, 1/4W, 5%, 220 OHM	R96
51.	2	RESISTOR, 1/4W, 5%, 680 OHM	R34,35
52.	2	RESISTOR, 1/4W, 5%, 3.3K	R55,56
53.	9	RESISTOR, 1/4W, 5%, 1.5K	R16,68,70,75,77, 82,84,89,91
54.	5	RESISTOR, 1/4W, 5%, 330 OHM	R11,14,19,26,97
55.	1	RESISTOR, 1/4W, 5%, 560 OHM	R1
56.	4	RESISTOR, 1/2W, 5%, 390 OHM	R72,79,86,93
57.	1	RESISTOR, 1/4W, 5%, 8.2K	R105
58.	1	RESISTOR, 1/8W, 1%, 13K	R107
59.	4	RESISTOR, 1/2W, 2%, 470 OHM (MAY SUB. 1/2W, 1%, 475 OHM)	R69,76,83,90
60.	4	RESISTOR, 1/2W, 2%, 510 OHM (MAY SUB. 1/2W, 1%, 511 OHM)	R71,78,85,92
61.	4	RESISTOR, 1W, 2%, 20 OHM	R73,80,87,94
62.	1	RESISTOR, 1/4W, 5%, 2.2K	R45
63.	32	DIODE, 1N4148	CR1-21,23,24,26-34
64.	1	DIODE, ZENER, 4.3V, 5%, 1N5229B	CR25
65.	1	DIODE, ZENER, 2.4V, 2%, 1N5221	CR22
66.	1	TRANSISTOR, 2N3904	Q1
67.	1	CAP,CERAMIC, .001uf, NPO,5%	C23
68.	1	CAP,CERAMIC, 100pf, NPO, 5%	C7
69.	1	CAP,CERAMIC, 33pf, NPO, 5%	C20
70.	1	CAP,CERAMIC, 150pf, NPO, 5%	C15
71.	1	CAP,CERAMIC, 470pf, NPO, 5%	C18
72.	1	CAP,CERAMIC, 330pf, NPO, 5%	C8
73.	1	CAP,CERAMIC, .047uf, X7R,10%	C4
74.	2	CAP,CERAMIC, .068uf, X7R,10%	C21,22
75.	37	CAP,CERAMIC,.1uf,Z5U,+80%-20%	C1-3,5,6,9-11,14, 17,19,25-28,32-50, 52,53
76.	4	CAP, TANT, 4.7uf, 35V, 10%	C12,13,29,30
77.	1	CAP, ELECTROLYTIC, 22uf, 16V	C31
78.	1	TRANS, ARRAY TPQ2907	4K
79.	2	TRANS, ARRAY, Q2T3244 (MAY SUB. MPQ3467)	1B,1D
80.	1	TRANS, ARRAY, Q2T3725 (MAY SUB. MPQ3725)	2D
81.	1	CRYSTAL, 2 MHZ, ±.1% B200HC-18/U	Y1
82.	1	INDUCTOR, 33uh	L5
83.	2	INDUCTOR, 2.2uh	L1,2
84.	3	INDUCTOR, 10uh	L3,4,6
85.	1	HEADER, 24 PIN, AMP-86479-2	J5

ITEM	QUANTITY	DESCRIPTION	LOCATION
86.	3	HEADER, 5 PIN, AMP-640457-5	J6,7,8
87.	1	HEADER, 2 PIN, AMP-350209-1	J4
88.	1	HEADER, 4 PIN, AMP-350211-1	J3
89.	2	RESISTOR PACK SIP, 560 OHM	RP3,RP4
90.	1	RESISTOR PACK SIP, 1.2K	RP1
91.	1	RESISTOR PACK SIP, 10K	RP2

4.6.4 MAIN CONTROL PCB - 20221

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	6	IC 7406	1A,2B,2D,5D,5G,6B
2.	2	IC 7408	3D,6E
3.	4	IC 74LS14	1F,5E,6D,6F
4.	1	IC 7426	1C
5.	2	IC 7438	6C,7C
6.	1	IC 7455	1G
7.	2	IC 74LS74	4C,6A
8.	1	IC 74S74	6G
9.	1	IC 74S86	7G
10.	1	IC 74123	4D
11.	1	DIODE ARRAY PREAMP LSI	3H
12.	1	IC 26LS31	7F
13.	1	IC 26LS32	7H
14.	1	IC LM339	2F
15.	1	IC LM358	5C
16.	1	IC NE592	6H
17.	1	IC 6500/1	4A
18.	1	IC SHUNT, 7 POSITION	7E
19.	2	TRANS ARRAY, TPQ2907	1J,5F
20.	2	TRANS ARRAY, TPQ3904	3F,4G
21.	1	TRANS ARRAY, MPQ3725	2C
22.	2	TRANS ARRAY, MPQ3467	1B,1D
23.	1	RESISTOR PACK, 220/330 OHM	7D
24.	1	RESISTOR PACK, 1.2K/680 OHM	1H
25.	2	RESISTOR, 1/8W, 1%, 162 OHM	R21,22
26.	2	RESISTOR, 1/8W, 1%, 178 OHM	R24,25
27.	1	RESISTOR, 1/8W, 1%, 1K	R63
28.	1	RESISTOR, 1/8W, 1%, 825 OHM	R64
29.	1	RESISTOR, 1/8W, 1%, 4.87k	R49
30.	1	RESISTOR, 1/8W, 1%, 61.9 OHM	R50
31.	1	RESISTOR, 1/8W, 1%, 6.65K	R53
32.	1	RESISTOR, 1/8W, 1%, 2.94K	R54
33.	2	RESISTOR, 1/8W, 1%, 1.5K	R7,55
34.	1	RESISTOR, 1/8W, 1%, 750 OHM	R8
35.	1	RESISTOR, 1/4W, 5%, 750 OHM	R4
36.	4	RESISTOR, 1/4W, 5%, 1.2K	R6,9,15,16
37.	5	RESISTOR, 1/4W, 5%, 10K	R17-20,101
38.	12	RESISTOR, 1/4W, 5%, 330 OHM	R2,23,26,31, 37-41,45,48,74
39.	9	RESISTOR, 1/4W, 5%, 1.5k	R27,87,89,94,96, 104,106,111,114
40.	2	RESISTOR, 1/4W, 5%, 100 OHM	R28,36
41.	4	RESISTOR, 1/4W, 5%, 470 OHM	R29,30,43,60
42.	1	RESISTOR, 1/4W, 5%, 2K	R32
43.	2	RESISTOR, 1/4W, 5%, 47 OHM	R35,58
44.	4	RESISTOR, 1/4W, 5%, 620 OHM	R1,46,47,56
45.	3	RESISTOR, 1/4W, 5%, 4.7K	R52,65,66
46.	4	RESISTOR, 1/4W, 5%, 100K	R62,82,120,122

ITEM	QUANTITY	DESCRIPTION	LOCATION
47.	1	RESISTOR, 1/4W, 5%, 15K	R67
48.	2	RESISTOR, 1/4W, 5%, 2.2K	R69,70
49.	2	RESISTOR, 1/4W, 5%, 220 OHM	R51,73
50.	6	RESISTOR, 1/4W, 5%, 150 OHM	R79,81,93,100, 110,118
51.	3	RESISTOR, 1/4W, 5%, 47K	R83,84,102
52.	1	RESISTOR, 1/4W, 5%, 24K	R119
53.	1	RESISTOR, 1/4W, 5%, 20K	R121
54.	23	RESISTOR, 1/4W, 5%, 1K	R5,12,13,33,34, 42,44,57,59,61, 68,71,72,75-78, 80,85,86,103,112, 123
55.	11	DIODE, IN4148	CR1-3,21-28
56.	1	DIODE, ZENER, 4.3V, 5%, 1N5229B	CR5
57.	1	DIODE, ZENER, 6.8V, 1%, 1N5235	CR4
58.	1	DIODE, ZENER, 6.8V, 2%, 1N5235C	CR6
59.	2	INDUCTOR, 2.2uh	L1,2
60.	3	INDUCTOR, 10uh	L3,4,6
61.	1	INDUCTOR, 3.3uh	L5
62.	4	RESISTOR, 1/2W, 2%, 470 OHM	R88,95,105,113
63.	4	RESISTOR, 1/2W, 2%, 510 OHM	R90,97,107,115
64.	4	RESISTOR, 1/2W, 2%, 390 OHM	R92,99,109,117
65.	1	RESISTOR, 1W, 2%, 270 OHM	R14
66.	4	RESISTOR, 1W, 2%, 20 OHM	R91,98,108,116
67.	1	CAP,CERAMIC, .033uf, X7R, 10%	C23
68.	1	CAP,CERAMIC, 330pf, NPO,5%	C6
69.	1	CAP,CERAMIC, 150pf, NPO,5%	C13
70.	1	CAP,CERAMIC, 470pf, NPO,5%	C16
71.	1	CAP,CERAMIC, 100pf, NPO,5%	C5
72.	1	CAP,CERAMIC, .012uf, X7R, 10%	C2
73.	1	CAP,CERAMIC, .068pf, X7R, 10%	C19
74.	5	CAP,TANT, 4.7uf, 35V, 10%	C10,11,22,29,30
75.	1	CAP, ELECTROLYTIC, 22uf, 16V	C28
76.	29	CAP,CERAMIC,.1uf,Z5U,+80%-20%	C1,3,4,7-9,12,14, 15,17,18,20,21, 26,27,31-36,38- 41,44,48,54,55,
77.	1	CRYSTAL, MOTOROLA K116A	Y1
78.	1	HEADER, 16 PIN, AMP-86479-2	J5
79.	3	HEADER, 5 PIN, AMP-640457-5	J6,7,8
80.	1	HEADER, 2 PIN, AMP-350209-1	J4
81.	1	HEADER, 4 PIN, AMP-350211-1	J3

4.6.5 MAIN CONTROL PCB - 20225

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	6	IC 7406	1A,2B,2D,5D,5G,6B
2.	2	IC 7408	3D,6E
3.	4	IC 74LS14	1F,5E,6D,6F
4.	1	IC 7426	1C
5.	2	IC 7438	6C,7C
6.	1	IC 7445	1G
7.	2	IC 74LS74	4C,6A
8.	1	IC 74S74	6G
9.	1	IC 74S86	7G
10.	1	IC 74123	4D
11.	1	IC DIODE ARRAY PREAMP LSI	3H
12.	1	IC 26LS31	7F
13.	1	IC 26LS32	7H
14.	1	IC LM339	2F
15.	1	IC LM358	5C
16.	1	IC NE592	6H
17.	1	IC 6500/1	4A
18.	1	IC SHUNT, 7 POS., AMP-435704-7	7E
19.	3	TRANS ARRAY, TPQ2907	1J,1K,5F
20.	2	TRANS ARRAY, TPQ3904	3F,4G
21.	1	TRANS ARRAY, MPQ 3725	2C
22.	2	TRANS ARRAY, MPQ 3467	1B,1D
23.	1	RESISTOR PACK, 220/330 OHM	7D
24.	1	RESISTOR PACK, 1.2K/680 OHM	1H
25.	2	RESISTOR, 1/8W, 1%, 162 OHM	R21,22
26.	2	RESISTOR, 1/8W, 1%, 178 OHM	R24,25
27.	1	RESISTOR, 1/8W, 1%, 1K	R63
28.	1	RESISTOR, 1/8W, 1%, 825 OHM	R64
29.	1	RESISTOR, 1/8W, 1%, 4.87K	R49
30.	1	RESISTOR, 1/8W, 1%, 61.9 OHM	R50
31.	1	RESISTOR, 1/8W, 1%, 11K	R53
32.	1	RESISTOR, 1/8W, 1%, 2.94K	R54
33.	2	RESISTOR, 1/8W, 1%, 1.5K	R7,55
34.	1	RESISTOR, 1/8W, 1%, 750 OHM	R8
35.	1	RESISTOR, 1/4W, 5%, 750 OHM	R4
36.	6	RESISTOR, 1/4W, 5%, 1.2K	R6,9,10,15,16,123
37.	7	RESISTOR, 1/4W, 5%, 10K	R11,17-20,101,124
38.	12	RESISTOR, 1/4W, 5%, 330 OHM	R2,23,26,31,37-41 45,48,74
39.	9	RESISTOR, 1/4W, 5%, 1.5K	R27,87,89,94,96, 104,106,111,114
40.	3	RESISTOR, 1/4W, 5%, 100 OHM	R28,36,126
41.	4	RESISTOR, 1/4W, 5%, 470 OHM	R29,30,43,60
42.	1	RESISTOR, 1/4W, 5%, 2K	R32
43.	2	RESISTOR, 1/4W, 5%, 47 OHM	435,58
44.	4	RESISTOR, 1/4W, 5%, 620 OHM	R1,46,47,56
45.	3	RESISTOR, 1/4W, 5%, 4.7K	R52,65,66
46.	4	RESISTOR, 1/4W, 5%, 100K	R62,82,120,122

ITEM	QUANTITY	DESCRIPTION	LOCATION
47.	1	RESISTOR, 1/4W, 5%, 15K	R67
48.	2	RESISTOR, 1/4W, 5%, 2.2K	R69,70
49.	2	RESISTOR, 1/4W, 5%, 220 OHM	R51,73
50.	5	RESISTOR, 1/4W, 5%, 150 OHM	R81,93,100,110,118
51.	1	RESISTOR, 1/4W, 5%, 51 OHM	R79
52.	3	RESISTOR, 1/4W, 5%, 47K	R83,84,102
53.	1	RESISTOR, 1/4W, 5%, 24K	R119
54.	1	RESISTOR, 1/4W, 5%, 20K	R121
55.	23	RESISTOR, 1/4W, 5%, 1K	R5,12,13,33,34,42, 44,57,59,61,68,71, 72,75-78,80,86,103, 112,125
56.	4	RESISTOR, 1/2W, 2%, 470 OHM	R88,95,105,113
57.	4	RESISTOR, 1/2W, 2%, 510 OHM	R90,97,107,115
58.	4	RESISTOR, 1/2W, 2%, 390 OHM	R92,99,109,117
59.	1	RESISTOR, 1W, 2%, 270 OHM	R14
60.	4	RESISTOR, 1W, 2%, 20 OHM	R91,95,108,116
61.	1	CAP,CERAMIC, .033uf,X7R,10%	C23
62.	1	CAP,CERAMIC, 330pf, NPO,5%	C6
63.	1	CAP,CERAMIC, 150pf, NPO,5%	C13
64.	1	CAP,CERAMIC, 470pf, NPO,5%	C16
65.	1	CAP,CERAMIC, 100pf, NPO,5%	C5
66.	1	CAP,CERAMIC, .012uf,X7R,10%	C2
67.	1	CAP,CERAMIC, .068uf,X7R,10%	C19
68.	5	CAP,TANT, 4.7uf, 35V, 10%	C10,11,22,29,30
69.	1	CAP, ELECTROLYTIC, 22uf, 16V	C28
70.	28	CAP,CERAMIC,.1uf,Z5U,+80%-20%	C1,3,4,7-9,12,14, 15,17,21,25-27,31- 39,41,42,44,48,54
71.	1	CRYSTAL, MOTOROLA, K116A	Y1
72.	11	DIODE, 1N4148	CR1-3,21-28
73.	1	DIODE,ZENER, 4.3V, 5%,1N5229B	CR5
74.	2	DIODE,ZENER, 6.8V, 1%,1N5235	CR4
75.	1	DIODE,ZENER, 6.8V, 2%,1N5235C	CR6
76.	2	INDUCTOR, 2.2uh	L1,2
77.	3	INDUCTOR, 10uh,	L3,4,6
78.	1	INDUCTOR, 3.3uh	L5
79.	1	HEADER, 24 PIN, AMP-86479-7	J5
80.	3	HEADER, 5 PIN, AMP-640457-5	J6,7,8
81.	1	HEADER, 2 PIN, AMP-350209-1	J4
82.	1	HEADER, 4 PIN, AMP-350211-1	J3

4.6.6 MOTOR CONTROL PCB - 20099

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	1	TRANS ARRAY, TPQ2907 (MAY SUB. TPQ3906)	A1
2.	1	IC LM358	A2
3.	1	IC ULN 20748 (MAY SUB. ULN 2075)	A3
4.	1	CAP, POLYCARB, .1uf, 50V, 10%	C5
5.	1	CAP, AL.ELECTROLYTIC, 150uf, 25V	C1
6.	1	CAP, AL.ELECTROLYTIC, 22uf, 16V	C2
7.	2	CAP, CERAMIC, .0047uf, X7R	C3,4
8.	2	CAP, CERAMIC, .047uf, X7R	C6,7
9.	1	CAP, CERAMIC, .068uf, X7R	C8
10.	1	CAP, CERAMIC, .001uf, X7R	C10
11.	3	CAP, CERAMIC, .1uf, Z5U	C9,11,12
12.	1	DIODE, 1N4005	CR1
13.	1	DIODE, ZENER, 1N5234, 6.2V	CR2
14.	1	DIODE, ZENER, 1N4148	CR3
15.	1	TRANSISTOR, 2N3904	Q1
16.	3	RESISTOR, 1/4W, 5%, 10K	R2,5,11
17.	2	RESISTOR, 1/4W, 5%, 47K	R4,9
18.	1	RESISTOR, 1/4W, 5%, 1K	R8
19.	1	RESISTOR, 1/4W, 5%, 470 OHM	R6
20.	2	RESISTOR, 1/4W, 5%, 1.5K	R7,16
21.	2	RESISTOR, 1/4W, 5%, 20K	R10,14
22.	1	RESISTOR, 1/4W, 5%, 510K,	R12
23.	1	RESISTOR, 1/4W, 5%, 100K	R13
24.	1	RESISTOR, 1/4W, 5%, 1.2MEG	R15
25.	2	RESISTOR, 1/4W, 5, 4.7K	R17,20
26.	1	RESISTOR, 1/2W, 2%, 130 OHM	R1
27.	2	RESISTOR, 2W, 5%, .20 OHM	R18,19
28.	1	POT, 3/4W, 10%, 50K	R3
29.	1	HEADER, 6 PIN	J1
30.	1	HEADER, 2 PIN	J2

4.6.7 MOTOR CONTROL PCB - 20136

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	1	TRANS ARRAY TPQ2907 (MAY SUB. TPQ3906)	1A
2.	1	IC LM358	2A
3.	1	CAP, POLYCARB, .1uf, 50V, 10%	C5
4.	2	CAP, ALUM, ELECT, 150uf, 25V	C1,13
5.	1	CAP, ALUM, ELECT, 22uf, 16V	C2
6.	2	CAP, CERAMIC, .0047uf, X7R	C3,4
7.	2	CAP, CERAMIC, .047uf, X7R	C6,7
8.	1	CAP, CERAMIC, .068uf, X7R	C8
9.	1	CAP, CERAMIC, .001uf, X7R	C10
10.	3	CAP, CERAMIC, .1uf, Z5U	C9,11,12
11.	3	DIODE, 1N4005	CR1,4,5
12.	1	DIODE, XENER, 1N5234, 6.2V	CR2
13.	1	DIODE, 1N4148	CR3
14.	3	TRANSISTOR, 2N3904	Q1,2,6
15.	1	TRANSISTOR, 2N3906	Q7
16.	3	TRANSISTOR, TIP 120	Q3,4,5
17.	1	RESISTOR, 1/4W, 5%, 4.3K	R29
18.	1	RESISTOR, 1/4W, 5%, 220K	R27
19.	2	RESISTOR, 1/4W, 5%, 10K	R2,11
20.	2	RESISTOR, 1/4W, 5%, 47K	R9,25
21.	2	RESISTOR, 1/4W, 5%, 1K	R8,21
22.	1	RESISTOR, 1/4W, 5%, 470 OHM	R6
23.	2	RESISTOR, 1/4W, 5%, 1.5K	R7,16
24.	2	RESISTOR, 1/4W, 5%, 20K	R10,26
25.	2	RESISTOR, 1/4W, 5%, 510K	R12,28
26.	2	RESISTOR, 1/4W, 5%, 100K	R13,24
27.	1	RESISTOR, 1/4W, 5%, 1.2MEG	R15
28.	2	RESISTOR, 1/4W, 5%, 4.7K	R17,20
29.	1	RESISTOR, 1/8W, 1%, 33.2 OHM	R22
30.	1	RESISTOR, 1/8W, 1%, 68.1 OHM	R23
31.	1	RESISTOR, 1/8W, 1%, 10K	R5
32.	1	RESISTOR, 1/8W, 1%, 20K	R14
33.	1	RESISTOR, 1/2W, 2%, 130 OHM	R1
34.	1	RESISTOR, 1/8W, 1%, 61.9K	R4
35.	2	RESISTOR, 2W, 5%, .20 OHM	R18,19
36.	1	POT, 3/4W, 10%, 25K	R3
37.	1	HEADER, 6 PIN	J1

4.6.8 MOTOR CONTROL PCB - 20217

ITEM	QUANTITY	DESCRIPTION	LOCATION
1.	1	TRANS, ARRAY, TPQ2907 (MAY SUB. TPQ3906)	1A
2.	1	IC LM324	2A
3.	1	CAP, POLYCARB, .1uf, 50V, 10%	C5
4.	2	CAP, ALUM, ELECT, 150uf, 25V	C1,13
5.	1	CAP, ALUM, ELECT, 22uf, 16V	C2
6.	2	CAP, CERAMIC, .0047uf, X7R	C3,4
7.	2	CAP, CERAMIC, .047uf, X7R	C6,7
8.	1	CAP, CERAMIC, .068uf, X7R	C8
9.	1	CAP, CERAMIC, .001uf, X7R	C10
10.	3	CAP, CERAMIC, .1uf, Z5U	C9,11,12
11.	1	CAP, CERAMIC, .47uf, Z5U	C14
12.	4	DIODE, 1N4005	CR1,4,5,6
13.	1	DIODE, ZENER, 1N5234, 6.2V	CR2
14.	2	DIODE, 1N4148	CR3,7
15.	3	TRANSISTOR, 2N3904	Q1,2,6
16.	1	TRANSISTOR, 2N3906	Q7
17.	3	TRANSISTOR, TIP 120	Q3,4,5
18.	1	RESISTOR, 1/4W, 5%, 510 OHM	R33
19.	1	RESISTOR, 1/4W, 5%, 2K	R31
20.	1	RESISTOR, 1/4W, 5%, 4.3K	R29
21.	1	RESISTOR, 1/4W, 5%, 220K	R27
22.	2	RESISTOR, 1/4W, 5%, 10K	R2,11
23.	2	RESISTOR, 1/4W, 5%, 47K	R9,25
24.	2	RESISTOR, 1/4W, 5%, 1K	R8,21
25.	1	RESISTOR, 1/4W, 5%, 470 OHM	R6
26.	2	RESISTOR, 1/4W, 5%, 1.5K	R7,16
27.	3	RESISTOR, 1/4W, 5%, 20K	R10,26,32
28.	2	RESISTOR, 1/4W, 5%, 510K	R12,28
29.	2	RESISTOR, 1/4W, 5%, 100K	R13,24
30.	2	RESISTOR, 1/4W, 5%, 1.2MEG	R15,30
31.	2	RESISTOR, 1/4W, 5%, 4.7K	R17,20
32.	1	RESISTOR, 1/8W, 1%, 33.2 OHM	R22
33.	1	RESISTOR, 1/8W, 1%, 68.1 OHM	R23
34.	1	RESISTOR, 1/8W, 1%, 10K	R5
35.	1	RESISTOR, 1/8W, 1%, 20K	R14
36.	1	RESISTOR, 1/8W, 1%, 61.9K	R4
37.	1	RESISTOR, 1/8W, 2%, 130 OHM	R1
38.	2	RESISTOR, 2W, 5%, .20 OHM	R18,19
39.	1	POT, 3/4W, 10%, 25K	R3
40.	1	HEADER, 6 PIN	J1

4.6.9 PARTS LIST, FIELD SERVICE

ST406/412

ITEM	PART NUMBER	DESCRIPTION
1.	20096-001	MAIN CONTROL PCB
2.	20221-001/ST406 20221-002/ST412	MAIN CONTROL PCB
	[PCB is downward compatible with all MLC levels.]	
3.	20217-001 [PCB is downward compatible with all MLC levels.]	MOTOR CONTROL PCB
4.	54037-001	INDEX SENSOR ASSY.
5.	58415-001	GROUND SPRING ASSY.
6.	58424-001	TRACK Ø SENSOR KIT [12620-001 SENSOR/1 SCREW]
7.	58425-001	TRACK Ø SENSOR KIT [12624-001 SENSOR/2 SCREW]
8.	58501-001	4 POINT SHOCK MOUNT KIT
9.	58504-001	3 POINT SHOCK MOUNT KIT
10.	62020-001	4 POINT FRONT COVER
11.	62022-001	3 POINT FRONT COVER
12.	58189-001	4 POINT FRAME ASSY.
13.	58243-001	3 POINT FRAME ASSY.
14.	58503-001	FRONT COVER LED KIT
15.	11653-001	IC 6500/1
16.	11663-001	IC 2732A-2

PARTS LIST, FIELD SERVICE

ST419

ITEM	PART NUMBER	DESCRIPTION
1.	20118-001	MAIN CONTROL PCB
2.	20225-001	MAIN CONTROL PCB
3.	20217-001	MOTOR CONTROL PCB
4.	54037-001	INDEX SENSOR ASSY.
5.	58415-001	GROUND SPRING ASSY.
6.	58425-001	TRACK Ø SENSOR KIT
7.	58504-001	SHOCK MOUNT KIT
8.	62022-001	FRONT COVER
9.	58243-001	FRAME ASSY.
10.	58503-001	FRONT COVER LED KIT
11.	11663-001	IC 2732A-2
12.	11642-001	DIODE ARRAY PREAMP LSI
13.	11653-001	IC 6500/1

SHIPPING CONTAINERS

1.	15638-001	SINGLE PACK [1 DRIVE]
2.	15634-001	FOUR PACK
3.	15629-001	EIGHT PACK

HANDLING

1.	15666-001	PLASTIC TRAY WITH ENSOLITE PAD [24 PER PACKAGE]
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MANUALS

1.	ST406/412/419	OEM MANUAL
2.	ST506	OEM MANUAL
3.	ST406/412/419	SERVICE MANUAL
4.	ST506	SERVICE MANUAL
5.	RTS	RECEIVING TEST STATION OPERATIONS MANUAL

5.0 FIELD SALES OFFICES

CORPORATE HEADQUARTERS

NORTHWEST SALES OFFICE
SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066
408/438-6550 TELEX:176455 SEAGATE SCVL

FIELD OFFICE

1150 North First Street, #130
San Jose, CA 95112
408/286-7580

SOUTHWEST SALES OFFICE

SEAGATE TECHNOLOGY
5850 Canoga Avenue, Suite 400
Woodland Hills, CA 91367
213/884-2699

FIELD OFFICE

4000 McArthur Blvd. Suite 3000
Newport Beach, CA 92660
714/851-9964

MIDWEST SALES OFFICE

SEAGATE TECHNOLOGY
9451 LBJ Freeway, Suite 220
Dallas, TX 75243
214/783-6711 TWX:758760

NORTH CENTRAL SALES OFFICE

SEAGATE TECHNOLOGY
1931 North Meacham Road, Suite 323
Schaumburg, IL 60195
312/397-3727 TWX:253327

EAST COAST SALES OFFICE

SEAGATE TECHNOLOGY
12 Grove Street
Hopkinton, MA 01748
617/435-6961 TELEX:951431

FIELD OFFICE

9700 Koger Blvd. Suite 310
St. Petersburg, FL 33702
813/577-1199 TWX:709049

EUROPEAN HEADQUARTERS
SEAGATE TECHNOLOGY
Gassnerstrasse 5
8000 Munich
West Germany
49 89 177017 TELEX: 524275

920 Disc Drive • Scotts Valley, California 95066 • (408) 438-6550

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