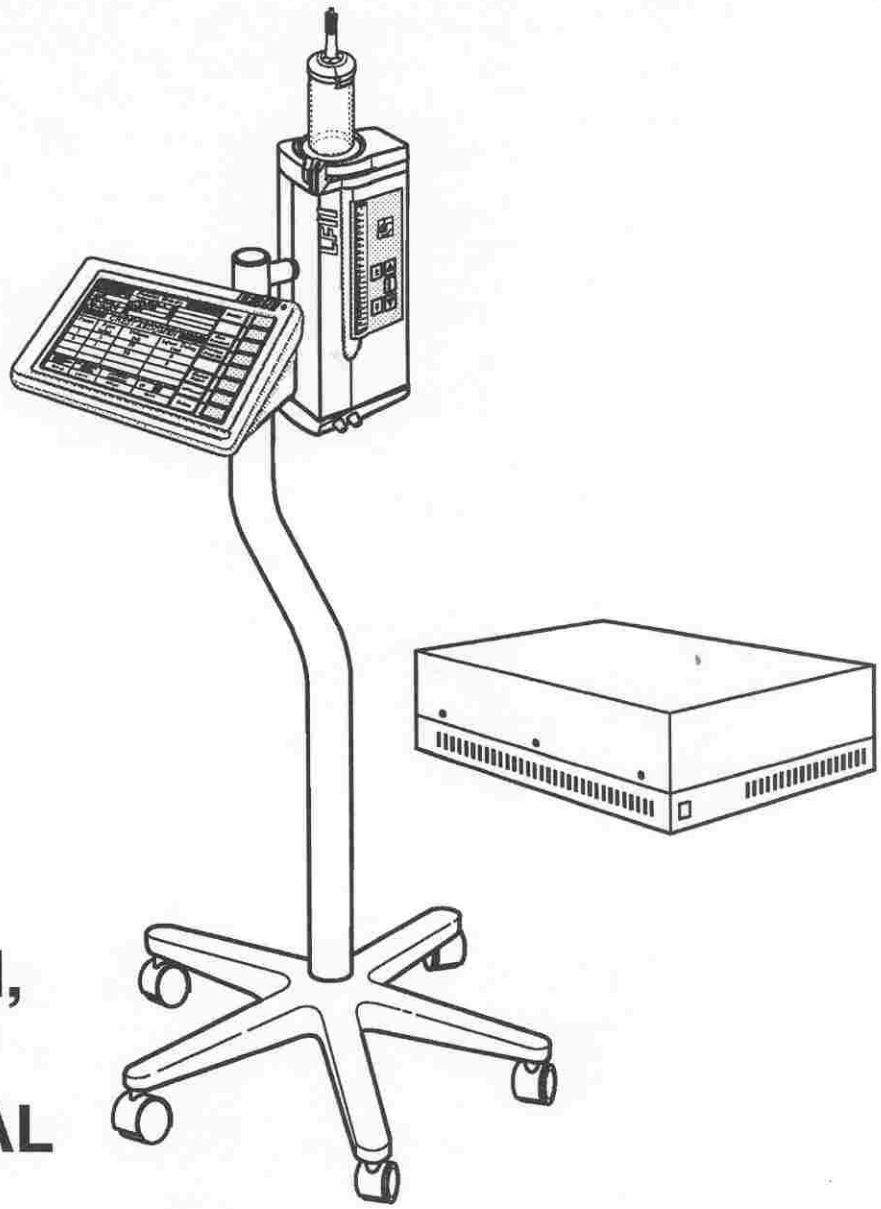
CT 9000

800951

DIGITAL INJECTION SYSTEM



INSTALLATION, SERVICE AND PARTS MANUAL

Liebel-Flarsheim Company
2111 EAST GALBRAITH ROAD, CINCINNATI, OHIO 45215 U.S.A.

The serial numbers and date of manufacture must be supplied when requesting replacement parts or optional accessories. For convenience, record the requested information below:

Base/Elect Cab S/N ☐☐☐☐☐☐☐☐

Powerhead S/N ☐☐☐☐☐☐☐☐

Console S/N ☐☐☐☐☐☐☐☐

Model Number ☐☐☐☐☐☐☐☐☐

Date of Installation ☐☐/☐☐/☐☐

Installing Company _____

Address _____

Phone No. _____

FOREWORD

Congratulations on your purchase of the Liebel-Flarsheim CT 9000 Digital Injection System. The CT 9000 represents our effort to provide a quality product to support better health care throughout the world.

Regardless of how well a piece of equipment is designed misuse or abuse will deny its owner the expected safe, efficient, and quality service. Often, misuse or abuse occurs unintentionally, simply because the proper method of operating or servicing the equipment is unknown. We urge you to carefully read this manual and the Operator's Manual before servicing the CT 9000. Retain this manual for future reference.

MEANINGS OF SYMBOLS

Please regard any message that follows a Danger, Warning, or Caution symbol.

DANGER!—Hazards which could result in severe personal injury or death.
WARNING!—Hazards which could result in personal injury.
CAUTION!—Hazards which could result in equipment or property damage.

WARNING!—Electrical hazards which could result in personal injury.

Non- Anesthetic proof

Remote handswitch

Printer

Primary console

Secondary console

Powerhead

Toggle On/Off switch

Push-push On/Off

Viewing Angle Adjustment

Injecting

Enabled (Ready)

Scan delay

Time

Date

Syringe volume

Patient volume

Protocol volume

Injecting in Progress (rotating wheel)

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1 SYSTEM OVERVIEW

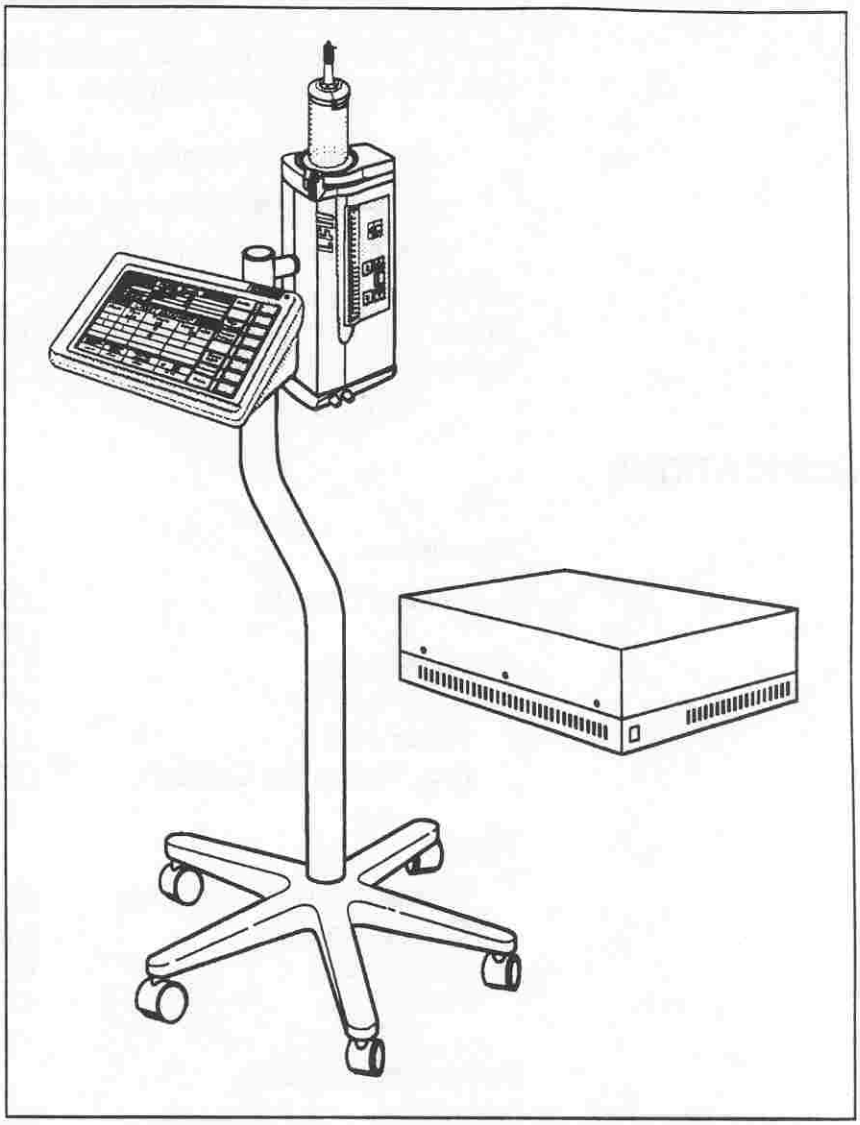


Figure 1-1
Liebel-Flarsheim CT 9000 Digital Injection System

The CT 9000 Injector is designed to inject a radiopaque contrast medium into a patient's vascular system which enhances diagnostic images obtained with computed tomography (CT). Each injection is accomplished with a motor-driven syringe mechanism with microprocessor control of the flow rate, volume, and timing.

This manual provides service and calibration procedures for the CT 9000 Injectors. For further information about operating and daily maintenance of the unit, refer to the CT 9000 Operator's Manual.

SERVICE TECHNICIAN QUALIFICATION

The CT 9000 Digital Injection System should be serviced and calibrated ONLY by qualified personnel who:

- are completely familiar with the unit
- have read and understood this manual and the Operator's Manual
- are properly trained in servicing equipment of this type.

Failure to follow these guidelines could result in serious injury to the service technician.

SPECIFICATIONS

Dimensions

Control Console	12 W x 8.4 D x 4.2 H inches (30 W x 21 D x 10.4 H cm)
Powerhead	3.5 W x 16 D x 6 H inches (9 W x 41 D x 16 H cm)
Power Pack (i.e., Electronics Cabinet)	12 W x 14 D x 6.5 H inches (30.5 W x 35.5 D x 16.5 H cm)

Weight

Standard System, complete	38 lbs (17.2 kg)
Control Console	7 lbs (3.2 kg)
Powerhead	18 lbs (8.1 kg)
Power Pack	13 lbs (5.9 kg)

Power Requirements

Standby	less than 1 A
Standard	115 VAC, 3 A, 50/60 Hz 230 VAC, 1.5 A, 50/60 Hz

Voltage Requirements

Unit automatically adapts for input voltages from 100 to 240VAC.

Electrical Leakage

Chassis	less than 100 microamps

Environmental

CAUTION!
The CT 9000 is not water proof. If any part of the unit is subjected to a liquid spill, remove the unit from operation and contact your authorized service personnel.

DANGER!
Possible explosion hazard if used in the presence of flammable anesthetics. The unit is not designed for use in explosive environments.

WARNING!
The powerhead may only be operated in an area that is located beyond the 20 gauss limit. Operating the unit within magnetic fields that are higher than this limit may cause the unit to malfunction, resulting in operator or patient injury.

Syringes

Syringe Sizes	200 ml, 125 ml (pre-filled)

Fill Rate

Forward or reverse: 30-100 sec. Accelerates from zero to maximum within approximately 3 seconds after pressing the [Forward] or [Reverse] key in conjunction with one of the [Fast] keys.

Syringe Heater

98° ± 6° F (37° ± 3° C) nominal. Maintains the temperature of preheated contrast. Overtemp condition will occur at 107.6° F (42° C).

Flow Rate Parameters

200 ml Syringe	0.1—7.2 ml/s
125 ml Syringe	0.1—4.9 ml/s

Pressure Limit

Pressure Units	pounds per square inch (psi)
Range	25, 50—300 (in 50 psi increments)

Inject Delay

Inject Delay Parameters	0—255 sec

Scan Delay

Scan Delay Parameters	0—99 sec

Stored Protocols

12 protocols can be stored and recalled.

2 INSTALLATION

UNPACKING AND ASSEMBLY PROCEDURES

When receiving the CT 9000 Digital Injection system, first check the equipment for signs of damage. If any of the items are damaged or missing, don't accept the shipment until the freight or express agent notes the problem on the receipt or bill. If equipment is later discovered to be damaged or missing, notify the shipping agent within 15 days after receiving the items.

Store the equipment in the shipping cartons until ready for installation. The storage area should be clean and dry and should not subject the equipment to temperature extremes.

When unpacking the CT 9000, remember that it contains fragile electronic parts. Don't drop it or subject it to other mechanical shocks.

INSTALLATION PROCEDURE

Refer to the Checklist included in the front of this manual.

1. After unpacking, identify these parts of the system and rcord each component's Serial Number in the Installation Checklist:
   - ❑ Console
   - ❑ Power pack (Electronics Cabinet)
   - ❑ Powerhead
   - ❑ Printer and its associated hardware (optional)
   - ❑ Console to Power pack cable
   - ❑ Powerhead to Power pack cable
   - ❑ Power Cord
   - ❑ Ordered Accessories

2. Inspect the exterior of the Console:
   Check the Console Cable connector for cracks or bent pins.
   Check the Console case for dents or other external damage.

3. Inspect the exterior of the Power pack:
   Check the Power pack cabinet for dents or scratches.
   Check the connectors located on the rear of the cabinet for cracks or protruding pins.

4. Inspect the exterior of the Powerhead:
Check the cable for nicks or impairment due to crimping.
Check the Heater connector and the Powerhead Cable connector for cracks or bent pins.

5. Inspect the Console cable, the Powerhead cable and the Power Cord.
Check each cable for nicks or impairment due to crimping.
Check the Power Cord for nicks or impairment due to crimping.

6. Inspect each Accessory to ensure there are no dents or scratches.

7. Mounting the Powerhead, Power pack and Console will depend on the type of accessories ordered. Refer to the Installation Instructions that accompanies the accessories in order to mount the components to your desired configuration.

8. Power must be off before connecting or disconnecting the system's cabling. Connecting cables after the Unit is powered may cause generation of false error messages. System connections are as follows:

Electronics Cabinet

Remote Handswitch Connection

An 8-pin circular DIN connection allows for interfacing with an optional remote handswitch.

Printer Connection

An 8-pin circular mini-DIN connection allows for interfacing with an optional printer.

1 

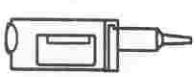
Primary Console

A 15-pin D-shell connection sends and receives information to and from the Console.

2 

Secondary Console

A second 15-pin D-shell connection sends and receives information to and from an optional second Console.



Powerhead Connection

A 25-pin D-shell connection sends and receives information to and from the powerhead.

Power Cord Connection

The supplied power cord connects to the Electronics Cabinet at the power connection. The unit can accept either 115 VAC (50/60 Hz) or 220 VAC (50/60 Hz) without modification. The unit will automatically sense the input voltage during power-up sequences.

CAUTION!
Use only the supplied power cord to connect power to the Power Cord Connection. Use of other power cords could result in damage to the equipment. Units installed outside of the U.S. must use hospital approved power cords.

Powerhead

Heater Blanket Connection

A 4-pin connection, located on the bottom of the Powerhead, sends and receives information to and from the Heater Blanket.

Electronics Cabinet Connection

A 25-pin connection, located on the bottom of the Powerhead, sends and receives information to and from the Electronics Cabinet.

Console

Electronics Cabinet Connection

A 15-pin connection, located on the rear of the console, sends and receives information to and from the Electronics Cabinet.

9. Install the Pressure Plate Assembly. Instructions covering installation of the Pressure Plate Assembly are contained in the Operator's Manual, P/N 800950.

10. Perform the Preventive Maintenance Checks listed in Chapter 6. If all requirements for these tests are passed, then proceed to the next section.

TURN ON THE CT 9000

Turn the unit on by first toggling the Power pack's Power Switch located on the rear of the cabinet and then pushing the Console power switch located on the left-hand side of the console. The LED located on the Power pack and on the upper right-hand corner of the console will glow and the Start-up Menu will be displayed.

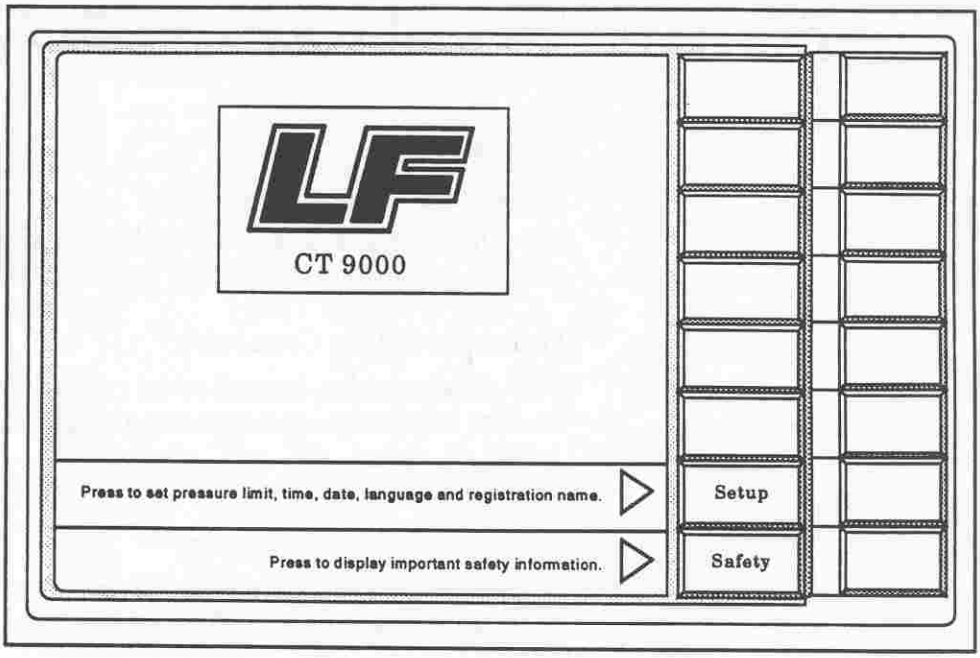


Figure 2-1
Start-up Menu

RECORD THE VERSION LEVEL

Press the [Safety] key, then the [Version] key. Record the firmware version level of each component in the Installation Checklist. Press the [Exit] key.

ENTER THE PRESSURE LIMIT, TIME, DATE, LANGUAGE AND REGISTRATION NAME

Press the [Setup] key and enter the required Pressure Limit, Time, Date, Language and Registration Name. Instructions on entering these items are contained in the Operator's Manual, P/N 800950.

3 THEORY OF OPERATION

This section describes the design of the CT 9000 and how it works. Block diagrams and complete circuit schematics are included to supplement the descriptions, and for reference during troubleshooting.

The overall system is covered first, describing the main design features. Then we list the major circuit groups, summarizing their functions.

The remainder of this section details the circuit groups. For each circuit group we'll describe its major functions, summarize its inputs and outputs, and describe how the circuit works.

OVERALL SYSTEM

As shown in Figure 3-1, the CT 9000 system consists of three basic components: the power pack, the powerhead and the console. The power pack contains the main microprocessor, the system power supplies and the servo circuitry. The console contains the LCD display controller and a microprocessor. The powerhead contains heater blanket control circuitry, and a microprocessor circuit.

The CT 9000 is designed to control three main parameters: velocity, volume and pressure.

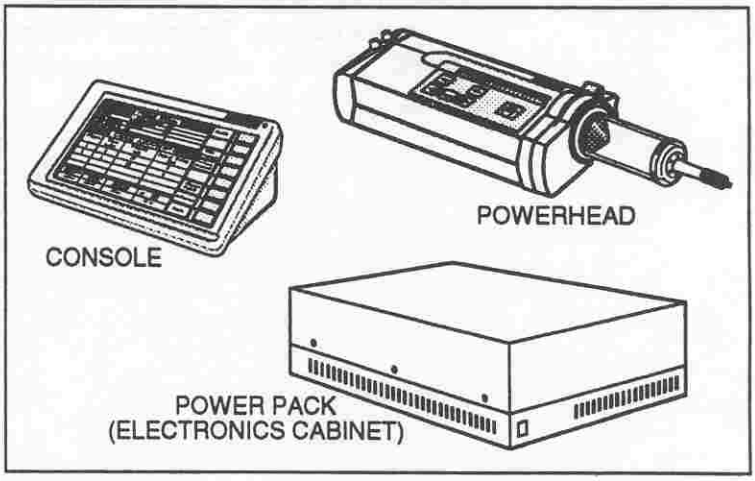


Figure 3-1
Complete CT 9000 System

VELOCITY CONTROL

The main microprocessor writes a 12-bit word to a D/A. The resulting output voltage is input to a PWM (Pulse Width Modulator) circuit that controls a flyback regulator. The Flyback regulator genèrates a voltage which is applied to the motor. As the motor turns, an encoder on the motor provides a quadrature signal to the main microprocessor and the powerhead microprocessor. The main microprocessor compares the velocity of the motor, as derived from the motor encoder, to the desired velocity and adjusts the D/A output voltage accordingly. The powerhead microprocessor compares the velocity of the motor to a calculated velocity range. If the velocity is out of range the powerhead microprocessor will notify the main microprocessor and then stop the motor.

VOLUME CONTROL

The plungers absolute position is determined by a linear potentiometer attached to the ball screw. When the motor is halted the linear potentiometer is read and an absolute position is calculated. For accurate volume delivery, the microprocessor counts the pulses from the motor encoder. As the actual position approaches the calculated position, the brake circuit is applied. The potentiometer is monitored during volume delivery to ensure that the pulses from the motor encoder correlate with the motion detected by the linear potentiometer.

PRESSURE CONTROL

A hardware circuit provides the primary pressure limiting control. Motor current is compared against a preset pressure limit threshold. If the pressure limit threshold is reached the circuit will halt the servo until the sensed pressure falls below the preset pressure limit threshold.

Secondary pressure limit control is provided through software monitoring of the motor current. The motor current is monitored by the A/D on the CPU board. The flow rate is restricted if the actual pressure exceeds the preset limit.

POWER PACK OVERVIEW

The power pack consists of three major functional sections. First is the MAIN POWER INPUT, second is the MOTHERBOARD and third is the CPU BOARD. Figure 3-2 below shows a block diagram of these sections.

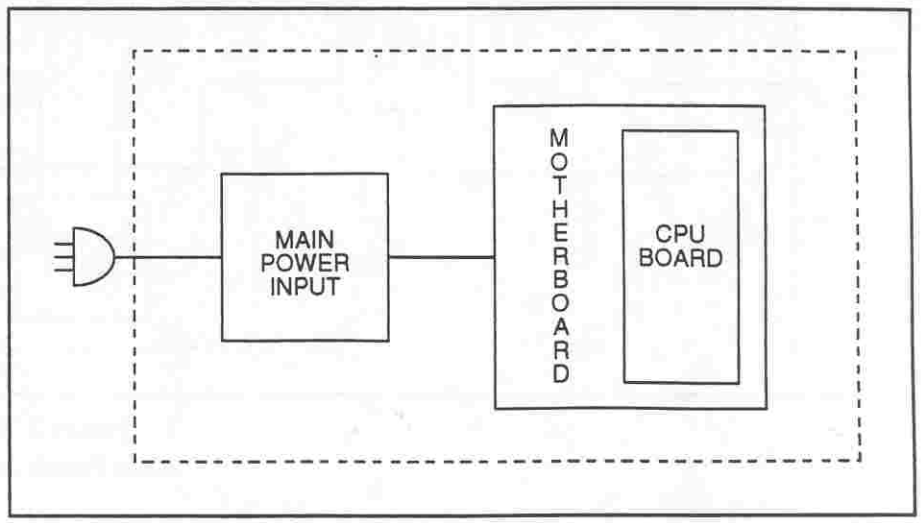


Figure 3-2
Power Pack Overview

MAIN POWER INPUT

The line voltage enters the Power Pack through an IEC 320 power inlet. As shown in Figure 3-3, the power inlet is wired to a 3 amp, double pole, double throw circuit breaker. The circuit breaker output is connected to a line filter. The chassis ground of the power inlet and the line filter are connected to the frame. The filtered line voltage is input to the VOLTAGE SELECT board. The VOLTAGE SELECT board, which is actually mounted on the main power transformer, senses the line voltage and configures the main power transformer's primary winding so that the secondary output is 24VAC. A complete description of this boards operation is given below.

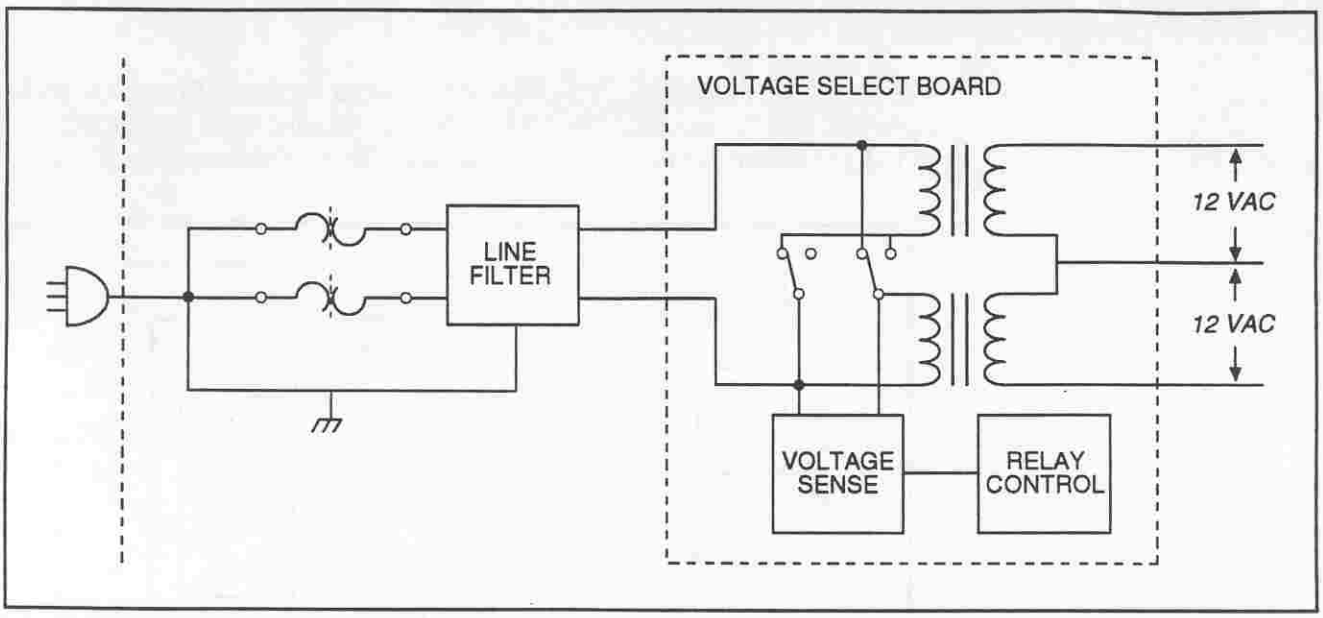


Figure 3-3
Main Power Input

VOLTAGE SELECT BOARD

As mentioned above, the VOLTAGE SELECT board is responsible for sensing the line voltage and configuring the main power transformer's primary winding. The sensing circuit samples the transformer's center tap to keep the circuit's input at 115VAC. Resistor R1, and varistor MOV1 prevent transient voltages from tripping the circuit.

The bridge rectifier—BR1, R2, DZ1 and C2—powers the circuit and provides base drive for transistor Q2. The dc voltage from the bridge rectifier varies with the input AC voltage.

The MC34064 under-voltage sensor, U1, trips at 4.6V. Note that U1's RESET pin is an output, not an input; the chip's intended function is resetting µP systems. When the rectified line voltage is below U1's trip point, RESET is low, which sets up R3 and R4 as a voltage divider.

When the input voltage goes above 4.6V, U1 trips, setting the RESET output high. RESET's going high turns on Q2, which energizes relay K1. K1 reconfigures the transformer's primary for 220V. This trip point will occur at approximately 155V. To prevent relay K1 from oscillating or "hunting," resistor R4 adds hysteresis to U1's operation. Once the primary is configured for 220V, the line voltage must fall to approximately 75V before the transformer's primary will be re-configured to 115V.

Relay K1 cannot handle the large transient voltages that sometimes occur around the switching point. Transistor Q1 and resistor R7 limit current through K1 to 10 ma.

MOTHERBOARD

The MOTHERBOARD consists of the following major components, each of which will be discussed in greater detail in the following sections:

- Power Supplies
- Powerhead Interface
- Servo
- Auxiliary I/O Interface
- Handswitch Interface
- Status LED's
- Console Connectors

Power Supplies

The power supply section consists of four major functional sections: Remote on/off, +3.5V supply, +5V supply and +12V supply.

Remote On/Off

The main power transformer supplies 24VAC to the motherboard. One side of the 24VAC goes directly to a diode bridge, BR1. The other side of the 24VAC goes through a solid state relay, SSR1, and then to the diode bridge. The solid state relay is controlled by U17. When the solid state relay is off, the 24VAC is not applied to both sides of the bridge and, therefore, the +5V and +12V supplies are off. However, U17 requires power to operate the remote on/off function, so the +3.5V supply is used to power U17 while the +5V and +12V supplies are off.

The Power Supply Control Input (/PSI, U17 pin 8) and Power Supply Control Output (/PSO, U17 pin 16) are used to control the solid state relay. Prior to establishing a voltage on VCC (U17 pin 3), PSI is internally held at a high level at all times by the +3.5V supply on VBAT (U17 pin 1). When /PSI is forced low by the motherboard reset switch, SW1, or by the momentary switch on a console, PSO is connected to VBAT to provide a high level. This high level turns on the solid state relay. A subsequent falling edge on /PSI will tristate PSO to shut off the solid state relay.

Relay K3 is used to isolate +5V from U17 pin 3 until the solid state relay turns on. This, along with a filter formed by L3 and C34, helps to eliminate noise related problems.

Opto-isolator U18 is used to interface /PSI to the console switches and the motherboard switch, SW1. Capacitor C8 is placed across the LED side of U18 to prevent it from inadvertently turning on when a long console cable is attached.

+3.5V Supply

The +3.5V supply is used to supply power to U17 when the +5V supply is off. It also powers the LED located on the front of the Power Pack.

The adjustable regulator VR3 is supplied +14V unregulated DC by rectifying (D3 and 1/4 of BR1) and filtering (C9) the main transformer secondary center tap voltage. VR3's output voltage is set as follows:

$$Vout = 1.25V\ (1 + R13/R14) = 1.25V(1 + 1500/680) = 4V$$

This +4V is dropped to approximately 3.5V by D13 before being connected to U17 pin 1.

+5V Supply

The +5V supply is used to power the MOTHERBOARD logic circuitry and the CPU board. The +5V regulator is a step down DC to DC converter capable of sourcing up to 5A of output current.

At intervals of approximately 10µs (100kHz) VR2 connects VR2-5 to VR2-4 impressing a voltage across inductor L2. This causes current to build up in the inductor while also supplying current to the load and filter capacitor C4.

VR2 determines when to disconnect VR2-5 and VR2-4 during the 10µs interval to keep the output voltage at +5V. When VR2-5 and VR2-4 are disconnected, the magnetic field in the inductor collapses and the polarity of the voltage across the inductor changes to try and maintain the current in the inductor. This current in the inductor is now directed (due to the change in voltage polarity across the inductor) by the diode D2, to the load. The current will flow from the inductor until the switch turns on again or until the inductor runs out of energy.

The divider circuit of R6 and R5 is used to set the output voltage of the supply against an internal voltage reference of 2.21VDC. The output voltage is calculated as follows:

$$Vout = 2.21V\ (1 + R6/R5) = 2.21V(1 + 2870/2210) = 5.08V$$

R4 and C5 make up the frequency compensation network used to stabilize the feedback loop.

+12V Supply

The +12V supply is supplied to the MOTHERBOARD, the CPU board and is used as the bulk supply for the POWERHEAD board. The +12V regulator is identical to the +5V regulator with the exception of the divider circuit which sets the output voltage. The output voltage for the +12V supply is calculated as follows:

$$Vout = 2.21V\ (1 + R3/R2) = 2.21V(1 + 9760/2210) = 11.97V$$

Powerhead Interface

The powerhead interface provides the interface between the powerhead DB-25 connector and the CPU board. The pin out for the powerhead DB-25 connector is given in Table 3-1.

RS-422 transmitter U4 pin 9 translates serial communications (TXDB) from the CPU board for transmission to the POWERHEAD. RS-422 receiver U13 pin 11 translates the RS-422 serial communications (RXDB) and motor encoder quadrature pulses transmitted from the POWERHEAD board to the CPU board. The motor encoder quadrature pulses are input to J-K flip flop U14 pin 3 and 4 to generate a motor direction signal to the CPU board. A high on U14 pin 6 indicates the motor is expelling. A low on U14 pin 6 indicates that the motor is filling.

The serial communications between the POWERHEAD and CPU boards are combined by U6 pin 6 and converted to RS-422 by U4 pin 15. The resulting signal is output to connector J13 and may be used to monitor powerhead communications.

J5 Pin	*Signal Name*	*Signal Description*
1	CHGND	Chassis GND
2	MOTPWR-	Motor power
3	MOTPWR-	Motor power
4	MOTPWR-	Motor power
5	MOTPWR+	Motor power
6	MOTPWR+	Motor power
7	MOTPWR+	Motor power
8	GND	Signal GND
9	GND	Signal GND
10	GND	Signal GND
11	CHGND	Chassis GND
12	CHGND	Chassis GND
13	RCV+	Head data receive +
14	+12V	Logic power
15	+12V	Logic power
16	+12V	Logic power
17	ENCTRL	ENABLED lamp control

18	INJCTRL	INJECTING lamp control
19	TXD+	Head data transmit +
20	TXD-	Head data transmit -
21	ENCB-	Motor encoder phase B -
22	ENCA-	Motor encoder phase A -
23	ENCA+	Motor encoder phase A +
24	ENCB+	Motor encoder phase B +
25	RCV-	Head data receive -

Table 3-1
Powerhead DB-25 Pin Designations

Servo

The servo section of the motherboard is concerned with generating the motor power, stopping the motor, sensing pressure and hardware safety features. Each topic will be covered separately.

Motor Power

Motor power is generated by a flyback regulator circuit. Flyback regulators (Figure 3-4) use a transformer to transfer energy from input to output. During S1 "on" time, energy builds up in the core due to increasing current in the primary winding. At this time, the polarity of the output winding is such that D1 is reverse biased. When S1 opens, the total stored energy is transferred to the secondary winding and current is delivered to the load. This circuit provides isolation and safety. If S1 shorts out, no voltage is generated on the secondary and the motor will not move.

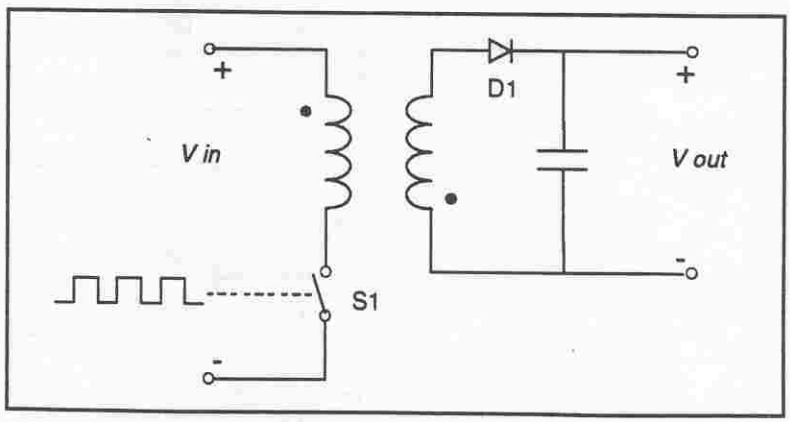


Figure 3-4
Typical Flyback Regulator Circuit

The main components of the flyback regulator circuit on the MOTHER-BOARD consist of T1, Q4, D5, C11 and U16. An analog voltage from the CPU board is input to PWM (Pulse Width Modulator) IC U16 pin 2. This IC converts a 0 to +5V analog voltage to a 0 to +10V PWM output signal on IC U16 pin 14. The PWM signal is characterized by a 100kHz frequency and a 0 to 50% duty cycle. C14 and the potentiometer R80 set the PWM frequency using the following formula:

$$f = 1/2\,(C14\,(0.7R80))$$

The potentiometer R80 (R27 on boards 800906 Rev G and earlier) is preset at the factory to generate a 100kHz frequency. The PWM output, U16 pin 14, controls FET Q4. This FET acts as the switch in the flyback regulator circuit shown in Figure 3-4. T1 transfers energy from input to output. During the FET "on" time (i.e. gate voltage = 10V), energy builds up in the core. During the FET "off" time (i.e. gate voltage = 0V), the total stored energy is transferred to the secondary winding and current is delivered to the load.

Flyback converters require a clamp to protect the FET switch from overvoltage spikes when it opens. These spikes are caused by leakage inductance in the transformer. D7, R23 and C12 form a voltage clamp which limits the voltage spikes from exceeding the BVDSS rating of Q4.

Capacitor C11 smooths out the ripple to provide a DC voltage to the motor. The motor voltage is routed through relay K1 which controls the direction of the motor movement. When the relay is off, the motor will expel; when the relay is on, the motor will fill.

Stopping

The motor can be braked by either shorting the motor leads together, shorting the output of the flyback transformer, T1, or by setting the STOP pin on U16 pin 10 high.

When the SAFE RELAY K2 is off, any voltage impressed on the motor will turn on triac Q1 which shorts the motor leads together. In order for the motor to move, therefore, it is necessary to turn the SAFE RELAY on. To turn on the SAFE RELAY it is necessary to set the SAFE RELAY CTL line (U6 pin 9) high and to toggle the watchdog fail-safe (U17 pin 11) at least once every 170 ms. This sets the fail-safe line (U6 pin 10) high.

The output of the flyback transformer is shorted by the brake circuit consisting of Q2, Q3, R20-R22. If U15 pin 16 is low the gate of Q2 is low, so it is "off". If U15 pin 16 is high the gate of Q2 is high, Q2 turns on and the output of the servo transformer is shorted. Motor current flowing through Q2 generates a voltage across R21. If excessive current flows through Q2 the voltage across R21 will rise high enough to turn on Q3. When Q3 turns on, Q2 is turned off thus preventing excessive current from damaging Q2. When the DEAD STOP signal from the CPU is high and if either SIGN or INJECT are high (but not both), U15 pin 16 is low (i.e. brake is off).

When the PWM STP STATUS line (U16 pin 10) is high the PWM output (U16 pin 14) is held low and, therefore, FET Q4 is kept off. The PWM STP STATUS line is high under the following conditions: U17 pin 11 is not toggled within 170 ms (this causes fail safe U14 pin 10 to go low), DEAD STOP is low, PRESSURE LIMIT 3 is low, either SIGN and INJECT are high, but not both.

The following table lists the signal status required to run the motor:

Signal Name	*Status Required To Run The Motor*
PWM CONTROL	> ≈ 0.5V
DEAD STOP	+5V
SIGN	0V (expel), +5V (fill)
INJECT	+5V (expel), 0V (fill)
FAILSAFE	+5V
PRESSURE LIMIT 3	+5V
SAFE RELAY CTL	+5V

Table 3-2
Motor Signals

Pressure Sensing and Control

Motor current is run through a sensing resistor which generates a voltage that is proportional to the pressure. This voltage is then amplified to a usable level and input to both the A/D located on the CPU board and a hardware pressure limit circuit located on the motherboard.

There are actually two pressure sensing circuits. One is located on the primary side of the servo transformer, T1, the second is located on the secondary side of the servo transformer. The two circuits are identical with the exception of some resistor values. The following discussion will refer to the pressure sensing circuit on the secondary side of T1.

When the motor is running, current flows through R19. The voltage developed across R19 is amplified by two separate operational amplifier circuits. The first circuit consists of U9, R33 and R36. The output of U9 pin 1 is input to the A/D, U16 pin 2, located on the CPU board and into one side of a comparator, U10 pin 4. The output of the comparator is input to the CPU board. The second circuit consists of U9, R31 and R35. The output of U9 pin 7 is input to one side of a comparator, U10 pin 6. The output of this comparator is input to the PWM control circuitry. This circuit is referred to as the hardware pressure limit control.

The other inputs of the comparators, Level 1 and Level 2, in these two circuits are set to a level corresponding to the current pressure limit value. This value is determined during pressure calibration and is set by the digital potentiometer, U8. When the pressure sensed exceeds the pressure limit value two actions occur. First the hardware pressure limit control will turn off the PWM control, thereby reducing the power output to the motor and reducing pressure. Second, the CPU board is notified through the comparator output and the A/D that a pressure limit condition has occurred.

For example, assume that the pressure limit is set to 200 psi and an injection is enabled. Assume that during pressure calibration it was determined that at 200 psi the gained up voltage level equals 1.5V. The digital potentiometer, U8, will output 1.5V to the two comparators used for pressure limit detection on the secondary side of the servo transformer, U10 pin 5 and U10 pin 7. Assume the injection starts and the pressure approaches 200 psi. When 200 psi is exceeded, the gained up voltage from the sense resistor R19 will exceed 1.5V. At this point the hardware pressure limit comparator will go low thereby disabling the PWM controller, U16. In addition, the 1.5V is sensed by the A/D on the CPU board and the comparator input to the CPU board also goes low.

The hardware pressure limit circuitry provides the primary pressure limit control with the software providing the backup pressure limit function. A circuit similar to the circuitry that provides information to the CPU board (i.e. gained up voltage level and pressure limit comparator output) from the secondary side of the servo transformer also exists on the primary side of the servo transformer. This circuitry is not currently used for pressure limit control.

Auxiliary I/O Interface

The auxiliary I/O interface provides the RS-422 interface between an external device and the CPU board. U4 pin 1 is used to translate the serial communications transmitted from the CPU board to the external device to RS-422 levels. U13 pin 3 is used to translate RS-422 serial communications from the external device to the CPU board.

An RS-232 device can be connected to this port by connecting the minus output of U4 (U4 pin 3) to the external device receive line. The auxiliary I/O connector pinout is shown in Table 3-3.

J12 Pin	*Signal Name*
1	Not Used
2	Not Used
3	RCV-
4	GND
5	TXD-

6	RCV+
7	Not Used
8	TXD+

Table 3-3
Auxiliary I/O Connector Pinout

Handswitch Interface

The handswitch interface connects the remote start handswitch to the CPU board. +12V is supplied to the handswitch connector, J1. Four identical isolated inputs are also connected to J1. Two of the isolated inputs are used for the handswitch and two are spare.

The isolated input circuit consists of a current limiting resistor (RN3) connected to the LED side of an opto-isolator (U1, U2). The output of the opto-isolator is pulled high by RN7 and input to inverter U3. The remote handswitch uses a double action switch to connect +12V to the isolated inputs. This is done as a safety feature to eliminate a single fault failure from initiating an injection. The software has to see both handswitch inputs open and then closed in order to start an injection.

The handswitch connector pinout is shown in Table 3-4.

J1 Pin	*Signal Name*
1	Spare in 2
2	+12V
3	Handswitch in 1
4	+12V
5	+12V
6	Chassis GND
7	Handswitch in 2
8	Spare in 1

Table 3-4
Handswitch Connector Pinout

Status LED's

Ten status LED's are supplied on the MOTHERBOARD. These LED's are described in Table 3-5.

LED #	NAME	LED ON	LED OFF
1	Servo Power Voltage	Servo power supply on	Servo power supply off
2	+12V	+12V supply on	+12V supply off
3	+5V	+5V supply on	+5V supply off
4	Dead Stop	PWM stop off	PWM stop on
5	Brake	Brake is on	Brake is off
6	Pressure Limit 1	No pressure limit	Pressure limit
7	Direction	Motor moving forward (expel)	Motor moving reverse (fill)
8	Safe Relay	Safe relay is off	Safe relay is on
9	Pressure Limit 3	No pressure limit	Pressure limit
10	Pressure Limit 2	No pressure limit	Pressure limit

Table 3-5
Motherboard Status LED's

Mother Board BUS Connectors

The 64-pin EuroDIN connectors that make up the Motherboard bus (J6, J7, J8, K11, K10, K9) are designed to provide 3 identical slots for plug-in boards (i.e. CPU board). The 3 slots are configured as follows:

Slot	Configuration
1	J6, K11
2	J7, K10
3	J8, K9

Table 3-6
Mother Board Slot Configuration

Several pins on these connectors are used for CPU control of the Motherboard. Refer to the CPU board Theory of Operation for a complete listing of these pins.

Console Connectors

The DB-15 connectors for the two consoles are located on the MOTHER-BOARD. These connectors are connected straight through to the CPU board. Filtering (EF3-EF6) is provided on the transmit lines. The console cable pinout is shown in Table 3-7.

J3 & J4 Pin	*Signal Name*
1	Chassis GND
2	HALT+
3	HALT-
4	TXD+
5	TXD-
6	Not Used
7	RCV+
8	RCV-
9	REMOTE ON/OFF
10	Chassis GND
11	Chassis GND
12	+VDC
13	+VDC
14	GND
15	GND

Table 3-7
LCD Module Interface Connector

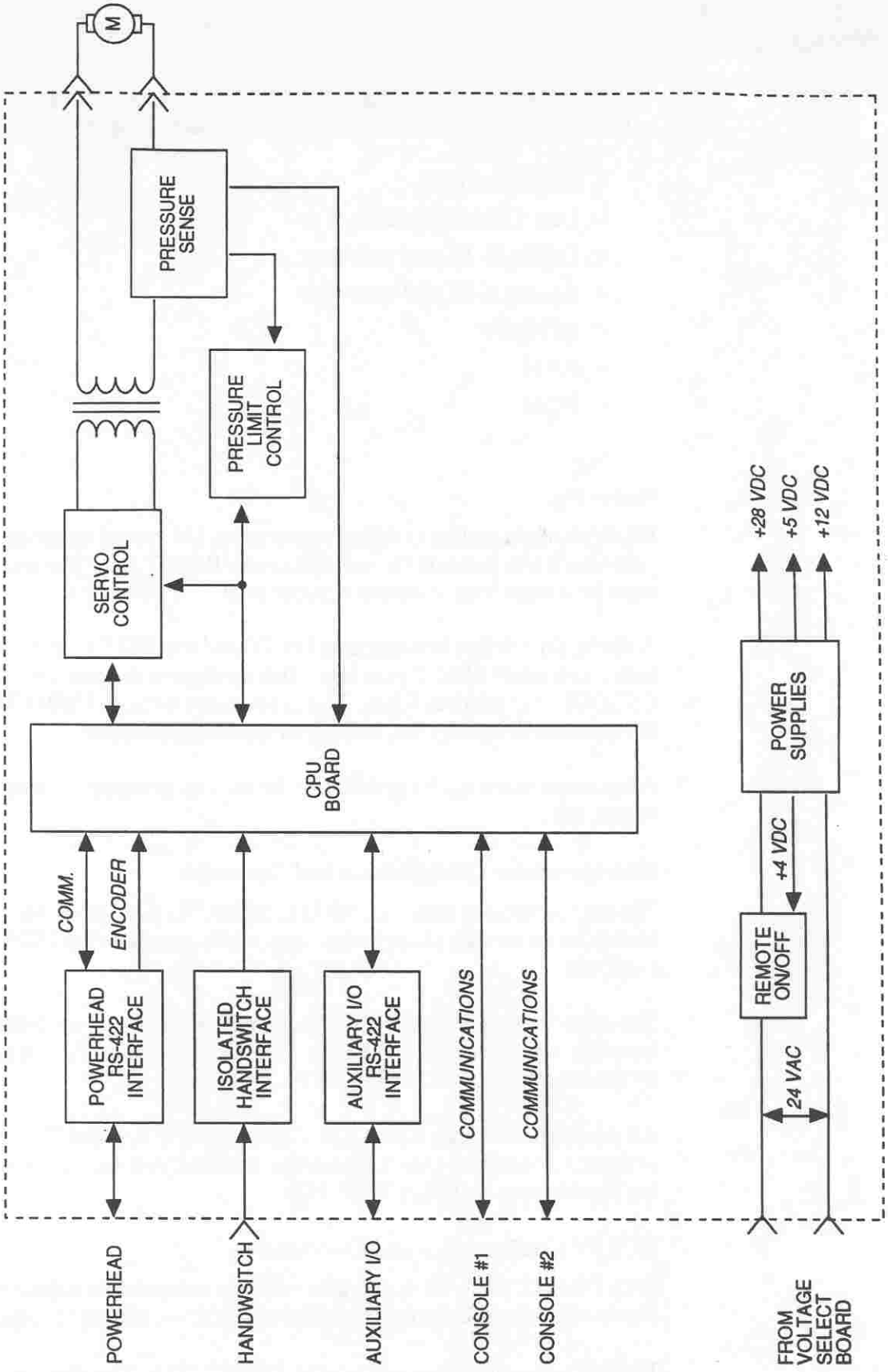


Figure 3-5
Motherboard Block Diagram

CPU BOARD

The CPU board consists of the following major components, each of which will be discussed in greater detail in the following sections:

- Microcontroller
- Data Communications
- Digital to Analog converter
- Analog to Digital converter
- EEPROM
- RAM
- ROM

Power Up

When power is applied to the microprocessor, U4, a reset controller, U8, generates a low pulse on the microprocessor RESET line. The reset pulse must be at least 35µs to ensure a proper reset.

A diode, D19, is tied between data line D0 and the RESET pin so that D0 is pulled low when RESET goes low. This configures the port size of the CSBOOT chip select to 8 bits. This is necessary because CSBOOT is connected to an EPROM, U10, that has an 8-bit wide data bus.

After initial power up the system may be reset by pressing the reset push-button, PB1.

Microprocessor Configuration and Operation

The microprocessor uses a 32.768 kHz crystal, X1 as a reference frequency source for an on-chip phase-locked loop which generates the 16.76 MHz clock speed.

The 16 external data lines (D0-D15) are buffered by two 8-bit 3-state non-inverting bus transceivers (U2, U3). The direction of data flow is controlled by the unbuffered R/W line U4 pin 79.

All the chip select lines (CSBOOT-CS10), the R/W line and 17 of the 19 external address lines (A0-A16) are also buffered by 8-bit 3-state non-inverting bus transceivers (U1, U5, U6, U7).

DUART Configuration and Operation

Each DUART (U13, U14) provides two fully independent full duplex asynchronous communications channels, six input lines, and eight outputs lines.

The following discussion will refer to DUART U14. The clock input is supplied by buffering the X1/CLK pin of DUART U13 with a 74HC14, U9. The six input lines are connected to a dip switch, SW1. Pull ups R7-R11 are provided so that the input is high if the switch is open and low if the switch is

closed. Four of the eight output lines (OP1, OP3-OP5) are used to control LED's. A high on these outputs will drive the output of the 74LS05, U11, low, thereby pulling current through the current limiting resistors, R13-R16, and the LED's, LED1-LED4. Output OP6 provides on/off control for the RS-422 line driver, U20. Output OP7 provides on/off control for the RS-422 line receiver, U19. LED1-LED4 are for programming and are not used for data during normal operation.

The interrupt line for DUART U14 is connected to IRQ5 on the microprocessor and the chip select is connected to CS8 on the microprocessor.

The transmit outputs of U14 are connected to a 34C87, U20 pin 9 and 15, which is a quad RS-422 line driver. The outputs of each driver has a 10Ω series resistor and an EMI filter on each differential output. As mentioned above, on/off control for this chip is provided by OP6. The receive inputs are connected to a 34C86, U19 pin 3 and 5, which is a quad RS-422 line receiver. A 220Ω resistor is placed across the differential inputs. As mentioned above, on/off control for this chip is provided by OP7.

The following discussion will refer to DUART U13. All 6 input lines (IP0-IP5) all 8 output lines (OP0-OP7) and both pairs of receive and transmit lines are output to connector K1, K9, K10, K11.

A 3.6864 MHz crystal (X2) is used by U13 to generate standard bit rates.

The interrupt line for DUART U13 is connected to IRQ6 on the microprocessor and the chip select is connected to CS6 on the microprocessor.

Auxiliary RS-422 Inputs

Two line receivers U19 pins 1 and 13 are used both as inputs to a microprocessor I/O pin and as input to IRQ7, the non-maskable interrupt. The output of the two line receivers are input to an RC network—R45, C29 and R46, C30—and then to open collector inverters, U11. When the output of the line receiver goes low the RC network generates a pulse into the open collector inverter. This prevents the NMI line from bouncing and from staying low indefinitely. The output of these two open collector gates are then tied together, pulled up by RN5 and input to IRQ7.

EEPROM Operation

The EEPROM (U17) is socketed so that either an 8K x 8-bit or 32K x 8-bit EEPROM can be used. No modification is necessary to move from one size to the other.

The R/W line is inverted by U9 pin 6 to generate the EEPROM output enable (OE).

RAM Operation

The RAM (U15) is socketed so that it can handle any JEDEC standard 32K x 8-bit, 64K x 8-bit or 128K x 8-bit RAM. The socket will be 32-pin to accommodate the 128K x 8-bit device. If a smaller (28-pin) RAM is used it should

use the lower portion of the socket (i.e. pin 1 of the device = pin 3 of the socket). Note that the chip select line is tied to the output enable line, which means that the outputs will be enabled for both reads and writes. However, during a write operation, the output enable is a "don't care" input.

EPROM Operation

Any JEDEC standard 64K x 8-bit or 128K x 8-bit EPROM may be used in the sockets occupied by U10 and U12. The CPU system will boot from EPROM U10. Therefore, if only one EPROM is used, it must be placed in U10.

Digital to Analog Converter Operation

U18 is the Digital to Analog Converter (DAC) chip. It is a 12-bit DAC with a full 12-bit interface to the microprocessor.

An RC network (R37, C21, C9) is connected to the REFOUT pin in order to provide decoupling for the internal voltage reference.

The DAC uses a +12 V supply. This is the only chip on the CPU board that uses +12 V. The output range is jumper configurable as 0 to +5 V or 0 to +10 V. It is hardwired for 0 to +5 V. The output code is natural binary with 1 LSB defined as follows:

For 0 V to +10 V Range: $1\ LSB = V_{REF}(1/2048) = 2.44\ mV$

For 0 V to +5 V Range: $1\ LSB = V_{REF}(1/4096) = 1.22\ mV$

Analog to Digital Converter Operation

U16 is the Analog to Digital Converter (ADC) chip. It is an 8-channel, 8-bit ADC. The microprocessor uses the Serial Peripheral Interface (SPI) bus to communicate with the DAC.

The input range is 0 to +5 V. The inputs are protected by 4.7 kΩ resistors (R24-R30, R36).

The output code is natural binary with 1 LSB defined as follows:

$$1\ LSB = FS/256 = (5/256)V = 19.5\ mV$$

A conversion is started when the microprocessor reads one of the eight channels. When the INT line goes low an interrupt is generated on microprocessor IRQ3. Another read of the same channel will contain valid conversion data.

Jumpers and LED's

Jumpers and LED's are for Liebel-Flarsheim testing use only.

Hardware Summary

Table 3-8 contains a summary of the hardware connections for the significant integrated circuits on the CT 9000 CPU board.

U#	Description	Data Lines	Address Lines	Chip Select	IRQ
10	EPROM-Prog.	DB8-DB15	A0-A16	BOOT	-
12	EPROM-Lang.	DB8-DB15	A0-A16	10	-
13	UART	DB8-DB15	A0-A3	6	6
14	UART	DB8-DB15	A0-A3	8	5
15	RAM	DB8-DB15	A0-A16	9	-
16	ADC	-	-	-	3
17	EEPROM	DB8-DB15	A0-A14	3	-
18	DAC	DB0-DB11	-	5	-

Table 3-8
CT 9000 CPU Board Hardware Summary

Input/Output Definition

There are 128 signal lines contained on the two Euro-DIN connectors that connect the CPU board to the Motherboard. The following table describes those signals:

Pin #	Signal	CPU Board Description	Motherboard Usage
J1A	BD0	Buffered data bus line 0	Not used
J1C	BD1	Buffered data bus line 1	Not used
J2A	BD2	Buffered data bus line 2	Not used
J2C	BD3	Buffered data bus line 3	Not used
J3A	BD4	Buffered data bus line 4	Not used
J3C	BD5	Buffered data bus line 5	Not used
J4A	BD6	Buffered data bus line 6	Not used
J4C	BD7	Buffered data bus line 7	Not used
J5A	BD8	Buffered data bus line 8	Not used
J5C	BD9	Buffered data bus line 9	Not used

Pin #	Signal	CPU Board Description	Motherboard Usage
J6A	BD10	Buffered data bus line 10	Not used
J6C	BD11	Buffered data bus line 11	Not used
J7A	BD12	Buffered data bus line 12	Not used
J7C	BD13	Buffered data bus line 13	Not used
J8A	BD14	Buffered data bus line 14	Not used
J8C	BD15	Buffered data bus line 15	Not used
J9A	RESET	MC68332 reset	Not used
J9C	Not used	Not used	Not used
J10A	TPU2	TPU Channel 2	Motor Channel A Encoder
J10C	TPU3	TPU Channel 3	Safe Relay Status
J11A	TPU4	TPU Channel 4	Handswitch Start 1
J11C	TPU5	TPU Channel 5	Handswitch Start 2
J12A	TPU6	TPU Channel 6	Handswitch Spare 2
J12C	TPU7	TPU Channel 7	Handswitch Spare 1
J13A	TPU8	TPU Channel 8	Motor Channel B Encoder
J13C	TPU9	TPU Channel 9	Motor Channel A Encoder
J14A	Not used	Not used	Not used
J14C	TPU10	TPU Channel 10	Motor Direction
J15A	TPU11	TPU Channel 11	Pressure Limit 3
J15C	Not used	Not used	Not used
J16A	Not used	Not used	Not used
J16C	TPU12	TPU Channel 12	Inject Lamp Control
J17A	TPU13	TPU Channel 13	Pressure Limit 2
J17C	TPU14	TPU Channel 14	Safe Relay Control
J18A	TPU15	TPU Channel 15	Reverse Enable
J18C	TXD	Not used	MC68332 Transmit
J19A	RXD	Not used	MC68332 Receive
J19C	PCS2	SPI Chip Select 2	Not used
J20A	PCS1	SPI Chip Select 1	Not used
J20C	PCS3	SPI Chip Select 3	Not used

Pin #	Signal	CPU Board Description	Motherboard Usage
J21A	PCS0	SPI Chip Select 0	Not used
J21C	SCK	SPI Serial Clock	Not used
J22A	MOSI	SPI Master Out Slave In data	Not used
J22C	MISO	SPI Master In Slave Out data	Not used
J23A	BA18	Buffered Address Line 18	Not used
J23C	BA17	Buffered Address Line 17	Not used
J24A	BA0	Buffered Address Line 0	Not used
J24C	BA1	Buffered Address Line 1	Not used
J25A	BA2	Buffered Address Line 2	Not used
J25C	BA3	Buffered Address Line 3	Not used
J26A	BA4	Buffered Address Line 4	Not used
J26C	BA5	Buffered Address Line 5	Not used
J27A	BA6	Buffered Address Line 6	Not used
J27C	BA7	Buffered Address Line 7	Not used
J28A	BA8	Buffered Address Line 8	Not used
J28C	BA9	Buffered Address Line 9	Not used
J29A	BA10	Buffered Address Line 10	Not used
J29C	BA11	Buffered Address Line 11	Not used
J30A	BA12	Buffered Address Line 12	Not used
J30C	BA13	Buffered Address Line 13	Not used
J31A	BA14	Buffered Address Line 14	Not used
J31C	BA15	Buffered Address Line 15	Not used
J32A	R/W	Buffered Read/Write line	Not used
J32C	BA16	Buffered Address Line 16	Not used
K1A	IRQ3	MC68332 Interrupt Request 3	Not used
K1C	RMC	MC68332 Read Modify Write Cycle	Not used
K2A	Not used	Not used	Not used
K2C	DSACK1	Data and Size Acknowledge 1	Direction Status

Pin #	Signal	CPU Board Description	Motherboard Usage
K3A	CS0	MC68332 Chip Select 0	Not used
K3C	DSACK2	Data and Size Acknowledge 2	Pressure Limit 1
K4A	DS	Data Strobe	Not used
K4C	AS	Address Strobe	Not used
K5A	SIZ0	Size 0	Brake Status
K5C	SIZ1	Size 1	Not used
K6A	IRQ1	MC68332 Interrupt Request 1	Not used
K6C	IRQ2	MC68332 Interrupt Request 2	Not used
K7A	IRQ4	MC68332 Interrupt Request 4	Not used
K7C	IRQ7	MC68332 Interrupt Request 7 (NMI)	Power Fail
K8A	IP2-1	Input 2 on U13	Not used
K8C	IP5-1	Input 5 on U13	Not used
K9A	RXDA	Receive Channel A on U13	Auxiliary I/O Receive
K9C	TXDA	Transmit Channel A on U13	Auxiliary I/O Transmit
K10A	OP0-1	Output 0 on U13	Dead Stop
K10C	OP2-1	Output 2 on U13	Sign
K11A	OP4-1	Output 4 on U13	Not used
K11C	OP6-1	Output 6 on U13	Not used
K12A	OP7-1	Output 7 on U13	Not used
K12C	OP5-1	Output 5 on U13	Not used
K13A	OP3-1	Output 3 on U13	Watchdog
K13C	OP1-1	Output 1 on U13	Enable Lamp Control
K14A	TXDB	Transmit Channel B on U13	Power Head Transmit
K14C	RXDB	Receive Channel B on U13	Power Head Receive
K15A	IP4-1	Input 4 on U13	Not used
K15C	IP1-1	Input 1 on U13	Not used
K16A	IP0-1	Input 0 on U13	PWM Stop Status
K16C	IP3-1	Input 3 on U13	Not used
K17A	OP2-2	Output 2 on U14	Not used
K17C	OP0-2	Output 0 on U14	Not used

Pin #	Signal	CPU Board Description	Motherboard Usage
K18A	CH1	A/D Channel 1	Pressure Limit 1 A/D Channel
K18C	CH2	A/D Channel 2	Pressure Limit 2 A/D Channel
K19A	CH3	A/D Channel 3	+12VDC Status A/D Channel
K19C	CH4	A/D Channel 4	Digital Pot. Level 1 A/D Channel
K20A	CH5	A/D Channel 5	Digital Pot. Level 2 A/D Channel
K20C	CH6	A/D Channel 6	Not used
K21A	CH7	A/D Channel 7	Not used
K21C	D/A1	D/A Channel 1	PWM Control
K22A	HLT2-	NMI 2 -	Console 2 Halt -
K22C	HLT2+	NMI 2 +	Console 2 Halt +
K23A	HLT1+	NMI 1 +	Console 1 Halt +
K23C	HLT1-	NMI 1 -	Console 1 Halt -
K24A	RXD2-	Receive Channel B- on U14	Console 2 Receive-
K24C	RXD2+	Receive Channel B+ on U14	Console 2 Receive+
K25A	RXD1-	Receive Channel A- on U14	Console 1 Receive-
K25C	RXD1+	Receive Channel A+ on U14	Console 1 Receive+
K26A	TXD2-	Transmit Channel B- on U14	Console 2 Transmit-
K26C	TXD2+	Transmit Channel B+ on U14	Console 2 Transmit+
K27A	TXD1-	Transmit Channel A- on U14	Console 1 Transmit-
K27C	TXD1+	Transmit Channel A+ on U14	Console 1 Transmit+
K28A	+12VDC	+12VDC Power	+12VDC Power
K28C	+12VDC	+12VDC Power	+12VDC Power
K29A	GND	Logic GND	Logic GND
K29C	GND	Logic GND	Logic GND
K30A	+5VDC	+5VDC Power	+5VDC Power
K30C	+5VDC	+5VDC Power	+5VDC Power
K31A	CS2	MC68332 Chip Select 2	Not used
K31C	CS3	MC68332 Chip Select 3	Not used
K32A	CS1	MC68332 Chip Select 1	Not used
K32C	CS4	MC68332 Chip Select 4	Not used

Table 3-9
CT 9000 CPU Board to Motherboard Connections

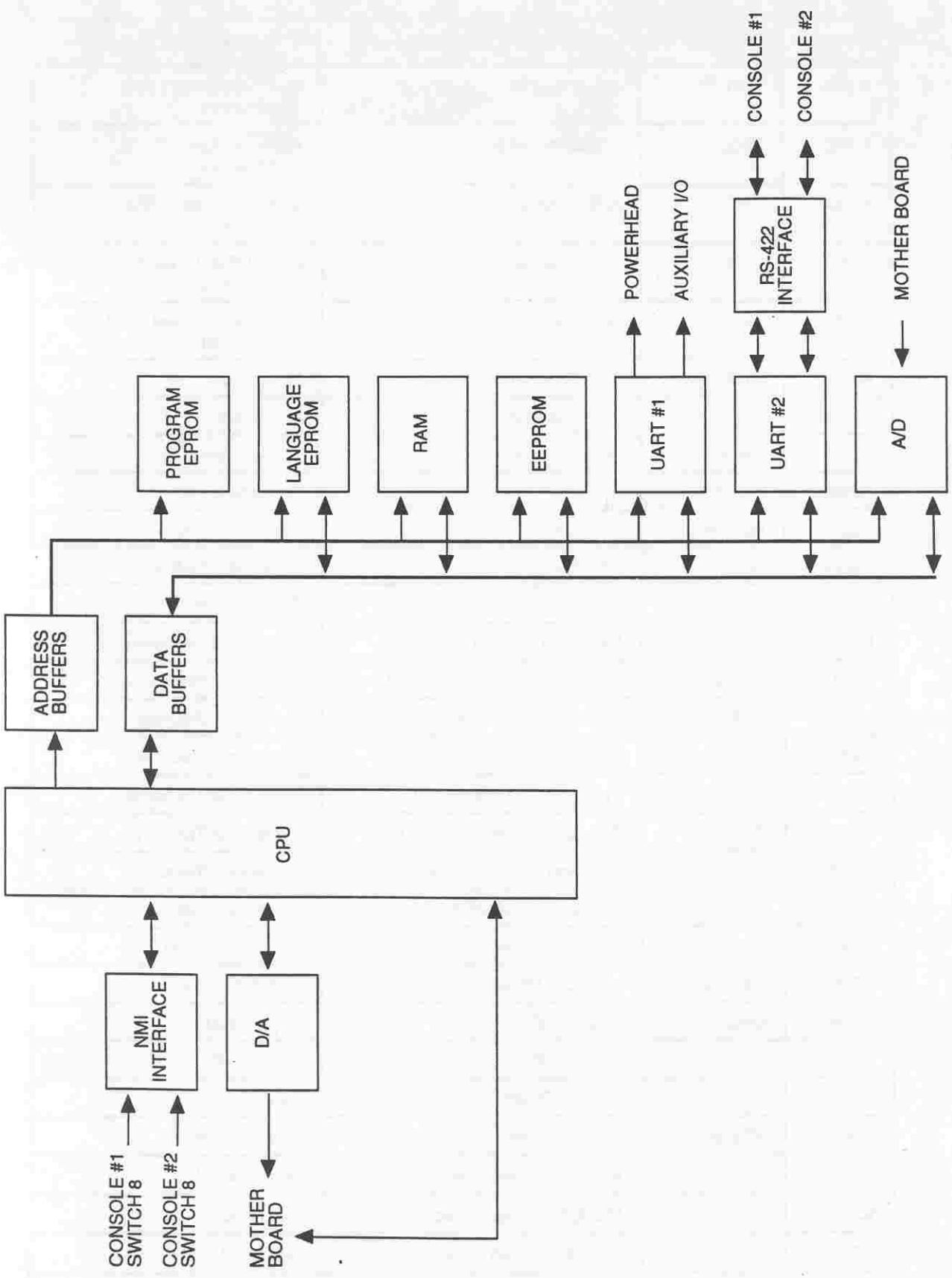


Figure 3-6
CPU Block Diagram

CONSOLE OVERVIEW

The console consists of four major functional sections. First is the MAIN CONSOLE board, second is the VIEWING ANGLE board, third is the KEYBOARD and fourth is the DISPLAY. Figure 3-7 shows a block diagram of these sections.

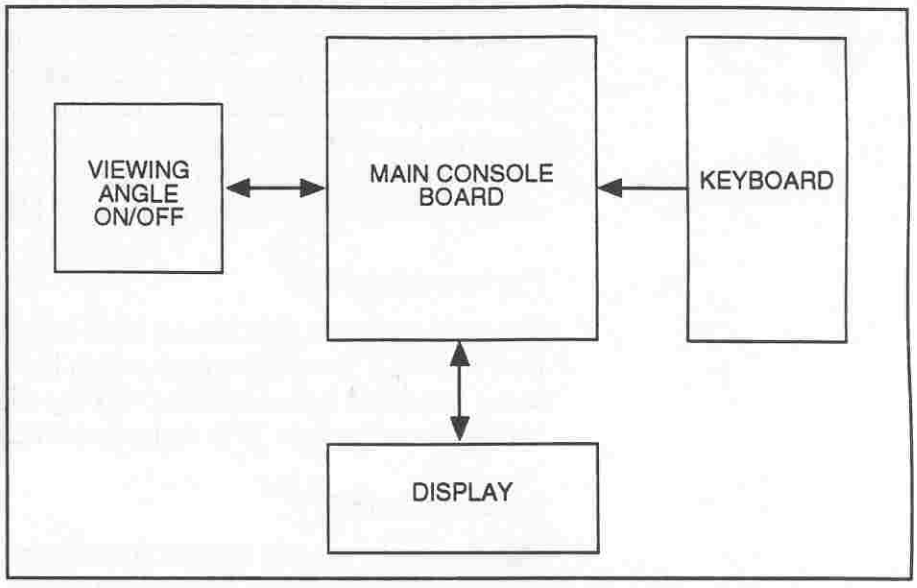


Figure 3-7
Console Overview

MAIN CONSOLE BOARD

The main console board consists of the following major components, each of which will be discussed in greater detail in the following sections:

- Power Supplies
- Keyboard Interface
- Speaker Control
- CPU
- Display Controller

Power Supplies

There are four power supplies on the main console board: +5V, +12V, -15V and 600VAC.

With the exception of a small filter inductor, L3, added to the input of the regulators, the +5V and +12V supplies are identical to the +5V and +12V supplies on the MOTHERBOARD. Refer to the MOTHERBOARD theory of operation for a complete discussion of these circuits. +12V is used to power the speaker and the inverter used to generate the voltage for the cold cathode fluorescent tubes used to backlight the display. The +5V is used to power all remaining circuitry on the main console board.

Inverter INV-1 is used to convert +12V to the 600VAC needed for the cold cathode fluorescent tubes used to backlight the display. The inverter is turned on and off by the CPU. A high signal placed on U26 pin11 is inverted twice by U26 and turns on FET Q1. This provides a ground path for the primary side of the inverter. A low signal on U26 pin11 turns the inverter off by opening the primary side ground path.

Switching regulator U23 is configured as a buck regulator to generate an adjustable negative voltage supply. This supply is used to control the viewing angle of the LCD. The voltage can range from -12V to -18V. Transistor Q4 is used to limit the top range of the viewing angle voltage input. Transistor Q2 chops the input D.C. voltage into a square wave. This square wave is then converted into a negative D.C. voltage by L4, D12 and C22. Capacitor C10 is used to set the switching frequency to 40 kHz.

Keyboard Interface

The eight keyboard switches are input to a buffer, U28, through series resistors, R40-R47. In addition each switch line is pulled up to +5V by R32-R39, and is prevented from exceeding +5V by diodes D3-D10. The output of the buffer is input to eight TPU channels of U22 (MC68332).

Speaker Control

One side of the console speaker is connected to +12V the other side is connected to the collector of transistor Q3. The base of Q3 is driven by one side of an RS-422 driver, U10. The frequency and duration of the base drive is controlled by U22 (MC68332) using one of the TPU channels. A capacitor, C33, is placed across the speaker to prevent damage from high voltage spikes.

Console CPU

The Console CPU consists of the following major components, each of which will be discussed in greater detail in the following sections:

- Microcontroller
- Battery Backed RAM
- RAM
- ROM

Power Up

When power is applied to the microprocessor, U22, a reset controller, U27 generates a low pulse on the microprocessor RESET line. The reset pulse must be at least 35µs to ensure a proper reset.

A diode, D11, is tied between data line D0 and the RESET pin so that D0 is pulled low when RESET goes low. This configures the port size of the CSBOOT chip select to 8 bits. This is necessary because CSBOOT is connected to an EPROM, U16 that has an 8-bit wide data bus.

Microprocessor Configuration and Operation

The microprocessor uses a 32.768 kHz crystal, X4, as a reference frequency source for an on-chip phase-locked loop which generates the 16.76 MHz clock speed.

The 16 external data lines (D0-D15) are buffered by two 8-bit 3-state non-inverting bus transceivers (U18, U19). The buffered data lines are used only by the LCD controller, U11. The LCD controller determines the bus transceiver direction.

Sixteen address lines (A0-A15) are also buffered by 8-bit 3-state non-inverting bus transceivers (U20, U21) and are input to the LCD controller.

Battery Backed RAM

The DS1386, U13, is a self-contained real time clock with 8K by 8-bits of battery backed RAM. It contains an embedded lithium energy source and a quartz crystal which eliminates the need for any external circuitry. Data contained within the 8K by 8-bit memory can be read or written in the same manner as static RAM. U13 is used as the upper 8 bits of a 16-bit wide RAM address range.

RAM Operation

The Static RAM, U12, is socketed so that it can handle any JEDEC standard 32K x 8-bit RAM. Timing constraints require that the RAM speed be 100ns or faster. Note that the chip select line is tied to the output enable line, which means that the outputs will be enabled for both reads and writes. However, during a write operation, the output enable is a "don't care" input. U12 is used as the lower 8-bits of a 16-bit wide RAM address range.

EPROM Operation

Any JEDEC standard 32K x 8-bit EPROM may be used for the two EPROM, U14 and U16. Timing constraints require that the EPROM speed be 55ns or faster. The CPU system will boot from EPROM U16 as this contains the main console program. EPROM U14 contains the fonts and must also be present.

U#	Description	Data Lines	Address Lines	Chip Select	IRQ
11	LCD Controller	PD0-PD15	A0-A18	6-10	7
12	RAM	PD0-PD7	A1-A15	1	
13	Battery Backed RAM	PD8-PD15	A1-A15	2	1, 2
14	EPROM	PD8-PD15	A0-A14	4	
15	EPROM	PD8-PD15	A0-A14	3	
16	EPROM	PD8-PD15	A0-A14	BOOT	

Table 3-10
Hardware Summary

Display Controller

The display controller consists of an 82C455 flat panel VGA controller, U11, eight 64K x 4 DRAMS, U1-U8, and three oscillators, X1-X3.

The CPU transmits information to the display controller, U11. Flip-flop U25 is used to delay the display controller READY line for two MC68332 clock cycles so that the display controller can be read correctly by the MC68332. The display controller is responsible for generating the 4-bit wide video data stream used to refresh the display. In addition, the display controller generates all the sync and timing signals for the display and also generates the multiplexed row and column addresses used for both display refresh and CPU access of display memory.

The display controller supports a total of 256 Kbytes of display memory. The display controller serves as a DRAM controller for the systems display memory, U1-U8. It handles DRAM refresh, fetches data from display memory as required to refresh the screen, interfaces the CPU to display memory, and supplies all necessary DRAM control signals. The display memory is arranged as four planes of 64 Kbytes each. Each plane is made up of two 64K x 4 DRAMS as follows:

Plane 0 U6, U8
Plane 1 U5, U7
Plane 2 U1, U3
Plane 3 U2, U4

Oscillators X1 and X3 are used for internal display controller functions. Oscillator X2 is used to generate the dot clock which updates the LCD pixels.

VIEWING ANGLE BOARD

The VIEWING ANGLE board connects a potentiometer to the negative voltage supply on the main console board. This potentiometer adjusts the negative voltage which controls the LCD viewing angle. In addition, the remote on/off switch is connected to the board and is passed straight through to the main console board.

KEYBOARD

The keyboard consists of an 8 x 1 matrix. A conductive rubber keyboard is attached to the keyboard. Each key contains 6 conductive pads any one of which will short the key when pressed.

The console power LED is also connected to the keyboard.

DISPLAY

The display is a 640 x 480 triple super twisted nematic Liquid Crystal Display (LCD). Two cold cathode fluorescent tubes are used for backlighting.

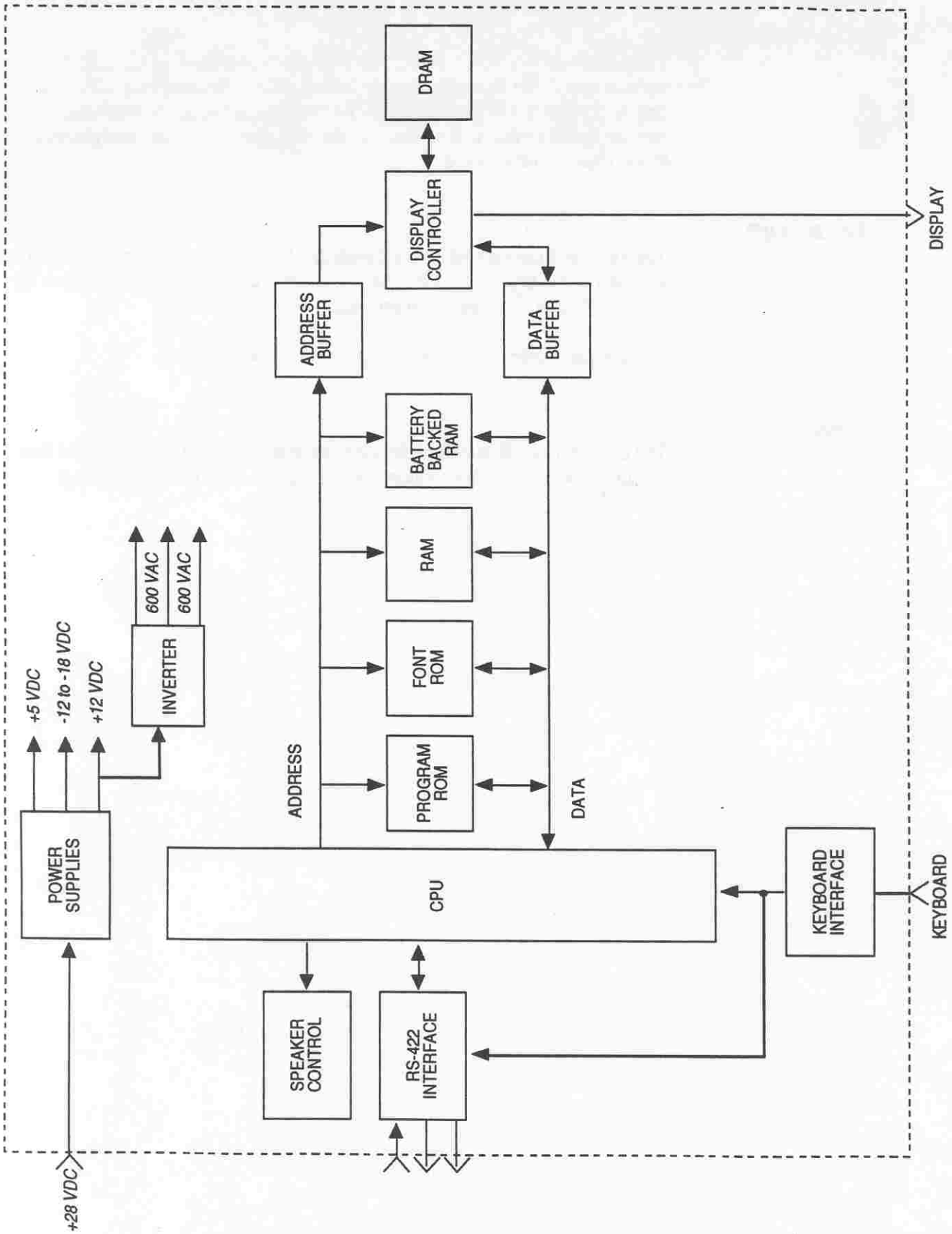


Figure 3-8
Console Block Diagram

POWERHEAD OVERVIEW

The powerhead holds the syringe and plunger, and contains an electric motor, gear train, and ballscrew to drive the plunger forward and reverse. An encoder mounted to the motor shaft and a linear potentiometer mounted to the ballscrew provide feedback to the Power Pack about the actual velocity and position of the plunger.

The major functions of the powerhead are shown in Figure 3-9. These major functions are described below:

- To drive the syringe plunger the head transforms electrical power into rotary motion with a motor, then into linear motion with a ballscrew assembly.
- To keep track of the plunger's velocity and position, the head contains two feedback devices: a linear potentiometer mounted to the ballscrew and an optical encoder mounted to the motor shaft.
- A heater blanket maintains the temperature of the fluid in the syringe through a temperature controlling circuit.
- Push-buttons allow the operator to move the plunger forward or reverse for loading or expelling. A knob encoder provides feedback to the powerhead CPU which informs the Power Pack that a slow plunger movement is requested.
- The head contains sensors which detect syringe size and face plate position.
- Lamps are provided which indicate when the injector is enabled, when it is injecting and when a fault has occurred.
- A small circuit board containing two LED's is attached to the ballscrew and can be seen through a clear scale containing index marks for both 125 and 200 ml syringes.

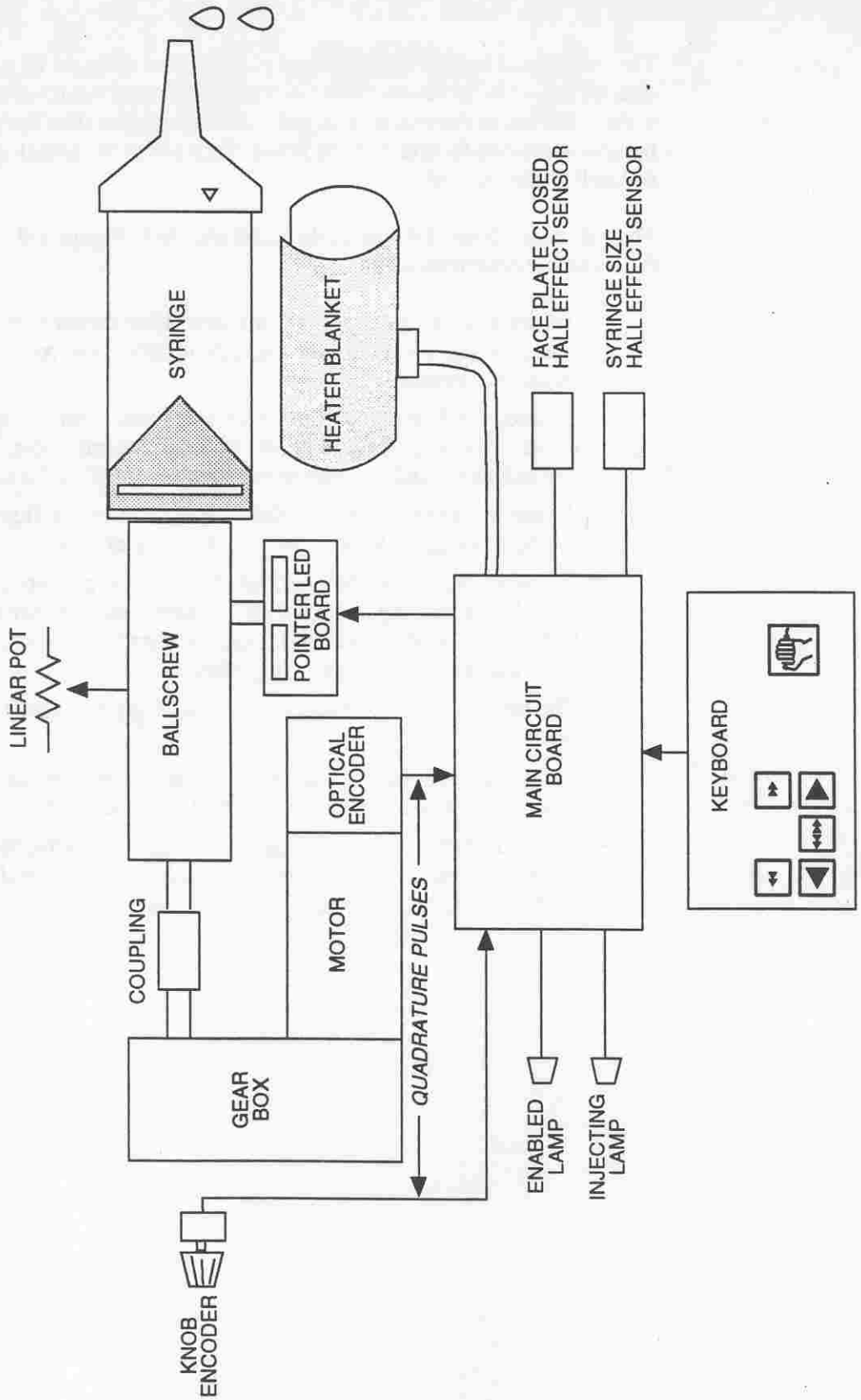


Figure 3-9
Powerhead Functional Diagram

MAIN POWERHEAD BOARD

The main powerhead board consists of the following major components, each of which will be discussed in greater detail in the following sections:

- Microcontroller
- Heater blanket controller
- RS-422 interface
- Keyboard and sensor interface
- Power Supplies
- Knob Encoder interface
- Lamp interface
- Motor interface
- Status LEDs

The Power Pack provides a female DB-25 connector which connects to the male end of the powerhead cable. Table 3-11 contains the connector pinout and signal description for the DB-25 connector. The female end of the cable connects to a male DB-25 connector located on the powerhead circuit board.

Pin	*Signal Name*	*Signal Description*
1	CHGND	Chassis GND
2	MOTPWR-	Motor power
3	MOTPWR-	Motor power
4	MOTPWR-	Motor power
5	MOTPWR+	Motor power
6	MOTPWR+	Motor power
7	MOTPWR+	Motor power
8	GND	Signal GND
9	GND	Signal GND
10	GND	Signal GND
11	CHGND	Chassis GND
12	CHGND	Chassis GND
13	TXD+	Head data transmit +
14	+12V	Logic power
15	+12V	Logic power

16	+12V	Logic power
17	ENCTRL	ENABLED lamp control
18	INJCTRL	INJECTING lamp control
19	RCV+	Head data receive +
20	RCV-	Head data receive -
21	ENCB-	Motor encoder phase B -
22	ENCA-	Motor encoder phase A -
23	ENCA+	Motor encoder phase A +
24	ENCB+	Motor encoder phase B +
25	TXD-	Head data transmit -

Table 3-11
Powerhead DB-25 Pin Designations

MICROCONTROLLER

The microcontroller, U1, is an MC68HC11E2. The powerhead software is stored inside the microcontrollers EEPROM. The microprocessor uses a 4.9152 MHz crystal, X1, to generate the system clock. This value was chosen to provide accurate baud rate times. A power up reset and low voltage detect circuit is implemented using U6, R7 and C4.

HEATER BLANKET CONTROL

The heater blanket is powered by the +12VDC supplied by the Power Pack. In order for the +12VDC to be applied to the heater blanket element, the microprocessor must turn on relay K2 and transistor Q1.

Two thermistors located in the heater blanket provide temperature feedback to the microcontroller. When the injector first turns on, the microcontroller outputs a high duty cycle PWM signal to Q1. As the desired heater blanket temperature is reached the microcontroller will decrease the PWM duty cycle. When the heater blanket temperature falls below the desired temperature the microcontroller will increase the PWM duty cycle.

RS-422 INTERFACE

The two motor encoder channels and the microcontroller communications transmit line are input to an RS-422 transmitter, U3 pin 9 and 15. These signals are then transmitted to the Power Pack. In addition, the RS-422 communications data transmitted from the Power Pack to the powerhead are converted by the RS-422 receiver U5 pin 3.

KEYBOARD AND SENSOR INTERFACE

The keyboard contains six normally open switches: fill, expel, start/pause and three fast switches. The three "fast" switches are electrically tied together. One side of each switch is connected to an input port on the microcontroller. Each of these lines is pulled up by a resistor, RN-1. The other side of the switches are tied to ground. Therefore, a high voltage on the input port indicates the switch is open. A low voltage on the input port indicates the switch is closed.

There are two hall effect sensors connected to the powerhead circuit board. The first sensor is connected to J1 and indicates if the face plate is closed. If the line connecting the sensor to the microcontroller is high, the face plate is not closed. If it is low, the face plate is closed. The second sensor connected to J12 determines the syringe size. If the line connecting the sensor to the microcontroller is high, it indicates a 200 ml syringe. If it is low, it indicates a 125 ml syringe.

POWER SUPPLIES

The Power Pack supplies +12VDC to the powerhead. A voltage regulator, VR2, is used to generate +5VDC. An adjustable voltage regulator, VR1, is used to generate reference voltages for the linear potentiometer AR1 and the microcontroller's A/D. VR1's output voltage is set as follows:

$$Vout = 1.25V\ (1 + R2/R3) = 1.25V(1 + 866/243) = 5.7V$$

This voltage is used to power the linear potentiometer. Since the linear potentiometer does not utilize its entire range of motion, using 5.7V allows the potentiometer to maximize the dynamic range of the microcontrollers A/D.

In addition, since the linear potentiometer does not travel fully to its opposite limit (i.e. 0V), a voltage divider circuit consisting of R1, R4 and R18, is used to generate reference voltages for the microcontrollers A/D. This divider circuit produces a usable range of approximately 4.84V (Vrh) to 1.23V (Vrl). This corresponds to the range of the linear potentiometer using the 5.7V supply. By using the linear potentiometer supply to generate the A/D reference voltages the two devices will track each other in case of voltage fluctuations.

KNOB ENCODER INTERFACE

The knob encoder located on the rear of the powerhead generates quadrature encoder pulses back to the powerhead circuit board. A flip-flop, U4, is used to determine knob direction. The output of the flip-flop, U4-6, is input to the microcontroller and the direction information is transmitted to the Power Pack. A high on U4-6 indicates clockwise knob movement. A low on U4-6 indicates counterclockwise knob movement.

The microcontroller uses one encoder channel to measure the time between the pulses and then transmits this information to the Power Pack.

LAMP INTERFACE

The enabled and injecting lamp are powered by the power pack. The powerhead board simply passes the control signals from the powerhead connector to the lamp connector J4.

MOTOR INTERFACE

The motor power is passed through a normally open relay, K1, before being connected to the motor via J5. When open, the relay shorts the two motor leads together providing dynamic braking of the motor. When closed, the relay simply passes the two motor lines supplied by the Power Pack to the motor. K1 is energized by the microcontroller whenever the motor should move.

A snubber circuit, SN1, is connected across the motor leads for noise suppression.

STATUS LEDS

There are six status LEDs used on the powerhead. The meaning of each is shown below:

LED #	*Description*	*ON*	*OFF*
1	+5 VDC	+5 VDC	0 V
2	+5.7 VDC	+5.7 VDC	0 V
3	Not used	-	-
4	Not used	-	-
5	Knob Encoder Direction	Fill	Expel
6	Motor Encoder Direction	Expel	Fill

Table 3-12
Status LED's

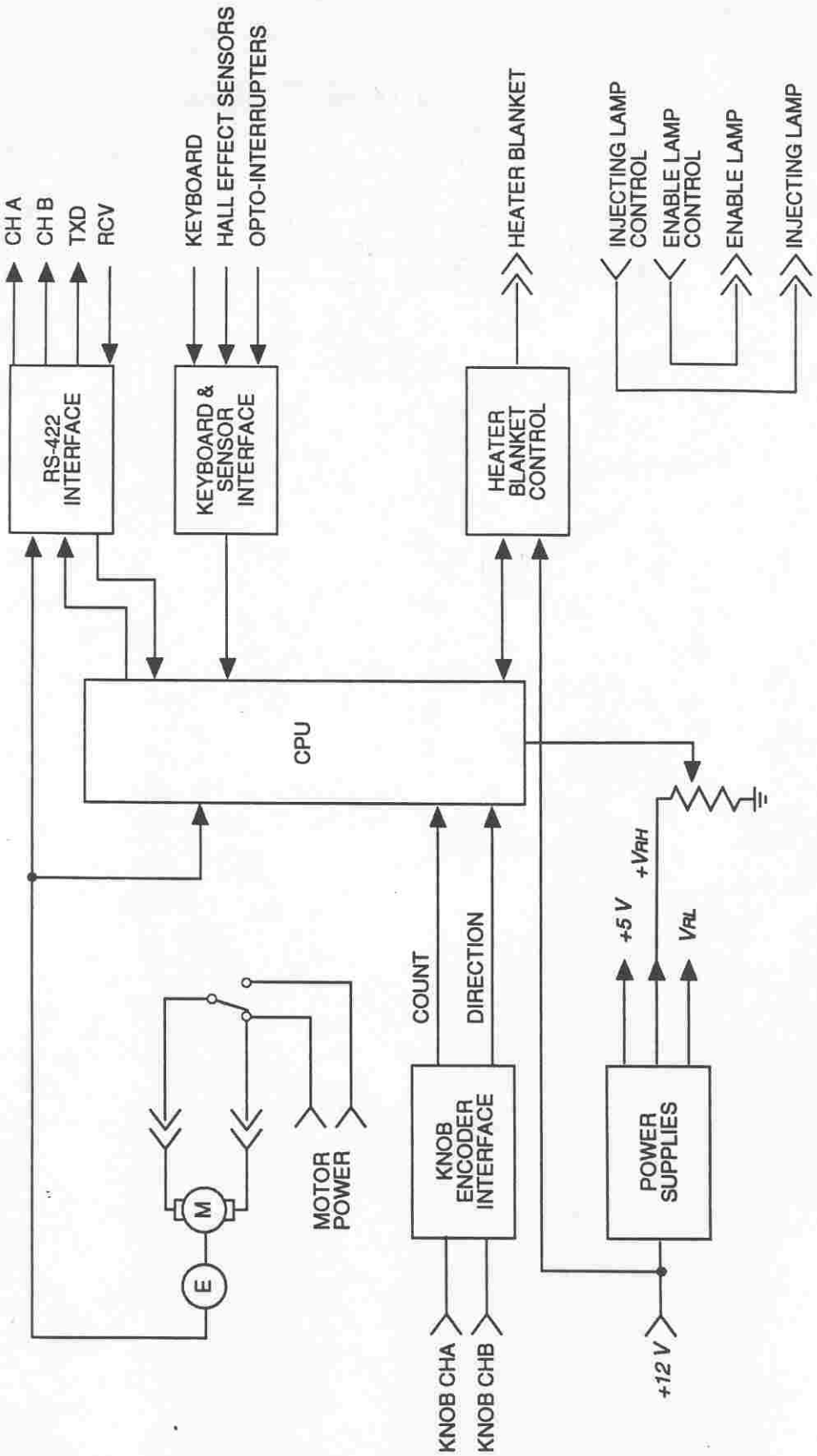
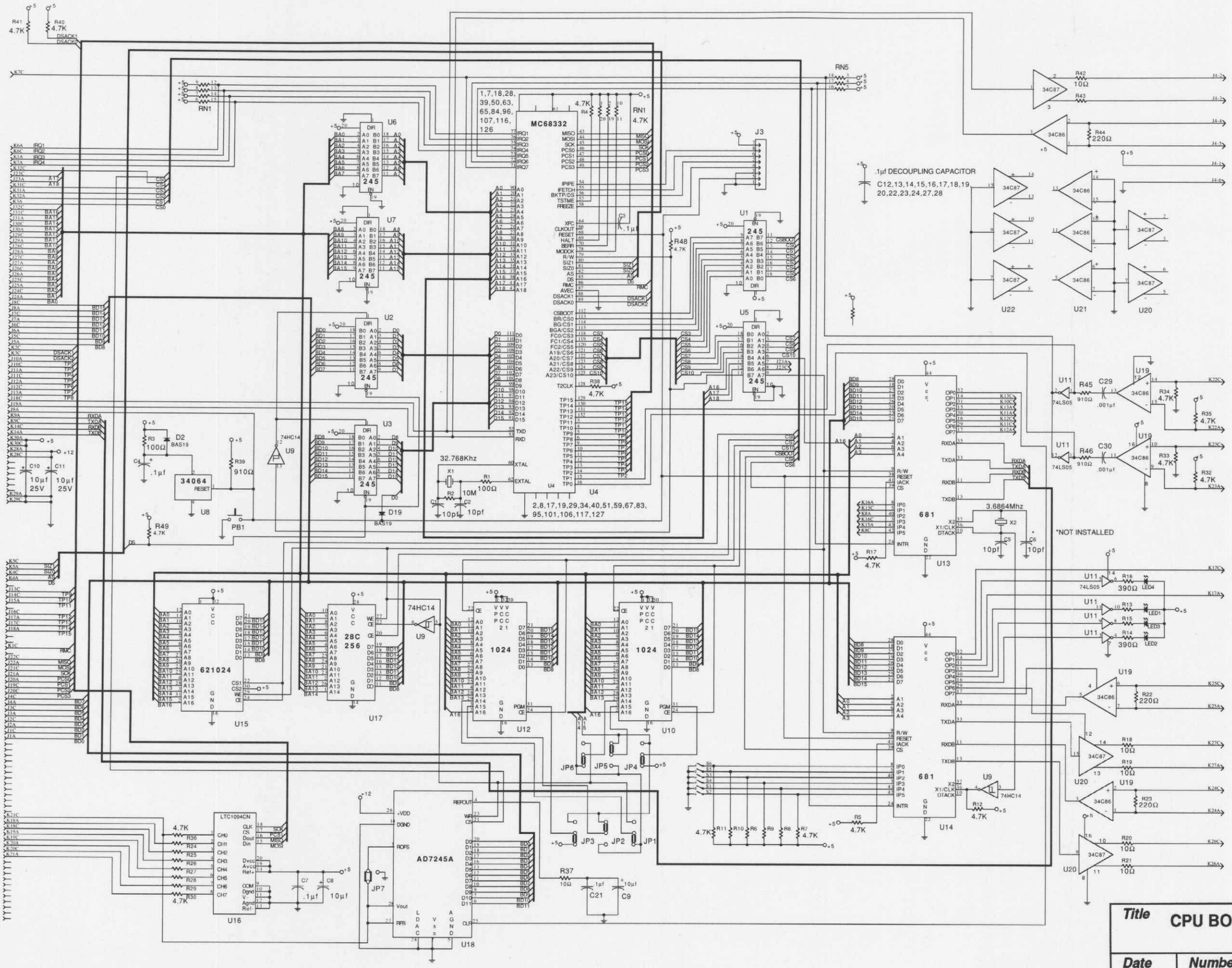


Figure 3-10
Powerhead Block Diagram

SCHEMATICS

Schematics for the CT 9000 include the following:



Title	CPU BOARD	
Date	Number 800902	Rev

J CONNECTOR	
PIN	SIGNAL
1A	BD0
1C	BD1
2A	BD2
2C	BD3
3A	BD4
3C	BD5
4A	BD6
4C	BD7
5A	BD8
5C	BD9
6A	BD10
6C	BD11
7A	BD12
7C	BD13
8A	BD14
8C	BD15
9A	RESET
9C	
10A	TPU2
10C	TPU3
11A	TPU4
11C	TPU5
12A	TPU6
12C	TPU7
13A	TPU8
13C	TPU9
14A	
14C	TPU10
15A	TPU11
15C	
16A	
16C	TPU12
17A	TPU13
17C	TPU14
18A	TPU15
18C	TXD
19A	RXD
19C	PCS2
20A	PCS1
20C	PCS3
21A	PCS0
21C	SCK
22A	MOSI
22C	MISO
23A	A18
23C	A17
24A	BA0
24C	BA1
25A	BA2
25C	BA3
26A	BA4
26C	BA5
27A	BA6
27C	BA7
28A	BA8
28C	BA9
29A	BA10
29C	BA11
30A	BA12
30C	BA13
31A	BA14
31C	BA15
32A	R/W
32C	BA16

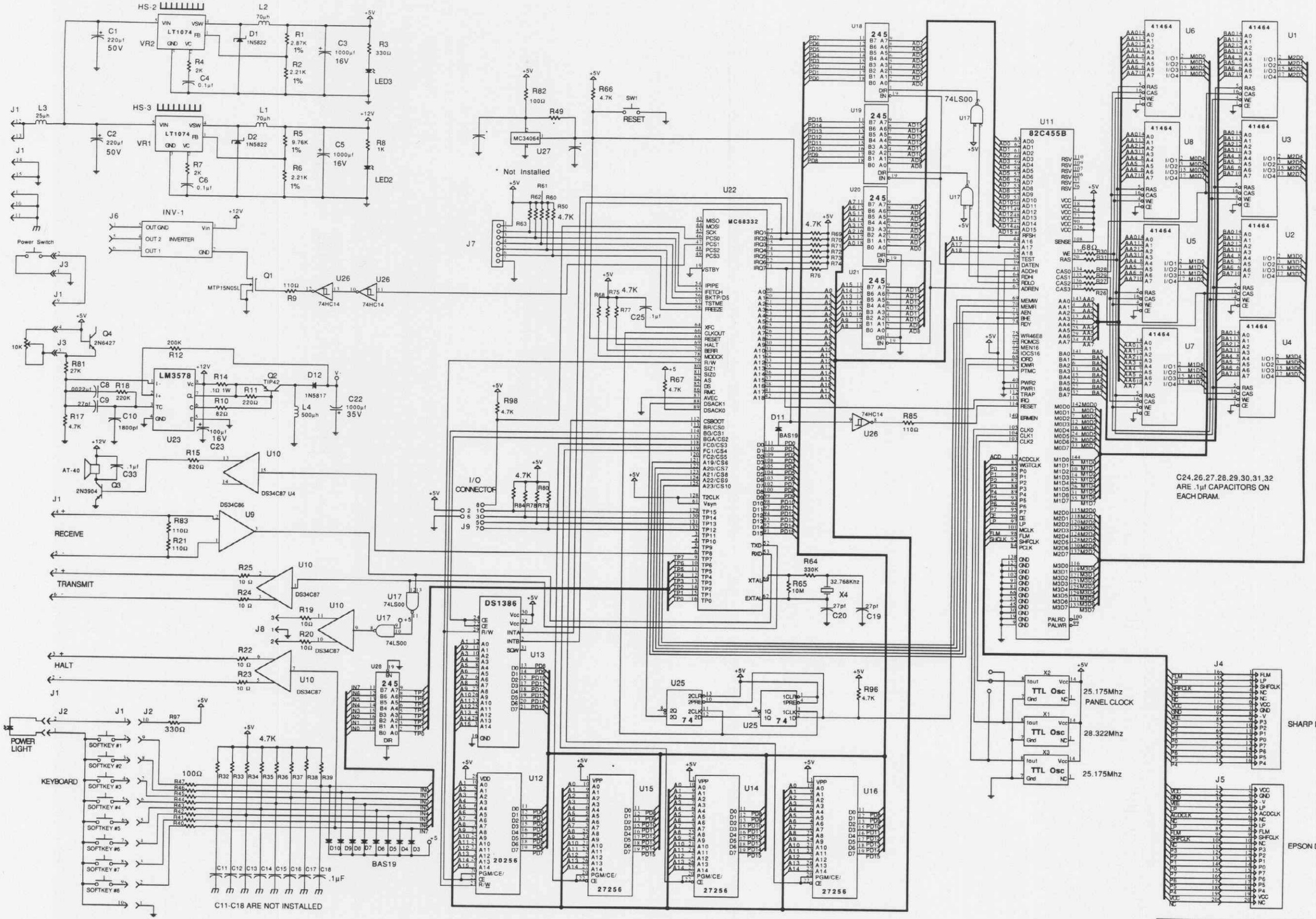
K CONNECTOR	
PIN	SIGNAL
1C	IRQ3
2A	RMC
2C	DSACK1
3A	
3C	DSACK2
4A	DS
4C	AS
5A	SIZ0
5C	SIX1
6A	IRQ1
6C	IRQ2
7A	IRQ4
7C	IRQ7
8A	TP2-1
8C	TP5-1
9A	TXDA
9C	TXDB
10A	OP0-1
10C	OP2-1
11A	OP4-1
11C	OP6-1
12A	OP7-1
12C	OP5-1
13A	OP3-1
13C	OP1-1
14A	TXDB
14C	RXDB
15A	TP4-1
15C	TP1-1
16A	TP0-1
16C	TP3-1
17A	OP2-2
17C	OP0-2
18A	CH1
18C	CH2
19A	CH3
19C	CH4
20A	CH5
20C	CH6
21A	CH7
21C	CH8
22A	NMI2-
22C	NMI2+
23A	NMI1+
23C	NMI1-
24A	RXDB-
24C	RXDB+
25A	RXDA-
25C	RXDA+
26A	TXDB-
26C	TXDB+
27A	TXDA-
27C	TXDA+
28A	+12V
28C	+12V
29A	GND
29C	GND
30A	+5V
30C	+5V
31A	CS2
31C	CS3
32A	CS1
32C	CS4

LED FUNCTION TABLE		
LED #	ON	OFF
1	+SERVO VDC	NO POWER
2	+12VDC	NO POWER
3	+5VDC	NO POWER
4	PWM STOP OFF	PWM STOP ON
5	BRAKE ON	BRAKE OFF
6	NO PRESS. LIMIT	PRESS. LIMIT
7	EXPELL	FILL
8	SAFE RELAY OFF	SAFE RELAY ON
9	NO PRESS. LIMIT	PRESS. LIMIT
10	NO PRESS. LIMIT	PRESS. LIMIT

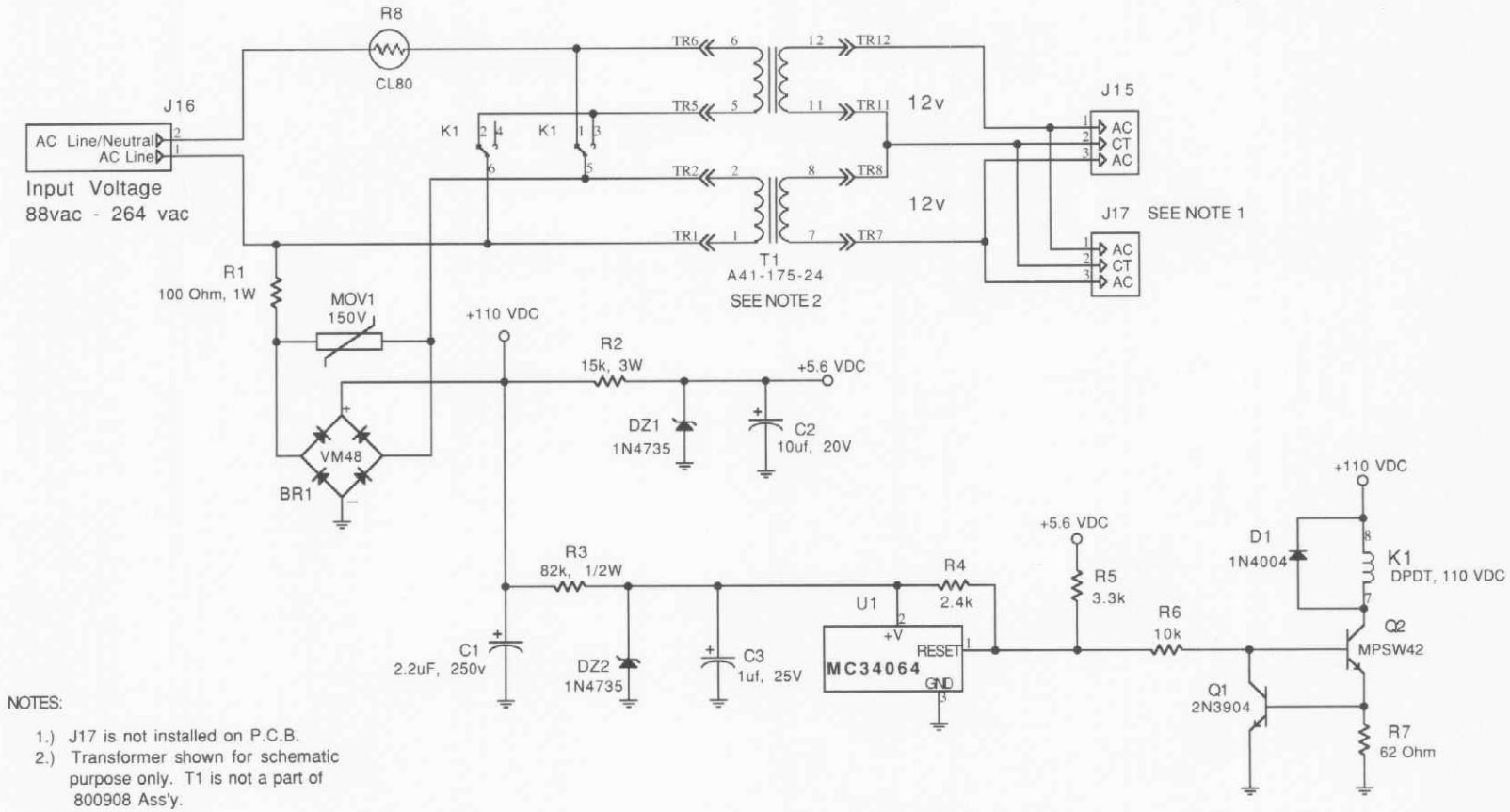
* U20 IS NOT INSTALLED LS7081

* NOT INSTALLED

Title	MOTHER BOARD	
Date	Number 800906	Rev



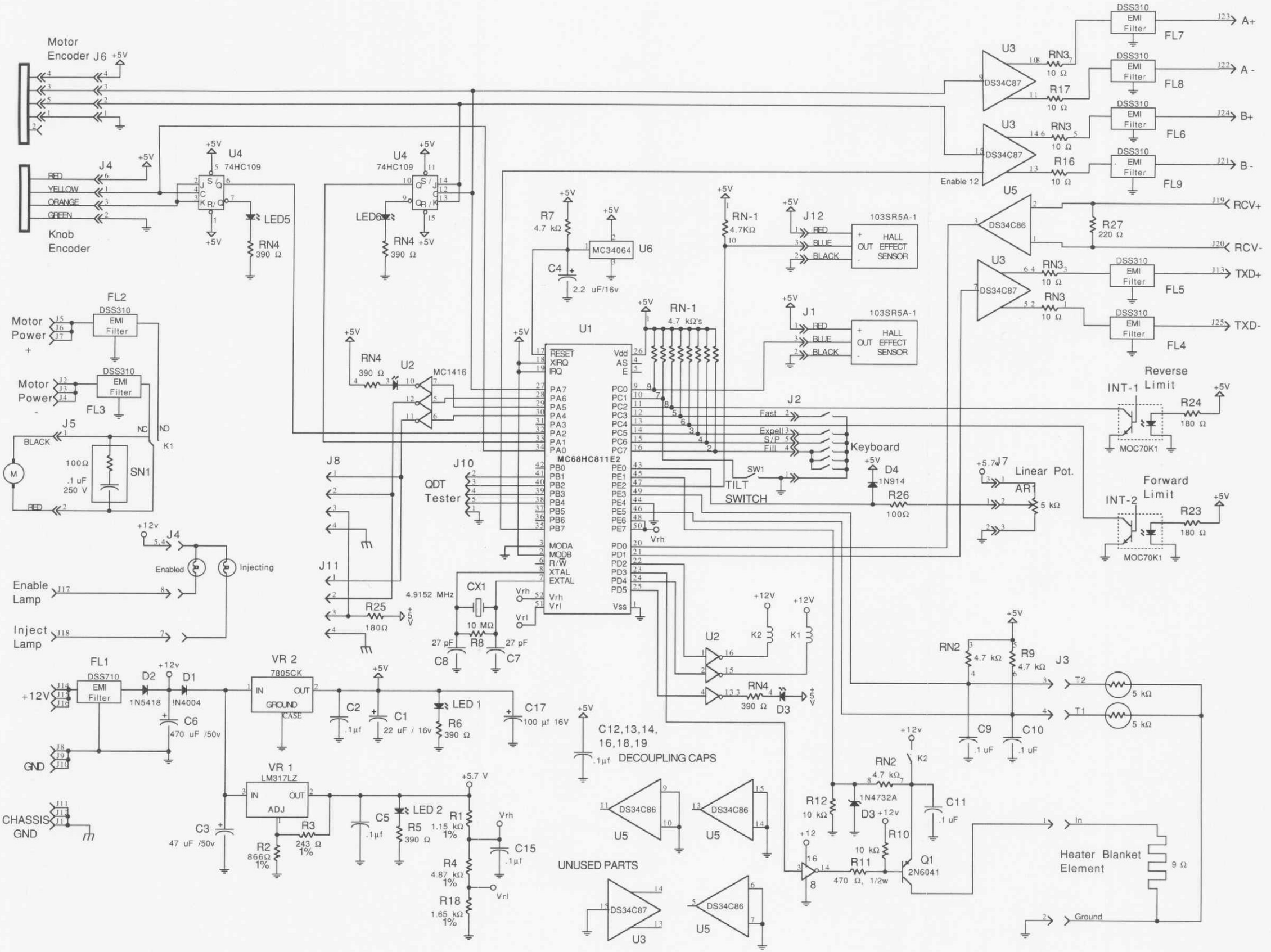
Title	**CONSOLE BOARD**	
Date	**Number** 800907	**Rev**



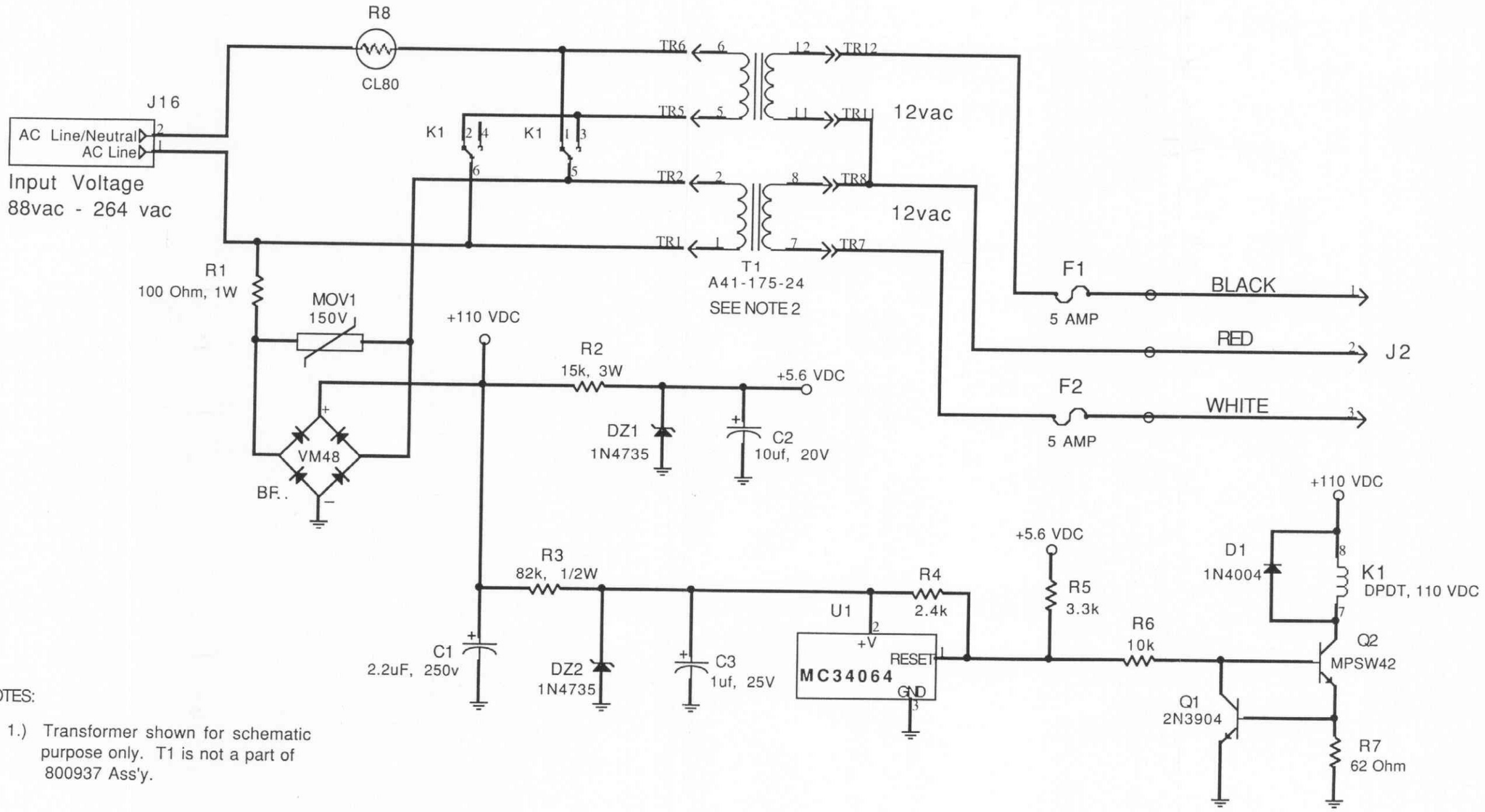
NOTES:

1.) J17 is not installed on P.C.B.
2.) Transformer shown for schematic purpose only. T1 is not a part of 800908 Ass'y.

Title	VOLTAGE SELECT BOARD	
Date	Number 800908	Rev



Title	HEAD BOARD	
Date	Number 800909	Rev



NOTES:

1.) Transformer shown for schematic purpose only. T1 is not a part of 800937 Ass'y.

Title	VOLTAGE SELECT	
Date	Number 800937	Rev

4 TROUBLESHOOTING

This chapter includes descriptions of the Error and Fault Messages of the CT 9000. Refer to the Parts Section of this Manual for exploded drawings of the Power Pack (i.e. Electronics Cabinet), Powerhead, and Console in order to obtain a thorough understanding of disassembling these components. Critical dimensions for re-assembly of the Powerhead are included at the end of this chapter.

DANGER! SHOCK HAZARD!
Be extremely careful when the CT 9000 is open. Lethal voltages are exposed. Be careful not to leave an open system unattended with power plugged. in. DISCONNECT THE POWER CORD BEFORE DISASSEMBLING THE SYSTEM, AND BEFORE REMOVING OR REPLACING BOARDS.

ERROR AND FAULT MESSAGES

The CT 9000 generates messages in response to operator input and the monitoring of equipment status. These messages fall into two general categories:

Error Messages—Those messages that appear in response to incorrect operator input.

Fault Messages—Those messages that appear when the CT 9000's self-diagnostics detect a problem in the control circuitry.

With a few noted exceptions, the Error Messages can be corrected by the operator.

ERROR MESSAGES

INJECTION WAS PRESSURE LIMITED

Occurs when: The required pressure to deliver protocol exceeds the Pressure Limit value or when an obstruction is present in the line or catheter.

Operator Action: Reduce the flow rate or increase the Pressure Limit. Check for obstruction in line or catheter.

Insufficient Syringe Volume!
Press OVERRIDE to inject available volume.

Occurs when: The protocol volume is greater than the volume available in the syringe.

Operator action: Reset protocol volume to a level lower than the syringe volume or press [OVERRIDE] to use existing volume.

Invalid Injection!
Press EXIT to continue.

Occurs when: The [Enable] key is pressed when in Protocol Memory or Change Values Screen while a protocol parameter is invalid or the available syringe volume is 0.

Operator action: Press [EXIT] to return to the Protocol Memory screen or the Change Values screen and enter a valid parameter.

Lock the syringe in place.

Occurs when: The operator attempts to enable a protocol when the syringe face plate is not in the locked position or when the face plate is opened while the injector is running.

Operator action: Ensure the syringe face plate is in the Locked position. Refer to Chapter 5 for more information.

That name already exists!

Occurs when: The operator tries to enter a blank name or the name of a protocol that already exists in memory.

Operator action: Choose a new name for the protocol.

Heater thermistor tracking error.
To continue, press override. See manual for further instructions.
(See also Fault Message # 22)

Occurs when: A problem with the heater blanket has been detected.

Operator action: Press [Override], power down the unit and disconnect the heater blanket. Discontinue use of the heater blanket until serviced by a qualified Liebel-Flarsheim service technician. The CT 9000 is completely functional, however, the temperature of heated contrast cannot be maintained.

Overheating error.
To continue, press override. See manual for further instructions.
(See also Fault Message # 23)

Occurs when: A problem with the heater blanket has been detected.

Operator action: Press [Override], power down the unit and disconnect the heater blanket. Discontinue use of the heater blanket until serviced by a qualified Liebel-Flarsheim service technician. The CT 9000 is completely functional, however, the temperature of heated contrast cannot be maintained.

FAULT MESSAGES

The dual microprocessor control circuits in the CT 9000 continuously monitor all important functions from the moment that the unit is turned on. These checks, transparent to the operator, occur many times each second, monitoring the safe performance of the injector. If a fault is detected, the unit will lock into the Fault Mode and then display a Fault Message. Refer to Figures 4-1 and 4-2.
In all cases, the appearance of a Fault Message requires that the operator contact a qualified service technician to correct the problem. A listing of these Fault Messages, along with its corrective action, follows.

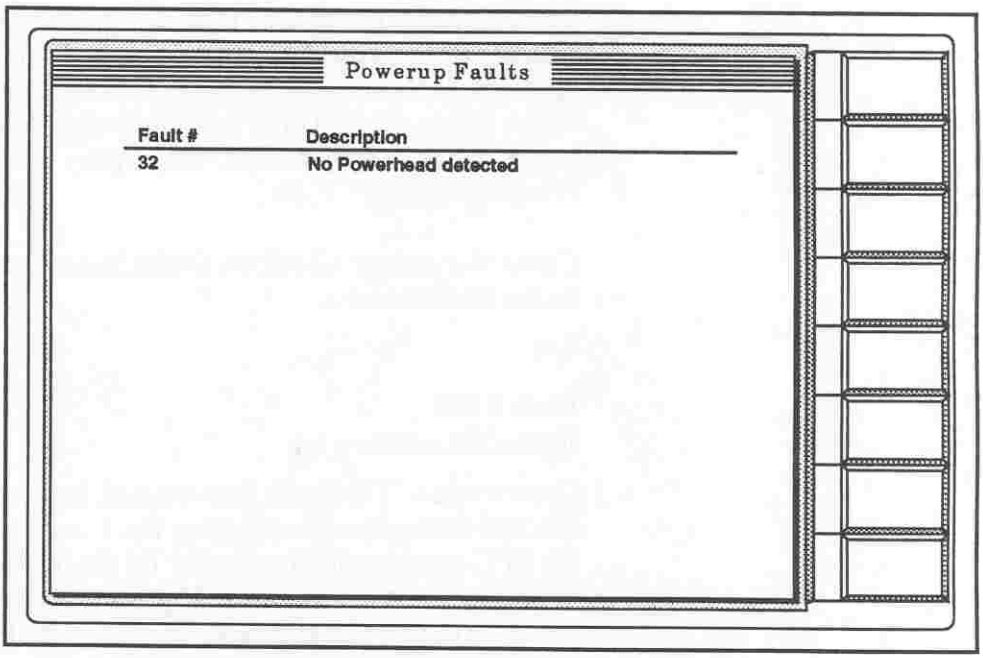


Figure 4-1
Fault Message Appearing at Powerup

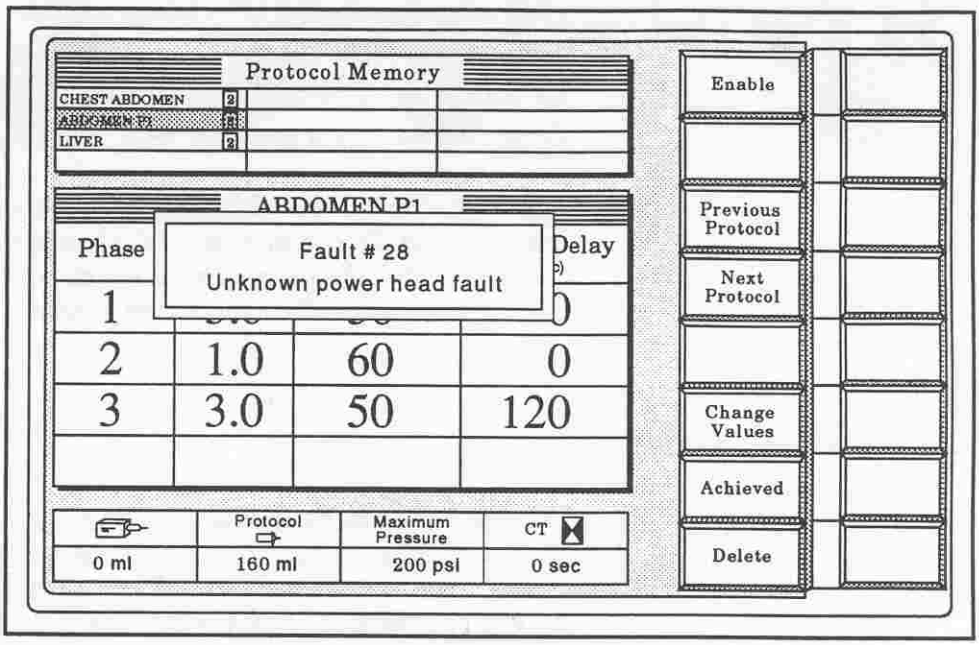


Figure 4-2
Fault Message Appearing on Protocol Memory Menu

Fault # 001
Brake did not turn off

Occurs when: The Brake Status signal, located on the Mother board, is checked during Power-up testing. Pin 1 of U6 is toggled low by the CPU causing a low output by U6 pin 3. This signal is inverted by U15 to cause the Brake Status signal U7 pin 8 to toggle high. If a problem exists to cause the output to toggle low, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check the Brake Status circuitry of U5, U6, U7 and U15 on the Mother board.

Fault # 002
Brake did not turn on

Occurs when: The Brake Status signal, located on the Mother board, is checked during Power-up testing. Pin 1 and pin 2 of U6 are toggled high by the CPU causing a high output by U6 pin 3. This signal is inverted by U15 to cause the Brake Status signal U7 pin 8 to toggle low. If a problem exists to cause the output to toggle high, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check the Brake Status circuitry of U5, U6, U7 and U15 on the Mother board.

Fault # 003
Reverse relay would not turn off

Occurs when: The Reverse Relay control signals, located on the Mother board, is checked during Power-up testing. Pin 13 and pin 12 of U6 are toggled low by the CPU, causing the output of U6 pin 11 to go low. This low signal then causes the output of U7 pin 6 to go high. If a problem exists to cause the output to stay low, the CPU will display the Fault Message at the end of Power-up testing.

Corrective action: Check chips U6, U15 and U7 on the Mother board.

Fault # 004
Reverse relay would not turn on

Occurs when: The Reverse Relay control signals, located on the Mother board, are checked during Power-up testing. Pin 13 and pin 12 of U6 are toggled high by the CPU, causing the output of U6 pin 11 to go high. This high signal then causes the output of U7 pin 6 to go low. If a problem exists to cause the output to stay high, the CPU will display the Fault Message at the end of Power-up testing.

Corrective action: Check chips U6, U15 and U7 on the Motherboard.

Fault # 005
Safe relay would not turn off

Occurs when: During Power-up testing, relay K2 on the Mother board is monitored by the CPU to ensure that it turn off. U6 pin 9 is set low by the CPU and U6 pin 10 is kept low due to the CPU not toggling U14 pin 12. If a problem exists to cause the output to toggle incorrectly, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check chips U14, U6, U15 and Relay K2 on the Mother board.

Fault # 006
Safe relay would not turn on

Occurs when: During Power-up testing, relay K2 on the Mother board is monitored by the CPU to ensure that it toggles accurately according to the inputs of U6 pin 9 and pin 10. If a problem exists to cause the output to toggle incorrectly, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check chips U14, U6, U15 and Relay K2 on the Mother board.

Fault # 009
Safe relay turned on with no failsafe

Occurs when: During Power-up testing, the safe relay failsafe is tested to ensure that it is not stuck in an unsafe state. U6 pin 9 is set high by the CPU but the failsafe (U14 pin 12) is not toggled. If the safe relay turns off the CPU, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check chips U14, U6, U15 and Relay K2 on the Mother board.

Fault # 010
PWM stop turned off with no failsafe

Occurs when: During Power-up testing, the PWM STP STATUS line (U5 pin 3) is checked to ensure that the PWM controller, U16, is not active unless the failsafe is toggled. U6 pin 1 is toggled low, causing U5 pin 2 to be low. The failsafe is not toggled, so U5 pin 1 should also be low If the output of U5 pin 3 is not high, the CPU will display the Fault message at the end of the Power-up testing.

Corrective action: Check chips U5, U6 and U14 on the Mother board.

Fault # 011
PWM D/A conflicts with A/D (5V)

Occurs when: During Power-up testing, the CPU outputs +5V on the D/A, U18 pin 3 located on the CPU board. The output value is read by the A/D, U16 pin 1 on the CPU board. Any discrepancy between the two values will cause the CPU to display the Fault message at the end of Power-up testing.

Corrective action: Check chips U16 and U18 on the CPU board and U8 on the Mother board.

Fault # 012
PWM D/A conflicts with A/D (2.5V)

Occurs when: During Power-up testing, the CPU outputs +2.5V on the D/A, U18 pin 3 located on the CPU board. The output value is read by the A/D, U16 pin 1 on the CPU board. Any discrepancy between the two values will cause the CPU to display the Fault message at the end of Power-up testing.

Corrective action: Check chips U16 and U18 on the CPU board and U8 on the Mother board.

Fault # 013
PWM D/A conflicts with A/D (0V)

Occurs when: During Power-up testing, the CPU outputs 0V on the D/A, U18 pin 3 located on the CPU board. The output value is read by the A/D, U16 pin 1 on the CPU board. Any discrepancy between the two values will cause the CPU to display the Fault message at the end of Power-up testing.

Corrective action: Check chips U16 and U18 on the CPU board and U8 on the Mother board.

Fault # 014
PWM stop would not turn off

Occurs when: During Power-up testing, the PWM STP STATUS line, U5 pin 3, is checked to ensure that the DEAD STOP line, U6 pin 1, can enable the PWM controller. U6 pin 1 is toggled high, causing U5 pin 2 to be high. The failsafe is toggled, causing U5 pin 2 to be high. If the output of U5 pin 3 is high, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check U5, U6, U14, and U16 on the Mother board.

Fault # 015
PWM stop would not turn on

Occurs when: During Power-up testing, the PWM STP STATUS line, U5 pin 3, is checked to ensure that the DEAD STOP line, U6 pin 1, can turn the PWM stop on by itself. The failsafe is toggled which causes U5 pin 1 to be high. U6 pin 1 is toggled low, causing U5 pin 2 to be low. If the output of U5 pin 3 is low, the CPU will display the Fault message at the end of Power-up testing.

Corrective action: Check U5, U6 U14, and U16 on the Mother board.

Fault # 016
Position is not calibrated

Occurs when: Calibration position parameters are stored in two addresses within chip U17 on the CPU board. During power-up testing and before an Injection is enabled, these two parameters are compared. If the parameters do not match, the Fault message will be displayed.

Corrective action: Re-calibrate the Powerhead position. If the error persists, replace chip U17 on the CPU board.

Fault # 017
Lost power head communications

Occurs when: During operation of the CT 9000, the CPU continually checks for signals from the powerhead. If a 3 second lapse occurs between receiving signals from the powerhead, the Fault message will be displayed.

Corrective action: Check the powerhead cable to ensure it is securely connected to the connectors in the rear of the powerhead and the rear of the electronics cabinet . If the Fault message continues, replace chips U13 and U14 on the Mother board and U1 on the Powerhead board.

Fault # 018
Lost console communications

Occurs when: This Fault message is only visible when two consoles are active. If this problem occurs while using a one-console system, the Fault Indicator light (the Injecting light) on the Powerhead will flash and the console keyboard will be locked-up.

Corrective action: Check the console cable to ensure it is securely connected to the connectors in the rear of the console and the rear of the electronics cabinet. If the console does not respond to these actions, replace the Console board.

Fault # 019
Flow rate error

Occurs when: The actual flow rate delivered by the syringe plunger is monitored by the CPU by using feedback from the motor encoder. When this flow rate is approximately 20% higher than the programmed flow rate, this Fault message will occur.

Corrective action: Replace chip U13 on the Mother board. If the problem persists, replace the Motor encoder.

Fault # 020
Motor moving wrong direction

Occurs when: Motor direction output from U14 pin 6 on the Mother board is incorrect. Fill syringe movement = high signal; Expel syringe movement = low signal.

Corrective action: Check to ensure J5 pins 1 and 2 on the Powerhead board are connected properly. Replace chips U14 and U13 on the Mother board.

Fault # 022
Heater thermistor tracking error

Occurs when: Heater Blanket thermistors are not at the approximate same level.

Corrective action: Replace the Heater Blanket. If the problem persists, replace U1 on the Powerhead board.

Fault # 023
Overheating error

Occurs when: If the Heater Blanket temperature is greater than 42 °C, this Fault message will be displayed.

Corrective action: Replace the Heater Blanket. If the problem persists, replace U1 on the Powerhead board.

Fault # 024
Power head communication error

Occurs when: The power pack indicates to the powerhead that the power pack communications packets are not valid.

Corrective action: Check U1 on the Powerhead board and U3 on the Mother board

Fault # 025
Power head flow rate error

Occurs when: The actual flow rate delivered by the syringe plunger is measured by the microcontroller in the powerhead. When this flow rate is approximately 25 % higher than the programmed flow rate, this Fault message will occur. This precaution acts as a backup to Fault # 19—Flow Rate Error.

Corrective action: Replace U1 on the Powerhead board.

Fault # 026
Ram past extend limit error

Occurs when: During plunger movement, the linear pot has moved past the calibrated 0 ml point.

Corrective action: Re-calibrate the position. Check the linear pot on the powerhead. Replace U1 on the Powerhead board.

Fault # 022
Heater thermistor tracking error

Occurs when: Heater Blanket thermistors are not at the approximate same level.

Corrective action: Replace the Heater Blanket. If the problem persists, replace U1 on the Powerhead board.

Fault # 023
Overheating error

Occurs when: If the Heater Blanket temperature is greater than 42 °C, this Fault message will be displayed.

Corrective action: Replace the Heater Blanket. If the problem persists, replace U1 on the Powerhead board.

Fault # 024
Power head communication error

Occurs when: The power pack indicates to the powerhead that the power pack communications packets are not valid.

Corrective action: Check U1 on the Powerhead board and U3 on the Mother board

Fault # 025
Power head flow rate error

Occurs when: The actual flow rate delivered by the syringe plunger is measured by the microcontroller in the powerhead. When this flow rate is approximately 25 % higher than the programmed flow rate, this Fault message will occur. This precaution acts as a backup to Fault # 19—Flow Rate Error.

Corrective action: Replace U1 on the Powerhead board.

Fault # 026
Ram past extend limit error

Occurs when: During plunger movement, the linear pot has moved past the calibrated 0 ml point.

Corrective action: Re-calibrate the position. Check the linear pot on the powerhead. Replace U1 on the Powerhead board.

Fault # 027
Ram past retract limit error

Occurs when: During plunger movement, the linear pot has moved past the calibrated 125/200 ml point.

Corrective action: Re-calibrate the position. Check the linear pot on the powerhead. Replace U1 on the Powerhead board.

Fault # 028
Unknown power head fault

Occurs when: The powerhead transmits garbled information to the power pack.

Corrective action: Replace the receiver U13 on the Mother board or the transmitter U3 on the Powerhead board.

Fault # 029
Pressure is not calibrated

Occurs when: Calibration pressure parameters are stored in two addresses within chip U17 on the CPU board. During power-up testing and before an Injection is enabled, these two parameters are compared. If the parameters do not match, the Fault message will be displayed.

Corrective action: Re-calibrate the Powerhead pressure. If the error persists, replace chip U17 on the CPU board.

Fault # 030
Illegal state transition

Occurs when: The software has inadvertently moved into an erroneous state.

Corrective action: Cycle power to correct problem. If this problem persists, replace chips U10, U12, and U15 (RAM and ROM) on the CPU board.

Fault # 031
Bad power head communications

Occurs when: The power pack detects a number of invalid communications packets from the powerhead.

Corrective action: Replace U13 on the Mother board and/or U3 on the Powerhead board.

Fault # 032
No power head detected

Occurs when: During Power-up tests, the CPU checks for signals from the powerhead. If signals are not found, the Fault message will be displayed.

Corrective action: Check the powerhead cable to ensure it is securely connected to the connectors in the rear of the powerhead and the rear of the electronics cabinet . If the Fault message continues, replace chips U13 and U14 of the Mother board and U1 of the Powerhead board.

Fault # 033
Bad EEPROM detected on CPU Board

Occurs when: During Power-up testing, the CPU performs a Write function to the EEPROM, chip U17. If this cannot be completed, the CPU displays the Fault message at the end of Power-up testing.

Corrective action: Replace the EEPROM U17 on the CPU board.

Fault # 035
Software error

Occurs when: A Power-up Fault message is called to be displayed when no Power-up Faults have been detected by the CPU.

Corrective action: Cycle power to correct problem. If this problem persists, replace chips U10 and U12 on the CPU board.

Fault # 036
RAM test failed

Occurs when: This Fault message will be displayed when the RAM R/W test performed by the CPU during Power-up testing has failed.

Corrective action: Replace the RAM chip U15.

Fault # 037
ROM test failed

Occurs when: This Fault message will be displayed when the EPROM (U10) Cyclic Redundancy Check (CRC) has failed.

Corrective action: Replace U10.

Fault # 038
No encoder counts detected

Occurs when: This Fault message will be display when the encoder counts are not being detected by the CPU even though a voltage is being delivered to the motor.

Corrective action: Check the motor, connector J5 on the powerhead and Fuse 2 on the Mother board.

Fault # 039
Linear pot. tracking error

Occurs when: This Fault message will be displayed when the linear pot position on the RAM does not match the motor encoder position.

Corrective action: Ensure the linear pot is connected securely to J7 and that the wiper on the linear pot is attached to the ball screw.

Fault # 041
Overvolume error detected

Occurs when: This Fault message will by displayed when the volume delivered exceeds programmed volume by 2 ml.

Corrective action: Re-calibrate position. If the problem persists, check the brake circuitry on the Mother board consisting of U15, Q2, and Q3.

Fault # 042
Console key closed on powerup

Occurs when: During Power-up testing, all console keys must be in the opened position. Otherwise, this Fault message will be displayed by the CPU at the end of Power-up testing.

Corrective action: Ensure all keys are released during Power-up testing. If the problem persists, replace the Console keyboard.

Fault # 043
Power head key closed on powerup

Occurs when: During Power-up testing, all powerhead keys must be in the opened position. Otherwise, this Fault message will be displayed by the CPU at the end of Power-up testing.

Corrective action: Ensure all keys are released during Power-up testing. If the problem persists, replace the Powerhead keyboard.

RE-ASSEMBY OF THE POWERHEAD

Two critical dimensions and one screw torque necessary for the re-assemby process of the Powerhead are as follows:

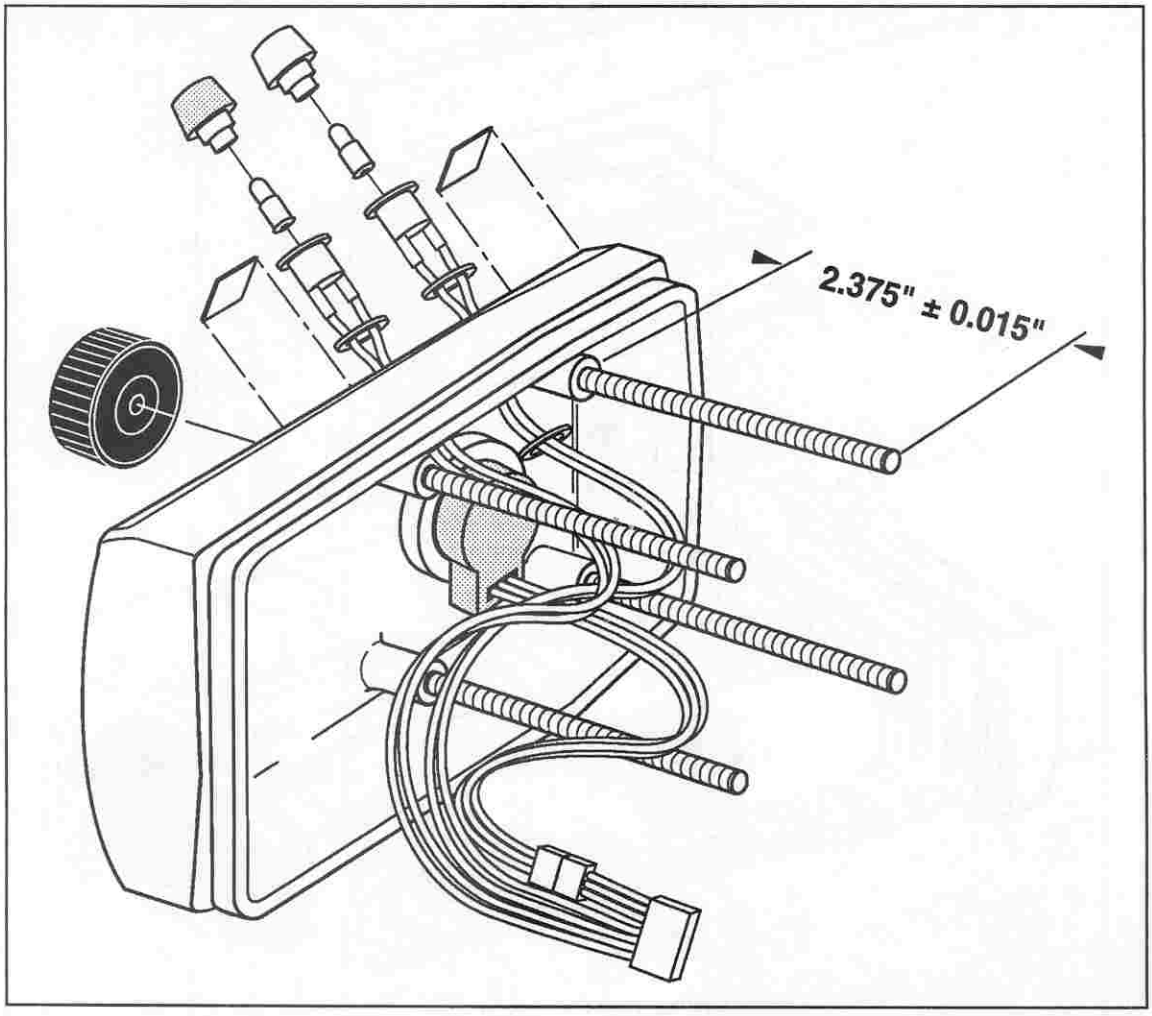


Figure 4-3
Critical Dimension of the End Bracket Assembly

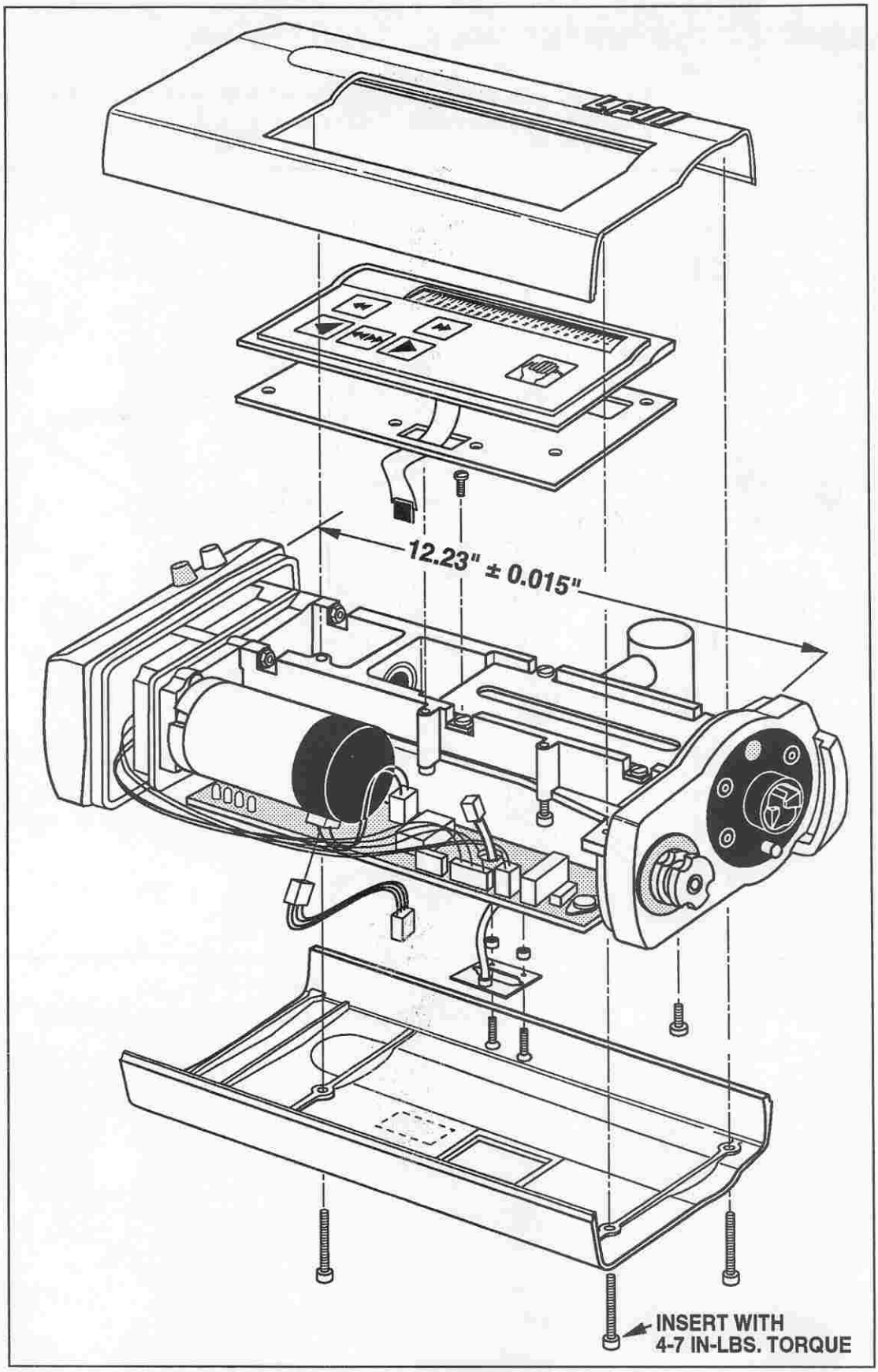


Figure 4-4
Critical Dimension of the Powerhead Assembly

5 CALIBRATION

These calibration procedures are for field calibration of a properly working unit. In order to calibrate the unit correctly, the service technician must have some familiarity with the operational procedures of the injector such as loading a syringe into the unit, filling the syringe, setting the protocol parameters and injecting. For more information on these procedures refer to the Operator's Manual, P/N 800950.

TOOLS REQUIRED

Screwdriver to remove the Power Pack (i.e., Electronics Cabinet) cover
Screwdriver to remove face plate
#2 Philips Head Screwdriver with at least a 9" shaft
Pressure Gage Assembly (LF P/N 600867)
Water
Water container to collect expelled water

PLACING UNIT IN CALIBRATION MODE

In order to calibrate the unit, Switch 1 of the Power Pack's CPU board must be re-configured.

1. Turn off power to the unit by moving the toggle switch located in the rear of the Power Pack to the "off" position.
2. Remove the cover from the Power Pack. Refer to the Parts section for an exploded drawing of the Power Pack.
3. Move position 1 of SW1 of the CPU board to the "off" position. See Figure 1-4 of the Parts section for location of Switch 1.
4. Power the unit by turning the toggle switch to the "on" position and pushing the control console power switch once to return power. The unit is now in the Calibration Mode.

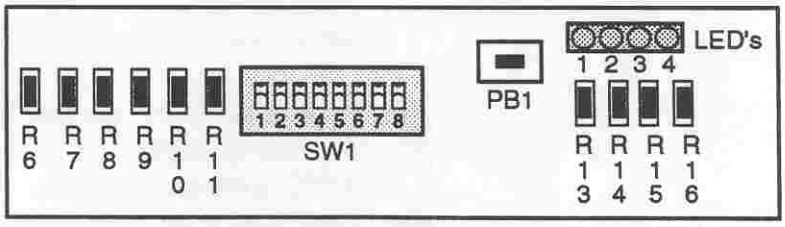


Figure 5-1
SW1 of the CPU Board

POSITION CALIBRATION

NOTE: The Position Calibration must be performed prior to performing the Pressure Calibration.

Refer to Figure 5-2.

1. Place the unit in the Calibration Mode (Refer to the previous Section—*Placing Unit in Calibration Mode*). Remove the Pressure Plate Assembly from the powerhead.

2. Press [Calibrate Position].

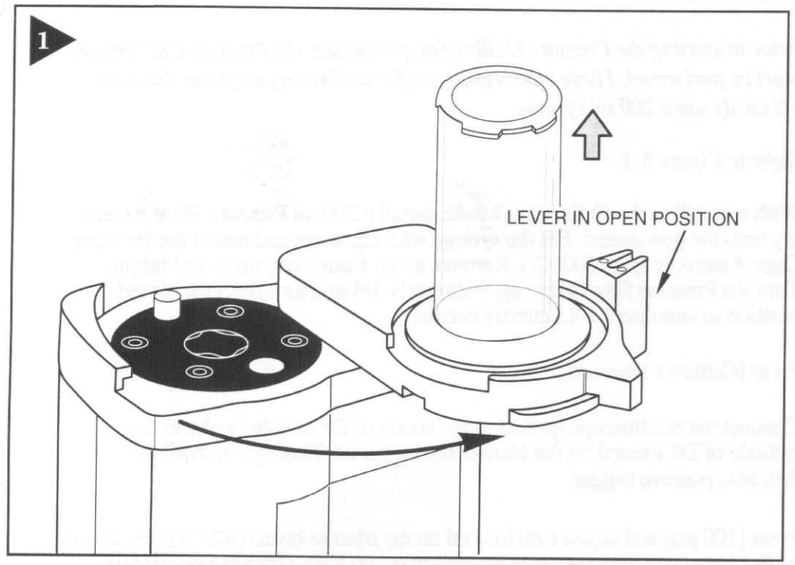
3. 1. Using the Manual Control knob, incrementally move the ram to align its top to be flush with the face plate (±0.010"). The use of a straight edge will allow the technician to view the alignment easier.
   2. Press the 'Set' key. The 'Set' key will momentarily turn white to indicate a successful input.

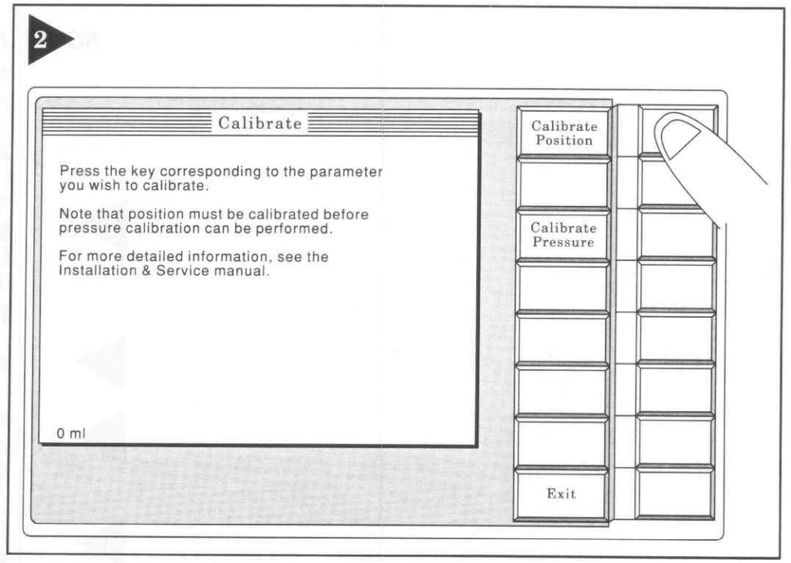
4. 1. Press the [Fast] key and [Forward] key to advance the ram to extend 4.590" (±0.010") from the face plate.
   2. Press the 'Set' key again. The CT 9000 will display the prompt "Position calibration completed! Press EXIT to continue."
   3. Determine if the Pointer and the 0 mark of the 200 ml scale are aligned. If the Pointer and the 0 mark are aligned proceed to Step 7. If not aligned, proceed to Step 5.

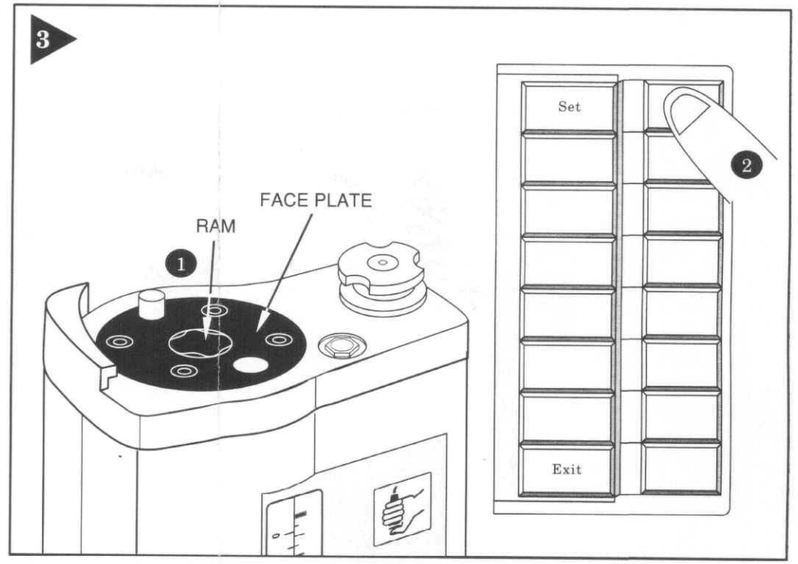
5. 1. Visually measure the distance needed to align the Pointer to the 0 mark of the 200 ml scale.
   2. Press the [Fast] key and [Reverse] key to return the ram to align flush with the face plate.
   3. Remove the four screws securing the face plate to the powerhead. Gently lift and rotate the face plate clockwise, pivoting around the sleeve to expose the slot located underneath. *The face is attached to the powerhead by wires connected to the face plate sensor. Do not attempt to completely remove the face plate: damage to these wires may occur.*
   4. Insert the 9"—#2 Philips head screwdriver into the slot in order to connect to the Philips head screw located inside the powerhead (units with S/N XXXX0100-XXXX0150 will use a 9"—7/64" hex head Allen wrench). While viewing the Pointer, turn the screw to move it the amount visually measured in Step 5-1.

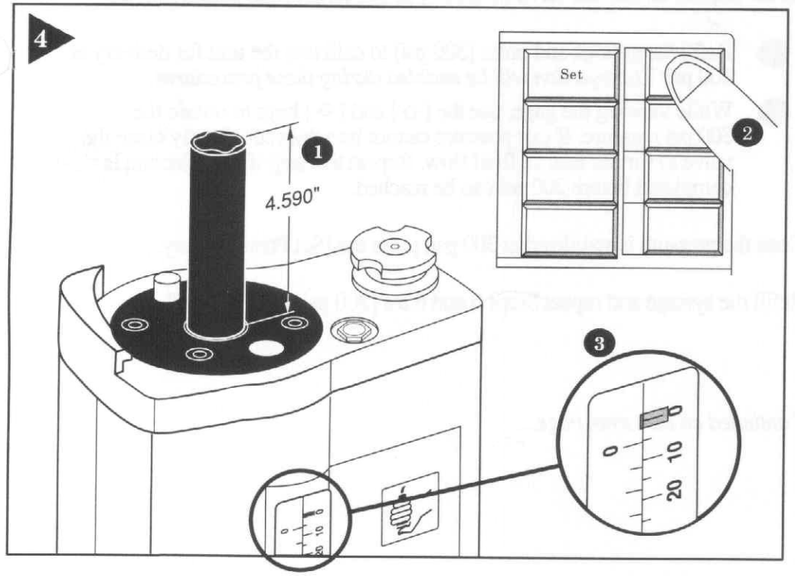
6. 1. Replace the face plate, making sure the O-ring is properly in place.
   2. Press the [Fast] key and [Forward] key to advance the ram to extend 4.590" from the face plate.
   3. Determine if the Pointer and the 0 mark of the 200 ml scale are aligned. If the Pointer and the 0 mark are not aligned, repeat Step 5.

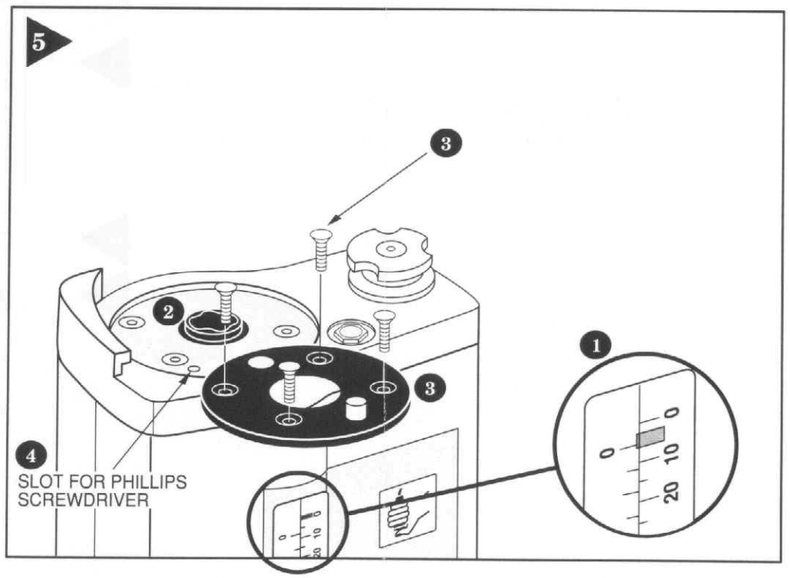
7. Press the [Exit] key to continue with Pressure Calibration.











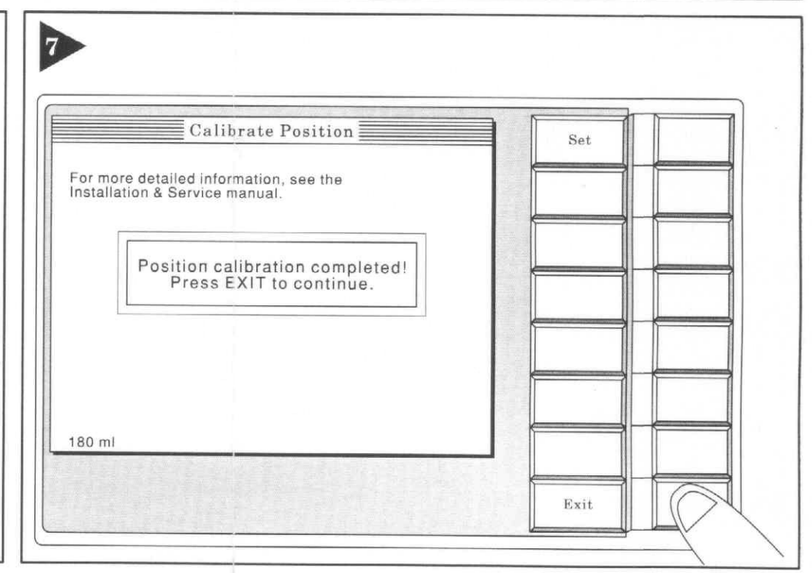


Figure 5-2
Position Calibration

PRESSURE CALIBRATION FOR 200 ML SYRINGE USE WITH 125 ML COMPENSATION

NOTE: Prior to starting the Pressure Calibration procedure, the Position Calibration must be performed. These instructions are for calibrating a system that will primarily use a 200 ml syringe

Refer to Figure 5-3.

1. With unit still in the Calibration Mode, install a 200 ml Pressure Plate Assembly onto the powerhead. Fill the syringe with tap water and install the Pressure Gage Assembly (P/N 600867). Remove all air from the syringe and tubing. Turn the Pressure Gage valve approximately 1/4 of a turn from the closed position to simulate a # 8 butterfly needle.

2. Press [Calibrate Pressure].

3. Connect the oscilloscope ground to the anode of D8 and the probe to the cathode of D8 located on the Mother board. Set oscilloscope to 5v/div., 2µs/div., positive trigger.

4. Press [100 psi] and adjust R80 located on the Mother board (R27 on Rev G and earlier boards) so that the servo frequency is 100 KHz (10µs period ±0.5µs).

5. 1. Refill the syringe and press [300 psi] to calibrate the unit for delivery at 300 psi. *The injection will be enabled during these procedures.*
   2. While viewing the gage, use the [⇧] and [⇩] keys to obtain the 300 psi pressure. If this pressure cannot be achieved, slightly close the valve to further restrict fluid flow. Repeat this step if the injection is completed before 300 psi can be reached.

6. Once the pressure is stabilized at 300 psi, press the [Set Pressure] key.

7. Refill the syringe and repeat Steps 5 and 6 for [200 psi] and [100 psi].

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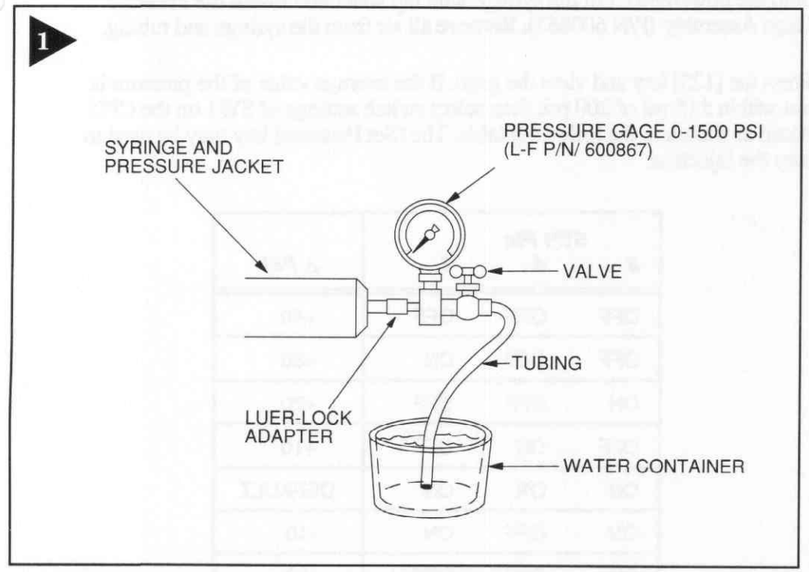
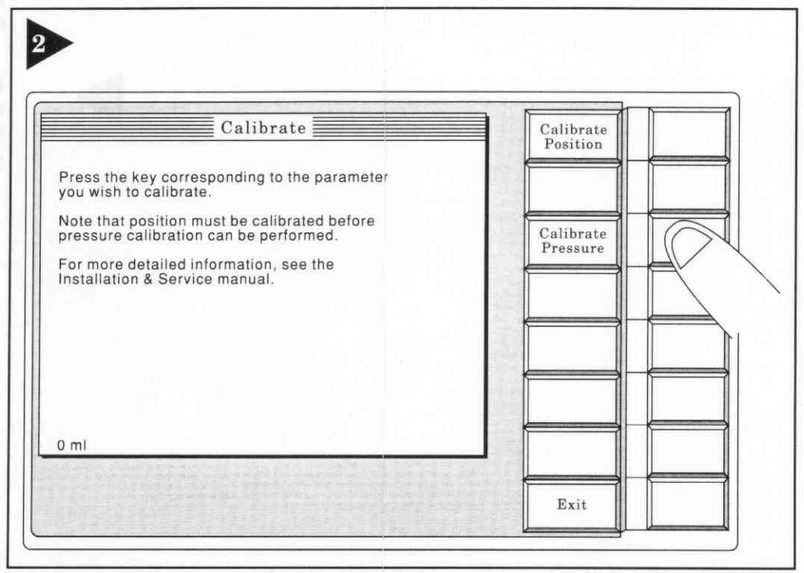
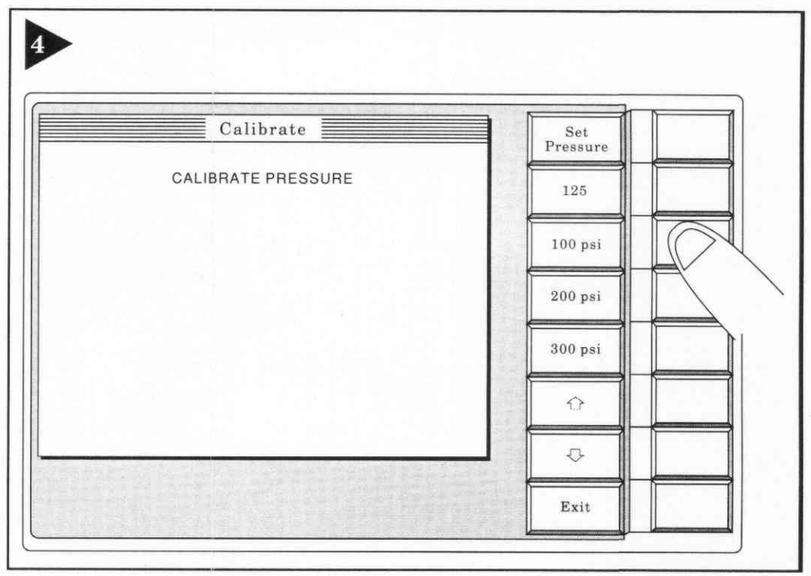
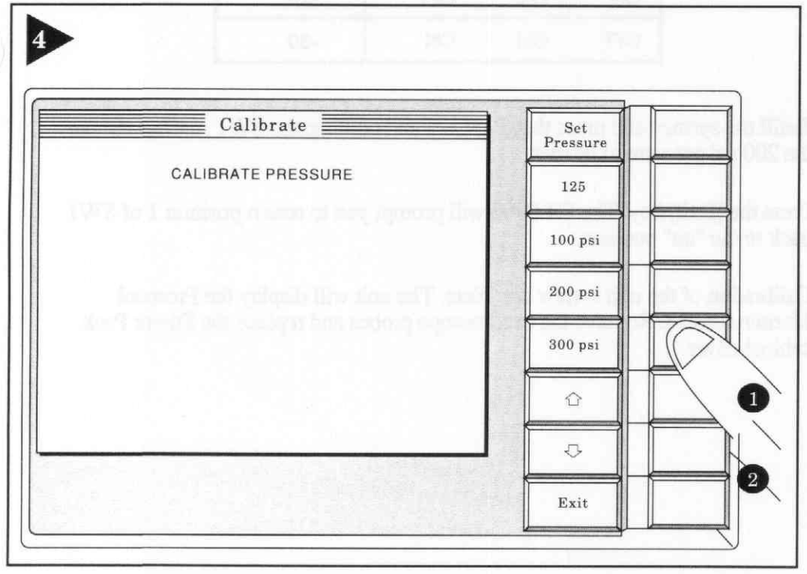








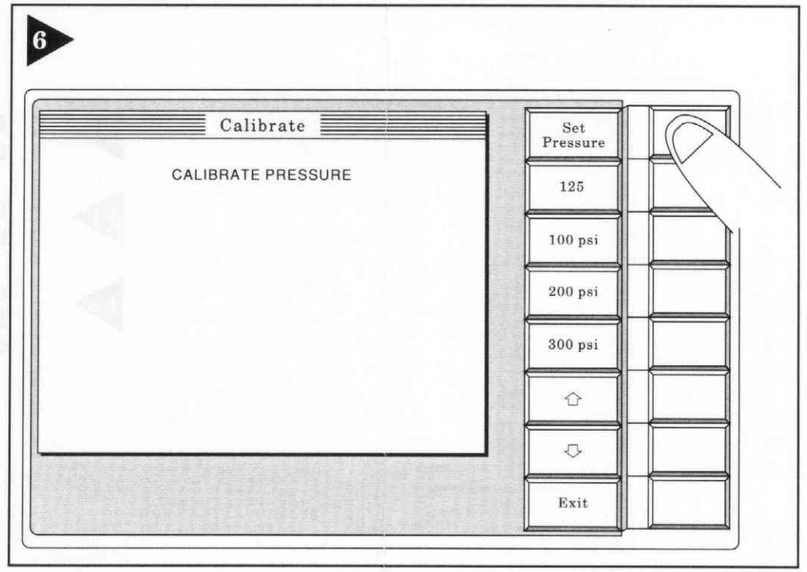


Figure 5-3
200 ml Pressure Calibration

8 Remove the 200 ml Pressure Plate Assembly and Pressure Gage Assembly, *leaving the valve in the same position.* Install a 125 ml Pressure Plate Assembly onto the powerhead. Fill the syringe with tap water and install the Pressure Gage Assembly (P/N 600867). Remove all air from the syringe and tubing.

9 Press the [125] key and view the gage. If the average value of the pressure is not within ±15 psi of 200 psi, then select switch settings of SW1 on the CPU board as shown in the following table. The [Set Pressure] key may be used to stop the injection.

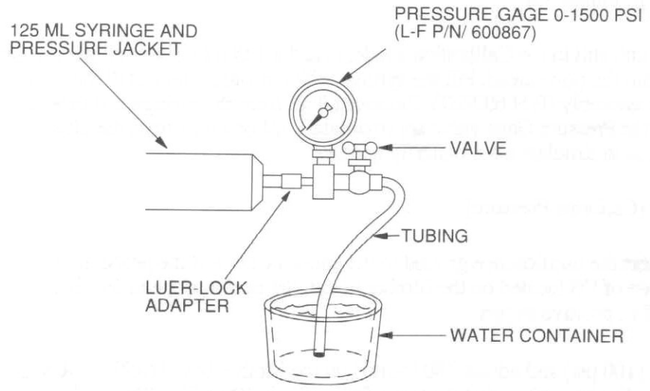
SW1 Pin 3	4	5	Δ PSI
OFF	OFF	OFF	+40
OFF	OFF	ON	+30
ON	OFF	OFF	+20
OFF	ON	OFF	+10
ON	ON	ON	DEFAULT
ON	OFF	ON	-10
ON	ON	OFF	-20
OFF	ON	ON	-30

10 Refill the syringe and press the [125] key and confirm the SW1 settings enable the 200 psi pressure to be met.

11 Press the [Exit] key. The CT 9000 will prompt you to return position 1 of SW1 back to the "on" position.

12 Calibration of the unit is now complete. The unit will display the Protocol Memory screen. Remove the oscilloscope probes and replace the Power Pack cabinet cover.

8



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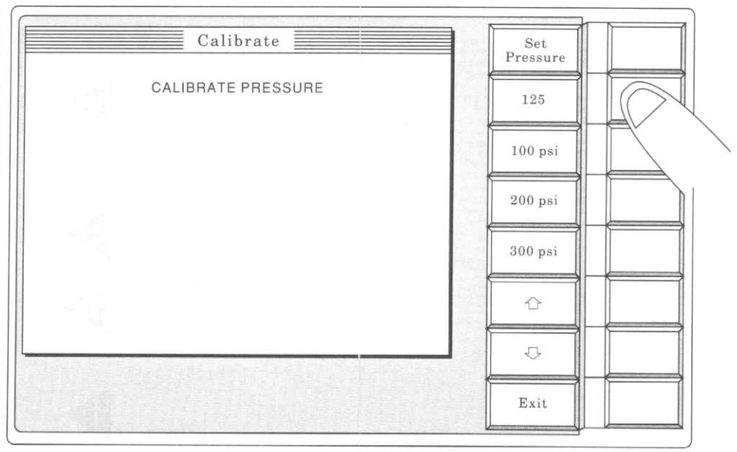

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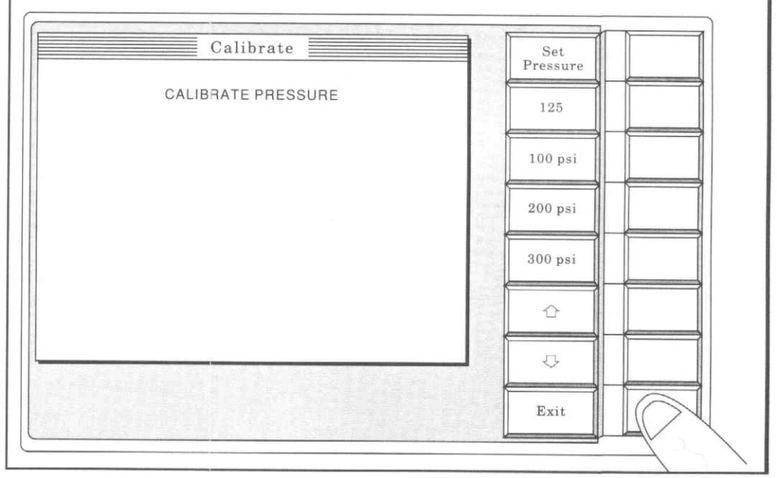

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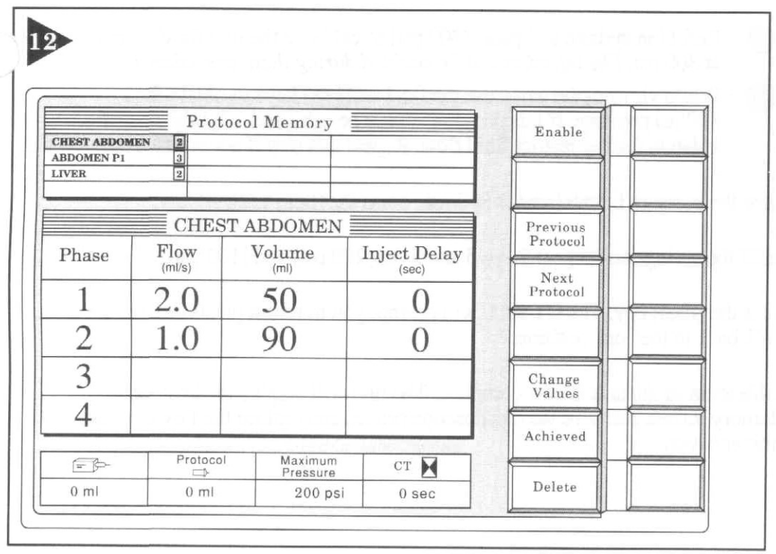


Figure 5-3
200 ml Pressure Calibration (Continued)

PRESSURE CALIBRATION FOR 125 ML SYRINGE USE ONLY

NOTE: Prior to starting the Pressure Calibration procedure, the Position Calibration must be performed. These instructions are for calibrating a system that will primarily use a 125 ml syringe.

Refer to Figure 5-4.

1. With unit still in the Calibration Mode, install a 125 ml Pressure Plate Assembly onto the powerhead. Fill the syringe with tap water and install the Pressure Gage assembly (P/N 600867). Remove all air from the syringe and tubing. Turn the Pressure Gage valve approximately 1/4 of a turn from the closed position to simulate a # 8 butterfly needle.

2. Press [Calibrate Pressure].

3. Connect the oscilloscope ground to the anode of D8 and the probe to the cathode of D8 located on the Mother board. Set oscilloscope to 5v/div., 2µs/div., positive trigger.

4. Press [100 psi] and adjust R80 located on the Mother board (R27 on Rev G and earlier boards) so that the servo frequency is 100 KHz (10µs period ±0.5µs).

5.
   1. Refill the syringe and press [300 psi] to calibrate the unit for delivery at 300 psi. *The injection will be enabled during these procedures.*
   2. While viewing the gage, use the [⇧] and [⇩] keys to obtain the 300 psi pressure. If this pressure cannot be achieved, slightly close the valve to further restrict fluid flow. Repeat this step if necessary.

6. Once the pressure is stabilized at 300 psi , press the [Set Pressure] key.

7. Refill the syringe and repeat Steps 5 and 6 for [200 psi] and [100 psi].

8. Press the [Exit] key. The CT 9000 will prompt you to return position 1 of SW1 back to the "on" position.

9. Calibration of the unit is now complete. The unit will display the Protocol Memory screen. Remove the oscilloscope probes and replace the Power Pack cabinet cover.

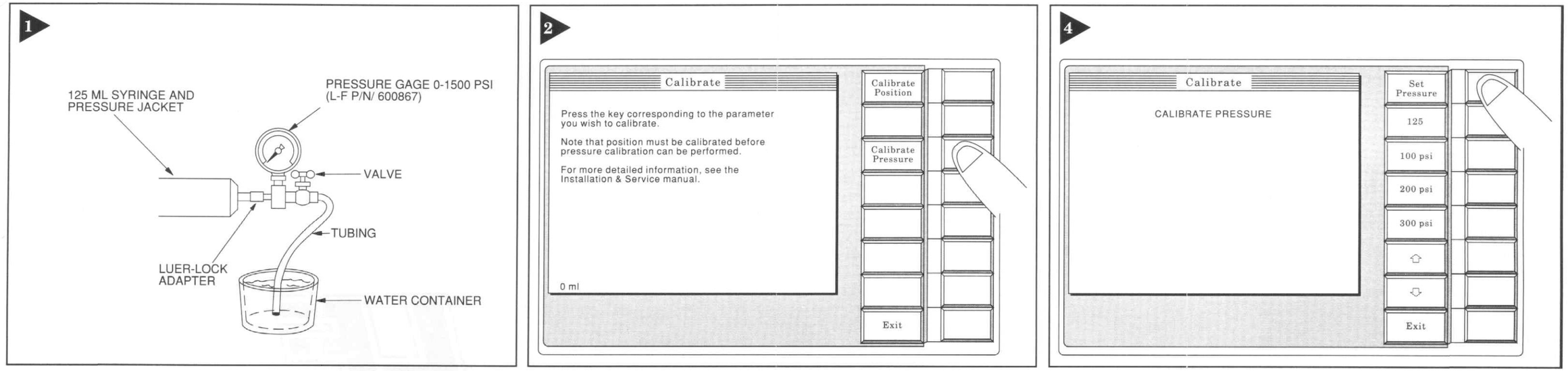


Figure 5-4
125 ml Pressure Calibration

6 MAINTENANCE

A checklist is included in the front pocket of this manual. Fill in the necessary information on a copy of the checklist. File the checklist according to the Serial Number or Hospital in order to maintain a Preventive Maintenance history of the unit.

QUALIFICATIONS

Preventive Maintenance on any unit must be performed by a Qualified Technician who is completely familiar with the use and operation of the Injector, trained by a Liebel-Flarsheim instructor in the area of preventive maintenance for the Injector and familiar with the content of the Operator's Manual and the Installation and Service Manual.

MAINTENANCE SCHEDULE

Preventive Maintenance should be performed in accordance with the following table:

Injections per Day	Maintenance Schedule
Up to 3	every 6 months
4 or more	every 3 months

LEAKAGE AND GROUND CONTINUITY CHECKS

1. With the unit plugged in, check the electrical leakage with a leakage meter, or use an AC voltmeter with the attenuation network shown in Figure 6-1. The leakage should be less than 100 microamperes. If higher, check for the cause and repair.

WARNING!
If system leakage remains above 100 microamperes, do not use the injector as it may be a shock risk for the operator. Contact an authorized service representative.

2. Disconnect the leakage test equipment.
3. Check the ground impedance as follows: Unplug the power cord. Using an ohmmeter, verify continuity between exposed metal parts of the powerhead, console, and power pack and the ground pin on the power plug.

DANGER!
If ground continuity is nonexistent, do not use the injector, contact an authorized service representative. Failure to follow this instruction can result in serious injury.

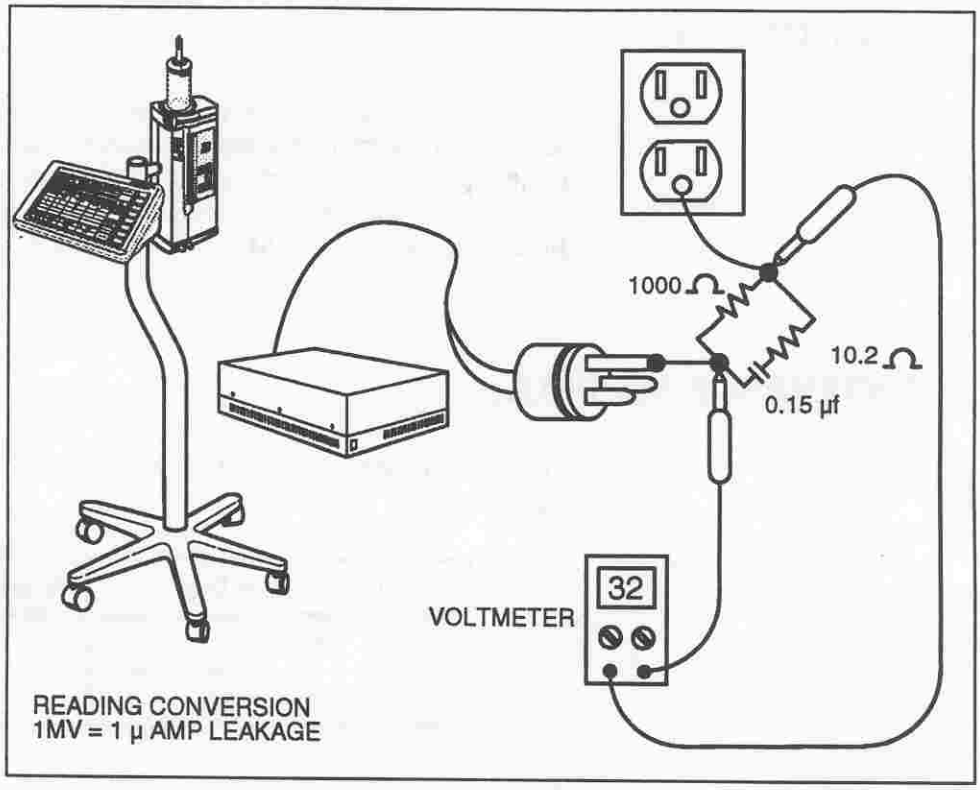


Figure 6-1
Leakage Test Set-up (Unit is plugged in)

EXTERIOR OF COMPONENTS

Perform Steps 1 through 5 of the *Installation Procedure* located in Chapter 2.

POWERHEAD/PRESSURE JACKET

1. Remove the syringe from the pressure jacket in order to fully inspect the pressure jacket. As a preventive measure, replace the pressure jacket once a year.

WARNING!
Syringe pressure jackets must withstand pressures generated during injection delivery. Defective jackets may shatter or explode under these conditions. Always inspect pressure jacket closely before using injector. Rotate the pressure jacket while viewing all areas; look for stress cracks (around the front or at the shoulder area), discard any pressure jacket exhibiting signs of stress, crazing lines or cracks. The use of such parts may cause injury and/or an aborted injection.

2. Inspect the ram, seals and heater connector to ensure they are free from dried contrast. If necessary, clean as directed in the section *Cleaning and Lubrication.*
3. Check the powerhead pivot movement (if applicable). Adjust as necessary.
4. Turn on the injector. Check the operation of the powerhead keys. Make sure the keys are operating freely and not sticking.
5. Check that the ram correctly picks up the syringe plunger. Also check for unusual powerhead noise while running the ram.
6. Check operation of the 200 ml and/or 125 ml pressure jacket plate latch. Open and close the plate. It should operate smoothly without interference or binding. Check for contrast build up. If necessary, clean as directed in the section *Cleaning and Lubrication.*
7. Check the volume indicator LED by installing both a 200 ml and a 125 ml face plate.

KEYBOARD CONSOLE

1. Check that the Console keys and Remote Start switch is operating properly and not sticking.

ELECTRONICS CABINET

1. Check that the LED on the front of the cabinet is working properly

FLOW RATE CHECK

1. Enter an Injection with the following parameters:

   200 ml Pressure Plate Assembly:
   Flow Rate: 7.2 ml/sec
   Volume: 195 ml
   Pressure Limit: 300 psi

   125 ml Pressure Plate Assembly:
   Flow Rate: 4.9 ml/sec
   Volume: 123 ml
   Pressure Limit: 300 psi

   Enable the injection without saving.

2. Verify that the display will ask if air has been evacuated.
3. Press the [Yes] key. Expected Duration shall be 27 seconds.
4. Verify the Powerhead's Enable light is illuminated.
5. Press the [Start] key. Verify that the "Inject Time", rotating wheel, and "Volume Delivered" are tracking correctly and that the Powerhead's Injecting light is illuminated.
6. When the "Achieved Values" screen is displayed, verify the Time, Flow, Volume and Pressure results are within tolerances as follows:

   200 ml Pressure Plate Assembly:

   Time = 27 ± 1 second

   Flow = 7.2 ± 0.2 ml/sec

   Volume = 195 ± 2 ml

   Pressure = less than 300 psi

   125 ml Pressure Plate Assembly:

   Time = 25 ± 1 second

   Flow = 4.9 ± 0.2 ml/sec

   Volume = 195 ± 2 ml

   Pressure = less than 300 psi

7. Run a second injection with the following parameters:

200 ml or 125 ml Pressure Plate Assembly:

Flow Rate: 3.0 ml/sec

Volume: 99 ml

Pressure Limit: 300 psi

Verify the "Achieved Values":

Time = 33 +2/-1 seconds

Flow = 3.0 ± 0.1 ml/sec

Volume = 99 ± 2 ml

Pressure = less than 300 psi

8. Run a third injection with the following parameters:

200 ml or 125 ml Pressure Plate Assembly:

Flow Rate: 0.1 ml/sec

Volume: 10 ml

Pressure Limit: 300 psi

Verify the "Achieved Values":

Time = 1:40 ± 30 seconds

Flow = 0.1 ± 0.1 ml/sec

Volume = 10 ± 1 ml

Pressure = less than 300 psi

CLEANING THE UNIT

PRESSURE SLEEVE AND PLATE

On a daily basis, move the ram to the retract position and wipe out the inside of the pressure sleeve with a damp, lint-free towel.

WARNING! DO NOT AUTOCLAVE PRESSURE SLEEVE
This type of pressure sleeve must not be autoclaved.

The entire syringe plate and pressure sleeve may be placed or soaked in warm water with a mild soap to remove any hardened contrast. *Do not use alcohol-based detergents.* This procedure is also helpful if the locking lever is hard to rotate. Refer to the Sections—*Removing a 200 ml Pressure Plate* and *Removing a 125 ml Pressure Plate.*

CONTROL CONSOLE

The control console screen may be dusted by using a lint-free cloth. The key pad of the control console may be cleaned by using an all-purpose household cleaner. Spray the cleaner on the cloth, then gently buff the key pads clean.

POWER PACK

Clean the exterior of the power pack (i.e., electronics cabinet) by spraying a cloth with an all-purpose household cleaner, then gently wipe clean.

CUSTOMER INTERFACE

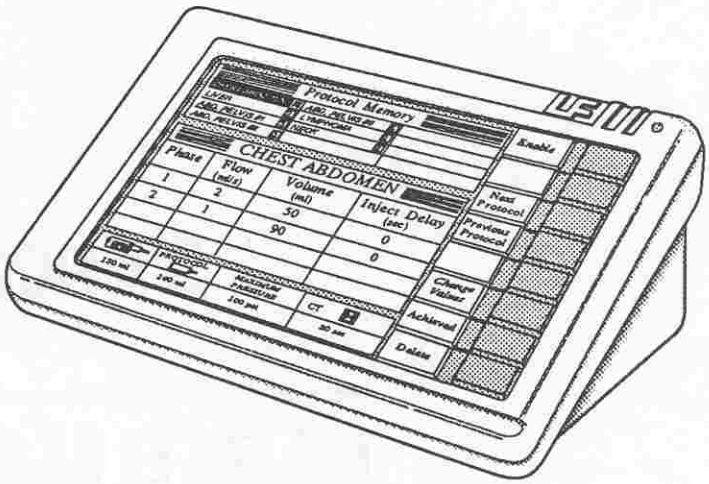
Answer all customer questions regarding operation or use of the equipment. Discuss any areas of concern the customer may have about the unit.

CT 9000

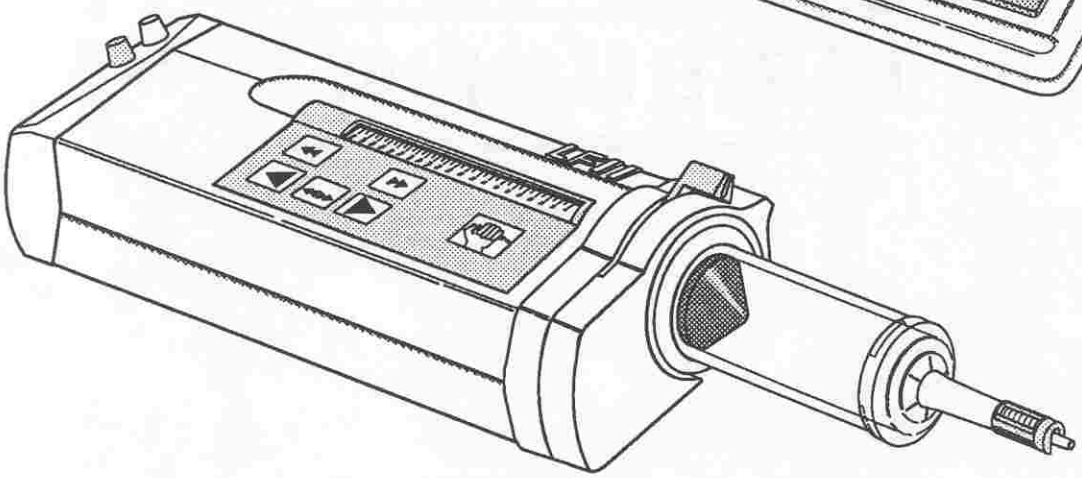
PARTS MANUAL

Major Components

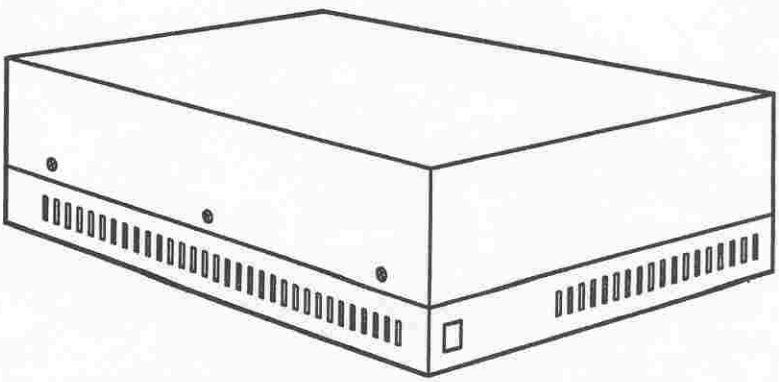
Console
Section III



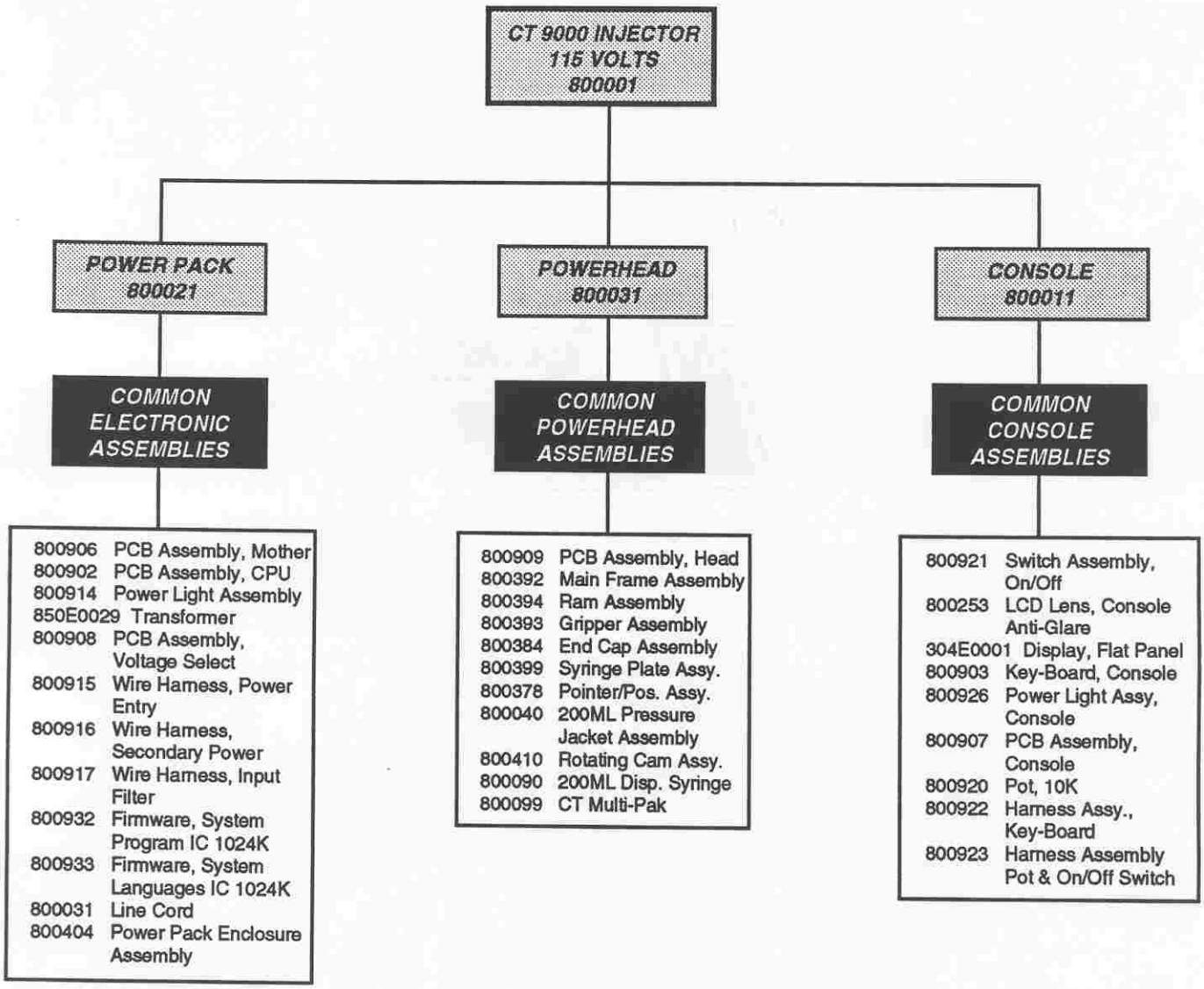
Powerhead
Section II



Power Pack Assembly
Section I



Product Structure for *CT 9000* Parts Manual
115 Volt Units



INTRODUCTION

GENERAL

The following is intended to facilitate the procurement of parts applicable to the CT 9000 Digital Injection System with a 115 volt chassis.

PRODUCT STRUCTURE DIAGRAM

The Product Structure Diagram, on page iv is a tree-structured diagram listing all major assemblies under the three main components comprising the CT 9000. The three main components are :

- Power Pack Assembly
- Powerhead
- Console

GROUP ASSEMBLY PARTS LISTS

The Group Assembly Parts List, Sections 1 through 4, consists of the complete end item, divided into its major assemblies, subassemblies, and component parts. See Table of Contents. It has five columns: Figure and Index Number, Part Number, Description, Units per Assembly and Component Designator (used to highlight individual components on printed circuit boards.)

FIGURE & INDEX NUMBER COLUMN

The first number in this column, preceding a dash, indicates the figure or illustration number, and the number following the dash indicates the index for that particular illustration.

PART NUMBER COLUMN

This column contains the identification number of the assembly, subassembly, or component by which it may be procured.

DESCRIPTION COLUMN

This column contains the nomenclature and/or description of the assemblies, subassemblies or components used in the end item. References are made to next higher assemblies, and to subassemblies that are further disassembled. Each assembly or subassembly is followed by its component parts, properly indented thereunder, to show their relationship to the assembly or subassembly. The attaching parts for the assembly, subassembly, or component immediately follow the part they attach in the same indentation.

UNITS-PER-ASSEMBLY COLUMN

The quantities listed in this column are the total used at the location shown and are not necessarily the total used on the end item.

COMPONENT DESIGNATOR COLUMN

This column is used to list all individual components on printed circuit boards that match the description. For example, a particular diode or capacitor may be used a number of times in different locations on the same board. To determine the specifications of a particular component, simply find it in the Component Designator column, then read the description.

ABBREVIATIONS

The following are abbreviations used in this parts catalog.

BRKT.....BRACKET	T.H.....TRUSS HEAD
SL.....SLOTTED	P.H.....PAN HEAD
BUT. HD. .....BUTTON HEAD	S.S.....SOCKET SET
SOC. CAP.....SOCKET CAP	ST.STL.....STAINLESS STEEL
F. H. .....FLAT HEAD	M.S.....MACHINE SCREW
SOC. HD.....SOCKET HEAD	BRKT.....BRACKET

ORDERING PARTS

All parts may be ordered from the factory. When ordering parts, always include the complete serial number of the CT 9000 Injector, the part number required, the figure and index number, and the description of the part as indicated in the parts list. For further information contact:

Liebel-Flarsheim Company, Customer Service Department
P.O. Box 156305 2111 East Galbraith Road Cincinnati, Ohio USA 45215-6305

Service:.....1-800-877-0791
Order Management:..... 1-800-877-0611
Fax (U.S. & Canada Orders):..... 1-800-998-0898
Fax (All Correspondence & International orders:.....1-513-761-2388
Telex:.....275370 LBFL UR

LIST OF ILLUSTRATIONS ***PAGE***

SECTION I POWER PACK ASSEMBLY

SECTION II POWER HEAD

SECTION III CONSOLE

SECTION IV OPTIONS & ACCESSORIES

SYRINGE PARTS

LIST OF ILLUSTRATIONS (cont.) *PAGE*

INJECTOR HEAD & CONSOLE MOUNTING PARTS

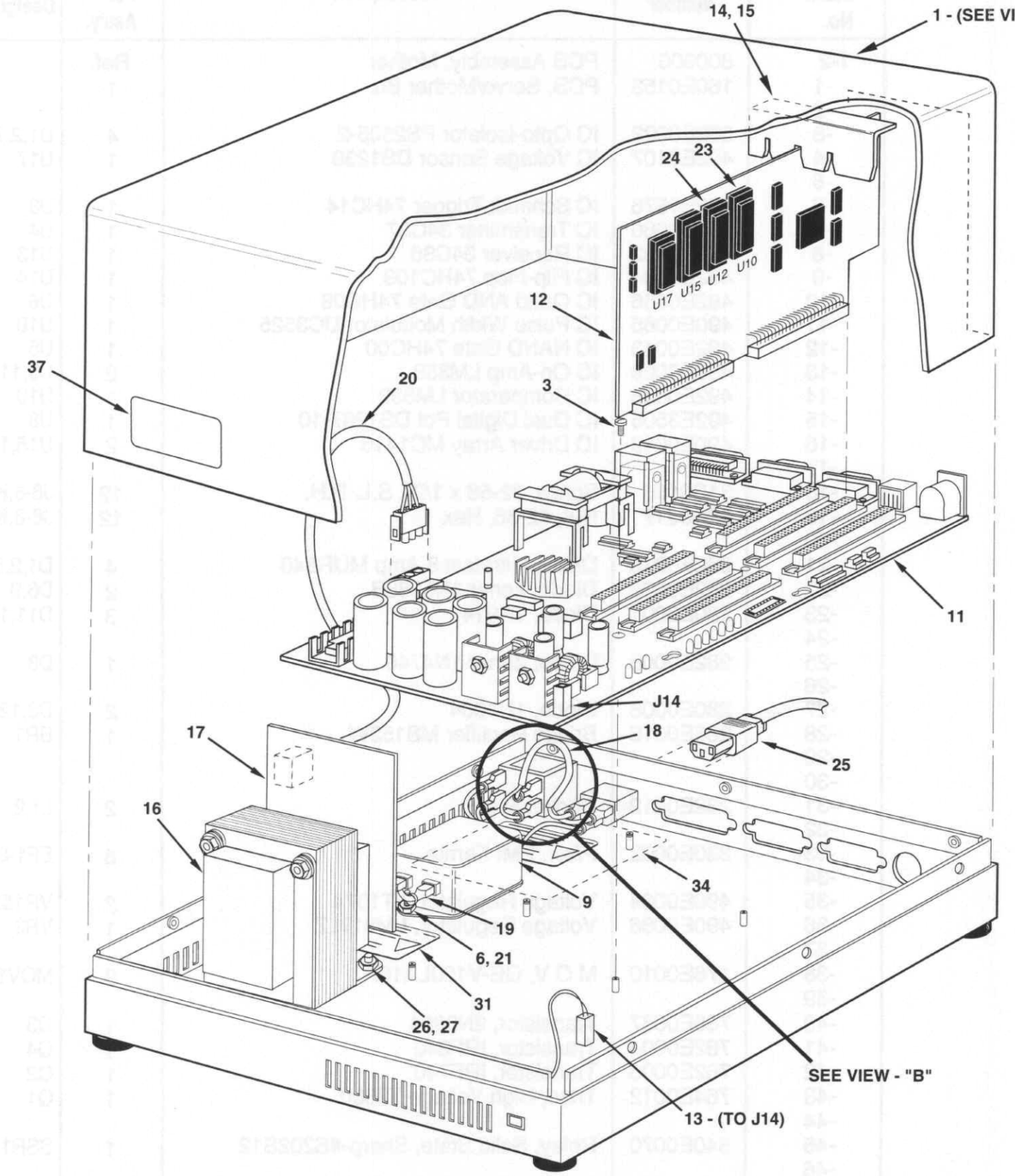
POWER HEAD & CONSOLE EXTENSION CABLES

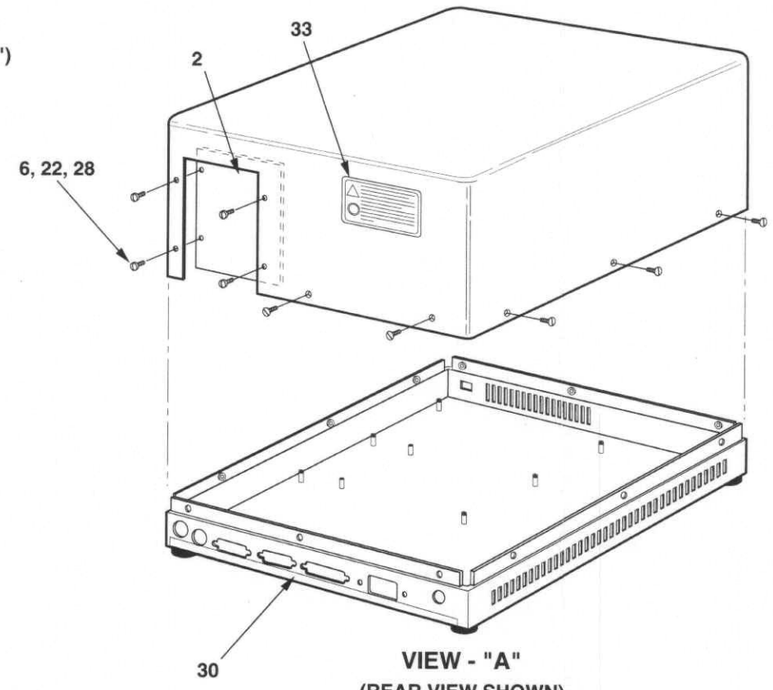
TEST FIXTURES

Section I

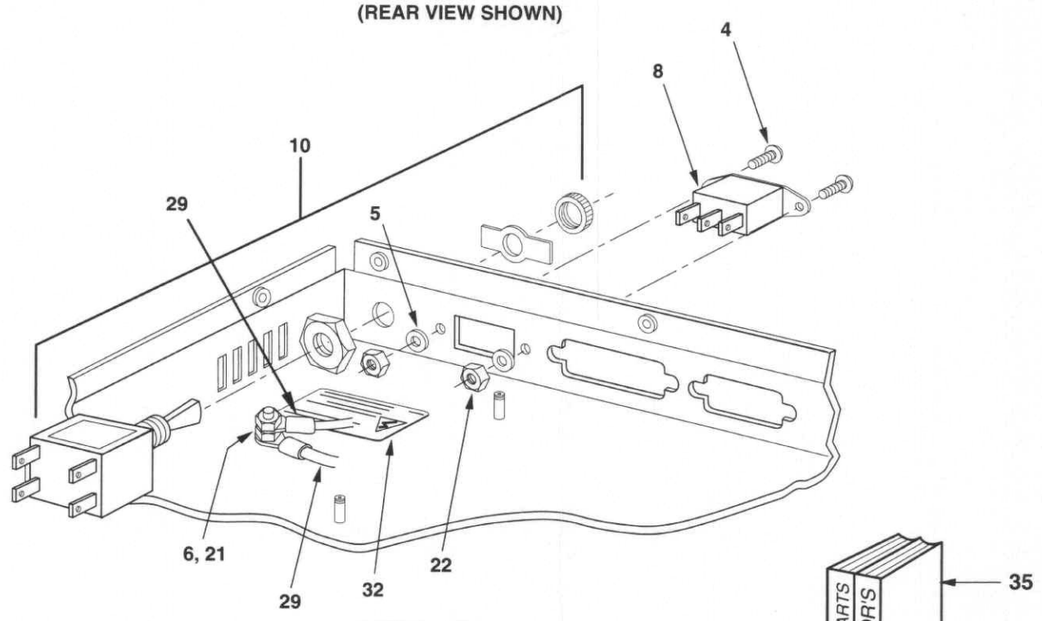
POWER PACK ASSEMBLY

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
1-1	800021	Power Pack Assembly	Ref.	
-1	800400	Power Pack Enclosure Assembly	1	
-2	800402	Back Panel Power Pack	1	
-3	800442	Sems External Tooth Lock	1	
-4	242S0014	Screw, #4-40 x 3/8 Flat Head	2	
-5	137S0007	Washer, #4 Lock Internal Tooth	2	
-6	137S0006	Washer, #6 Lock Internal Tooth	10	
-7	800483	Label, Toggle On/Off	1	
-8	240E0379	Entry Module, Vac IEC Type	1	
-9	332E0009	Filter, Line	1	
-10	170E0021	Circuit Breaker, On off Switch	1	
-11	800906	PCB Assembly, Mother (see fig. 1-2)	1	
-12	800902	PCB Assembly, CPU (see fig. 1-4)	1	
-13	800914	Power Light Assembly	1	
-14	800407	Support, Power Pack PCB's	1	
-15	262018	Tape, Double Sided	8"	
-16	850E0029	Transformer	1	
-17	800908	PCB Assembly, Voltage Select (see fig. 1-3)	1	
-18	800915	Cable Assembly, Power Entry	2	
-19	800917	Cable Assembly, Filter to Voltage Board	1	
-20	800916	Cable Assembly, Secondary Power	1	
-21	32S0013	Nut, #6-32 Hex	4	
-22	32S0015	Nut, #4-40 Hex	2	
-23	800932	Firmware, System Program	1	
-24	800933	Firmware, System Language	1	
-25	800918	Line Cord, 115 VAC IEC Entry	1	
-26	32S0010	Nut, #10-32 Hex	4	
-27	137S0004	Washer, #10 Internal Tooth	4	
-28	31S0045	Screw, #6-32 x 1/4 Pan Head	4	
-20	600554	Lead Assembly, Filter Ground	2	
-30	800441	Label, Connector Plate	1	
-31	800453	Label, Fuse Replacement	1	
-32	800454	Label, High Voltage Warning	1	
-33	800452	Label, Shock/Explosion	1	
-34	800440	Rating Plate	1	
-35	800950	Operator's Manual	1	
-36	800951	Service and Parts Manual	1	
-37	800489	Label, CT9000 Liebel-Flarsheim	1	





VIEW - "A"
(REAR VIEW SHOWN)



VIEW - "B"

Fig. 1-1 Power Pack Assembly (800021)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
1-2	800906	PCB Assembly, Mother	Ref.	
-1	160E0153	PCB, Servo/Mother Bd.	1	
-2				
-3	602E0022	IC Opto-Isolator PS2505-2	4	U1,2,7,18
-4	492E3107	IC Voltage Sensor DS1239	1	U17
-5				
-6	492E0576	IC Schmidt Trigger 74HC14	1	U3
-7	490E0060	IC Transmitter 34C87	1	U4
-8	490E0032	IC Receiver 34C86	1	U13
-9	492E1504	IC Flip-Flop 74HC109	1	U14
-10	492E0056	IC Quad AND Gate 74HC08	1	U6
-11	490E0065	IC Pulse Width Modulator UC3525	1	U16
-12	492E0043	IC NAND Gate 74HC00	1	U5
-13	490E0009	IC Op-Amp LM358	2	U9,11
-14	492E0035	IC Comparator LM339	1	U10
-15	492E3506	IC Dual Digital Pot DS1267-10	1	U8
-16	490E0049	IC Driver Array MC1416	2	U15,19
-17				
-18	31S0115	Screw, #2-56 x 1/2", S.L. P.H.	12	J6-8,K9-11
-19	32S0017	Nut, #2-56, Hex	12	J6-8,K9-11
-20				
-21	282E0019	Diode, Ultrafast 8 Amp MUR840	4	D1,2,5,7
-22	282E0020	Diode, Zener 1N5388B	2	D6,9
-23	280E0001	Diode, 1N914	3	D11,10,13
-24				
-25	282E0003	Diode, Zener 1N4740	1	D8
-26				
-27	280E0008	Diode, 1N4004	2	D3,12
-28	286E0016	Bridge Rectifier MB152W	1	BR1
-29				
-30				
-31	232E0012	Choke, 55µh	2	L1,2
-32				
-33	330E0002	Filter, EMI Ferrite	8	EF1-8
-34				
-35	490E0064	Voltage Regulator, LT1074	2	VR1&2
-36	490E0066	Voltage Regulator, LM317LZ	1	VR3
-37				
-38	176E0010	M O V, GE-V150LA10A	2	MOV1,2
-39				
-40	760E0037	Transistor, 2N3904	1	Q3
-41	762E0004	Transistor, IRF240	1	Q4
-42	762E0003	Transistor, IRF740	1	Q2
-43	764E0012	Triac, High Voltage T2800	1	Q1
-44				
-45	640E0070	Relay, Solid State, Sharp-#S202S12	1	SSR1
-46				

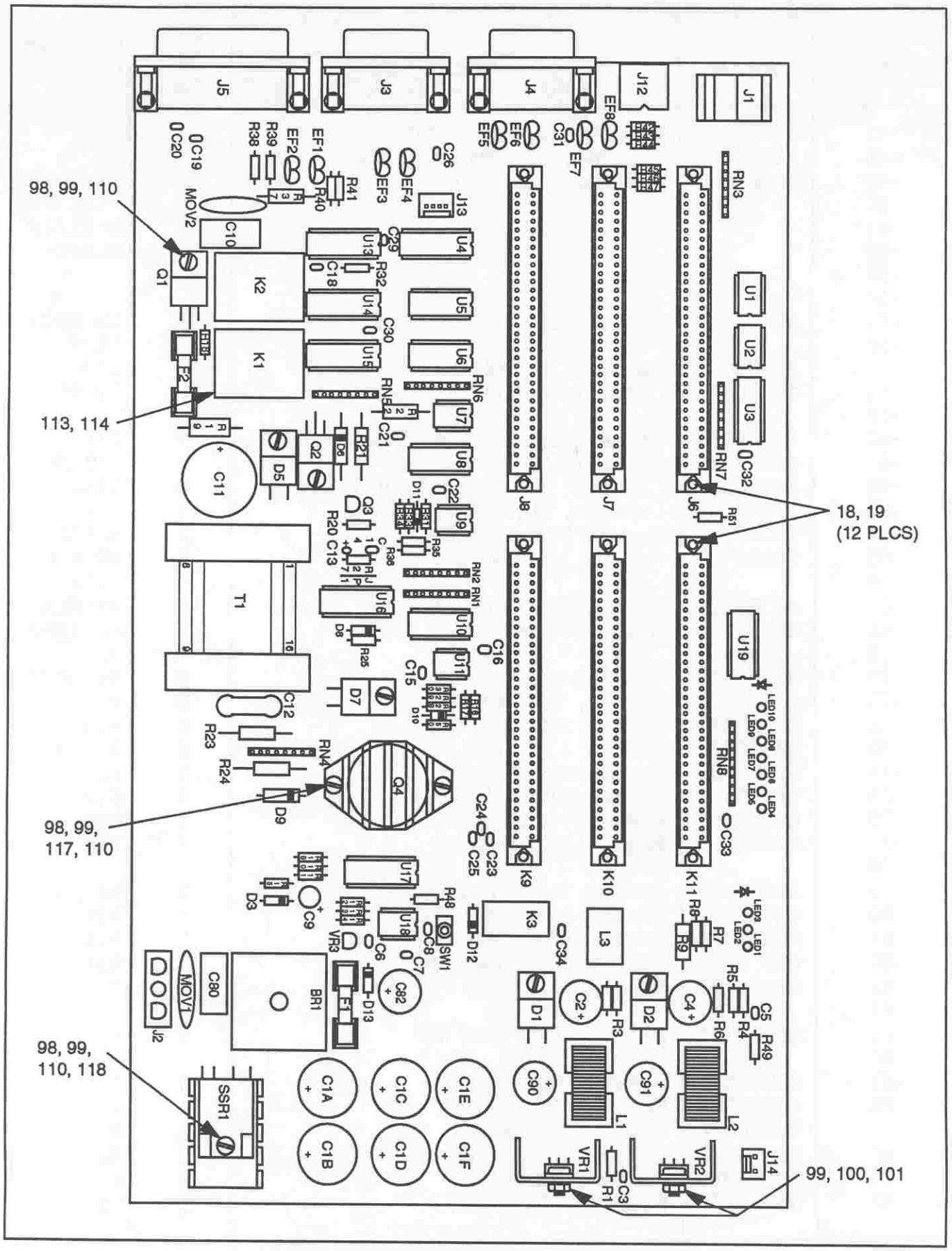


Fig. 1-2 PCB Assembly, Mother (800906)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
-47	180E3009	Capacitor, Ceramic .001µf	1	C14
-48	188E5016	Capacitor, Electrolytic 47µf 50VDC	1	C9
-49	180E3002	Capacitor, Ceramic .1µf	20	C3,6,5,8,15,
-50				16,18,19,20,
-51				21,23,24,25,
-52				26,29-34
-53				
-54				
-55	188E5009	Capacitor, Electrolytic 1000µf 50VDC	6	C1A,1B,1C,1D,
-56				1E,1F
-57	188E5011	Capacitor, Electrolytic 1000µf 16VDC	2	C2,4
-58	188E5010	Capacitor, Electrolytic 220µf 50VDC	2	C90,91
-59				
-60	188E5015	Capacitor, Electrolytic 47µf 450VDC	1	C11
-61	182E7005	Capacitor, .1µf 250VDC	2	C10, 80
-62	190E0002	Capacitor, 1µf Tantalum 25VDC	3	C13,22,82
-63	184E0001	Capacitor, 10,000pf 500VDC Mica	1	C12
-64	680E2562	Resistor, 5.6K 1/4W 5%	2	R27,33
-65	680E2100	Resistor, 10Ω 1/4W 5%	6	R25,40,41,43,
-66				44,50
-67	680E2221	Resistor, 220Ω 1/4W 5%	4	R37,38,39,42
-68	680E2102	Resistor, 1K 1/4W 5%	5	R8,16,29,35,
-69				36
-70	680E2470	Resistor, 47Ω 1/4W 5%	3	R45,46,47
-71	680E2202	Resistor, 2K 1/4W 5%	3	R17,1,4
-72	680E2331	Resistor, 330Ω 1/4W 5%	2	R7,49
-73	680E2472	Resistor, 4.7K 1/4W 5%	2	R32,48
-74	680E2103	Resistor, 10K, 1/4W 5%	1	R30
-75	680E2471	Resistor, 470Ω 1/4W 5%	1	R12
-76	680E2181	Resistor, 180Ω 1/4W 5%	1	R20
-77	680E2680	Resistor, 68Ω 1/4W 5%	1	R18
-78				
-79	680E2105	Resistor, 1M 1/4W 5%	2	R28,34
-80	680E2332	Resistor, 3.3K 1/4W 5%	1	R31
-81	680E2271	Resistor, 270Ω 1/4W 5%	1	R15
-82	680E2681	Resistor, 680Ω 1/4W 5%	1	R14
-83	680E2152	Resistor, 1.5K 1/4W 5%	1	R13
-84				
-85	680E2104	Resistor, 100K 1/4W 5%	1	R51
-86				
-87	688E0022	Resistor, .1Ω, 3W, 1%	1	R24
-88	688E0021	Resistor, 10K, 3W 5%	1	R23
-89	688E0017	Resistor, .5Ω 3W 1%	1	R19
-90	680E3511	Resistor, 510Ω 1/2W	1	R22
-91	688E0018	Resistor, 1Ω 1W	1	R21
-92	680E3272	Resistor, 2.7K 1/2W	1	R9

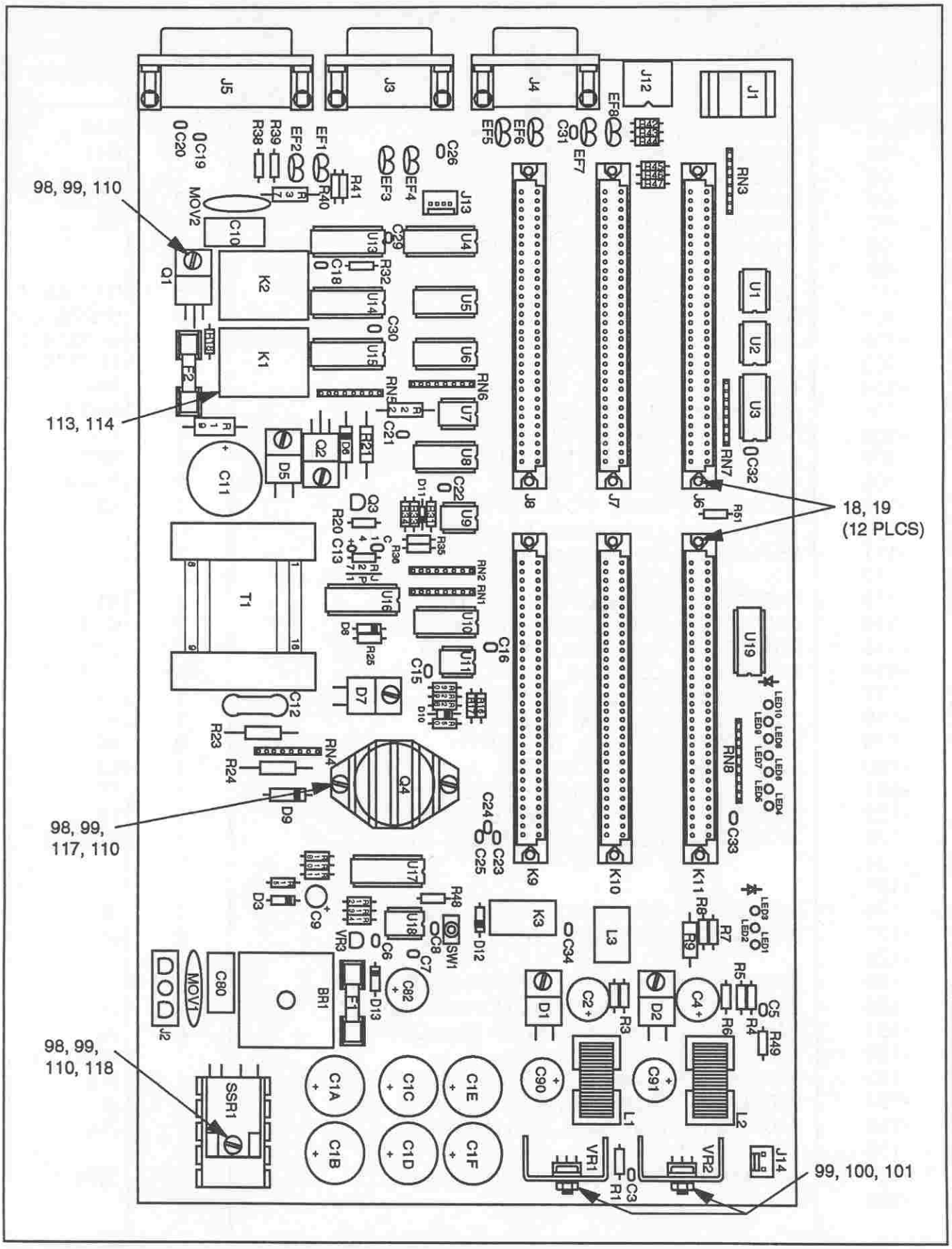


Fig. 1-2 PCB Assembly, Mother (800906)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
-93	686E0073	Resistor, 6.65K 1% 1/4W	1	R10
-94	686E0044	Resistor, 7.5K 1% 1/4W	1	R11
-95	686E0123	Resistor, 2.87K 1% 1/4W	1	R6
-96	686E0124	Resistor, 2.21K 1% 1/4W	2	R2,5
-97	686E0125	Resistor, 9.76K 1% 1/4W	1	R3
-98	31S0057	Screw, #4-40 x 3/8 Pan Head	11	
-99	32S0015	Nut, Hex #4-40	11	
-11	384E0007	Socket, IC 14 Pin	5	U3,5,6,8,10
-101	384E0026	Socket, IC 8 Pin	6	U1,2,7,9,11,18
-102	384E0027	Socket, IC 16 Pin	7	U4,13,14,15,
-103				16,17,19
-104	692E0038	Resisitor, SIP 390Ω	1	RN8
-105	692E0029	Resistor, SIP 1K	3	RN3,6,7
-106	692E0041	Resistor, SIP 4.7K	1	RN1
-107	692E0043	Resistor, SIP 1M	1	RN2
-108	692E0042	Resistor, SIP 33K	2	RN4,5
-109	640E0039	Relay, PC Board Mount	1	K3
-110	137S0007	Lockwasher, #4 Internal Tooth	13	
-111	854E0005	Transformer, VDE Flyback	1	T1
-112				
-113	640E0071	Relay, DPDT 2 Form C	2	K1,2
-114	640E0072	Socket, Relay with clip	2	K1,2
-115	256707	Buss Wire, Solid 20AWG	1.5"	JP1
-116	544E0001	LED, Red	10	LED1-10
-117	150E0025	Heatsink, TO-3	1	Q4
-118	150E0027	Heatsink, TO-220	1	SSR1
-119	150E0026	Heatsink, TO-220	2	VR1,2
-120	232E0009	Choke, Dual Coil	1	L3
-121	172E0016	Fuse, 6.3 AMP 5 x 20 mm	1	F1
-122	172E0057	Fuse, 3.15 AMP 5 x 20 mm	1	F2
-123	172E0013	Fuse Clip, PCB Mount 5mm	4	F1,F2
-124				
-125				
-126	240E0381	Connector, 25 Pin D-Shell	1	J5
-127	240E0380	Connector, 15 Pin D-Shell	2	J3,4
-128				
-129	240E0383	Connector, 8 Pin Cicular Euro-DIN	1	J1
-130	240E0382	Connector, 8Pin Circular Mini-DIN	1	J12
-131	240E0377	Connector, 64 Pin Euro-DIN	6	J6,7,8;
-132				K9,10, 11
-133	240E3020	Connector, 4 Pin Header MTE	1	J13
-134	240E0197	Connector, 3 Pin Header	1	J2
-135	240E3021	Connector, 2Pin Header	1	J14
-136				
-137	802E0002	Switch, SPST, Momentary	1	SW1
-138				

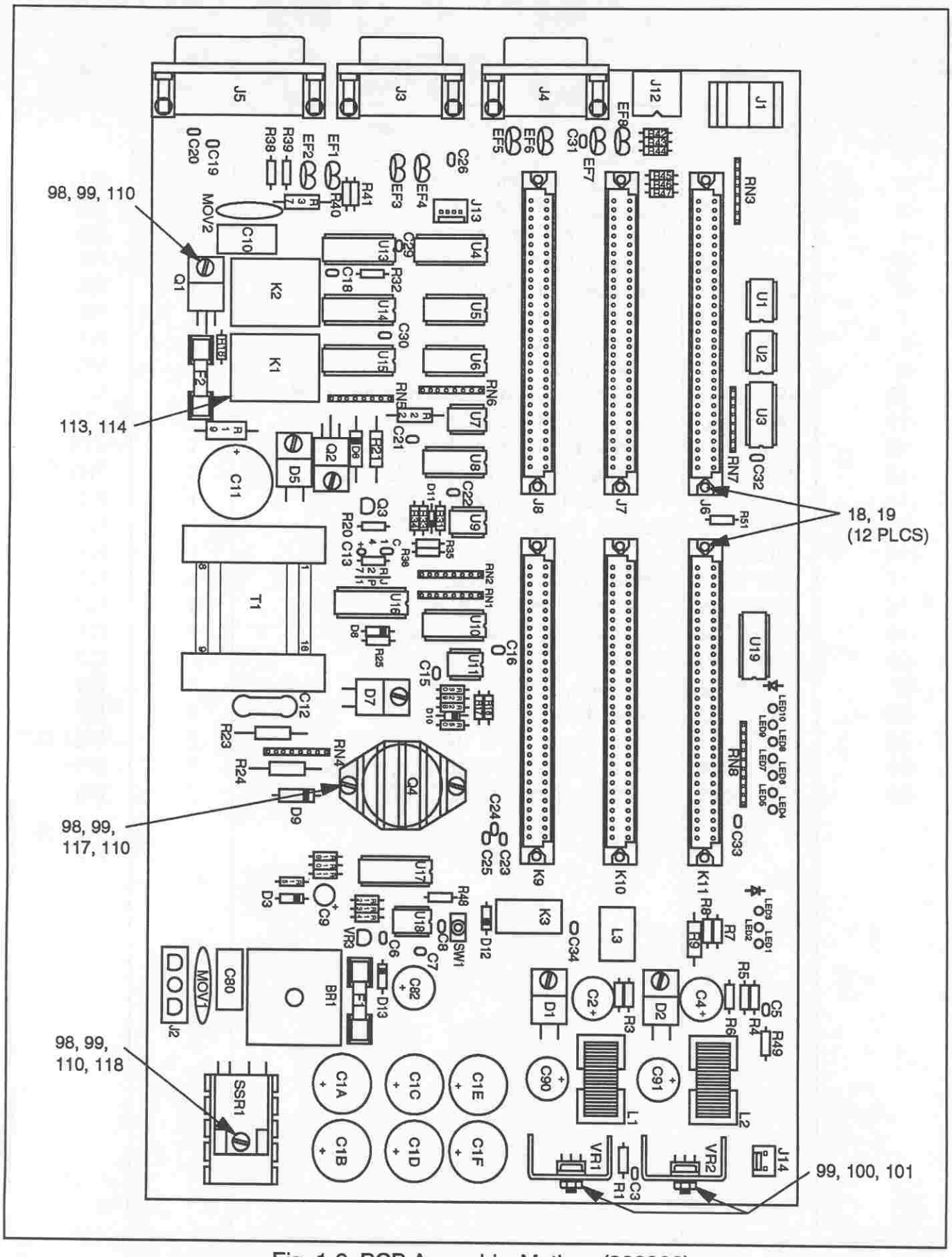


Fig. 1-2 PCB Assembly, Mother (800906)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
1-3	800908	PCB Assembly, Voltage Select	Ref.	
-1	Ref.	P.C.B., Voltage Selection Board	1	
-2	682E4101	Resistor, 100 Ohm, 1 W, 5%	1	R1
-3	688E0015	Resistor, 15K, 3W, 5%	1	R2
-4	682E3823	Resistor, 82K, 1/2W, 5%	1	R3
-5	680E2242	Resistor, 2.4K, 1/4W, 5%	1	R4
-6	680E2332	Resistor, 3.3K, 1/4W, 5%	1	R5
-7	680E2103	Resistor, 10K, 1/4W, 5%	1	R6
-8	680E2620	Resistor, 62 Ohm, 1/4W, 5%	1	R7
-9	176E0010	Varistor, 150V	1	VR1
-10	490E0058	I.C., Voltage Sensing Device, MC34064P-5	1	U1
-11	240E0280	Connector, Header 2 Position	1	J16
-12	240E0197	Connector, Header 3 Position	1	J15
-13	380E0067	Terminal, Faston Receptacle .250, P.C.B.	8	TR1-TR8
-14	640E0074	Relay, DPDT, 110VDC Power	1	K1
-15	640E0068	Socket, Relay, 8 Pin, DPDT	1	K1
-16	640E0069	Clip, Relay Socket	1	K1
-17	760E0037	Transistor, NPN, 2N3904	1	Q1
-18	760E0058	Transistor, NPN, MPSW42	1	Q2
-19	188E5014	Capacitor, 2.2uf, 250V, Axial, A.E.	1	C1
-20	190E0010	Capacitor, 10uf, 20V, Tantalum	1	C2
-21	190E0002	Capacitor, 1uf, 25V, Tantalum	1	C3
-22	280E0008	Diode, 1N4004	1	D1
-23	282E0022	Diode, Zener 6.2V, 1N4735, 1W	2	DZ1,DZ2
-24	286E0004	Bridge Diode, DIP Package, VM48	1	BR1
-25	176E0016	Inrush Current Limiter, CL80	1	R8

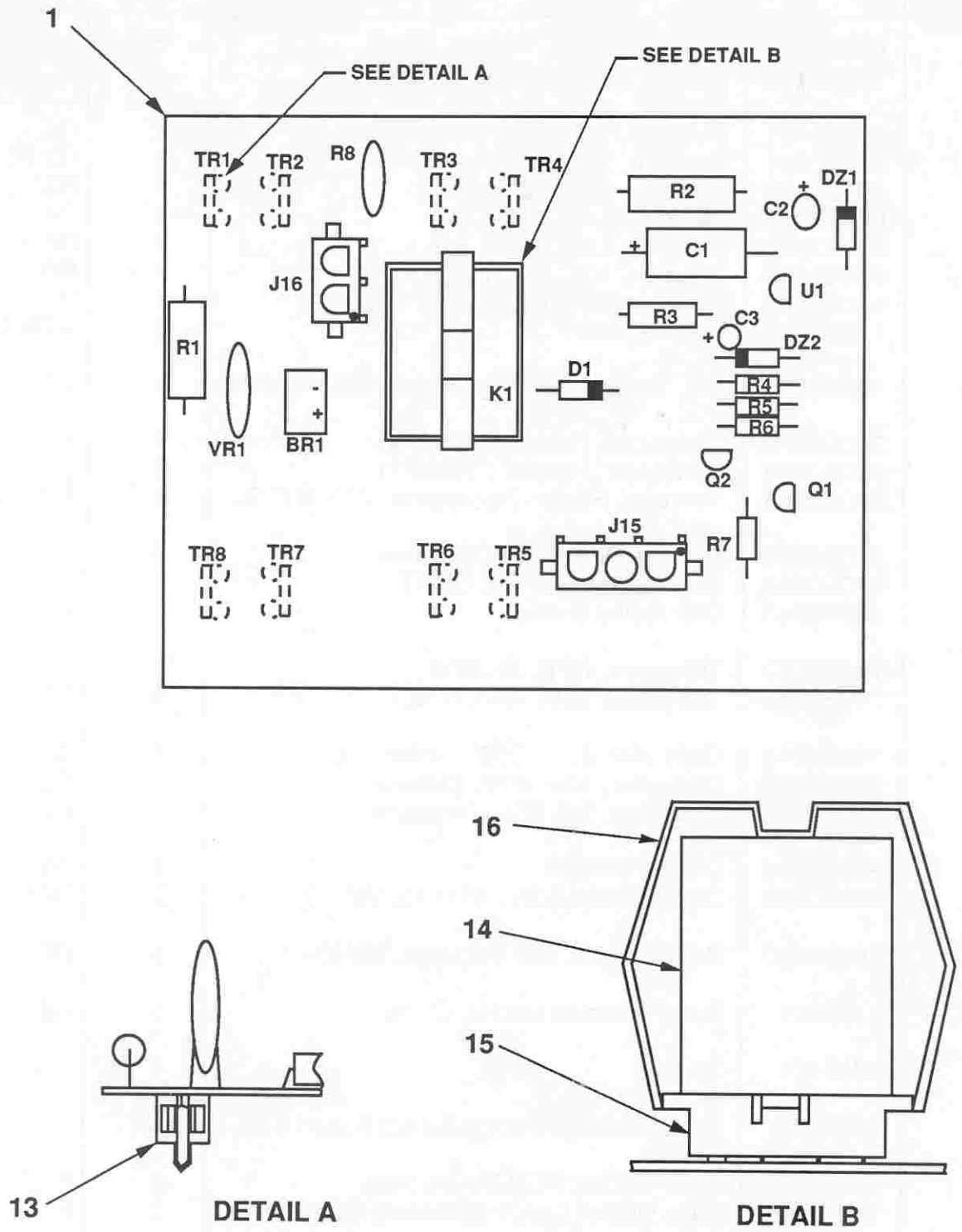


Fig. 1-3 PCB Assembly, Voltage Select (800908)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
1-3	800937	PCB Assembly, Voltage Select	Ref.	
-1	160E0147	P.C.B., Voltage Selection Board	1	
-2				
-3	682E4101	Resistor, 100 Ohm, 1 W, 5%	1	R1
-4	688E0011	Resistor, 15K, 3W, 5%	1	R2
-5	682E3823	Resistor, 82K, 1/2W, 5%	1	R3
-6	680E2242	Resistor, 2.4K, 1/4W, 5%	1	R4
-7	680E2332	Resistor, 3.3K, 1/4W, 5%	1	R5
-8	680E2103	Resistor, 10K, 1/4W, 5%	1	R6
-9	680E2620	Resistor, 62 Ohm, 1/4W, 5%	1	R7
-10	176E0006	Varistor, 150V	1	MOV1
-11				
-12	490E0054	I.C., Voltage Sensing Device, MC34064P-5	1	U1
-13				
-14	240E0276	Connector, Header 2 Position	1	J16
-15	240E0193	Connector, Header 3 Position	1	J15
-16	380E0063	Terminal, Faston Receptacle .250, P.C.B.	8	TR1,2,5,6
-17				
-18	640E0070	Relay, DPDT, 110VDC Power	1	K1
-19	640E0064	Socket, Relay, 8 Pin, DPDT	1	K1
-20	640E0065	Clip, Relay Socket	1	K1
-21				
-22	760E0033	Transistor, NPN, 2N3904	1	Q1
-23	760E0054	Transistor, NPN, MPSW42	1	Q2
-24				
-25	188E5014	Capacitor, 2.2uf, 250V, Axial, A.E.	1	C1
-26	190E0006	Capacitor, 10uf, 20V, Tantalum	1	C2
-27	001E002	Capacitor, 1uf, 25V, Tantalum	1	C3
-28				
-29	280E0004	Diode, 1N4004	1	D1
-30	282E0018	Diode, Zener 6.2V, 1N4735, 1W	2	DZ1, DZ2
-31				
-32	286E0000	Bridge Diode, DIP Package, VM48	1	BR1
-33				
-34	176E0011	Inrush Current Limiter, CL80	1	R8
-35				
-36	021E001	Ty-Rap	1	
-37				
-38	080E001	Harness Assy, Votage Select Fused Sec.	1	
-39				
-40	172E0058	Fuse Holder, PCB Mount 5mm	2	F1,2
-41	172E0059	Fuse Holder Cap, PCB Mount 5mm	2	F1,2
-42				
-43	172E0013	Fuse, 5 AMP SLO-BLO 5mm	2	F1,2
-44				
-45	080E001	Label, Voltage Select Fuses	1	

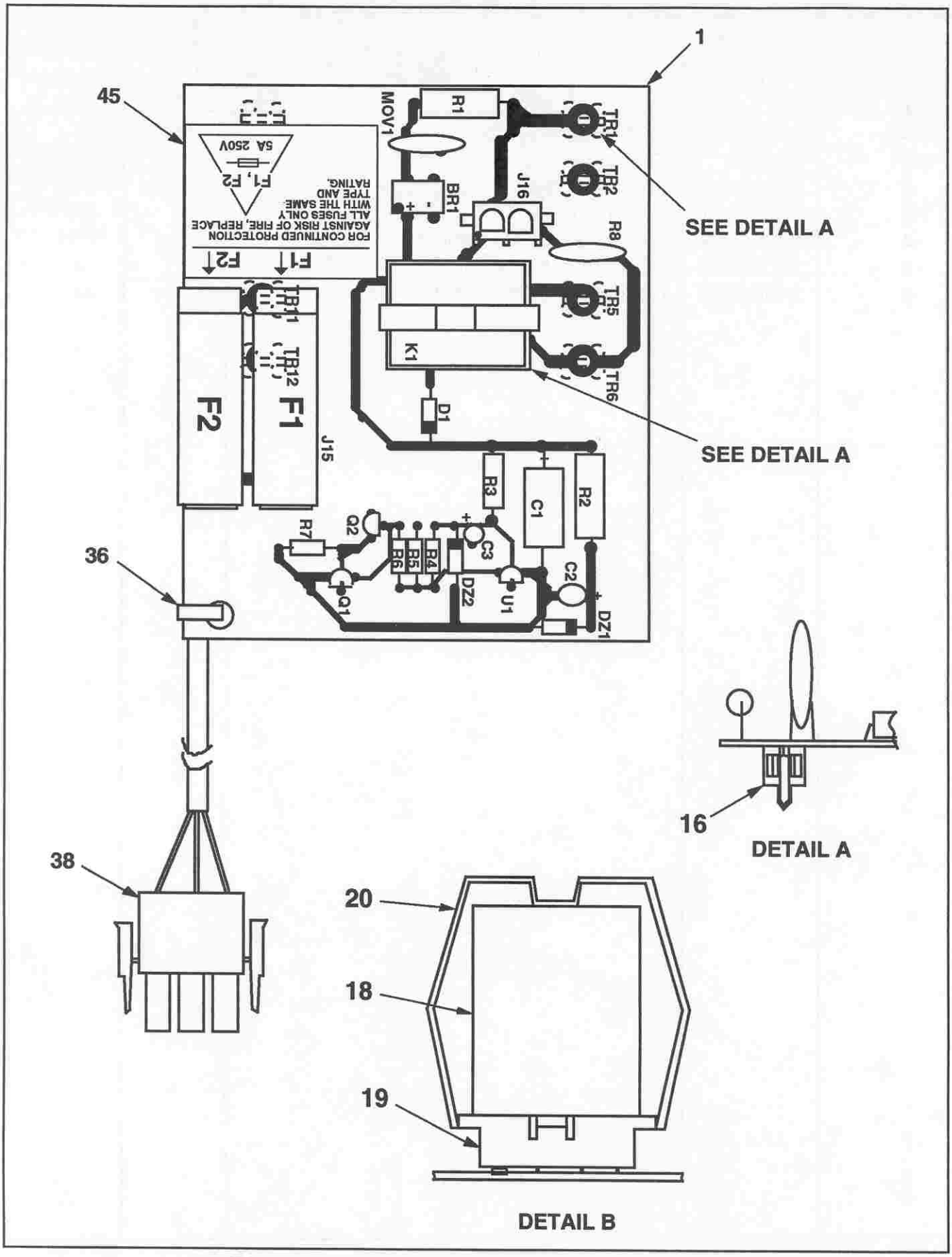


Fig. 1-3 PCB Assembly, Voltage Select (800937)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
1-4	800902	PCB Assembly, CPU	Ref.	
-1	800932	Firmware, System Program	1	U10
-2	800933	Firmware, System Language	1	U12
-3	532E0001	Switch, DIP 8 Position SMT	1	SW1
-4	802E0002	Switch, SPST Momentary	1	PB1
-5	240E0375	Connector, 8 Position Dual Row .025 Sq.	1	J3
-6	240E0283	Connector, 6 Position .025 Sq.	1	J4

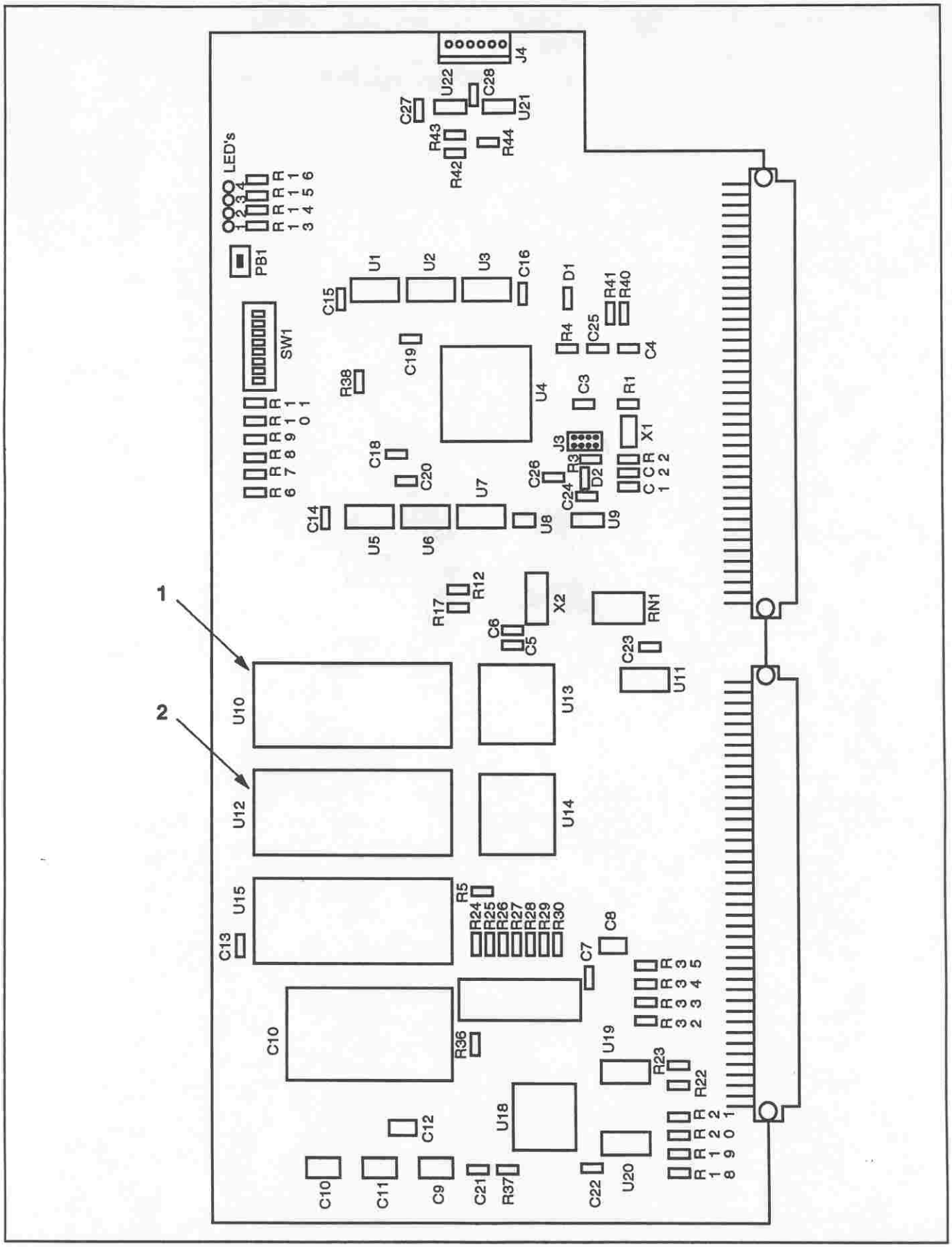
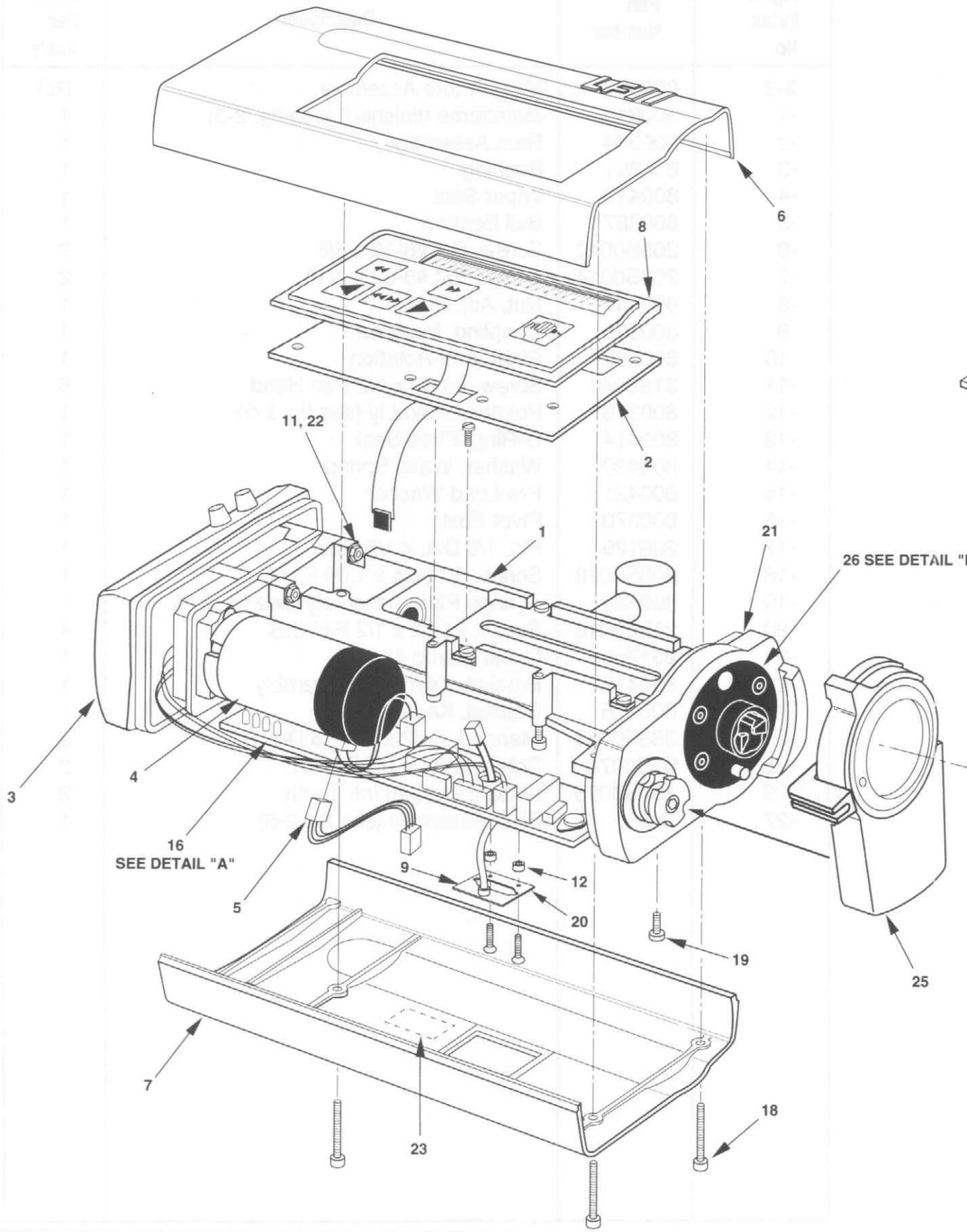


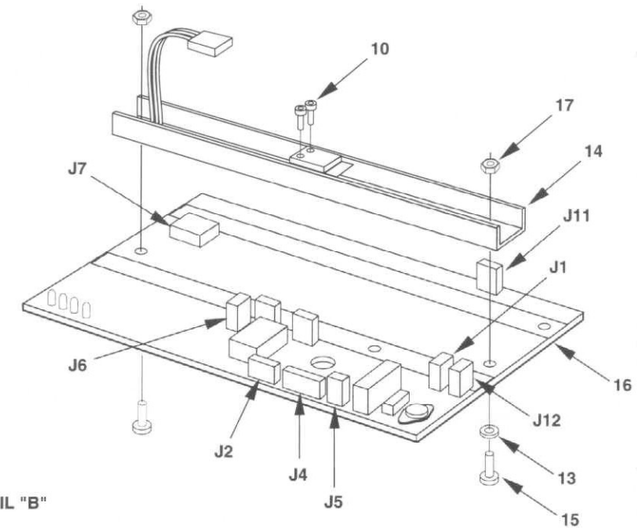
Fig. 1-4 PCB Assembly, CPU (800902)

Section II

POWERHEAD ASSEMBLY

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-1	800031	Powerhead Assembly	Ref.	
-1	800392	Main Frame Assembly (see fig. 2-2)	1	
-2	800412	Bracket, Keyboard Assembly (see fig.2-2)	1	
-3	800384	End Cap Assembly (see fig. 2-5)	1	
-4	800398	Motor and Encoder Assembly (see fig. 2-8)	1	
-5	800924	Harness Assembly, Motor Encoder	1	
-6	800313	Top Cover, Finished	1	
-7	800408	Bottom Cover Assembly	1	
-8	800904	Keyboard, 200 ml	1	
-9	800409	Connector Plate Assembly	1	
-10	245S0043	Screw, #2-56 x 1/4 S.H.Cap	2	
-11	800448	Washer, #8 Rubber	8	
-12	388E0084	Spacer, #8 Clearance x 1/4"	2	
-13	137S0009	Washer, #2 Lock	2	
-14	800928	Pot Assembly, Slide	1	
-15	31S0100	Screw, #2-56 x 5/16 P.H.	2	
-16	800909	P.C.B. Assembly, Head (See fig. 2-9)	1	
-17	32S0017	Nut, #2-56 Hex	2	
-18	245S0054	Screw, #8-32 x 1-1/2 S.H.C.S.	6	
-19	31S0045	Screw, #6-32 x .25 Flat Pan	2	
-20	31S0075	Screw, #6-32 x 5/8 Flat P.H.	2	
-21	262024	Gasket Material	A.R.	
-22	501859	Nut, Nylok, #8-32 Hex	4	
-23	800450	Part & Serial Number	1	
-24	800114	Heater Blanket Assembly	1	
-25	800050	Pressure Jacket Assembly, 200 ML (See fig. 2-10)	1	
	800040	Pressure Jacket Assembly, 125 ML (See fig. 4-1)	1	
-26	800399	Syringe Plate Assembly	Ref.	
-27	800369	Plate, Syringe	1	
-28	800912	Hall Effect Sensor Assembly	1	
-29	800431	Pin, 1/4 x 3/8 Lg., SS	1	
-30	257043	Loctite Screwlock	A.R.	
-31	800429	Gasket, 1-3/4" O.D. x 1-1/4 x .03 Thk.	1	
-32	800098	Syringe Assembly, Disposable, 200 ml	1	





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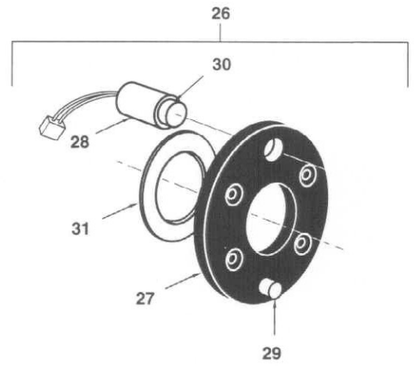

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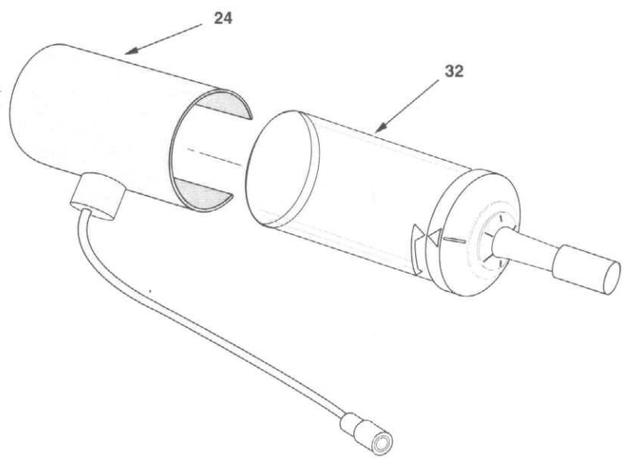

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Fig. 2-1 Powerhead Assembly (800031)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-2	800392	Main Frame Assembly	Ref.	
-1	800310	Mainframe (finished) (see fig. 2-3)	1	
-2	800394	Ram Assembly	1	
-3	800391	Bushing	1	
-4	800413	Wiper Seal	1	
-5	800387	Ball Bearing	1	
-6	205S0012	Screw, Set #8-32 x 3/8	2	
-7	205S0014	Screw, Set #8-32 x 3/16	2	
-8	800447	Nut, Adj. Clamp	1	
-9	800396	Coupling, Modified	1	
-10	800380	Plate, Anti-Rotation	1	
-11	31S0041	Screw, #6-32 x 1/2 Pan Head	6	
-12	800378	Pointer Assembly (see fig. 2-9)	1	
-13	800414	O-Ring, Plate Seal	1	
-14	800420	Washer, Wave Spring	1	
-15	800421	Pre-Load Washer	1	
-16	800370	Pivot Post	1	
-17	206129	Pin, 1/8 Dia. x 1/5 Roll	1	
-18	208S0028	Screw, 5/16-24 x 1.00 F.H.C.S.	1	
-19	800399	Syringe Plate Assembly (see fig. 2-1)	1	
-20	252S0016	Screw, #8-32 x 1/2 F.H.C.S.	4	
-21	251768	Cable Clamp #6	1	
-22	800412	Bracket, Keyboard Assembly	1	
-23	800376	Bracket, Keyboard	1	
-24	388E0083	Standoff, 6-32 x 1 x .25 Dia. S.S.	2	
-25	31S0076	Screw, 6-32 x 1/2 SL.F.H.	2	
-26	137S0006	Lockwasher, #6 Int. Tooth	2	
-27	Ref.	Pivot Assembly (see fig. 2-5)	1	

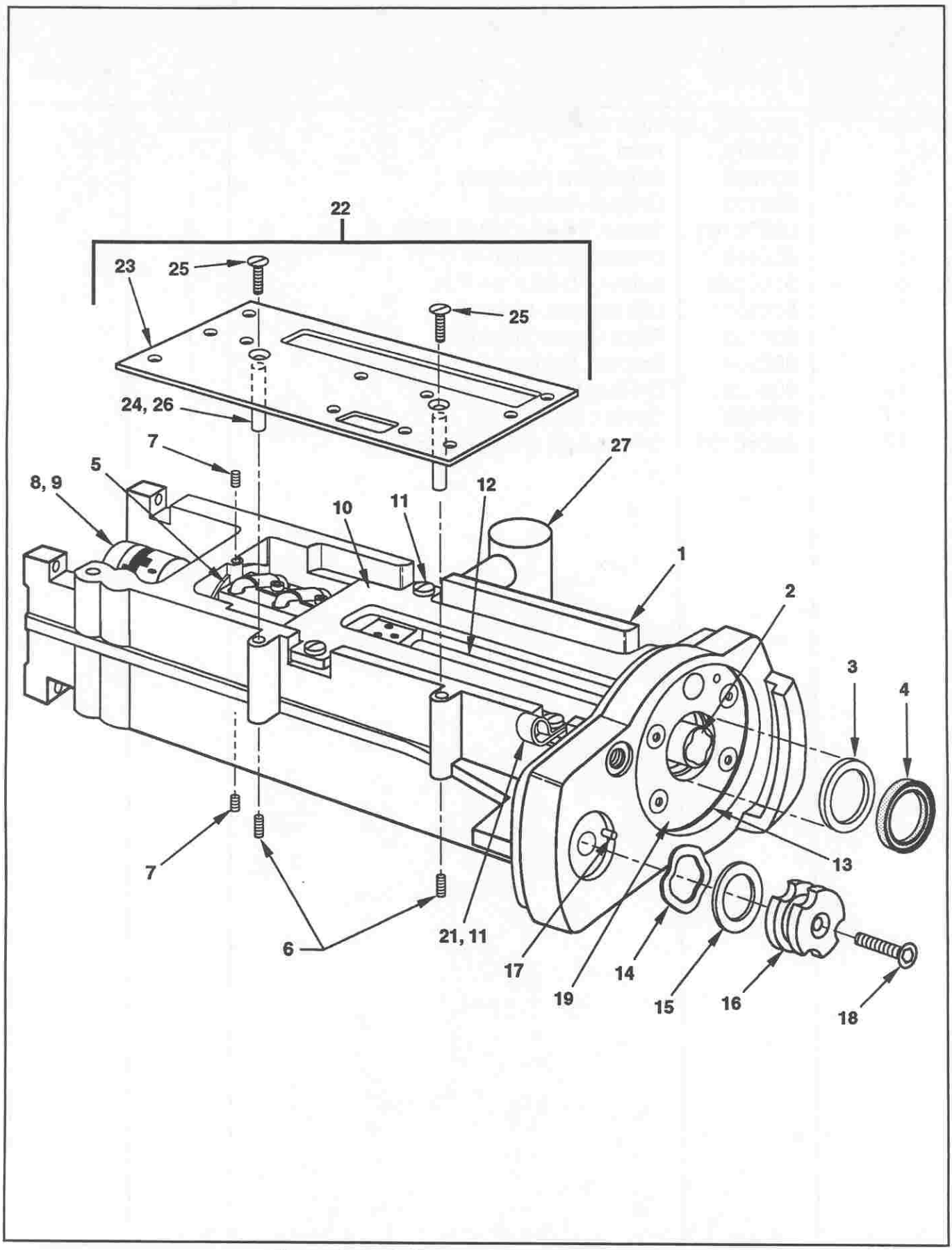


Fig. 2-2 Main Frame Assembly (800392)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-3	800394	Ram Assembly	Ref.	
-1	800374	Ram	1	
-2	800252	Ball Screw Assembly	1	
-3	800393	Gripper Assembly	1	
-4	282S0101	Screw, #4-40 x 3/8 S.H.C.S.	2	
-5	800415	Bracket, Actuator	1	
-6	31S0045	Screw, #6-32 x 1/4 P.H.	2	
-7	800362	Left Gripper, Molded	1	
-8	800363	Right Gripper, Molded	1	
-9	800364	Bracket, Gripper	1	
-10	800428	O-Ring, Gripper	1	
-11	800498	Spacer, Ram	1	
-12	282S0103	Screw, 2-56 x 3/16 P.R.F.H.	1	

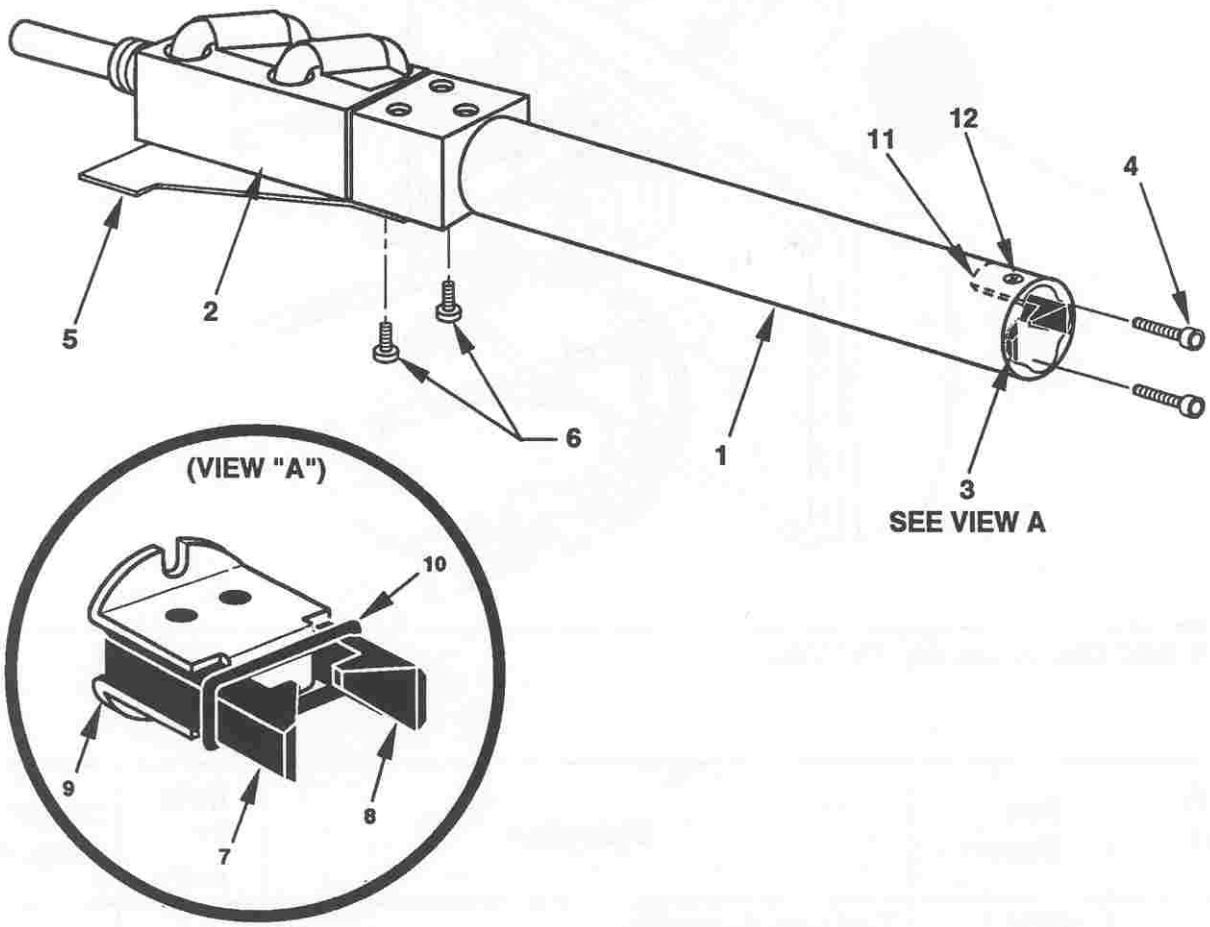


Fig. 2-3 Ram Assembly (800394)

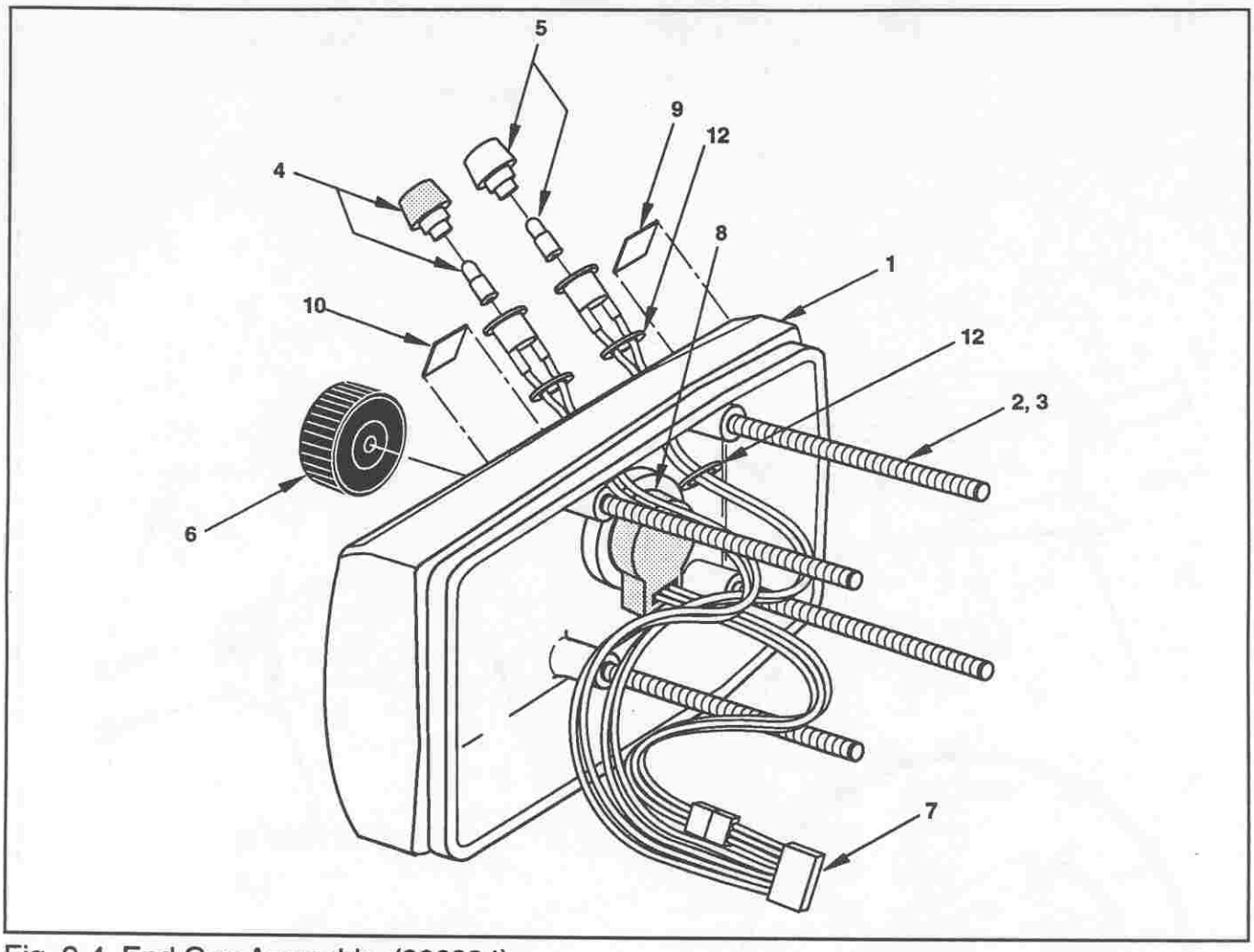


Fig. 2-4 End Cap Assembly (800384)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-4	800384	End Cap Assembly	1	
-1	800312	Endcap, Finished	1	
-2	800419	Stud, 8-32 x 2-3/4 Long	4	
-3	257047	Loctite, Screwlock	A.R.	
-4	540E0021	Lamp Assembly, Incandescent, Clear	1	
-5	540E0022	Lamp Assembly, Incandescent, Amber	1	
-6	800385	Knob, Encoder	1	
-7	800925	Harness Assembly, Lights and Encoder	1	
-8	800929	Assembly, Encoder	1	
-9	800479	Label, Powerhead Injecting Light I.D.	1	
-10	800480	Label, Powerhead Injecting Light I.D.	1	
-11	544E0024	Incandescent Lamp, Miniature	2	
-12	800501	Lockwasher	4	

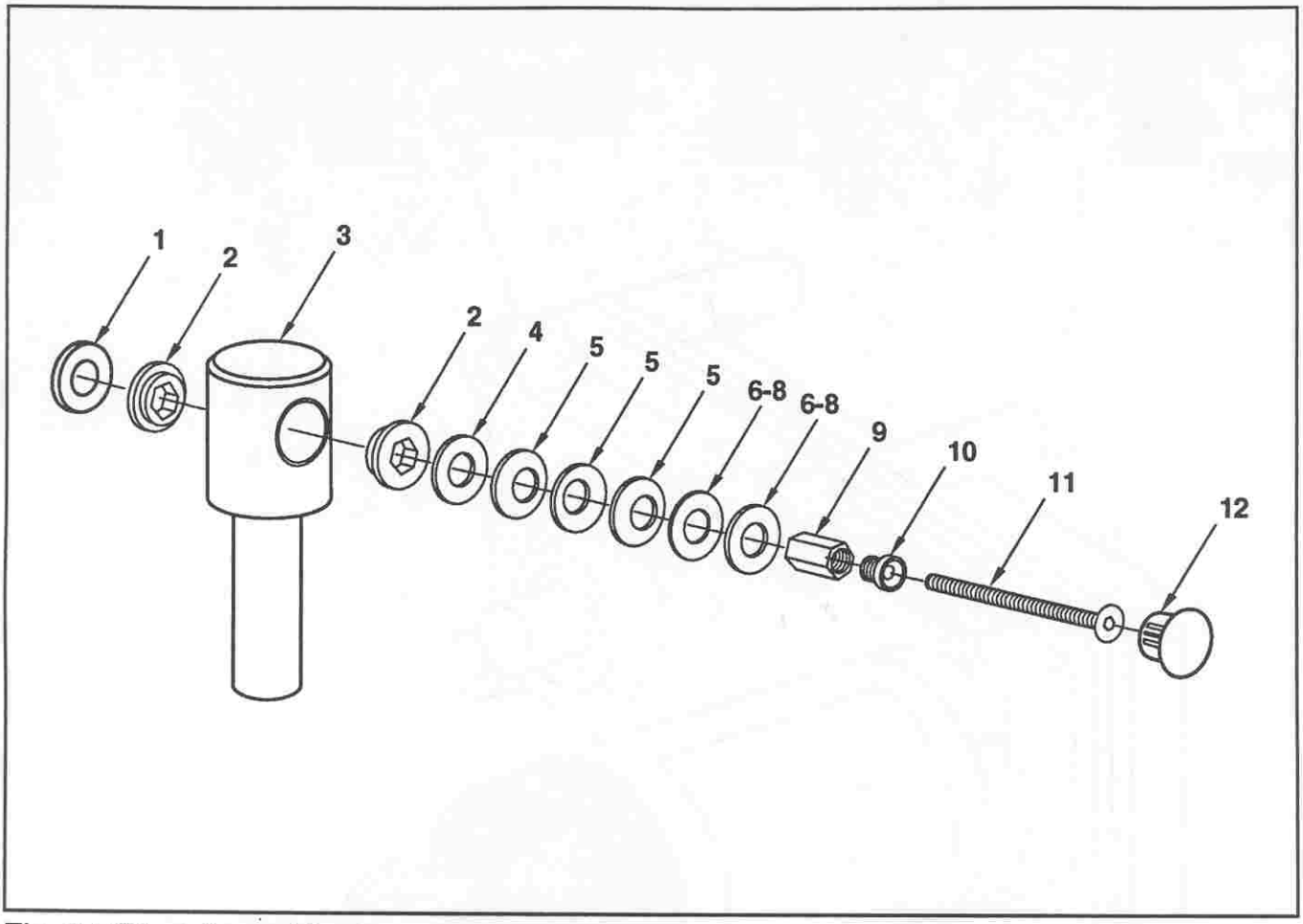


Fig. 2-5 Pivot Assembly

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-5	Ref.	Pivot Assembly	Ref.	
-1	800430	Washer, 1/4 Flat Steel .75 O.D.	1	
-2	600423	Hex Washer	2	
-3	800322	Pivot, Machined	1	
-4	600659	Thrust Race	1	
-5	600660	Washer, Bell Spring	3	
-6	301666	Washer, .031 Thick	A.R.	
-7	222409	Washer, .010 Thick	A.R.	
-8	300966	Washer, .003 Thick	A.R.	
-9	800439	Hex Shaft	1	
-10	300390	Shoulder Shaft	1	
-11	252S0046	Screw, 1/4-20 x 2" Flat Head Socket	1	
-12	800323	Plug, Hole Nylon	1	

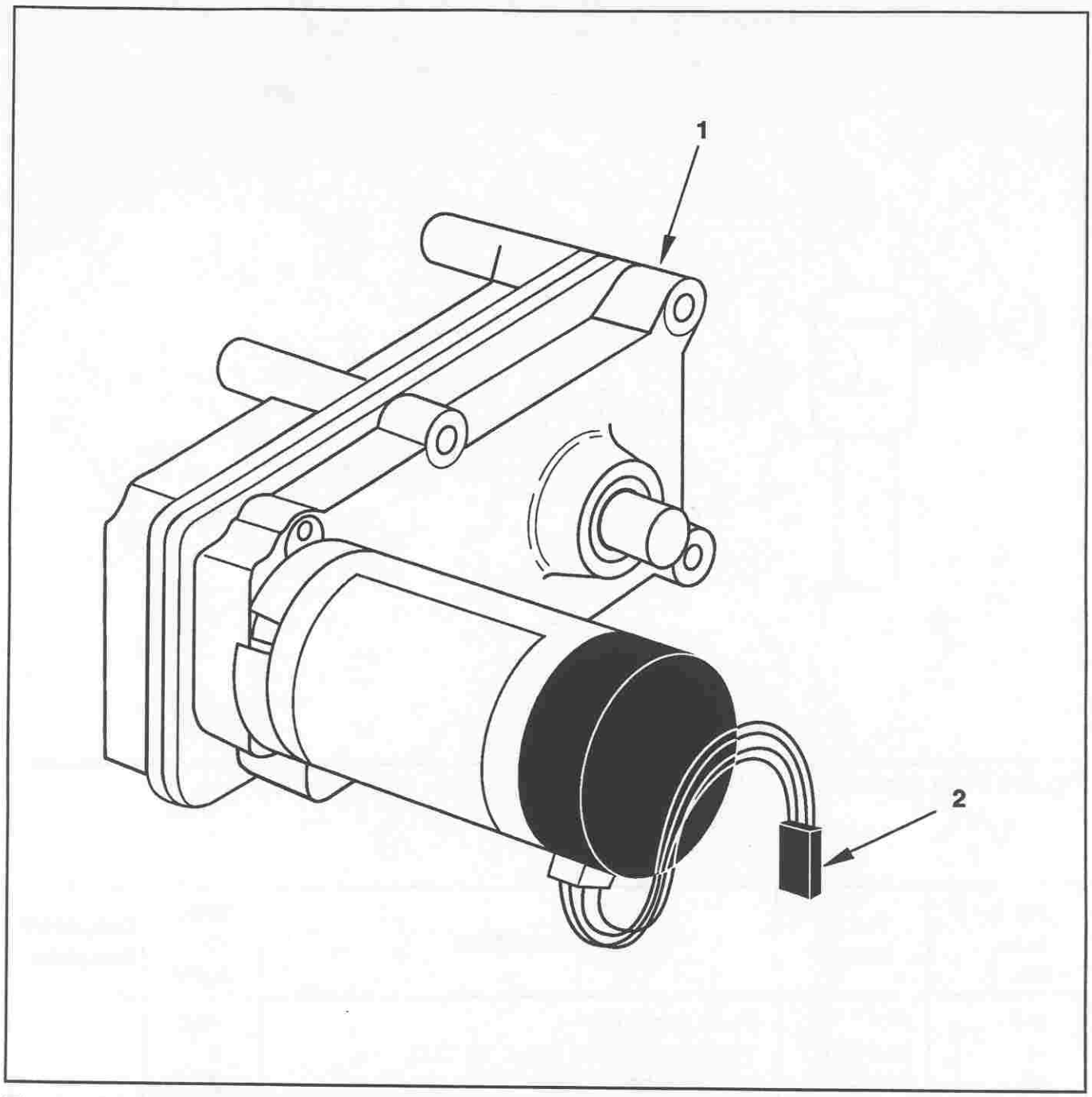


Fig. 2-6 Motor & Encoder Assembly (800398)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-6	800398	Motor & Encoder Assembly	Ref.	
-1	800390	Motor, Gearbox & Encoder	1	
-2	240E3027	Connector, 2 pos. MTE	1	

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-7	800378	Pointer/Positioner Assembly	Ref.	
-1	800910	P.C.B. Assembly, Pointer	1	
-2	257489	Resin Core Solder	A.R.	
-3	800434	Shoulder Screw, 6-32 x 1/2	3	
-4	800379	Bracket, Pointer Indicator	1	
-5	31S0059	Screw, 4-40 x 1/4 P.H.	2	
-6	257784	Sheathing, Mesh	7"	
-7	800425	Flex Steel Strip	1	
-8	800427	P.C.B. Carrier	1	
-9	257600	Tubing, Heat Shrink	2"	
-10	31S0193	Screw, #6-32 x 2" P.R.	1	
-11	221538	Nut, Nylok #6-32 Hex	1	
-12	32S0013	Hex Nut, #6-32	2	
-13	240E3037	Connector, 3 Position MTE	1	
-14	31S0045	Screw, #6-32 x 1/2 P.H.	2	
-15	137S0006	Washer, #6 Internal Tooth Lock	2	
-16	41S0006	Washer, #6 Flat Steel	2	
-17	800449	Mount, Wire Holder	1	
-18	256565	Ribbon Cable, 5 Conductor	1.5'	
-19	262024	Gasket, 1/8 x .06	.87"	
-20	800443	Mask, Pointer Assembly	1	
-21	800487	Spacer, Pointer LED	1	
-22	800418	Mounting Block, Position Pointer	1	

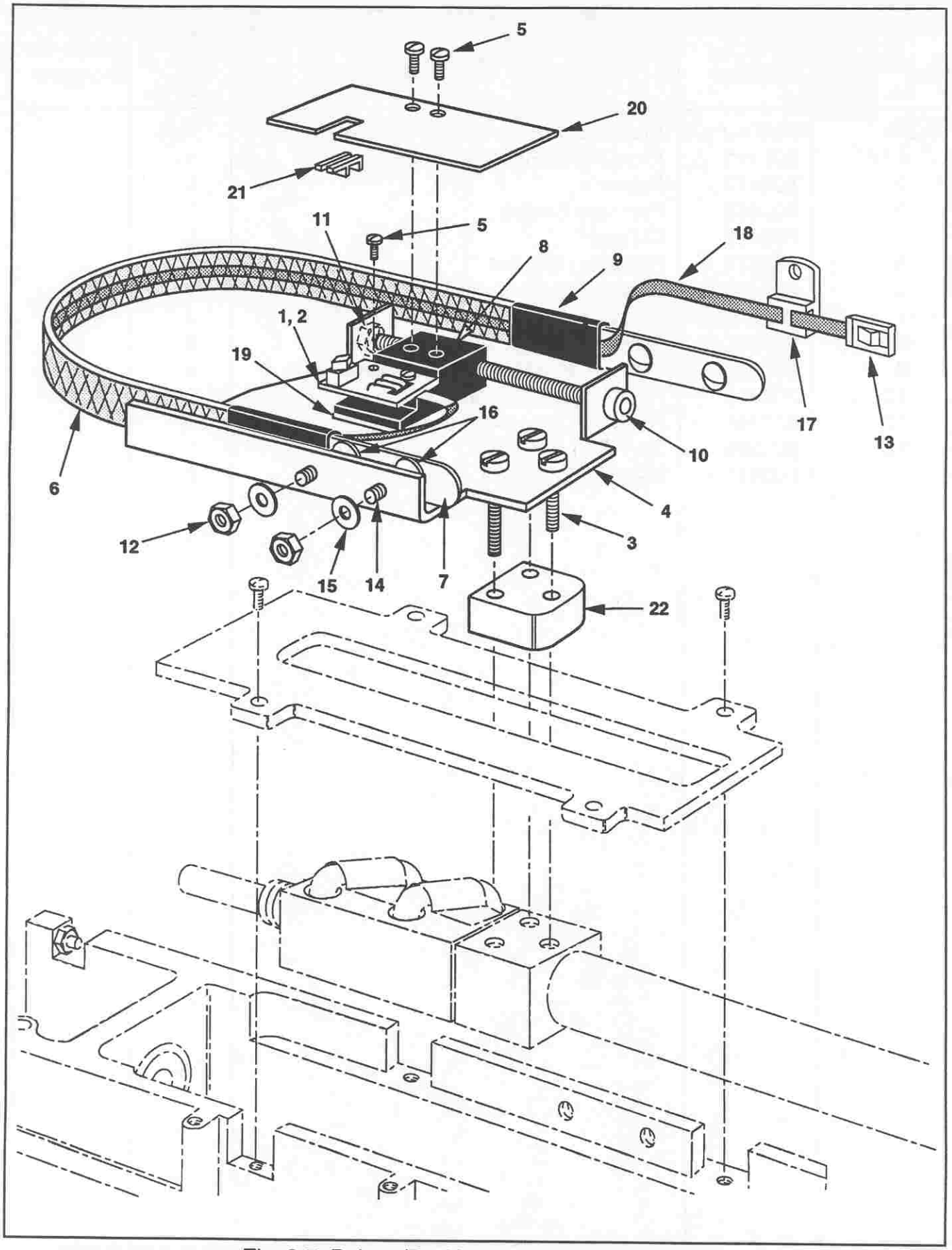


Fig. 2-7 Pointer/Positioner Assembly (800378)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-8	800040	Pressure Jacket Assembly, 200 ml	Ref.	
-1	800311	Front Plate, Finished	1	
-2	800417	Detent	1	
-3	800366	Pressure Sleeve	1	
-4	800422	O-Ring	1	
-5	800371	Retaining Washer	3	
-6	800486	Screw, #10-32 Special	1	
-7	282S0073	Screw, #10-32 x 5/16 Lg. Truss Hd.	4	
-8	208S0019	Screw, #10-32 x 1/2 Lg. Soc.Flat Hd.	3	
-9	800500	Washer, #10 Flat Stainless Steel	2	
-10	800410	Rotating Cam Assembly	Ref.	
-11	800361	Rotating Cam, Molded	1	
-12	800368	Spring	1	
-13	800411	Magnet, .25 O.D. x .25	1	

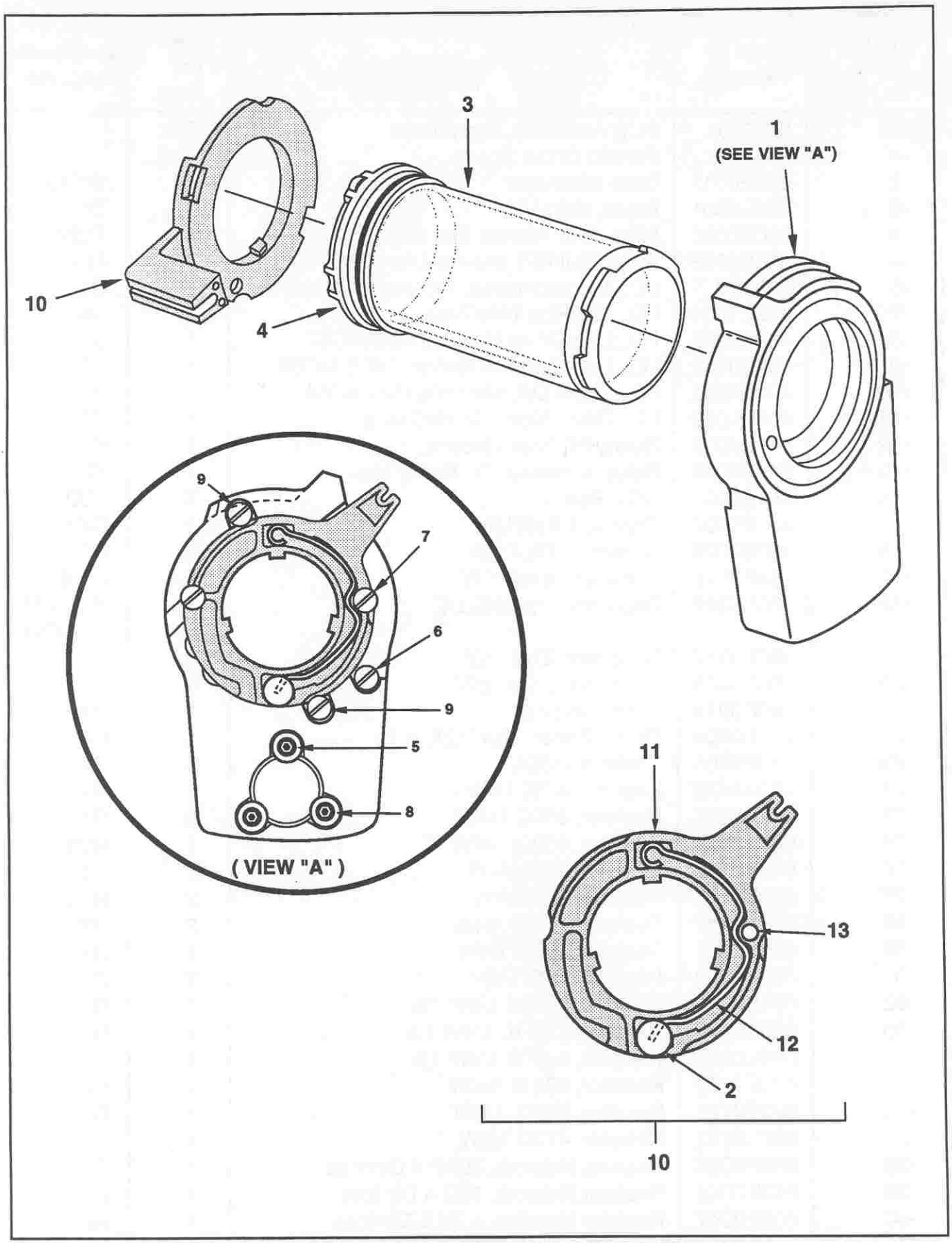


Fig. 2-8 Pressure Jacket Assembly, 200 ml (800040)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
2-9	800909	PCB Assembly, Powerhead	Ref.	
-1	Ref.	Printed Circuit Board	Ref.	
-2	602E0017	Opto-Interrupter	2	INT1,2
-3	280E0001	Diode, IN914	1	D4
-4	330E0002	Filter, EMI Murata Erie #DSS310	8	FL2-9
-5	330E0003	Filter, EMI/RFI Murata Erie #DSS710	1	FL1
-6	800934	I.C., Microcomputer, Programed Motorola	1	U1
-7	492E1504	I.C., Flip-Flop 74HC109	1	U4
-8	490E0060	I.C., Line Driver National #DS34C87	1	U3
-9	490E0032	I.C., Line Receiver National #DS34C86	1	U5
-10	490E0058	I.C., Reset LVI, Motorola #MC34064	1	U6
-11	490E0049	I.C., Driver Motorola #MC1416	1	U2
-12	640E0039	Relay, PC Board Mount	1	K1
-13	640E0073	Relay, Minature, PC Board Mount	1	K2
-14	544E0001	LED, Red	6	LED1-6
-15	331E0007	Crystal, 4.9152Mhz	1	CX1
-16	190E0020	Capacitor, 22µf,16V	1	C1
-17	188E5016	Capacitor, 47µf, 50V	2	C3,6
-18	180E3016	Capacitor, .1µf, 50VDC	13	C2,5,C9-16, C18-C20
-19	180E3517	Capacitor, 27pf,1KV	2	C7,8
-20	190E0023	Capacitor, 2.2µf, 25V	1	C4
-21	280E0014	Diode, 1N5418	1	D2
-22	282E0004	Diode, Zener 1N4732A, 4.7V	1	D3
-23	280E0008	Diode, 1N4004	1	D1
-24	680E2472	Resistor, 4.7K 1/4W	1	R7
-25	680E2391	Resistor, 390Ω 1/4W	3	R5,6,25
-26	680E2101	Resistor, 100Ω 1/4W	1	R26
-26	680E2106	Resistor, 10M 1/4W	1	R8
-28	680E2103	Resistor, 10K 1/4W	2	R10,12
-29	680E2181	Resistor, 180Ω 1/4W	2	R23,24
-30	680E2221	Resistor, 220Ω 1/4W	1	R27
-31	680E2100	Resistor, 10Ω 1/4W	2	R16,17
-32	686E0048	Resistor, 1.15 K 1/4W 1%	1	R1
-33	686E0126	Resistor, 1.65 K 1/4W 1%	1	R18
-34	686E0127	Resistor, 4.87 K 1/4W 1%	1	R4
-35	680E0128	Resistor, 866 K 1/4W	1	R2
-36	680E0129	Resistor, 243Ω 1/4W	1	R3
-37	692E2471	Resistor, 470Ω 1/2W	1	R11
-38	692E0036	Resistor Network, 390Ω 4 Devices	1	RN4
-39	692E0044	Resistor Network, 10Ω 4 Devices	1	RN3
-40	692E0041	Resistor Network, 4.7K 4 Devices	1	RN2

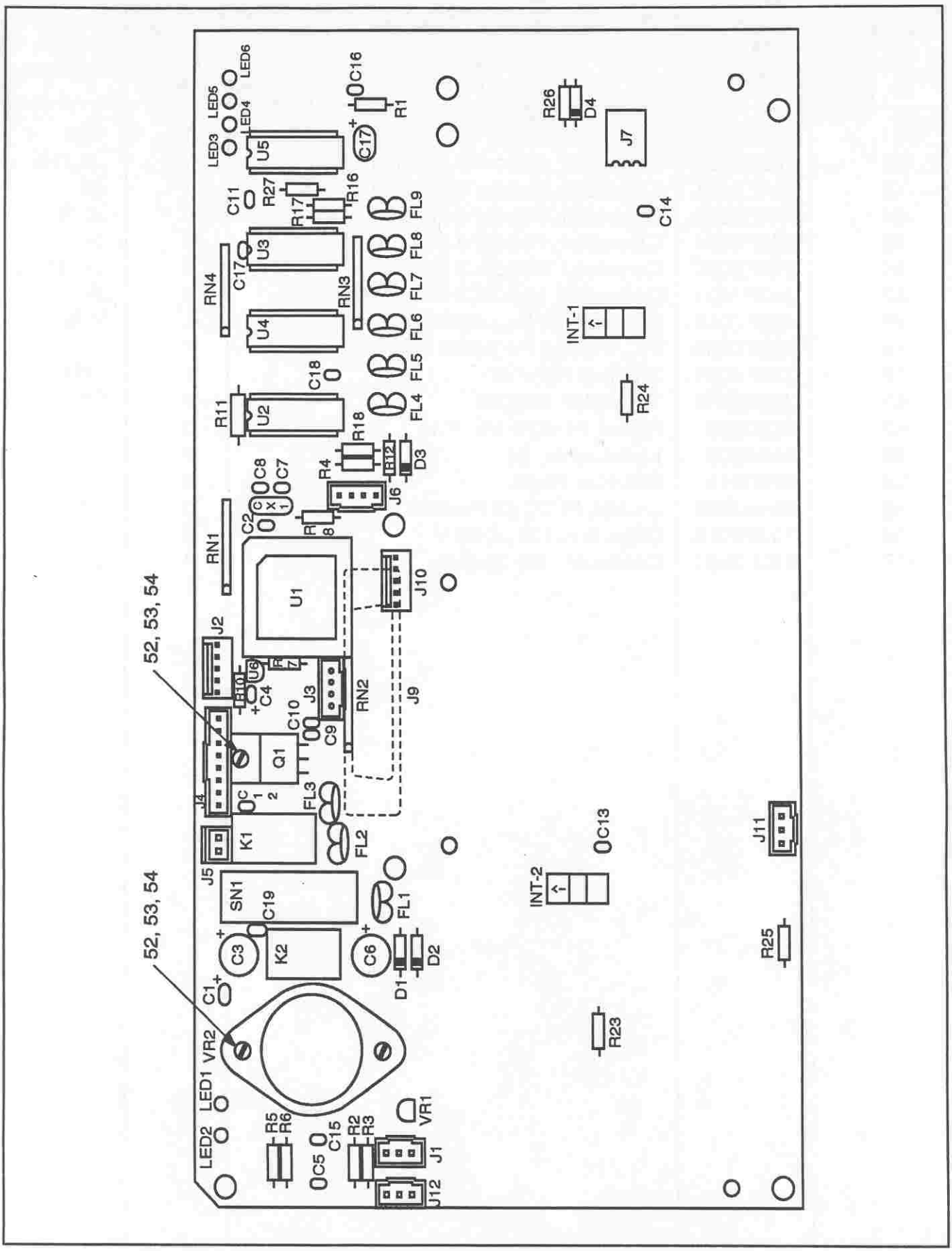


Fig. 2-9 PCB Assembly, Powerhead (800909)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
-41	692E0034	Resistor Network, 4.7K 9 to Common	1	RN1
-42	240E0302	Connector, Header 5 Position	2	J2,J10
-43	240E3021	Connector, Header 2 Position	1	J5
-44	240E3026	Connector, Header 4 Position	4	J6,3,
-45	240E3024	Connector, Header 8 Position	1	J4
-46	240E3036	Connector, Header 3 Position	3	J1,J11-12
-47	240E1531	Connector, Header 3 Pos. Right Angle	1	J7
-48	490E0019	I.C., Voltage Regulator 7805	1	VR2
-49	490E0066	I.C., Voltage Regulator LM317	1	VR1
-50	330E0001	Snubber Network	1	SN1
-51	760E0055	Transistor, 2N6041	1	Q1
-52	31S0059	Screw, #4-40 x 1/4 P.H.	3	
-53	23S0008	Lockwasher, #4	3	
-54	32S0015	Nut, Hex #4-40	3	
-55	384E0034	Socket, PLCC 52 Position	1	V1
-56	190E0016	Capacitor, 100 µf, 20 V	1	C17
-57	240E0384	Connector, DB-25 Male	1	J9

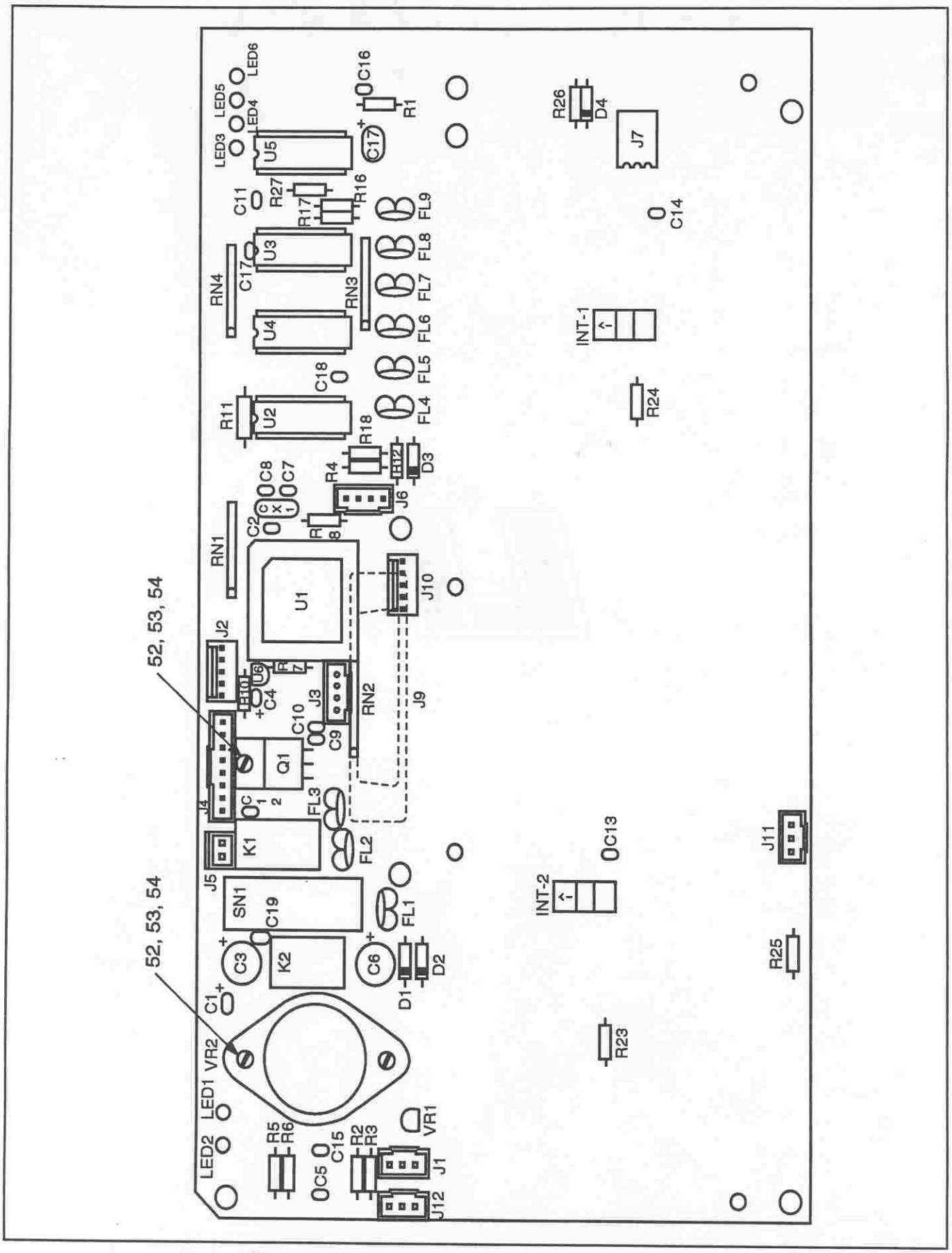
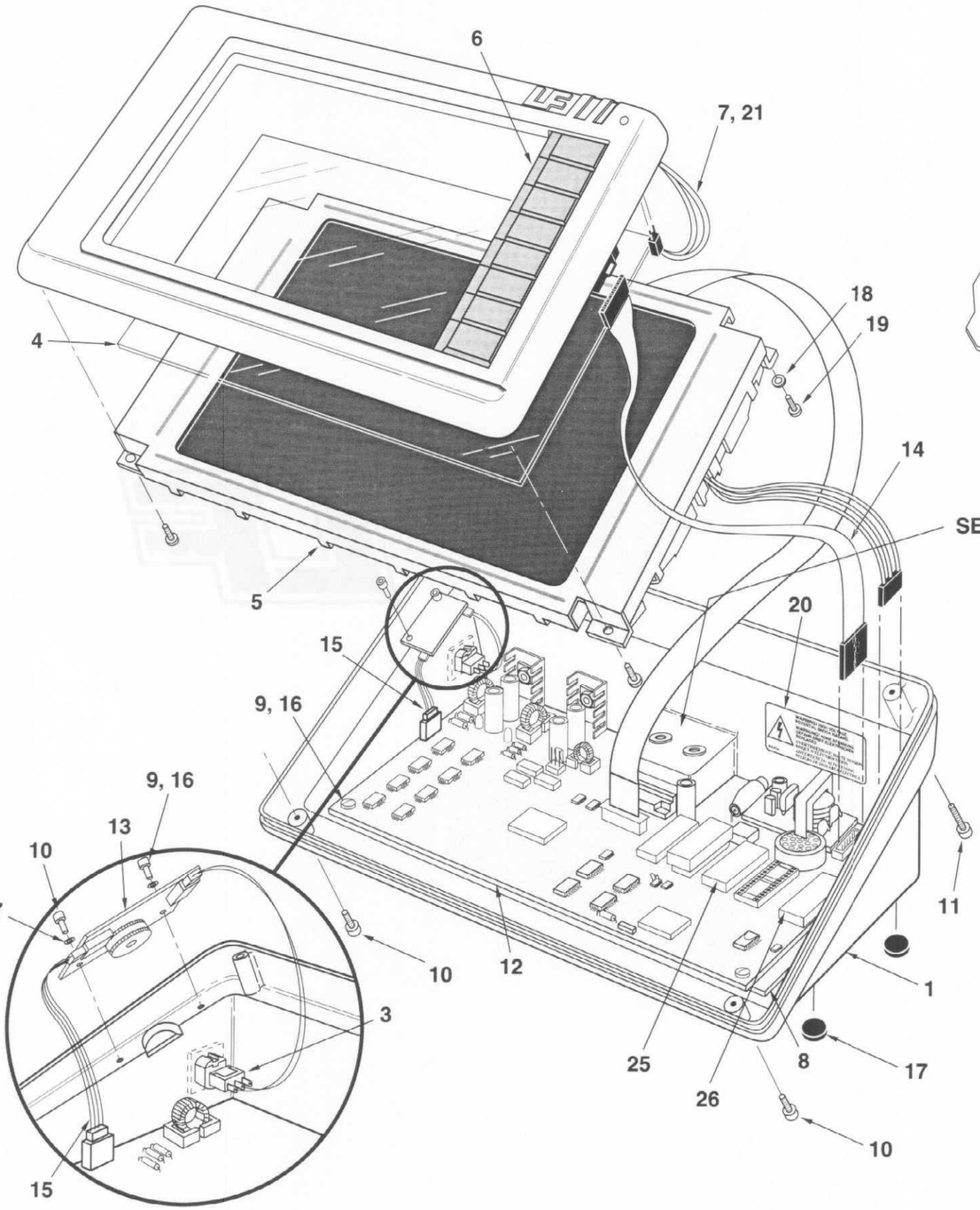


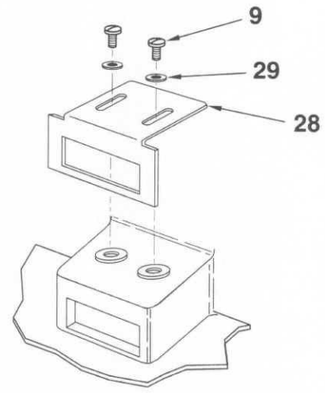
Fig. 2-9 PCB Assembly, Powerhead (800909)

Section III

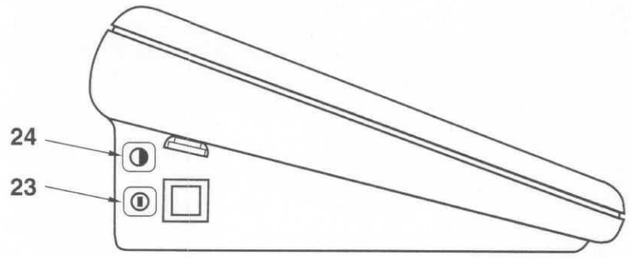
CONSOLE ASSEMBLY

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
3-1	800011	Console Assembly	Ref.	
-1	800294	Base, Console, Painted	1	
-2	800289	Bezel, Painted	1	
-3	800921	Switch Assembly, On/Off	1	
-4	800253	LCD Lens, Console, Anti-Glare	1	
-5	304E0001	Display, Flat Panel	1	
-6	800903	Key-Board, Console	1	
-7	800926	Power Light Assembly, Console	1	
-8	800405	Insulator, PCB	1	
-9	31S0045	Screw, #6-32 x 1/4 Pan Head	10	
-10	245S0038	Screw, #6-23 x 5/8 S.H. Cap	2	
-11	245S0058	Screw, #6-32 x 1-1/8 S.H. Cap	2	
-12	800907	PCB Assembly, Console	1	
-13	800920	Pot, Thumbwheel Type, 10k	1	
-14	800922	Harness Assembly., Key-Board	1	
-15	800923	Harness Assembly, Pot & On/Off Switch	1	
-16	137S0006	Washer, #6, Lock Internal Tooth	8	
-17	800446	Foot, Rubber	4	
-18	23S0006	Washer, #6 Lock	4	
-19	31S0043	Screw, #6-32 x 3/8 Pan Head	4	
-20	800454	Label, High Voltage Warning	1	
-21	257004	Black Silicon Rubber	A.R.	
-22	800450	Label, Part & Serial Number	1	
-23	800482	Label, Push On/Off switch	1	
-24	800481	Label, Viewing Angle	1	
-25	800930	Software, Console Fonts	1	
-26	800931	Software, Console Program	1	
-27	388E0035	Washer, Nylon	2	
-28	800254	Rear Connector Plate	1	
-29	41S0006	Washer, #6 Flat	2	

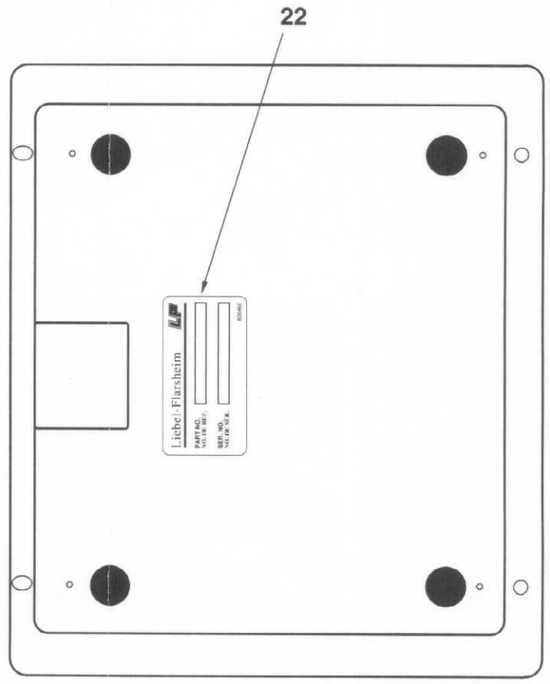




VIEW "A"



SIDE VIEW



BOTTOM VIEW

Fig. 3-1 Console Assembly (800011)

Section IV

OPTIONS & ACCESSORIES

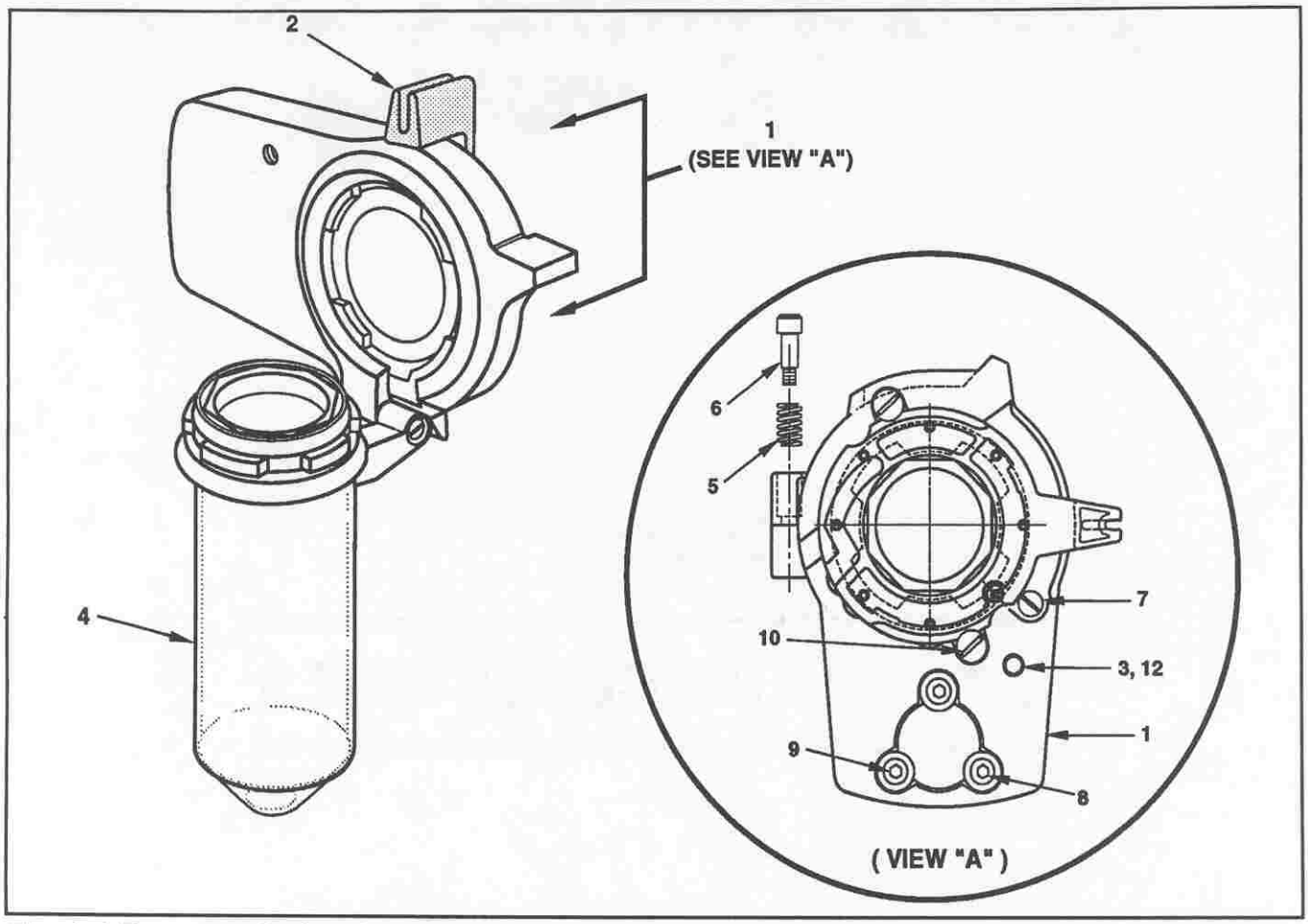


Fig. 4-1 Pressure Jacket Assembly, 125 ML (800050)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-1	800050	Pressure Jacket Assembly, 125 ML	Ref.	
-1	800047	Front Plate, Finished	1	
-2	800043	Rotating Cam Ass'y (see fig. 4-2)	1	
-3	800411	Magnet, Hall Effect	1	
-4	800049	Pressure Sleeve	1	
-5	800042	Pivot Friction Spring	1	
-6	800041	Screw, Shoulder 8-32 x 5/8	1	
-7	47L112	Screw, 10-32 Binding Head	1	
-8	208S0019	Screw, 10-32 Socket Flat Head	3	
-9	800371	Retaining Washer	3	
-10	282S0073	Screw, 10-32 Truss Head	2	
-11	800500	Washer, #10 Stainless Steel	2	
-12	257047	Retaining Compound	A.R.	

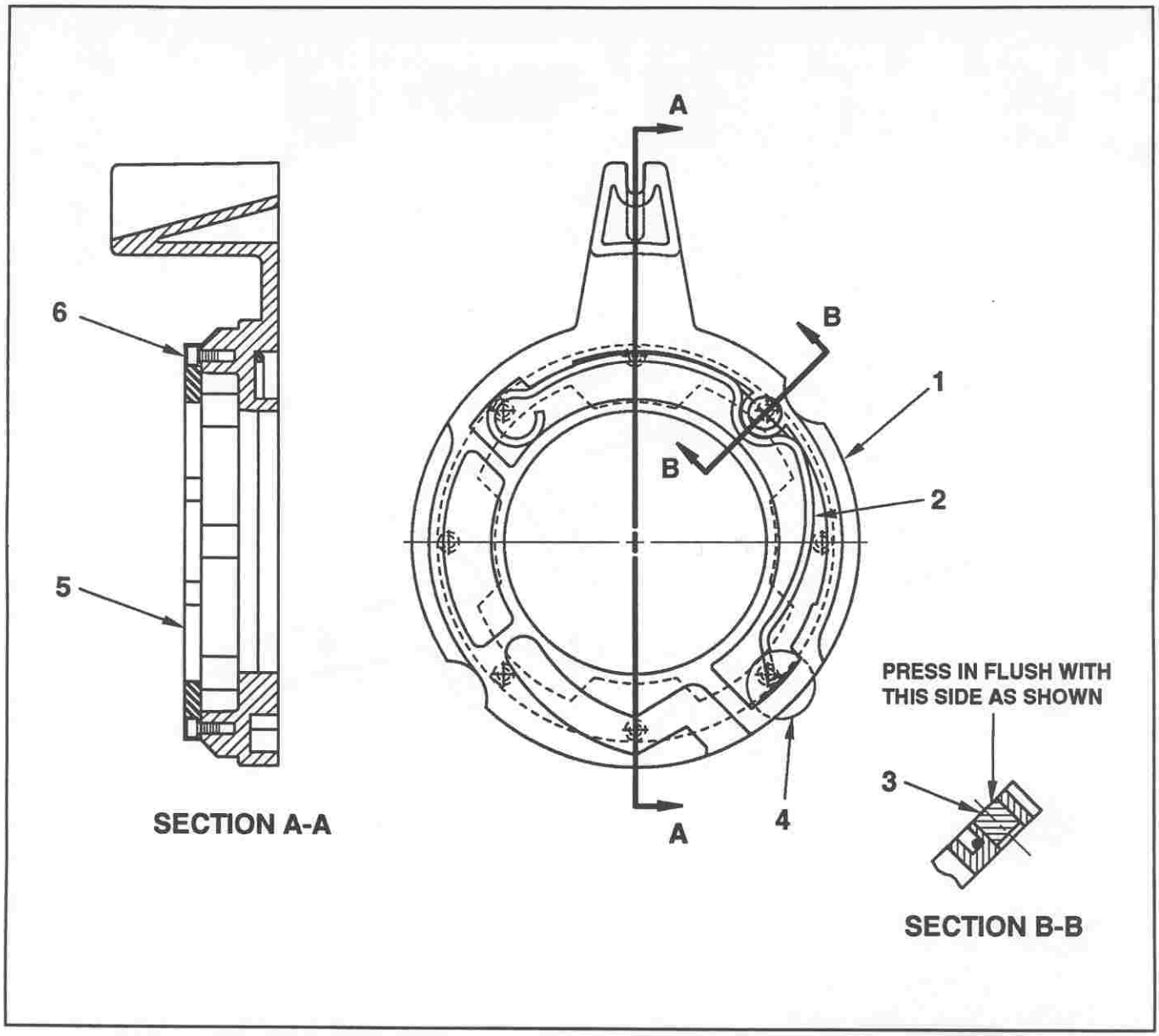


Fig. 4-2 Rotating Cam Assembly-125 ML (800043)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-2	800043	Rotating Cam Assembly-125 ML	Ref.	
-1	800048	Rotating Cam	1	
-2	800368	Spring	1	
-3	800411	Magnet, .25 O.D. x .25"	1	
-4	800417	Detent	1	
-5	800044	Locking Ring, 125 ML	1	
-6	245S0043	Screw, #2-56 x .25 S.H.C.	8	

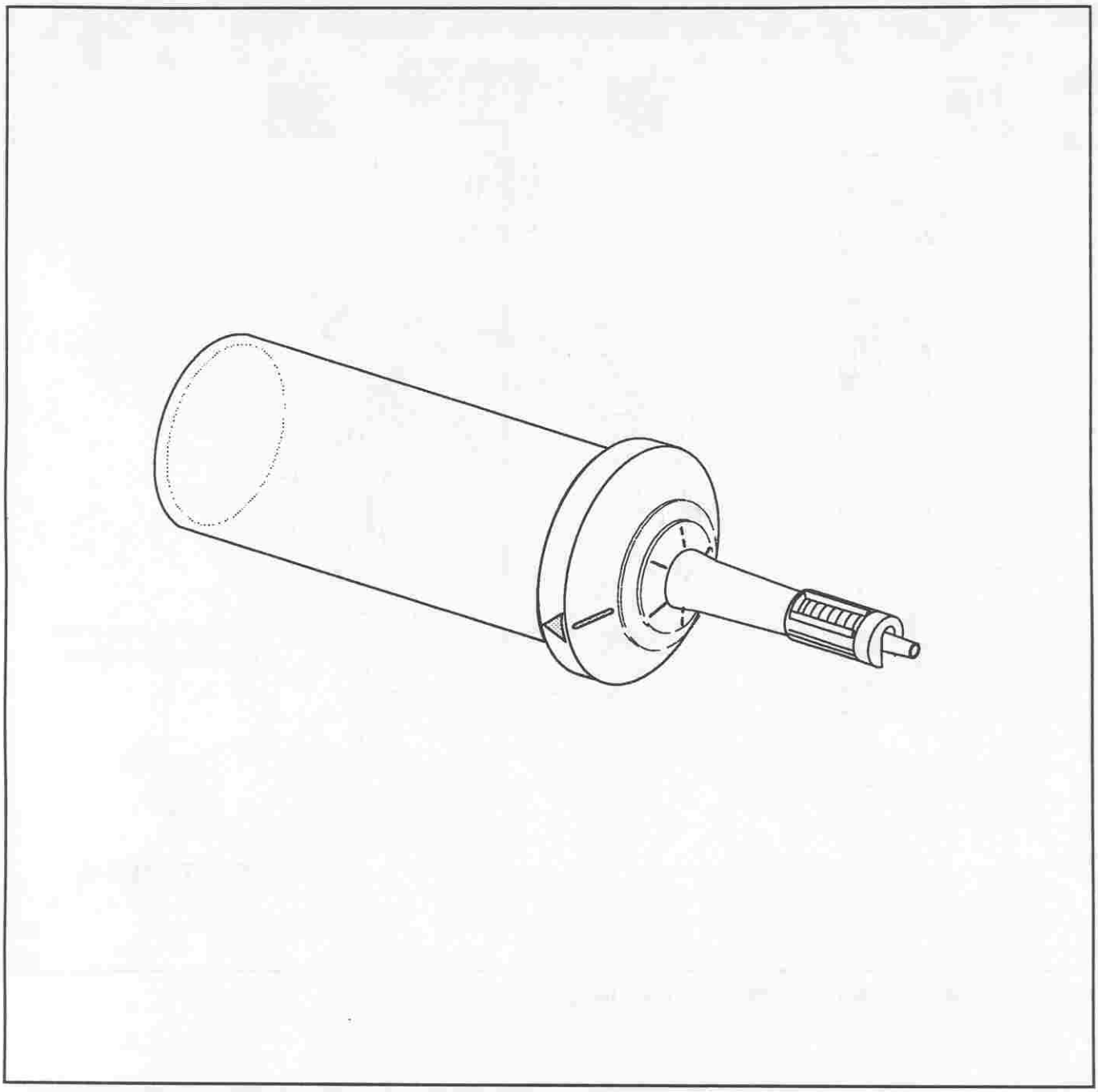


Fig. 4-3 Syringe Assembly, Disposable, 200 ml (800098)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-3	800098	Syringe Assembly, Disposable, 200 ml	Ref.	

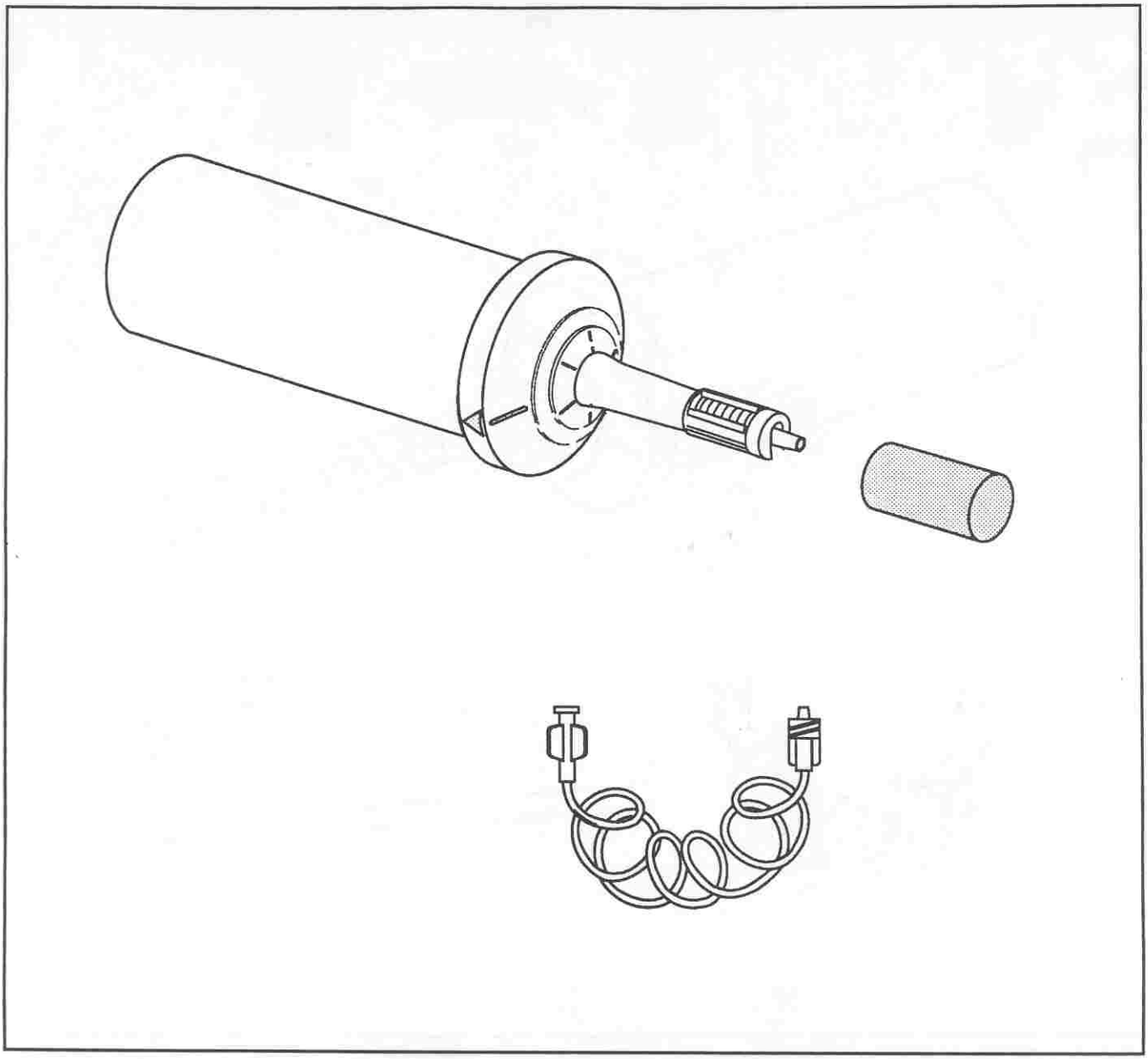


Fig. 4-4 Syringe Assembly, Disposable, 200 ml (800099)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-4	800099	CT Multi-Pak 200 ML	Ref.	
	Includes:	200 ML Syringe Assembly Disposable Filler Tube Protective Cap		

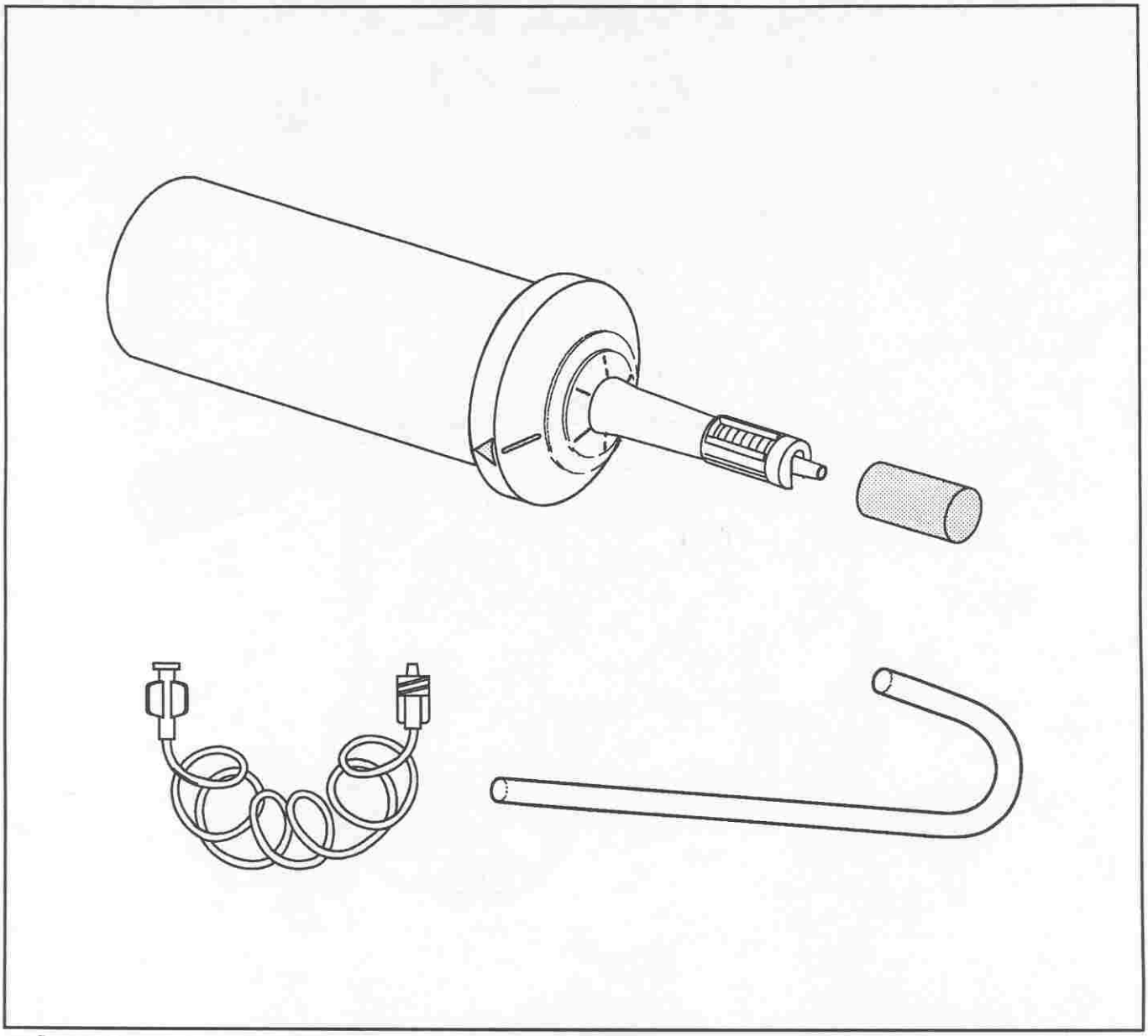


Fig. 4-5 CT Multi-Pak 200 ML (800096)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-5	800096	CT Multi-Pak 200 ML W/Handi-Fil	Ref.	
	Includes:	200 ML Syringe Assembly Coiled Tubing Disposable Filler Tube Protective Cap		

INJECTOR HEAD, POWERPACK & CONSOLE MOUNTING PARTS

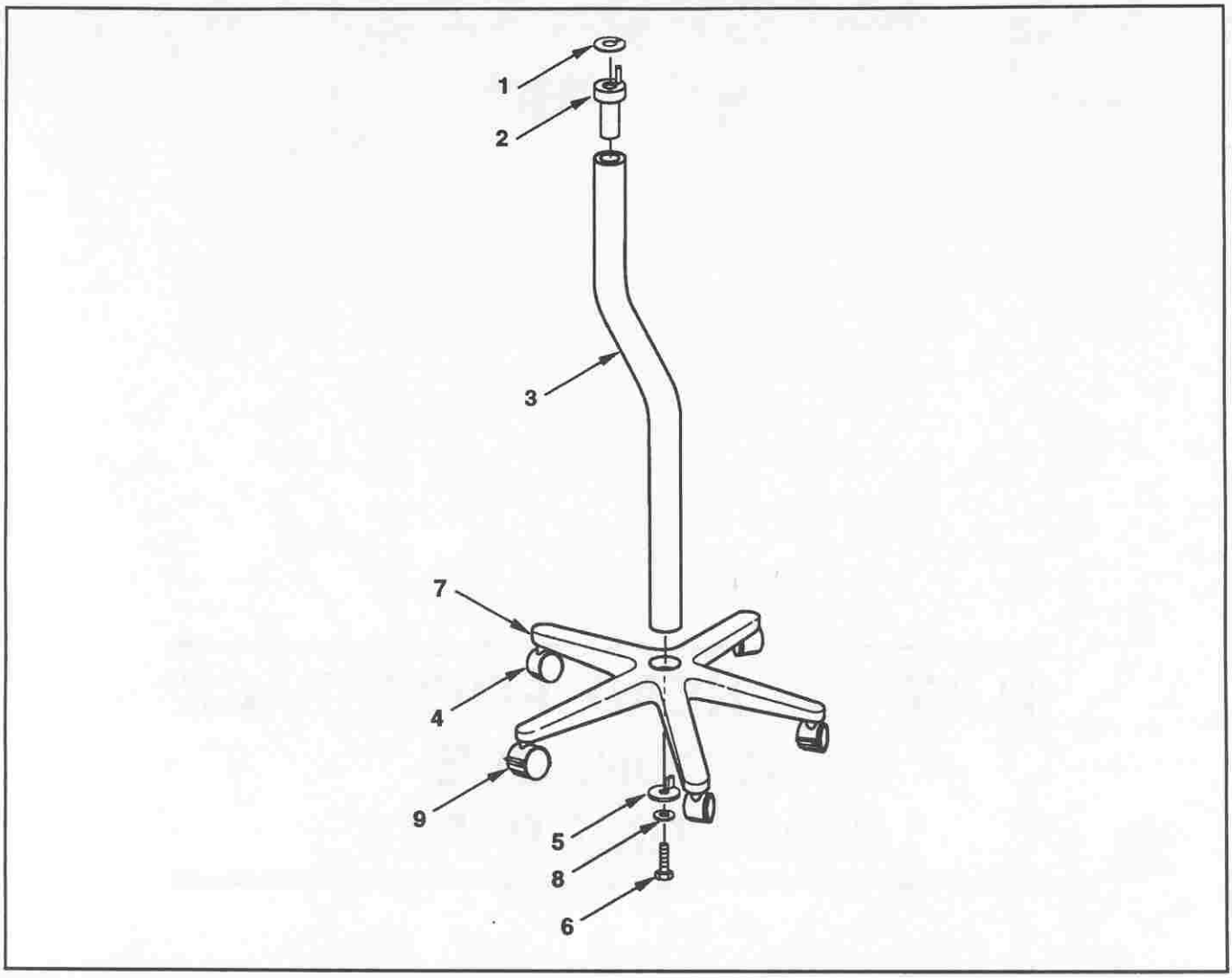
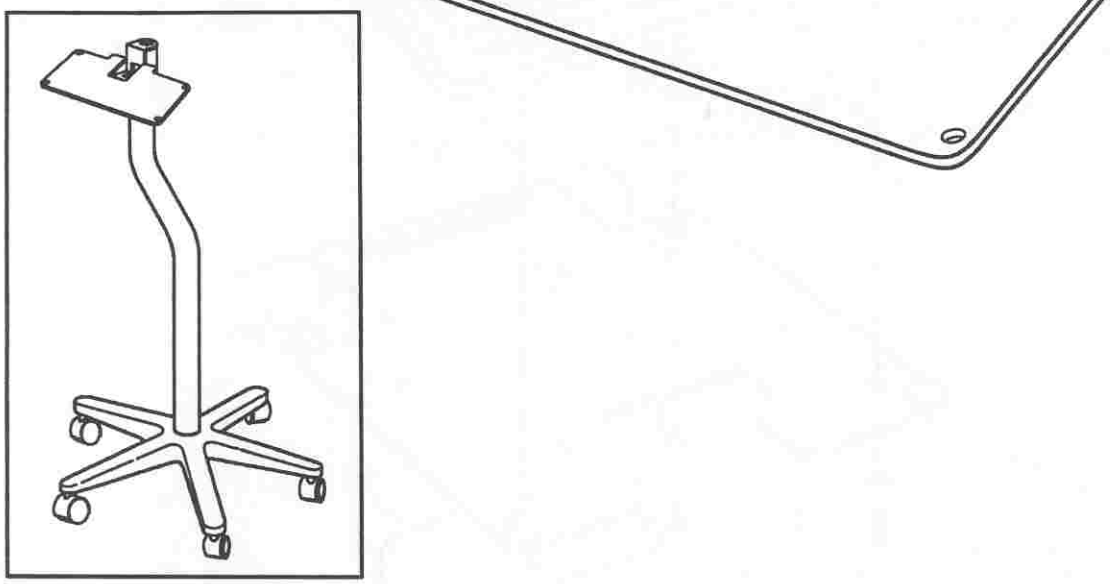


Fig. 4-6 Remote Stand Assembly (800112)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-6	800112	Remote Stand Assembly	Ref.	
-1	800455	Washer, Rubber	1	
-2	800466	Pivot Attachment Stub Assembly	1	
-3	800463	Vertical Column	1	
-4	800461	Caster	1	
-5	800458	Key Assembly	1	
-6	246S0028	Screw, 1/2-13 x 2.00 H.H. Cap	1	
-7	800465	Roller Base	1	
-8	137S0010	Washer, 1/2" Internal Tooth	1	
-9	800493	Caster, Locking	2	



BRACKET MOUNTED
ON REMOTE STAND

Fig. 4-7 Bracket, Console Remote Stand (800444)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-7	800444	Bracket, Console Remote Stand	Ref.	
-1	800478	Bracket Assembly, Remote Stand	1	
-2	800422	Bumper, Rubber	1	

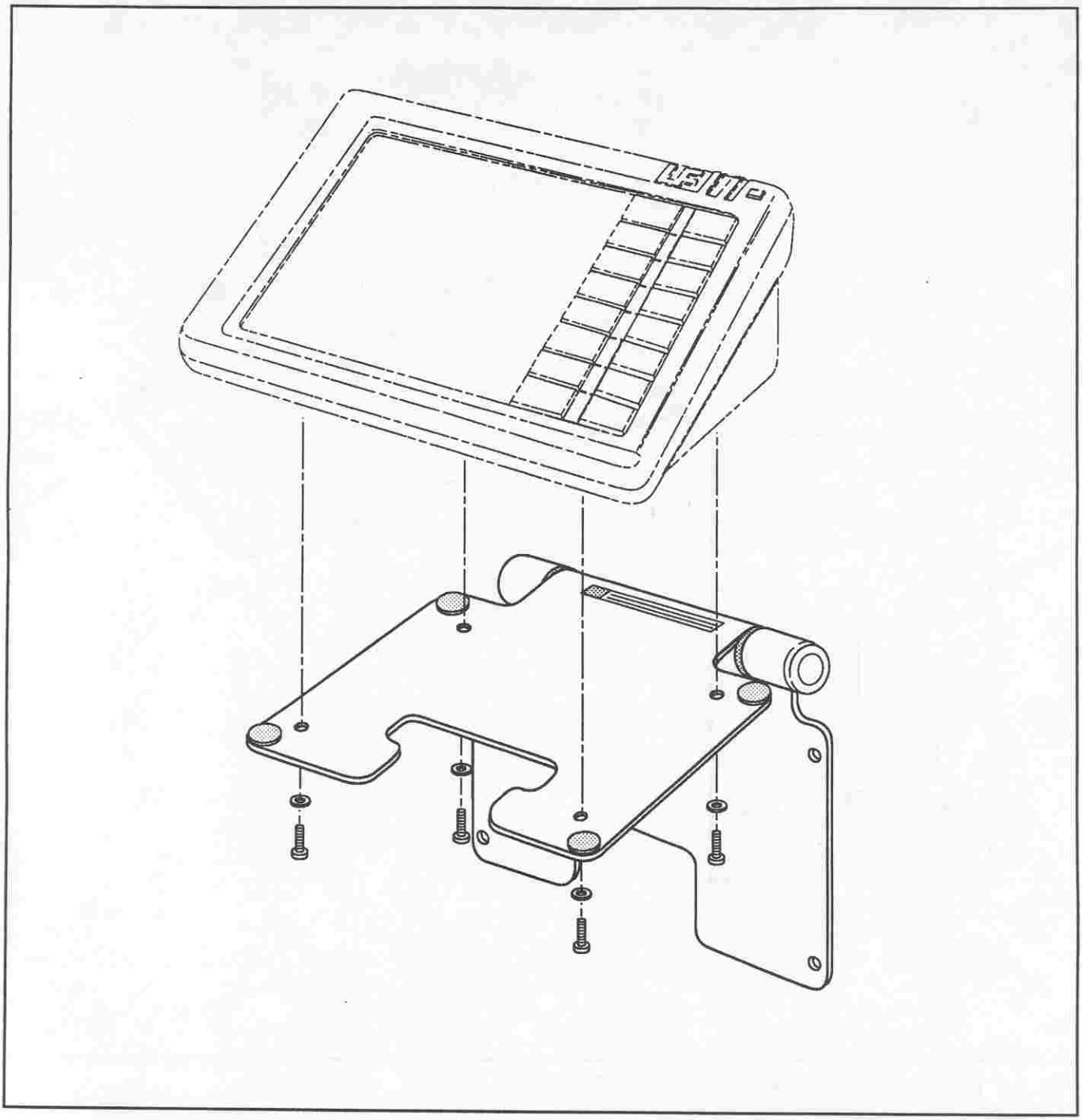


Fig. 4-8 Bracket, Console Pivoting (800445)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-8	800445	Bracket, Console Pivoting	Ref.	

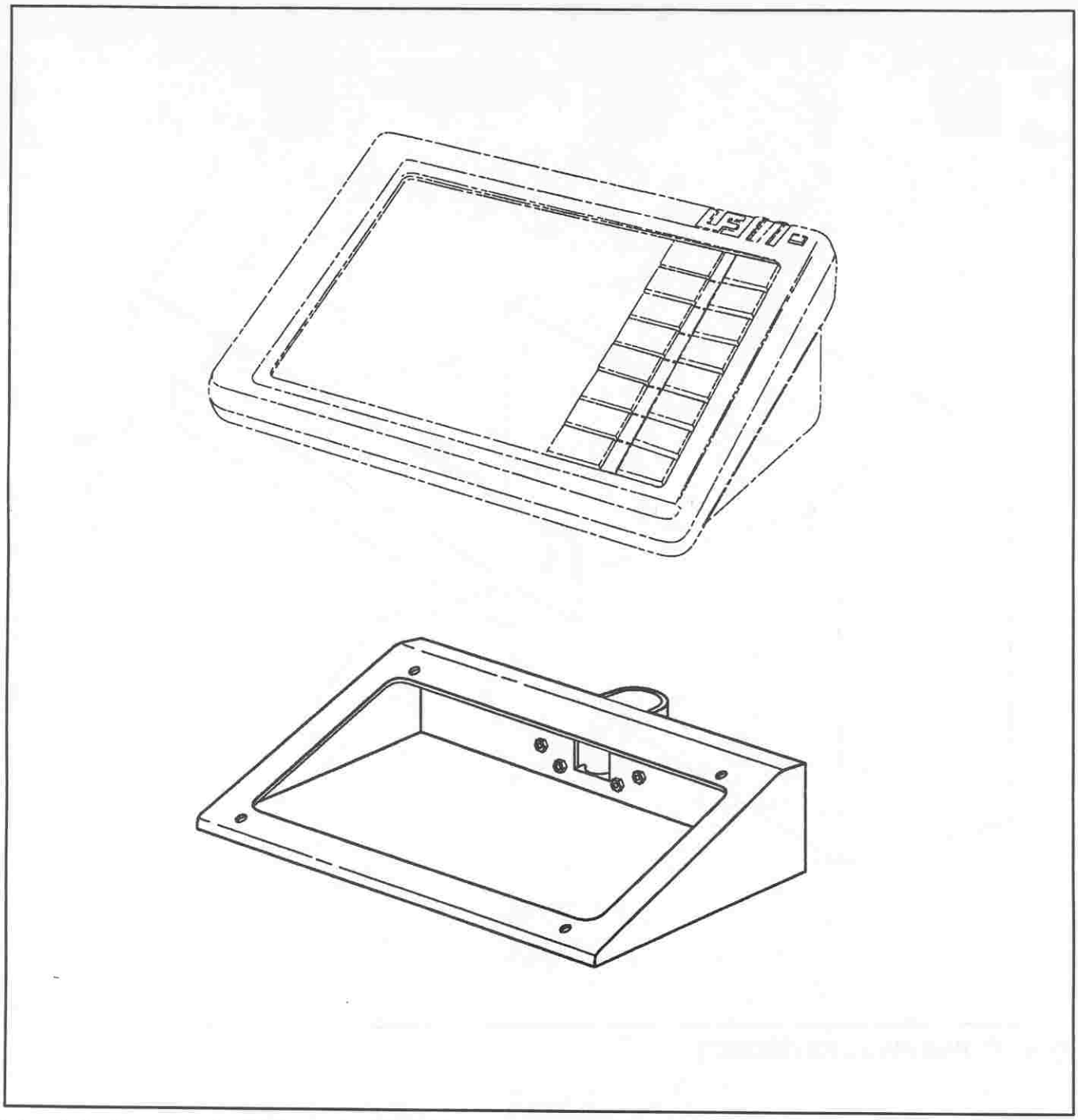


Fig. 4-9 Console Ceiling Bracket (800113)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-8	800113	Console Ceiling Bracket	Ref.	

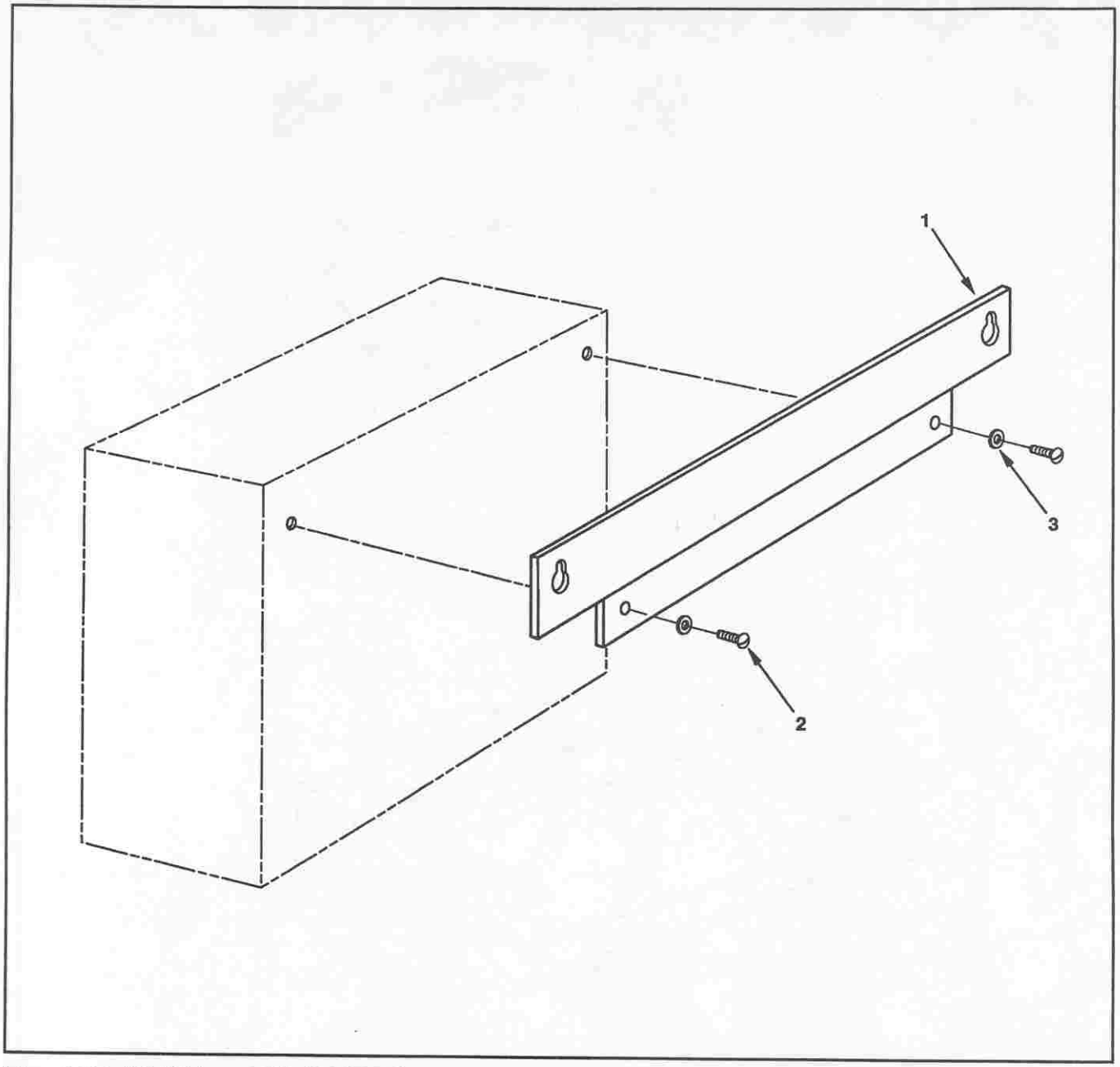


Fig. 4-10 Wall Mount Kit (800060)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-10	800060	Wall Mount Kit	Ref.	
-1	800492	Bracket, Wall Mount	1	
-2	248S0004	Screw, #10-32 x 3/8 Slotted Truss Hd.	2	
-3	137S0004	Washer, #10-32 Internal Tooth	2	

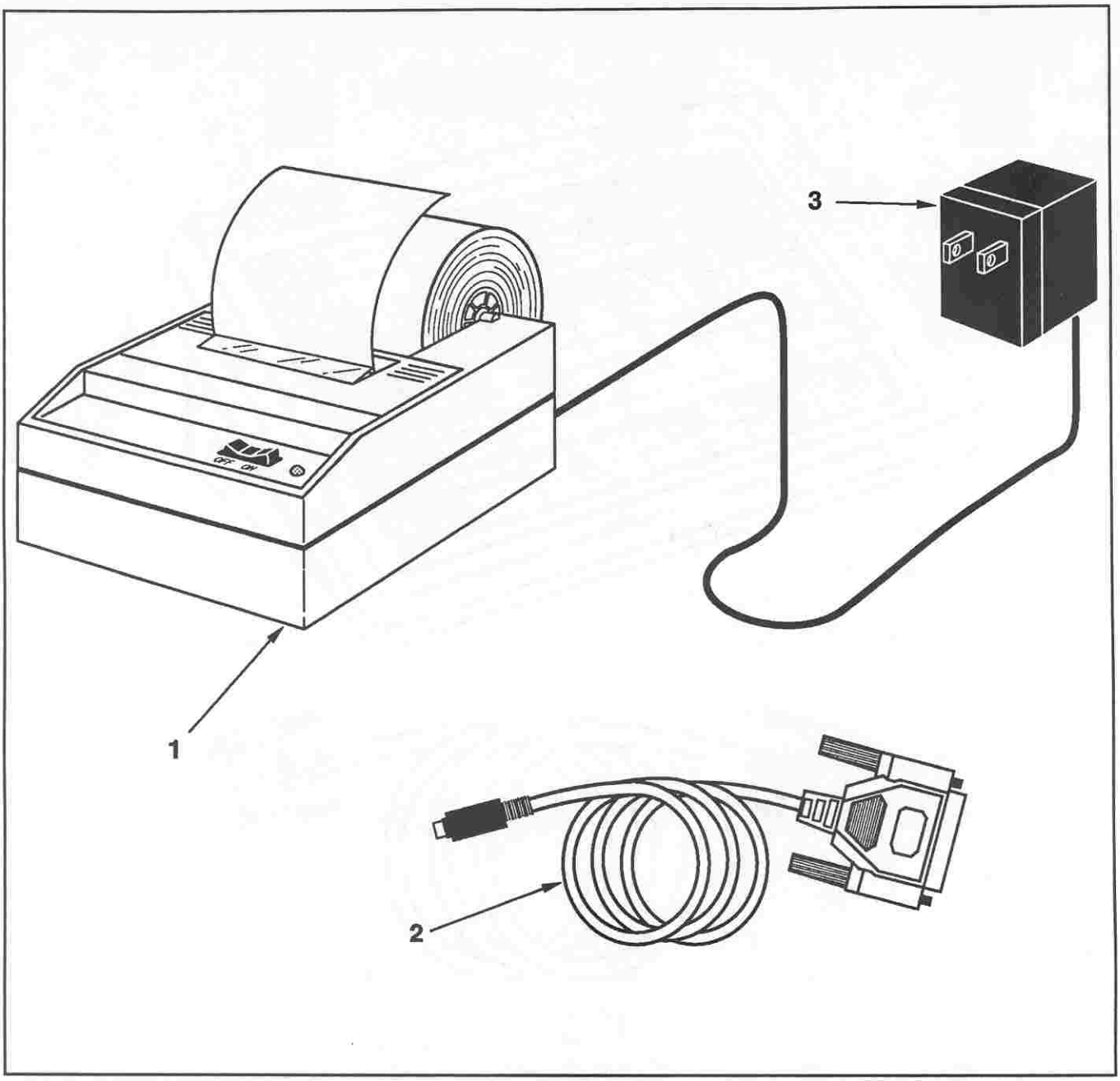


Fig. 4-11 Printer Kit Assembly (800061)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-11	800061	Printer Kit Assembly	Ref.	
-1	800116	Printer	1	
-2	800117	Cable Assembly, Printer	1	
-3	800118	Power Supply-Printer (Included with 800116)	1	

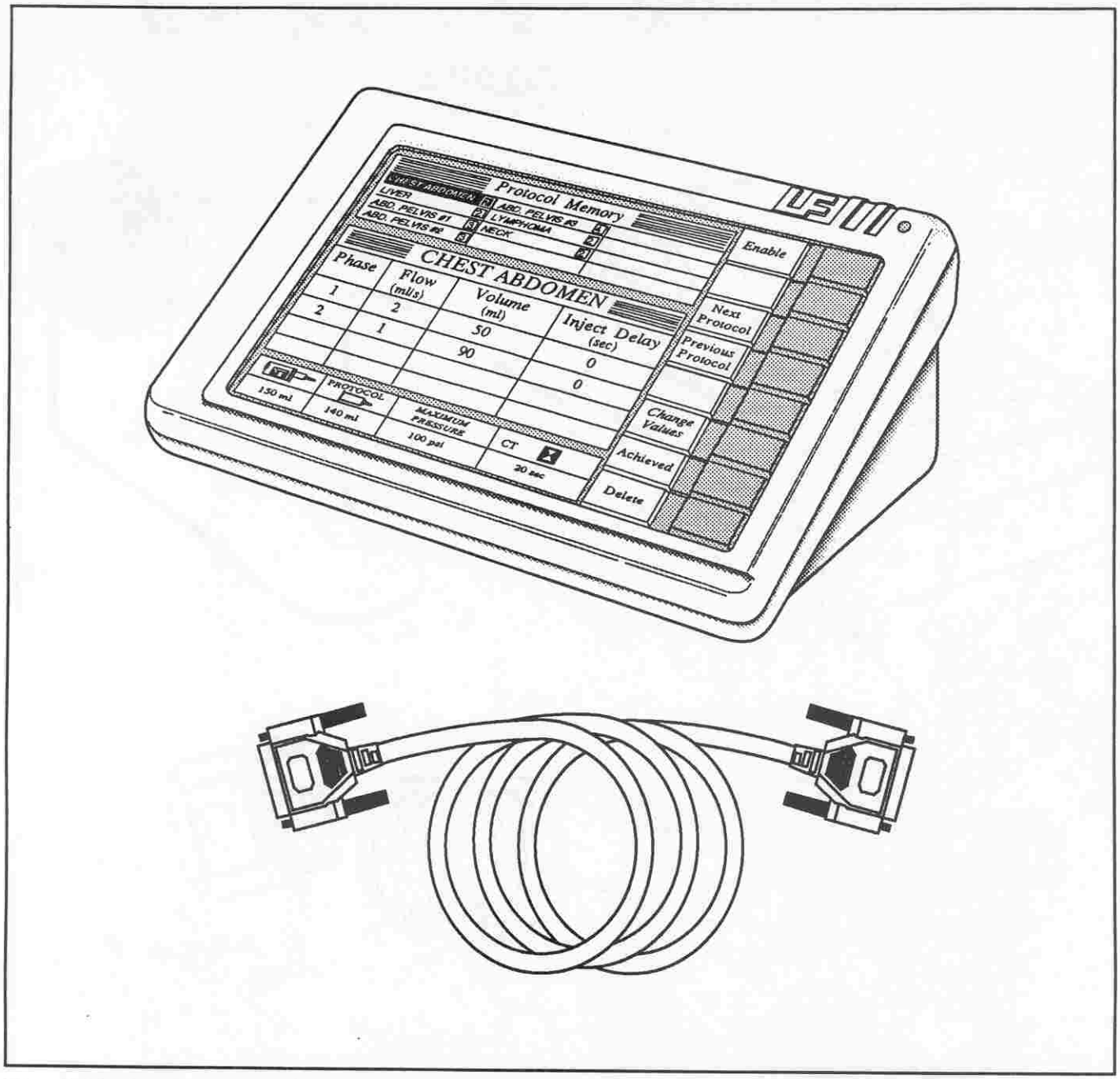


Fig. 4-12 Auxiliary Console Kit (800012)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-12	800012	Auxiliary Console Kit	Ref.	
-1	800011	Console Assembly	1	
-2	800109	Cable Assembly, 25 Pin Male/Female D Shell 50'	1	

POWERHEAD & CONSOLE EXTENSION CABLES

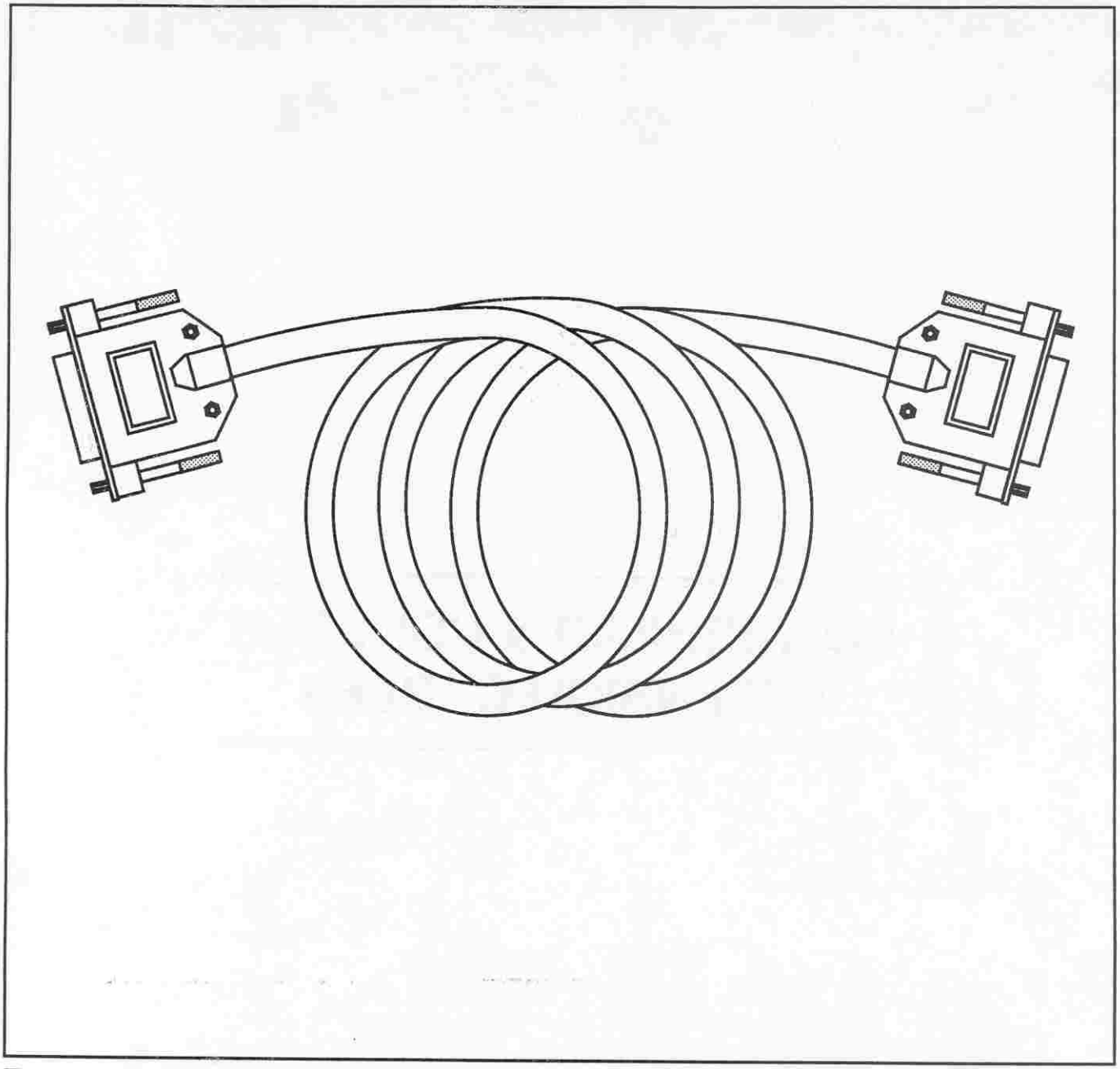


Fig. 4-13 Powerhead Extension Cables

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-13	Ref	Powerhead Extension Cables	Ref.	
-1	800105	Cable Assembly, 15 Pin D Shell 50'	1	
	800106	Cable Assembly, 15 Pin D Shell 75'	1	
	800107	Cable Assembly, 15 Pin D Shell 100'	1	

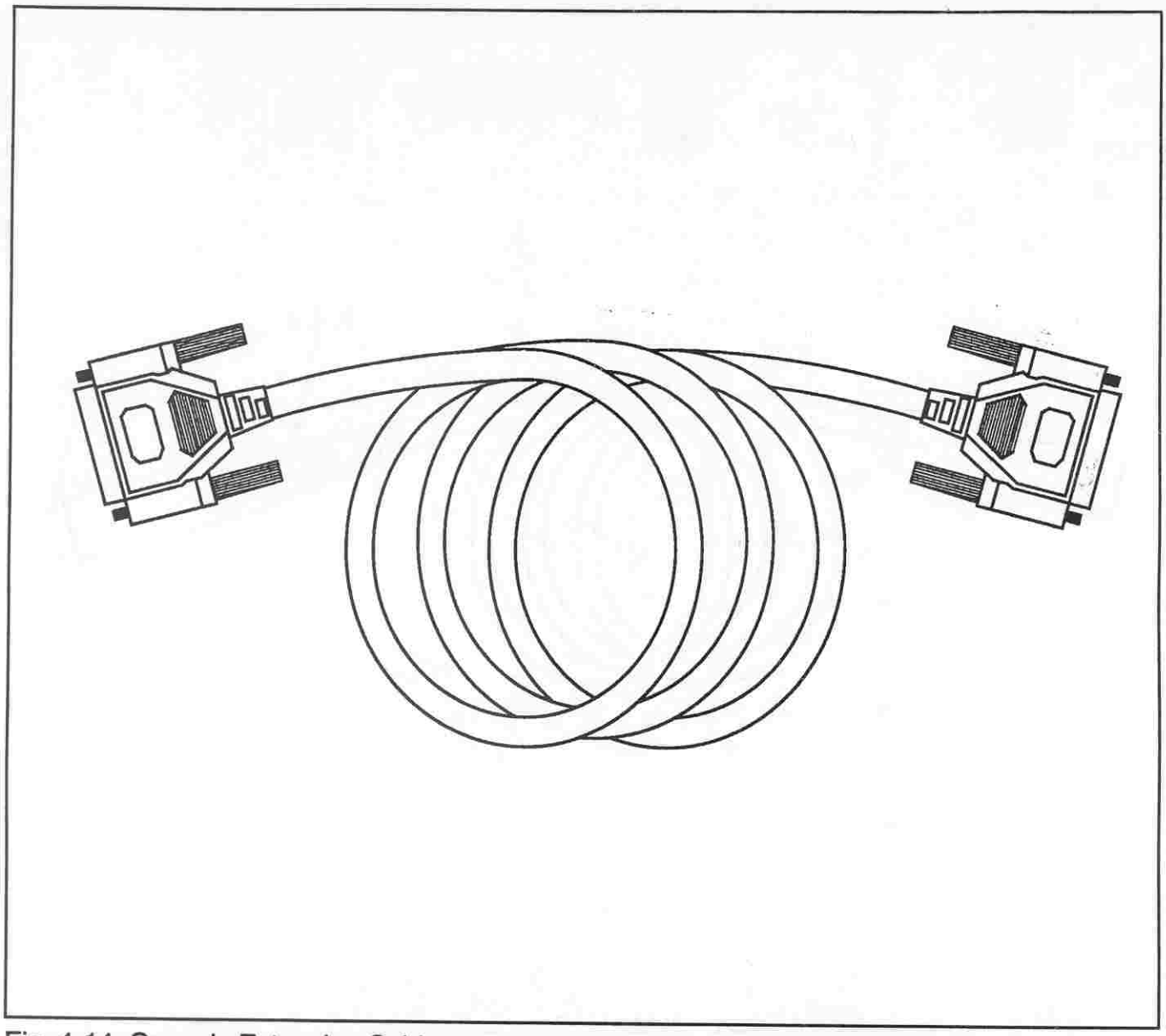


Fig. 4-14 Console Extension Cables

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-14	Ref	Console Extension Cables	Ref.	
-1	800109	Cable Assembly, 25 Pin Male/Female D Shell 50'	1	
	800110	Cable Assembly, 25 Pin Male/Female D Shell 75'	1	
	800111	Cable Assembly, 25 Pin Male/Female D Shell 100'	1	

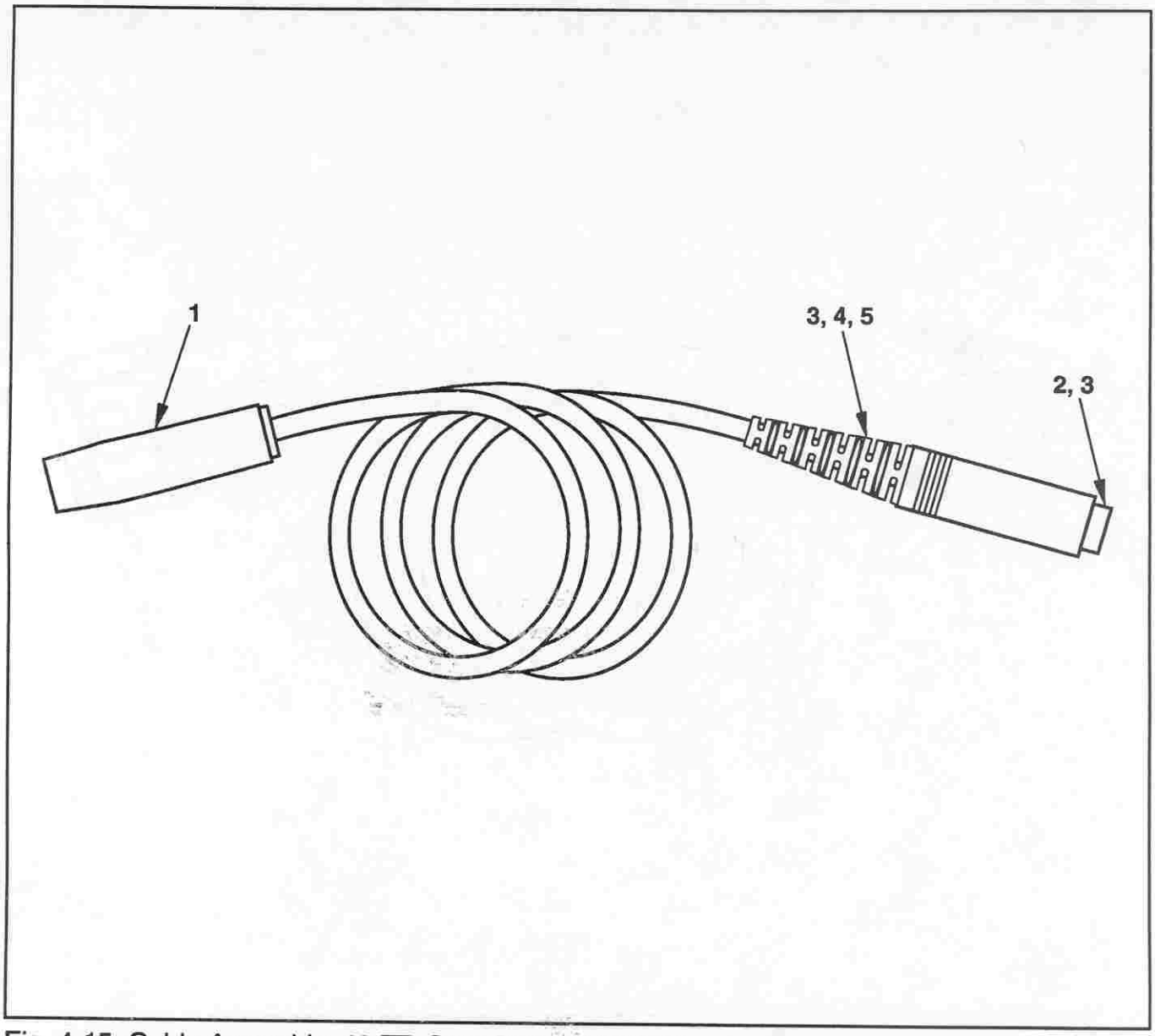


Fig. 4-15 Cable Assembly, 40 FT. Start Switch (800919)

Fig. & Index No.	Part Number	Description	Units Per Ass'y.	Component Designator
4-15	800919	Cable Assembly, 40 FT. Startswitch	Ref.	
-1	802E0013	Handswitch and cable Assembly	1	
-2	240E3100	Contact Pin Circular Din	4	
-3	240E3097	Connector, 8 Position Housing	1	
-4	240E3098	Cord Guard, Circular Din	1	
-5	240E3099	Ferrule, Circular Din Conn.	1	

TEST FIXTURES

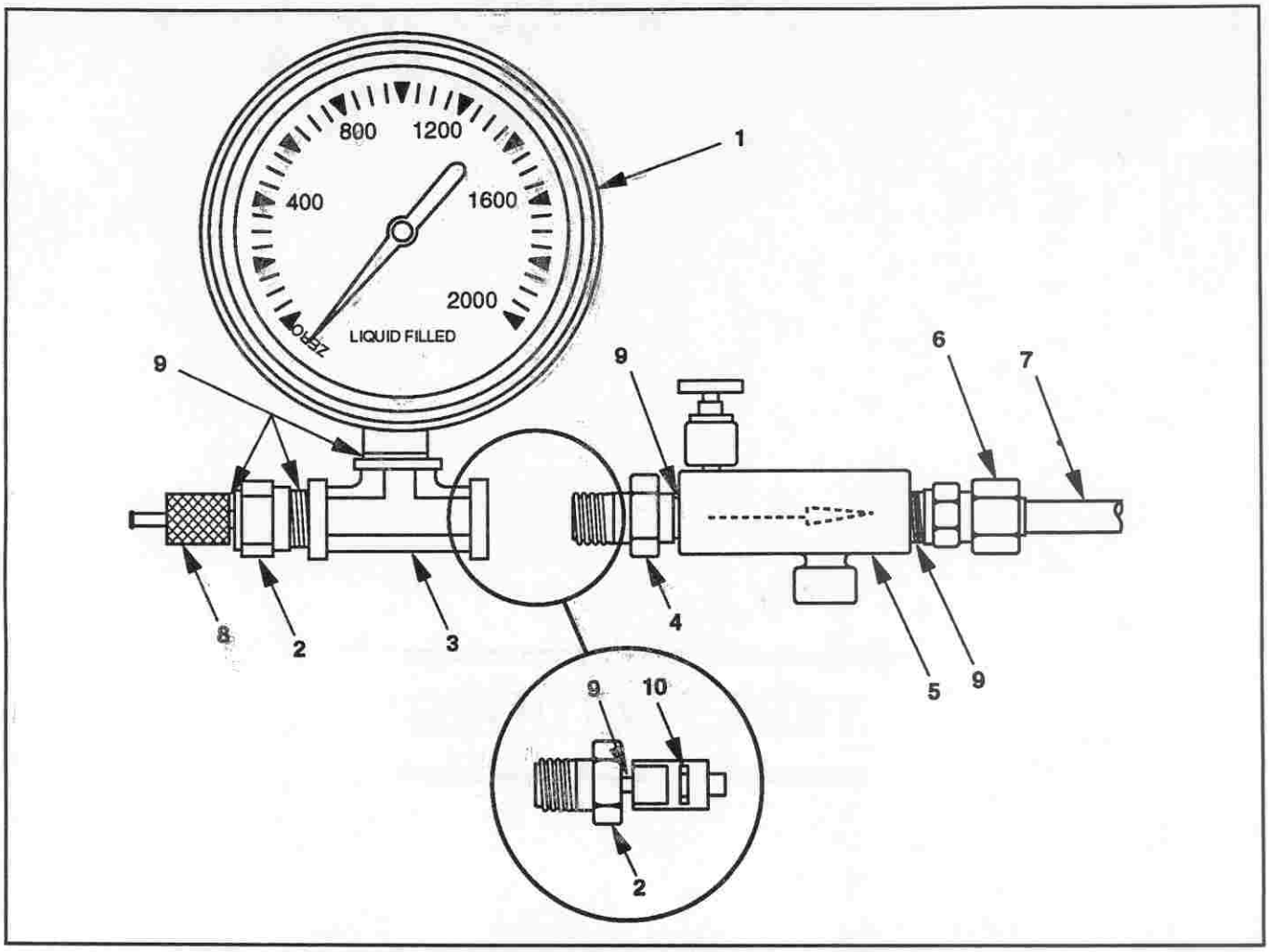


Fig. 4-16 Pressure Test Fixture Kit (600867)

Fig. & Index Number	Part Number	Description	Units Per Ass'y.	Component Designator
4-16	600867	Pressure Test Fixture Kit	Ref.	
-1	300964	Gauge, 2000 PSI Max. Liq. Fill	1	
-2	600869	Adapter	2	
-3	600870	Pipe Tee, Female	1	
-4	600871	Pipe Nipple, Male 1/4 x 1/8	1	
-5	500311	Valve, Flow Control	1	
-6	207102	Connector, 1/8 Male Compression	1	
-7	257700	Tubing, Nylon 1/4 O.D.	Ref.	
-8	600873	Luer, Female 10-32	1	
-9	257025	Hyraulic Sealant	A.R.	
-10	600874	Luer Needle Lock, Male 10-32	1	