



For use with following list numbers:

Plum A+ Infusion Pump	11971-04 11973-04
Plum A+ Module	12101-04 12102-04 12380-04 12393-04

Technical Service Manual



ABBOTT LABORATORIES
NORTH CHICAGO, IL 60064
USA

42

Controlled Copy
HPD Quality Systems
Original In Red

430-95150-002 (Rev. 09/01)

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Change History

Part Number	Description of Change
430-95150-001 (Rev. 05/00)	Original issue
430-95150-002 (Rev. 09/01)	Second issue

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Section 1

INTRODUCTION

The Plum A+™ Infusion System is an infusion system designed to meet the growing demand for hospital wide, alternate site, and home healthcare device standardization. These features make the Plum A+ Infusion System convenient and cost-effective.

1.1

SCOPE

This manual is organized into 11 sections:

- ❑ Section 1 Introduction
- ❑ Section 2 Warranty
- ❑ Section 3 System Operating Manual
- ❑ Section 4 Theory of Operation
- ❑ Section 5 Maintenance and Service Tests
- ❑ Section 6 Troubleshooting
- ❑ Section 7 Replaceable Parts and Repairs
- ❑ Section 8 Specifications
- ❑ Section 9 Drawings
- ❑ Section 10 Index
- ❑ Technical Service Bulletins

If a problem in device operation cannot be resolved using the information in this manual, contact Abbott Laboratories (*see Section 6.1, Technical Assistance*).

Specific instructions for operating the device are contained in the Plum A+ System Operating Manual. Provision is made for the inclusion of the system operating manual in *Section 3* of this manual.

Note: Figures are rendered as graphic representations to approximate actual product; therefore, figures may not exactly reflect the product.

1.2

CONVENTIONS

The conventions listed in *Table 1-1, Conventions*, are used throughout this manual.

Table 1-1. Conventions		
Convention	Application	Example
<i>Italic</i>	Reference to a section, figure, table, or publication	<i>(see Section 6.1, Technical Assistance)</i>
[ALL CAPS]	In-text references to touchswitches are described in all caps and enclosed in brackets	[START]
ALL CAPS Initial Caps with lowercase	Screen displays (as appropriate)	LOW BATTERY Cassette test in progress
Bold	Emphasis	Caution: Use proper ESD grounding techniques when handling components.

Throughout this manual, warnings, cautions, and notes are used to emphasize important information as follows:

WARNING

A WARNING CONTAINS SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING IS POTENTIALLY LIFE THREATENING.

CAUTION: A caution usually appears prior to a procedure or statement. A caution contains information that could prevent irreversible equipment damage or failure.

Note: A note highlights information that helps explain a concept or procedure.

1.3

ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

- A** Ampere
- AC** Alternating current
- A/D** Analog-to-digital
- ADC** Analog-to-digital converter
- APP** Air, pressure, and pin
- BCR** Barcode reader

CCFT	Cold cathode fluorescent tube
CMOS	Complementary metal-oxide semiconductor
CPU	Central processing unit
DAC	Digital-to-analog converter
DC	Direct current
DIP	Dual in-line package
DMA	Direct memory access
DMM	Digital multimeter
DPM	Digital pressure meter
ECG	Electrocardiograph
EEG	Electroencephalogram
EEPROM	Electrically erasable/programmable read-only memory
EMG	Electromyogram
EMI	Electromagnetic interference
EPROM	Erasable/programmable read-only memory
ESD	Electrostatic discharge
ETO	Ethylene oxide
FPGA	Field programmable gate array
FSR	Force sensing resistor
HI-Z	High impedance
hr	Hour
ID	Identification
I/O	Input/output
IPB	Illustrated parts breakdown
IV	Intravenous
kHz	Kilohertz
KVO	Keep vein open
lbs	Pounds
LCD	Liquid crystal display
LED	Light emitting diode
L/S	Line select
mA	Milliampere
MB	Megabytes
MHz	Megahertz
ml	Milliliter
ml/hr	Milliliter per hour
MMIO	Memory-mapped input/output
MOSFET	Metal-oxide semiconductor field-effect transistor
ms	Millisecond
mV	Millivolt

N/A	Not applicable
Op-amp	Operational amplifier
PROM	Programmable read-only memory
psi	Pounds per square inch
psig	Pounds per square inch gauge
PVT	Performance verification test
PWA	Printed wiring assembly
PWM	Pulse width modulator
RAM	Random-access memory
RMS	Root-mean-square
ROM	Read-only memory
RTC	Real-time clock
SCC	Serial communication controller
SCP	Serial communication port
SMT	Surface mount technology
SRAM	Static random access memory
TQFP	Thin quad flat pack
V	Volt
V_{CC}	Collector supply voltage
VCO	Voltage-controlled oscillator
V_{DC}	Volts DC
VSC	5 V _{DC} supply circuitry
VTBI	Volume to be infused
WDI	Watchdog input

1.4

USER QUALIFICATION

The Plum A+ Infusion System is intended for use at the direction or under the supervision of licensed physicians or certified healthcare professionals who are trained in the use of the pump and the administration of parenteral and enteral fluids and drugs, and whole blood or red blood cell components. Training should emphasize preventing related IV complications, including appropriate precautions to prevent accidental infusion of air. The epidural route can be used to provide anesthesia or analgesia.

1.5

ARTIFACTS

Nonhazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion devices. These potentials are well within accepted safety standards, but may create artifacts on voltage-sensing equipment such as ECG, EMG, and EEG machines. These artifacts vary at a rate that is associated with the infusion rate. If the monitoring machine is not operating correctly or has loose or defective connections to its sensing electrodes, these artifacts may be accentuated so as to simulate actual physiological signals. To determine if the abnormality in the monitoring equipment is caused by the pump instead of some other source in the environment, set the pump so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the pump. Proper setup and maintenance of the monitoring equipment should eliminate the artifact. Refer to the appropriate monitoring system documentation for setup and maintenance instructions.

1.6

INSTRUMENT INSTALLATION PROCEDURE

CAUTION: Infusion pump damage may occur unless proper care is exercised during product unpacking and installation. The battery may not be fully charged upon receipt of the infusion pump. Do not place the infusion pump in service if it fails the self test.

CAUTION: Infusion pump performance may be degraded by electromagnetic interference (EMI) from devices such as electrosurgical units, cellular phones, and two-way radios. Operation of the infusion pump under such conditions should be avoided.

The instrument installation procedure consists of unpacking, inspection, and self test.

Note: Do not place the infusion pump in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infusion pump to AC power for eight hours (*see Section 8, Specifications*).

1.6.1

UNPACKING

Inspect the infusion pump shipping container as detailed in *Section 1.6.2, Inspection*. Use care when unpacking the infusion pump. Retain the packing slip and save all packing material in the event it is necessary to return the Plum A+ Infusion System to the factory. Verify that the shipping container contains a copy of the system operating manual.

1.6.2

INSPECTION

Inspect the infusion pump shipping container for shipping damage. Should any damage be found, contact the delivering carrier immediately.

CAUTION: Inspect the infusion pump for evidence of damage. Do not use the infusion pump if it appears to be damaged. Should damage be found, contact Abbott Laboratories (see *Section 6.1, Technical Assistance*).

Inspect the infusion pump periodically for signs of defects such as worn accessories, broken connections, or damaged cable assemblies. Also inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts.

1.6.3

SELF TEST

CAUTION: Do not place the infusion pump in service if the self test fails.

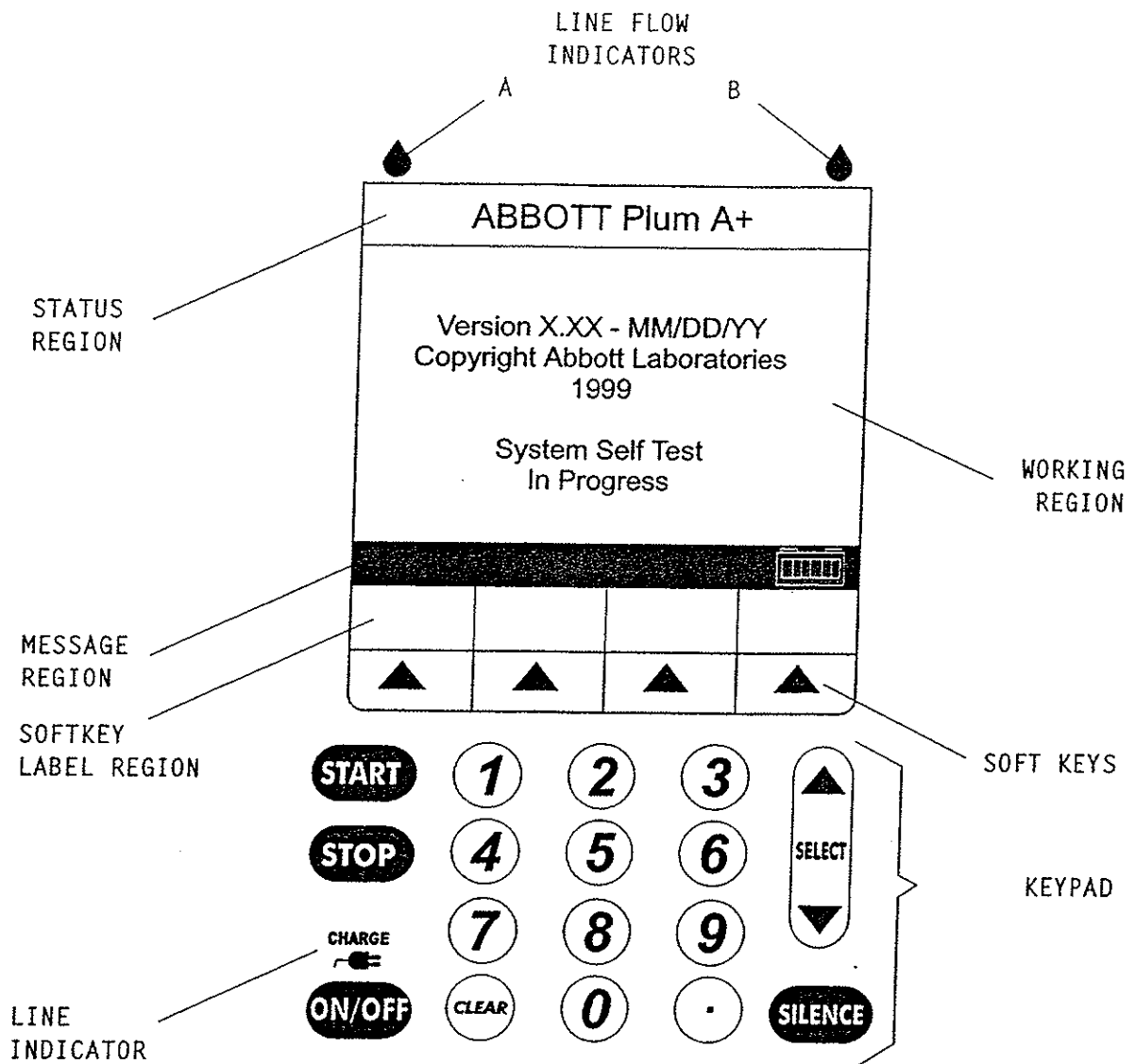
To perform the self test, refer to *Figure 1-1, LCD Display and Keypad*, and proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charging/line indicator CHARGE illuminates and an alarm beep sounds.
2. Without a cassette installed, turn on the pump by pressing [ON/OFF].
3. The LCD screen briefly displays the self test screen. Verify that the screen display matches *Figure 1-1*.

Note: If the self test screen does not appear, contact Abbott Laboratories.

4. After the self test is complete, the message "Insert Plum Set Close Lever" appears. Press the decimal [.] key, then the [START] key.
5. Using the [SELECT] arrow keys, select **Set Time and Date**. Press the [Choose] soft key.
6. Verify the time, year, month, and day are correct. If any parameters are incorrect refer to *Section 1.7.3, Setting the Time and Date*.
7. Exit the **Set Time and Date** screen by pressing [ON/OFF].
8. Turn the pump back on by pressing [ON/OFF].
9. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the "Cassette test in progress" message disappears.
10. If previously entered programming exists, the "Clear Settings?" message appears. Press the [Yes] soft key to clear the settings.

Note: If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action (see *Section 6, Troubleshooting*). Repeat the self test. If the alarm condition recurs, remove the Plum A+ Infusion System from service and contact Abbott Laboratories.



98G01002

Figure 1-1. LCD Display and Keypad

1.7

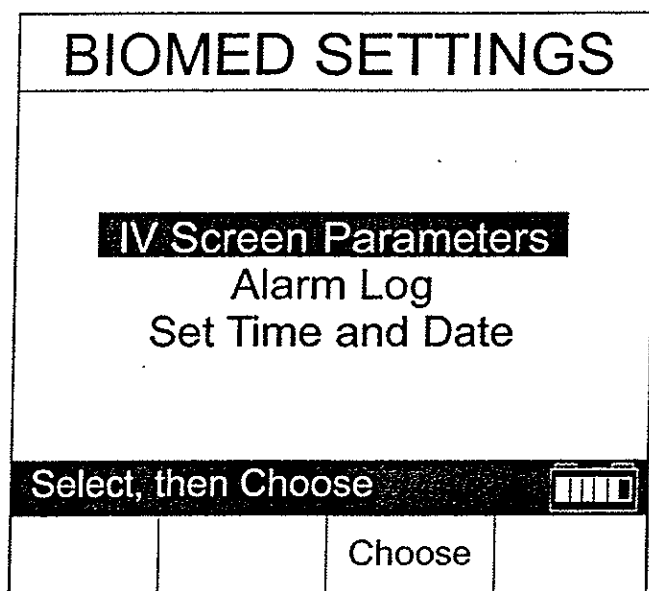
BIOMED SETTINGS

Refer to *Figure 1-2, Biomed Settings*. The biomed settings screens contain the following options that qualified personnel can change or review:

- ☐ IV screen parameters
- ☐ Alarm log
- ☐ Set time and date

To access the service mode, refer to *Figure 1-1, LCD Display and Keypad*, then proceed as follows:

1. Open the door and turn on the pump by pressing the [ON/OFF] key.
2. After the self test is complete, the message "Insert Plum Set Close Lever" appears. Press the decimal [.] key, then the [START] key.



00H03002

Figure 1-2. Biomed Settings

1.7.1

IV SCREEN PARAMETERS

Refer to *Figure 1-3, IV Parameters*. The IV screen parameters contain the following:

- ☐ Common IV parameters
- ☐ Macro IV parameters

To change the IV parameters, refer to *Figure 1-6, Common IV Parameters*, and *Figure 1-7, Macro IV Parameters*, then proceed as follows:

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.7, Biomed Settings*.
2. Using the [SELECT] arrow keys, select **IV Screen Parameters**. Press the [Choose] soft key.
3. Using the [SELECT] arrow keys, select the desired parameters to be changed. Press the [Choose] soft key.
4. Using the [SELECT] arrow keys, select the parameter to be changed.
5. Change the parameter value by using the [Change Value] soft key.
6. Repeat steps 4 and 5 for each parameter to be changed.
7. Press the [Enter] soft key.
8. If there are no other changes, turn off the infusion pump by pressing the [ON/OFF] key.

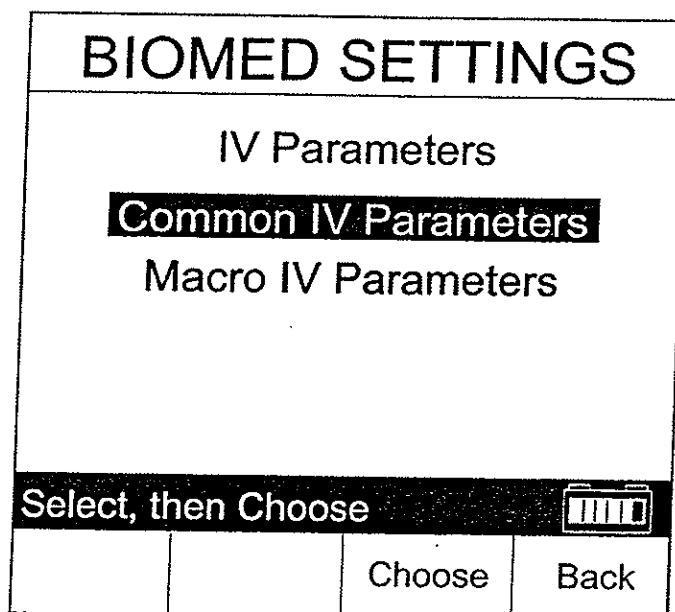



Figure 1-3. IV Parameters

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1.7.2**ALARM LOG**

To view the alarm log, refer to *Figure 1-2, Biomed Settings* and *Figure 1-5, Setting the Time and Date*, then proceed as follows:

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.7, Biomed Settings*.
2. Using the [SELECT] arrow keys, select **Alarm Log**. Press the [Choose] soft key.
3. To view the alarm log, use the [Page Up] and [Page Down] soft keys.
4. Press the [Back] soft key to exit the alarm log.

ALARMS LOG			
04/24/01 08:35 E437 S/W failure #509			
04/24/01 08:33 E102 Infuser Idle 2 Minutes			
04/24/01 08:23 E102 Infuser Idle 2 Minutes			
04/20/01 07:44 E234 Distal Air			
04/20/01 07:41 E251 Cassette Test Failure			
04/20/01 07:40 E251 Cassette Test Failure			
04/17/01 10:04 E251 Cassette Test Failure			
02/20/01 14:57 E250 Door open while pumping			
			
	Page Up	Page Down	Back

00K03001

Figure 1-4. Alarm Log

1.7.3


SETTING THE TIME AND DATE

To set the time and date, refer to *Figure 1-2, Biomed Settings*, and *Figure 1-5, Setting the Time and Date*, then proceed as follows:

Note: The infuser will automatically display February 29 on leap years.


Note: Daylight savings and time zone changes must be made manually.

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.7, Biomed Settings*.
2. Using the [SELECT] arrow keys, select **Set Time and Date**. Press the [Choose] soft key.
3. Using the [SELECT] arrow keys, select the parameter to be changed.
4. Using the numerical keypad, enter the desired value.
5. Repeat steps 3 and 4 for each parameter to be changed.
6. Press the [Enter] soft key.
7. If there are no other changes to the biomed settings, turn off the infusion pump by pressing the [ON/OFF] key.

BIOMED SETTINGS			
Set Time and Date			
Time	21	: 15	hr:min
Year	2001		
Month	06		
Day	05		
Enter value using keypad 			
		Enter	Cancel/ Back


00K13004

Figure 1-5. Setting the Time and Date

BIOMED SETTINGS			
Common IV Parameters			
Continue Rate		KVO	
Deliver Together		Concurrent	
Enable Delay Start		Yes	
Callback Default		Yes	
Select using Change Value			
Change Value		Enter	Cancel/Back

00K13006

Figure 1-6. Common IV Parameters

BIOMED SETTINGS			
Macro IV Parameters			
Default Distal Press		6.0 psi	
Max Rate		999 mL/hr	
Enter value using keypad			
		Enter	Cancel/Back

00K13005

Figure 1-7. Macro IV Parameters

Section 2

WARRANTY

Subject to the terms and conditions herein, Abbott Laboratories, herein referred to as Abbott, warrants that (a) the product shall conform to Abbott's standard specifications and be free from defects in material and workmanship under normal use and service for a period of one year after purchase, and (b) the replaceable battery shall be free from defects in material and workmanship under normal use and service for a period of 90 days after purchase. Abbott makes no other warranties, express or implied, as to merchantability, fitness for a particular purpose, or any other matter.

Purchaser's exclusive remedy shall be, at Abbott's option, the repair or replacement of the product. In no event shall Abbott's liability arising out of any cause whatsoever (whether such cause be based in contract, negligence, strict liability, other tort, or otherwise) exceed the price of such product, and in no event shall Abbott be liable for incidental, consequential, or special damages or losses or for lost business, revenues, or profits. Warranty product returned to Abbott must be properly packaged and sent freight prepaid.

The foregoing warranty shall be void in the event the product has been misused, damaged, altered, or used other than in accordance with product manuals so as, in Abbott's judgment, to affect its stability or reliability, or in the event the serial or lot number has been altered, effaced, or removed.

The foregoing warranty shall also be void in the event any person, including the Purchaser, performs or attempts to perform any major repair or other service on the product without having been trained by an authorized representative of Abbott and using Abbott documentation and approved spare parts. For purposes of the preceding sentence, "major repair or other service" means any repair or service other than the replacement of accessory items such as batteries, flow detectors, detachable AC power cords, and patient pendants.

In providing any parts for repair or service of the product, Abbott shall have no responsibility or liability for the actions or inactions of the person performing such repair or service, regardless of whether such person has been trained to perform such repair or service. It is understood and acknowledged that any person other than an Abbott representative performing repair or service is not an authorized agent of Abbott.

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Section 3

SYSTEM OPERATING MANUAL

A copy of the system operating manual is included with every Plum A+ Infusion System. Insert a copy here for convenient reference. If a copy of the system operating manual is not available, contact Abbott Laboratories Technical Support Operations (*see Section 6.1, Technical Assistance*).

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Section 4

THEORY OF OPERATION

This section describes the Plum A+ Infusion System theory of operation. Related drawings are provided in *Section 9, Drawings*. The theory of operation details the general description, electronic subsystem overview, printed wiring assemblies (PWAs), remote mounted peripherals, and mechanical overview of the infusion pump.

4.1

GENERAL DESCRIPTION

The infusion pump includes the following features:

- ☐ Dose calculation
- ☐ Loading dose
- ☐ Multi-step programming
- ☐ Therapy selection
- ☐ Nurse call back
- ☐ Delayed start setting
- ☐ Drug label library
- ☐ Piggyback and concurrent delivery modes
- ☐ Titration
- ☐ Macro 0.1-99.9 ml/hr (in 1.0 ml/hr increments) flow rate range for both lines
- ☐ Anti free-flow protection
- ☐ Air removal/backpriming
- ☐ Air detection - proximal and distal
- ☐ Battery gauge
- ☐ Long battery life (6 hours) for emergency backup and temporary portable operation
- ☐ Serial communication
- ☐ Alarm history
- ☐ Plug-in barcode reader for drug identification (optional)
- ☐ Volumes infused (A, B, total volumes)
- ☐ KVO at dose end (1.0 ml/hr or less depending on delivery rate) or continue rate (CR) to continue
- ☐ Variable distal pressure settings
- ☐ Nonpulsatile volumetric accuracy
- ☐ Microprocessor control
- ☐ Large liquid crystal display (LCD) screen
- ☐ Panel back illumination on mains power
- ☐ Lockout switch
- ☐ Standard fullfill, partfill, syringe and vial use
- ☐ Parenteral and non parenteral (enteral) fluid delivery

- ☐ Blood and blood product delivery
- ☐ Wide range of standard and specialty administration sets

Alarms include the following:

- ☐ Distal occlusion
- ☐ Proximal occlusion
- ☐ Proximal air-in-line
- ☐ Distal air-in-line
- ☐ Low battery
- ☐ Door open while pumping
- ☐ Lockout violation
- ☐ VTBI complete
- ☐ Valve/Cassette test failure
- ☐ Nurse call back
- ☐ No action alarm
- ☐ Infuser idle for 2 minutes

4.2

ELECTRONIC SUBSYSTEM OVERVIEW

This section describes the function and electronic circuitry of three main subsystems in the infusion pump: CPU subsystem, power supply subsystem, and mechanism subsystem. Schematic diagrams of subsystem PWAs are in *Section 9, Drawings*.

4.2.1

CPU SUBSYSTEM

The CPU subsystem contains the main microcontroller, which is responsible for controlling the display/keyboard interface, external communications interfaces, barcode reader interface, and system management. Refer to *Figure 9-12, Peripheral PWA Schematic*, and *Figure 9-13, CPU PWA Schematic*.

The CPU subsystem provides the following functions:

- ☐ External memory devices access
- ☐ LCD display interfaces
- ☐ Real-time clock generator interface
- ☐ System watchdog
- ☐ Analog-to-digital and digital-to-analog converter interface
- ☐ Keypad interfaces
- ☐ Control and monitor status signals (LEDs, audible alarms, volume control, nurse call switch, lockout switch, etc.)
- ☐ Serial communication with host computer (DataPort) and barcode reader
- ☐ Power supply subsystem interface
- ☐ Mechanism subsystem interface

4.2.1.1

CPU

The central processing unit is a Motorola MC68302 CPU. The CPU has a closely coupled 16 bit data bus and 24 bit address bus, MC68000 microprocessor core, a system integration block for peripherals, and an RISC communications processor. The MC 68302 is packaged in a 144 pin thin quad flat pack (TQFP) package and operates from a 3.3 V_{DC} power supply.

The on-chip peripheral devices are isolated from the system through the dual port RAM. The 1152 byte dual port RAM has 576 bytes of system RAM and 576 bytes of parameter RAM, which contains various peripheral registers, parameters, and the buffer descriptors for each of the three serial communication controller (SCC) channels and the serial communication port (SCP) channels. The 24 bit address bus is capable of accessing up to 16 MB of data.

4.2.1.2

SYSTEM MEMORY ADDRESS MAP

The CPU has a 24 bit address bus when combined with UDS*/A0. The address bus is a bi-directional, three state bus capable of addressing 16 MB of data that is configured as 16 bits per word (including the IMP internal address space).

Each of the four programmable chip-select lines has two registers that define the starting address of a particular address space and the block size.

4.2.1.3

PROGRAMMABLE READ-ONLY MEMORY

The CPU subsystem has two 512 K x 8 bit programmable read-only memory (PROM) memory devices, which provide a total of 1024 KB. The PROM space is expandable up to 2 MB. The PROM memory devices operate off the 3.3 V_{DC} supply.

The CPU chip-select 0 pin (CS0*), is connected to the PROM chip-enable (CE*) pin (signal CSROM*). This special chip-select signal can support bootstrap operation after reset. The interface to the CPU is the 16 bit data bus, and a 19 bit address bus. The address bus is connected to the ADDR<19:1> lines, and the data bus is connected to the DATA<15:0> lines.

4.2.1.4

STATIC RANDOM ACCESS MEMORY

There are two 512 K x 8 bit CMOS static random access memory (SRAM) devices, which provide a total of 1024 KB of data memory. During an SRAM read or write cycle, the chip-enable (CE*) is controlled by the CPU chip-select pin 1 (CS1*, signal name (CSRAM*)). The SRAM space is expandable up to 2 MB. The SRAM operates off the 3.3 V_{DC} supply.

The CPU subsystem includes the additional SRAM for video buffer and real-time clock. Refer to *Section 4.2.1.6. LCD Controller*, and *Section 4.2.1.9, Real-Time Clock*.

4.2.1.5

CONTROL LOGIC

The CPU PWA uses field programmable gate arrays (FPGA), which are high density, high speed, I/O intensive general purpose devices. They are used to implement all the digital control functions, including: memory-map address decoding, memory read-write enable, DMA request, I/O status signals, chip-select control, motor control, sensor select, and power up/system reset control.

4.2.1.6

LCD CONTROLLER

The LCD controller is used to interface the LCD display to the CPU. The device displays layered text and graphics, scrolls the display in any direction, and partitions the display into multiple screens. It stores bit-mapped graphic data in external frame buffer memory. The display controller functions include: transferring data from the controlling microprocessor to the buffer memory, reading memory data, converting data to display pixels, and generating timing signals for the buffer memory and LCD panel.

The LCD controller accesses 32 KB of frame buffer SRAM (video) via the controller's video address and data busses (VA<14:0> and VD<7:0>). The LCD controller external clock frequency is 8 MHz.

The interface to the CPU is through the lower 8 bits of the data bus, which is connected to DATA<7:0> lines, address line A1, and LCD chip-select signal CSLCD* (CS2*). This controller is also configured as 8080 family compatible interface device with all the control signals, such as WRLCD* (WR*) and RDLCD* (RD*), generated by the FPGA logic.

The LCD controller and the display memory are operated off the 3.3 V_{DC} supply. The output signal levels are shifted up to 5 V_{DC} by buffers for interface with the 5 V_{DC} LCD panel.

4.2.1.7

LCD BACKLIGHT CONTROL

The LCD display panel is backlit by a cold cathode fluorescent tube (CCFT) lamp. The CCFT lamp requires 300 V_{rms} to operate; a current controlled DC to AC voltage inverter circuit is used to deliver a current regulated sine wave to the lamp. A switching regulator regulates the CCFT current by monitoring feedback pin 3, and varies its output duty cycle to drive a DC/AC inverter. Intensity control is achieved by superimposing a DC control signal with the feedback signal. The DC control signal is sourced by a voltage divider consisting of a digitally controlled non-volatile potentiometer and three series diodes.

The CPU can adjust LCD backlight intensity by selecting the digitally controlled non-volatile potentiometer and controlling TUBU/D and TUBINC* signals. The potentiometer has a five bit up/down counter with non-volatile memory. It is used to store one of 31 settings of the potentiometer. Each count represents 323 Ω with a range of 323 to 10 K Ω . The current counter value is stored in non-volatile memory after CSTUB* is returned high while the TUBINC* input is also high. The current counter value is not stored if CSTUB* is returned high and TUBINC* is low. The CCFT intensity is directly proportional to the CCFT current, where 0 mA_{rms} is minimum intensity and 5 mA_{rms} is maximum intensity. The CCFT current is inversely proportional to the counter value.

4.2.1.8**LCD CONTRAST CONTROL**

A digitally adjustable LCD bias supply is used to control the LCD contrast over a range of -24 to -8 V_{DC} . It is digitally adjustable in 64 equal steps by an internal digital-to-analog converter (DAC). The CPU provides two signals, LCDADJ (ADJ) and LCDCTL (CTL), to interface with this device. On power up or after a reset, the counter sets the DAC output to the mid-range value.

Each rising edge of LCDADJ increments the DAC output. When incremented beyond full scale, the counter rolls over and sets the DAC to the minimum value. Therefore, a single pulse applied to LCDADJ increases the DAC set point by one step, and 63 pulses decrease the set point by one step.

4.2.1.9**REAL-TIME CLOCK**

The watchdog timekeeper chip includes a complete real-time clock/calendar (RTC), watchdog timer, alarm, and interval timer. The time/date information includes hundredths of seconds, seconds, minutes, hours, day, date, month, and year. The date at the end of the month is automatically adjusted for months with less than 31 days, including correction for leap year. The watchdog timekeeper operates in either 24-hour or 12-hour format with an AM/PM indicator. The device can be programmed to set up an interval timer, and it can generate an alarm every day, hour, or minute. These alarm functions may be used to schedule real-time related activities. A parallel resonant 32,768 Hz crystal oscillator drives the internal time base.

The external interface is a separate (non-multiplexed) 8 bit data bus and 6 bit address bus, with a contiguous address space of 64 bytes. When system power is turned off, a battery voltage input is available, which makes the RTC data non-volatile. The address bus is connected to the ADDR<6:1> lines, and the data bus is connected to DATA<7:0> lines. Since the CPU accesses are 16 bits wide, the RTC data is on the lower byte of the word.

The RTC chip-enable pin (CE*) is active low enabled for read and write operations. It is driven by the FPGA control logic, chip-select RTC signal (CSRTC*), which involves address decoding circuitry (*see Section 4.2.1.2, System Memory Address Map*).

4.2.1.10**VOLTAGE MONITOR WATCHDOG TIMER**

It is important to protect the system during power transitions, and the CPU is reset after the V_{CC} power supply is applied. The microprocessor supervisory circuit generates an automatic reset output during power up, power down, or brownout conditions. When the V_{CC} falls below the reset threshold voltage of 2.90 V_{DC} , the reset signal (RESET*) goes low and holds the microprocessor in reset for approximately 200 ms after V_{CC} rises above the threshold.

This device also provides a watchdog timer function to monitor the activity of the microprocessor. To service the watchdog timer immediately after reset, the device has a longer time-out period (1.6 second minimum) right after a reset. The normal time-out period (70 ms minimum) is effective after the first transition of watchdog input (WDI) after RESET* is inactive. If the microprocessor does not toggle WDI within the time-out period, both RESET* and watchdog out (WDO*) outputs are asserted low. The RESET* remains active low for a minimum of 140 ms and it resets the CPU. The WDO* remains low as long as the WDI remains either high or low for longer than the watchdog time-out period. After a reset, the software reads this memory-mapped bit to determine if the latest reset was a watchdog time-out.

The supervisory circuit includes a chip-select inhibit circuit, which is used to disable access to the real-time clock's non-volatile SRAM during power transitions and power down mode.

4.2.1.11

ANALOG-TO-DIGITAL CONVERTER

The analog-to-digital converter (ADC) monitors the proximal pressure sensor, distal pressure sensor, proximal air sensor, distal air sensor, battery charge/discharge current, battery voltage, buzzer test signal, LCD contrast voltage, CCFT test signal, and two chopper motor drive reference voltages.

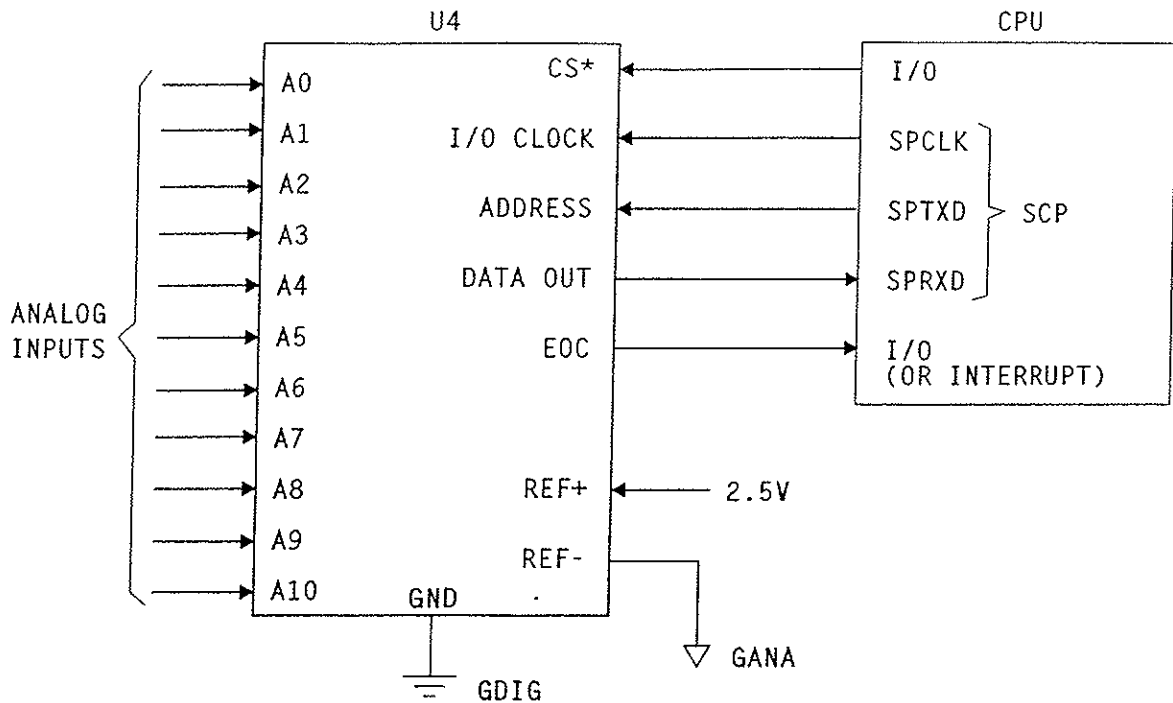
The ADC is an advanced 10 bit accurate, 11 channel, switched-capacitor, successive-approximation device. It has three inputs and a three-state output (chip-select, I/O clock, address input, and data out) that provide a direct four-wire interface to the serial communication port of the CPU.

In addition to a high-speed ADC and versatile control capability, this device has an on-chip 14 channel multiplexer that can select any one of 11 analog inputs or any one of three internal self test voltages. The sample-and-hold function is automatic. The end-of-conversion (EOC) output goes high to indicate that conversion is complete. The CPU polls the EOC signal.

The ADC is designed to be used in conjunction with multiple serial devices on a common bus; consequently, the data-out pin is driven only when the chip-select (CS*) pin is asserted. *Figure 4-1, Serial Interface to ADC* illustrates the serial interface between the ADC and the CPU.

Channel selection and conversion results are transferred through the SCP pins. A serial transfer synchronizing clock (SPCLK) must be fed into the I/O clock input pin when the CS* pin is driven low. The address to be converted is serially transmitted into the address pin, and the conversion results are serially shifted out the data-out pin. Typical access time is 21 μ sec. The APP PWA is the source of the 2.5 V_{DC} reference voltage.

The analog inputs are selected by the channel multiplexer according to the input address (see *Table 4-1, Analog Inputs*). The input multiplexer is a break-before-make type to reduce input-to-input noise injection resulting from channel switching.



98G01022

Figure 4-1. Serial Interface to ADC

Table 4-1. Analog Inputs			
Signal Name	Analog Input	Address (hex)	Description
PRPRS	A0	\$00	Proximal pressure sensor
DIPRS	A1	\$01	Distal pressure sensor
PXAIR	A2	\$02	Proximal air sensor
DIAIR	A3	\$03	Distal air sensor
IBATT	A4	\$04	Battery current
VBATT	A5	\$05	Battery voltage
BUZTST	A6	\$06	Buzzer test voltage
LCDTST	A7	\$07	LCD contrast test voltage
TUBTST	A8	\$08	CCFT intensity test voltage
MI_STA	A9	\$09	Motor current A control
MI_STB	A10	\$0A	Motor current B control
		\$0B	$(V_{ref(+)} - V_{ref(-)}) / 2$
		\$0C	$V_{ref(-)}$
		\$0D	$V_{ref(+)}$

4.2.1.12

DIGITAL-TO-ANALOG CONVERTER

The dual 8 bit digital-to-analog converter (DAC) generates two analog signals to control the phase A and phase B motor coil currents. The interface between the DAC device and the CPU is the 8 bit data bus, which is connected to DATA15:8. All the control signals for this DAC are generated by FPGA logic devices. Buffer amplifier/ground compensation circuits (U6 and U7) condition the DAC outputs.

4.2.1.13

FRONT PANEL KEYPAD MATRIX

A 5 x 5 membrane switch keypad matrix is located on the front panel. The keypad column lines (COL4:0) are driven by open collector type memory mapped input ports, while the keypad row lines (ROW4:0), are read by memory mapped input ports. The keypad strobing, scanning, and switch de-bouncing is accomplished by software. The keypad interface is designed with ESD protection. Refer to *Table 4-2, Keypad Map*.

Table 4-2. Keypad Map					
	COL 0	COL 1	COL 2	COL 3	COL 4
Row 4	Soft key 1	Soft key 2	Soft key 3	Soft key 4	
Row 3	Start	1	2	3	[▲]
Row 2	Stop	4	5	6	
Row 1		7	8	9	[▼]
Row 0		Clear	0	.	Silence

4.2.1.14

FRONT PANEL [ON/OFF] KEY

The [ON/OFF] key on the front panel provides a start up (STRUP) signal to wake up the power supply when the system is shutdown. When activated during normal operation, the [ON/OFF] key interrupts (STRUPD*) the CPU, signaling a request for shutdown.

4.2.1.15

FRONT PANEL LED INDICATORS

The CPU drives the three light emitting diode (LED) indicators embedded in the front panel. Two memory mapped I/O signals activate the two LED lights used to indicate which channel is in delivery mode (LEDAE*, LEDBE*). The AC power on LED indicates the status of AC power (LEDAC) and that the system is in the battery charge mode. A buffered AC on signal (BACON) drives the LED and is active only when AC power is present.

4.2.1.16**KEYPAD LOCKOUT INTERFACE**

A lockout switch (SW1) on the peripheral PWA indicates the front panel keypad is locked. A memory mapped input port (LOTSW*) reads the switch. The switch serves as a lockout request and software performs the lockout.

4.2.1.17**NURSE CALL INTERFACE**

A nurse call relay switch on the peripheral PWA indicates alarm conditions to a remote operator. A memory-mapped output signal (NURSE) activates the relay during alarm conditions. The relay has both 'normally open' and 'normally closed' contacts. A jumper on the peripheral board selects the contact type. The factory setting is 'normally open'.

4.2.1.18**AUDIBLE INDICATORS**

There are two audible indicators on the CPU subsystem. A loud, main audible indicator is mounted on the main chassis. This main alarm is used for alerting the operator to alarm conditions. A keypad beeper (LS1), with lower power and a distinctly different tone, is used to provide audible feedback to the operator.

The keypad beeper is driven by a memory-mapped output (KEYALM). It is used to indicate keypad activation, and confirmation to the operator.

The main alarm has an adjustable volume control on the peripheral PWA (R2), mounted on the rear of the instrument.

The main alarm can be activated by either a memory-mapped control (MAINALM), the reset pulse(s), or by a power failure alarm latch. The main alarm will sound a chirp for every reset pulse sent by the watchdog timer IC. Continuous chirping indicates a stuck processor.

The alarm is activated continuously during power failure. If the control software does not shut down power in a proper sequence, a latch on the CPU PWA (U2), powered by a backup supply (0.1F super cap), will activate a continuous alarm. This continuous alarm sounds until either the backup supply is discharged or the user resets the latch by pressing the front panel [ON/OFF] key.

Reliable operation of the main alarm is assured by software monitoring of a buzzer test signal (FBUZTST) via the ADC.

4.2.1.19**BARCODE READER INTERFACE**

The CPU communicates with a barcode wand that is connected to the peripheral PWA from the rear of the infusion device. The barcode wand reads and decodes a "Code 128" barcode symbology and outputs the barcode data via an RS-232 port using an asynchronous, serial ASCII format. The software controls power to the barcode reader and to the interface circuits via memory-mapped outputs BARPWR and COMPWR*.

The barcode reader is isolated from the main system by an optical data path on the peripheral PWA (U10, U11, and U13) and an isolated power supply (U3 and T1).

4.2.1.20

DATAPORT INTERFACE

The CPU communicates with an external computer by way of a DataPort interface. The DataPort interface provides for remote monitoring of up to 15 pumps using a host computer with a modified RS-232-D serial interface.

Pumps are either connected directly to the host or in a daisy chain configuration using junction boxes that provide a 5 bit hard ID via DIP-switches on the junction box. The DIP-switches are buffered (peripheral PWA U8) and read by the CPU via the MMIO port.

The DataPort system conforms to the EIA-232-D standard, with the following exceptions:

- DataPort uses non-standard DB-15 and 6 pin modular connectors in addition to the standard DB-25 and DB-9 connectors
- With DataPort, more than one pump is allowed on the line
- The minimum line impedance is 2 K Ω (EIA-232-D standard: 3 K Ω min.)
- The maximum line impedance is 30 K Ω (EIA-232-D standard: 7 K Ω max.)
- The maximum line capacitance is 13 nF (EIA-232-D standard: 2,500 pF)

The communications default is 1200 BAUD, no parity, 8 data bits and 1 stop bit. The Plum A+ BAUD rate is selectable (1200, 2400, 4800, and 9600 BAUD). The data format on the serial port is a 10 bit frame with asynchronous start and stop. The CTS line is held high and the RTS line is disconnected.

The DataPort is isolated from the main system by an optical data path on the peripheral PWA (U10, U11, and U13) and an isolated power supply (U3 and T1).

4.2.1.21

POWER SUPPLY INTERFACE

The CPU subsystem interfaces the power supply subsystem by providing the memory-mapped input/output (MMIO) signals needed for power control and battery management. Additionally, the CPU subsystem measures the battery terminal voltage and charge/discharge current via the ADC. Refer to *Table 4-3, CPU-Power Supply Interface*.

Table 4-3. CPU-Power Supply Interface		
Signal Name	Type	Description
PWRHLD	D, O	Holds system power on
STRTUP	A, I	Startup pulse from the [ON/OFF] key
STRUPD*	D, I	Digital startup pulse, used as interrupt to the CPU
V3_3	P	3.3 volt system power
V5_0/VANA	P	5.0 volt analog and interface power
VMOT	P	Raw, unregulated charger voltage or battery voltage

Table 4-3. CPU-Power Supply Interface		
Signal Name	Type	Description
V2_7	P	2.7 volt backup power for RTC and NV-SRAM
VSC	P	Full time 5 volt supply, backed up by super cap
V12_0	P	12 volt, low current supply for audio alarm
OVRVLT*	D, I	Signal that indicates overvoltage, regulation problem on the power supply main regulator
BACON	D, I	Buffered AC on signal
IBATT	A, I	Voltage proportional to integration of battery charge/discharge current
VBATT	A, I	Divided battery terminal voltage
CHG*	D, O	Battery charger enable
VFLOAT*	D, O	Set the main regulator voltage to battery float charge level
ITGRST	D, O	Reset the charge current integrator

Note: P = power, A = analog, D = digital, I = input, O = output

4.2.1.22

MECHANISM INTERFACE

The CPU subsystem provides the memory-mapped input/output (MMIO) ports for interface to the mechanism subsystem, in addition to the analog interface mentioned in the ADC and DAC sections (see Section 4.2.1.11, *Analog-to-Digital Converter* and Section 4.2.1.12, *Digital-to-Analog Converter*). Refer to Table 4-4. *CPU-Mechanism Interface Signals*.

Table 4-4. CPU-Mechanism Interface Signals		
Signal Name	Type	Description
MI_STA	A, O	Motor current set for phase A
MI_STB	A, O	Motor current set for phase B
GDAC	A, O	Ground signal from chopper (for compensation)
M_PHA	D, O	Motor phase A
M_PHB	D, O	Motor phase B
M_SEL1, M_SELO	D, O	Motor select bits
FLCAME	D, O	I/O and L/S cam flag sensors enable
FLPINE	D, O	L/S pin motion detectors enable
FLPLE	D, O	Plunger motor sensor pair enable
FLLS_C	D, I	Flag, L/S valve cam sensor
FLIO_C	D, I	Flag, I/O valve cam sensor

Table 4-4. CPU-Mechanism Interface Signals

Signal Name	Type	Description
FLLS_A	D, I	Flag, L/S valve A pin detector
FLLS_B	D, I	Flag, L/S valve B pin detector
FLPLRO	D, I	Flag, plunger rotation sensor
FLPLTR	D, I	Flag, plunger translation sensor
PXPRE	D, O	Proximal pressure sensor enable
PXPRS	A, I	Proximal pressure sensor
DIPRE	D, O	Distal pressure sensor enable
DIPRS	D, O	Distal pressure sensor
PXARE	D, O	Proximal air sensor enable
PXAIR	A, I	Proximal air sensor
DIARE	D, O	Distal air sensor enable
DIAIR	A, I	Distal air sensor
CASPR*	D, I	Cassette present
CASS2*, CASS1*, CASSO*	D, I	Cassette type coding: Macro (111), Micro (010), all others are invalid
SPCLK	D, O	SCP clock output
SPRXD	D, I	SCP receive data
SPTXD	D, O	SCP transmit data
CSSEP*	D, O	Chip select, EEPROM
V5_0	P	5.0 volt supply for interface power
V3_3	P	3.3 volt supply for logic power
GDIG	P	Digital ground
VANA	P	5.0 volt supply for analog power
GANA	P	Analog ground
VMOT, GMOT	P	Motor power is directly from power supply PWA
V2_5	A, I	Reference voltage for ADC and DAC

Note: P = power, A = analog, D = digital, I = input, O = output (referred to CPU)

4.2.2

POWER SUPPLY SUBSYSTEM

The power supply subsystem provides direct current (DC) power to system circuits and interface software controlled power and battery management. Refer to *Figure 9-11. Power Supply PWA Schematic*. The power supply subsystem provides for the following functions:

- ☐ Main switching regulator
- ☐ AC power detection
- ☐ Main regulator fault detection
- ☐ System power (secondary regulators)
- ☐ Auxiliary supplies
- ☐ Power control
- ☐ Battery charging circuitry
- ☐ Battery terminal voltage measurement
- ☐ Battery charge/discharge current measurement

The following sections describe these functions.

4.2.2.1

MAIN SWITCHING REGULATOR

The main source of power for the Plum A+ is the AC line. The main switching regulator is a pulse width modulated, AC to DC converter which provides the system an isolated DC voltage of 6.9 V_{DC} (or 7.5 V_{DC} in battery charger boost mode). The main regulator is preceded by: line fuses F1 and F2, surge suppressor VR1, and a line filter (T3, T4, C54-56). The bridge rectifier U14 and capacitors C52 and C53 provide the DC voltage required for the switching circuit. Voltage regulator U13 provides the pulse width modulator (PWM) device U12 startup supply voltage. After startup, supply voltage for U12 is supplied by half wave rectifier circuitry CR14, R76 and C51.

The PWM oscillation frequency is approximately 40 kHz, determined by external resistor R72 and capacitor C45. U12 controls the power delivered by varying the duty cycle of the power metal-oxide-semiconductor field-effect transistor (MOSFET) Q9, which drives T2. A half-wave rectifier (CR9 and C37-C41) rectifies the transformer's secondary voltage, which provides the raw DC voltage for the battery charger and system power. There are three feedback mechanisms that maintain control: a main loop for normal control, a secondary loop for overvoltage protection, and a current limit loop.

4.2.2.1.1

Main Loop

The main loop uses an optical feedback path to regulate the charger voltage (BATPOS) at 6.9 V_{DC} (except during boost charge, when the limit is raised to 7.5 V_{DC} by software control of the VFLOAT* line). A shunt regulator and opto-isolator provide feedback to the PWM error amplifier.

4.2.2.1.2***Secondary Loop***

Diode CR10 and opto-isolator U10 provide overvoltage protection. CR10 conducts and activates U10 when secondary voltage exceeds approximately 10 V_{DC}. The duty cycle of U12 is reduced until the excessive voltage is removed.

4.2.2.1.3***Current Limit Loop***

The current limit loop is activated when the primary current, sensed by R71, exceeds 3.0 A. Resistor R70 and capacitor C46 filter the voltage across R71 and feed it back to the current sense input (1.5 V_{DC} threshold) of U12. The duty cycle of U12 is reduced until the excessive load is removed.

4.2.2.2**MAIN REGULATOR FAULT DETECTION**

If the switching regulator's main loop fails, the secondary voltage limit loop takes over. However, the battery charger and motors must be disabled, and an alarm must be generated. A comparator is used to monitor the raw DC (+BUSS) for overvoltage. A 3.3 V_{DC} logic signal (OVRVLT*) is provided to the CPU subsystem.

4.2.2.3**SYSTEM POWER**

Along with the unregulated VMOT supply, a secondary switching regulator provides system power. The secondary switching regulator includes IC U4, transformer T1, and transistors Q4 and Q5. The regulator is a triple output, wide supply range, fly-back converter that provides regulated 3.3 V_{DC}, 5.0 V_{DC}, and 12.0 V_{DC} outputs from the five winding transformer T1. The regulator operates over an input range of 4 to 10 V_{DC} and provides output current limit as well as voltage overshoot limit. Primary feedback is metered through a bias arrangement on transistor Q3. A Schottky rectifier diode CR4 provides feedback in the event of V3_3 or V12_0 failure, and transistor Q10 provides feedback in the event of V5_0 failure.

The positive terminal of the battery provides the raw DC voltage, VMOT, for the motors and backlight of the display.

4.2.2.4**AUXILIARY SUPPLIES**

The power supply subsystem provides full time 5.0 and 2.7 V_{DC} supplies, which are active when battery or AC voltage is present. The full time 5.0 V_{DC} supply (VSC) uses a linear low dropout voltage regulator U6, whose power source is directly from the battery and is backed up by a 0.1 F capacitor. VSC is used for the ON/OFF switch and a power failure alarm latch. The full time 2.7 V_{DC} supply (V2_7) is derived from VSC and is used to supply the ultra-low current needed to power the real-time clock and non-volatile SRAM during shutdown.

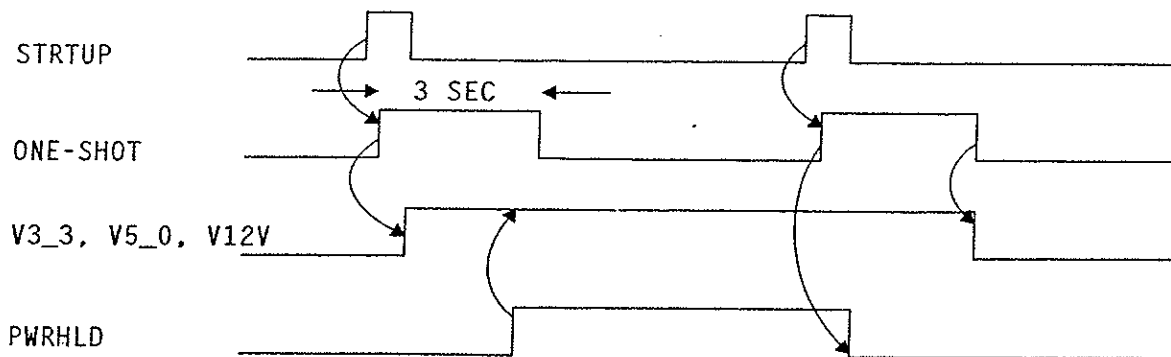
4.2.2.5

POWER CONTROL

The infusion pump will operate in one of three modes: normal, standby, or shutdown. During normal operation, the user interface is active and either on battery or AC line power. During standby mode the user interface is inactive while the CPU is still operating, servicing the battery management and waiting for a startup interrupt. Shutdown mode is when system power is off. Shutdown mode only occurs during battery operation; otherwise, +BUSS holds the system power on.

The infusion pump is activated when the [ON/OFF] key is pressed or the AC line is plugged in. The [ON/OFF] key activates the STRTUP signal, triggering a three second one-shot circuit (C3, R10, CR1, and Q1) that will temporarily turn the system power on. This three second one-shot period allows the CPU enough time to power up, initialize, and turn on the PWRHLD signal. The CPU monitors the STRTUP signal, via interrupt, to signal a user request for turning off the infuser.

Figure 4-2. System Startup and Shutdown Timing, Battery Powered illustrates the system startup/shutdown sequence while battery powered (system power is always on while AC powered).



98G01021

Figure 4-2. System Startup and Shutdown Timing, Battery Powered

4.2.2.6

BATTERY VOLTAGE MEASUREMENT

The battery terminal voltage (BATPOS - BATNEG) is measured with a differential amplifier consisting of U1, R1, R2, R4, R7, and R8. It has a gain of 0.317 to generate a single ended VBATT signal. The VBATT signal is then provided to the CPU A/D converter as input for the battery management algorithms.

4.2.2.7

BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT

The battery management algorithms measure battery charge/discharge current for battery capacity estimation and charger control. The charge/discharge current is measured by integrating the voltage across current sense resistor R57. An operational amplifier (op-amp) integrator circuit, consisting of U2, C5, R12, R13, R19, and R20, provides a voltage proportional to the integration of battery current (IBATT) over a CPU controlled measurement period. The IBATT signal is fed to the CPU A/D converter, where it is sampled at the end of the measurement period. The battery management algorithm further accumulates the charge/discharge current for battery capacity estimation. The op-amp integrator is reset by the CPU system at the beginning of each measurement period by parallel analog switches U3, controlled by the CPU's ITGRST signal. The battery management algorithm periodically calibrates the op-amp integrator.

4.2.2.8

BATTERY CHARGER

The software battery management algorithm controls the battery charger. The charging scheme is a current limit/two stage voltage limit charger. The charge current is limited to 1.3 A and the voltage is limited to either 6.9 V_{DC} or 7.5 V_{DC}.

The source of the charge current is power MOSFET transistor Q7 operating in the linear mode. Charge current passes through a current sense resistor R57, where it develops a feedback signal for the charger control amplifier consisting of U7, Q6, and associated parts. The feedback signal is compared against a 2.5 V_{DC} voltage reference U8. A .5A fuse F4 protects against damage due to a short circuit. The battery management algorithm maintains on/off control of the charger by the charger enable signal CHG*. When set high, CHG* activates a comparator U7, which overrides the feedback signal and disables the charger. Excessive voltage on the BATNEG terminal indicates that there is a shorted battery cell, and will disable the charger through the same comparator.

4.2.3

MECHANISM SUBSYSTEM

The mechanism subsystem includes the electronics and electromechanical components that interface the Plum A+ pumping mechanism. Refer to *Figure 9-14, Driver PWA Schematic*, *Figure 9-15, Switch PWA Schematic*, and *Figure 9-16, APP PWA Schematic* for circuit details. Refer to *Table 4-4, CPU-Mechanism Interface Signals* for an interface signal summary.

The mechanism subsystem provides the following functions:

- ❑ Chopper motor drive for three stepper motors (plunger, L/S valve, I/O valve)
- ❑ Four motor position sensors (flag detectors)

- ❑ Precision voltage reference
- ❑ Two air sensors (distal, proximal)
- ❑ Two pressure sensors (distal, proximal)
- ❑ Cassette presence and type detection
- ❑ Serial electrically erasable PROM (EEPROM)

4.2.3.1

MOTORS/MOTOR DRIVE

The Plum A+ Infusion System uses three stepper motors for pumping: one for fluid displacement and two for cassette valve actuation. The stepper motors are driven, under step-by-step control from software, by a unipolar chopper drive.

4.2.3.1.1

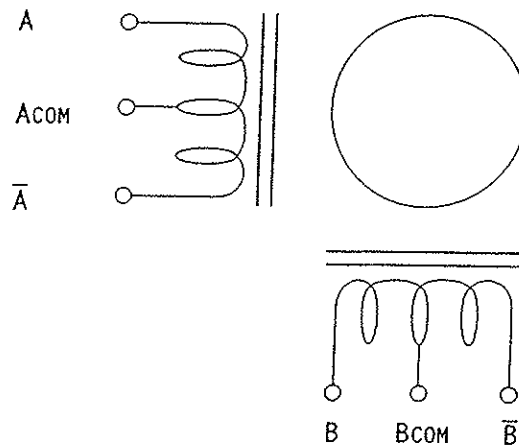
Stepper Motors

Each motor is named by its function:

- Plunger motor for driving the plunger screw
- I/O valve motor for moving the input-output valve pins
- L/S valve motor for moving the line select valve pins A and B

All three motors are four phase stepper types. One electrical revolution is accomplished after four motor steps (phases) are completed. The step-angle (the number of steps per shaft revolution) resolutions are $3.6^\circ/\text{step}$ (100 steps/rev) for the plunger motor, and $7.5^\circ/\text{step}$ (48 steps/rev) for the I/O and L/S valve motors.

The unipolar motor windings have a center tap connected on each of the two coils as shown in Figure 4-3, *Stepper Motor Coils*. Unidirectional current enters the center tap and is steered to one end of the coil or the other end by the driver electronics, creating positive or negative flux lines in the motor coil. With two coils each with a choice of flux polarity, four electrical combinations or phases are possible.



98G01020

Figure 4-3. Stepper Motor Coils

4.2.3.1.2***Chopper Motor Drive***

The Plum A+ stepper motor drive is a chopper drive, which is a pulse width modulation of the coil current in each motor winding. Current is switched on and off to maintain a predetermined coil current independent of supply voltage and motor speed. The motor winding inductance acts as a filter to smooth out the switching currents, slowing the current rise when turned on and storing a decaying current when turned off.

Each motor coil is modulated independently, allowing different coil currents in the two motor windings. The coil current is sensed and compared to a reference input for each winding. Modulation circuits correct for any error between the sensed current and the reference. This reference input can be changed to set a different coil current.

4.2.3.2**MOTOR POSITION SENSORS**

Motor position is estimated by counting the motor steps, relative to a position reference. Optical switches and flags serve as position references, which are used to find the motor home positions and to verify proper motion (flag positions are anticipated by software). Optical switch, flag sensors are used for tracking:

- Plunger motor rotational position (coupler flag)
- Plunger translational (linear) position
- I/O valve motor rotational position (cam flag)
- L/S valve motor rotational position (cam flag)

Each optical switch consists of an infrared LED, which shines through a rectangular aperture, across a slot, to illuminate a photo-transistor. The photo-transistor is activated as long as the beam is on and not blocked (by a flag in the slot). The optical switches are distributed throughout the mechanism, near their associated flags. The motor rotational optical switches (U5, U9, and U10) are mounted on the driver PWA along with the control circuitry. The plunger translational optical switch is mounted remotely on the switch PWA. The switches are used intermittently to save power. There are two control signals that enable associated switch pairs:

- FLCAME Flag, valve motor cam sensor enable
- FLPLE Flag, plunger motor rotation and translation sensors enable

Each of these control signals enables a constant current source which turns on the associated switch's infrared LEDs. The photo transistor states are sensed by Schmidt trigger inverters (U11 on driver PWA) which provide a 3.3 volt logic high when the optical path is blocked or a logic low when the optical path is clear. The Schmidt trigger output is high when the sensor is disabled. The following output signals are provided to the CPU subsystem:

- FLIO_C Flag I/O valve motor cam sensor
- FLIS_C Flag L/S valve motor cam sensor
- FLPLRO Flag plunger motor rotation sensor
- FLPLTR Flag plunger motor translation sensor

4.2.3.3

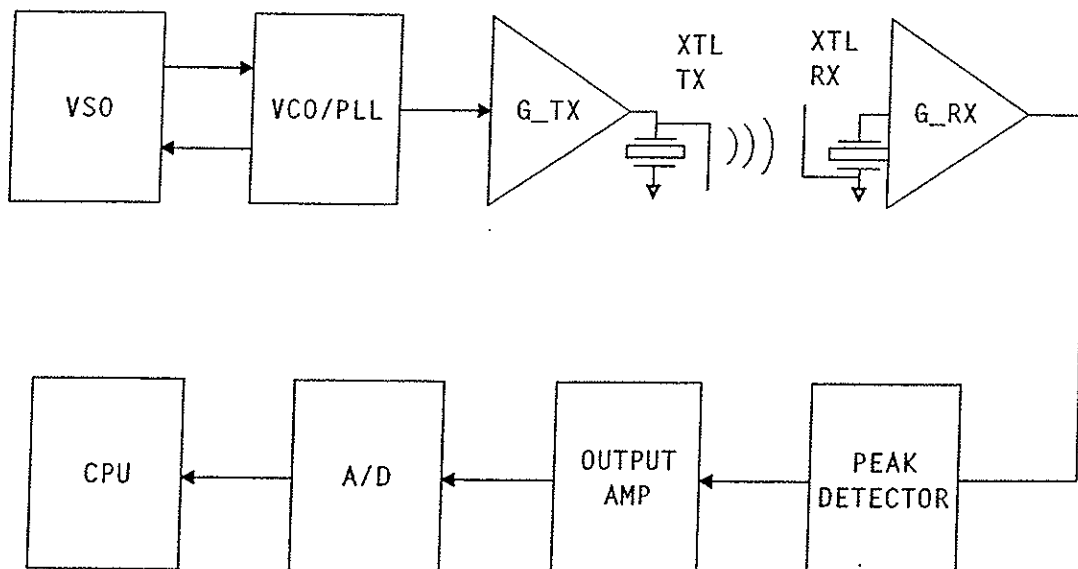
V2_5 REFERENCE VOLTAGE

A precision $2.50\text{ V}_{\text{DC}}$ reference voltage is generated on the APP PWA for use by the pressure sensor excitation circuits, the air sensor amplifier circuits, and the ADC and DAC reference voltage. The precision $2.50\text{ V}_{\text{DC}}$ reference (U1) is buffered by a voltage follower (U3). The signal name is V2_5.

4.2.3.4

AIR SENSORS

The mechanism subsystem includes two air sensors, used to detect air passage into (proximal) or out of (distal) the cassette. Both sensors are piezoelectric crystal transmitter receiver pairs. Liquid between the transmitter and receiver will conduct the ultrasonic signal, while air will not. Refer to *Figure 4-4, Air Sensor Block Diagram*.



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Figure 4-4. Air Sensor Block Diagram

4.2.3.4.1

Transmitter Circuitry

The transmitter circuitry consists of a voltage sweep oscillator, a voltage-controlled oscillator (VCO), and a transmitter amplifier, and are located on the APP PWA.

The voltage sweep oscillator circuit (U10B, R24, C12, and part of U9) oscillates at approximately 12 kHz at 50 percent duty cycle. The output of the sweep oscillator is between $+2 V_{DC}$ and $+3 V_{DC}$, and is used to sweep the VCO. The VCO sweeps through the sensor's peak coupling frequency, which is between 3.0 and 6.0 MHz. A resistor and capacitor (R28 and C13) are used to configure the VCO center frequency. The VCO is enabled when the CPU asserts either DIARE or PXARE control signals.

The transmitter amplifier consists of a push-pull, emitter-follower, complementary pair of transistors (Q15 and Q16). The transmitter amplifier drives both proximal and distal sensors simultaneously.

4.2.3.4.2

Receiver Circuitry

When the cassette's test port is filled with fluid, the transmitted signal will be coupled to an identical piezoelectric crystal, where it is amplified and detected by the receiver circuitry. The receiver circuitry consists of an amplifier, a peak detector, and an adjustable gain buffer stage. There is a separate, symmetrical receiver circuit for each channel (proximal and distal). Component references (called out in this design description) will be made to the distal channel only.

The first amplifier includes two, directly coupled common emitter stages (Q5 and Q7), biased from the V2_5 supply. DIARE and PXARE are used to enable the distal and proximal sensors, respectively.

The detector stage consists of an emitter follower (Q3), charging a 400 μ sec time constant, refreshed every 40 μ sec (twice per VCO sweep).

The peak detector output is buffered by an op-amp (U7) configured as a basic non-inverting amplifier with a trimming potentiometer (R31) for gain adjustment. Each sensor has an independent gain adjustment. The two air sensor, gain-trimming potentiometers are accessible for calibration in an assembled mechanism. The final signals are read by the CPU subsystem via the ADC.

The signal names are:

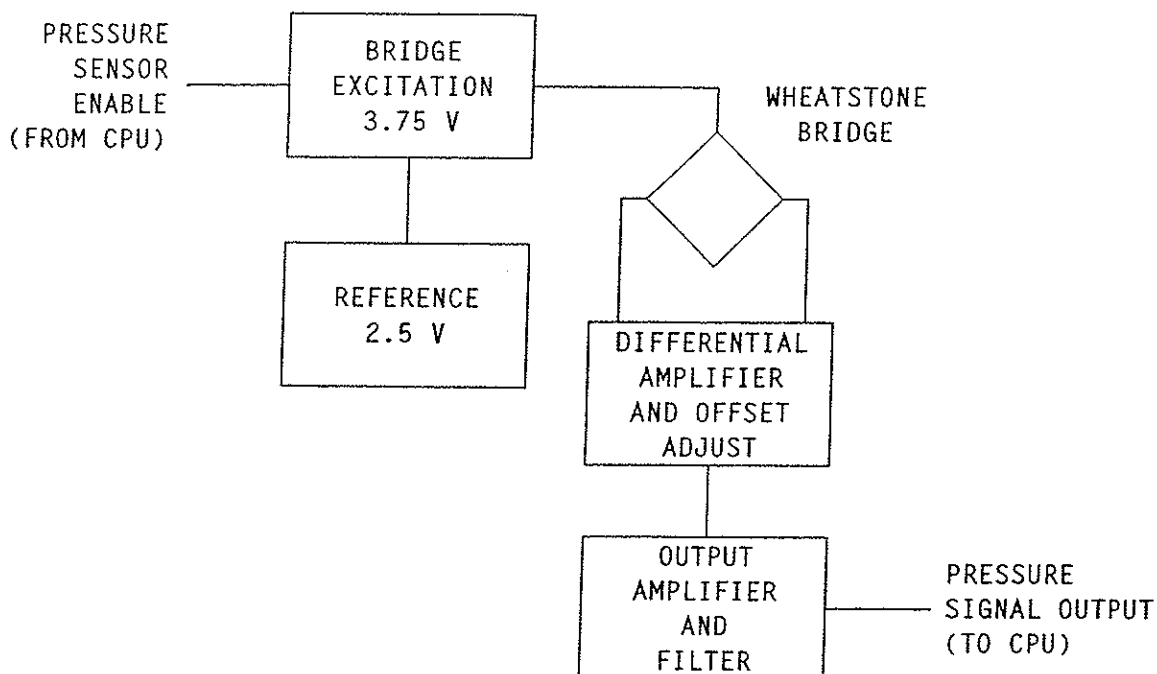
- PXAIR Proximal air sensor output
- DIAIR Distal air sensor output

4.2.3.5

PRESSURE SENSORS

The mechanism subsection contains two strain gauge-type pressure sensors, one at the proximal and the other at the distal cassette ports. Electrically, the strain gauge is a Wheatstone bridge made of four strain gauge resistors. When the bridge is electrically excited, the bridge will output a millivolt level signal proportional to the applied pressure. The output signal is amplified and offset adjusted before being read by the ADC. Each pressure sensor circuit includes an excitation voltage supply, sensor amplifiers, and a low pass filter. A block diagram of this circuit is shown in *Figure 4-5. Pressure Sensor Excitation and Amplifier Block Diagram*.

The pressure sensor circuitry is on the APP PWA. Each of the two channels has an identical topology, but different gain and filter response. Component references (called out in this design description) will be made to the distal channel only.



98G01018

Figure 4-5. Pressure Sensor Excitation and Amplifier Block Diagram

4.2.3.5.1

Bridge Excitation Supply

The bridge excitation voltage is 3.75 V_{DC}, and is derived from the 2.5 V_{DC} reference signal (V2_5), gained 1.5 times by amplifier (U8A, Q13). The CPU subsystem may independently enable power to each pressure sensor bridge. These enable signals are active high 3.3 volt logic level inputs named:

- PXPRES Proximal pressure sensor enable
- DIPRES Distal pressure sensor enable

4.2.3.5.2

Amplifier and Low Pass Filter

The pressure sensor amplifiers include a high gain differential pre-amplifier (U4), followed by a second stage non-inverting amplifier (U6B) with low gain. A trimming potentiometer (R48) is adjusted to minimize any offset in the impedance of the bridge.

A two-pole filter is used to filter the pressure signals. The first pole is formed by a capacitor (C39, multiplied by 230 due to Miller effect) and a Thevenin resistance (seen at U4-2). The second pole is the RC filter at the ADC input, which is located on the CPU PWA.

The output signals to the A/D converter in the CPU PWA are:

- PXPRS Proximal pressure signal
- DIPRS Distal pressure signal

4.2.3.6

PRESSURE SENSOR CALIBRATION

Pressure sensors are calibrated for offset and gain during mechanism calibration. A trimming potentiometer is used to adjust the initial, zero pressure offset. The proximal and distal pressure sensors have independent offset adjustments.

The final system gain (cassette pressure to corrected amplifier output) is adjusted in software. During mechanism calibration, each channel's gain (amplifier output/cassette pressure) will be measured, and stored in the serial EEPROM (on driver PWA).

4.2.3.7

CASSETTE TYPE/PRESENCE SELECTION

The mechanism subsystem includes four force sensing resistor (FSR) switches, which are coupled to the cassette. Three FSRs are used for cassette type decoding and one is used for cassette present detection.

The FSR is a polymer thick film device, which exhibits a decrease in resistance with any increase in force applied to the active surface. The FSRs have a resistance that is either very large ($> 1 \text{ M}\Omega$) or relatively small ($< 100 \text{ K}\Omega$). The large resistance is defined as a logical '0', and the small resistance is defined as logical '1'. Each FSR is arranged in a voltage divider configuration with a fixed resistor, followed by a comparator with hysteresis. The comparator circuits are located on the CPU PWA. The comparators (CPU PWA: U8 and associated passives) are designed to trip as the FSR's resistance falls below $120 \text{ K}\Omega$.

4.2.3.8

SERIAL EEPROM

The driver PWA holds the 8 K x 8 bit, serial EEPROM, which is used to store event, alarm, malfunction, and calibration data specific to the pumping mechanism. It is accessed through a serial peripheral interface (SPI) compatible interface, which is a high-speed serial interface to the CPU. The CPU PWA accesses this device through its SCP serial interface. This interface is a subset of the SPI, and consists of clock (SPCLK), data in (SPRXD), and data out (SPTXD) pins.

This device is in the driver PWA to allow the calibration data to stay with the mechanism.

4.3

PRINTED WIRING ASSEMBLIES

The Plum A+ electronics are packaged into six printed wiring assemblies (PWA) and several remote mounted peripherals (see Section 4.4. Remote Mounted Peripherals). A brief mention of the functional interfaces of each PWA is provided in this section.

4.3.1

POWER SUPPLY PWA

The power supply PWA (see Figure 9-11, Power Supply PWA Schematic) contains most of the functions of the power supply subsystem:

- ☐ Main switching regulator
- ☐ AC power detection
- ☐ Main regulator fault detection
- ☐ System power
- ☐ Auxiliary supplies
- ☐ Power control
- ☐ Battery management

Refer to Section 4.2.2, Power Supply Subsystem for a function description. Refer to Table 4-5, Power Supply PWA Interface Connections for power supply PWA interface connections.

Table 4-5. Power Supply PWA Interface Connections		
Connector	Type	Interface
P2	30 pin receptacle	Board-to-board connection to CPU PWA
J16	4 pin header	Motor power connection to driver PWA
J21	3 pin receptacle	AC power cord connection
J22	2 pin header	Battery cable connection

The power supply is a four layer PWB, with primarily surface mount technology (SMT) components. The board is fully testable from the bottom side. An insulating tape covers the back of the power supply PWA. Open system troubleshooting should be done under battery power. If connection to the AC line is required, an isolation transformer should be used since AC line potentials are present on the power supply PWA.

4.3.2

PERIPHERAL PWA

The peripheral PWA (see Figure 9-12, Peripheral PWA Schematic) contains part of the CPU subsystem circuitry, including system program and data memories (PROM and SRAM), external communication interface circuits, and the rear instrument user controls. The peripheral PWA is designed to be field replaceable, to facilitate software upgrades or additional external interfaces.

Refer to *Section 4.2.1, CPU Subsystem* for a functional description. Refer to *Table 4-6, Peripheral PWA Interface Connections* for peripheral PWA interface connections.

Table 4-6. Peripheral PWA Interface Connections		
Connector	Type	Interface
P1	96 pin receptacle	Board-to-board connection to CPU PWA
J26	15 pin D-sub	DataPort
J27	9 pin D-sub	Barcode reader connection
J28	3 pin phone jack	Nurse call jack

The peripheral PWA is a four layer PWB, including one ground plane, one power plane, and two signal layers. In its initial configuration, all of the components are mounted on the top-side.

4.3.3

CPU PWA

The CPU PWA (see *Figure 9-13, CPU PWA Schematic*) contains most of the CPU subsystem functions, with the exception of main memory and communications ports, which are located on the peripheral PWA. The CPU PWA also accommodates system interconnect.

Refer to *Section 4.2.1, CPU Subsystem* for a functional description. Refer to *Table 4-7, CPU PWA Interface Connections* for CPU interface connections.

Table 4-7. CPU PWA Interface Connections		
Connector	Type	Interface
J7	96 pin header	Connection to peripheral PWA (CPU bus, rear panel I/O, and communication ports)
J2	30 pin header	Connection to power supply PWA
J3	50 pin SMT	Ribbon cable connection to driver PWA (mechanism)
J4	21 pin header	Front panel connector (keypad, LEDs, on/off switch)
J5	14 pin SMT	Flat flex cable to LCD panel
J6	4 pin header	Lock box connector
J20	4 pin header	CCFT backlight connector
J24	2 pin header	Main audible alarm connector

The CPU PWA is an eight layer PWB, with one ground plane, one power plane, and six signal layers. The CPU PWA primarily contains SMT components. Most of the components are on the top side, while the bottom side holds wave-solder compatible SMT resistors and capacitors.

4.3.4

DRIVER PWA

The driver PWA (see Figure 9-14, *Driver PWA Schematic*) contains the mechanism subsystem's motor drive circuitry, motor position sensors, and serial EEPROM. The driver PWA is mounted in the mechanism sub-chassis.

Refer to Section 4.2.3, *Mechanism Subsystem* for a functional description. Refer to Table 4-8, *Driver PWA Interface Connections* for driver PWA interface connections.

Table 4-8. Driver PWA Interface Connections		
Connector	Type	Interface
J7	6 pin header	Plunger motor
J8	6 pin header	Input/output motor
J9	6 pin header	Line select motor
J10	20 pin SMT	Flat flex cable to APP PWA
J11	50 pin header	Ribbon cable to CPU PWA
J12	6 pin SMT	FSR flex circuit
J13	4 pin header	Motor power, from power supply PWA
J14	8 pin SMT	Flat flex cable to switch PWA

The driver PWA is a four layer PWB, with one ground plane, one power plane and two signal layers. The driver PWA primarily uses SMT components. Most of the components are located on the topside of the board, while the bottom side holds wave-solder compatible resistors and capacitors.

4.3.5

SWITCH PWA

The switch PWA (see Figure 9-15, *Switch PWA Schematic*) contains the plunger translation position sensor, which is one of six position sensors in the system. The switch PWA is located at the side of the mechanism sub-chassis, and connects to the driver PWA. Refer to Section 4.2.3.2, *Motor Position Sensors* for more information.

4.3.6

APP PWA

The APP (air, pressure, and pin) PWA (see Figure 9-16, *APP PWA Schematic*) is mounted in the mechanism sub-chassis. The APP PWA contains the following mechanism subsystem circuitry:

- ❑ Proximal and distal air sensors and circuitry
- ❑ Proximal and distal pressure sensor amplifiers and excitation
- ❑ V2_5 precision voltage reference
- ❑ Pin detector optical switch module

Refer to *Section 4.2.3. Mechanism Subsystem* for a functional description. Refer to *Table 4-9. APP PWA Interface Connections* for APP PWA interface connections.

Table 4-9. APP PWA Interface Connections		
Connector	Type	Interface
J15	20 pin SMT	Flat flex cable to driver PWA
J11	10 pin SMT	Pressure sensor connector

The APP board is a four layer PWB, with one ground plane, one power plane and two signal layers. The APP PWA uses SMT components, mounted on both sides of the board. The air sensors and the pin detector module are board mounted.

4.4

REMOTE MOUNTED PERIPHERALS

The following sections describe the major remote mounted peripherals.

4.4.1

LIQUID CRYSTAL DISPLAY (LCD)

The infusion pump uses a graphic LCD module with a cold cathode fluorescent tube (CCFT). The CCFT provides a backlight source for the LCD. The LCD requires a nominal -16 V_{DC} supply for contrast control, which is controlled by the CPU. The pump's graphic display data is shifted out to the LCD by the CPU LCD controller (*see Section 4.2.1.6, LCD Controller*), which interfaces directly with the CPU. The display is configured as a 240 x 240 dot matrix with a viewing angle of approximately 60°.

4.4.2

SEALED LEAD ACID BATTERY

The infusion pump uses a nominal 6.0 V_{DC} rechargeable sealed lead acid battery with 4.0 amp-hour capacity.

4.4.3

BARCODE READER WAND

The barcode reader (BCR) wand connects to the BCR port J27 on the peripheral PWA (*see Figure 9-12, Peripheral PWA Schematic*). The BCR wand interfaces through the infusion pump's optically isolated, TTL logic level, asynchronous interface. The BCR wand is also capable of interfacing at RS-232 levels. The infusion pump provides an isolated +5.0 V_{DC} regulator to power the BCR wand.

When the LED at the tip of the BCR wand is swiped across a barcode label, the reflected light is scanned and processed. After a successful scan, the data is sent over the communication interface to the CPU.

4.5

MECHANICAL OVERVIEW

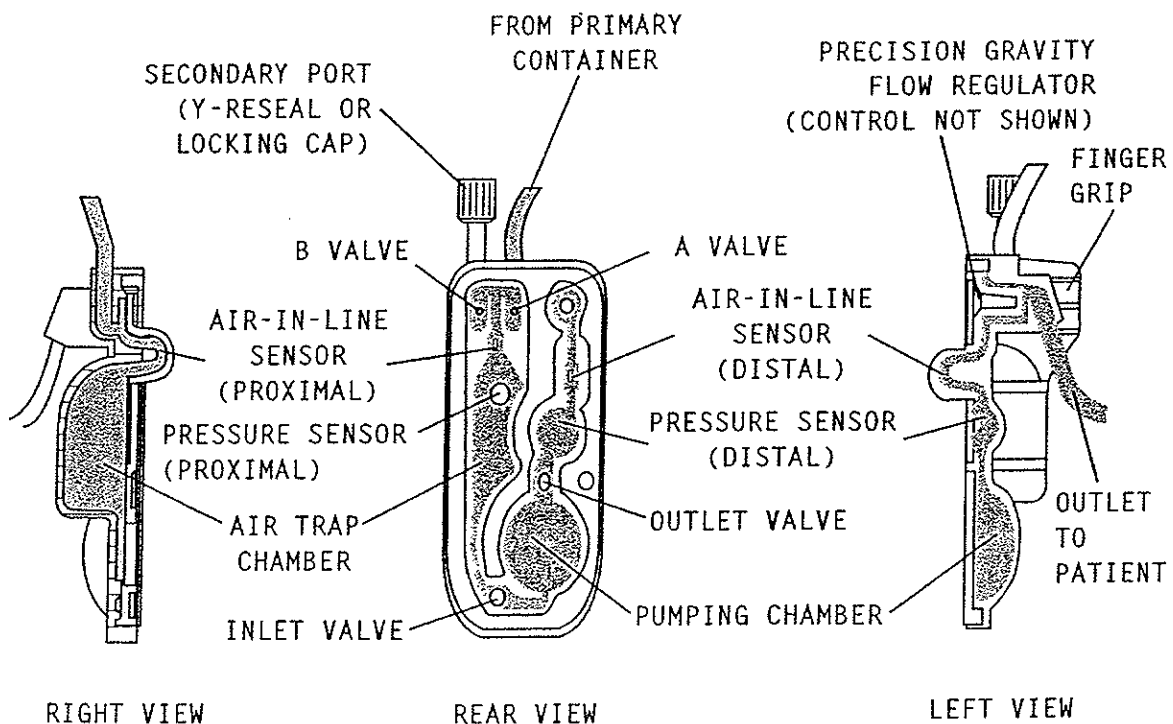
The principal mechanical elements of the infusion pump include the cassette and the mechanism assembly. When a cassette is locked into the operating position and the [ON/OFF] switch is pressed, the infusion pump performs a self test to verify the integrity of the internal systems. The operation of the mechanism assembly moves a plunger, causing a pumping action. A valve motor selects the A or B valve, depending on the command. An additional valve motor alternately opens and closes an inlet valve and outlet valve to control fluid flow through the cassette pumping chamber.

The following sections detail the cassette and the mechanism assembly.

4.5.1

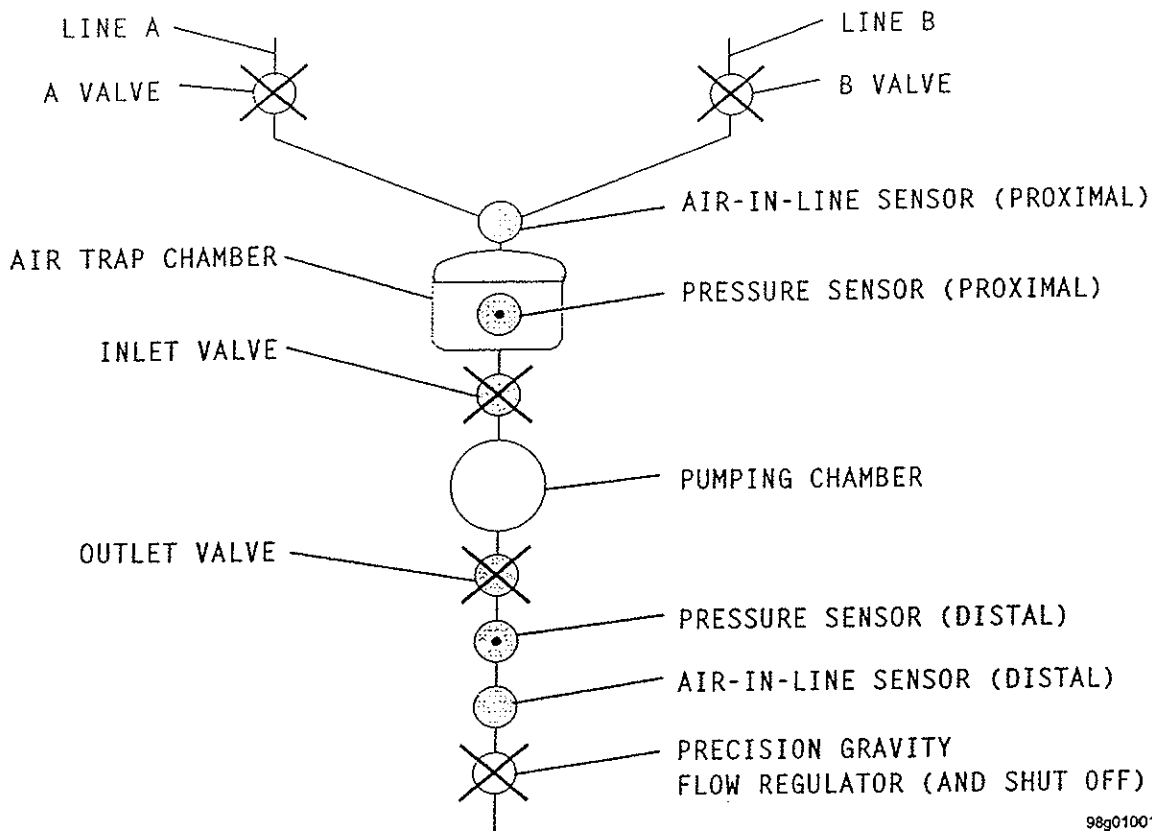
CASSETTE

The cassette operates on a fluid displacement principle to volumetrically deliver fluid (see Figure 4-6. *Major Elements of the Dual-Channel Cassette*, and Figure 4-7. *Fluid Path in the Cassette*). Refer to the system operating manual for a description of the major cassette functions.



98G01017

Figure 4-6. Major Elements of the Dual-Channel Cassette



98g01001

Figure 4-7. Fluid Path in the Cassette

The pumping cycle begins when the outlet valve is opened and the inlet valve is closed. The plunger extends to deflect the cassette diaphragm and expel fluid. At the end of the pumping stroke, the outlet valve is closed, the inlet opens, the appropriate A or B valve opens, and the plunger retracts to allow fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed, the A and B valves are closed, and the cycle repeats.

The cassette contains two chambers: an upper air trap chamber and a pumping chamber. The two chambers are separated by an inlet valve (see Figure 4-6 and Figure 4-7) and operate together to detect air. The air trap chamber receives fluid from the intravenous (IV) container through either the A or B valve. The air trap chamber collects air bubbles from the IV line and container to prevent them from entering the pumping chamber and can collect a substantial amount of air.

A proximal air-in-line sensor (bubble detector) is located between the A/B valves and the upper air-trap chamber. The proximal air-in-line sensor detects air entering the upper air-trap chamber and initiates an audible alarm if the predetermined air collection threshold is exceeded. Similarly, a second air-in-line sensor located distal to the pumping chamber initiates an audible alarm if a predetermined amount of air is detected. The infusion pump expels air from the cassette.

The pumping chamber receives fluid from the upper air-trap chamber through an inlet valve. A pressure sensor located in the upper air-trap chamber monitors pressure on the proximal side of the cassette. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through an outlet valve. A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator is incorporated into the cassette distal end. This flow regulator is used to manually control flow when the cassette is not inserted in the infusion pump. When the cassette is properly inserted into the pump and the door is closed, a mechanism opens the flow regulator to allow the pump to control fluid flow.

When the door is opened, the same mechanism closes the flow regulator to disable fluid flow.

4.5.2

MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit consisting of the motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, plunger drive subsystem, air bubble (ultrasonic) sensor assemblies, cassette door, and pressure sensor assemblies. The motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, and plunger drive subsystem are detailed in the following sections.

During pump operation, the mechanism assembly plunger motor drives a lead screw that is coupled to the plunger. The motor action and lead screw move the plunger forward to cause the delivery of approximately 0.33 ml of fluid per cycle. The plunger motion is synchronized to the valve motors to provide controlled fluid delivery.

4.5.2.1

MOTOR AND VALVE ASSEMBLIES

The mechanism assembly pumping action is controlled by three stepper motors. The first stepper motor, in conjunction with an associated valve assembly, activates the A or the B valve of the cassette, depending on the command. The second stepper motor alternately opens and closes the inlet and outlet valve to control fluid delivery through the cassette pumping chamber. A third stepper motor controls plunger movement.

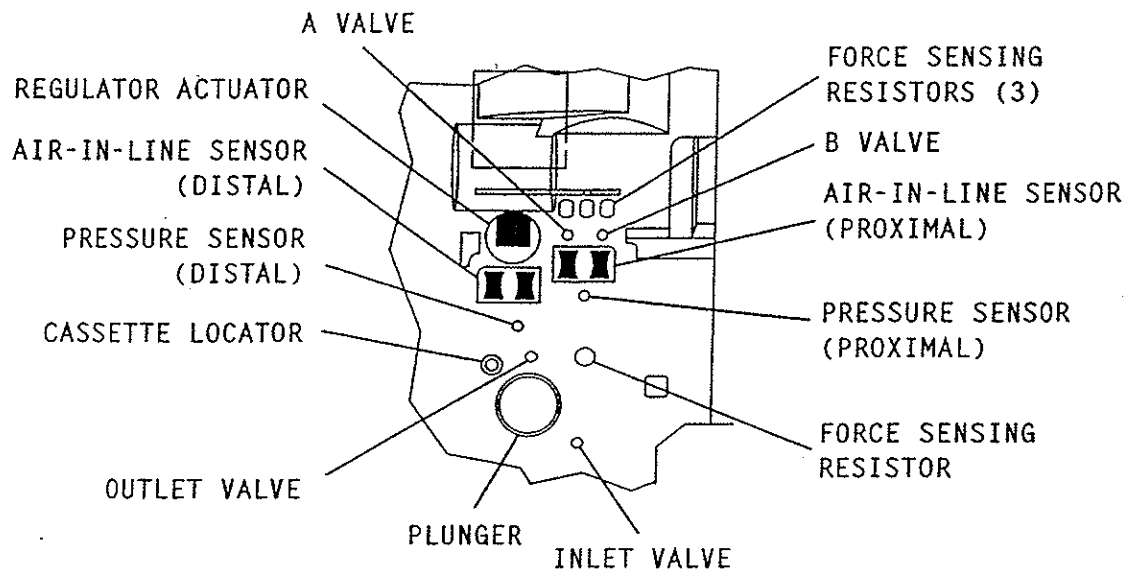
4.5.2.2

A/B VALVE SUBSYSTEM

The A/B valve subsystem includes a motor designed to rotate a cam (*Figure 4-8, Mechanism Valve Pins and Sensor Locations*). When the cam is positioned at the top dead center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the A valve, while the B valve remains closed. Counterclockwise rotation opens the B valve, while the A valve remains closed.

The A/B valve subsystem consists of a stepper motor with attached cam and integral cam flag, A and B rockers and valve pins, and a pin detector assembly. The cam flag passes through an interrupter module as it rotates with the cam. Valve home position is determined by this cam flag/interrupter module combination through predetermined factory calibration data. During operation, if the cam flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

The rocker is the connecting link between the cam and the valve pin.



98G01023

Figure 4-8. Mechanism Valve Pins and Sensor Locations

4.5.2.3

INLET/OUTLET VALVE SUBSYSTEM

The inlet/outlet valve subsystem is similar in function and build to the A/B valve subsystem. Refer to *Section 4.5.2.4, Plunger Drive Subsystem*, for similar theory of operation.

4.5.2.4

PLUNGER DRIVE SUBSYSTEM

The main components of the plunger drive subsystem are: plunger, lead screw and coupler, and stepper motor. When the pump is turned on, the plunger moves from the retracted, PARK position to the HOME position. The cassette diaphragm is engaged. The stepper motor rotates approximately 1 2/3 revolutions per pump cycle to permit a 0.33 ml fluid displacement every pump cycle. The stepper motor then reverses and the plunger returns to HOME position. This cycle repeats for the duration of fluid administration.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter module. This screw/coupler, flag/interrupter module combination is used in conjunction with predetermined factory calibration data to determine the plunger position. During operation, if the screw/coupler flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

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Section 5

MAINTENANCE AND SERVICE TESTS

A complete maintenance program promotes infusion pump longevity and trouble-free instrument operation. Such a program should include routine maintenance, periodic maintenance inspection, and following any repair procedure, performance verification testing.

5.1

ROUTINE MAINTENANCE

Routine maintenance consists of basic inspection and cleaning procedures. As a minimum requirement, inspect and clean the infusion pump after each use. In addition, establish a regular cleaning schedule for the infusion pump.

5.1.1

INSPECTING THE INFUSION PUMP

Inspect the infusion pump periodically for signs of defects such as worn accessories, broken instrument connections, or damaged cables. In addition, inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts. See *Section 5.2.2, Inspection*, for a detailed list of areas to be inspected.

5.1.2

CLEANING THE INFUSION PUMP

The following procedures are designed to maintain the infusion pump, sustain system longevity, and promote trouble-free instrument operation.

Follow hospital protocol for establishing the infusion pump cleaning schedule.

WARNING

DISCONNECT THE INFUSION PUMP FROM AC POWER PRIOR TO CLEANING THE INSTRUMENT. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN ELECTRICAL SHOCK.

CAUTION: Do not immerse the infusion pump in liquids. Immersion could damage the instrument. Do not allow liquids to enter the infusion pump electronics compartment.

CAUTION: Do not spray cleaning solutions toward any openings in the infusion pump.

CAUTION: Certain cleaning and sanitizing compounds may slowly degrade components made from some plastic materials. Using abrasive cleaners or cleaning solutions not recommended by Abbott Laboratories may result in product damage and, potentially, void the product warranty. Do not use compounds containing combinations of isopropyl alcohol and dimethyl benzyl ammonium chloride.

CAUTION: Clean the exposed surfaces of the infusion pump with a soft, lint-free cloth dampened with one of the cleaning solutions listed in *Table 5-1, Cleaning Solutions*, or a mild solution of soapy water. Remove soap residue with clear water. Do not use solvents that are harmful to plastic, such as isopropyl alcohol or acetone. Do not use abrasive cleaners.

CAUTION: To avoid infusion pump damage, cleaning solutions should be used only as directed in *Table 5-1*. The disinfecting properties of cleaning solutions vary; consult the manufacturer for specific information.

Table 5-1. Cleaning Solutions		
Cleaning Solution	Manufacturer	Preparation
Coverage™ HBV	Steris Corporation, a division of Calgon Vestal Laboratories	Per manufacturer's recommendation
Dispatch™	Caltech Industries	Per manufacturer's recommendation
Formula C™	Diversey Corporation	Per manufacturer's recommendation
Manu-Klenz®	Calgon Vestal Laboratories	Per manufacturer's recommendation
Precise™	Caltech Industries	Per manufacturer's recommendation
Sporicidin®	Sporicidin International	Per manufacturer's recommendation
Super Edisonite®	S. M. Edison Chemical Co.	Per manufacturer's recommendation
Vesphene® Ilse	Calgon Vestal Laboratories	Per manufacturer's recommendation
Household bleach	Various	Per hospital procedures; do not exceed one part bleach in ten parts water

5.1.3

SANITIZING THE INFUSION PUMP

Sanitize the external surfaces of the infusion pump using a cleaning solution listed in *Table 5-1*.

Note: Not all cleaning solutions are sanitizers. Check product labeling.

CAUTION: Do not sterilize the infusion pump using heat, steam, ethylene oxide (ETO), or radiation. These methods may cause the instrument to malfunction.

5.2

PERFORMANCE VERIFICATION TEST

The performance verification test (PVT) consists of the tests described in the following sections. The PVT can be used for diagnostic purposes during the troubleshooting of a malfunctioning infusion pump. The PVT should be used for performance verification before an infusion pump is placed back in service after repair. If any malfunction is detected as a result of the PVT, refer to *Table 6-3, Troubleshooting with the PVT*.

Note: The PVT must be performed exactly as described in this manual to assure effective and reliable product evaluation information.

5.2.1

EQUIPMENT REQUIRED

The PVT requires the following equipment (or equivalents):

- ☐ Graduated cylinder, 25 ml, with 0.2 ml graduations (Type A)
- ☐ Sterile water or tap water in an IV bag/container
- ☐ Digital pressure meter (DPM), Bio-Tek® DPM II
- ☐ Three-way stopcock, List No. 3233-01 or 3232-01
- ☐ IV Set, List No. 11419 or equivalent
- ☐ 21-gauge needle, List No. 4492-01, or 18-gauge blunt cannula
- ☐ Digital multimeter (DMM), Fluke® 8012A (optional)
- ☐ Stopwatch
- ☐ Barcode directory (optional)

5.2.2

INSPECTION

Inspect the infusion pump periodically for signs of defects such as worn accessories or damaged cables. Also, inspect the infusion pump after repair or during cleaning. Replace any damaged or defective external parts.

Inspect the following areas for missing or damaged parts:

- ☐ Labels
- ☐ AC power cord
- ☐ Velcro® retainer strap
- ☐ Rubber foot pads
- ☐ Door assembly, shield, and handle
- ☐ Keypad switches
- ☐ External screws
- ☐ Pole clamp knob/shaft, extrusion, and tip insert
- ☐ Front and rear enclosures
- ☐ Battery access cover
- ☐ LCD screen

5.2.3

INFUSION PUMP TEST SETUP

WARNING

A PATIENT SHOULD NEVER BE CONNECTED TO THE INFUSION PUMP DURING DEVICE TESTING.

To set up the infusion pump for the PVT, proceed as follows:

1. Confirm the infusion pump and appropriate accessories are assembled..
2. Hang two sterile water containers at a height of 18 ± 6 inches (46 ± 15.3 cm) above the pumping head of the infusion pump.
3. Connect the infusion pump to AC power. Conduct all tests with the infusion pump connected to AC power unless otherwise specified.
4. Turn on the pump by pressing [ON/OFF].
5. Verify the infusion pump is in the unlocked mode. Toggling the [LOCKOUT] switch alternates between unlocked and locked modes.
6. Turn off the pump by pressing [ON/OFF].

5.2.4

SELF TEST

CAUTION: Do not place the infusion pump in service if the self test fails.

To perform the self test, refer to *Figure 5-1, LCD Display and Keypad*, and proceed as follows:

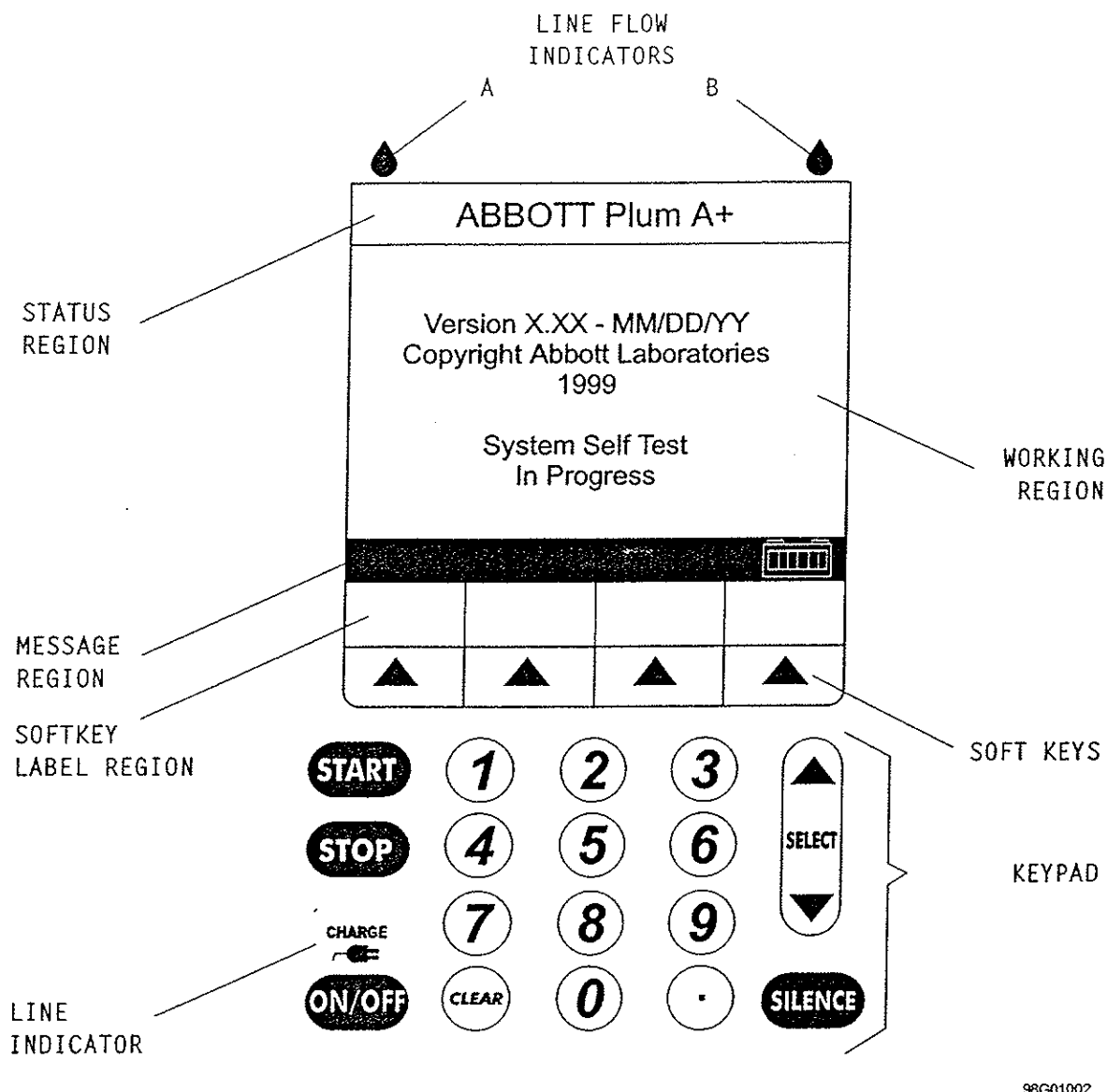
1. Connect the AC power cord to a grounded AC outlet. Verify the charging/line indicator CHARGE illuminates and an alarm beep sounds.
2. Without a cassette installed, turn on the pump by pressing [ON/OFF].
3. The LCD screen briefly displays the self test screen. Verify that the screen display matches *Figure 5-1*.

Note: If the self test screen does not appear, contact Abbott Laboratories.

4. After the self test is complete, the message "Insert Plum Set Close Lever" appears. Press the decimal [.] key and then the [START] key.
5. Using the [SELECT] arrow keys, select **Set Time and Date**. Press the [Choose] soft key.
6. Verify the time, year, month, and day are correct. If any parameters are incorrect refer to *Section 1.7.3, Setting the Time and Date*.
7. Exit the **Set Time and Date** screen by pressing [ON/OFF].
8. Turn the pump back on by pressing [ON/OFF].
9. Open the cassette door and insert a primed cassette. Close the cassette door.

Note: The cassette test is complete when the "Cassette test in progress" message disappears.

10. If previously entered programming exists, the "Clear Settings?" message appears. Press the [Yes] soft key to clear the settings.



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Figure 5-1. LCD Display and Keypad

5.2.5

CASSETTE ALARM TEST

To perform the cassette alarm test, proceed as follows:

1. Verify the infusion pump is on. Insert an empty cassette and close the door.
2. Verify the **Valve/Cassette Test Fail** message is flashing on the display and the alarm sounds after the cassette test is complete.
3. Open the door and remove the cassette.
4. Press the [ON/OFF] key to turn the pump off.

5.2.6**FREE FLOW TEST**

To perform the free flow test, proceed as follows:

1. With a primed cassette installed, turn the infusion pump on by pressing [ON/OFF].
2. After the self test, press the [YES] soft key to clear settings.

Note: If no settings currently exist or all settings are zero, this screen will be bypassed.

3. Place distal end of tubing into a collection container a minimum of 36 inches below the cassette.
4. With the cassette door closed, check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).
5. Open the cassette door and check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).

Note: A small amount of fluid may be expelled from the cassette when opening or closing the door.

6. Close the cassette door.

5.2.7**DISPLAY TEST**

To perform the display/LED test, refer to *Figure 5-1, LCD Display and Keypad*, then proceed as follows:

1. Verify the LCD backlight is illuminated and the display is clearly legible at eye level from approximately 18 inches.
2. With the pump in the Delivery screen, press the [Options/Vol Inf] soft key to select the Option Menu screen.
3. Using the [SELECT] [▼] (down arrow), select **Lighting/Contrast**. Press the [Choose] soft key.
4. Press the [Decrease Setting] and [Increase Setting] soft keys to change the Backlight Intensity. Verify intensity decreases and increases.
5. Using the [SELECT] [▼] (down arrow), select Display Contrast.
6. Press the [Decrease Setting] and [Increase Setting] soft keys to change the Display Contrast. Verify the contrast decreases and increases.
7. Press the [Cancel] soft key to return to the Option Menu screen.
8. Press the [Back] soft key to return to the Delivery screen.

5.2.8**KEYPAD VERIFICATION/FUNCTIONAL TEST**

To perform the keypad verification/functional test, refer to *Figure 5-1, LCD Display and Keypad*, then proceed as follows:

1. With the pump in the Delivery screen, press the [A] soft key to select line A.
2. Verify the PROGRAM screen is displayed.

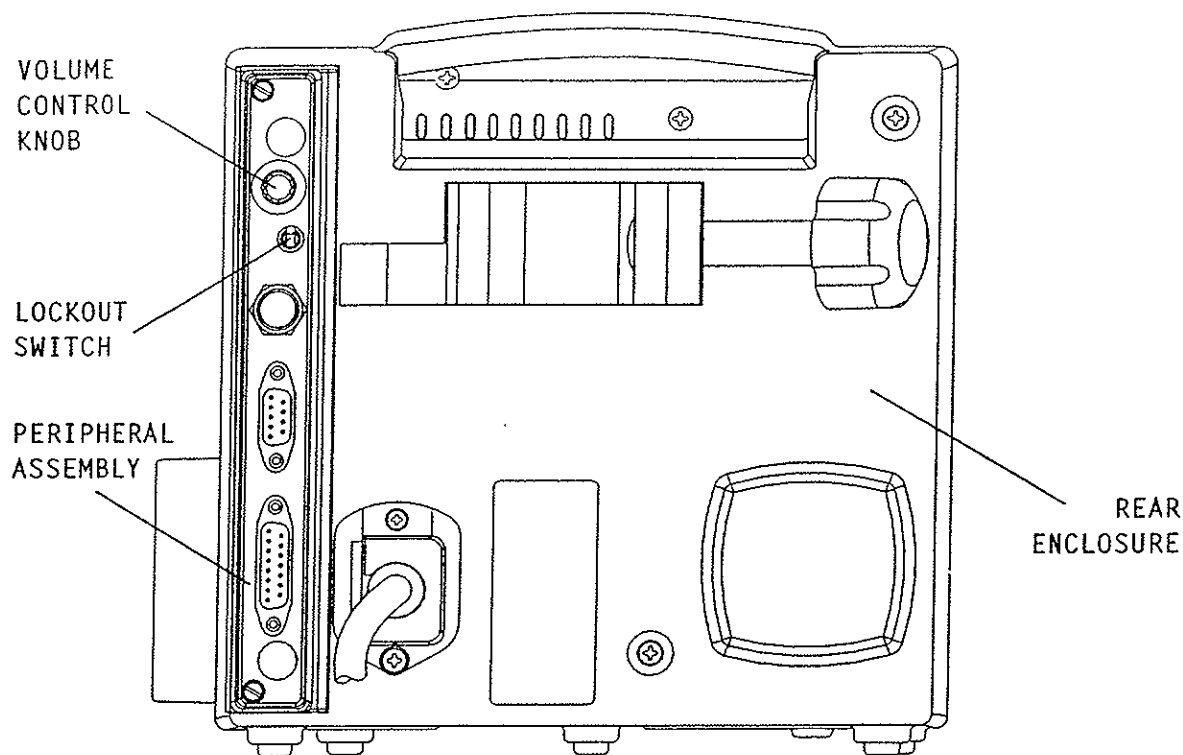
3. Using the numeric keypad, enter a rate of 123 ml/hr.
4. Using the [SELECT] [▼] (down arrow), select VTBI.
5. Using the numeric keypad, enter a VTBI of 4567 ml.
6. Press the [START] key. Verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
7. Press the [STOP] key.
8. Press and hold the [BACKPRIME] soft key.
9. Verify the **Backpriming** and **Release Backprime to stop** messages are displayed.
10. Verify the pump is actually backpriming.
11. Release the [Backprime] soft key, press the [START] key. Verify normal pumping operation.
12. Press the [B] soft key.
13. Verify Piggyback is the displayed delivery mode. If necessary, change the delivery mode by pressing the [Change Mode] soft key.
14. Using the SELECT [▼] (down arrow), select Rate.
15. Using the numeric keypad, enter a rate of 890 ml/hr.
16. Using the SELECT [▼] (down arrow), select VTBI.
17. Using the numeric keypad, enter a VTBI of 2.0 ml.
18. Press the [START] key and verify fluid is pumping, the message **PUMPING** is displayed in the line B status bar, the line B LED flashes and line A goes into **DELAYED** mode.
19. After 20 seconds, verify pumping switched to line A.
20. Press the [STOP] key.
21. Press the [Options/Vol Inf] soft key, select **Volume Infused** using the [Choose] soft key.
22. Using the SELECT [▼] (down arrow) key, select line A.
23. Press the [CLEAR] key. Verify the line A volume is 0.0 ml.
24. Press the [Enter] soft key.

5.2.9

ALARM LOUDNESS TEST

To perform the alarm loudness test, refer to *Figure 5-2, Rear Enclosure and Peripheral Assemblies*, then proceed as follows:

1. Press the [A] soft key to select line A.
2. Enter a rate of 400 ml/hr and a VTBI of 1 ml. Press [START].
3. Verify the alarm sounds when the dose has been delivered.
4. Turn the volume control knob between HIGH and LOW. The volume control knob is found on the peripheral assembly. Verify the alarm loudness changes.
5. Press the [SILENCE] key. Verify alarm is silenced.
6. Press [STOP].



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Figure 5-2. Rear Enclosure and Peripheral Assemblies

5.2.10

LOCKOUT SWITCH TEST

To perform the lockout switch test, refer to *Figure 5-2, Rear Enclosure and Peripheral Assemblies*, then proceed as follows:

1. Press the [A] soft key to select line A.
2. Enter a rate of 400 ml/hr and a VTBI of 50 ml.
3. Press [START]. Verify the pump is operating.
4. Toggle the lockout alarm switch up (ON) to engage the alarm. The lockout switch is located on the peripheral assembly.
5. Verify the **Lockout Enabled** message is displayed and an alarm sounds when a disabled key (any key except for [STOP]) is pressed. The pump must continue to operate until the [STOP] key is pressed.
6. Press the [STOP] key and verify the **Lockout Violation** message appears.
7. Toggle the lockout alarm switch down (OFF) and press [STOP]. Verify the **Lockout Violation** message disappears and the alarm stops.
8. Press the [START] key.
9. Open the door and verify the **Door open while pumping** message is displayed and the audio alarm activates.
10. Close the cassette door.
11. Press the [No] soft key to the "Clear Settings?" prompt.

5.2.11

PROXIMAL OCCLUSION TEST

To perform the proximal occlusion test, proceed as follows:

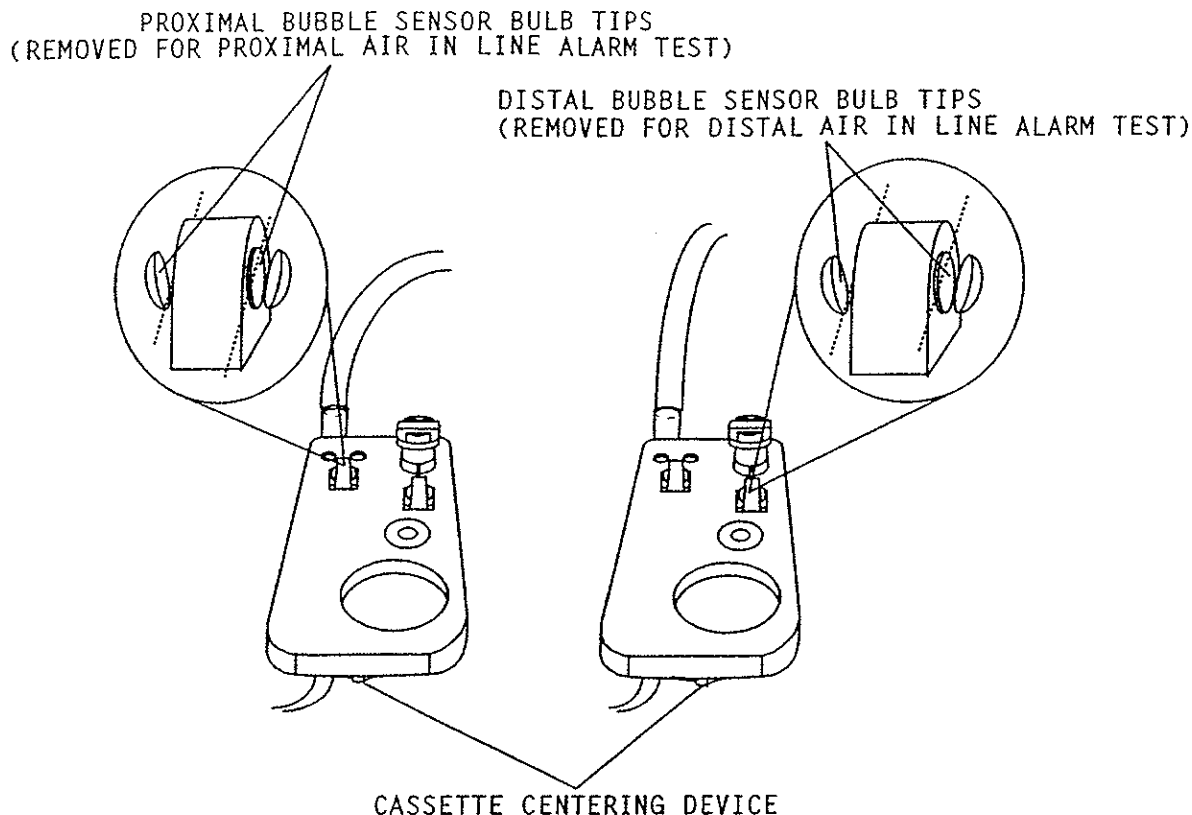
1. Press the [A] soft key to select line A.
2. Enter a rate of 400 ml/hr and a VTBI of 50 ml. Press [START].
3. After several pumping cycles, clamp line A tubing proximal to the cassette. Verify the **Negative Proximal Occlusion on A** message flashes and the alarm sounds before three pumping cycles are completed.
4. Press the [SILENCE] key and verify the alarm stops while the message on the display continue to flash.
5. Unclamp the proximal line and press [START]. Verify pumping resumes.
6. Press [STOP].

5.2.12

PROXIMAL AIR-IN-LINE TEST

To perform the proximal air-in-line alarm test, refer to *Figure 5-3, Special Cassettes with Bubble Sensor Tips Removed*, then proceed as follows:

1. Install the special cassette marked PROXIMAL. Close the cassette door.
Note: Confirm the special cassette proximal bubble sensor tips are removed (see *Figure 5-3*).
2. Press the [YES] soft key to clear settings.
3. Press the [A] soft key to select line A.
4. Enter a rate of 400 ml/hr and a VTBI of 5 ml. Press [START].
5. Before 1 ml of fluid is delivered, verify the alarm sounds and the **Proximal Air on Line A** message is flashing on the display.
6. Press the [STOP] key, open the door, and remove the special cassette.



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Figure 5-3. Special Cassettes with Bubble Sensor Tips Removed

5.2.13

DISTAL AIR-IN-LINE TEST

To perform the distal air-in-line alarm test, refer to *Figure 5-3, Special Cassettes with Bubble Sensor Tips Removed*, then proceed as follows:

1. Install the special cassette marked DISTAL. Close the cassette door.

Note: Confirm the special cassette distal bubble sensor tips are removed (see *Figure 5-3*).

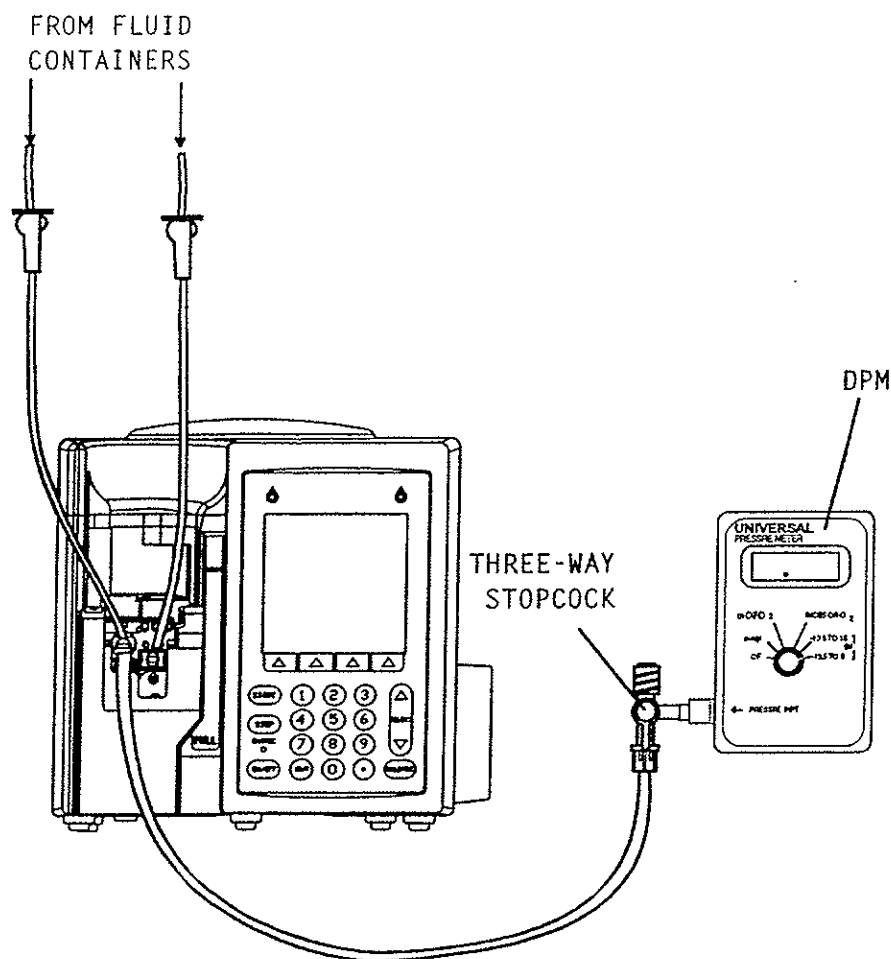
2. Press the [YES] soft key to clear settings.
3. Press the [A] soft key to select line A.
4. Enter a rate of 400 ml/hr and a VTBI of 5 ml. Press [START].
5. Before 1 ml of fluid is delivered, verify the alarm sounds and the **Distal Air Bolus** message is flashing on the display.
6. Press the [STOP] key, open the door and remove the special cassette.

5.2.14

DISTAL OCCLUSION TEST

To perform the distal occlusion test, refer to *Figure 5-4, Distal Occlusion Test Setup*, then proceed as follows:

1. Install the cassette and connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-4*. Close the cassette door.
- Note:** A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.
- Note:** The height of the DPM must be 0 ± 12 inches from the midline of the pumping chamber.
2. Press the [YES] soft key to clear settings.
3. Press the [Options/Vol Inf] soft key to select the Option Menu screen.
4. Using the [SELECT] [▼] (down arrow), select **Pressure/Post Infusion Rate**. Press the [Choose] soft key.
5. Verify the Distal Pressure Limit is set at 6.0 psi. If the pressure limit is not 6.0 psi, use the numeric keypad to enter 6.0 and then press the [Enter] soft key.
6. Press the [A] soft key to select line A.
7. Enter a rate of 40 ml/hr and a VTBI of 50.0 ml.
8. Open the three-way stopcock to air.
9. Press the [START] key and allow the infusion pump to stabilize for one minute. Verify all air is cleared from the tubing.
10. Set the three-way stopcock to measure pressure.
11. Verify the Distal Occlusion audible alarm occurs at 6.0 ± 2.0 psi. Verify the **Distal Occlusion** message is flashing on the screen.
12. Open the three-way stopcock to air.
13. Open and close the door. Press the [No] soft key at the "Clear settings?" prompt.
14. Press the [Options/Vol Inf] soft key to select the Option Menu screen.
15. Using the [SELECT] [▼] (down arrow), select **Pressure/Post Infusion Rate**. Press the [Choose] soft key.
16. Use the numeric keypad to enter 10.0 psi and then press the [Enter] soft key.
17. Set the three-way stopcock to measure pressure.
18. Press the [START] key.
19. Verify the Distal Occlusion audible alarm occurs at 10.0 ± 2.0 psi. Verify the **Distal Occlusion** message is flashing on the screen.
20. Press the [STOP] key to stop the pump.



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Figure 5-4. Distal Occlusion Test Setup

5.2.15

DELIVERY ACCURACY TEST

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infusion pump accuracy, contact Abbott Laboratories.

CAUTION: Do not remove the protective cover from the 21-gauge needle.

To perform the delivery accuracy test, proceed as follows:

1. Install an 18-gauge blunt cannula, or a 21-gauge needle to the distal end of the tubing. Verify the fluid container is 18 to 24 inches above the pumping chamber. Verify all lines are unclamped.
2. Place the distal output into the graduated cylinder.
3. Press the [A] soft key to select line A.

4. Enter a rate of 200 ml/hr and a VTBI of 10 ml. Start the stopwatch and press the [START] key simultaneously.
5. Press the [B] soft key to select line B.
6. Verify the pump is in the Piggyback delivery mode. If necessary, change the delivery mode by pressing the [Change Mode] soft key.
7. Enter a rate of 200 ml/hr and a VTBI of 10 ml.
8. Press the [START] key.
9. Verify the pump switches to line B.
10. Verify the KVO message flashes on the display and an audible alarm sounds when total delivery is complete on line A.
11. Stop the stopwatch and press the [STOP] key when the KVO message appears.
12. Verify the volume delivered is 20 ml \pm 0.8 ml.
13. Use the following formula to calculate the delivery accuracy.

$$\frac{[(\text{Total volume delivered (ml)}) \times (18 \text{ sec/ml})]}{\text{Total delivery time (sec)}}$$

An example:

$$\frac{[(20.4 \text{ ml}) \times (18 \text{ sec/ml})]}{360 \text{ sec}} = 1.02$$

14. Verify the accuracy is 1.0 \pm 0.04.

5.2.16

ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the infusion pump AC power cord to a safety analyzer.
2. Connect the safety analyzer ground lead to the infusion pump ground test-point located on the rear of the infusion pump.
3. Check the leakage current with the safety analyzer. Leakage current (both open and closed ground) must not exceed 100 microamperes (μ A) (AC RMS).
4. Measure the resistance of the AC connector ground lug with the safety analyzer. Resistance should not exceed 0.1 Ω .

5.2.17

END OF PERFORMANCE VERIFICATION TEST

If all tests have been successful, proceed as follows:

1. Press [Options/Vol Inf] soft key. Select **Volume Infused** by pressing the [Choose] soft key.
2. Using the [Clear] key, clear the volume infused. Press the [Enter] soft key.
3. Press the [A] soft key.
4. Press the [Clear Program] soft key. Press the [Yes] soft key to the prompt "Clear Line A Settings?" prompt.
5. Press the [Cancel/Back] soft key to return to the delivery screen.
6. Press the [B] soft key.
7. Repeat Steps 4 and 5 for line B.
8. Reset the infusion pump to the original configuration.
9. Turn the infusion pump off.
10. Return the infusion pump to service.

Note: If any tests fail, refer to *Section 6, Troubleshooting*, or contact Abbott Laboratories.

5.3

BARCODE READER WAND TEST (OPTIONAL)

To perform the barcode reader wand test, proceed as follows:

1. Remove the plastic connector cover from the 9-pin connector on the peripheral assembly.
2. Connect the barcode reader wand to the 9-pin connector on the peripheral assembly.
3. Insert a primed cassette and close the door.
4. Turn the infusion pump on by pressing [ON/OFF]. Press the [YES] soft key to clear settings.
5. Set the rate to 100 ml and the VTBI to 50 ml.
6. Verify "Wand Active" message appears on the display. Scan a barcode label from the barcode directory.
7. Verify the corresponding drug name is displayed.

5.4

PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommended that JCAHO and/or hospital protocol be followed for establishing an infusion pump periodic maintenance inspection schedule. Product specifications for this inspection are listed in *Section 8, Specifications*. To perform the periodic maintenance inspection, complete the performance verification test (see *Section 5.2, Performance Verification Test*).

5.5

BATTERY OPERATION OVERVIEW

The infusion pump is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC power failure or inadvertent disconnection of the AC power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The infusion pump should be connected to AC power whenever possible to allow the battery to remain fully charged. The infusion pump line power indicator turns off and the BATTERY legend illuminates when the infusion pump is operating on battery power. The backlight extinguishes after one minute of pump operation on battery power.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. As a general rule, the more often the battery is discharged and recharged, the sooner it will need replacement. The primary cause of damage is leaving the battery in a less than fully charged state for any period of time. Battery damage can occur in a matter of hours and cause a permanent loss of battery capacity. The amount of lost capacity depends on the degree of discharge, the storage temperature, and the length of time the battery was stored in a discharged state.

Note: A permanently damaged battery cannot be recharged to full capacity.

When the battery discharges below the acceptable level while the infusion pump is operating, the alarm sounds and the LOW BATTERY message displays. Although it is not recommended to continue operating the infusion pump on battery power at this point, the battery continues providing power until discharged. At this point, the infusion pump enters the battery discharged mode, a continuous audible alarm sounds and after three minutes, operation ceases.

CAUTION: As soon as the LOW BATTERY alarm occurs, connect the infusion pump to AC power.

Recharging occurs any time the infusion pump is connected to AC power. It is recommended that the infusion pump be connected to AC power whenever practical to maximize available battery charge during transport or ambulation. The infusion pump does not have to be on for the battery to recharge. Recharging while the infusion pump is operating is rate dependent.

Note: The infusion pump should be operated on battery power for six continuous hours at least once every six months for optimum battery performance and life.

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Section 6

TROUBLESHOOTING

This section contains information on obtaining technical assistance, and alarm messages and error codes for the Plum A+ Infusion System.

6.1

TECHNICAL ASSISTANCE

For technical assistance, product return authorization, and to order parts, accessories, or manuals within the United States, contact Abbott Laboratories Technical Support Operations.

1-800-241-4002

For additional technical assistance, including Technical Service Bulletins, technical training, and product information, visit the website at:

www.abbotthpd.com/service

Send all authorized, prepaid returns within the United States to the following address:

**Abbott Laboratories
Technical Support Operations
755 Jarvis Drive
Morgan Hill, California 95037**

For technical assistance, product return authorization, and to order parts, accessories, or manuals from outside the United States, contact the nearest Abbott Laboratories sales office.

6.2

ALARM MESSAGES AND ERROR CODES

Under most alarm conditions the infusion pump ceases normal operation, generates an audible alarm, and displays an alarm message or error code on the LCD screen. There are two categories of alarm messages: alarm codes that can be cleared by the operator, and error codes that require qualified service personnel:

6.2.1

OPERATIONAL ALARM MESSAGES

Table 6-1, *Operational Alarm Messages and Corrective Actions*, lists infusion pump alarm codes that can be cleared by the operator. Also listed in Table 6-1 are the alarm messages, descriptions, possible causes, and corrective actions.

Note: Operational alarm messages are displayed on the LCD screen. Associated error codes are displayed in the alarm log. Refer to Section 1.7.2, *Alarm Log* to access the alarm log.

Table 6-1. Operational Alarm Messages and Corrective Actions				
Alarm Code (DataPort)	Alarm	Description	Possible Cause	Corrective Action
E100 (URC)	Unrecognizable cassette	Incorrect cassette type	An incorrect cassette is inserted	Insert proper cassette
E101 (NAA)	No action alarm	No operator action and no delivery for 2 minutes during delivery parameters entry	Interruption of a partial change to a program	Complete the programming of the pump
E102 (RL)	Infuser Idle 2 minutes	Infuser in reset or idle for over 2 minutes	Pump programming set without start for 2 minutes	Press [START]
E103 (SEEP CRC)	NV RAM lost thpy data	Therapy data is lost	Infuser did not complete the previous non-volatile memory write successfully	Re-enter all programmed data
E104 (NC2)	Nurse Callback B	The delivery line B has changed (if alarm is enabled)	End of delivery step on line B other than VTBI complete while callback is enabled	Press [SILENCE]
E105 (NC1)	Nurse Callback A	The delivery line A has changed (if alarm is enabled)	End of delivery step on line A other than VTBI complete while callback is enabled	Press [SILENCE]
E160 (VTB2)	Line B VTBI complete	Programmed volume to be infused completed on line B	VTBI is complete on line B	Press [SILENCE] and replace IV bag and restart line B

Table 6-1. Operational Alarm Messages and Corrective Actions				
Alarm Code (DataPort)	Alarm	Description	Possible Cause	Corrective Action
E161 (VTB1)	Line A VTBI complete	Programmed volume to be infused completed on line A	VTBI is complete on line A	Press [SILENCE] and replace IV bag and restart line A
E180 (OD1)	Distal Occl	Peak distal occlusion, non-delivery	Distal occlusion detected during non-delivery (e.g. cassette test)	Backprime cassette and restart pump
E181 (OD1)	Distal Occl	Negative distal occlusion, non-delivery	Distal occlusion detected during non-delivery (e.g. cassette test)	Backprime cassette and restart pump
E182 (OP2)	Prox. Occl B	Negative proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery (e.g. cassette test)	Backprime cassette and restart line B or Stop all lines, backprime cassette and restart all lines
E183 (OP2)	Prox. Occl B	Peak proximal occlusion B, non-delivery	Proximal occlusion detected on line B during non-delivery (e.g. cassette test)	Backprime cassette and restart line B or Stop all lines, backprime cassette and restart all lines
E184 (OP1)	Prox. Occl A	Negative proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery (e.g. cassette test)	Backprime cassette and restart line A or Stop all lines, backprime cassette and restart all lines
E185 (OP1)	Prox. Occl A	Peak proximal occlusion A, non-delivery	Proximal occlusion detected on line A during non-delivery (e.g. cassette test)	Backprime cassette and restart line A or Stop all lines, backprime cassette and restart all lines

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code (DataPort)	Alarm	Description	Possible Cause	Corrective Action
E186 (OD1)	Distal Occl	Peak distal occlusion, delivery	Distal occlusion detected during delivery	Fix occlusion (closed clamps, kinked tubing), restart pump
E187 (OD1)	Distal Occl	Negative distal occlusion, delivery	Distal occlusion detected during delivery (e.g. cassette test)	Fix occlusion (closed clamps, kinked tubing), restart pump
E188 (OP2)	Prox. Occl B	Negative proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B (e.g. cassette test)	Fix occlusion (closed clamps, kinked tubing), restart line B or Stop all lines, fix occlusion (closed clamps, kinked tubing), restart pump
E189 (OP2)	Prox. Occl B	Peak proximal occlusion B, delivery	Proximal occlusion detected during delivery on line B (e.g. cassette test)	Fix occlusion (closed clamps, kinked tubing), restart line B or Stop all lines, fix occlusion (closed clamps, kinked tubing), restart pump
E190 (OP1)	Prox. Occl A	Negative proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A (e.g. cassette test)	Fix occlusion (closed clamps, kinked tubing), restart line A or Stop all lines, fix occlusion (closed clamps, kinked tubing), restart pump

Table 6-1. Operational Alarm Messages and Corrective Actions				
Alarm Code (DataPort)	Alarm	Description	Possible Cause	Corrective Action
E191 (OP1)	Prox. Occl A	Peak proximal occlusion A, delivery	Proximal occlusion detected during delivery on line A (e.g. cassette test)	Fix occlusion (closed clamps, kinked tubing), restart line A or Stop all lines, fix occlusion (closed clamps, kinked tubing), restart pump
E230 (APT)	Prox. Air Total	Proximal air-in-line total Note: Air-in-line on either line applies to both lines	260 µl of air has entered the cassette	Backprime the cassette, restart pump or Remove and manually reprime cassette, restart pump
E231 (APB)	Prox. Air on B	Proximal air-in-line on line B Note: Air-in-line on either line applies to both lines	260 µl of air has entered the cassette on line B	Backprime the cassette, restart line B or Remove and manually reprime cassette, restart pump
E232 (APA)	Prox. Air on A	Proximal air-in-line on line A Note: Air-in-line on either line applies to both lines	260 µl of air has entered the cassette on line A	Backprime the cassette, restart line A or Remove and manually reprime cassette, restart pump
E233 (ADC)	Distal Air Cumulative	Distal air cumulative Note: Air-in-line on either line applies to both lines	260 µl of air detected in the last 2.5 ml of fluid delivered	Remove and manually reprime the cassette, restart pump
E234 (ADB)	Distal Air Bolus	Distal air bolus	100 µl bolus of air detected at distal sensor	Remove and manually reprime the cassette, restart pump

Table 6-1. Operational Alarm Messages and Corrective Actions

Alarm Code (DataPort)	Alarm	Description	Possible Cause	Corrective Action
E250 (DCO1)	Door opened while pumping	Door opened while pumping	Door opened while pumping	Turn the pump off or Insert the cassette and close the door
E251 (CS1)	Valve/Cass Test Fail	Valve/cassette test failure	Valve/cassette fails the leak test	Replace cassette and retest or Backprime and retest
E252 (BDP)	Depleted Battery	Discharged battery	The battery is discharged to the recommended maximum discharge condition	Connect the infuser to AC power or Recharge or replace the battery
E253 (LOV)	Lockout Violation	Lockout violation	The use of the [STOP] key or an attempt to open the door while lockout switch is locked	Unlock the lockout switch
E254 (FPL)	Lockout Enabled	Keypad locked	Any action not resulting in stopping of the delivery while the lockout switch is locked	Unlock the lockout switch

6.2.2**ERROR CODES REQUIRING TECHNICAL SERVICE**

Table 6-2, Error Codes Requiring Technical Service, lists infusion pump error codes that require technical service. Also listed in *Table 6-2* are the malfunction descriptions, possible causes, and corrective actions

Note: There are malfunction codes that include a sub-ID code. These sub-ID codes are intended for Abbott Laboratories internal use only. Sub-ID codes should be included when contacting Abbott Laboratories Technical Support Operations for additional assistance, see *Section 6.1, Troubleshooting*.

Table 6-2. Error Codes Requiring Technical Service			
Error/ DataPort Code	Malfunction	Possible Cause	Corrective Action
E300	ADC failure	Analog to digital converter failure	Replace CPU PWA (see Section 7.2.13.3)
E301	Audio alarm failure	Audio alarm failure	
E302	Backlight failure	Backlight (CCFT tube) is not at the expected range	Replace display/CPU assembly (see Section 7.2.13.2)
E320	Battery charge current bad	Battery charge current is out-of-range after 8 hours	Replace battery (see Section 7.2.4)
			Replace power supply PWA (see Section 7.2.13.1)
E321	Battery charger time out	Battery charging timed out	Replace power supply PWA (see Section 7.2.13.1)
E322	Bad battery current zero calibration	Current zero value is out of range	
E323	High battery trickle charge	Battery trickle charge current is too high (after charging is complete)	
E324	Supply over voltage	An over voltage condition is detected in the charging circuit	
E325	Battery over voltage	An over voltage condition is detected in the battery	
E326	Battery disconnected	Battery disconnected while pump is powered on	Replace battery (see Section 7.2.4)
E327	Brown out condition	Brown out condition detected	Replace power supply PWA (see Section 7.2.13.1)
E340	CPU instruction failure	Power-up "CPU Register Test" failed. (No malfunction message is displayed)	Replace CPU PWA (see Section 7.2.13.3)
E341	Critical mem fail	Critical data memory failure	
E342	Display failure	Defective display	Replace display/CPU assembly (see Section 7.2.13.2)

Table 6-2. Error Codes Requiring Technical Service

Error/ DataPort Code	Malfunction	Possible Cause	Corrective Action
E343	Distal air sensor failure 1	With the cassette removed, the distal air sensor self test detects liquid	Replace mechanism assembly (see Section 7.2.13.5)
E344	Distal air sensor failure 2	With the cassette inserted, the distal air sensor self test detects sensor out of range	
E345	Distal pressure sensor failure 1	Distal air sensor failed while pump is turned OFF	
E346	Distal pressure sensor failure 2	Distal air sensor failed while pump is turned ON	
E347	Hardware watchdog failure	Hardware watchdog failure	
E371	I/O valve motor failure 1	I/O valve motor malfunction when a total of four resynchronizations failed	
E372	I/O valve motor failure 2	I/O valve motor malfunction when three consecutive resynchronizations failed	
E373	L/S valve motor failure 1	L/S valve motor malfunction when a total of four resynchronizations failed	
E374	L/S valve motor failure 2	L/S valve motor malfunction when three consecutive resynchronizations failed	
E375	Motor position sensor failure	Motor position sensor failure	
E376	Plunger synch failure 1	Plunger malfunction when resynchronization has failed a total of four times	
E377	Plunger synch failure 2	Plunger malfunction when three consecutive resynchronizations failed	Replace mechanism assembly (see Section 7.2.13.5)
E378	I/O valve failure	Generic I/O valve failure	

Table 6-2. Error Codes Requiring Technical Service			
Error/ DataPort Code	Malfunction	Possible Cause	Corrective Action
E379	L/S valve failure	Generic L/S valve failure	Replace mechanism assembly (see Section 7.2.13.5)
E380	Plunger failure	Generic plunger motor failure	
E430	Proximal air sensor failure 1	Proximal air sensor ongoing test detects liquid with cassette removed	
E431	Proximal air sensor failure 2	Proximal air sensor self test detects liquid with cassette removed	
E432	Proximal pressure sensor 1	Proximal air sensor failed while pump is turned OFF	
E433	Proximal pressure sensor 2	Proximal air sensor failed while pump is turned ON	
E434	RAM failure	RAM failure	Replace CPU PWA (see Section 7.2.13.3)
E435	Real-time clock fail	Real-time clock failure	
E436	ROM failure	ROM checksum failure	
E437	Software failure	Generic software failure	
E438	Stack-out-of-range failure	Stack out-of-range failure	
E439	Stuck key	A key is sensed as pressed for over two minutes	Replace display/CPU assembly (see Section 7.2.13.2)
E440	Power-hold stuck	Power hold never dropped following a "turn off"	
E441	Valve self tests	I/O or L/S valve self test failed	Replace mechanism assembly (see Section 7.2.13.5)
E443	LCD bias fault	LCD bias is out of range	Replace display/CPU assembly (see Section 7.2.13.2)

Table 6-2. Error Codes Requiring Technical Service

Error/ DataPort Code	Malfunction	Possible Cause	Corrective Action
E444	CPU timebase fault	CPU "timer 2" and RTC measured times disagree	Replace CPU PWA (see Section 7.2.13.3)
E445	Real-time clock reset	RTC memory is corrupt (premature reset)	
E446	CPU timer failed	CPU "timer 1" and "timer 2" measured times disagree	
E447	Battery ADC reading failed	16 consecutive readings have been either all 0 or the max value	
E448	NVRAM write failed	SEEP data write has failed	
E449	Corrupt calibration data	Calibration data block is corrupted	Replace CPU PWA (see Section 7.2.13.3)
E450	MMIO port read/write failure	SEEP data write has failed	
E451	Delivery fault	Over/under delivery is detected	
E452	Software failure	Generic software failure	

6.3

TROUBLESHOOTING PROCEDURES

This section details recommended procedures for problems not associated with malfunction alarms. Before performing any troubleshooting procedure, turn the infusion pump off, then on. Allow the self test to complete and proceed as follows:

1. If a malfunction exists, carefully inspect the infusion pump for damage as described in *Section 5.2.2, Inspection*.
2. If an infusion pump inspection has not disclosed a malfunction, perform the PVT (see *Section 5.2, Performance Verification Test*) and refer to *Table 6-3, Troubleshooting with the PVT*, for PVT section reference, probable cause, and corrective actions.
3. If, after completing Steps 1 and 2, a malfunction has not been located, or if the infusion pump persistently fails, contact Abbott Laboratories Technical Support Operations.

Table 6-3. Troubleshooting with the PVT		
Test Failure	Probable Cause	Corrective Action
Self test <i>Section 5.2.4</i>	Cassette not properly installed	Reseat cassette
	Defective CPU PWA	Replace CPU PWA (see <i>Section 7.2.13.3</i>)
Cassette alarm test <i>Section 5.2.5</i>	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
Free flow test <i>Section 5.2.6</i>	Cassette not properly seated	Reseat cassette
	Defective cassette	Replace cassette
	Defective or dirty valve pins	Clean valve pins
		Replace mechanism assembly (see <i>Section 7.2.13.5</i>)
Display test <i>Section 5.2.7</i>	Defective display/CPU assembly	Replace display/CPU assembly (see <i>Section 7.2.13.2</i>)
Keypad test <i>Section 5.2.8</i>	Defective display/CPU assembly	Replace display/CPU assembly (see <i>Section 7.2.13.2</i>)
Alarm loudness test <i>Section 5.2.9</i>	Defective CPU	Replace CPU PWA (see <i>Section 7.2.13.3</i>)
	Defective peripheral PWA	Replace peripheral PWA (see <i>Section 7.2.7</i>)
	Defective piezo alarm assembly	Replace piezo alarm assembly (see <i>Section 7.2.13.4</i>)
Lockout switch test <i>Section 5.2.10</i>	Defective peripheral PWA	Replace peripheral PWA (see <i>Section 7.2.7</i>)
Proximal occlusion test <i>Section 5.2.11</i>	Closed proximal clamp	Open clamp
	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly (see <i>Section 7.2.13.5</i>)
Proximal air-in-line test <i>Section 5.2.12</i>	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly (see <i>Section 7.2.13.5</i>)

Table 6-3. Troubleshooting with the PVT		
Test Failure	Probable Cause	Corrective Action
Distal air-in-line test <i>Section 5.2.13</i>	Defective special cassette	Replace special cassette
	Dirty sensors	Clean sensors
	Defective APP PWA	Replace mechanism assembly (see <i>Section 7.2.13.5</i>)
Distal occlusion test <i>Section 5.2.14</i>	Cassette not properly primed	Re-prime cassette
	Defective cassette	Replace cassette
	Dirty sensor pin	Clean sensor pin
	Defective APP PWA	Replace mechanism assembly (see <i>Section 7.2.13.5</i>)
Delivery accuracy test <i>Section 5.2.15</i>	Set not properly primed	Re-prime cassette
	Damaged or faulty cassette	Replace cassette
	Defective mechanism assembly	Replace mechanism assembly (see <i>Section 7.2.13.5</i>)
Electrical safety test <i>Section 5.2.16</i>	Defective AC (mains) power cord	Replace AC (mains) power cord (see <i>Section 7.2.5</i>)

Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the Plum A+ Infusion System that are repairable within the scope of this manual. In addition, this section details replacement procedures for all listed parts.

7.1

REPLACEABLE PARTS

Replaceable parts for the Plum A+ Infusion System are itemized in the spare parts price list and are identified in *Figure 9-1, Illustrated Parts Breakdown. Table 9-2, IPB for the Infusion Pump* identifies each part by an index number that correlates to *Figure 9-1*. To request a copy of the current spare parts price list, contact Abbott Laboratories (see *Section 6.1, Technical Assistance*) or to view the catalog online, visit the website at:

www.abbotthpd.com/parts

For convenient reference, insert a copy of the spare parts price list here.

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7.2

REPLACEMENT PROCEDURES

This section contains safety and equipment precautions, required tools and materials, and step-by-step procedures for replacing parts in the infusion pump. Unless otherwise stated, always perform the PVT after a replacement procedure.

7.2.1

SAFETY AND EQUIPMENT PRECAUTIONS

Before opening the front enclosure of the infusion pump, take all necessary precautions for working on high-voltage equipment.

WARNING

UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSION PUMP FROM AC POWER BEFORE PERFORMING ANY REPLACEMENT PROCEDURE.

WARNING

POSSIBLE EXPLOSION HAZARD EXISTS IF INFUSION PUMP IS SERVICED OR REPAIRED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWAs in antistatic bags before placing them on any surface.

7.2.2

REQUIRED TOOLS AND MATERIALS

The following tools and materials, or equivalents, are required for the replacement procedures in this section. In addition, the beginning of each procedure lists tools and materials required for that specific procedure.

- ☐ Set of nutdrivers
- ☐ Small size flat-blade screwdriver
- ☐ Medium size flat-blade screwdriver
- ☐ No. 2 Phillips screwdriver
- ☐ Custom phono jack nut driver (Abbott P/N 519-95056-001)
- ☐ Wide-head pliers
- ☐ Long needle nose pliers
- ☐ Diagonal cutters
- ☐ X-acto® knife (with square, round, and pointed blades)
- ☐ Wood chisel, 3/8 inch
- ☐ Mild solvent (such as isopropyl alcohol)
- ☐ Tweezers
- ☐ Wire stripper
- ☐ Electrician's knife

7.2.3

RUBBER FOOT PAD REPLACEMENT

Recommended tools for this procedure are as follows: 3/8 inch wood chisel, or an X-acto knife, and mild solvent.

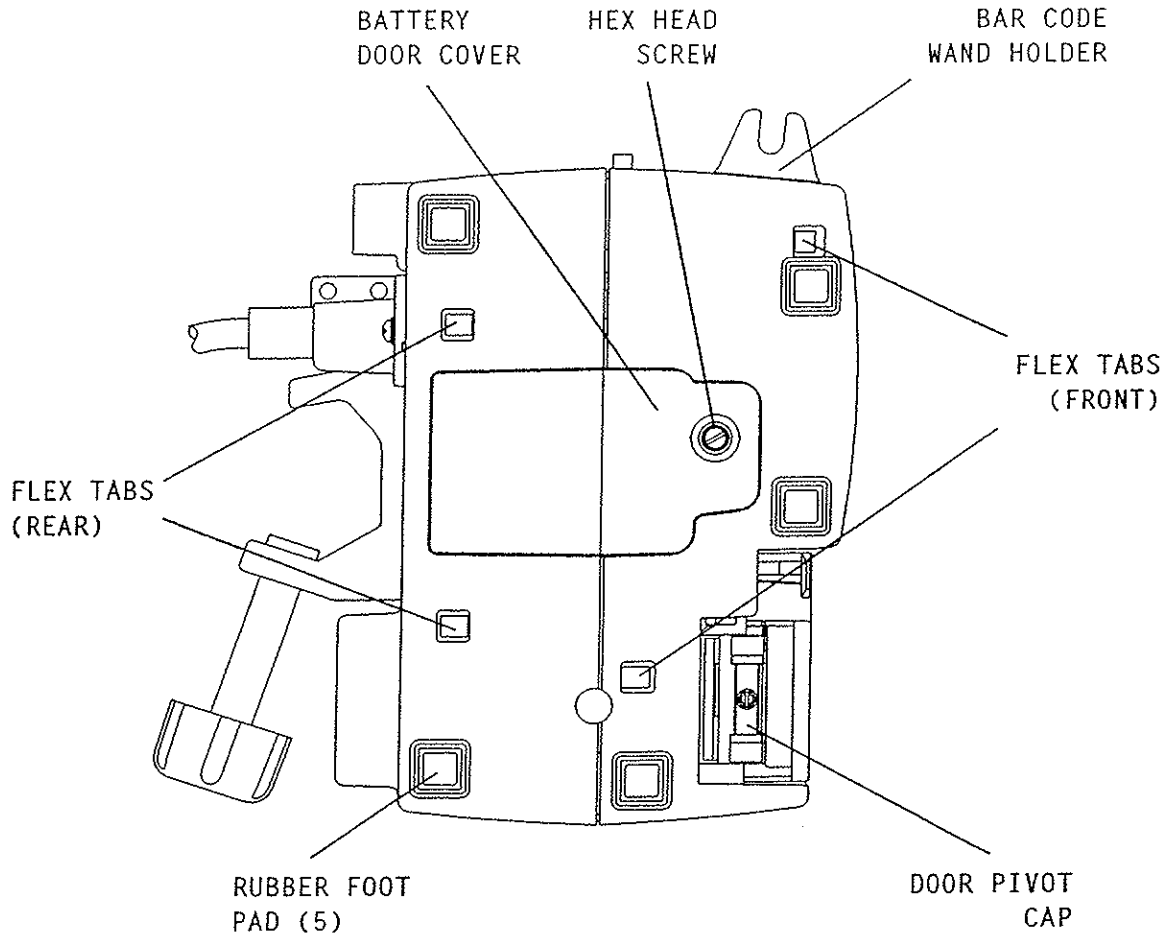
To replace the rubber foot pads, refer to *Figure 7-1, Bottom View of the Infusion Pump*, then proceed as follows:

1. Press [ON/OFF] to turn the infusion pump OFF.
2. Disconnect the infusion pump from AC power.
3. Set the infusion pump on its side to access the bottom.

Note: Each adhesive-backed rubber foot pad is bonded in its recess; do not damage the recess.

4. Using a 3/8 inch wood chisel or an X-acto knife, remove the rubber foot pad and scrape the enclosure recess to remove adhesive residue.
5. Using a mild solvent, clean the enclosure recess.
6. Remove the protective backing from the self-adhesive surface and bond the replacement rubber foot pad in place.
7. After approximately five minutes, verify the foot pad is secure.
8. Connect the infusion pump to AC power.

Replacement of a rubber foot pad is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during a rubber foot pad replacement, perform the PVT in *Section 5.2*.



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Figure 7-1. Bottom View of the Infusion Pump

7.2.4

BATTERY WITH WIRE HARNESS ASSEMBLY AND BATTERY DOOR COVER PAD REPLACEMENT

Recommended tools for this procedure are as follows: medium size flat-blade screwdriver, X-acto knife, and mild solvent.

To replace the battery with wire harness assembly and battery door cover pad, refer to *Figure 7-1, Bottom View of the Infusion Pump*, then proceed as follows:

1. Press [ON/OFF] to turn the infusion pump OFF.
2. Disconnect the infusion pump from AC power.
3. Set the infusion pump on its side to access the bottom.
4. Using a medium size flat-blade screwdriver, remove the hex head screw securing the battery door to the infusion pump. Remove the battery door.
5. Inspect the battery door cover pad for damage. If the pad is defective, use an X-acto knife and mild solvent to remove it. Dry the battery door thoroughly. Install a new battery door cover pad on the battery door.

6. Disconnect the battery cable from the charger circuit cable. Pull the battery cable wires and connector outside the enclosure. Remove the battery.
7. Connect the replacement battery cable to the charger circuit cable.

Note: The cable connectors are keyed so that cables cannot be connected incorrectly.

8. Insert the replacement battery into the enclosure.
9. Confirm the battery cable is not pinched between the battery and the enclosure.
10. Replace the battery door. Using a medium size flat-blade screwdriver, replace and tighten the hex-head screw to secure the battery door to the infusion pump.
11. Connect the infusion pump to AC (mains) power.

To verify successful battery and battery door cover pad replacement, perform the PVT in *Section 5.2*.

7.2.5

AC (MAINS) POWER CORD, AC (MAINS) POWER CORD RETAINER, AND VELCRO RETAINER STRAP REPLACEMENT

Recommended tools for this procedure are as follows: No. 2 Phillips screwdriver and 3/16 inch nutdriver.

Note: For Velcro retainer strap replacement only, go to Step 5.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the AC (mains) power cord, power cord retainer, and Velcro strap, refer to *Figure 7-2, AC (mains) Power Cord, AC (mains) Power Cord Retainer, and Velcro Retainer Strap Replacement*, then proceed as follows:

1. Press [ON/OFF] to turn the infusion pump OFF.
2. Disconnect the infusion pump from AC power.
3. Using a Phillips screwdriver, remove the two screws from the AC (mains) power cord retainer.
4. Remove the AC (mains) power cord. Slide the plug through the retainer.

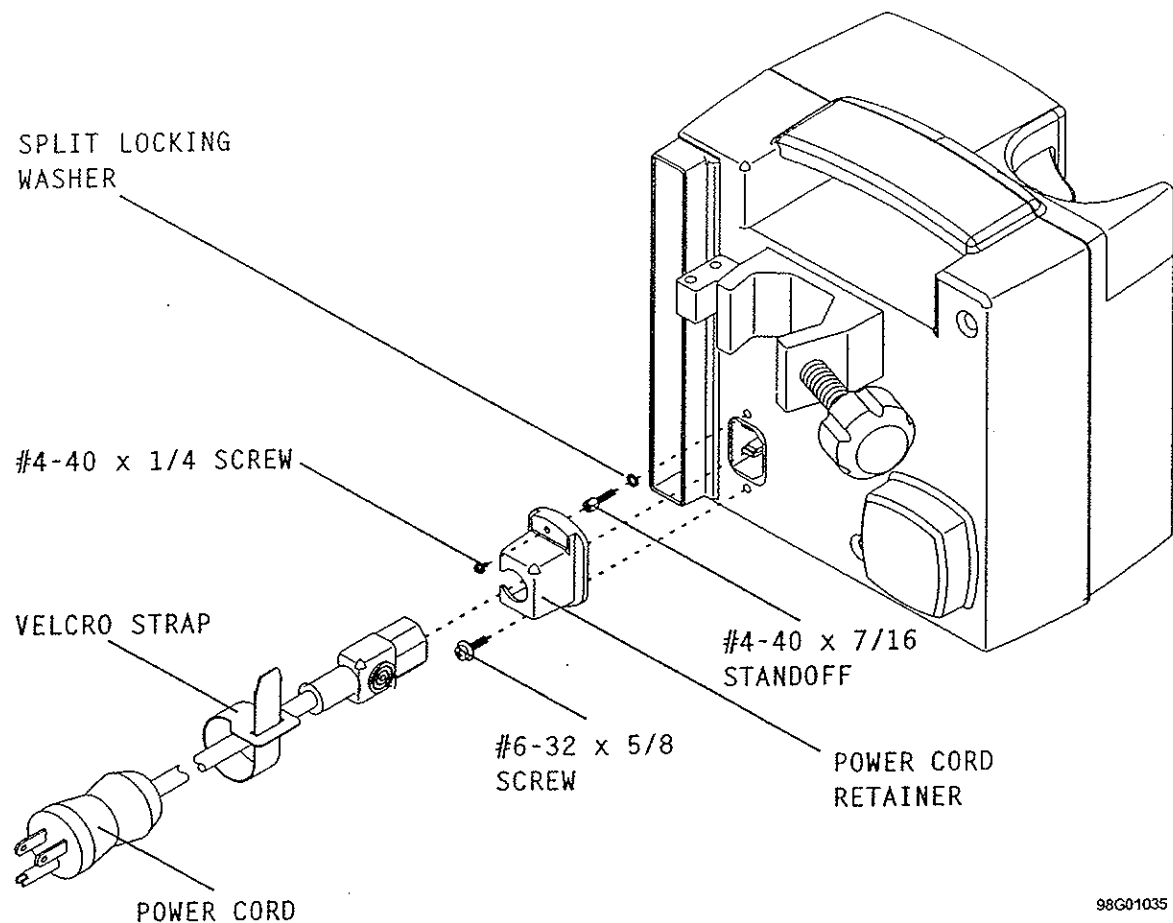
Note: If removing the AC power cord for pump disassembly, remove the standoff from the rear enclosure with a 3/16 nutdriver.

5. Remove the Velcro strap from the AC (mains) power cord.

Note: Inspect the Velcro strap for wear. Replace the strap if necessary.

6. Attach the Velcro strap on the replacement AC (mains) power cord.
7. Install the replacement AC (mains) power cord in the exact reverse order of removal.
8. Connect the infusion pump to AC (mains) power.

To verify successful AC (mains) power cord, power cord retainer, and Velcro retainer strap replacement, perform the PVT in *Section 5.2*.



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Figure 7-2. AC (mains) Power Cord, AC (mains) Power Cord Retainer, and Velcro Retainer Strap Replacement

7.2.6

PERIPHERAL ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a No. 2 Phillips screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

CAUTION: Assembly list numbers 12393-04 and 12101-04 are for use with infusion pump list number 11971-04 only. Assembly list numbers 12380-04 and 12102-04 are for use with infusion pump list number 11973-04 only.

Note: Replacing the peripheral PWA does not change the existing biomed settings.

To replace the peripheral assembly, refer to *Figure 7-3, Rear View of Infusion Pump*, and *Figure 7-4, Peripheral Assembly Replacement*, then proceed as follows:

1. Press [ON/OFF] to turn the infusion pump OFF.
2. Disconnect the infusion pump from AC power.
3. Carefully set the infusion pump face down.

4. Using a No. 2 Phillips screwdriver, remove the two screws from the peripheral assembly (one in the upper left corner and one in the lower left corner).
5. Carefully pull the assembly away from the pump.

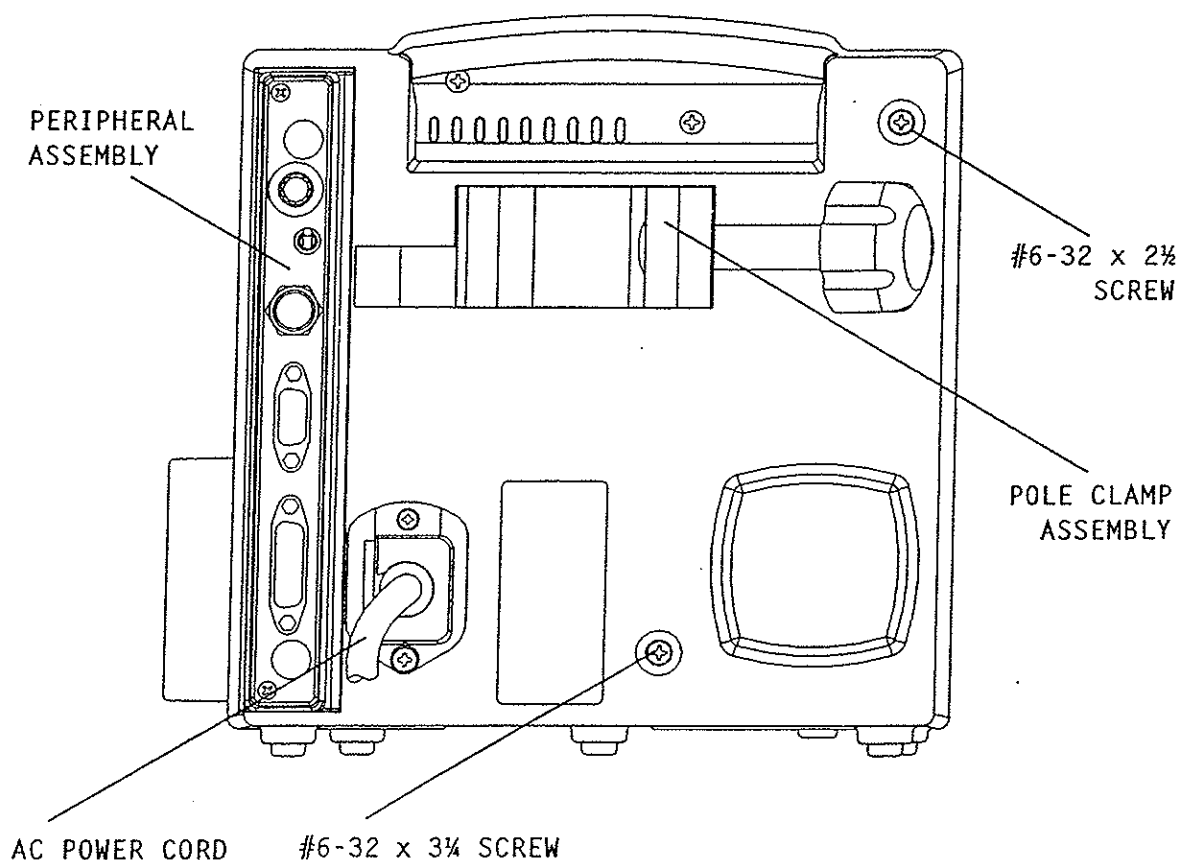
Note: When removing the peripheral assembly, note the placement guides the peripheral PWA rests between.

6. Install the replacement peripheral assembly in the exact reverse order of removal.

Note: Verify the peripheral assembly is placed properly between the guides and fits correctly into the CPU PWA.

7. Connect the infusion pump to AC (mains) power.

To verify successful peripheral assembly replacement, perform the PVT in *Section 5.2*.



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Figure 7-3. Rear View of Infusion Pump

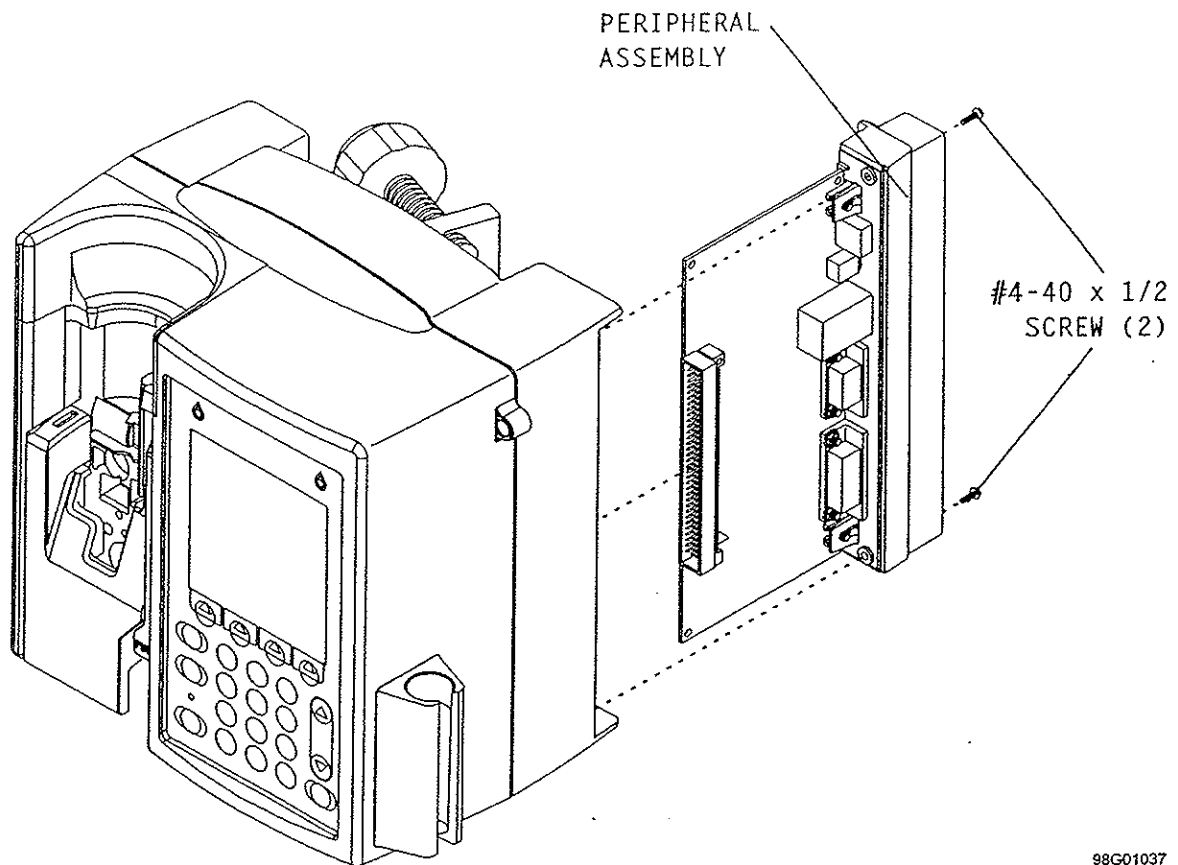


Figure 7-4. Peripheral Assembly Replacement

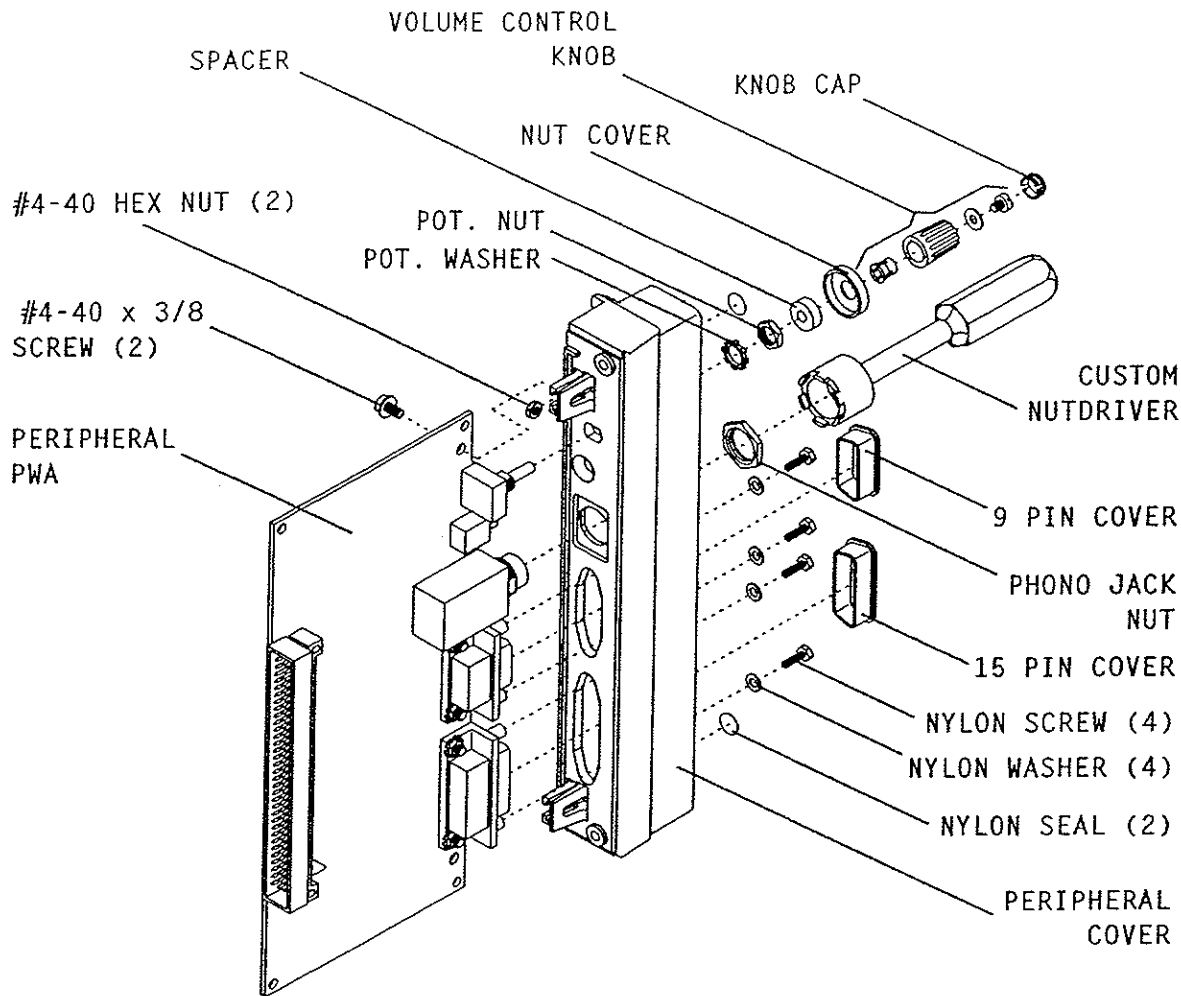
7.2.7

PERIPHERAL ASSEMBLY COMPONENT REPLACEMENT

Peripheral assembly component replacement includes the replacement of the following:

- ☐ Volume control knob
- ☐ Peripheral assembly cover

To replace the peripheral assembly components, refer to *Figure 7-5, Volume Control Knob and Peripheral Cover Replacement*, then proceed as detailed in the following sections.



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Figure 7-5. Volume Control Knob and Peripheral Cover Replacement

7.2.7.1

VOLUME CONTROL KNOB REPLACEMENT

Recommended tools for this procedure are as follows: medium size flat-blade screwdriver, No. 2 Phillips screwdriver, X-acto knife, and long needle nose pliers.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the volume control knob, refer to *Figure 7-5, Volume Control Knob and Peripheral Cover Replacement*, then proceed as follows:

1. Remove the peripheral assembly as described in *Section 7.2.6, Peripheral Assembly Replacement*.
2. Using an X-acto knife, lift the volume control knob end cap away from the knob, exposing a flat-head screw.

3. Using a medium size flat-blade screwdriver, remove the screw securing the gray knob. Remove the knob and plastic spacer with long needle nose pliers.
4. Install the replacement volume control knob in the exact reverse order of removal.
5. Replace the peripheral assembly in the exact reverse order of removal.
6. Connect the infusion pump to AC (mains) power.

To verify successful volume control knob replacement, perform the PVT in *Section 5.2*.

7.2.7.2

PERIPHERAL ASSEMBLY COVER REPLACEMENT

Recommended tools for this procedure are as follows: medium size flat-blade screwdriver, No. 2 Phillips screwdriver, 5/16 nutdriver, X-acto knife, custom phono jack nutdriver, and long needle nose pliers.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the peripheral assembly cover, refer to *Figure 7-5, Volume Control Knob and Peripheral Cover Replacement*, then proceed as follows:

1. Remove the peripheral assembly as described in *Section 7.2.6 , Peripheral Assembly Replacement*.
2. Remove the volume control knob as described in *Section 7.2.7.1 , Volume Control Knob Replacement*.
3. Using a 5/16 nutdriver, remove the nut securing the potentiometer to the peripheral cover. Remove the washer with needle nose pliers.
4. Using the custom nutdriver, remove the nut securing the phono jack to the peripheral cover.
5. Remove the covers from the 9 pin and 15 pin connectors.
6. Using a Phillips screwdriver, remove the two screws securing the peripheral PWA to the cover.
7. Install the replacement peripheral cover in the exact reverse order of removal.
8. Replace the volume control knob in the exact reverse order of removal.
9. Connect the infusion pump to AC (mains) power.

To verify successful peripheral assembly cover replacement, perform the PVT in *Section 5.2*.

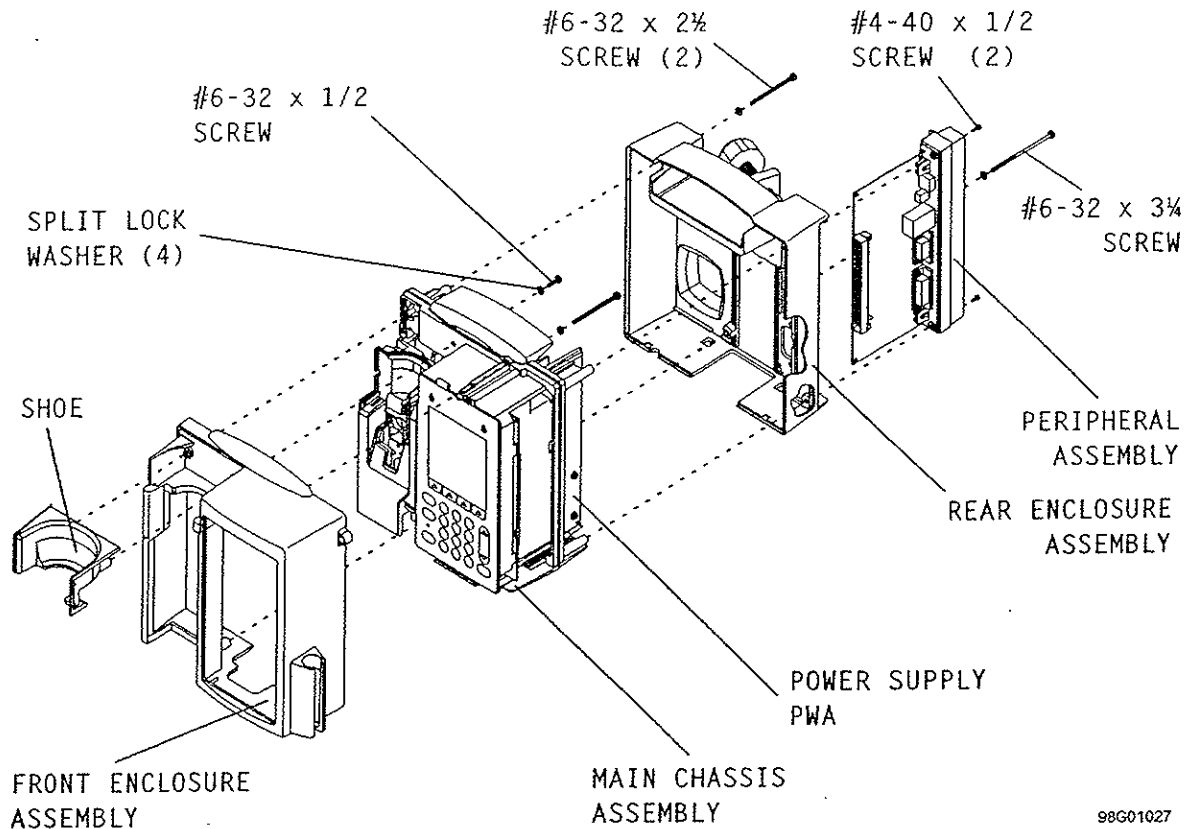
7.2.8**SEPARATING THE FRONT ENCLOSURE ASSEMBLY, REAR ENCLOSURE ASSEMBLY, AND MAIN CHASSIS ASSEMBLY**

The recommended tools for this procedure are as follows: No. 2 Phillips screwdriver and medium size flat-blade screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly, refer to *Figure 7-6, Separating the Front Enclosure, Main Chassis, and Rear Enclosure* then proceed as follows:

1. Remove the battery door and battery as described in *Section 7.2.4, Battery with Wire Harness Assembly and Battery Door Cover Pad Replacement*.
2. Remove the AC (mains) power cord and retainer as described in *Section 7.2.5, AC (Mains) Power Cord, AC (Mains) Power Cord Retainer, and Velcro Retainer Strap Replacement*.
3. Remove the peripheral assembly as described in *Section 7.2.6, Peripheral Assembly Replacement*.
4. Using a Phillips screwdriver, remove the remaining two screws from the upper right corner and lower center of the rear enclosure.
5. Carefully place the pump face down with the bottom of the pump facing forward.
6. Using a flat-blade screwdriver, depress the two flex tabs that secure the rear enclosure while lifting up the rear enclosure.
7. Using a Phillips screwdriver, remove the two screws in the pump handle area. Remove the shoe from the front enclosure.
8. Carefully place the pump face up with the bottom of the pump facing forward.
9. Using a flat-blade screwdriver, depress the flex tab that secures the front enclosure while lifting up the front enclosure.



98G01027

Figure 7-6. Separating the Front Enclosure, Main Chassis, and Rear Enclosure

7.2.9

FRONT ENCLOSURE, REAR ENCLOSURE, OR MAIN CHASSIS REPLACEMENT

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the front enclosure, rear enclosure, or main chassis, refer to *Figure 7-6, Separating the Front Enclosure, Main Chassis, and Rear Enclosure*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. To replace the front enclosure, remove the specific components described in *Section 7.2.10, Front Enclosure Assembly Component Replacement*. To replace the rear enclosure, remove the specific components described in *Section 7.2.11, Rear Enclosure Assembly Component Replacement*. To replace the main chassis, remove the specific components described in *Section 7.2.13, Main Chassis Assembly Component Replacement*.
3. Re-assemble the replacement front enclosure assembly, rear enclosure assembly, or main chassis assembly components. Refer to the specific procedure in *Section 7.2.10, Section 7.2.11, or Section 7.2.13*.

4. Join the front enclosure assembly, main chassis assembly, and rear enclosure assembly in the exact reverse order of separation.
5. Connect the infusion pump to AC (mains) power.

To verify successful front enclosure, rear enclosure, or main chassis replacement, perform the PVT in *Section 5.2*.

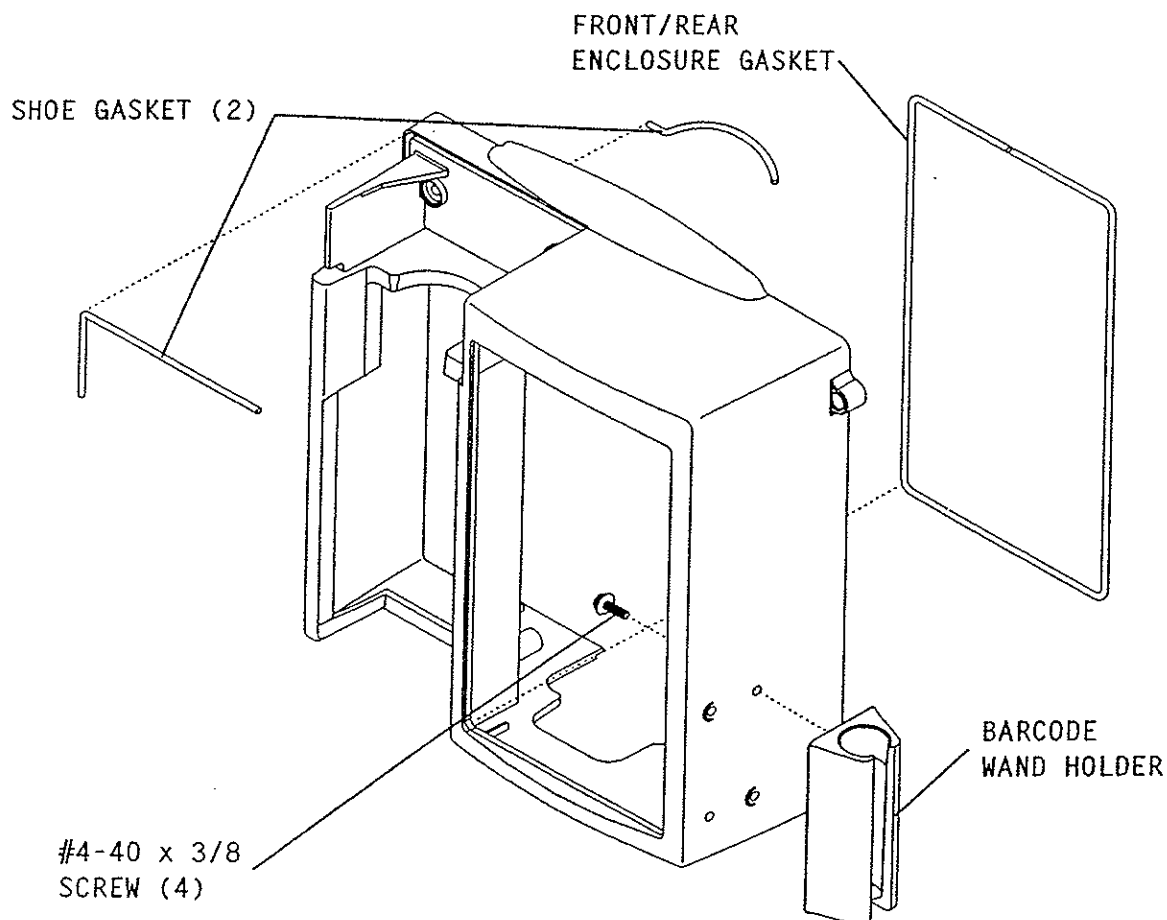
7.2.10

FRONT ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT

Front enclosure assembly component replacement includes the replacement of the following:

- ☐ Barcode wand holder
- ☐ Shoe gaskets
- ☐ Front/rear enclosure gasket

To replace the front enclosure assembly components, refer to *Figure 7-7, Front Enclosure Assembly Components*, then proceed as detailed in the following sections.



98G01028

Figure 7-7. Front Enclosure Assembly Components

7.2.10.1**BARCODE WAND HOLDER REPLACEMENT**

The recommended tool for this procedure is a No. 2 Phillips screwdriver.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the barcode wand holder, refer to *Figure 7-7, Front Enclosure Assembly Components*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Using a Phillips screwdriver, remove the four screws securing the barcode wand holder to the front enclosure.
3. Install the replacement barcode wand holder in the exact reverse order of removal.
4. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
5. Connect the infusion pump to AC (mains) power.

To verify successful barcode wand replacement, perform the PVT in *Section 5.2*.

7.2.10.2**SHOE GASKET REPLACEMENT**

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the shoe gaskets, refer to *Figure 7-7, Front Enclosure Assembly Components*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the shoe gaskets from the front and back of the front enclosure assembly as shown in *Figure 7-7*.
3. Install the replacement shoe gaskets in the exact reverse order of removal.
4. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
5. Connect the infusion pump to AC (mains) power.

To verify successful shoe gasket replacement, perform the PVT in *Section 5.2*.

7.2.10.3**FRONT/REAR ENCLOSURE GASKET REPLACEMENT**

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the front/rear enclosure gaskets, refer to *Figure 7-7, Front Enclosure Assembly Components*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the front/rear gasket from the front enclosure assembly.
3. Install the replacement front/rear gasket in the exact reverse order of removal.
4. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
5. Connect the infusion pump to AC (mains) power.

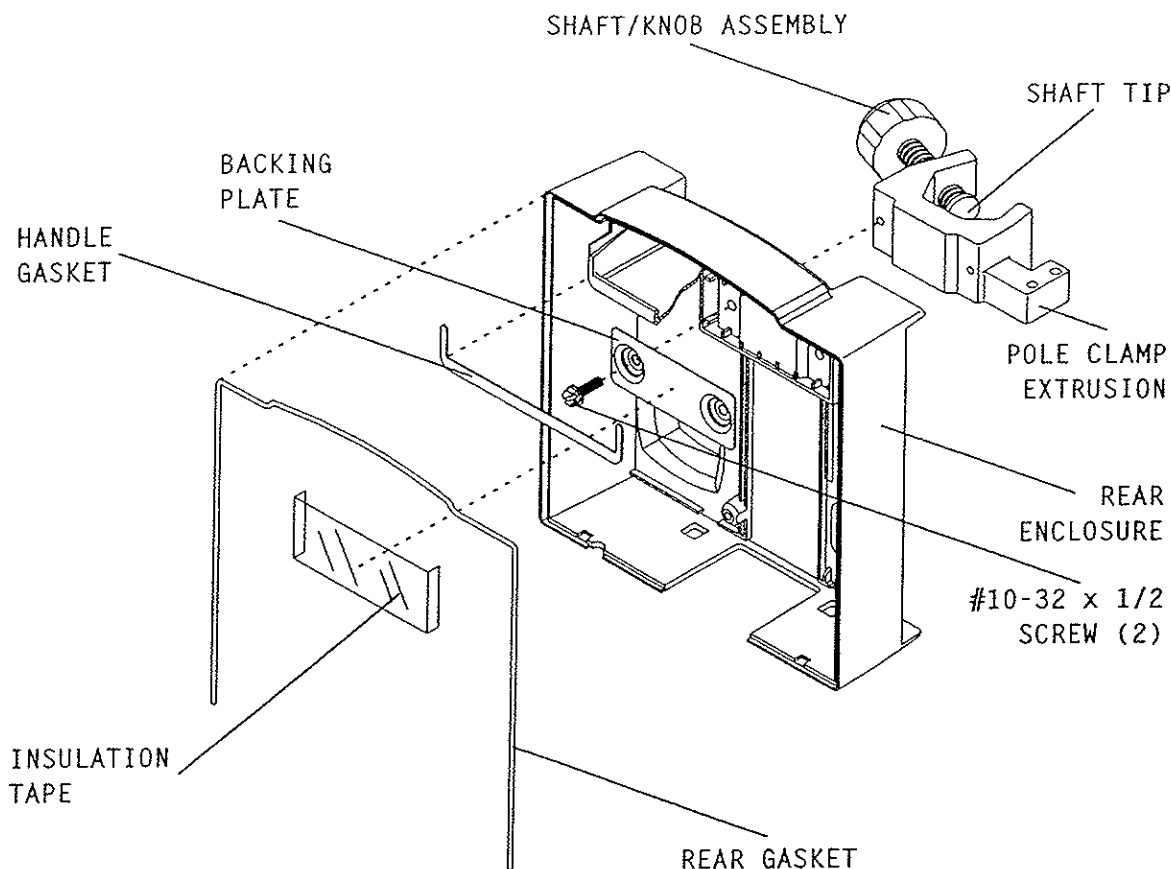
To verify successful front/rear enclosure gasket replacement, perform the PVT in *Section 5.2*.

7.2.11**REAR ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT**

Rear enclosure assembly component replacement includes the replacement of the following:

- ☐ Pole clamp extrusion, backing plate, and insulator
- ☐ Pole clamp shaft/knob assembly and the pole clamp shaft tip
- ☐ Rear enclosure and handle gaskets

To replace the rear enclosure assembly components, refer to *Figure 7-8, Rear Enclosure Assembly Components*, then proceed as detailed in the following sections.



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Figure 7-8. Rear Enclosure Assembly Components

7.2.11.1

POLE CLAMP EXTRUSION, POLE CLAMP BACKING PLATE, AND INSULATION TAPE REPLACEMENT

Recommended tools for this procedure are as follows: medium size flat-blade screwdriver and mild solvent.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the pole clamp extrusion, pole clamp backing plate, and insulation tape, refer to *Figure 7-8, Rear Enclosure Assembly Components*, then proceed as follows:

1. Separate the rear enclosure assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Grasp the insulation tape and remove it from the pole clamp backing plate.
3. Using mild solvent, clean the pole clamp backing plate and dry it thoroughly.
4. Using a medium size flat-blade screwdriver, remove the two hex-head screws securing the pole clamp backing plate to the pole clamp extrusion. Remove the pole clamp backing plate and pole clamp extrusion from the rear enclosure assembly.
5. Install the replacement pole clamp extrusion into the rear enclosure assembly.

6. Install the replacement pole clamp backing plate against the pole clamp extrusion. Using a medium size flat-blade screwdriver, replace and tighten the two hex-head screws.
7. Completely cover the pole clamp backing plate with the replacement insulation tape. Press firmly to adhere the insulation tape to the backing plate.

CAUTION: Make sure the insulation tape covers the entire backing plate. If the backing plate is exposed, the power supply PWA may be damaged when power is applied to the infusion pump.

8. Join the main chassis and rear enclosure assembly in the exact reverse order of separation.
9. Connect the infusion pump to AC (mains) power.

To verify successful pole clamp extrusion, backing plate, and insulation tape replacement, perform the PVT in *Section 5.2*.

7.2.11.2

POLE CLAMP SHAFT/KNOB ASSEMBLY AND POLE CLAMP SHAFT TIP REPLACEMENT

The recommended tool for this procedure is wide-head pliers.

To replace the pole clamp shaft/knob assembly and the pole clamp shaft tip, refer to *Figure 7-8, Rear Enclosure Assembly Components*, then proceed as follows:

1. Turn the control knob to OFF/CHARGE.
2. Disconnect the infusion pump from AC (mains) power.
3. Turn the pole clamp shaft/knob assembly counterclockwise to remove it from the pole clamp extrusion and loosen the pole clamp shaft tip from the pole clamp/shaft knob assembly.

Note: The pole clamp shaft tip has a long shaft that is pressed into the threaded pole clamp shaft/knob assembly.

4. Turn the pole clamp shaft/knob assembly back into the pole clamp extrusion. Using wide-head pliers, grasp the pole clamp shaft tip and remove.

Note: If the pole clamp shaft tip is in good condition, re-use it with the replacement pole clamp shaft/knob assembly. If the pole clamp shaft tip is defective, replace it.

5. Install the replacement pole clamp shaft/knob assembly into the pole clamp extrusion by turning the pole clamp shaft/knob assembly clockwise into the pole clamp extrusion until the threaded portion is visible.
6. Press the pole clamp shaft tip into the screw hole recess on the pole clamp shaft/knob assembly and turn the pole clamp shaft/knob assembly clockwise until the pole clamp shaft tip is secure against the pole clamp extrusion.
7. Connect the infusion pump to AC (mains) power.

Replacement of the pole clamp shaft/knob assembly and the pole clamp shaft tip is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during the pole clamp knob and tip insert replacement, perform the PVT in *Section 5.2*.

7.2.11.3**REAR ENCLOSURE AND HANDLE GASKETS REPLACEMENT**

There are no recommended tools for this procedure.

Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the rear enclosure and handle gaskets, refer to *Figure 7-8, Rear Enclosure Assembly Components*, then proceed as follows:

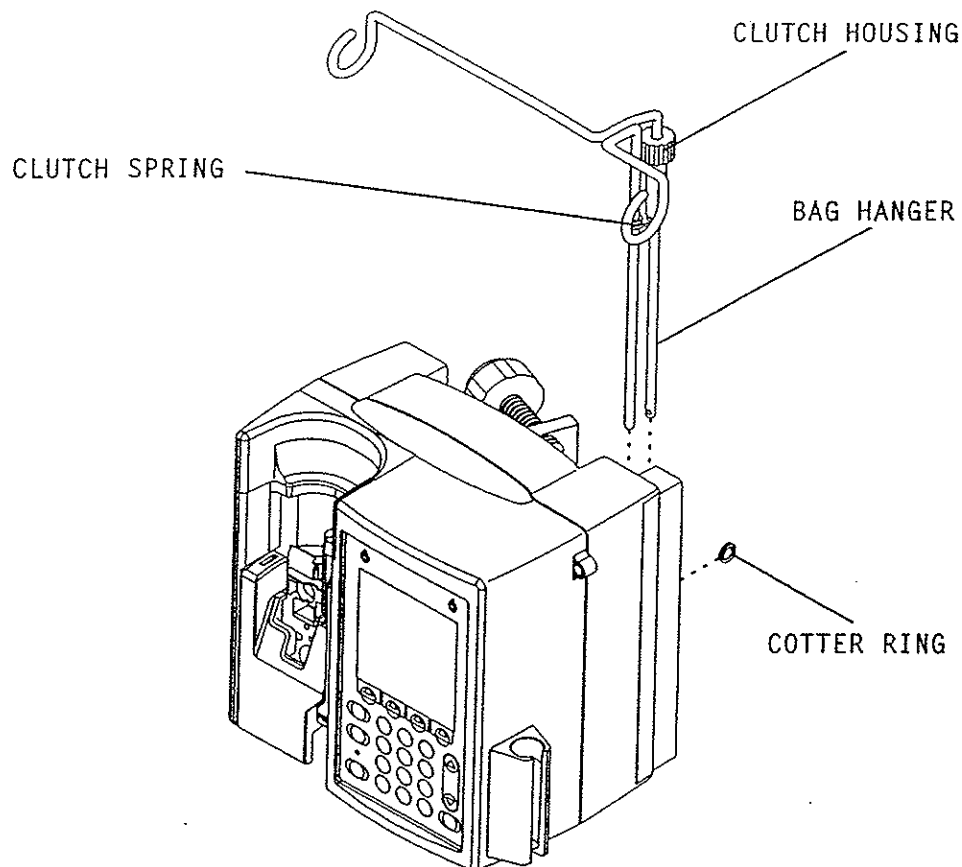
1. Separate the rear enclosure assembly and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the rear enclosure and handle gaskets from the rear enclosure assembly as shown in *Figure 7-8*.
3. Install the replacement gaskets in the exact reverse order of removal.
4. Join the main chassis and rear enclosure assembly in the exact reverse order of separation.
5. Connect the infusion pump to AC (mains) power.

To verify successful rear enclosure and handle gaskets replacement, perform the PVT in *Section 5.2*.

7.2.12**MINIPOLE ASSEMBLY REPLACEMENT**

There are no recommended tools for this procedure.

Note: The minipole assembly attaches to the infusion pump through two holes in the heatsink and is held in place by a cotter ring. This cotter ring passes through a hole near the end of the longer of the two vertical rods on the bag hanger and prevents the removal of the assembly from the holes in the pole clamp (*see Figure 7-9, Minipole Assembly*).



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Figure 7-9. Minipole Assembly

7.2.12.1

COTTER RING REPLACEMENT

There are no recommended tools for this procedure.

To replace the cotter ring, refer to *Figure 7-9, Minipole Assembly*, then proceed as follows:

1. Disconnect the infusion pump from AC (mains) power.
2. Place the infusion pump face down on a soft surface.
3. Grasp the cotter ring with thumb and finger. Twist, rotate, and remove the cotter ring from the rod hole.
4. Replace the cotter ring in exact reverse order of removal.

Replacement of the cotter ring is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during this procedure, perform the PVT as described in *Section 5.2*.

7.2.12.2**BAG HANGER REPLACEMENT**

There are no recommended tools for this procedure.

To replace the bag hanger, refer to *Figure 7-9, Minipole Assembly*, then proceed as follows:

1. Remove the cotter ring as described in *Section 7.2.12.1, Cotter Ring Replacement*.
2. Remove the bag hanger from the pole clamp rod holes.
3. Insert the replacement bag hanger in the pole clamp rod holes.
4. Insert the cotter ring.

Replacement of the bag hanger is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during this procedure, perform the PVT as described in *Section 5.2*.

7.2.12.3**CLUTCH HOUSING REPLACEMENT**

There are no recommended tools for this procedure.

To replace the clutch housing, refer to *Figure 7-9, Minipole Assembly*, then proceed as follows:

1. Remove the bag hanger from the infusion pump as described in *Section 7.2.12.2, Bag Hanger Replacement*.
2. Turn the clutch housing knob counterclockwise to loosen the clutch spring. Slide the knob and spring downward to remove them.
3. Work the clutch spring free from the clutch housing hole and place it into the new clutch housing.
4. Install the replacement clutch housing by turning the clutch housing knob counterclockwise and sliding it up the short rod. Confirm the clutch spring slides up the long rod.
5. Install the cotter ring.

Replacement of the clutch housing is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during this procedure, perform the PVT as described in *Section 5.2*.

7.2.12.4**CLUTCH SPRING REPLACEMENT**

There are no recommended tools for this procedure.

To replace the clutch spring, refer to *Figure 7-9, Minipole Assembly*, then proceed as follows:

1. Remove the clutch housing as described in *Section 7.2.12.3, Clutch Housing Replacement*.
2. Work the clutch spring free from the clutch housing hole and replace it with a new clutch spring.

Replacement of the clutch spring is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion pump may have been damaged during this procedure, perform the PVT as described in *Section 5.2*.

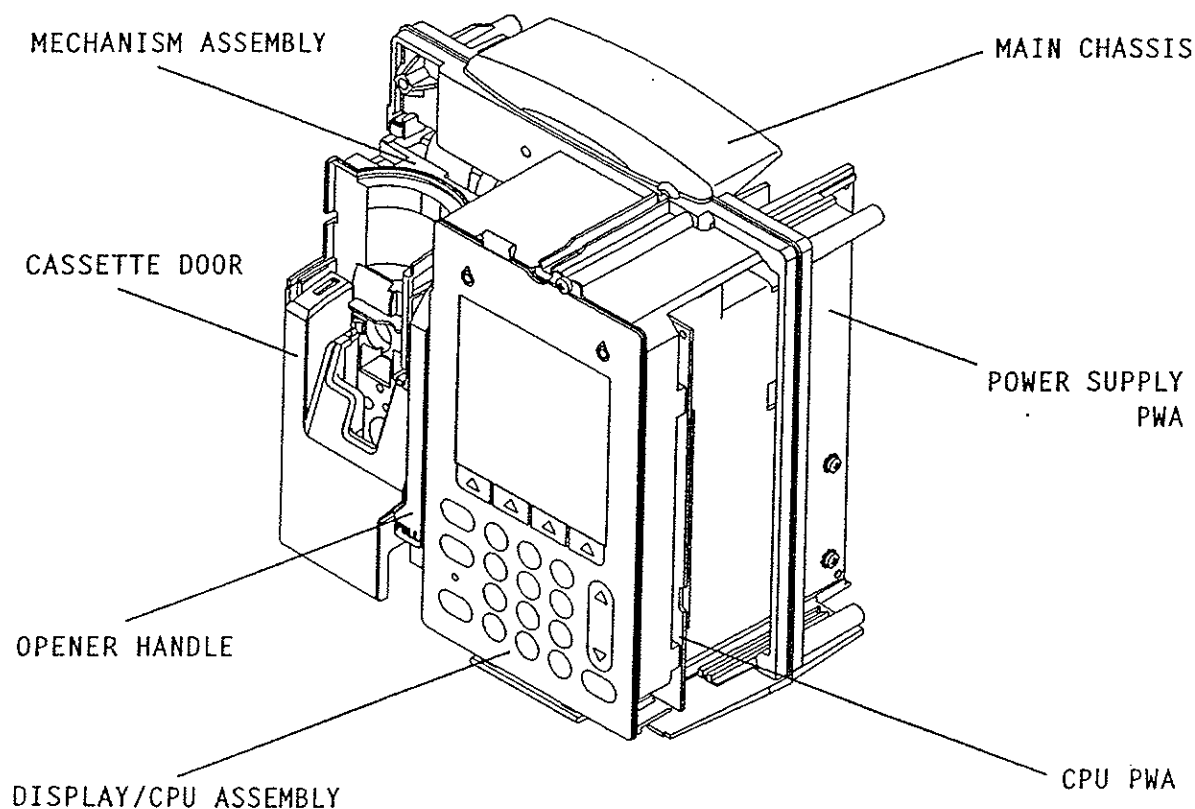
7.2.13

MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT

Main chassis assembly component replacement includes the replacement of the following:

- ☐ Power supply PWA
- ☐ Display/CPU assembly
- ☐ CPU PWA
- ☐ Piezo alarm assembly
- ☐ Mechanism assembly
- ☐ Cassette door and fluid shield
- ☐ Opener handle assembly

To replace the main chassis assembly components, refer to *Figure 7-10, Main Chassis Components*, then proceed as detailed in the following sections.



98G01039

Figure 7-10. Main Chassis Components

7.2.13.1**POWER SUPPLY PWA REPLACEMENT**

The recommended tool for this procedure is a medium size flat-blade screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the power supply PWA, refer to *Figure 7-10, Main Chassis Components*, then proceed as follows:

1. Separate the rear enclosure assembly from the main chassis as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the power supply/battery cable from J22 on the power supply PWA.
3. Remove the power supply/mechanism cable from J16 on the power supply PWA.
4. Remove the power supply PWA by sliding the board away from the CPU PWA.
5. Install the replacement power supply PWA in the exact reverse order of removal.

Note: Verify the replacement power supply PWA connects to the CPU PWA correctly to avoid misalignment.

Note: If an alarm sounds, press the [ON/OFF] key to deactivate the alarm.

6. Join the main chassis and rear enclosure assembly in the exact reverse order of separation.
7. Connect the infusion pump to AC (mains) power.

To verify successful power supply PWA replacement, perform the PVT in *Section 5.2*.

7.2.13.2**DISPLAY/CPU ASSEMBLY REPLACEMENT**

The recommended tools for this procedure are as follows: No. 2 Phillips screwdriver and medium size flat-blade screwdriver.

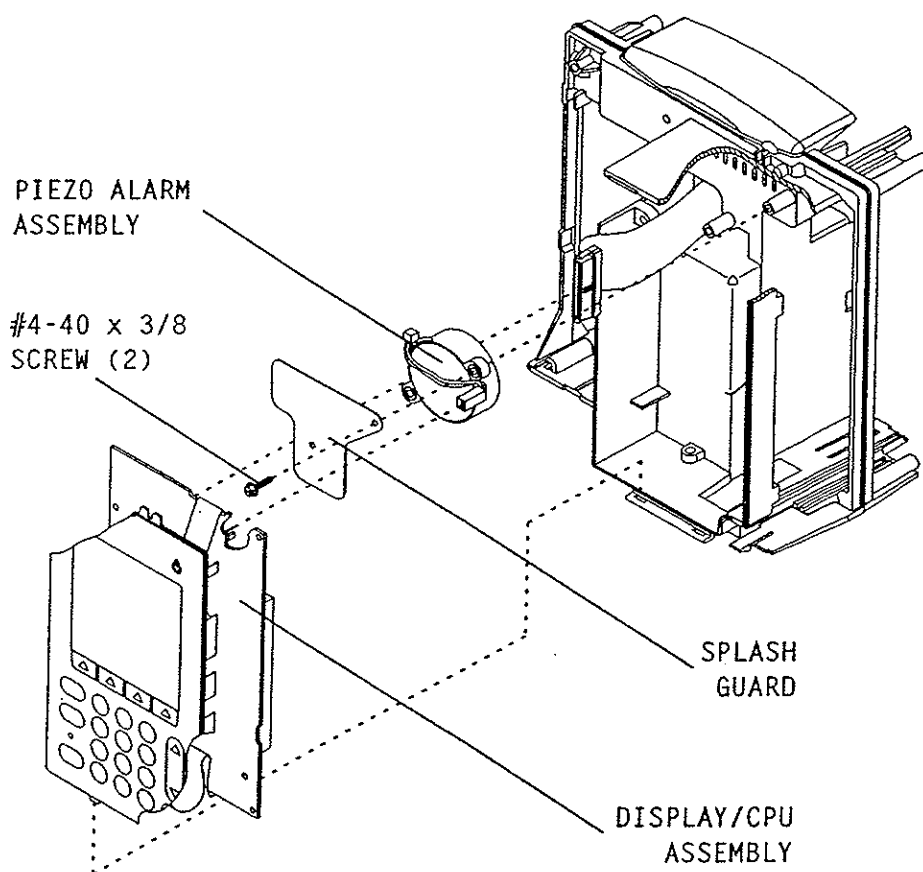
CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the display/CPU assembly, refer to *Figure 7-10, Main Chassis Components*, *Figure 7-11, Display/CPU Assembly and Piezo Alarm Assembly Replacement* and *Figure 7-12, CPU PWA Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the power supply PWA as described in *Section 7.2.13.1, Power Supply PWA Replacement*.
3. Using a Phillips screwdriver, remove the screw securing the display/CPU assembly to the main chassis.
4. Carefully disconnect the ribbon cable from the display assembly. Place the display assembly down with the keypad face down.

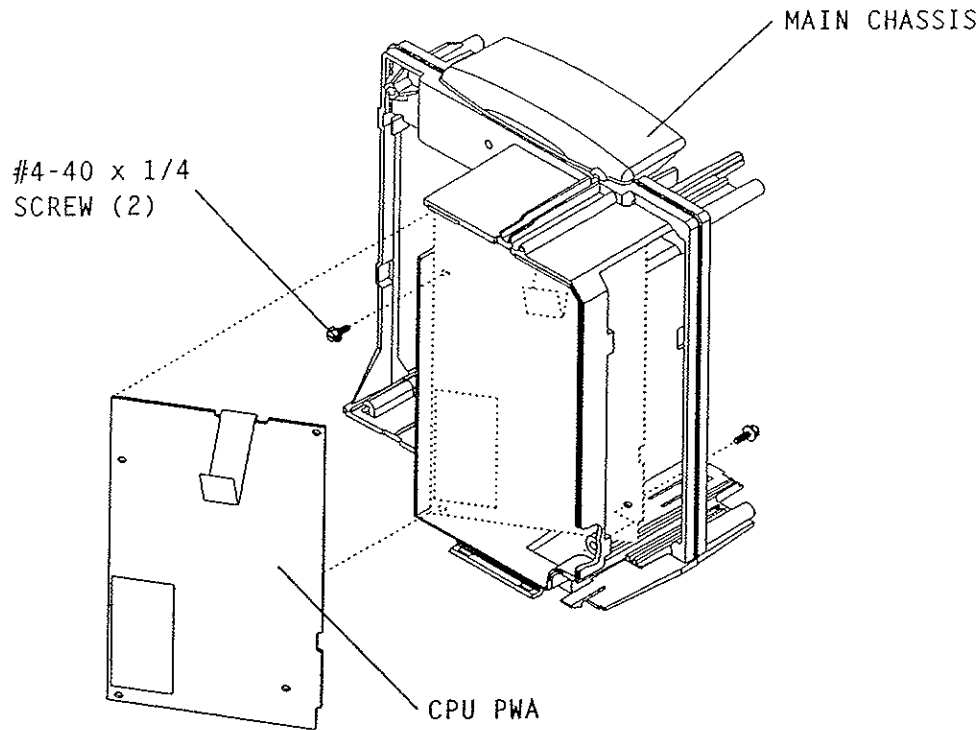
5. Using a medium size flat-blade screwdriver, remove the two hex head screws as shown in *Figure 7-11*.
6. Disconnect the piezo alarm assembly from the CPU PWA at J24.
7. Turn the CPU PWA as shown in *Figure 7-12*.
8. Disconnect the CPU/mechanism cable from J3.
9. Install the replacement display/CPU assembly in the exact reverse order of removal.
10. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
11. Connect the infusion pump to AC (mains) power.

To verify successful display/CPU assembly replacement, perform the PVT in *Section 5.2*.



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Figure 7-11. Display/CPU Assembly and Piezo Alarm Assembly Replacement



98G01034

Figure 7-12. CPU PWA Replacement

7.2.13.3

CPU PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat-blade screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the CPU PWA, refer to *Figure 7-11, Display/CPU Assembly and Piezo Alarm Assembly Replacement* and *Figure 7-12, CPU PWA Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the power supply PWA as described in *Section 7.2.13.1, Power Supply PWA Replacement*.
3. Remove the display/CPU assembly as described in *Section 7.2.13.2, Display/CPU Assembly Replacement*.
4. Disconnect the keypad ribbon cable from J4.
5. Disconnect the display cable from J20.
6. Install the replacement CPU PWA in the exact reverse order of removal.
7. Re-assemble the display/CPU assembly and power supply PWA in the exact reverse order of removal.

8. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
9. Connect the infusion pump to AC (mains) power.

To verify successful CPU PWA replacement, perform the PVT in *Section 5.2*.

7.2.13.4

PIEZO ALARM ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat-blade screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the piezo alarm assembly, refer to *Figure 7-11, Display/CPU Assembly and Piezo Alarm Assembly Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the power supply PWA as described in *Section 7.2.13.1, Power Supply PWA Replacement*.
3. Remove the display/CPU assembly as described in *Section 7.2.13.2, Display/CPU Assembly Replacement*.
4. Using a medium size flat-blade screwdriver, remove the two hex head screws securing the splash guard and piezo alarm to the main chassis.

Note: Note the alignment of the piezo alarm assembly connecting wires. Verify the replacement assembly is aligned the same way.

5. Install the replacement piezo alarm assembly in the exact reverse order of removal.
6. Re-assemble the display/CPU assembly and power supply PWA in the exact reverse order of removal.
7. Join the front enclosure, main chassis, and rear enclosure assembly in the exact reverse order of separation.
8. Connect the infusion pump to AC (mains) power.

To verify successful piezo alarm assembly replacement, perform the PVT in *Section 5.2*.

7.2.13.5

MECHANISM ASSEMBLY REPLACEMENT

The recommended tools for this procedure are as follows: a medium size flat-blade screwdriver and diagonal cutters.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

Note: Replacing the mechanism changes the biomed settings to those stored in the mechanism.

To replace the mechanism assembly, refer to *Figure 7-13, Mechanism Assembly Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Using diagonal cutters, cut the cable tie that secures the power supply/driver cable.
3. Using a medium size flat-blade screwdriver, remove the hex-head screw securing the mechanism assembly to the main chassis assembly. Slide the mechanism assembly away from the main chassis assembly.
4. Disconnect the CPU/driver cable from J11 by unlocking the metal tags. Remove the mechanism assembly.
5. Install the replacement mechanism assembly in the exact reverse order of removal.
6. Replace the cable tie.
7. Join the front enclosure assembly, rear enclosure assembly, and main chassis assembly in the exact reverse order of separation.
8. Connect the infusion pump to AC (mains) power.

To verify successful mechanism assembly replacement, perform the PVT in *Section 5.2*.

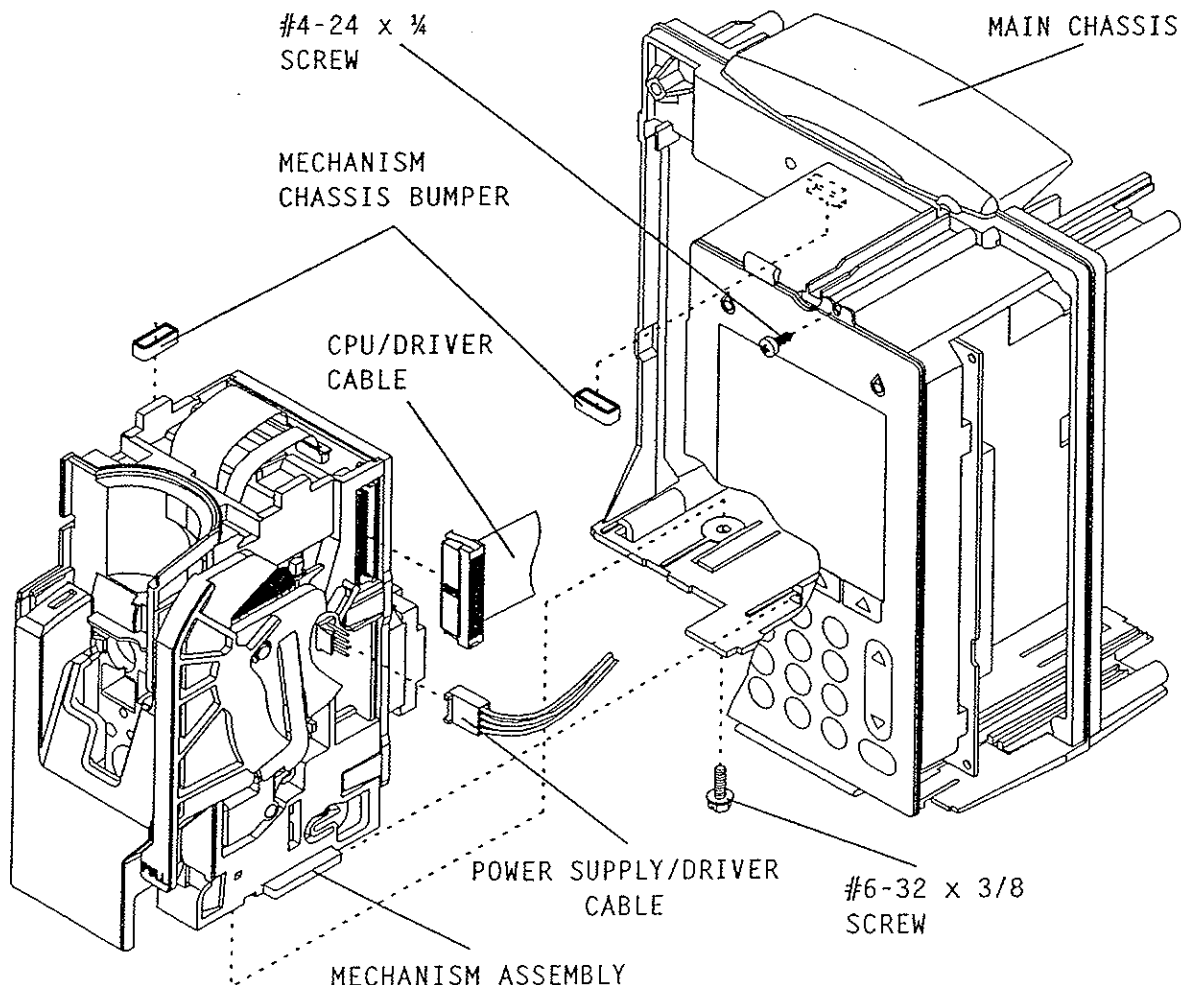


Figure 7-13. Mechanism Assembly Replacement

7.2.13.6**CASSETTE DOOR AND FLUID SHIELD REPLACEMENT**

Recommended tools for this procedure are as follows: medium size flat-blade screwdriver and long needle-nose pliers.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the cassette door and fluid shield, refer to *Figure 7-14, Fluid Shield Replacement*, and *Figure 7-15, Cassette Door and Opener Handle Assembly Replacement* then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the mechanism assembly as described in *Section 7.2.13.5, Mechanism Assembly Replacement*.
3. Using a medium size flat-blade screwdriver, remove the hex head screw securing the door pivot cap to the mechanism assembly. Disengage the cassette door from the opener handle assembly. Remove the door.
4. On the backside of the fluid shield, disengage the clips that retain the upper portion of the fluid shield to the mechanism assembly.
5. Disconnect the fluid shield/driver flex connector from J12 on the driver PWA.

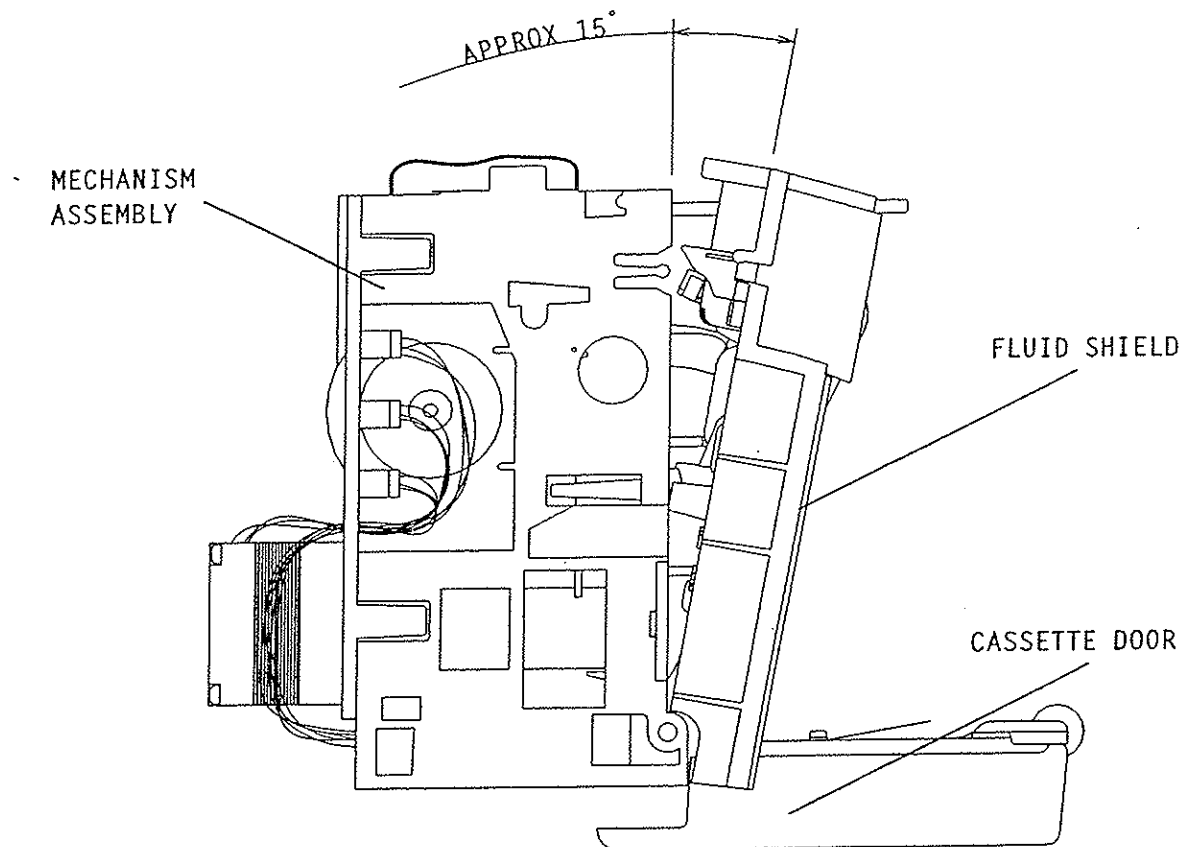
Note: Lift the locking pins of J12 to release the flex connector.

6. Pull the shield away from the top of the mechanism assembly at an approximate 15-degree angle. Pull shield up and away, clearing the mechanism assembly pins and plunger.
7. Install the replacement fluid shield in the exact reverse order of removal.

Note: Prior to fluid shield replacement, align the mechanism assembly pins.

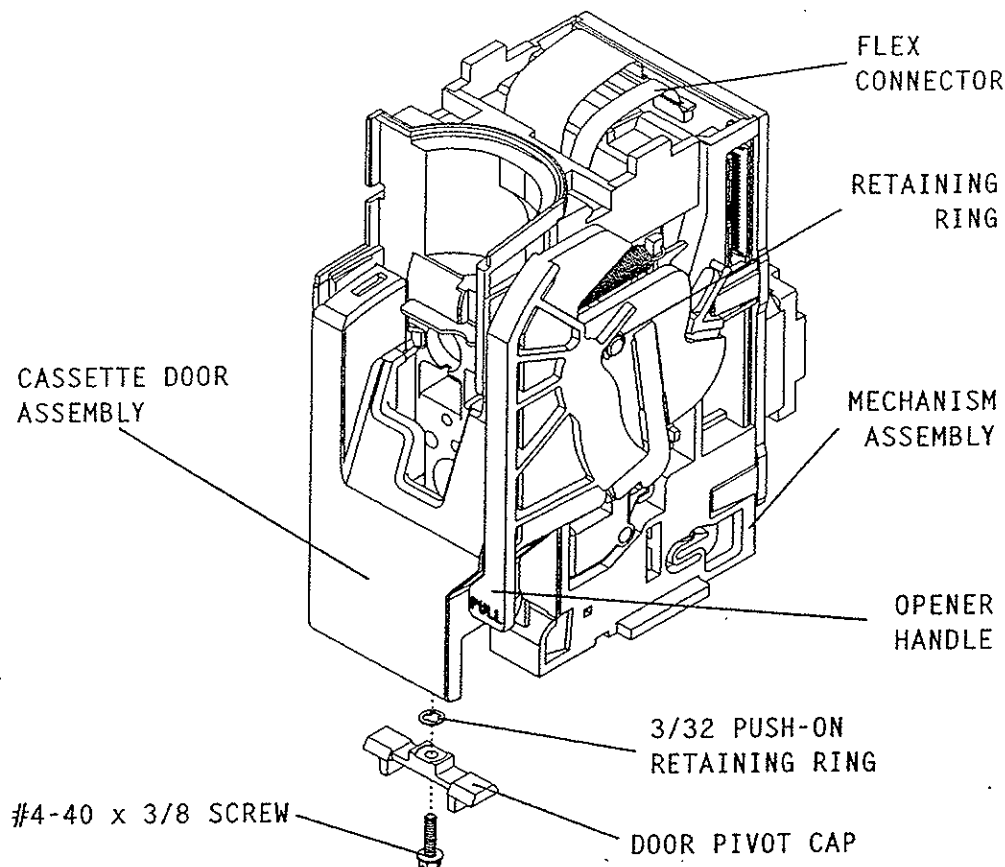
8. Install the replacement cassette door in the exact reverse order of the cassette door removal.
9. Replace the mechanism assembly in the exact reverse order of removal.
10. Join the front enclosure assembly, rear enclosure assembly, and main chassis assembly in the exact reverse order of separation.
11. Connect the infusion pump to AC (mains) power.

To verify successful cassette door and fluid shield replacement, perform the PVT in *Section 5.2*.



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Figure 7-14. Fluid Shield Replacement



98G01032

Figure 7-15. Cassette Door and Opener Handle Assembly Replacement

7.2.13.7

OPENER HANDLE ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat-blade screwdriver.

CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

To replace the opener handle assembly, refer to *Figure 7-15, Cassette Door and Opener Handle Assembly Replacement*, then proceed as follows:

1. Separate the front enclosure assembly, rear enclosure assembly, and main chassis assembly as described in *Section 7.2.8, Separating the Front Enclosure Assembly, Rear Enclosure Assembly, and Main Chassis Assembly*.
2. Remove the mechanism assembly as described in *Section 7.2.13.5, Mechanism Assembly Replacement*.
3. Open the cassette door. Disengage and fully open the cassette door from the opener handle assembly (see *Figure 7-14*). Close the opener handle assembly.
4. Remove the retaining ring.
5. Insert the medium size flat-blade screwdriver between the opener handle assembly and the mechanism assembly. Carefully pry the assemblies apart.

Note: The torsion spring may fall free.

6. Install the replacement opener handle assembly in the exact reverse order of removal. Confirm the opener handle is aligned properly.
7. Replace the mechanism assembly in the exact reverse order of removal.
8. Join the front enclosure assembly, rear enclosure assembly, and main chassis assembly in the exact reverse order of separation.
9. Connect the infusion pump to AC (mains) power.

To verify successful opener handle assembly replacement, perform the PVT in *Section 5.2*.

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Section 8

SPECIFICATIONS

PHYSICAL

Dimensions: Approximately 13.6 H x 8.0 W x 6.0 D inches (excluding pole clamp and power cord storage)

Weight: Approximately 9.5 lbs (with battery)

Casing: High-impact plastic

ELECTRICAL

Power Requirements: 120 V_{AC}, 50-60 Hz, 35 W

Power Cord: Hospital-grade AC cord. 10 feet with transparent plug and retainer plate

Fuses: 0.5 A, 250 V_{AC}

Battery: Sealed, lead-acid, rechargeable 6 V battery, internal to the infusion pump.

Battery Operation: A fully charged new battery provides six hours of operation at 125 ml/hr, or delivers 500 ml on one line, whichever occurs first. Operation time is measured from initial pumping to the Depleted Battery alarm. The infusion pump should be operated on battery power for six continuous hours every six months for optimum performance and battery life.

Recharge: The battery charges whenever the infusion pump is connected to AC power. If the infusion pump is operating at 125 ml/hr or less on one line, a full recharge takes less than 6 hours.

Self-Discharge: 50% of charge is retained for a minimum of one month when the infusion pump is not connected to AC power or is not operating.

Nurse Call System: Circuitry Ratings: Voltage - 30 V_{DC} Max
Current - 0.25 Amps max
Contact Rating - 3 W max

Default: Normally-open (NO)

Note: Contact Abbott Laboratories Technical Support Operations to make an internal adjustment to change the device from normally-open to normally-closed (NC).

ENVIRONMENT

- Operating:** 41° to 104° F (5° to 40° C) 10% to 90% relative humidity
- Transporting and Storage:** -4° to 140° F (-20° to 60° C) 10% to 90% relative humidity
- Atmospheric Pressure:** 0-10,000 feet (0-3000 meters) or equivalent atmospheric pressure
- Relative Humidity:** 10 - 90% (104° F max)

DELIVERY RATE RANGE

- Lines A and B:** 0.1 to 99.9 ml/hr (in 0.1 ml/hr increments)
100 to 999 ml/hr (in 1 ml/hr increments), cassette type dependent
- Concurrent Delivery:** 0.5 ml/hr minimum for each line
- PlumSet:** 500 ml/hr cumulative (A+B) maximum
- KVO:** 1.0 ml/hr or the last primary delivery rate, whichever is less
- VTBI RANGE:** 0.1 to 99.9 ml (in 0.1 ml/hr increments)
100 to 9999 ml (in 1 ml/hr increments)

OCCLUSION ALARM AND LIMITS

- Distal:** The distal occlusion alarm sounds after the distal tubing or set outlet fitting becomes occluded.
- Proximal:** The proximal occlusion alarm sounds within two pumping cycles when the tubing proximal to the cassette becomes occluded.
- Distal Pressure Limit (without alarm):** 1 to 15 psig. The maximum pressure limit is user-selectable. Factory default is 6 psig.
- Maximum Infusion Pressure:** 20 psig

AIR-IN-LINE ALARM

- PlumSet (Distal):** Bolus: 0.1 ml of air or larger
Cumulative: 0.26 ml of air out of 2.5 ml of fluid
- PlumSet (Proximal):** Bolus at 0.5 ml, Total 1.0 ml (0.5 ml concurrent)

Section 9

DRAWINGS

Figure 9-1 through Figure 9-16 show the illustrated parts breakdown (IPB), infusion pump assembly diagrams, and PWA schematic diagrams. Table 9-1, *Drawings*, lists drawings by figure number, title, and part number. Table 9-2, *IPB for the Infusion Pump*, identifies parts by index numbers which correlate to Figure 9-1.

Note: Drawings and schematics in Section 9 are provided as information only; drawings and schematics may not exactly reflect current product configuration.

Table 9-1. Drawings		
Figure No.	Title	Part Number
9-1	Illustrated Parts Breakdown	Not Applicable
9-2	Front Enclosure, Rear Enclosure, and Main Chassis Assemblies	
9-3	Front Enclosure Assembly	
9-4	Rear Enclosure Assembly	
9-5	Peripheral Assembly	
9-6	Main Chassis Assembly	
9-7	AC (mains) Power Cord, Power Cord Retainer, and Battery	
9-8	Minipole Assembly	
9-9	CPU PWA and Main Chassis	
9-10	Mechanism Assembly	
9-11	Power Supply PWA Schematic (10 sheets)	249-95005-011
9-12	Peripheral PWA Schematic (4 sheets)	249-95006-007
9-13	CPU PWA Schematic (10 sheets)	249-95007-007
9-14	Driver PWA Schematic (3 sheets)	249-95018-005
9-15	Switch PWA Schematic (1 sheet)	249-95022-003
9-16	APP PWA Schematic (3 sheets)	249-95034-005

Table 9-2. IPB for the Infusion Pump

Index No.	Nomenclature	Replacement Procedure
1	Enclosure, Front	Section 7.2.9
2	Chassis, Main	
3	Enclosure, Rear	
4	Assembly, Battery with Wire Harness	Section 7.2.4
5	PWA, Power Supply	Section 7.2.13.1
6	PWA, CPU	Section 7.2.13.3
7	Assembly, Display/CPU	Section 7.2.13.2
8	PWA, Peripheral	Section 7.2.7
9	Cover, Peripheral	Section 7.2.7
10	Assembly, Mechanism	Section 7.2.13.5
11	Foot, Rubber	Section 7.2.3
12	Assembly, Minipole	Section 7.2.12
12A	Housing, Clutch	Section 7.2.12.3
12B	Spring, Clutch	Section 7.2.12.4
12C	Hanger, Bag	Section 7.2.12.2
12D	Ring, Cotter	Section 7.2.12.1
13	Plate, Pole Clamp Backing	Section 7.2.11.1
14	Assembly, Shaft/Knob, Pole Clamp	Section 7.2.11.2
15	Tip, Shaft, Pole Clamp	Section 7.2.11.2
16	Extrusion, Pole Clamp	Section 7.2.11.1
17	Shoe	Section 7.2.8
18	Assembly, Piezo Alarm	Section 7.2.13.4
19	Pad, Battery Door	Section 7.2.4
20	Door, Battery	Section 7.2.4
21	Splash Guard	Section 7.2.13.4
22	Tape, Insulation, Pole Clamp Backing Plate	Section 7.2.11.1
23	Strap, Power Cord, Velcro	Section 7.2.5
24	Cable, Flex	Section 7.2.13.2
25	Retainer, Power Cord	Section 7.2.5
26	Cord, Power	Section 7.2.5
27	Holder, Barcode Wand	Section 7.2.10.1

Table 9-2. IPB for the Infusion Pump		
Index No.	Nomenclature	Replacement Procedure
28	Assembly, Door	Section 7.2.13.6
29	Gasket, Handle	Section 7.2.11.3
30	Gasket, Shoe	Section 7.2.10.2
31	Gasket, Rear Enclosure	Section 7.2.11.3
32	Gasket, Front/Rear Enclosure	Section 7.2.10.3
33	Cable, CPU PWA/Driver PWA	Section 7.2.13.2
34	Cable, Power Supply PWA/Driver PWA	Section 7.2.13.1
35	Cable, Power Supply PWA/Battery	Section 7.2.13.1
36	Screw, #4-40 x 3/8	Not Applicable
37	Screw, #10-32 x 1/2	
38	Screw, #6-32 x 1/2	
39	Screw, #6-32 x 3/8	
40	Screw, #4-24 x 1/4	
41	Screw, #4-40 x 1/4	
42	Screw, #4-40 x 3/8	
43	Screw, #4-40 x 1/2	
44	Screw, #6-32 x 5/8, Phillips	
45	Screw, #4-40 x 1/4, Phillips	
46	Screw, Jack, #4-40 x 7/16	
47	Screw, #4-40 x 3/8, Nylon	
48	Screw, #6-32 x 2 1/2	
49	Screw, #6-32 x 3 1/4	
50	Knob, Grey, Matte	Section 7.2.7
51	Bumper, Mechanism	Not Applicable
52	Cap, Door Pivot	Section 7.2.13.6

Table 9-2. IPB for the Infusion Pump

Index No.	Nomenclature	Replacement Procedure
53	Mount, Cable Tie	Not Applicable
54	Tie, Cable	
55	Washer, Split, Locking	
56	Washer, Helical, Split Lock	
57	3/32 Retaining Ring, Push-on	
58	Washer, Nylon	
59	Nut, #4-40, Hex	
60	Spacer, Round	Section 7.2.7
61	Cover, Nut, Grey	
62	Cap, Knob, Grey, Matte	
63	Seal, Nylon	
64	Cover, 9 pin	
65	Cover, 15 pin	

Section 10

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CAUTION: Federal (USA) law restricts this device to sale by or on the order of a physician or other licensed practitioner.

WARNING

POSSIBLE EXPLOSION HAZARD EXISTS IF INFUSION SYSTEM IS USED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

Patents pending.

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Attention, consult accompanying documents.



Type CF

Equipment providing adequate degree of protection against electrical shock and suitable for application to patient

IPX1

Drip Proof Medical Equipment

Class I

Mains supply equipment using protective earth



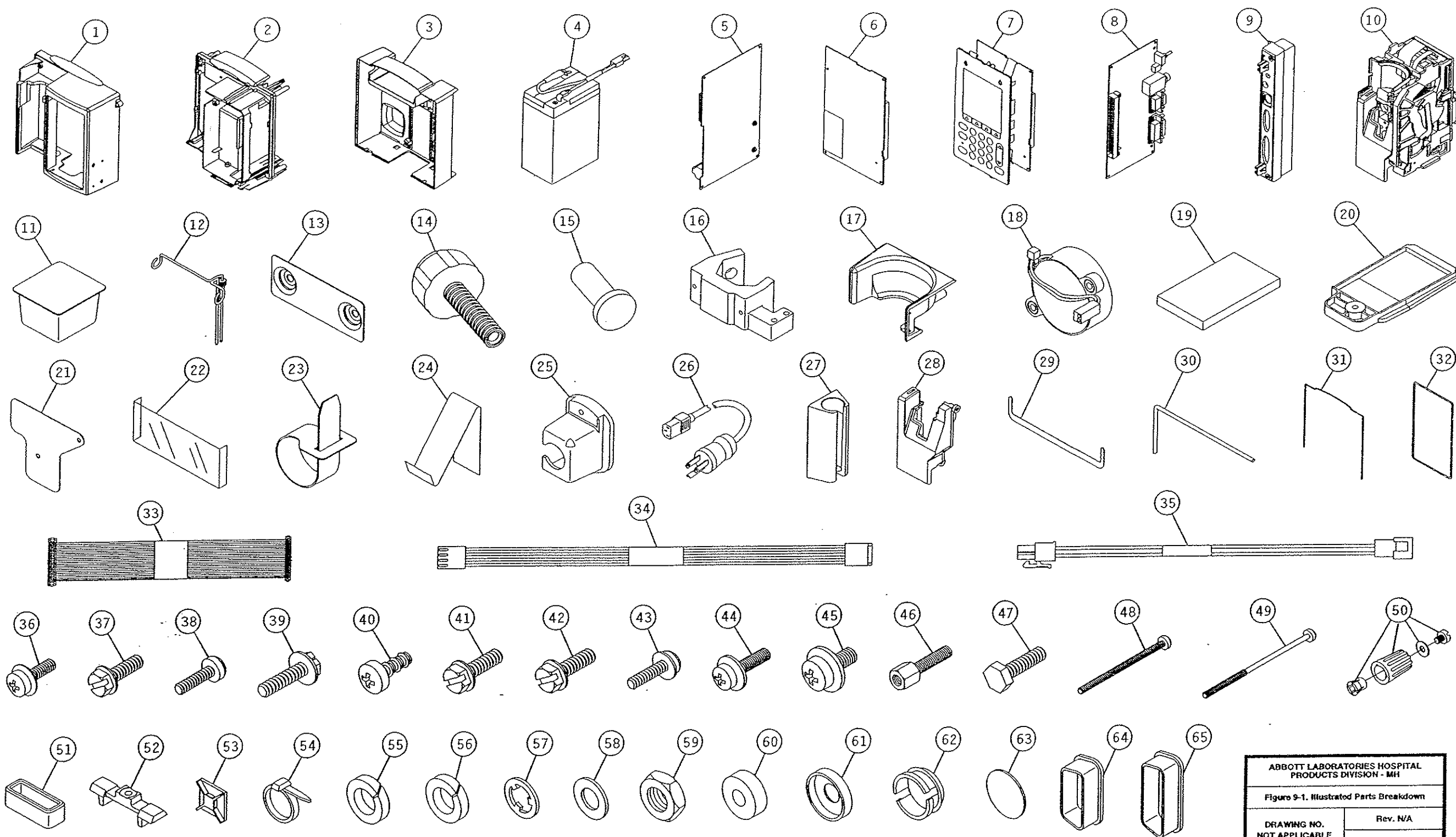
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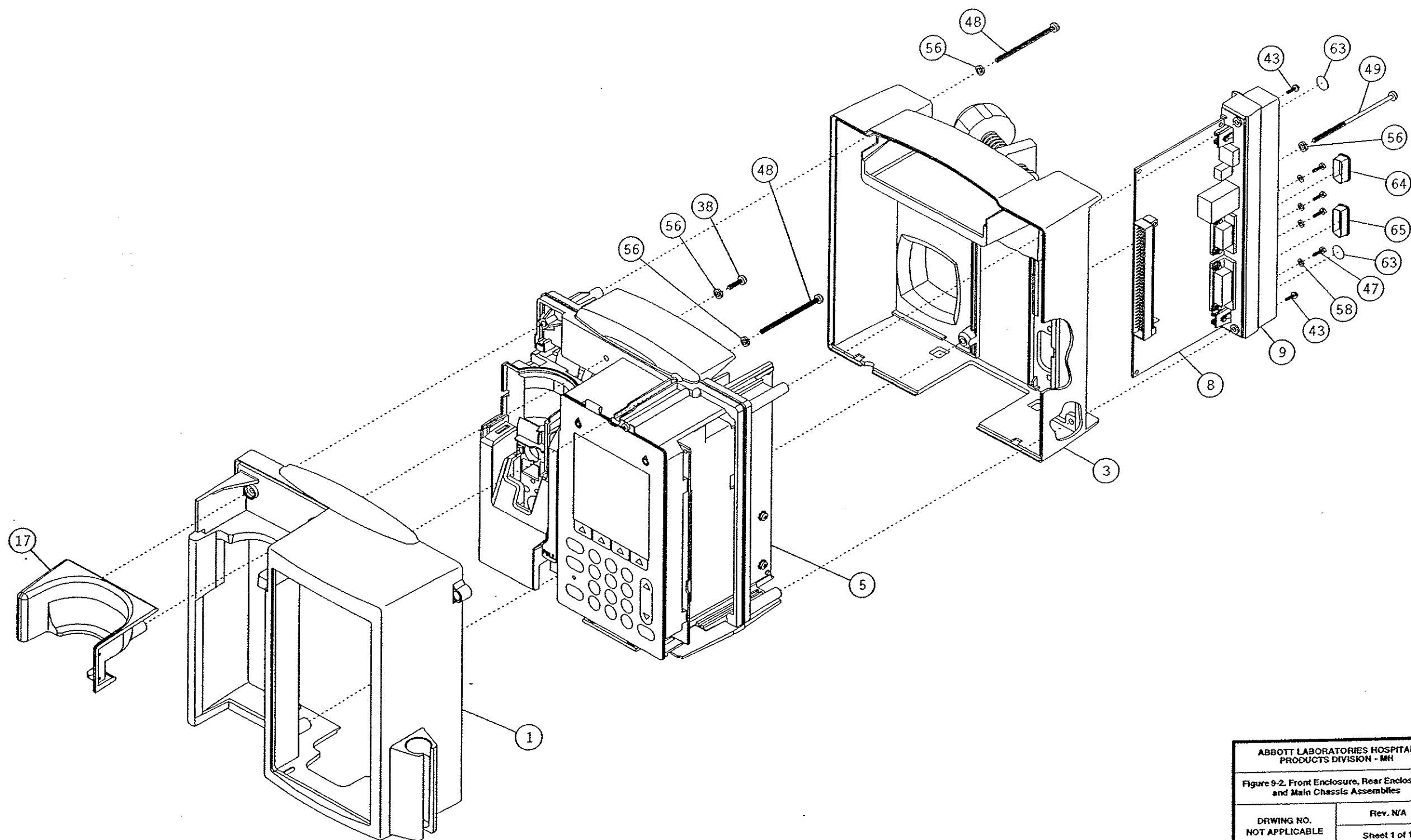
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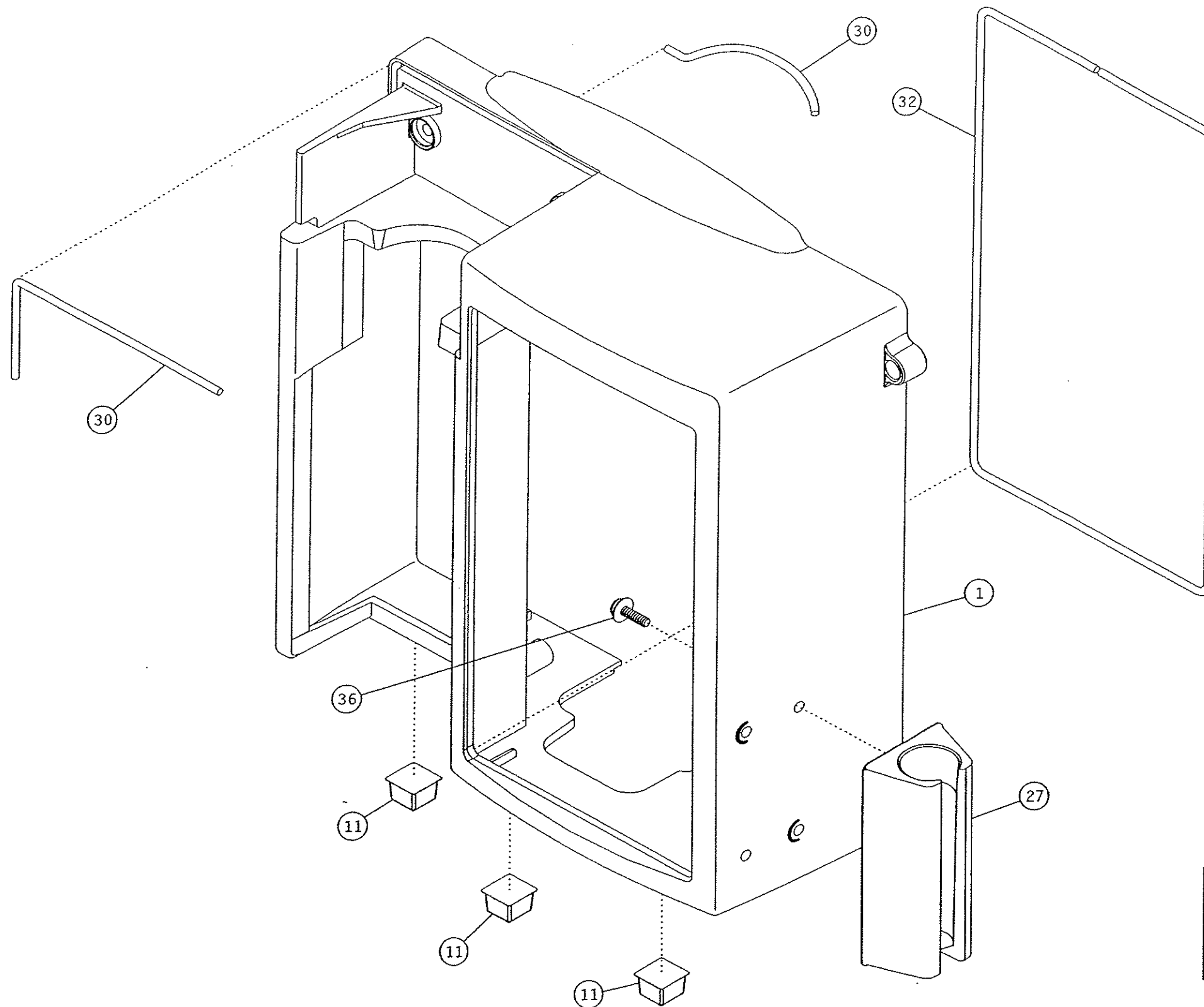


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Figure 9-1. Illustrated Parts Breakdown	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1

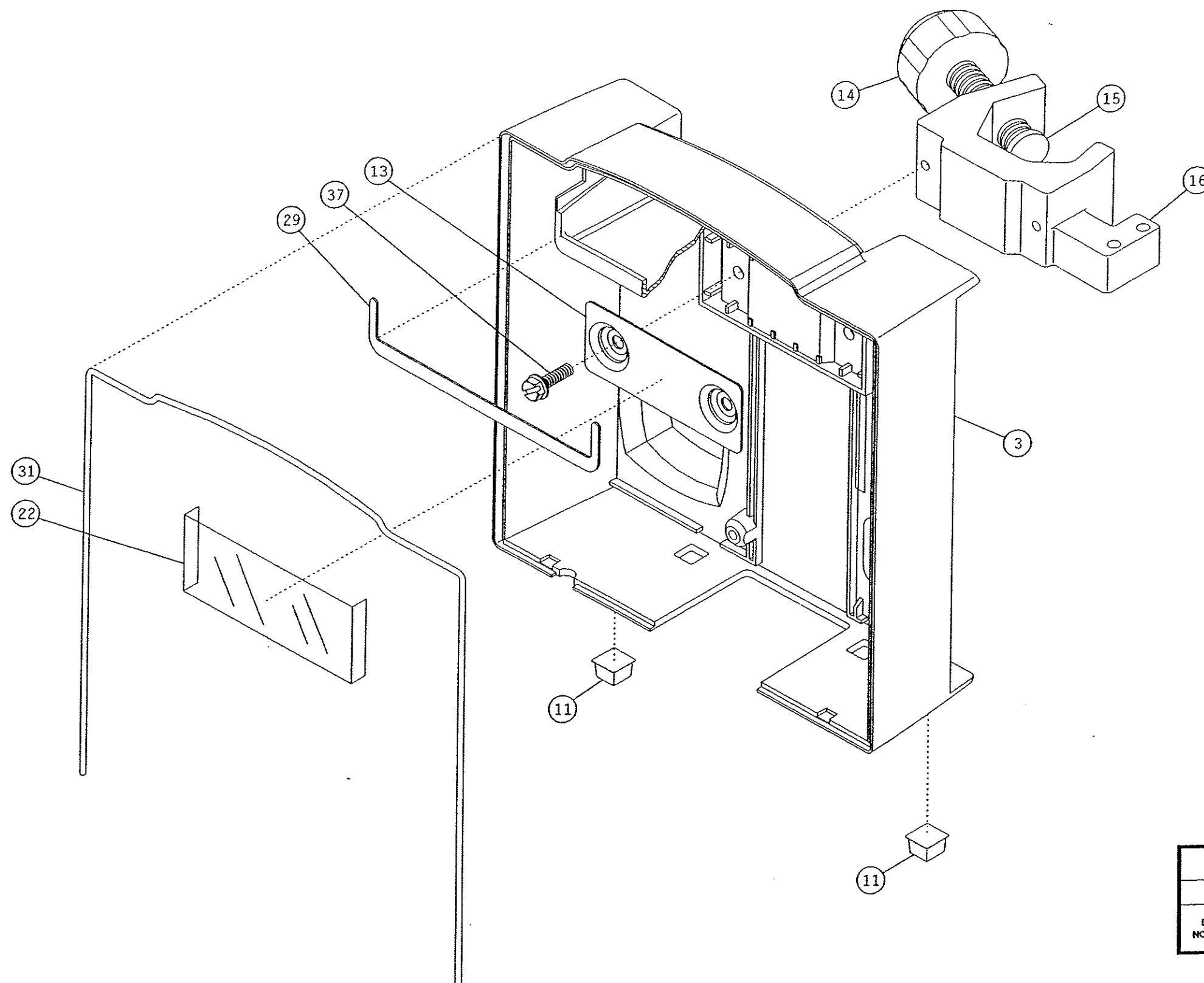
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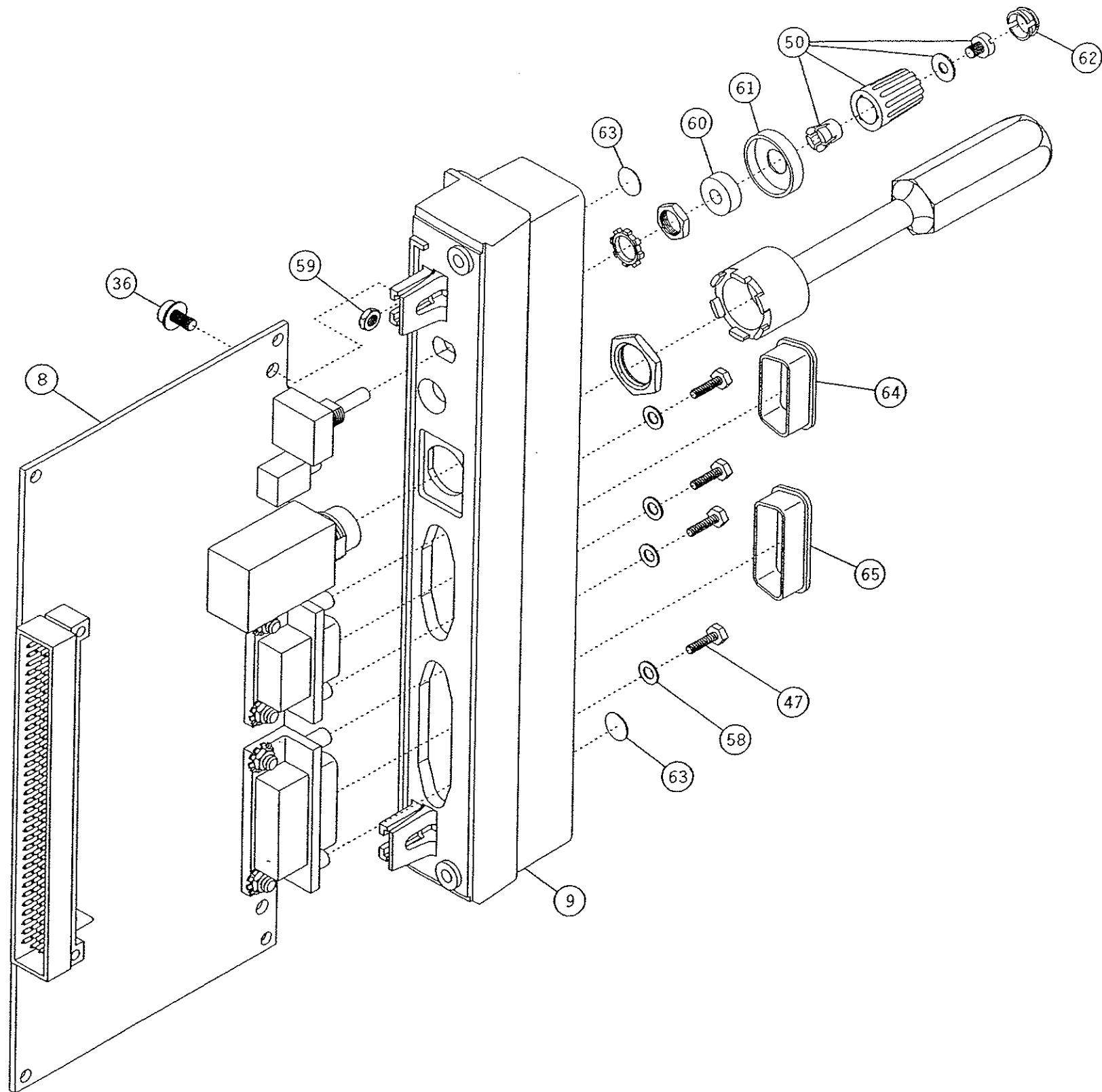
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Figure 9-2. Front Enclosure, Rear Enclosure, and Main Chassis Assemblies	
DRIVING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1



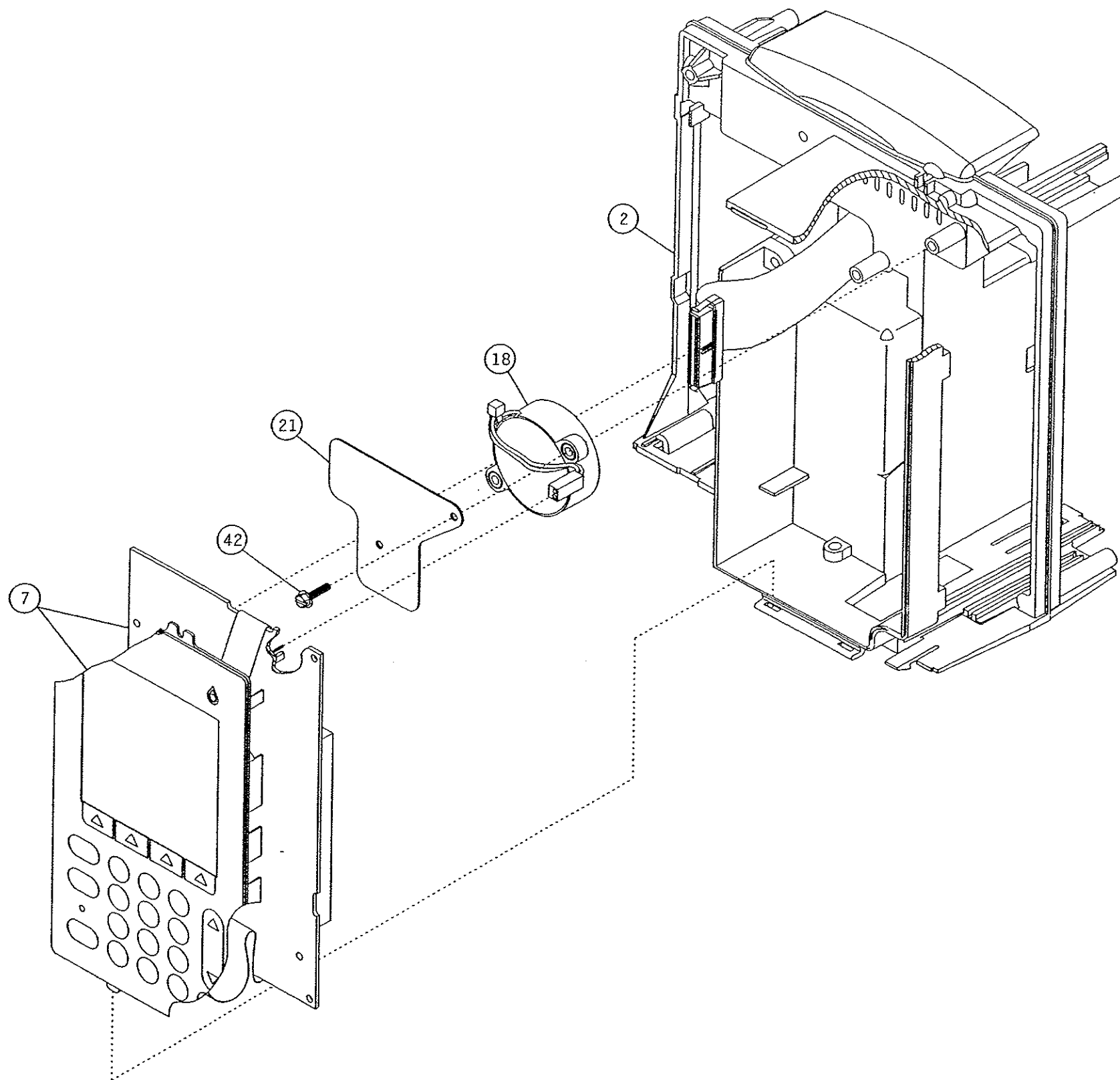
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DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1



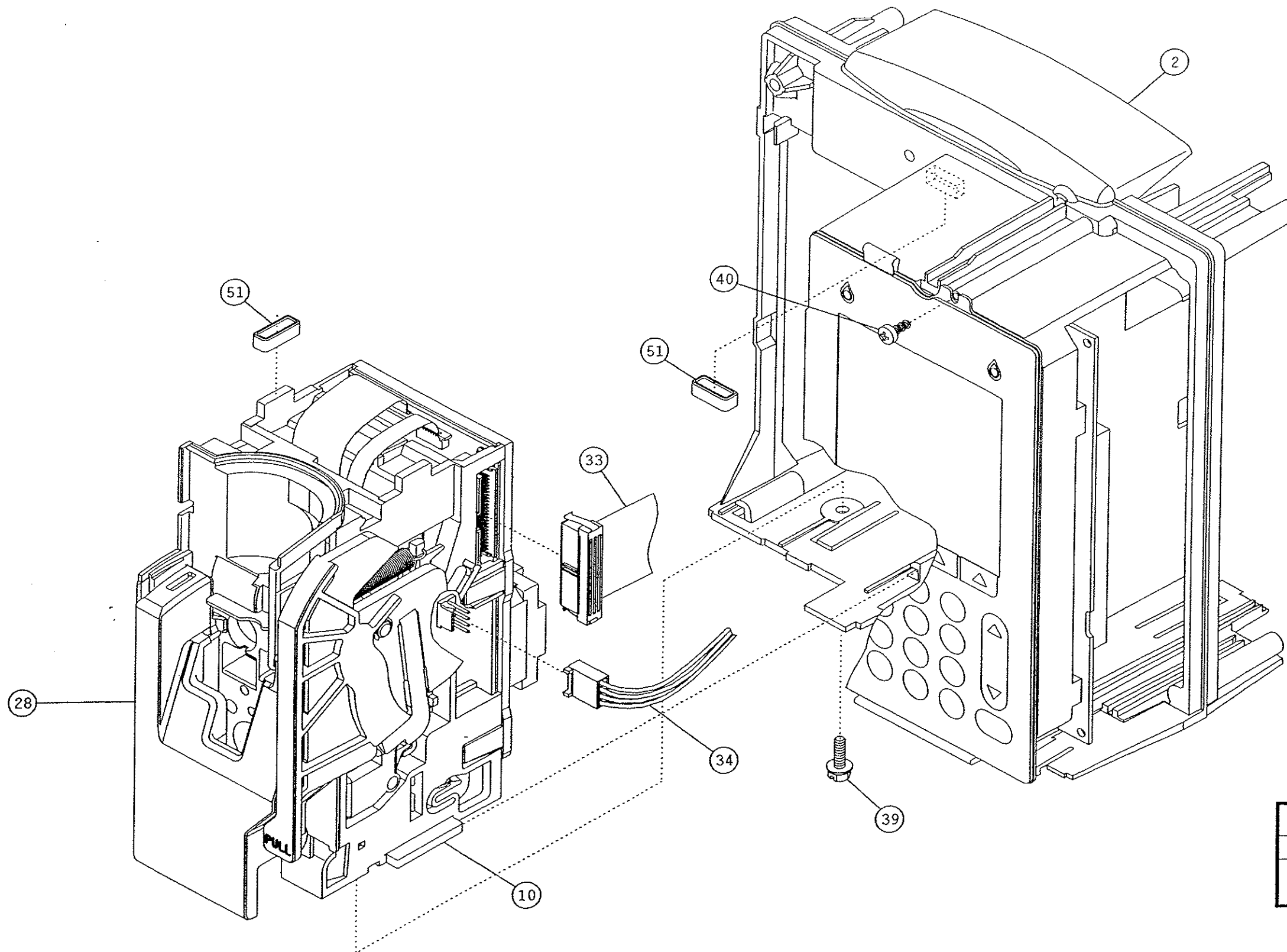
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DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1



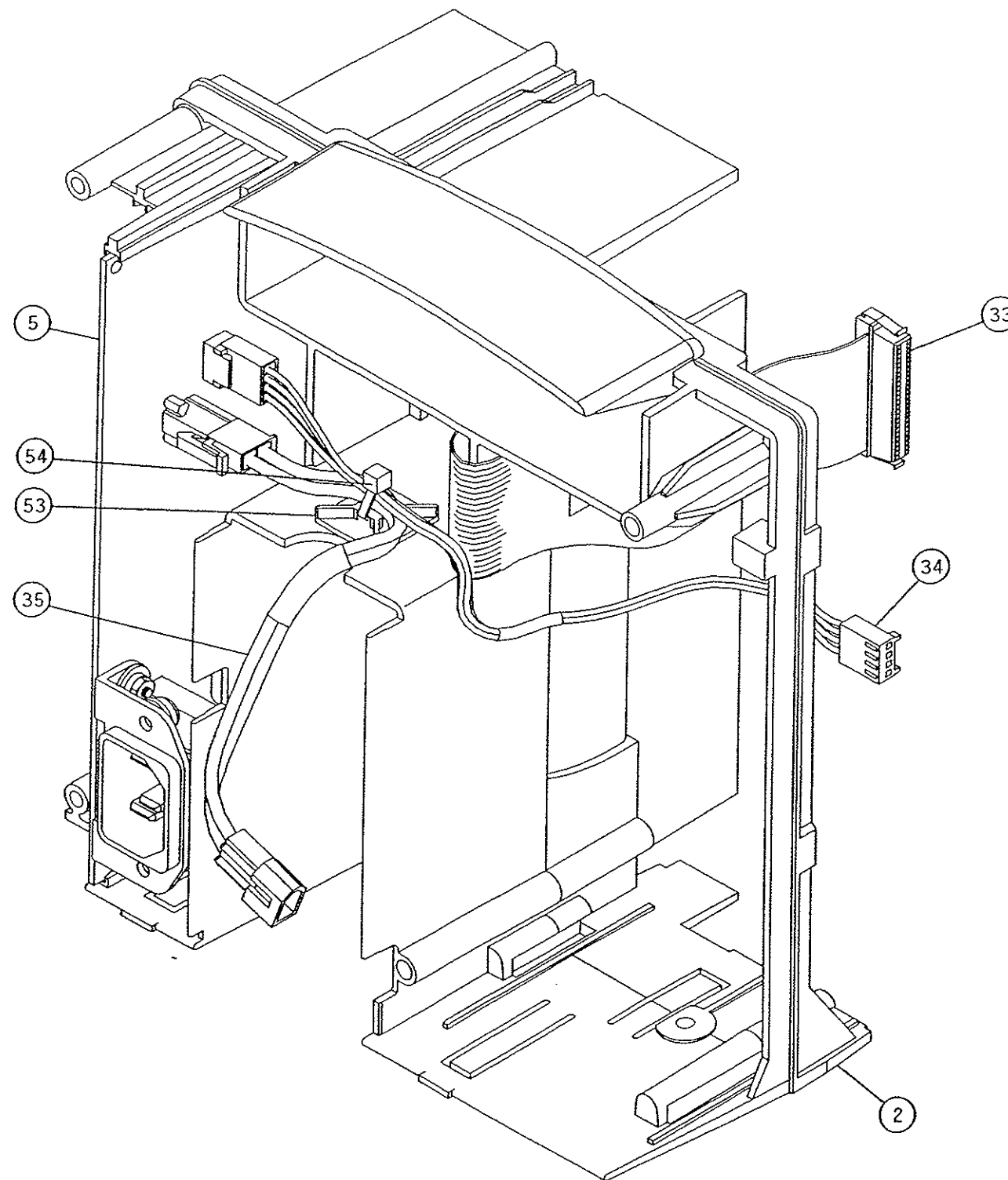
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DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1



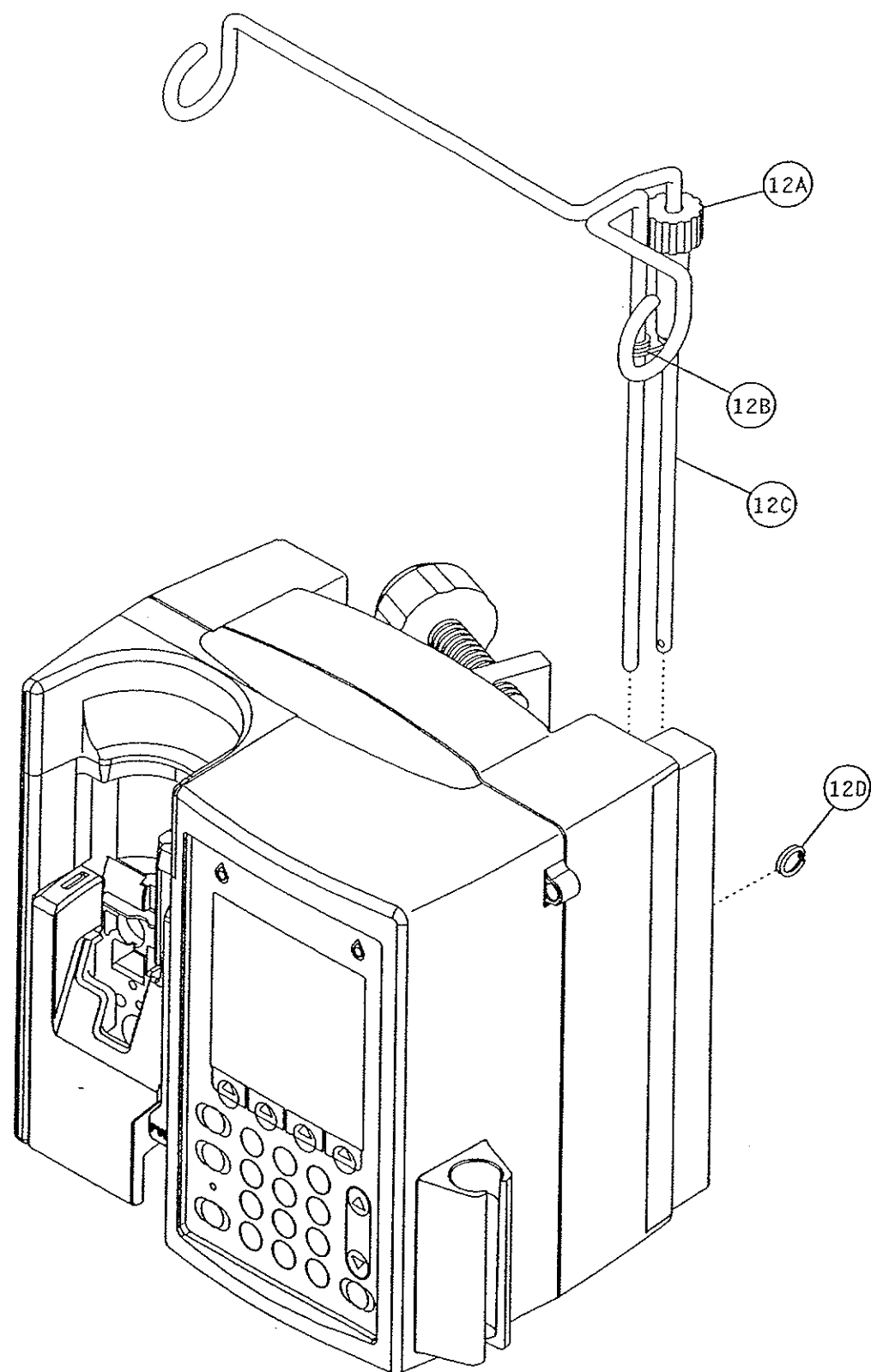
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Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 3



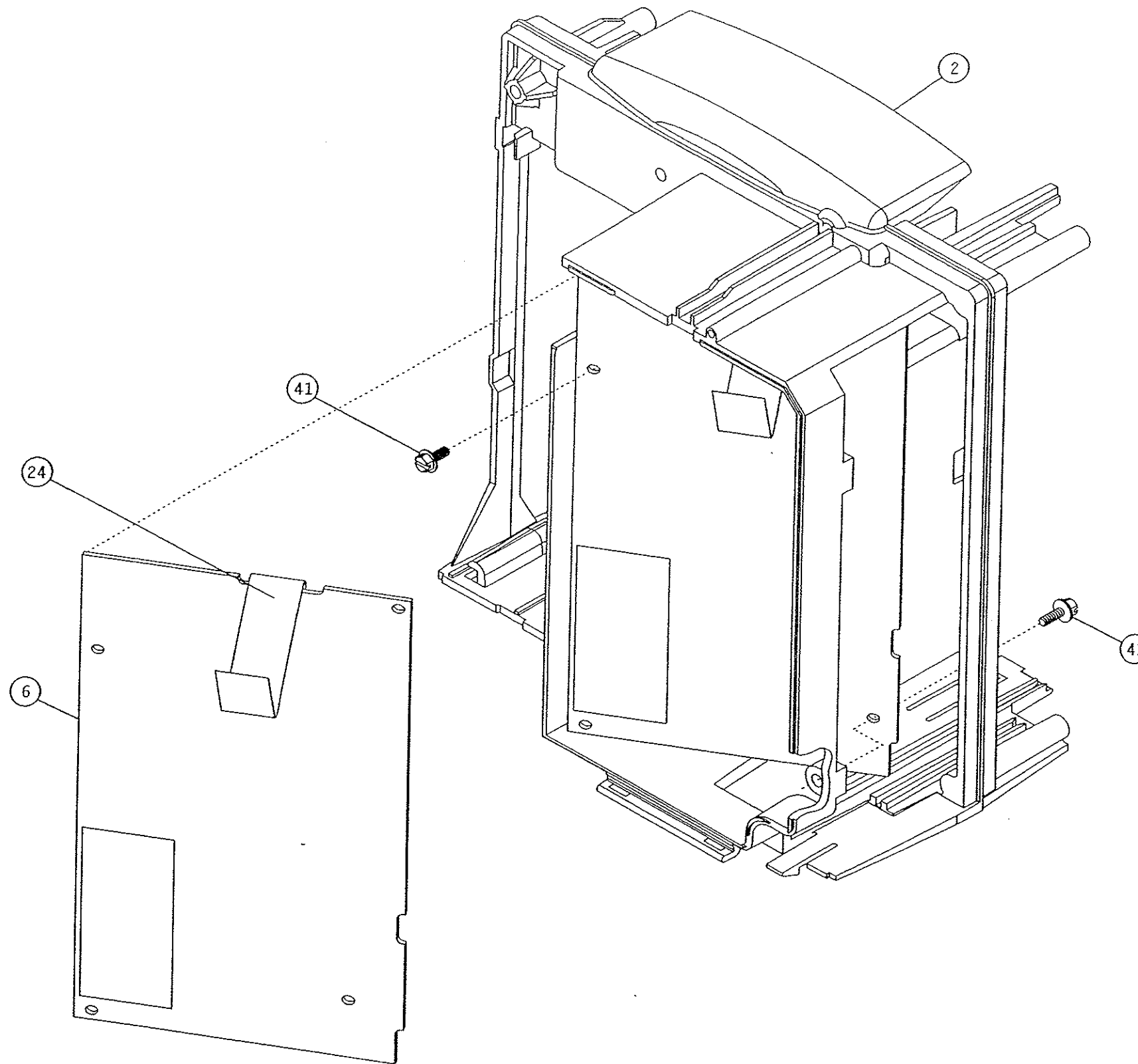
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Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 2 of 3



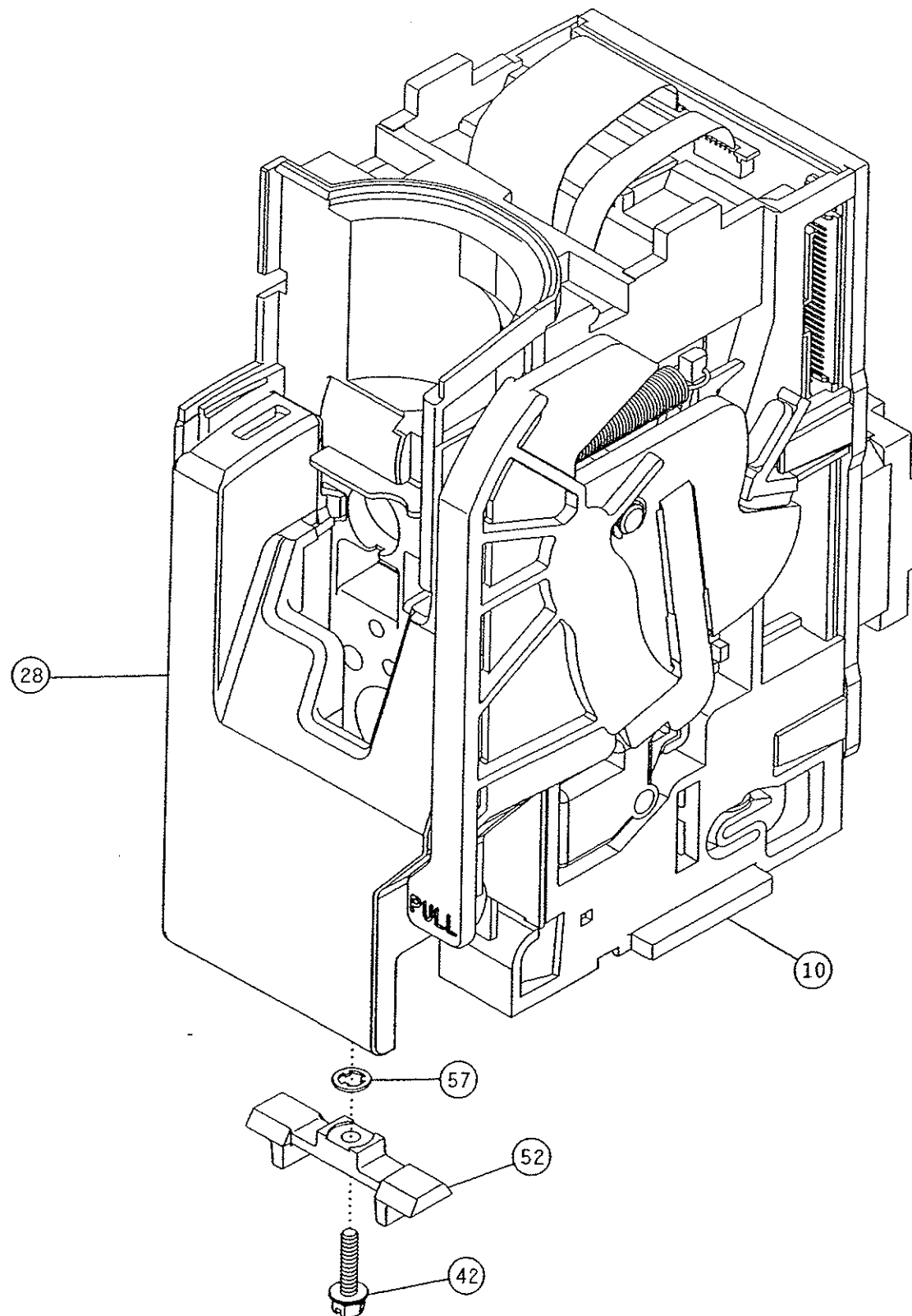
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Figure 9-6. Main Chassis Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 3 of 3



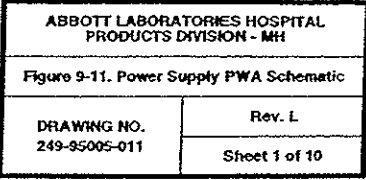
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-8. Minipole Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A
	Sheet 1 of 1

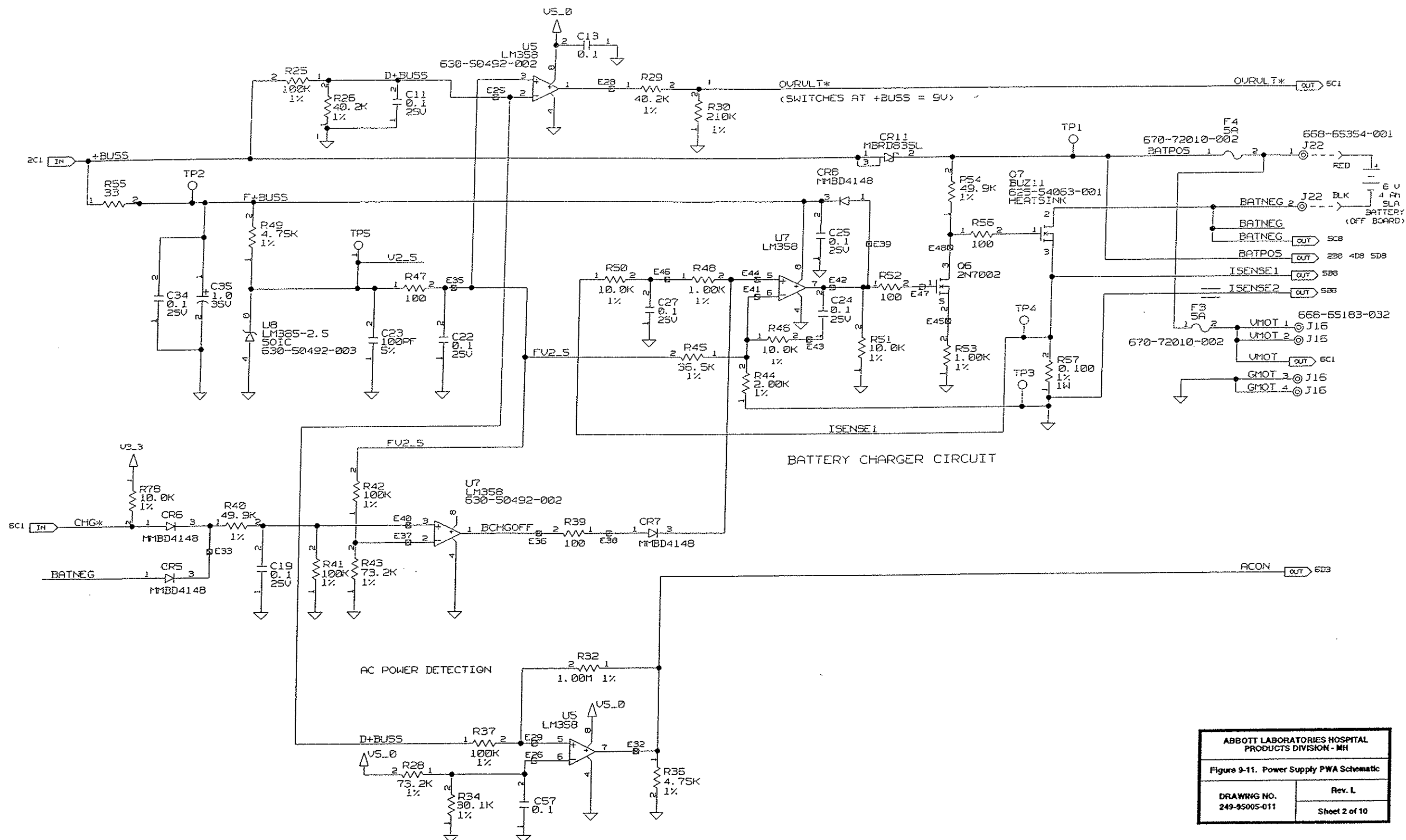


ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-9. CPU PWA and Main Chassis	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-10. Mechanism Assembly	
DRAWING NO. NOT APPLICABLE	Rev. N/A Sheet 1 of 1

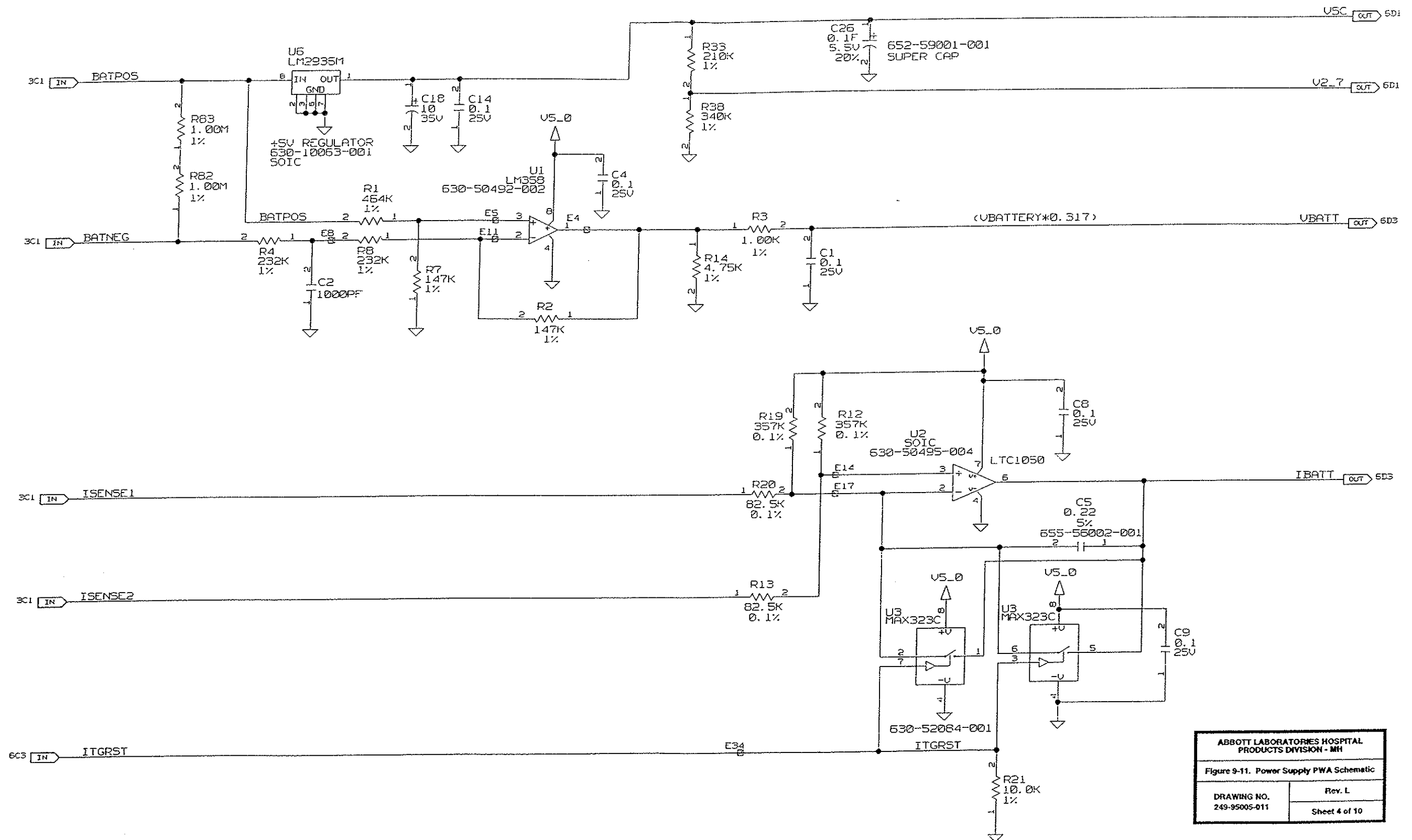




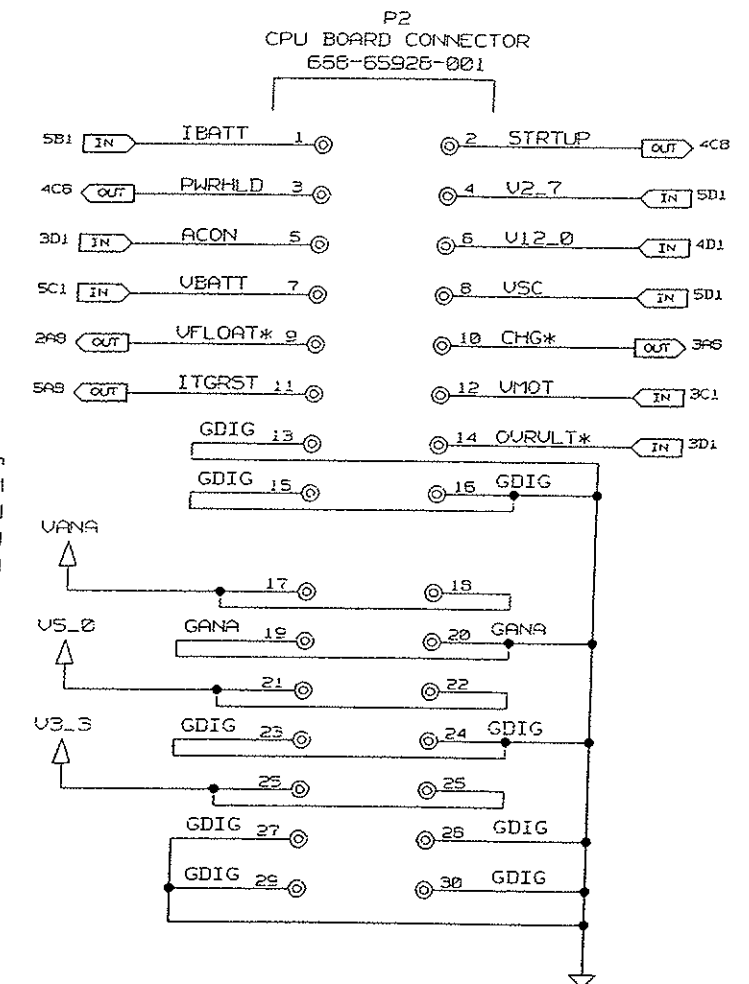
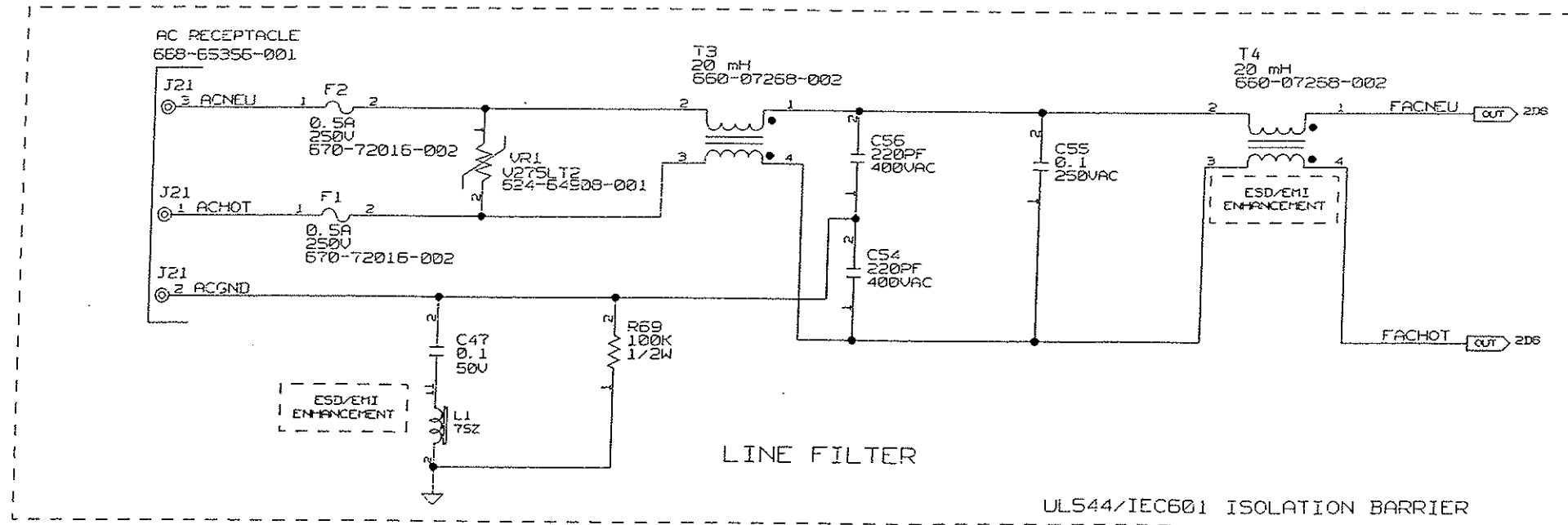
ABBOTT LABORATORIES HOSPITAL
PRODUCTS DIVISION - MH

Figure 9-11. Power Supply PWA Schematic

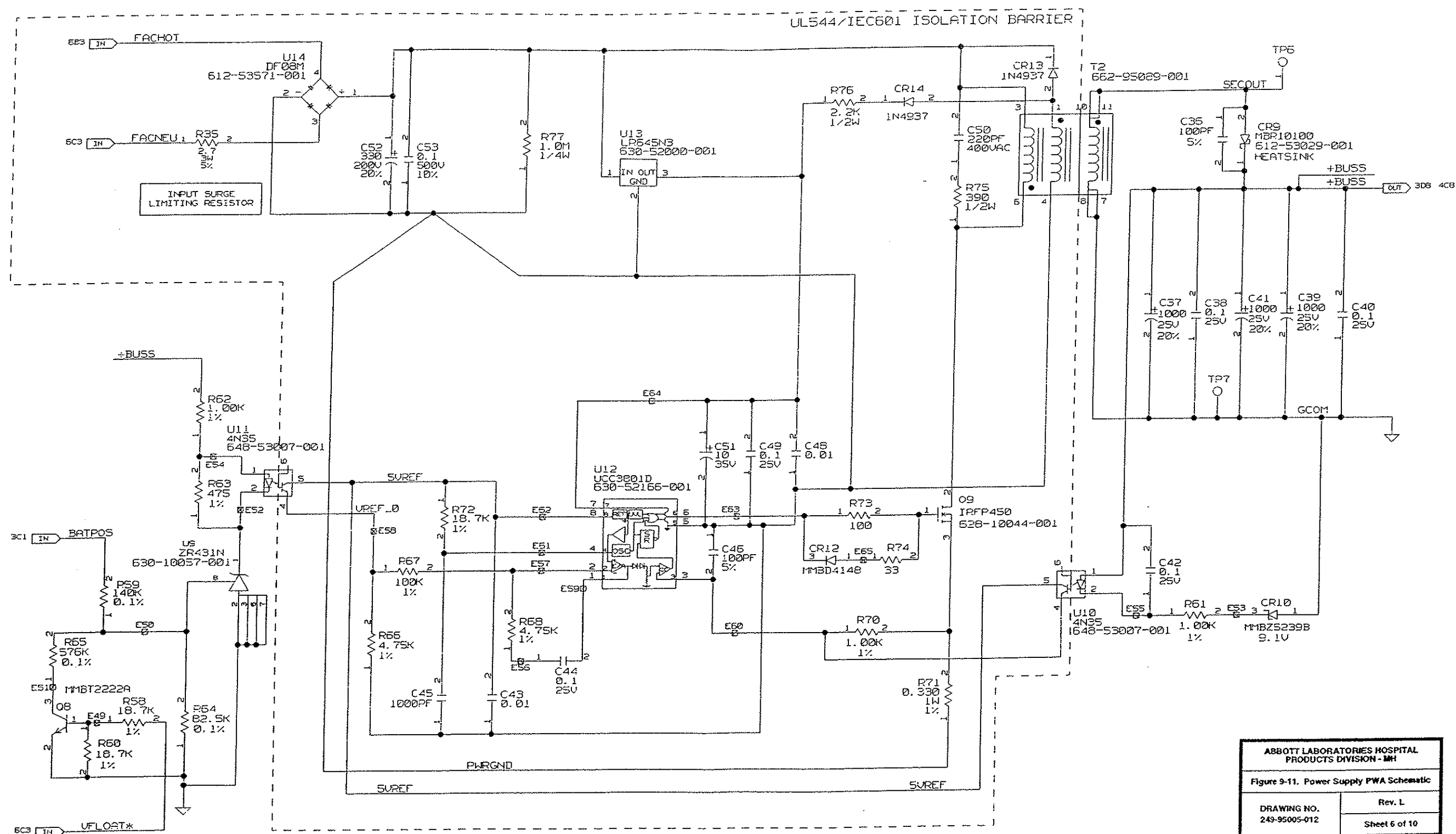
DRAWING NO. 249-95005-011	Rev. L Sheet 2 of 10
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ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-11. Power Supply PWA Schematic	
DRAWING NO. 249-95005-011	Rev. L Sheet 4 of 10



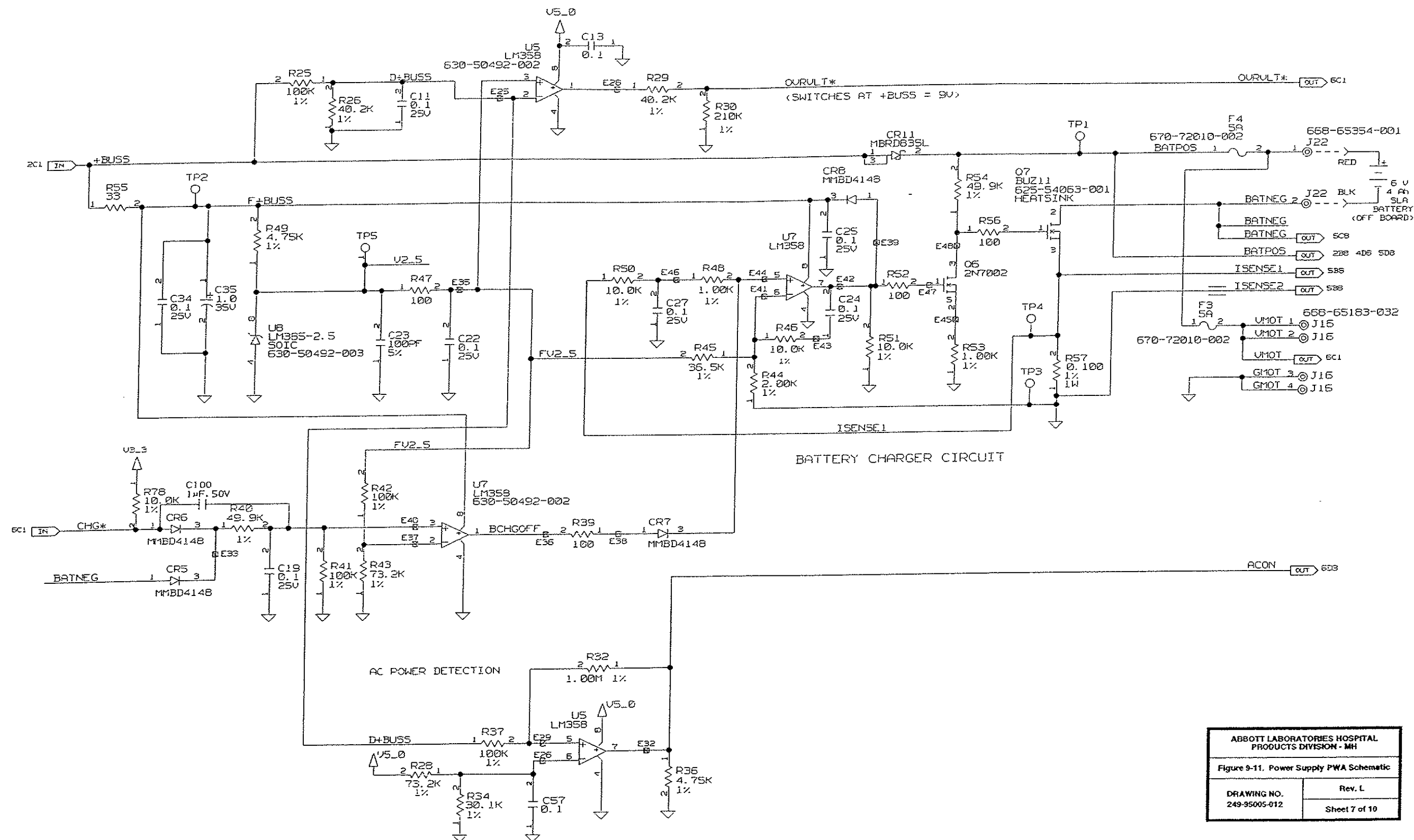
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-11. Power Supply PWA Schematic	
DRAWING NO. 249-95005-011	Rev. L Sheet 5 of 10



ABBOTT LABORATORIES HOSPITAL
PRODUCTS DIVISION - MH

Figure 9-11. Power Supply PWA Schematic

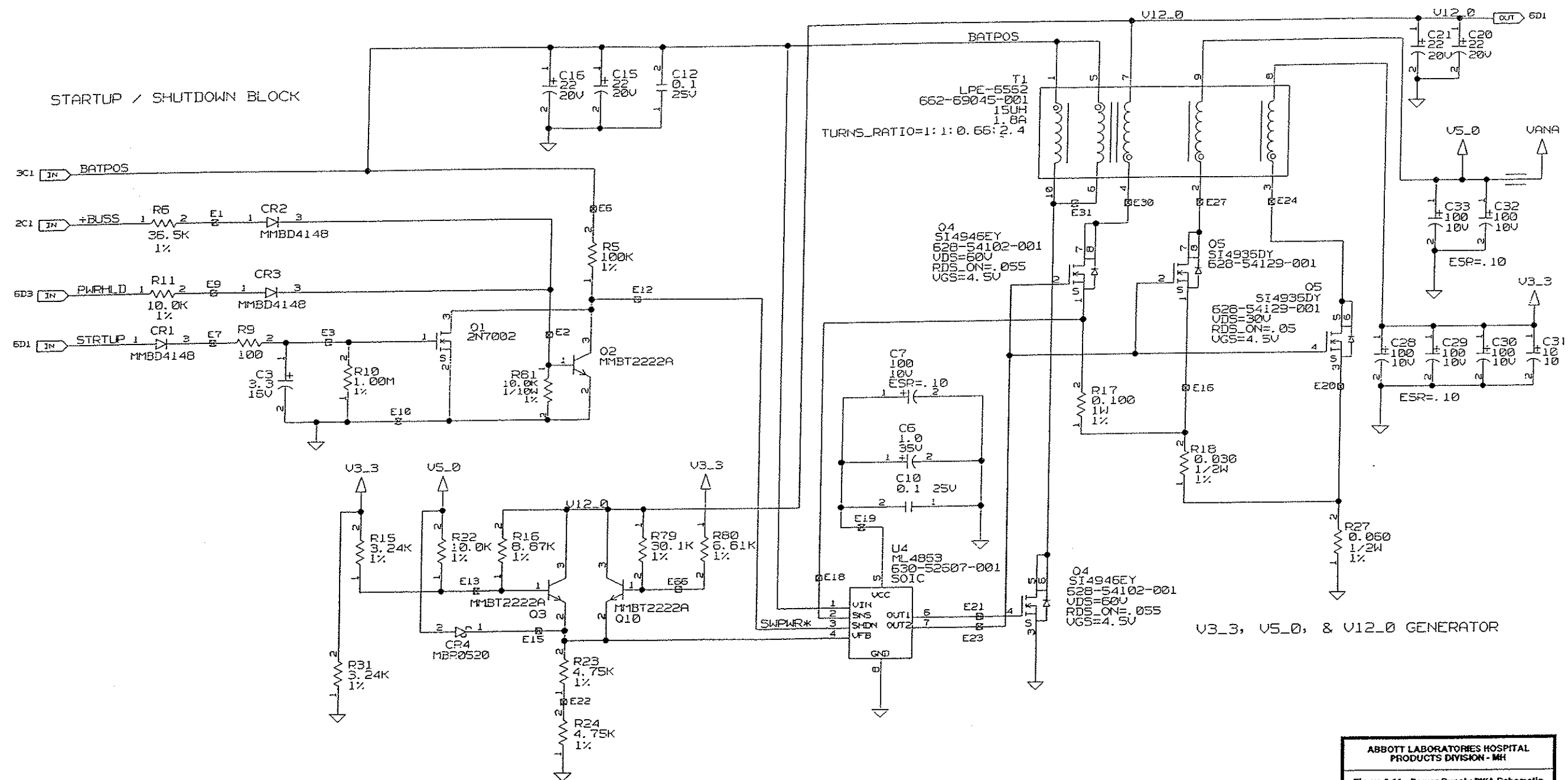
DRAWING NO. 249-95005-012	Rev. L Sheet 6 of 10
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ABBOTT LABORATORIES HOSPITAL
PRODUCTS DIVISION - MH

Figure 9-11. Power Supply PWA Schematic

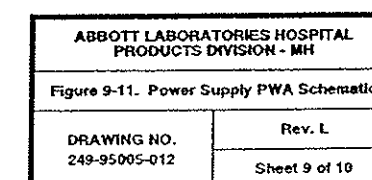
DRAWING NO. 249-95005-012	Rev. L Sheet 7 of 10
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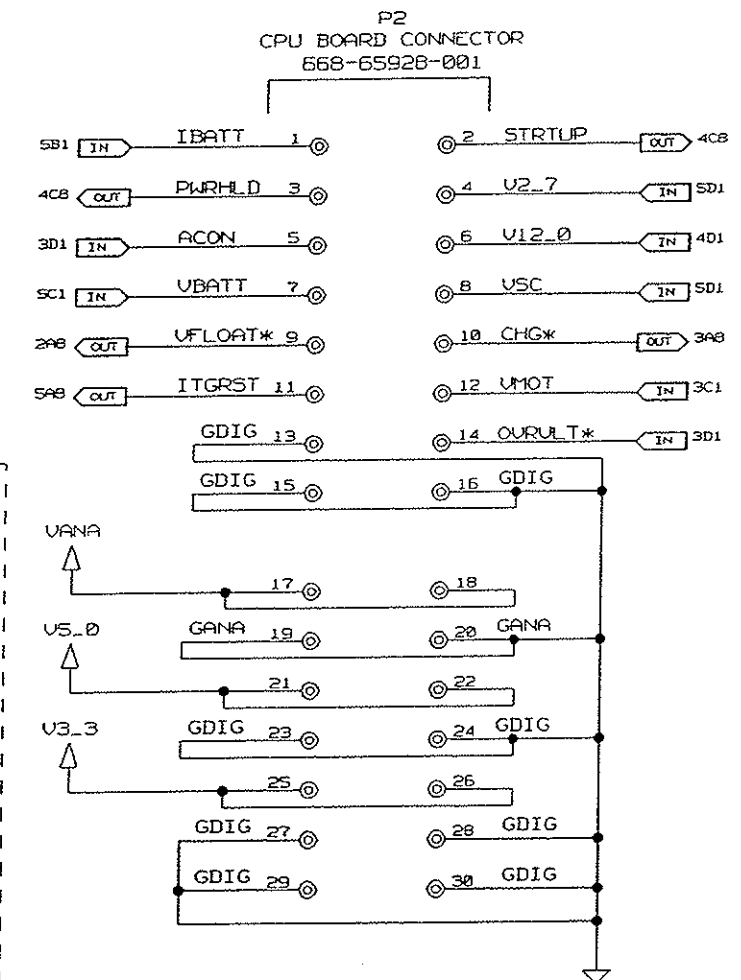
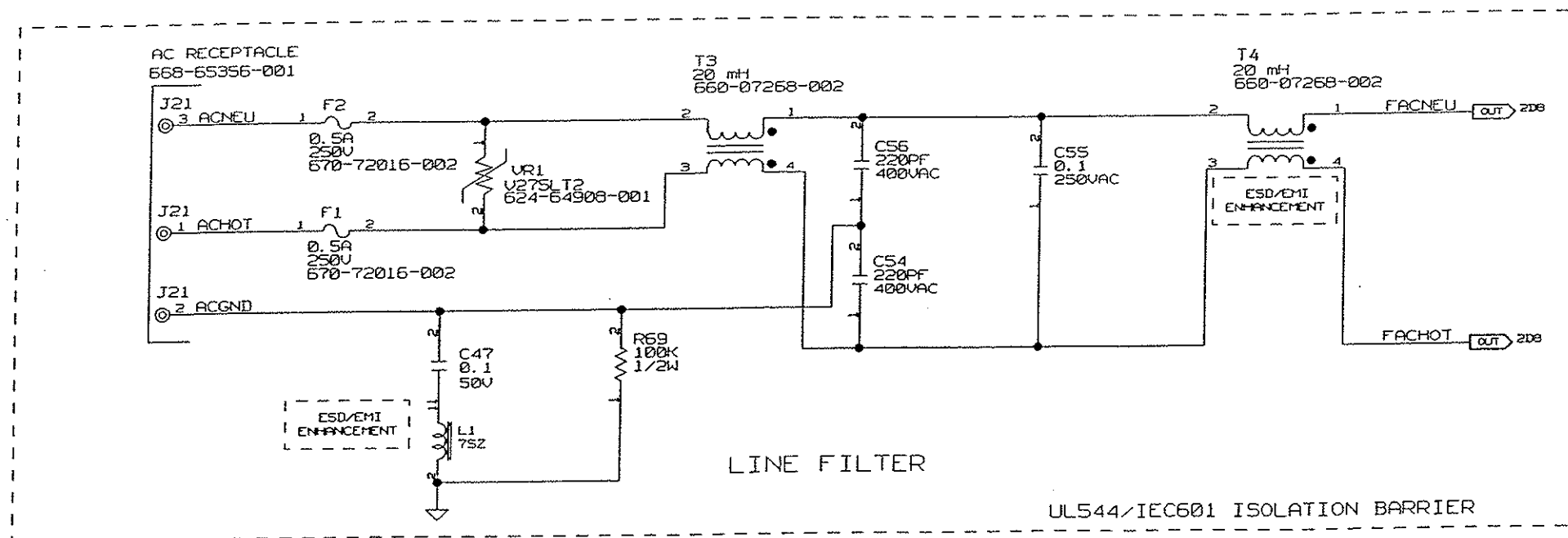


ABBOTT LABORATORIES HOSPITAL
PRODUCTS DIVISION - MH

Figure 9-11. Power Supply PWA Schematic

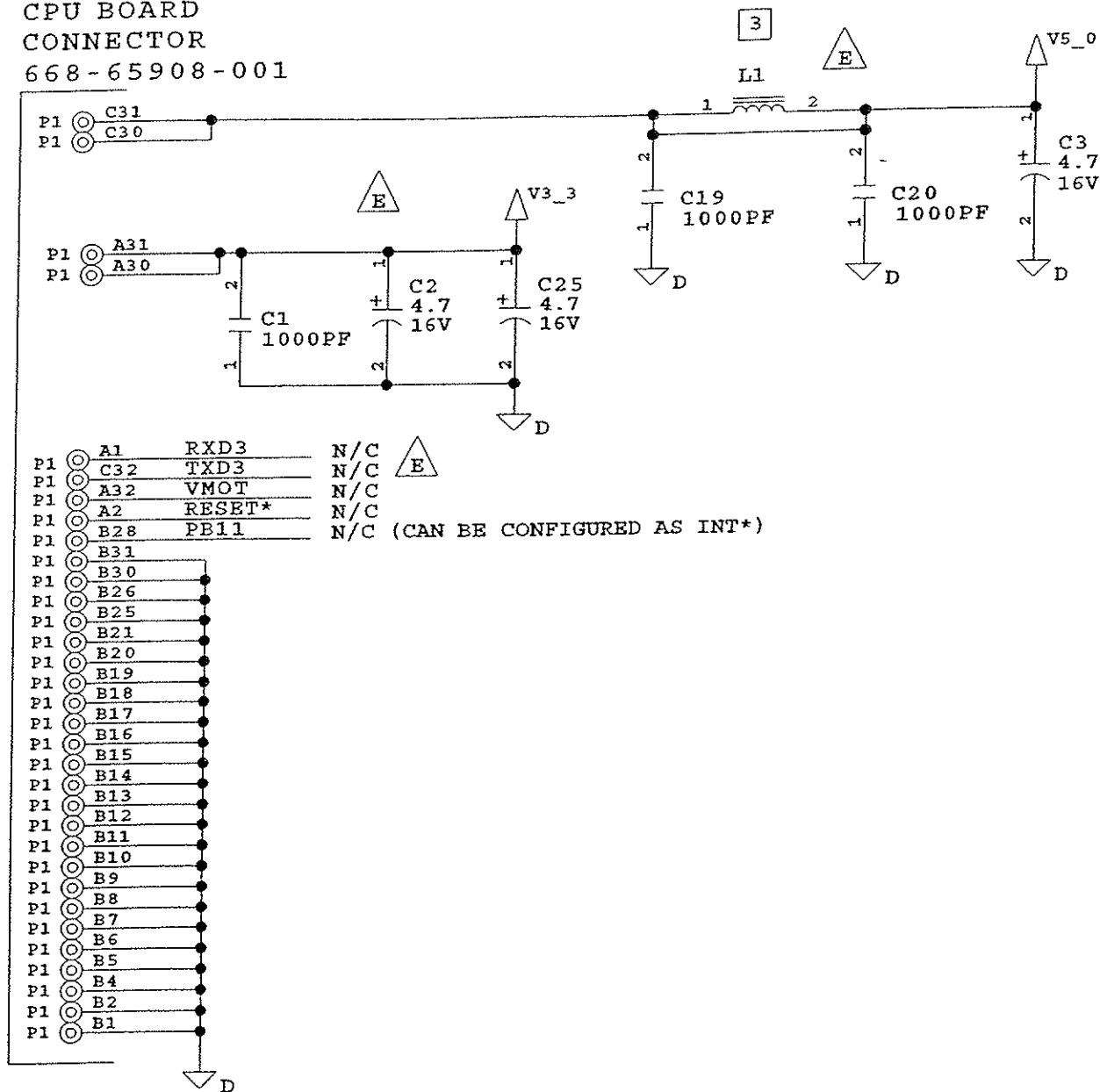
DRAWING NO. 249-95005-012	Rev. L Sheet 8 of 10
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ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-11. Power Supply PWA Schematic	
DRAWING NO. 249-95005-012	Rev. L Sheet 10 of 10

CPU BOARD
CONNECTOR
668-65908-001



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F Sheet 1 of 4

P1 C12 A<23> N/C
 P1 C13 A<22> N/C
 P1 A13 A<21> N/C
 P1 C14 A<20> N/C
 P1 A14 A<19>

P1 B23 AS* N/C
 P1 A24 R/W*

JP3 SETTINGS:
 27LV040 (DEFAULT) - SHUNT 2,3
 29W040 (FLASH ALTERNATE) - SHUNT 1,2

U1
 PLCC
 VCC=V3_3
 27LV040
 (29W040) FLASH ALT.
 512KX8
 V3_3 PIN: 32
 GDIG PIN: 16

U2
 PLCC
 VCC=V3_3
 27LV040
 (29W040) FLASH ALT.
 512KX8
 V3_3 PIN: 32
 GDIG PIN: 16

U3
 PLCC
 VCC=V3_3
 27LV040
 (29W040) FLASH ALT.
 512KX8
 V3_3 PIN: 32
 GDIG PIN: 16

U4
 PLCC
 VCC=V3_3
 27LV040
 (29W040) FLASH ALT.
 512KX8
 V3_3 PIN: 32
 GDIG PIN: 16

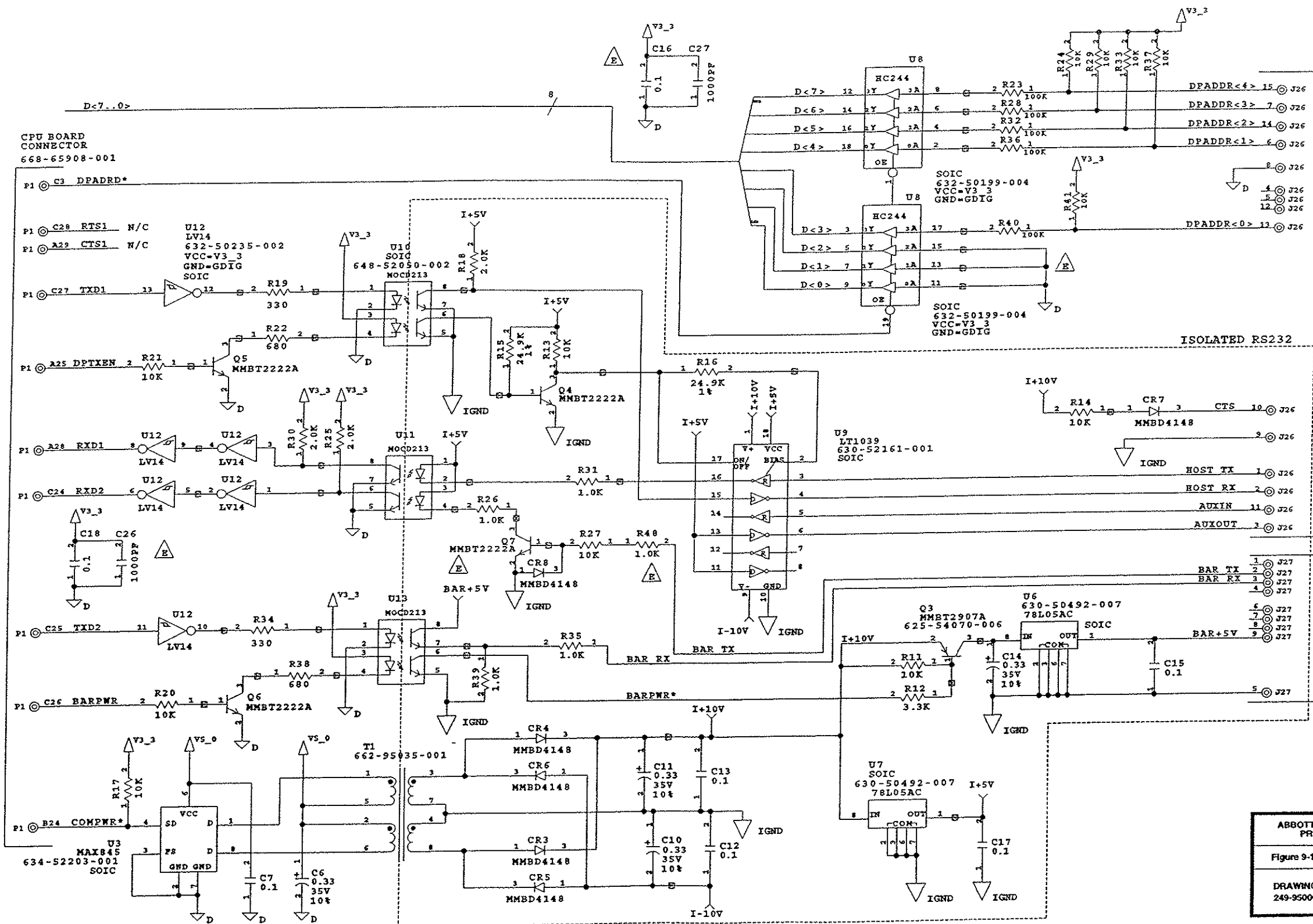
U5
 VCC=V3_3
 VSS=GDIG
 SOP
 637-10124-001
 512KX8
 V3_3 PIN: 32
 GDIG PIN: 16

668-65908-001
 CPU PWA
 CONNECTOR

P1 C15 A<18>
 P1 A15 A<17>
 P1 C16 A<16>
 P1 A16 A<15>
 P1 C17 A<14>
 P1 A17 A<13>
 P1 C18 A<12>
 P1 A18 A<11>
 P1 C19 A<10>
 P1 A19 A<9>
 P1 C20 A<8>
 P1 A20 A<7>
 P1 C21 A<6>
 P1 A21 A<5>
 P1 C22 A<4>
 P1 A22 A<3>
 P1 C23 A<2>
 P1 A23 A<1>

P1 B22 CSROM*
 P1 B32 CSRAM*
 P1 A26 LDS*
 P1 C29 UDS*
 P1 C4 UWRIT*
 P1 C1 UREAD*
 P1 B3 LWRIT*
 P1 C2 LREAD*

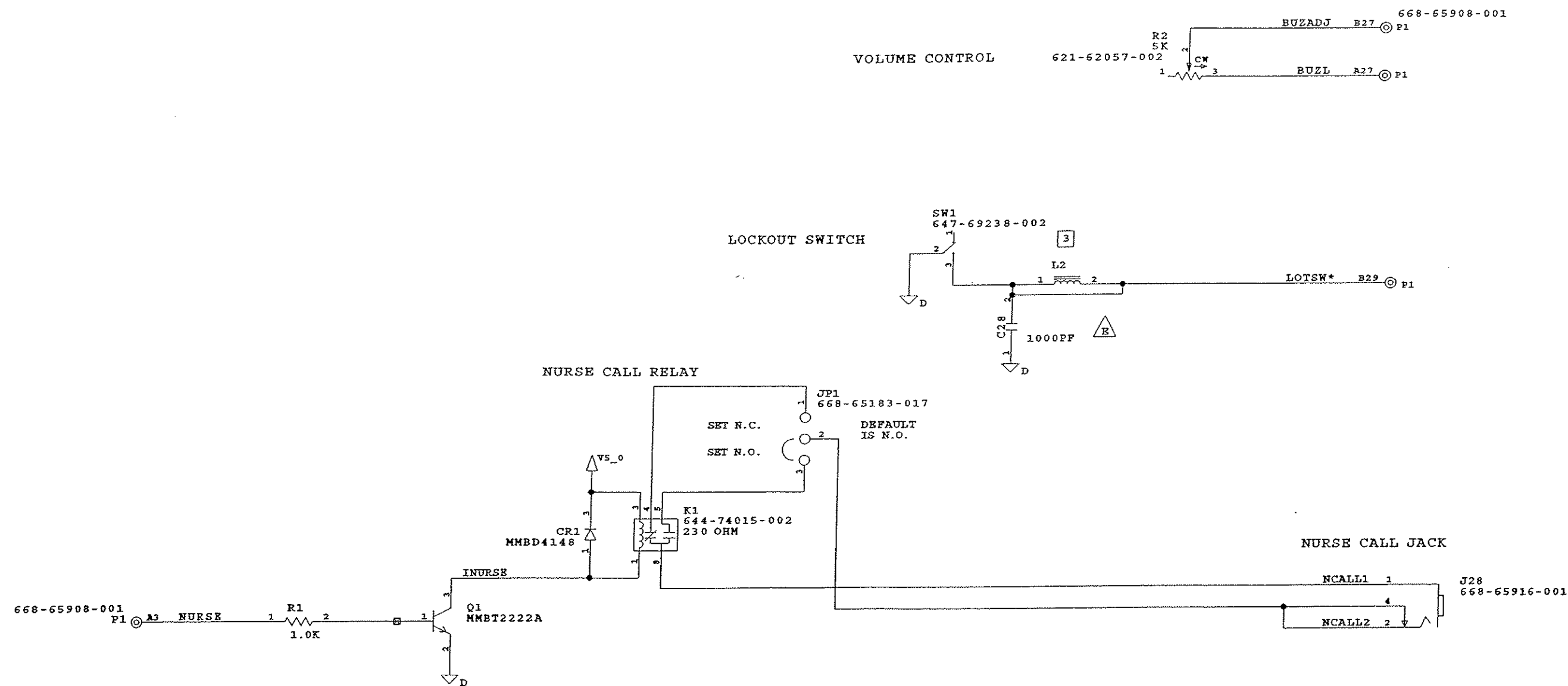
Figure 9-12. Peripherals



DATAPOINT
15 PIN
D-SUB FEM.
668-65059-004

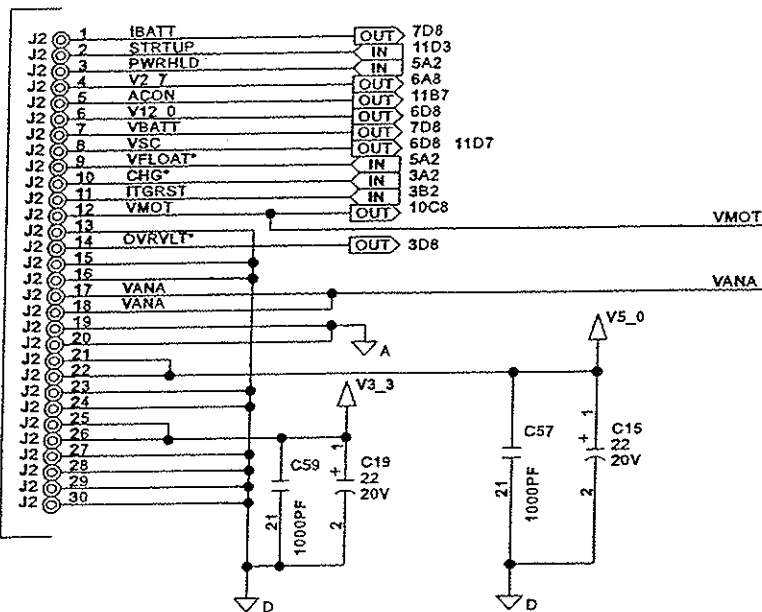
BAR CODE
READER PORT
9 PIN
D-SUB FEM.
668-65350-001

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 3 of 4

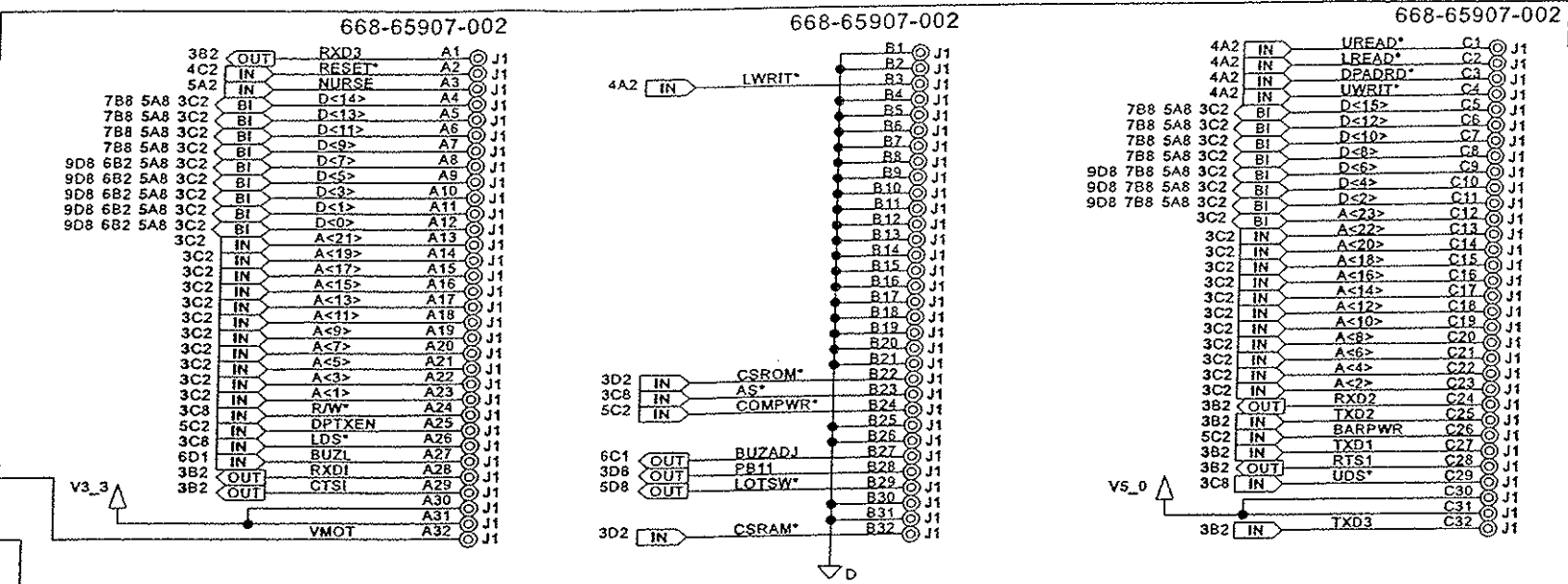


ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-12. Peripheral PWA Schematic	
DRAWING NO. 249-95006-007	Rev. F
	Sheet 4 of 4

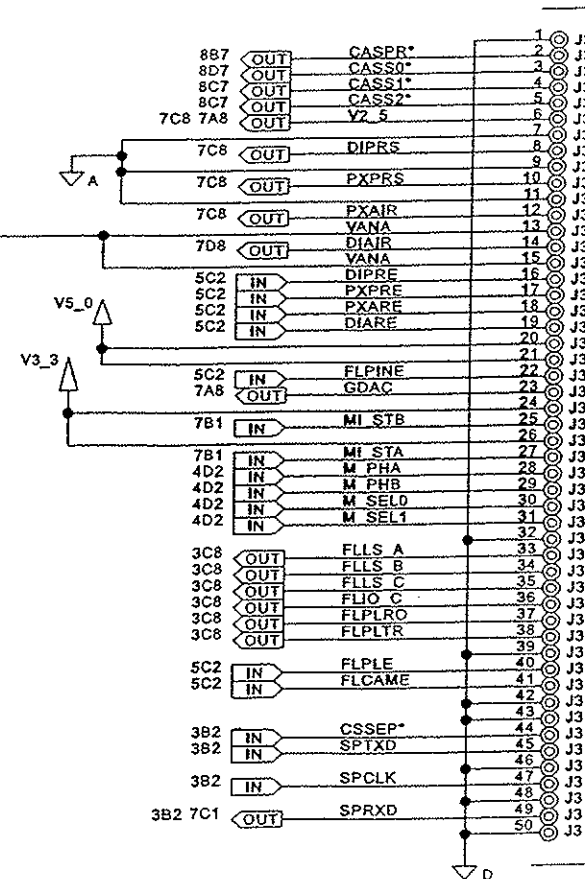
POWER SUPPLY CONNECTOR 668-65183-035



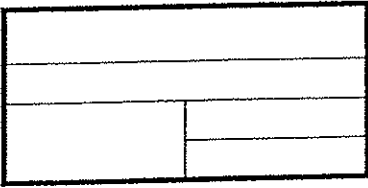
PERIPHERAL CONNECTOR

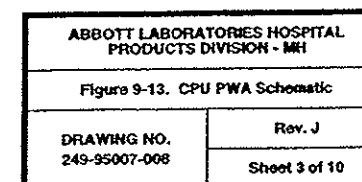


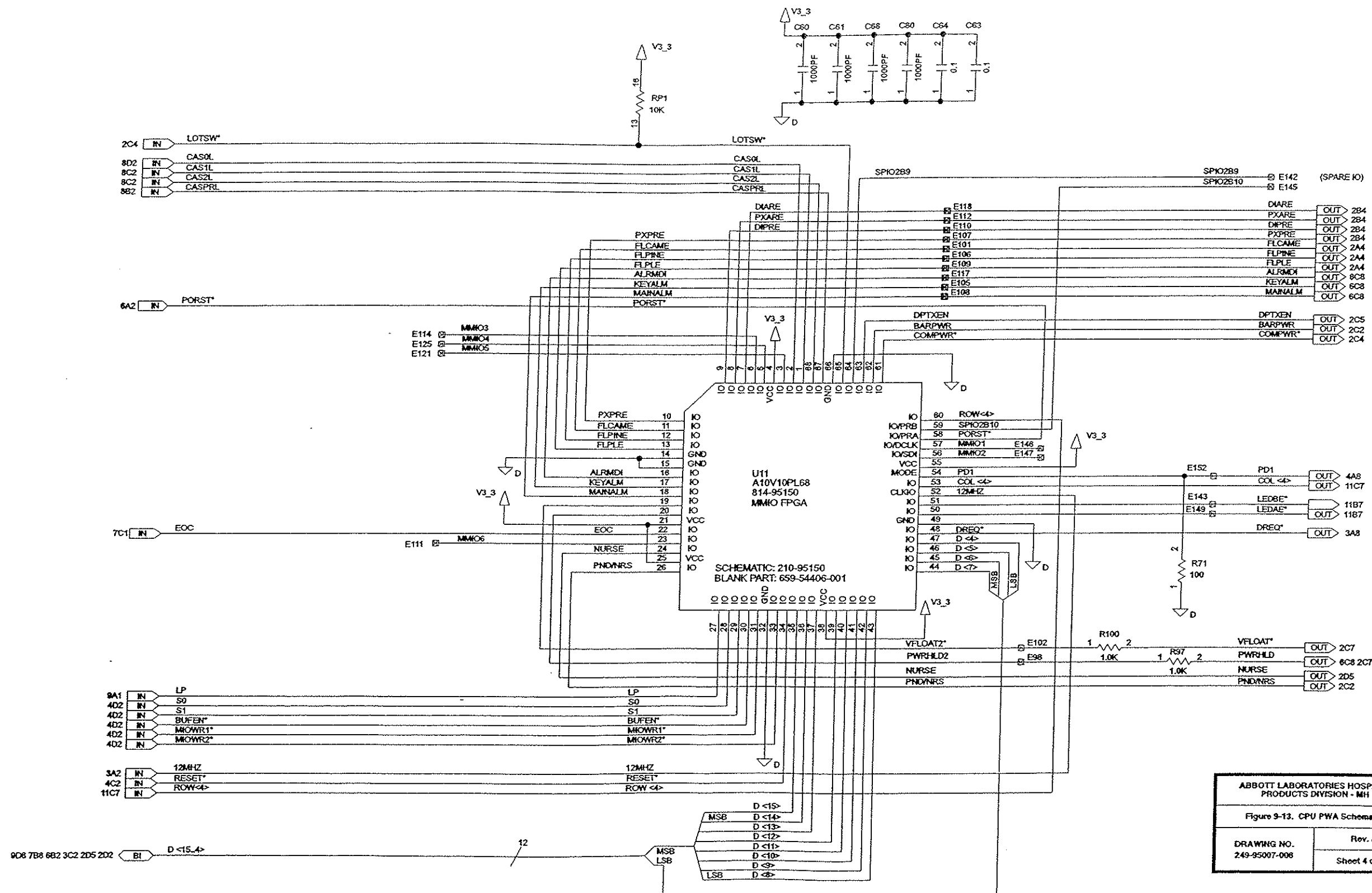
DRIVER PWA CONNECTOR 668-65923-002



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J Sheet 1 of 10



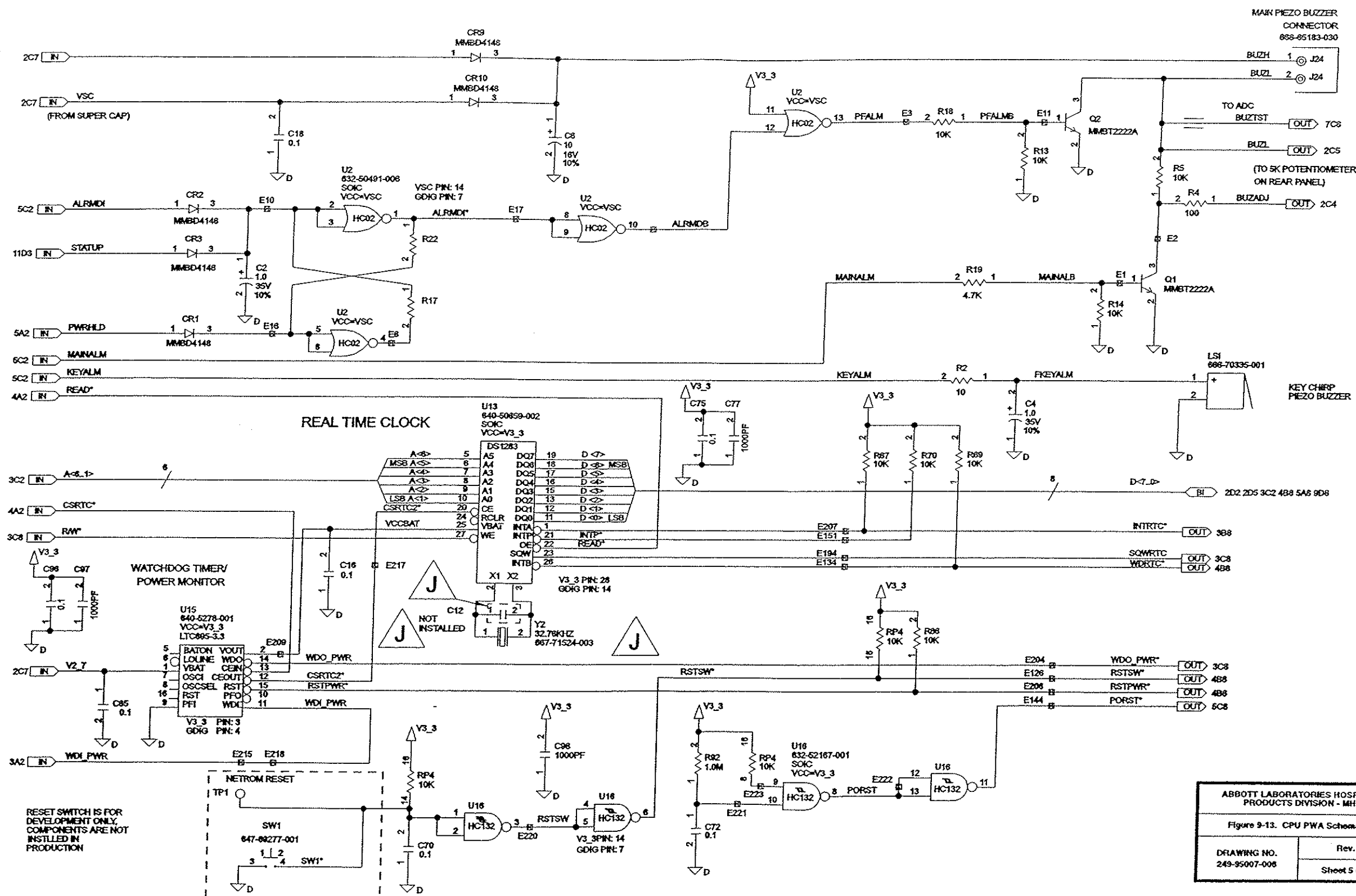




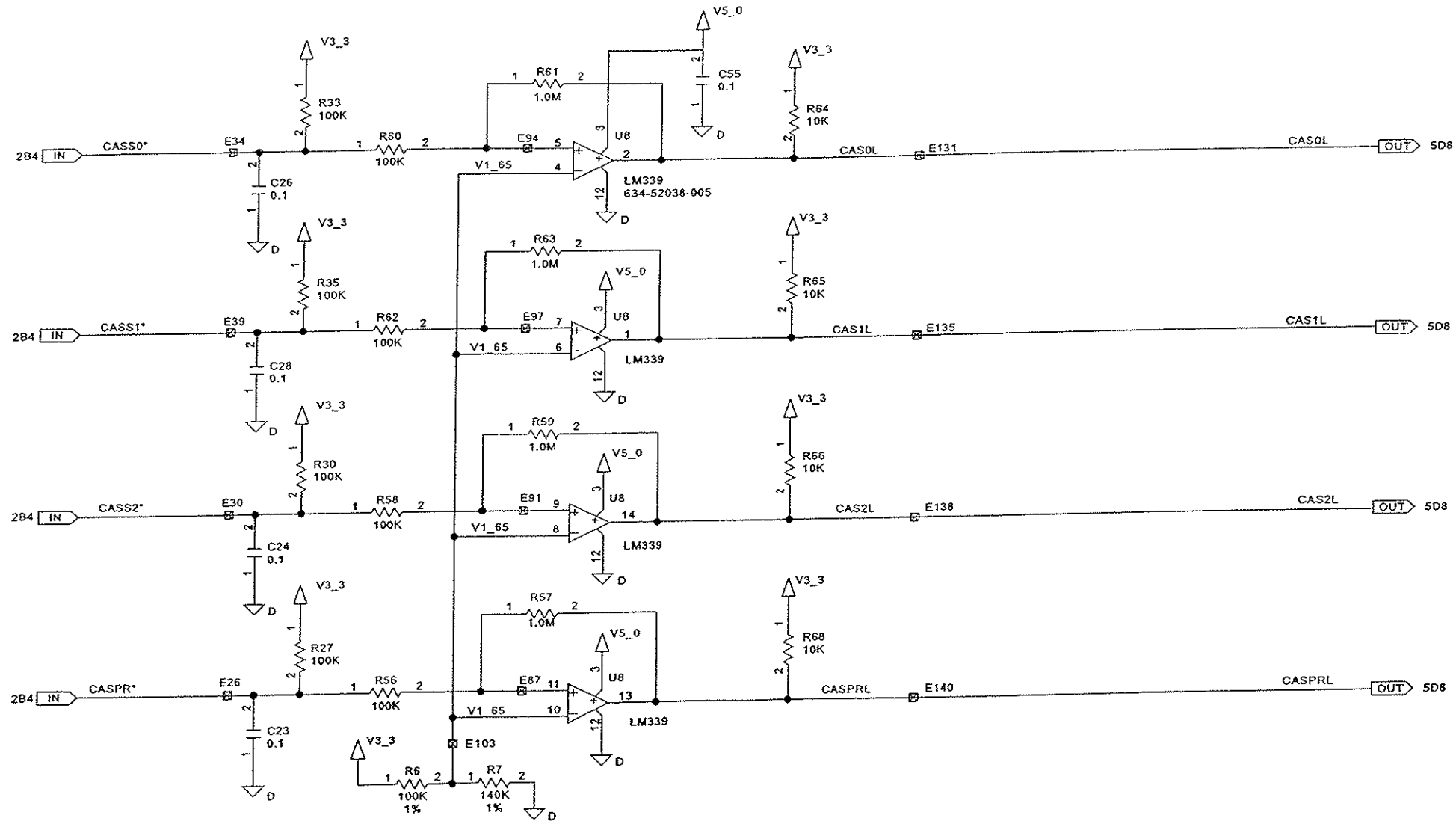
ABBOTT LABORATORIES HOSPITAL
PRODUCTS DIVISION - MH

Figure 9-13. CPU PWA Schematic

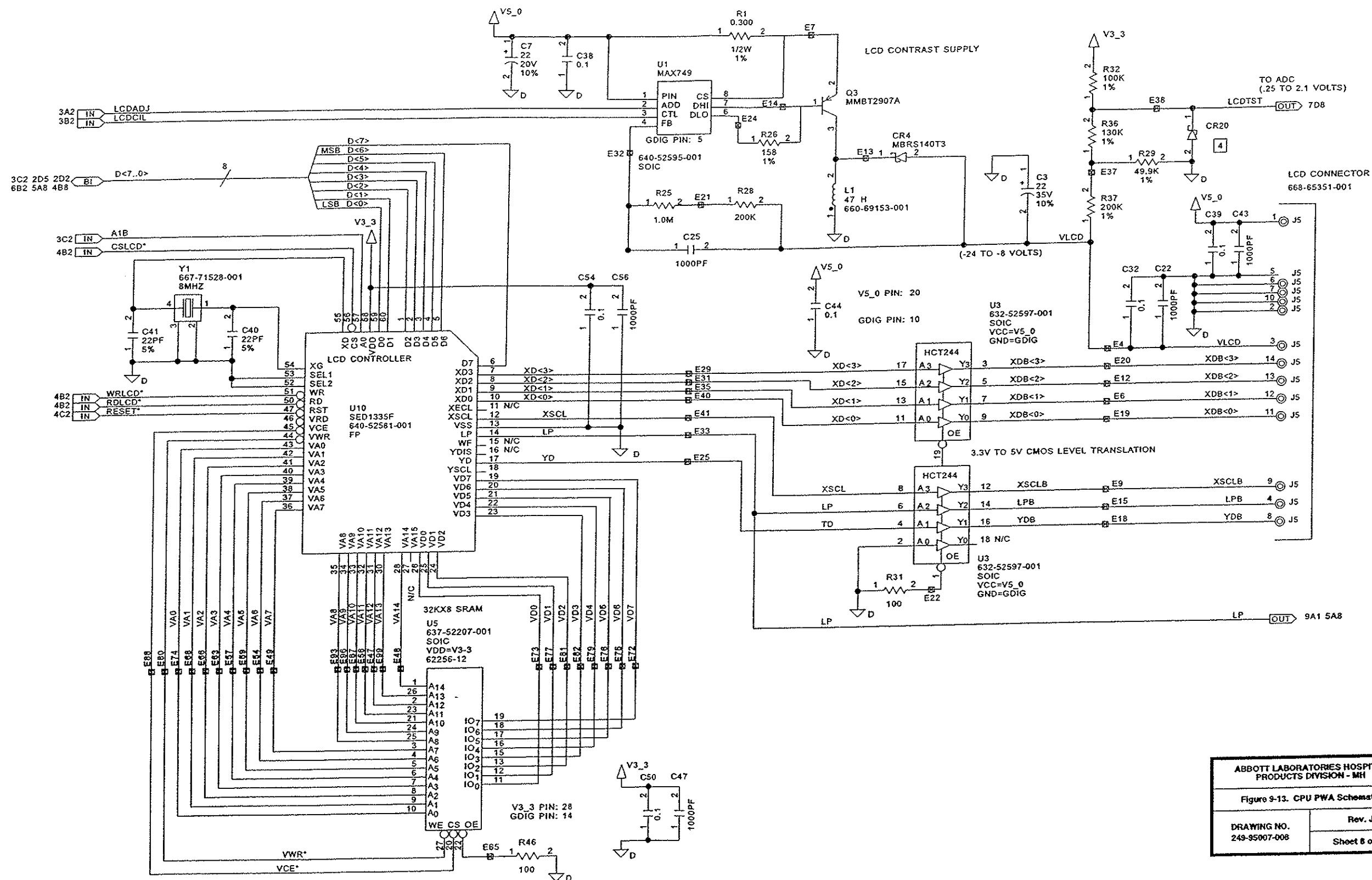
DRAWING NO. 249-95007-008	Rev. J Sheet 4 of 10
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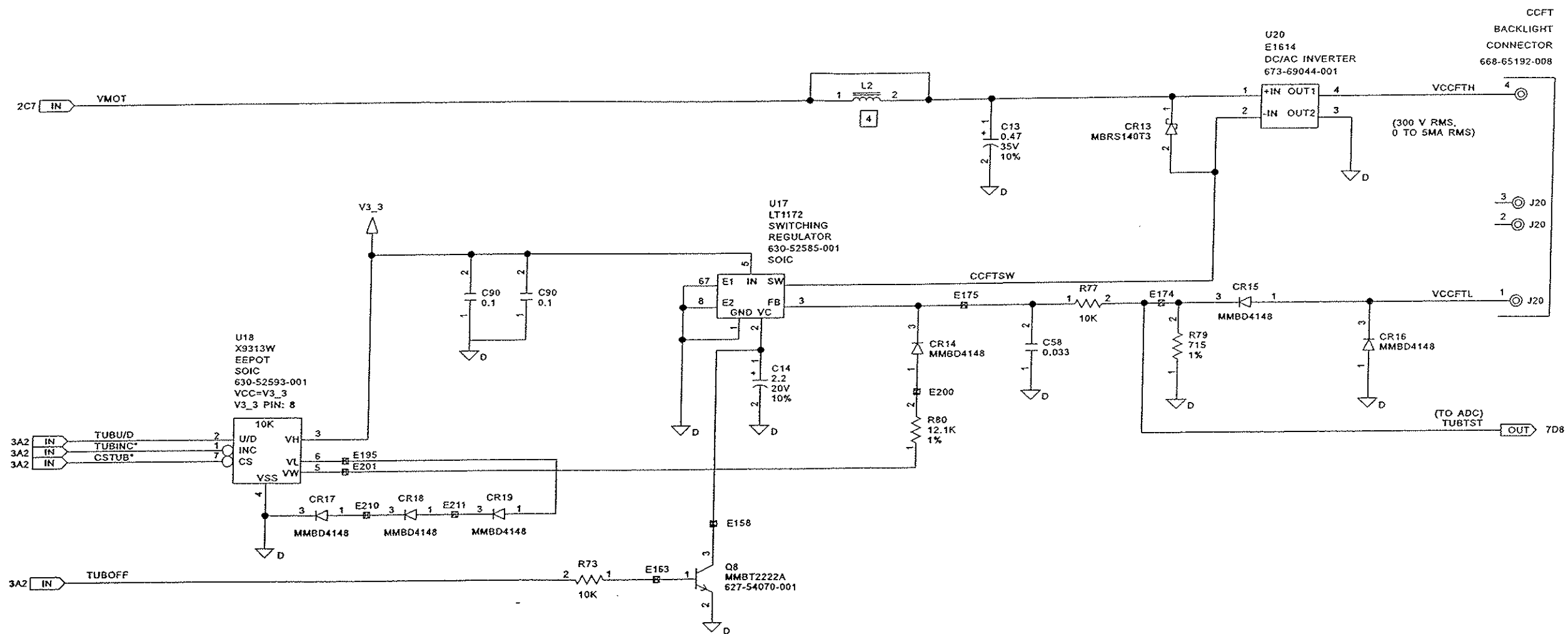
CASSETTE ID FSR
COMPARATORS



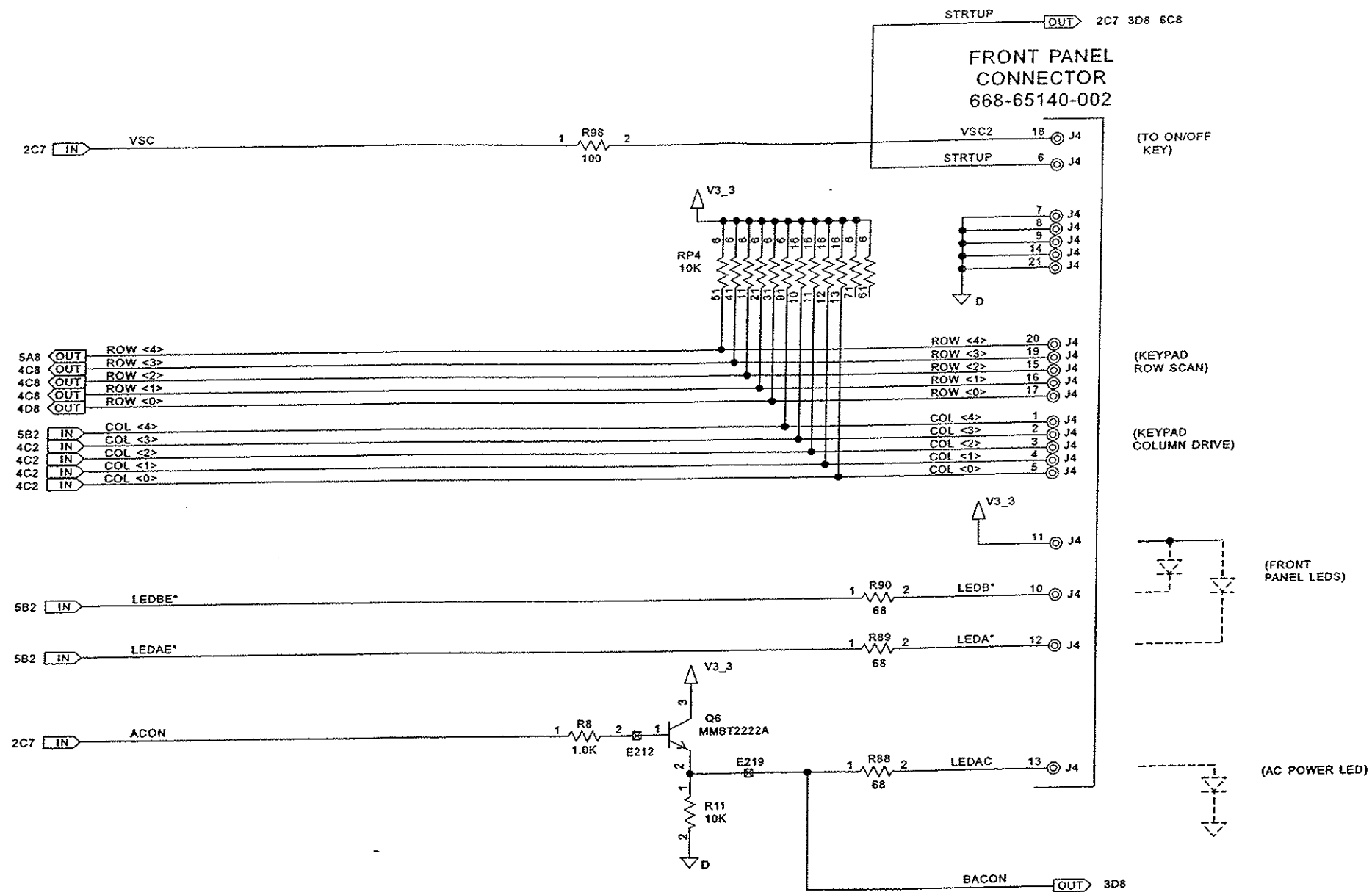
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 7 of 10



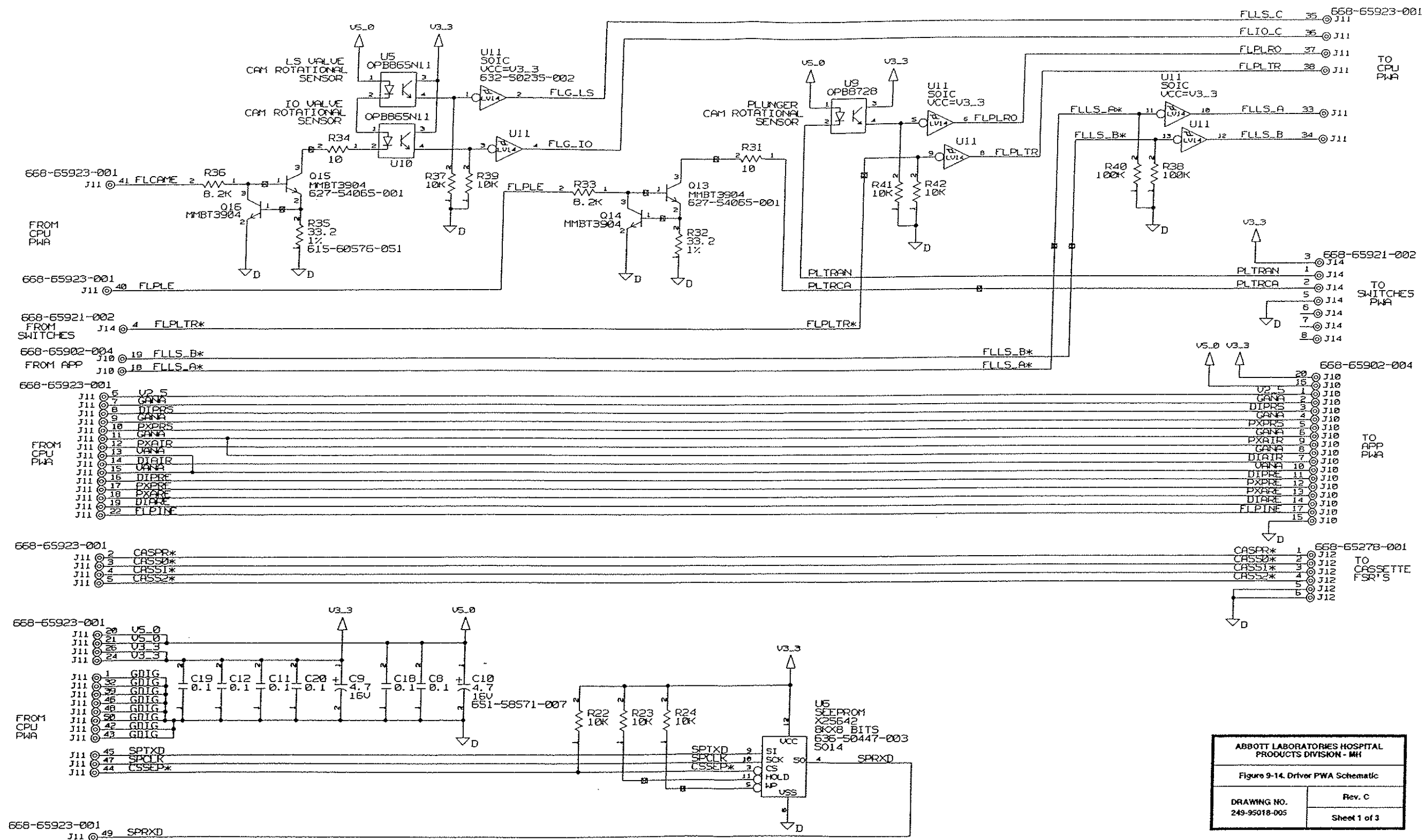
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J
	Sheet 6 of 10



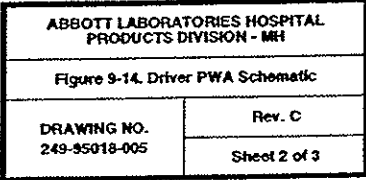
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J Sheet 9 of 10

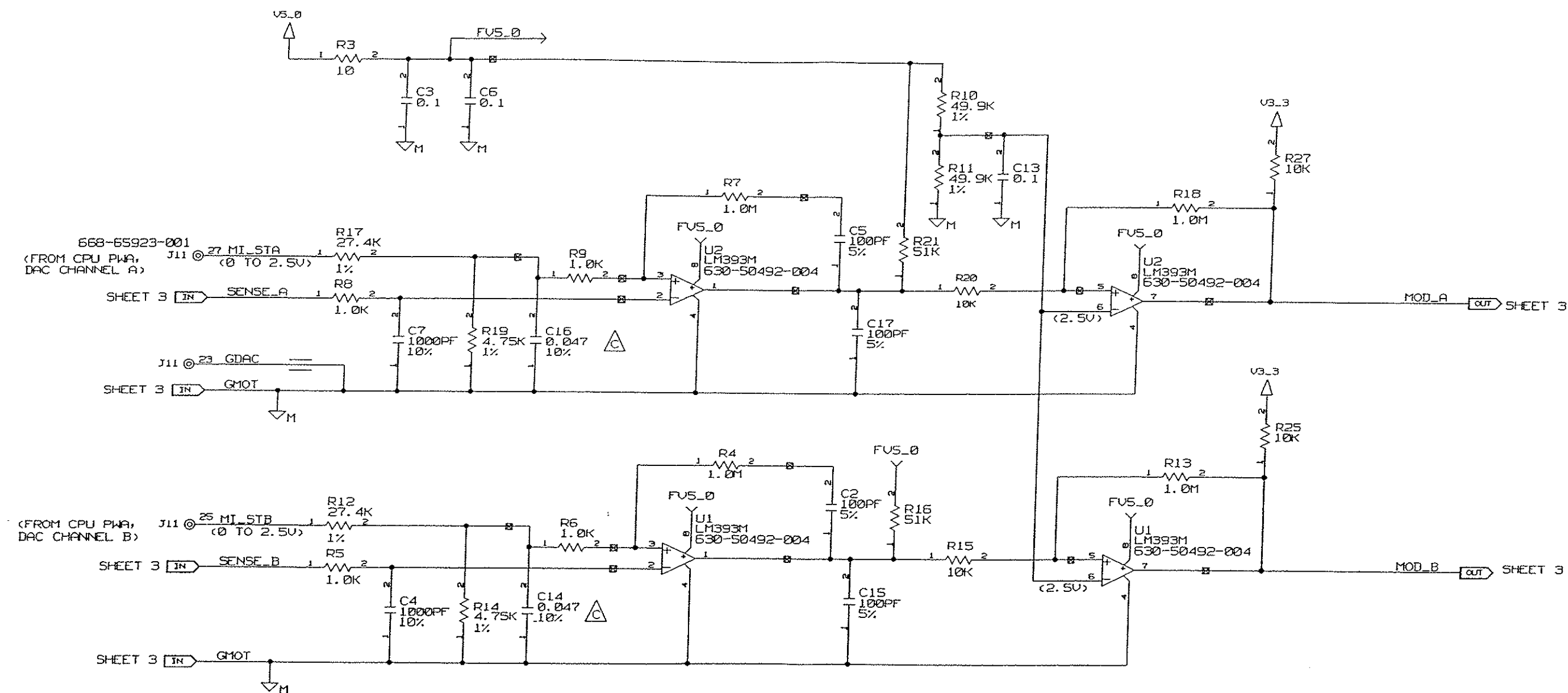


ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-13. CPU PWA Schematic	
DRAWING NO. 249-95007-008	Rev. J Sheet 10 of 10

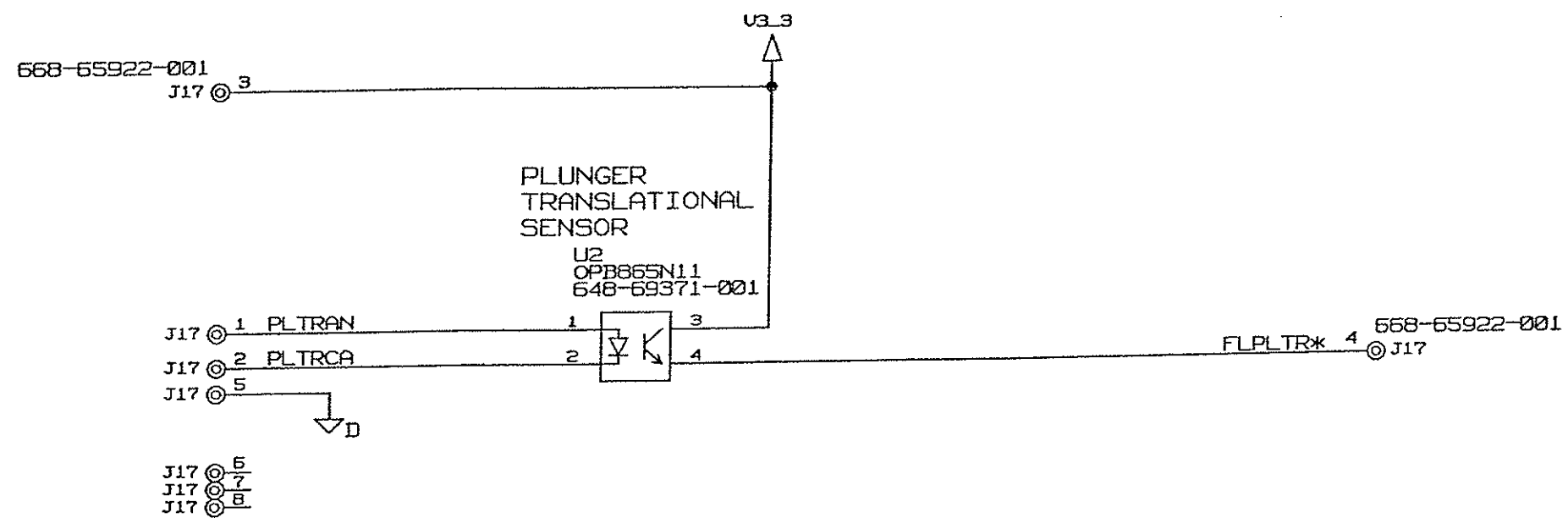


ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-95018-005	Rev. C
Sheet 1 of 3	

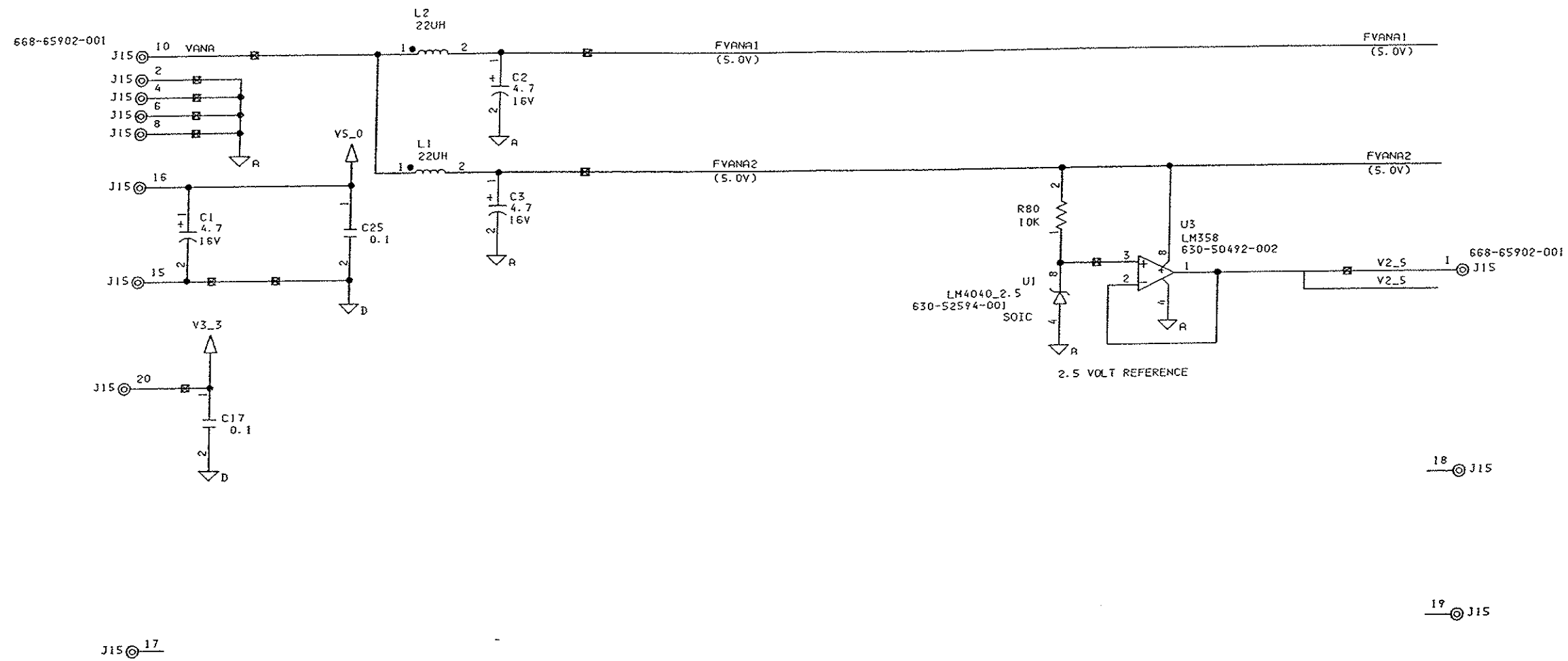




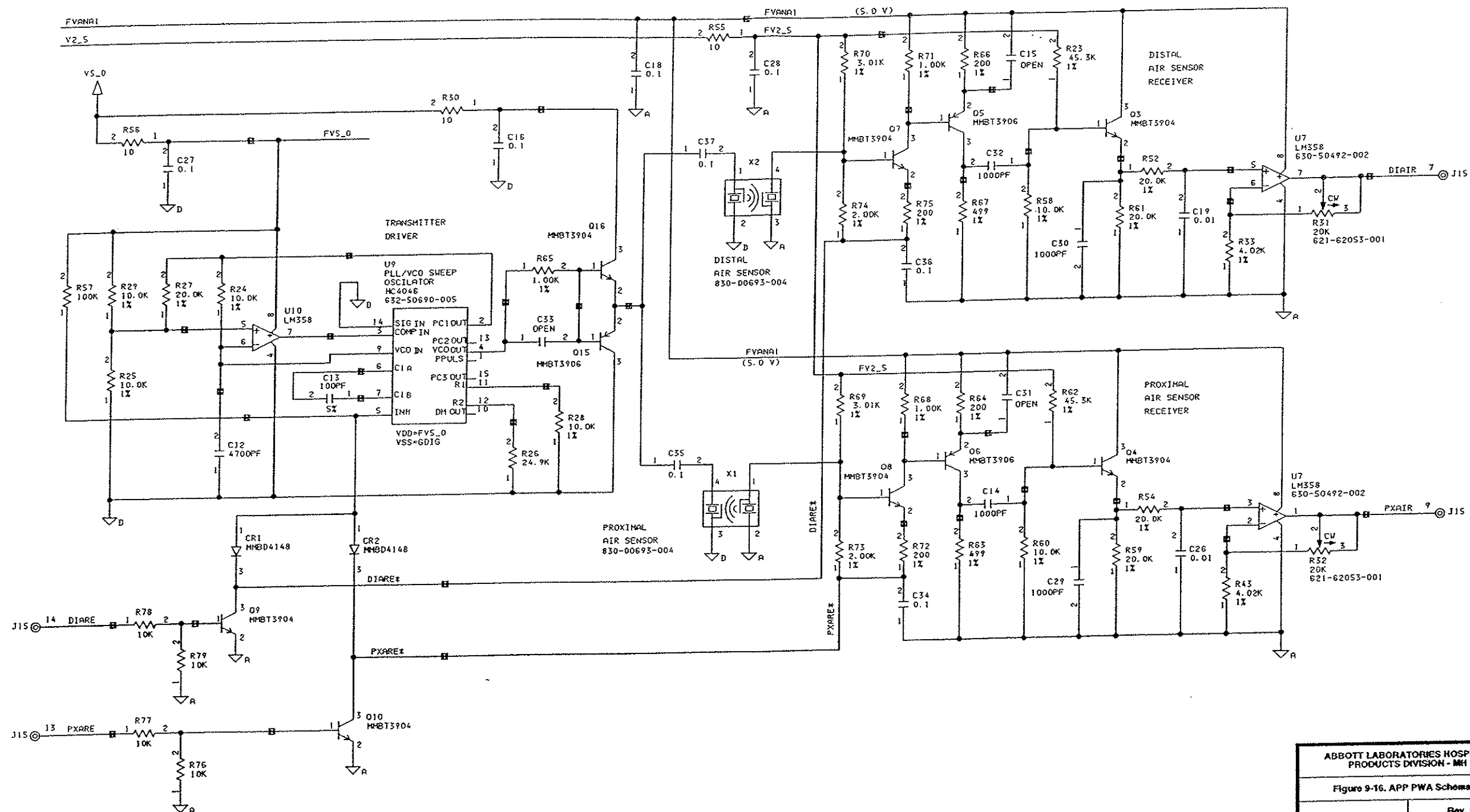
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-14. Driver PWA Schematic	
DRAWING NO. 249-85018-005	Rev. C
	Sheet 3 of 3



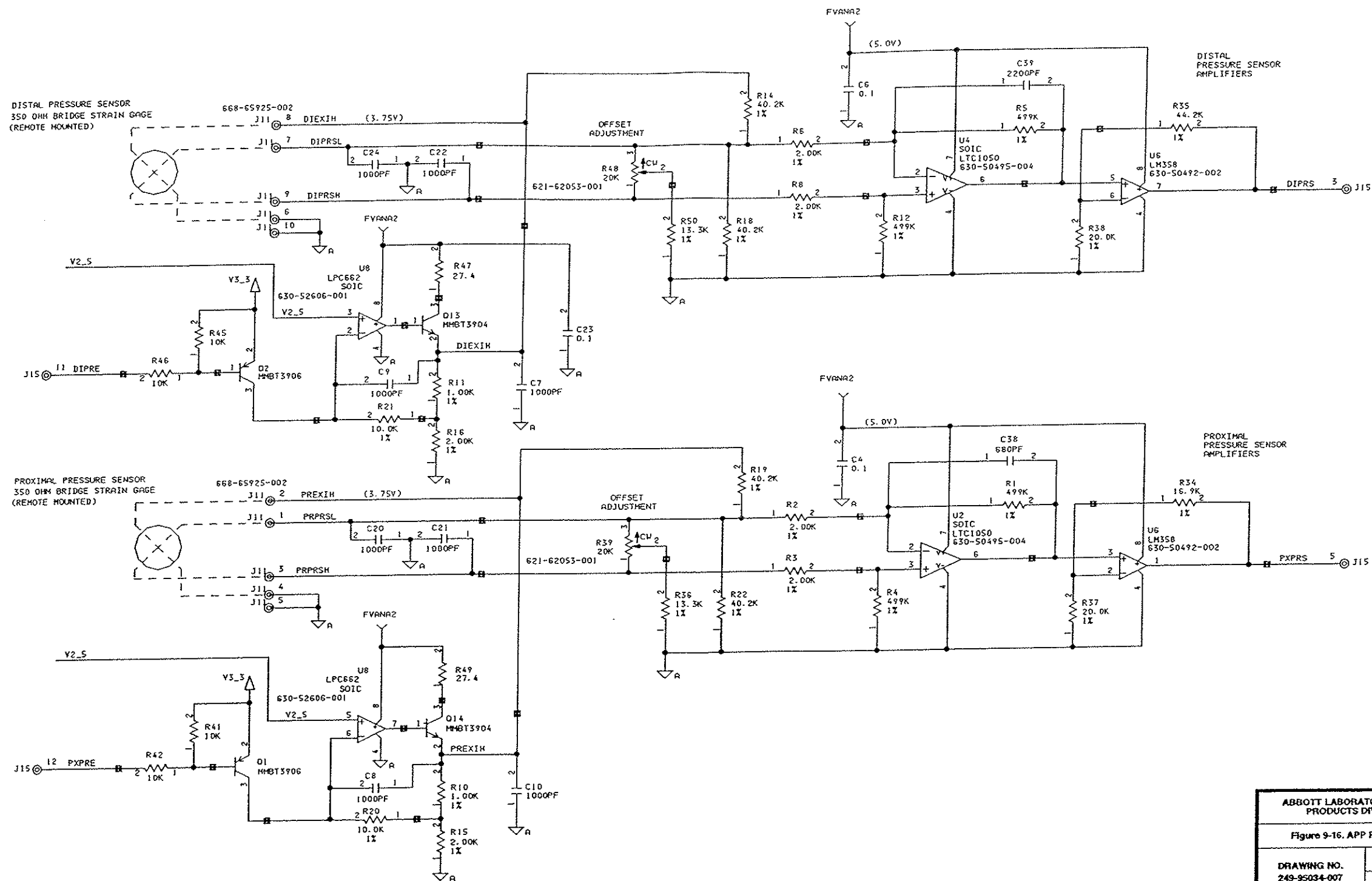
ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-15. Switch PWA Schematic	
DRAWING NO. 249-95022-003	Rev. B
	Sheet 1 of 1



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-16. APP PWA Schematic	
DRAWING NO. 249-95034-007	Rev. C
	Sheet 1 of 3



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-16. APP PWA Schematic	
DRAWING NO. 249-95034-007	Rev. C Sheet 2 of 3



ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION - MH	
Figure 9-16. APP PWA Schematic	
DRAWING NO. 249-95034-007	Rev. C Sheet 3 of 3

